



Adaptive edge/cloud compute and network continuum over a heterogeneous sparse edge infrastructure to support NextGen applications

Deliverable D7.2

Dissemination & exploitation activities (I)



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EXECUTIVE SUMMARY

ACCORDION project aims at unlocking the full potential of a big class of applications that are too latency-sensitive, or data-dependent, to be moved to the public cloud. ACCORDION couples efficient, decentralized and AI-based solutions for cloud and edge resource federation with novel approaches for application definition management and generation at runtime.

This deliverable provides a broad overview of the communication, dissemination and exploitation activities implemented within the ACCORDION project within the first 18 months of the project and a detailed market analysis. A detailed exploitation strategy for the project, as well as exploitation plans for individual partners, was presented in the previous deliverable D7.1. Based on those plans, in this deliverable we carry out an evaluation of the ACCORDION project's dissemination and exploitation activities made so far.

DISCLAIMER

ACCORDION (871793) is a H2020 ICT project funded by the European Commission.

ACCORDION establishes an opportunistic approach in bringing together edge resource/infrastructures (public clouds, on-premise infrastructures, telco resources, even end-devices) in pools defined in terms of latency, that can support NextGen application requirements. To mitigate the expectation that these pools will be “sparse”, providing low availability guarantees, ACCORDION will intelligently orchestrate the compute & network continuum formed between edge and public clouds, using the latter as a capacitor. Deployment decisions will be taken also based on privacy, security, cost, time and resource type criteria.

This document contains information on ACCORDION core activities. Any reference to content in this document should clearly indicate the authors, source, organisation and publication date.

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GLOSSARY

5G	5th Generation Mobile Network
A&PS	Advisory & Professional Services
AR	Augmented Reality
CCU	Concurrent Users
DevOps	Development and Operations
DevSecOps	development, security and operations
DMP	Data Management Plan
EC	European Commission
ECS	Entity Component System
EU	European Union
FAIR	Findable, Accessible Interoperable Re-usable
H2020	Horizon 2020 EU Framework Programme for Research and Innovation
HiPEAC	High Performance Embedded Architecture and Compilation
HMD	Head Mounted Display
ICT	Information Communication Technology
IoT	Internet of Things
IP	Intellectual Property
IT	Information Technology
KPIs	Key Performance Indicators
MEC	Multi-access Edge Computing
PPAI	Privacy-preserving AI
QoE	Quality of Experience
R&D	Research and Development
TRL	Technology Readiness Level
VIM	Virtualized Infrastructure Manager
VR	Virtual Reality
WP	Work Package

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1 Introduction

1.1 Purpose of this document

The goal of deliverable 7.2 is to provide an overview of the dissemination, communication and exploitation activities that have been (and will be) undertaken within the ACCORDION project together with a market analysis and identification of ACCORDION Competitive advantage.

1.2 The ACCORDION Impact Creation Phase I

The ACCORDION dissemination, communication and exploitation plan is divided into the following three phases: (i) development, (ii) pre-commercialization or “results wrap-up” and (iii) commercialization or “follow up”. During the development phase, which is expected to last for 2 years, the goal of the communication and dissemination strategy is to create awareness and greater visibility for the Accordion vision and approach followed. In the following 1-year pre-commercialization phase, where most Accordion components will have reached TLR 5 or 6, the goal will be to target specific audiences in order to create or stimulate further the market for the Accordion platform. The commercialization phase will start from the moment the project ends. In this case, the goal will be to continue interacting with targeted audiences and explore the path for future upgrades to the product/service offerings that will have been created as a result of the ACCORDION project.

For more information about the Accordion impact creation, we refer the reader to deliverable 7.1.

1.3 Document structure

This deliverable contains 7 sections and is structured as follows: Section 2 provides an in-depth market analysis of the core technologies used within Accordion following three distinct models. Section 3 aims to identify the unique selling propositions and competitive advantage of Accordion with respect to similar existing solutions, while Section 4 is centered around the exploitation strategies of each partner as well as the joint one. Section 5 outlines the dissemination and communication activities that have been carried out, as well as the data management plan. Section 6 details the main key performance indicators together with the achievements fulfilled so far. Finally, Section 7 gives concluding remarks on this deliverable.

2 Market Analysis

ACCORDION aims to provide high technologies and associated services to vertical industries for low-latency, high bandwidth and resource demanding applications. Describing the context of the NextGen applications industry in Europe (especially novel ICT for industry) is a key step for setting the framework in order to perform a concrete market analysis. This section performs a macro level analysis of the main economic, and technological trends impacting the marketing potential of ACCORDION products and services. Potential customers of ACCORDION products are companies with highest innovation potential, investment capacities and with needs correlated to our technologies.

The market analysis will give insights and valuable information to the Consortium regarding the potentiality of the markets we compete in and the trends, the opportunities, and the dynamics of the domains and the verticals that ACCORDION envisions to offer highly competitive and robust solutions. Important insights are provided by the monitoring of the potential competitors and the business development strategy they follow as this indicates their response logic to end-users' requirements and business needs. The market analysis also paves the way for the forming of our federation rationale regarding the requirements and business objectives of infrastructure and resource providers and telecommunication operators. The latter will be analyzed in detailed within the task 7.5 regarding the ACCORDION federation model & business logic.

2.1 Methodology

In order to take full benefit of the innovative offerings of the ACCORDION project, we should analyze the markets we compete in, to fully understand their potentials and identify the main drivers and restraints of the specific markets. The approach underpinning this deliverable requires an extensive research framework to ensure comprehensive coverage of industry opinions. To achieve this, a mixture of different models to get in-depth knowledge of the targeted markets were aggregated together to inform the key findings. In specific, ACCORDION consortium has utilized the following three models:

- The Market insight model, which involves studying publicly available industry reports for identifying long-term and emerging macroscopic market trends, including estimates about market size evolution, market challenges and business opportunities in the area of edge computing and its vertical application domains of VR, AR and cloud mobile gaming.
- The Competition insight model that attempts to list key potential competitors and their product offerings with an emphasis on the expansion and business development strategy they follow, for their better positioning to the market that they target.
- the Client insight model, which targets to identify the key activities that the main intended user groups seek to perform and better understand their existing pain points, as well as the expected gains by adopting the ACCORDION approach.

The current document has therefore the objective to initiate the work on these three models and collect critical information to support the ACCORDION consortium in the following directions:

- i. fine-tune the development plan of the ACCORDION Framework and align it to the target markets' expectations.
- ii. define best exploitation strategies for the individual framework capabilities and the joint solution within the application and technology contexts.

With this market analysis framework, we will be able to identify in which sectors and domains there is potential to enter the market and to identify the associated competing products. Via the market analysis, critical aspects, opportunities, influencing factors and relevant actors are identified so as to monitor them during the project development cycle.

2.2 Market analysis planning

After starting in early 2020, ACCORDION is in its second year. As planned, the first year of the project focused primarily on the analysis of the state of the art, the selection of base technologies and the definition of the overall architecture of the system: moving from the highly-level conceptual one to a more concrete one, in which the key modules of the system, along with the interactions incurring among them, have been defined and implemented. In parallel with ACCORDION technical WPs' progress, special focus is given to business development aspects, especially in terms of analyzing the market we compete in, the value that we provide to end-users, the differentiation factors compared to competitive offerings, and finally the market potentiality of the ACCORDION project.

In this section, we detail the work plan and the activities for the three models comprising the ACCORDION market analysis methodology that was introduced in the previous section.

The implementation of the market analysis methodology follows a two-phases approach for the identification of the market segments and the detailed planning of the exploitation activities. In this approach, we step on the project general scope, the business objectives, and the expected outcome, in order to position the results of ACCORDION in the target market segments and analyze better the roadmap for the specification of the business modelling activities. These phases of the market analysis methodology are:

- **Phase 1 (M3 – M18):** Establishing a common understanding of the expected project outcomes with respect to the key market innovations that we want to develop and the business stakeholders that are intended to use these innovations. Expected outcome: Through analyzing and sizing the edge computing and its vertical markets and the position of ACCORDION with the respect to the existing solutions and their maturity, this phase will result in the definition of the ACCORDION unique selling proposition.
- **Phase 2 (M19 – M24):** Preparing the pathway for exploitation and feeding the business planning and modelling activities towards the commercialization of the ACCORDION offering. Expected outcome: An update on the final target market segments, and the intended business stakeholders and relevant market representatives to approach, along with an analysis of existing business models and pricing strategies.
- **Phase 3 (M24 – M36):** Following the advancements of the previous two phases, during this period a concrete business plan will be created and a go-to-market strategy, by taking into account the current market environment and the federation logic alternatives we will have.

Based on the phases of exploitation strategy

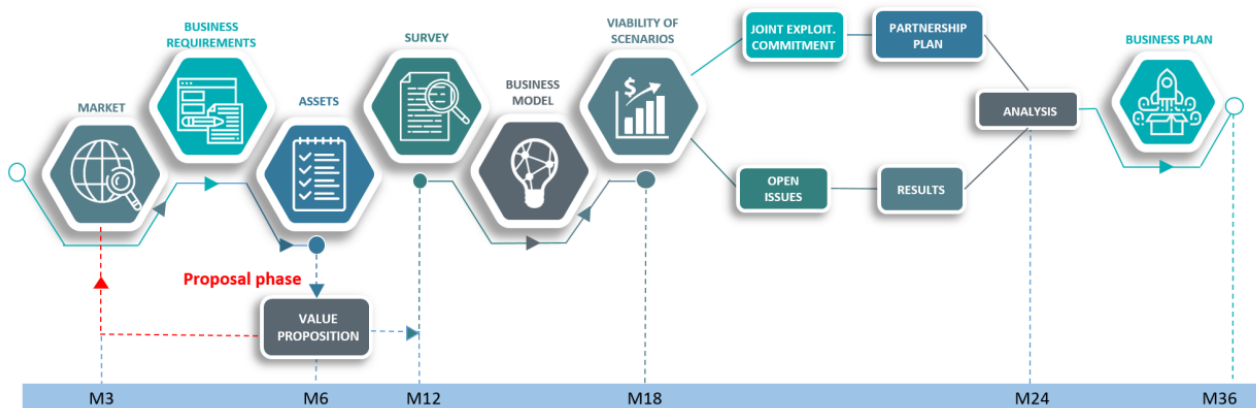


Figure 2-1: Exploitation Strategy

2.2.1 Market Insights

The purpose of this literature review aims to cover the scope of the project and presents the current maturity of the broader market of edge computing and the vertical industries that take advantage of the NextGen applications dynamics, including VR, AR and cloud mobile gaming. The activities in the implementation of this model step on top of the current trends and dynamics of each market in scope and elaborate on the following:

- a) identifying markets main drivers and constraints;
- b) identifying emerging technologies that may impact the markets;
- c) finetuning our offering to better serve potential customers;
- d) identifying risk reduction strategies;

To achieve the afore-mentioned activities, the project introduced desk research as a tool to ascertain the material in the public domain both within the academic and grey literature. The majority of the reports gave high level opinions and trends about the evolution and the dynamics of each market in global level. Due to the novelty and sensitivity of this area, many of the industry opinions and recent developments were not in the public domain. This illustrates the need for combining the results of this model with the Client insight model.

The execution of the activities in this model spans across the project lifetime, with emphasis on the second and third year of the project that set the baseline for business planning and commercial exploitation. Within this period, the following activities will be refined:

- Pillar I: Revise and expand the initial market considerations as presented in the Description of Action, with the aim to drive the positioning of the project to the general market environment, and
- Pillar II: Update the market trends and assumptions, based on the project developments in the first 18 months and the evolution of the targeted market in this period.

The activities of Pillar I refer to the results of this deliverable and they are analyzed in the following sections. The activities related to Pillar II will be documented in the forthcoming deliverable D7.6: Dissemination & exploitation activities report (II) on month 36.

2.2.2 Competition Insights

This model aims to assess the strengths and weaknesses of current and potential competitors of the ACCORDION offering. The respective analysis provides both an offensive and defensive strategic context to identify opportunities and threats. Profiling combines all of the relevant sources of competitor analysis into one framework in the support of efficient and effective strategy formulation, implementation, monitoring and adjustment. Competition insights, in combination with market insights and experts' opinions provide valuable inputs for the strategic ACCORDION positioning in the competitive vertical markets that next-generation applications rely on.

The main activities of this model occur through desk research, in which we put emphasis on listing indicative solutions, products, services and business strategies of other initiatives that bear similarity to the ACCORDION objectives. The results of these activities are documented in this deliverable, although the competition will be monitored throughout the project lifetime and any significant competitors will be documented in subsequent deliverables in WP7.

2.2.3 Clients and Experts insights

To build upon the desk research activities regarding the market and the competition landscape insights, this model aims to bring into the project the knowledge and expertise of the consortium members and the industry professionals in the field of cloud-edge continuum for a variety of business domains, with emphasis on VR/AR, multiplayer cloud gaming and QoE in content delivery that are represented by the use case providers that participate in the ACCORDION project.

To achieve this, a set of interaction sessions with the ACCORDION solution contributors and early adopters were planned with the aim to build a common vision among the industrial partners on the market segments that the ACCORDION framework targets. The activities in this model will enable the creation of an inventory with key trends and innovations. Such innovations, both in terms of technological advances and business priorities, will drive the specification of the key capabilities of the framework and their adoption scenarios, thus they will connect the activities in market analysis with the specification of the ACCORDION architecture and the development of the project exploitation roadmap.

This model is evolved in two phases: a) Phase A, which targets mainly the consortium partners to provide their view on the market directions of the ACCORDION solution, and b) Phase B, in which the experts and stakeholders that will be involved in the first and second evaluation phase of the ACCORDION prototype will also be asked to provide their perception on the market potentials of the ACCORDION, especially in the specification of the business modelling opportunities. The set-up of the activities in phase B will be implemented in the context of Deliverable D6.5, which is due M19 (July 2021).

In order to structure the interactions with users in the clients and experts insights model, a list of questions will be used, as the basis for deliberation and discussion with them. Part of these questions were used in phase A to facilitate the organization of group discussions with the involvement of all ACCORDION partners. Specifically, within WP7 activities a dedicated questionnaire was formed to set a framework of questions with the overall aim to investigate and form a common understanding of ACCORDION environment, regarding the value we offer, the competition we may face and our future marketization. The questions asked were designed either to fill gaps from the literature or to gain insight into the interviewees' understanding of the market and any perspectives on potential areas of opportunity.

In this context, all ACCORDION partners were asked to provide their feedback to the following questions:

- What problem does ACCORDION solve? What are the pain points we are addressing?
- Why is the problem important?
- What is the answer we are proposing?
- Describe ACCORDION product or service in two or three sentences. Put it in terms anybody could understand—no techno speech.
- Which is ACCORDION value proposition? What is the value that ACCORDION solution is creating?
- Why is ACCORDION value proposition important to the customer?
- Who are the key people with the key skills needed to do this?
- Who are our competitors?
- What do competitors sell and how does it compete against us?
- Describe how ACCORDION products/services differ from the competitors.
- Which are ACCORDION targeted markets? How large are these markets?
- Who is our target customer? Provide a detailed description of the target customer (B2B and/or B2C)
- How do we communicate with our customer? How do we deliver the value proposition?
- How do we maintain the relationship with customers?
- What is a reasonable pricing model for ACCORDION offering?
- What are the revenue streams?
- What are the main costs? Are the costs mostly fixed or variable? Do the costs change with scale?

The multidisciplinary dimension of ACCORDION consortium allowed us to gather insights from many different perspectives including Academia, large industries, technology providers and SMEs who are active in the field of research and implementation of innovative solutions. The insights emerged from this process contributed to better understand and identify ACCORDION competitive advantage and value proposition and form the preliminary business modelling in Section 4.3.

Working closely with the pilot evaluation and assessment activities, we will get the feedback from the experts-end users who will be engaged with the execution of the piloting tasks, in order to collect information that will allow us to focus on specific market segments and seek further business-related insights in the field of next-generation applications, on business requirements and their market capabilities. Thus, as part of the questionnaires to be used in the initial evaluation phase, we aim to extract the experts' opinion on possible viable pricing or business model, suitable to the nature of the ACCORDION project. The relevant results will be included as part of Deliverable D6.5.

2.3 Targeted Markets Outlook and Dynamics

In this section, we examine markets that we consider they have high relation with ACCORDION context, and we need to monitor the current trends and take notice of advancements and driving, as well restraining, factors that have impact on market evolution. In this context, for every market in our monitoring scope, we present the market growth potentials and the key take-aways regarding market influencing factors that we must consider, as these key points affect the ACCORDION potentially and market uptake.

ACCORDION’s key concept is aligned with recent developments of Edge Computing and Multi-Access Edge Computing (MEC) front, extending to both network and computation resources that serve the low-latency, high bandwidth and expected QoE requirements of next generation applications and relative services with strict business and technical needs. With the proliferation of head-mounted displays, cloud computing platforms, and machine learning algorithms, the next-generation of AR/VR applications stretch hardware capabilities, requiring proficient software and algorithms, and a new hybrid edge-cloud orchestration model for the execution of intensive computational tasks.

We commence our analysis by gathering valuable market insights from the very competitive market of edge computing and multi-access edge computing, drilling down to the vertical markets that accommodate nextgen applications in the field of content delivery, VR, and AR, with special reference to AR & VR gaming domains. In the same context, we monitor the overall cloud gaming sector for identifying the trends and the potentials of this specific market, highlighting the specialized needs of multiplayer cloud mobile gaming.

2.3.4 Edge Computing Market Outlook

Edge computing moves processing from centralized servers located hundreds or thousands of miles away to localized servers and devices in order to more quickly process data in applications, expanding the full potential of cloud computing. Edge data centers with their server racks have been a huge benefit for the computing world. These small facilities are located close to the users it serves, which makes it easier to deliver cloud computing resources and cached content to end users when and where they need it most.

A very insightful prediction about edge computing market is presented in Million Insights report¹ that the global edge computing market size is projected to reach **USD 43.4 billion by 2027** and registering a CAGR of 37.4% during the forecast period from 2020 to 2027. The same trends are reported by Grand View Research report² that values global edge computing market size at USD 61.14 billion in 2028 (CAGR of 38.4% from 2021 to 2028).

¹ Million Insights, ‘Edge Computing Market Analysis Report By Component, By Industry Vertical, By Region And Segment Forecasts From 2020 To 2027’, <https://www.millioninsights.com/industry-reports/edge-computing-market>

² Grand View Research, ‘Edge Computing Market Size, Share & Trends Analysis Report, 2021-2028’, <https://www.grandviewresearch.com/industry-analysis/edge-computing-market>

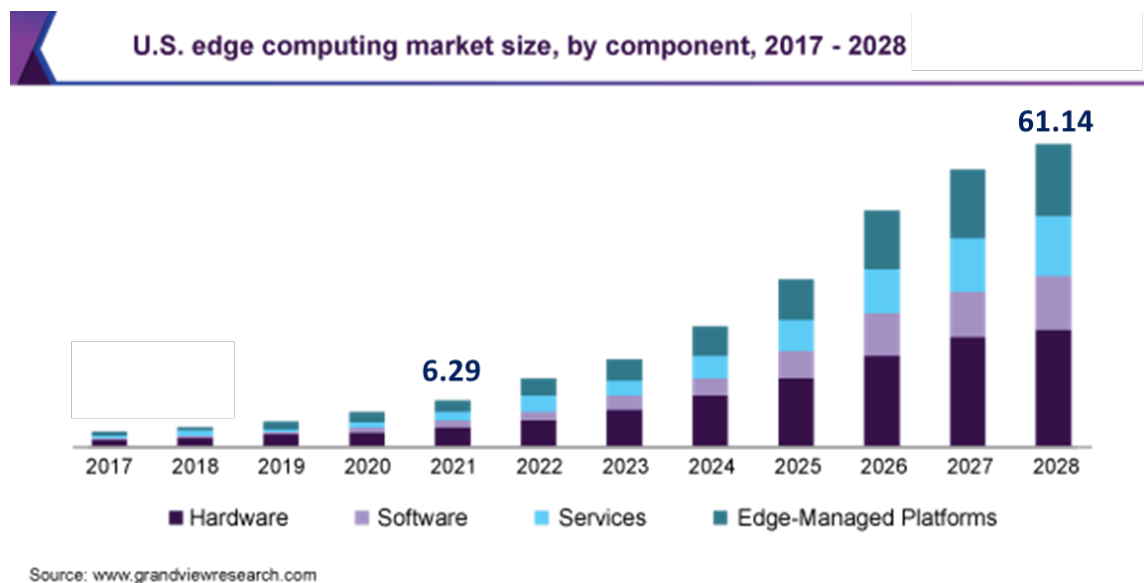


Figure 2-2: Edge Computer Market Size – Forecast (Grand View Research)

Market growth influencing factors:

- Large enterprises are the main users of cloud computing solutions. The adoption of edge computing solutions among large enterprises is high owing to the increased generation of data, which is attributed to the widespread geographical presence and customer base. Moreover, the increasing demand of employees to access computing resources and applications ubiquitously while ensuring proper data storage, drives the demand of edge computing solutions among large enterprises.
- Market opportunity for telecom providers: Telecom numerous applications with 5G technology are changing traffic patterns and opening technology growth opportunities for telecom providers. This factor has become a threat for cloud leaders, and they have started to invest in edge ecosystem by partnering with telecom companies.
- Lightweight frameworks and systems to enhance efficiency of edge computing solutions. With edge computing, cloud computing has started to change drastically from being centralized to autonomously distributed. In support of this, many companies are coming with local edge data centers that are tightly coupled with their cloud resources. However, high cloud-reliability for storage and the constraints of resources, such as computing power, primary memory, and storage in such edge data centers, raise reliability concerns among enterprises. These local edge centers connected to the cloud might also lose their connection with the centralized centers. Hence, they should be capable enough to operate autonomously in case of no network connectivity. All these challenges generate a need for introducing lightweight autonomous edge orchestration in local data centers to support virtualization and enable self-healing and local scaling. These advanced data centers based on event-driven and serverless computing can also be made deployable on the different runtime environment. Furthermore, in the case of zero network connectivity with data centers, lightweight cloud-agnostic frameworks and node-to-node interaction architecture in edge devices could help overcome heterogeneity and interoperability issues. These frameworks and applications could also facilitate autonomous data analysis within the device. Moreover, ML algorithms that consume less memory and storage would add to the benefits of edge computing.

- Growing adoption of IoT across industries. The proliferation of IoT has led to a significant increase in data, due to which organizations are increasingly relying on centralized cloud computing and storage solutions. Migrating to the cloud for the entire IT infrastructure poses latency and economic feasibility issues. Hence, organizations using IoT sensors, actuators, and other IoT devices are increasingly looking for edge computing solutions, such as edge nodes, devices, and hyper-localized data centers. Edge computing supplements the existing cloud paradigm by facilitating data processing closer to the data source, thereby enabling organizations to speed up decision-making.
- Hardware segment to hold the larger market size. The edge computing market by component covers hardware, platform, and services. The hardware component is estimated to hold the largest market size, owing to the large-scale deployment of hardware components for decentralizing storage and computing operations, enabling comprehensive edge infrastructure deployment, and reducing network traffic. Organizations offer advanced edge computing hardware that either acts as an initial point of data source (edge devices) or a facilitator of the entire network (gateways and servers); or serves as a storage and local processing unit (local data centres) in the overall edge computing process.
- Security concerns. Despite the benefits, edge computing architecture is susceptible to cyberattacks with the addition of vulnerable edge nodes and IoT devices. Many IoT devices, such as security cameras, smart doorbells, and baby monitors, have limited capability of authentication and encryption. Hence, they are prone to tampering, eavesdropping, malicious congestion, and identity forging. With the increasing number of IoT startups and rising competition, many small companies are relying on security through obscurity, while neglecting the risk of cyberattacks.

2.3.5 Multi-access edge computing

Within the broad topic of edge computing, multi-access edge computing (MEC) is the widely accepted standard that must be met for a technology to be considered edge computing. The global multi-access edge computing as a market size was valued at USD 1.3 million in 2019 and is anticipated to register **a CAGR exceeding 38% from 2020 to 2027**³. According to Statista⁴, the multi-access edge computing (MEC) market, formerly known as the mobile edge computing market, is expected to achieve revenues of **7.23 billion U.S. dollars by 2024**. In 2019, revenues in the market only reached 64.1 million U.S. dollars but is expected to exponentially increase, as edge computing becomes implemented by wireless network operators around the world. The rising trend among companies to establish cloud computing capability at the edge of mobile networks is expected to offer growth prospects over the forecast period.

Market growth influencing factors:

³ Grand View Research, 'Multi-access Edge Computing Market Size, Forecast 2020-2027', <https://www.grandviewresearch.com/industry-analysis/multi-access-edge-computing-market>

⁴ Statista, 'Multi-access edge computing (MEC) market revenue worldwide in 2019 and 2024', <https://www.statista.com/statistics/1183528/multi-access-edge-computing-market-revenue-worldwide/>

- **5G and virtualized network models.** Gradual rolling out of 5G internet and incrementing trend among Communications Service Providers (CSP) to adopt a virtualized, software-empowered network model, with a cloud-based architecture is expected to offer new growth avenues to the market growth. Additionally, the adoption of the 5G delivery model enables Control and User Plane Separation (CUPS), which facilitates flexible deployment of user plane functions at the network edge and allows the central deployment of the control plane for easier interfacing with several core network functions.
- **Augmented Reality/Virtual Reality (AR/VR) experience evolving requirements.** Next generation applications and AR/VR requirements of extending bandwidth to enhance 5G capabilities are driving the MEC market growth. Furthermore, the need to deliver high-quality AR, VR, and Mixed Reality (MR) experience via wireless medium has enabled the integration of MEC and 5G. Such integration is expected to offer attractive growth prospects in the market over the next few years. Combining multi-access edge computing infrastructure with VR/AR has led to major improvements in the broadcasting of sports and entertainment, thus enhancing users' viewing experience.
- **IoT devices proliferation.** The presence of several IoT devices in MEC-based ecosystem facilitates the need to have dedicated software that works and functions according to the available multi-access edge computing architecture. The growing need to use the software as per the given ecosystem to exercise multi-level load-balancing, distributed processing, and content synchronization is promoting the growth of the MEC software segment.

2.3.6 VR / AR market

AR/VR technology makes use of sensory devices to either virtually modify a user's environment or completely immerse them in a simulated environment. Virtual reality devices typically consist of specially designed headsets that offer complete visual immersion into a simulated environment, while augmented reality relies on headsets that add virtual elements to a user's actual environment.

According to Statista⁵, the global augmented reality (AR) and virtual reality (VR) market reached 18.8 billion U.S. dollars in 2020. This was an increase of over 78 percent over spending in 2019. The projection is that the market will reach **270 billion by 2024**. The research company TechNavio⁶ estimates that the augmented reality (AR) and virtual reality (VR) market is expected to grow by **USD 125.19 billion during 2020-2024**. Their report offers a detailed analysis of the impact of the COVID-19 pandemic on the augmented reality (AR) and virtual reality (VR) market in optimistic, probable, and pessimistic forecast scenarios.

⁵ Statista, 'Augmented reality (AR) and virtual reality (VR) market size worldwide from 2016 to 2020', <https://www.statista.com/statistics/591181/global-augmented-virtual-reality-market-size/>

⁶ TEchnavio, 'Augmented Reality and Virtual Reality Market by Technology and Geography - Forecast and Analysis 2021-2025', <https://www.technavio.com/talk-to-us&report=IRTNTR43509&type=sample>

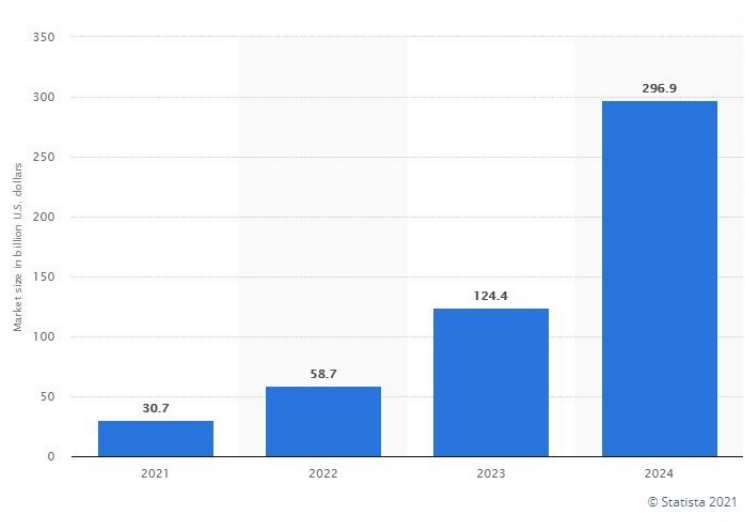


Figure 2-3: VR/AR market evolution, 2021-2024 (Statista)

VR Market

Based on Grand View Research⁷ analysis, the global virtual reality market size was valued at USD 15.81 billion in 2020 and is expected to grow at a compound annual growth rate (CAGR) of 18.0% from 2021 to 2028, reaching a value of **USD 69.60 billion in 2028**. The VR technology offers an immersive experience to the viewers with the help of VR devices, such as headsets or glasses, gloves, and bodysuits. The technology has brought a transformation in the gaming and entertainment industries by allowing users to experience immersion in a highly virtual realm. In addition, the increasing usage of this technology in instructive training, such as for training mechanics, engineers, pilots, soldiers in defense, field workers, and technicians, in the oil & gas and manufacturing sectors is driving the market growth.

⁷ <https://www.grandviewresearch.com/industry-analysis/virtual-reality-vr-market>

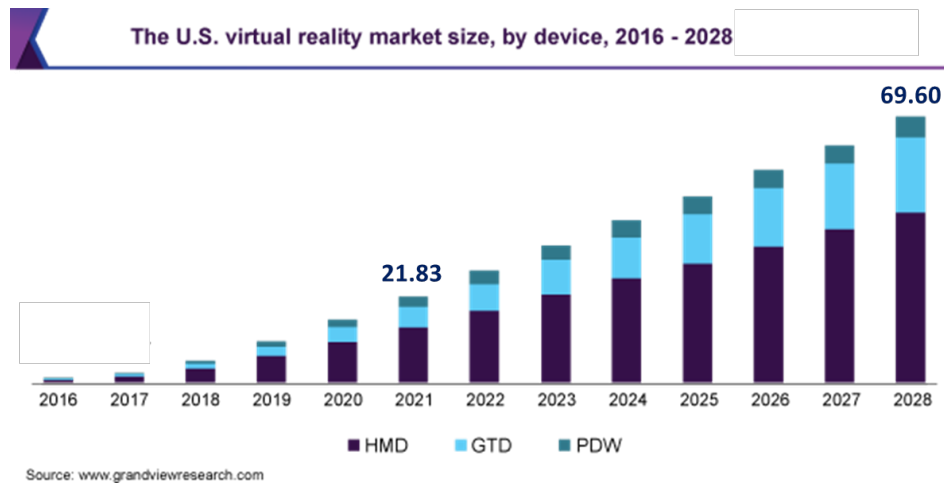


Figure 2-4: Virtual Reality Market Size - Forecast (Grand View Research)

Market growth influencing factors:

- **COVID-19 boosted the demand for virtual meetings and training.** COVID-19 has highly impacted the work culture across the industries. The lockdown has significantly raised the demand for virtual technology. The increasing adoption of virtual meets, conferences, exhibitions, gatherings are spurring the demand for immersive solutions. Industries such as automotive, manufacturing, and entertainment are also adopting the technology to cater to the business requirement.
- **5G connectivity to offer new potential of Virtual Reality.** The widespread implementation of the 5G network is boosting the adoption of virtual technology. The 5G services offer high-bandwidth and ultra-low latency. This is supporting the adoption of the technology for its various applications such as entertainment, training, simulation, and more. The 5G connectivity is offering new opportunities for the companies to boost the revenue scale. The network is bridging different verticals of industries such as telecom, virtual reality provider, gaming, sports, entertainment, and more to offer new advanced solutions.
- **Rising demand for Virtual Training across Industries.** Industries such as automotive, education, healthcare, aerospace & defense, and more are significantly investing in virtual training and education solutions. For instance, in the automotive industry the virtual training module offers workstation training for new joiners to avoid accidents.
- **Multipurpose applications expand VR potentials.** Besides providing training and fulfilling educational purposes, the technology is widely accepted across industries for various other purposes. For instance, in the automotive industry, it allows engineers to experiment with the design and structure of a vehicle at the concept stage before initiating expensive prototypes of the vehicle. The technology is also being used to provide treatments to patients with mental health challenges with the help of VR exposure therapy. Moreover, the tourism industry allows potential customers to go on a virtual tour of landmarks, famous locations, restaurants, and hotels with the use of VR technology. Thus, the rising adoption of VR across several industries for various applications is fueling the growth of the market.
- **Requirement of High Speed and Computation Power Might Hamper the Market Development.** The technology demands robust hardware components and high computing power. The majority of current desktop accessories are not compatible with applications. Similarly, most of the head mounted display are wireless and consume high energy, thus requiring high-energy batteries for long-duration

operations. In markets such as gaming and entertainment, it is necessary to have devices with long battery life. Further, the highly connected devices and components require high-speed network bandwidth such as 5G. Thus, the challenge of catering suitable speed and power for the operation might hinder the market growth.

- **Hardware segment is expected to dominate the market.** Based on components, the VR market is categorized into hardware, software development, and content. The hardware segment is expected to dominate the global virtual reality market share as the increasing capabilities of smartphones and other smart electronic devices are booting hardware demand. The software is likely to gain traction owing to the rising demand for immersive technology. The increasing application such as gaming, entertainment, live events and more is enhancing the software demand. Whereas, the content segment is likely to witness steady growth owing to the increasing demand for interactive environment virtual sessions.
- **Increasing Adoption of Head Mounted Display to Propel Market Growth.** Based on device type, the market is categorized into head mounted display (HMD), VR simulator, VR glasses, treadmills & haptic gloves, and others. The technology offers the most immersive environment through the head mounted devices. With technological development, the demand for smartphone connected headsets is growing owing to low-cost investment.

AR Market

The Augmented reality market is estimated to grow from USD 10.7 billion in 2019 and projected to reach **USD 72.7 billion** by 2024⁸, it is expected to grow at a CAGR of 46.6% from 2019 to 2024.

Market growth influencing factors:

- Increasing Demand for Enhanced Customer Experience to Propel Augmented Reality Market Growth. Maintaining customer relationships has become the most important factor for business expansion, so many companies are experimenting with AR to create a long-lasting impression on their customers as it offers a personalized and interactive experience that helps maintain enriched customer satisfaction. Additionally, the technology can offer online customer support systems, where the customers can see and interact with agents as visiting a store.
- Increasing Adoption of AR Technology in Healthcare Industry to Drive Market. The healthcare industry is witnessing the rising adoption of immersive technologies to support healthcare workers. The technology provides a real and virtual environment that helps in performing tasks efficiently. The increasing availability, accessibility, and affordability of devices boost its adoption across the industry and patients.

⁸ MarketsAndMarkets, 'Augmented Reality Market by Offering – Global Forecast to 2024', <https://www.marketsandmarkets.com/Market-Reports/augmented-reality-market-82758548.html>

- Increasing Adoption of Head Mounted Devices to Propel Market Growth: The heads-up display is expected to gain maximum market share during the following period, fueled by the increasing adoption of the heads-up display in the automotive industry and the vast presence of AR-based mobile games.
- Gaming and Media & Entertainment Industry to Lead the Market: The industries covered in the market are gaming, media & entertainment, automotive, retail, healthcare, education, manufacturing, and others. AR plays a vital role in boosting the gaming industry. The technology offers an immersive and interactive experience that is likely to raise its adoption in the gaming industry. With Pokemon Go's success, the gaming companies are extensively expanding the technology for its other games and applications. The technology offers vast scope to the media and entertainment industry for providing real-time experiences, including the domains of healthcare, shopping, entertainment, and retail industry.
- Long Term Impacts of Augmented Reality on Mental Health May Impede Growth. There are indications that the users of the technology are facing issues owing to the excessive usage of smart devices. The users react to the immersive environment the same as the physical environment, which affects their psychology and behavior. In addition, wearing the devices can affect the user's ability to social interaction. That might lead to loneliness and depression, factors that may be affect the growth of the market.

2.3.7 Cloud mobile gaming

Mobile Gaming market

The **global market for mobile gaming** is projected to reach **USD 153.3 billion** by the year 2027⁹, trailing a post COVID-19 CAGR of 11.5% over the analysis period 2020 to 2027. The growing smartphone penetration and technology advancement with the increasing adoption of trending technologies for developing games are major factors in developing the mobile gaming industry. Gaming industry worldwide is expanding, and smartphone is playing a significant role in this expansion. The development of mobile games has resulted in scalability for the gaming industry. Platforms, like Facebook and Instagram, have also started to develop innovative mobile games, to ensure high product differentiation and benefit from engaging games to enhance their advertisement strategies.

Trends, such as location-based games, cloud gaming, blockchain-based game, AR/VR enabled mobile games, are also fuelling the demand for mobile games. Moreover, due to the outbreak of COVID-19, online play has also increased, with respondents spending more time playing games with others via internet connection.

Cloud Gaming Market

⁹ ResearchAndMarkets, 'Mobile Gaming-Global Market Trajectory & Analytics', https://www.researchandmarkets.com/reports/516889/mobile_gaming_global_market_trajectory_and#rela4-5176393

One of the most important trends of mobile gaming is the expected rise of cloud mobile games. Cloud gaming enables users to play games through remote servers rather than installing a game on the computer or console, thereby eliminating storage issues and the need for buying the latest gaming PCs or consoles. In specific, the rising popularity of cloud gaming along with the prevalence of enhanced cross-platform gameplay, which improves gaming experience, is anticipated to drive market growth. The **global cloud gaming market** size was valued at USD 0.68 billion in 2021 and it is expected to reach **USD 7.24 billion in 2027¹⁰**, at a compound annual growth rate (CAGR) of 48.2% from 2021 to 2027. Benefits offered by cloud gaming include scalability, improved speed, and better user insights. Cloud gaming helps restructuring content on various smart devices, which improves the delivery of content across all mediums. These factors are anticipated to drive the market growth over the forecast period.

Market growth influencing factors:

- The easy access to games on the cloud and the increasing penetration of internet services drive the market growth. Additionally, network infrastructure developments such as 5G offer lower latency and higher bandwidth, which enables gamers to seamlessly stream XR (augmented reality and virtual reality) gaming. The proliferation of smartphones across the globe is further expected to drive the market growth.
- Smartphone developers are focused on enhanced gaming experience to gamers. Technology improvements in smartphones have brought incremental enhancements in hardware and software capabilities, including significant computational / processor power and 5G capabilities to offer a seamless and enhanced gaming experience to gamers.
- The rising trend of social media games is anticipated to have a positive impact on market growth. A significant percentage of the global population spends time on social networking sites such as Facebook, Instagram, and Reddit to play games. Additionally, social networking firms are focusing on acquiring cloud game providers to offer various cloud games on social media platforms and improve engagement with customers.
- The video streaming segment dominated the market. Based on type, the market has been segmented into file streaming and video streaming. The demand for video streaming is increasing as it eliminates the need for additional hardware devices. Furthermore, video streaming services allow users to play games on any platform and from anywhere via the Internet. The file streaming segment is expected to register the highest CAGR over the next years, as file streaming enables vendors to offer an enhanced and seamless gaming experience to users despite the lower internet speeds
- Focus of vendors on developing platforms for enhanced gaming experience is further anticipated to propel the segment growth. For instance, in November **2019, Google, Inc. launched Stadia**, a cloud video game service. Stadia allows users to play console-based games on smartphones or web browsers. The

¹⁰ Grand View Research, 'Cloud Gaming Market Size, 2021-2027', <https://www.grandviewresearch.com/industry-analysis/cloud-gaming-market>

demand for multiplayer games is also increasing rapidly as these games enable in-game communication and offer an improved gaming experience.

AR Gaming Market

The continuous rise in the number of mobile gamers has created a positive impact on the demand for augmented reality games. This trend is expected to continue during the following years. The global augmented reality gaming market reached a value of USD 4.7 billion in 2020, with the potential to reach a value of **USD 28.60 billion by 2026**, exhibiting a CAGR of 34.80% during 2021-2026¹¹. Augmented reality helps in creating a view for the players with intense video, graphics and sound by using a device-camera. For games on smartphones, augmented reality has become an important tool as it enables the gamers to create their own characters, targets and racing terrains.

Market growth influencing factors:

- AR technology is new and has immense potential. The global augmented reality gaming market is still in its novelty phase and is anticipated to dynamically transfigure the gaming technology businesses over next seven years owing to its feature of converging real and virtual realms. This implicit convergence of natural and virtual environment would be achieved with the help of HMDs (Head Mount Displays) and aligned augmented reality (AR) apparatus.
- The cost of augmented reality game equipment is a market restraint. The initial cost of obtaining a high-quality is high which makes it difficult for ordinary consumers to afford a console. In addition, tedious process of setting up a dedicated AR gaming session and high initial capital investment to acquire AR gaming equipment are expected to emerge as major restraints for augmented reality gaming market. Rising affordability of AR games coupled with increasing availability are key factors that are anticipated to drive the global AR gaming market. Leading organizations have been investing in incorporating AR gaming techniques in mobile devices, such as smartphones and tablets, which provide improved and enhanced gaming experience, and leads to expansion of the developers of AR gaming techniques. Increasing collaboration of technology providers with manufacturers of devices who offer innovative gaming solutions is further projected to increase the demand for AR gaming devices, and thereby drive the global AR gaming market.
- Intense competition from VR gaming. The market in focus is poised to face extreme competition from its novel technology counterpart, virtual reality gaming devices, which deliver aligned gaming experience with a gist of reality but majorly based on virtual environments.
- Technical requirements to take into account. Requirements such as dedicated session management procedures and dedicated bandwidth allocation for switching to real-time mode are expected to emerge as major challenges to the industry growth. Competitive television-based video-gaming service offerings, lower-cost systems, delayed customer buying decisions, and more software-centric

¹¹ ResearchAndMarkets, 'Augmented Reality Gaming Market', <https://www.researchandmarkets.com/reports/5263997/augmented-reality-gaming-market-global-industry>

products are foreseen to hamper the exorbitant AR gaming market. Rising stipulation to converge veracity with gaming experience delivery and corporate shift from fabrication of wired game controllers to sensory reception device controllers have led to the enlargement of augmented reality-based gaming services market.

- Privacy concerns. Concerns regarding privacy are likely to hinder the expansion of the global AR gaming market. AR gaming users often reveal their personal information, which creates a threat to their privacy. However, some users play as anonymous gamers, which prevents the revelation of any kind of personal information of the AR gaming user.

2.4 Competitors Landscape

The rise of connected ecosystem and new experiences powered by NextGen applications are putting increased pressure on limited bandwidth in centralized computing architectures. Moreover, latency-sensitive applications such as virtual assistants, VR and AR interactions and cloud mobile gaming cannot enjoy widespread adoption if the present centralized computing architecture is not able to ensure real-time decision-making. Hence, there is a need to move computation closer to the point of data generation/consumption to reduce bandwidth pressure and power uses that have tight real-time decision-making requirements. In this context, ACCORDION encapsulates a set of technologies that enable distributed computing and embeds intelligence at the proximity of the network.

ACCORDION offerings provide an end-to-end solution and architectural approach to meet the needs of next generation applications in the domains of platform, hardware, infrastructure, network and connectivity, real estate and software solutions. With this regard, the competition landscape is wide enough and an indicative map of competitors per category is depicted below¹², but it is only an indication that the competition in the specific markets is intense, and the consortium must monitor closely the business development strategies that these companies follow, including mergers, acquisitions, strategic partnerships, synergies, and operational interactions. Thus, this section aims to provide valuable insights for a better understanding of the competitive landscape and inform partners about the competitive environment that ACCORDION operates, presenting indicative examples of key competitors of all sizes, and different cloud to edge spectrum and their business development decisions and technical advancements of their offerings. It is also important to note that many companies can not be characterized to a specific category as they provide an extended portfolio of services in multiple domains, targeting to integrated solutions for their customers.

¹² Everest Group, <https://www.everestgrp.com/2019-05-the-edge-computing-landscape-market-insights-50133.html/>

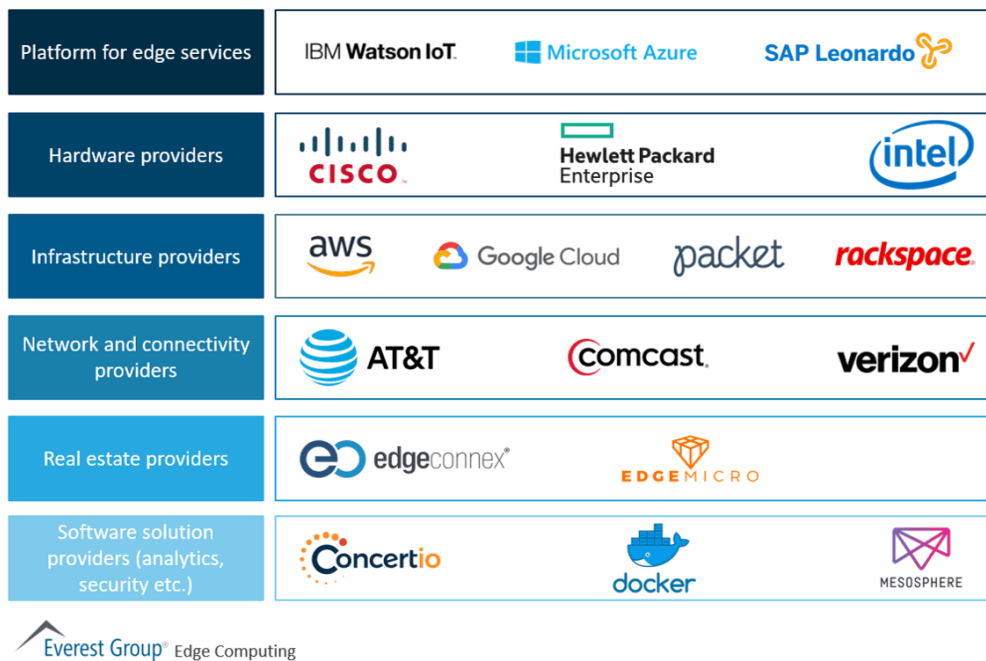


Figure 2-5: Indicative competitors per category

Below, there is a listing of worth-mentioned companies in random order.

Amazon Web Services (AWS): AWS is the leader in cloud computing and its edge credentials set the pace for the entire industry. Although better known for its cloud computing services, Amazon Web Services (AWS) also offers a range of services for the industrial, commercial, and connected home IoT markets. Those services include the Amazon FreeRTOS microcontroller operating system, AWS IoT Greengrass that brings AWS services like Lambda functions to edge devices, AWS IoT Core, AWS IoT Device Defender, AWS IoT Device Management, AWS IoT Analytics and many others. It also provides solutions like its Connected Vehicle solution, IoT Device Simulator, AWS IoT Camera Connector and others. And of course, it also sells edge devices, including its popular Echo and Alexa smart home devices. In addition, in 2020, the company launched Wavelength, which puts AWS infrastructure at the edge of telco networks. These deployments embed AWS compute and storage services within communications service providers’ (CSP) datacenters at the edge of the 5G network, so application traffic from 5G devices can reach application servers without leaving the telecommunications network. AWS will continue the expansion of AWS Wavelength Zones, with a planned launch of additional AWS Local Zones across 10+ cities in the United States. These Wavelength Zones will look to provide single digit millisecond access to AWS Infrastructure, facilitating a plethora of edge use cases which rely on ultra-low latency such as VR, real-time analytics, and ultra-HD video streaming and gaming.

Google Cloud Platform: The Key value proposition of Google Cloud Platform is its global network and the extended coverage. Few companies have the technical infrastructure to support edge computing like Google. Like Amazon, Google offers a line of connected home products for edge computing, and it also offers cloud computing services for managing edge data, most notably with its Cloud IoT Core service. In addition, it offers

hardware in the form of its Edge TPU for running AI and analytics at the edge of the network. Analytics at the edge is a particular focus for Google, and it touts its other AI cloud services as a good complement to its edge computing products. It serves a wide variety of different industries.

Microsoft: The company has an as extensive portfolio, realizing that Edge computing is a mix of many different elements. Much like the other leading cloud computing providers, Microsoft’s Azure division has rolled out several products and services to support edge computing. Those include its Internet of Things services like Azure IoT Central (IoT app platform), Azure IoT Edge (AI services deployed on edge devices), Azure IoT Hub (communication service that connects edge devices to the Azure cloud), Azure Sphere (IoT security) and Azure Stack Edge (on-premises processing for AI workloads that will be transferred to Azure), among others. The company also offers the Windows IoT platform, which includes developer tools and a lightweight version of Windows designed to run on edge devices.

Affirmed Networks: Ten-year-old Affirmed Networks was acquired by its partner Microsoft recently as the tech giant was attracted to Affirmed Networks' network virtualization software that empowers telecom operators deploying 5G networks. The Company, now a part of Microsoft, offers its Affirmed Cloud Edge (ACE) solution that helps service providers in their deployment of content delivery networks, AR and VR applications, autonomous vehicles, drones, IoT, and private networks for location-based services.

Mutable: Mutable is a public edge cloud provider and is bringing its platform to the market that uses micro-data centers close to the end user to host edge applications on the Mutable distributed cloud. Mutable, is helping developers with its software-based platform deliver edge technology for low latency, heightened security and operational efficiency for application providers, cable operators and cloud providers. The company is currently working with cable operators and other service providers to enable edge computing on their networks and offer applications to end customers. The upstart secured a \$1.6 million seed investment round in 2020.

AT&T: AT&T has been aggressive in the edge computing space in the form of its Multi-Access Edge Computing (MEC) offering that tie together cellular network architecture for real-time, high-bandwidth, low-latency access to latency-dependent mobile applications. The Dallas-based carrier is leveraging its expertise in connectivity by helping businesses harness LTE, and soon, 5G, at the network edge. AT&T is also working alongside its tech partners in the edge space. Microsoft Azure and AT&T unveiled a multiyear strategic alliance to leverage AI and 5G using AT&T’s network and the Azure cloud platform to market integrated solutions in areas including voice, collaboration, edge, IoT, public safety and cybersecurity. Microsoft is now AT&T’s preferred cloud provider for non-network applications.

IBM: IBM is a well-established company, position in Application/Software and PaaS domain. Recently, IBM announced the launch of its Edge Application Manager, an intelligent and flexible platform that provides autonomous management for edge computing. IBM also engaged in several partnerships with firms such as Samsung, Wipro and Intel, as well as a partnership with Clearblade within the IoT/Edge space. Strategically, IBM hopes to build stronger internal and external collaborations, and double down its time investment on industry-specific use cases within the Hybrid Cloud, AI and Edge spaces for the benefit of their customers. In addition, IBM is looking to corner the edge-to-cloud marketplace, as well as extending its edge offering to include MEC capabilities. IBM sells an Edge Computing platform based on OpenShift technology from its Red

Hat subsidiary. It also offers Edge Computing for Servers, which helps organizations manage the infrastructure at the edge of their networks, as well as the Watson Internet of Things platform, which applies its AI technology to IoT. It has specific IoT solutions for enterprise asset management, facilities management and systems engineering.

Aarna Networks: Aarna Networks is a startup specializing in 5G and edge computing application automation software and is bringing its open source, vendor-agnostic solution to business users. Specifically, the company is offering its Multi Cluster Orchestration Platform (AMCOP) for orchestration, lifecycle management, and real-time policy driven control loop automation of 5G network services and edge computing applications, including enterprise network-as-a-service solutions. The San Jose, Calif.-based company is channel-first and goes to market through Value-Added Resellers (VARs) to connect to enterprise customers.

HPE: HPE is a leader in Edge Cloud Infrastructure, Edge Aggregation and Orchestration. Recently, HPE announced Edge Orchestrator, a SaaS-based offering that enables telcos to deploy innovative new edge computing services to customers via IT infrastructure located at the edge of telco networks or on customer premises. This facilitates the driving of new revenue streams, exploring advanced use cases such as AI-powered video analytics, industrial automation and VR retail services.

EdgeConneX: The Company provides edge data centers including some cloud connectivity and hardware products and services. EdgeConneX builds and operates purpose-built edge data centres. They offer a range of data center products, from Hyperscale facilities to Edge Data Centers and Edge Small Cells located as close to the edge/end-user as possible. They work closely with customers so as to ensure tailored scalability, power, and connectivity. EdgeConneX currently operate across North America, South America, and Europe. Their main clients include content providers, network and cable operators, and colocation companies.

Intel: Intel's offerings include Hardware, Processor, Edge cloud infrastructure and IaaS solutions. Although better known as a chipmaker, Intel offers a family of edge computing products as part of its Intel IoT Platform. Those products include IoT gateways, the Intel Secure Device Onboard (SDO) service, Wind River Helix Device Cloud, Wind River Titanium Edge and edge computing components featuring Intel processors and storage. The company also has reference architecture, developer kits, tools and SDKs for IoT deployments. It primarily sells products that other companies can use to create their own IoT products and services. The company aims to enhance its edge product portfolio with optimisations such as Elkhart Lake, Intel Movidius (Edge AI) and processors for 5G. It's also creating toolkits (e.g. OpenNESS) to simplify the orchestration of edge platforms and hardware to meet use case needs. Intel Smart Edge is already deploying edge computing infrastructure for Private LTE (and applications) for enterprises in multiple sectors (e.g., industrial, retail, transport, venues and health) and has 242 IoT market-ready solutions, 7 OT platforms and growing. Also, Intel continues its work to develop technology for the edge ecosystem. Smart Edge will be adding to its independent software vendors (ISV) ecosystem (recruiting, onboarding, marketing and co-selling solutions), enhancing IoT capabilities (e.g., edge insights in industrial, time sensitive networking) and increasing the number of commercial deployments.

SAP: The company has a long reputation in enterprise IT for larger companies, and great expertise to compete in edge computing. SAP groups its edge computing products together under the brand name SAP Leonardo

IoT Edge. This end-to-end solution includes SAP Edge Services that can run on an IoT gateway and its Edge Platform, which extends the company’s cloud computing capabilities to the edge. The company serves enterprises in a wide variety of industries.

Oracle: Oracle is known for its flagship database but has moved aggressively into the cloud sector – positioning it to be successful in edge computing by offering hardware for the edge in the form of its Oracle Tactical Edge Cloud Infrastructure, ruggedized compute and storage based on the company’s cloud services architecture. It also has a set of IoT applications available on a SaaS basis, as well as industry-specific solutions for industrial manufacturing, construction and engineering, utilities, retail, healthcare and insurance. Its IoT customers include Hitachi Consulting, Accenture, AskStory and LT Infotech. It also offers enterprise software, hardware and cloud services.

Huawei: Huawei’s strength is Edge computing for the industrial sector runs on specialized networking gear. Like Cisco and HPE, Huawei sells a range of networking products that help enable edge computing and the Internet of Things. In addition, the company sells an Edge Computing Internet of Things (EC-IoT) solution for analytics at the edge. The company’s focus is on the industrial Internet of Things (IIoT), and it has specially targeted products for predictive maintenance and energy companies.

FogHorn Systems Inc: The Company won the Global Edge Platform Award¹³ at the Global IoT Awards 2020, and was named one of 100 Tech Pioneers¹⁴ by the World Economic Forum. FogHorn’s edge-native AI solution delivers comprehensive data enrichment and real-time analytics on high volumes of data and is optimized for constrained compute footprints and limited connectivity. Company’s strategy is strengthening its positioning in Edge Cloud Infrastructure, Edge Aggregation and Orchestration and to deliver its first 5G projects in EMEA and the US. Alongside this, the company is also releasing an Edge AI Energy Management solution for all types of buildings, while continuing to deliver edge Health & Safety projects at scale in both the US and EMEA.

Red Hat: Red Hat’s edge portfolio has advanced significantly in the last years as it added capabilities required by customers and partners to meet the challenges of shifting more and more computing outside of the cloud and data center to the edge. Alongside product announcements such as improvements to Red Hat OpenShift and Red Hat Advanced Cluster, it also produced a solution blueprint that brings the Red Hat portfolio and ecosystem together – from services to the infrastructure to help simplify the creation of edge stacks. Red Hat’s ambition is to work with its customers to understand their use cases, specifically around: hardware footprint size, serverless application architectures, and automated zero-touch provisioning of edge platforms with parallel provisioning to meet high frequency rollout demands. Will also continue to collaborate with partner ecosystem to deliver solutions e.g., combining GPU support with OpenShift for the use of AI/ML intelligent applications at the edge, and working with Intel in the Go-to-Market strategy (GTM) for the oil and gas industry and developing an automotive operating system. It became a subsidiary of IBM on July 9, 2019.

¹³ Global IoT Awards 2020, <https://www.iotworldtoday.com/2020/08/13/winners-of-the-2020-iot-world-awards-announced/>

¹⁴ WeForum 2020, <https://widgets.weforum.org/techpioneers-2020/foghorn-systems/>

Section: Section is an Edge-as-a-service provider and has launched several new products, including their patent-pending Adaptive Edge Engine technology and their Node.js Edge Hosting solution, which paves the way for full application hosting at the edge. Alongside this, Section released a traffic visualization console that provides next-gen observability tooling for DevOps teams to understand how their edge is performing in real-time. The company is also looking to develop a working solution for distributed databases at the edge, helping to solve one of the fundamental challenges that has impeded edge adoption to date. It is also considering an expansion of the edge infrastructure network and supporting more edge application hosting beyond its Node.js product.

Vapor IO: Vapor IO (edge co-location, exchange and network service platform provider) announced a unique aggregate Series C funding of \$90 million from private equity firms Berkshire Partners and Crown Castle, which helped solidify partnerships that utilize Vapor IO's Kinetic Edge as the backbone of a functioning edge computing ecosystem. They also plan to be first-to-market with a comprehensive package of edge colocation, interconnection and networking services to support the next generation of applications, (e.g., IoT, driverless cars, autonomous robots, AR and smart city). Construction of the Kinetic Edge platform is proceeding in 36 US cities and will offer Kinetic Edge coverage that reaches ~80% of US population. The company aims to deliver real-time telemetry feeds from all of its OT and network systems, to be consumed by software developers using an open API (Synse). This will allow real-time and predictive orchestration of workloads and network functions based on actual conditions on the platform.

VMware: VMware offers Edge Cloud Infrastructure and Multi-cloud platform solutions. Assisted in the creation of the Dell-SKT-VMware-Intel ONEBOX solution, a single multi-edge compute product for private 5G that helps enterprises use private mobility and edge computing to develop new services where data is created. Alongside this, VMWare also launched a Converged Edge Platform with WWT as the Systems Integrator and MobileEdgeX as the MEC Platform provider and announced a validated Media CDN solution in collaboration with Intel and Varnish software. VMware is looking to deepen its channel partnership with Dell by allowing Dell Technologies partners to transact VMware licensing deals directly. In addition to this, VMWare hopes to continue its constant product updates to realize further value for their customers and partners.

Vodafone: Vodafone aims to become a top-list player in the domains of Edge cloud infrastructure, Edge aggregation & orchestration. Through its partnership with AWS, Vodafone has rolled out MEC at the edge of its 5G network. This has facilitated pilot programs to explore use case viability, including real time video streaming for emergency services, security applications and general mapping functions. By taking advantage of its partnerships with both AWS and Microsoft, Vodafone is looking to continue its 5G roll-out program to expand the potential for enterprises to make use of its edge computing solutions.

XENIRO: XENIRO's open-source software SnapScale (distributed ledger technology) was tested, trialed and deployed on China Mobile (Sigma MEC Platform) Huawei (Edgegallery MEC Platform) China Unicom (StarlingX MEC Platform) and their own platform (Hyzen MEC Platform). They have taken part in joint trials of 5G and MEC embedded blockchain solutions with mobile operators in China in three industries – Industrial manufacturing, Commercial Drones and Healthcare. They intend to launch the first MEC embedded blockchain for enterprises (with private 5G & private MEC). It is also architecting applications for Healthcare (MRI combining AI) and Manufacturing (Equipment-As-A-Service model).

Packet: Packet’s main offering is bare metal public cloud at the edge. The company’s aim is to help SaaS companies deploy physical network infrastructure at a global scale. By selling bare-metal public cloud, Packet helps to deliver the capabilities of hyperscalers to smaller players. Moving beyond the public cloud, Packet now plans to offer a bare-metal edge cloud solution which is customizable with respect to location, hardware, and environment. Equinix, one of the largest data center providers, acquired Packet in 2020 by fulfilling its strategy to combine its network of colocation data centers with Packet’s network of edge data centers, providing a single platform for all service-provider of enterprise computing needs.

Saguna Networks: Their any-access Edge-Cloud solutions transform communication networks (Saguna is a Multi access Edge Cloud Computing pioneer) into powerful cloud computing infrastructures for game changing applications including augmented and virtual reality, IoT, edge analytics, high definition video, connected cars, autonomous drones, etc., helping communication companies.

Kontron: it is a global leader in embedded computing technology (ECT) and in its offering they have a combined portfolio of secure hardware, middleware and services for Internet of Things (IoT) and Industry 4.0 applications like their edge servers that enable content and applications closer to the edge, while allowing operators to solve restricted space and power challenges and savings on costs. Their solutions enable applications such as Radio Access Network (RAN), Artificial Intelligence, Data Caching, ultra-low latency, and high-bandwidth edge applications, among others.

GEC: As a specialist in innovative edge and cloud solutions they offer ONCITE, an Industrial Edge Appliance product that encompasses the operation of edge cloud and cloud-based infrastructure solutions in the manufacturing industry, together with a powerful IIoT platform.

Altran: they offer ENSCONCE edge computing platform that combines multiple capabilities, accelerators and frameworks for rapid development of multi-access edge computing (MEC) solutions. As a result of the integration, infrastructure resources will be able to increase computing and I/O performance and reduce network latency. Altran’s ENSCONCE platform can reside on micro data centers close to the access network, aggregation points, regional data centers and central offices, reducing the barrier for application developers to host their edge applications.

AlibabaCloud: they offer Link IoT Edge that fully integrates cloud and edge computing and has native support for Alibaba Cloud. Link IoT Edge is compatible with a large variety of IoT application layer data collection protocols. It shields the differences in underlying hardware communication links, standardizes data conversion, and provides standard object model data, enabling cloud applications to seamlessly use edge capabilities.

TencentCloud: the company is extremely active in the field of edge computing. The company has launched a Tencent Smart Edge Connector (TSEC) solution, a connector between the mobile user and the service provides a customizable, high-quality, and differentiated edge computing network layer service for users and services, and realizes intelligent collaboration of applications in the cloud, edge, and end. It can solve the pain problems such as network delay and bandwidth cost in business scenes such as cloud games, VR/AR and ultra-high-definition video and in Innovative applications such as telemedicine, smart manufacturing, and car networking.

Nokia: Nokia Edge Automation tool simplifies the management of hundreds of independent cloud solutions deployed across multiple sites by enabling edge data planning integration, automated deployment, and mass software upgrades for any edge cloud infrastructure. It also manages the life cycle of edge site infrastructures and supports on-premises deployments for enterprise customers.

Multi-access edge Computing competition landscape

Solution providers in **multi-access edge computing**, such as Verizon, have started offering software developer kits to its customers, thus allowing in-house teams to develop programs that are in-line with the company's needs and requirements. Furthermore, these companies also provide predesigned software compatible with existing multi-access edge computing architecture of companies and ensure optimum processing capability, thereby stimulating multi-access edge computing market growth. Organizations worldwide have started collaborating with other companies to enhance their service offerings and generate new revenue streams. New entrants in the market, such as FogHorn Systems, are disrupting the industry by integrating AI into their platforms, thus offering better decision-making ability and functionality. Additionally, established players, such as Hewlett Packard, are increasing investments to innovate newer and better products by incorporating intelligent edge technology in their products.

As mobile edge computing is one of the emerging technologies, independent software providers, public cloud service providers, industrial automation, and networking companies are entering the multi-access edge computing landscape. Start-ups and new entrants are focusing on establishing themselves as key enablers by developing innovative techniques and solutions. Saguna Networks, Ltd. and Vapor IO are such companies with the latest advancements in the field of edge and cloud computing. Saguna Networks has developed a technique to support edge computing on a communication network, whereas Vapor IO is building next-generation edge and hybrid cloud.

Additionally, established players are signing agreements to join a group of companies that aim to promote multi-access edge computing practices. For instance, Huawei Technologies Co, Ltd. recently joined the Edge Computing Consortium Europe (ECCE), which is expected to provide a co-operative platform for IT companies to accelerate smart city development. The company also introduced an Edge-Computing-IoT (EC-IoT) solution for easier network management on cloud.

The rapid increase in the number of connected devices and accompanying need to engage in real-time decision making is paving the way for the adoption of enhanced data centers and servers. Companies have started offering advanced **Telecommunications Computing Architecture (TCA) hardware platforms** for enterprises and individuals. These platforms are cost-efficient, compact, and can be customized according to the user's requirements to maintain availability, serviceability, and reliability. For instance, Lanner Electronics has recently rolled out a new hybrid TCA platform that is extremely efficient at access networks and is expected to offer new revenue channels for the company.

VR, AR and Cloud Computing Competition Landscape

In **VR domain**, the key players emphasize on creating more advanced products. The prominent vendors of the VR market, such as Google and Oculus (Facebook LLC) are aiming to provide advanced virtual solutions. The ongoing trend of technology giants getting commercial products to the industry has directed the collaboration of start-ups to integrate and absorb VR technology that drives the industry growth. The key players in the market are engaging in mergers & acquisitions and partnerships with technology start-ups to gain a competitive advantage. For instance, Oculus's (Facebook LLC) recent acquisition of Beat Games and Sanzaru Games showcases the company's interest in the gaming industry. Moreover, in June 2020, Facebook Technologies, LLC acquired Ready at Dawn, a VR-based video game development company, with an agreement of creating games with immersive VR-based content for Oculus Studios. In May 2020, Apple Inc. acquired NextVR Inc. to boost Apple's VR ingenuities for entertainment and sports. With increasing competition in the market, companies focus on offering quality services to their viewers with continuous innovation in their content and exploring various industries with VR technology solutions.

The key companies are significantly investing in R&D to incorporate state-of-the-art technologies with various features in their offerings. Companies such as HTC Corporation, Oculus, Sony Corporation are highly investing in further developments in its head mounted devices. The players are entering into strategic acquisition and partnerships to expand their customer reach. Similarly, the company is investing in upgrading its software versions for providing better experience. Recently, Facebook LLC Oculus launched advanced virtual remote work applications on Quest and Rift platforms. Along with this, the company has updated software such as hand tracking, guardian system, and more by further integrating with the Facebook platform.

Another important trend to be noted is that VR companies are converging on the AR technology and Smart Glasses. The companies in the global market are receiving huge funds and investments across the globe. Companies such as Facebook and Google are acquiring start-ups in the market to gain expertise. Similarly, companies such as Microsoft Corporation, Vuzix Corporation, and Qualcomm Technologies, Inc., among others, are collaborating with different industries to expand their businesses. Apple is aiming to develop smart glasses like Google LLC. The company offers technology apps such as ARKit for developers to build augmented solutions. In this context, Apple Inc. announced a partnership with Dent Reality. The partnership aims to offer AR-based indoor apps and navigation solutions. It is the only official partner of Apple in Indoor Maps documentation.

In **AR gaming industry** the key vendors dealing in the augmented reality gaming equipment include Apple, Microsoft, Google and Sony. Information and communication technologies sector is expected to be revolutionized by dynamic phase change from wire-based reception technologies to the protocol-based sensory technologies such as immersive head mount devices. Recent mergers and acquisitions in augmented reality gaming market are expected to trigger the dawn of augmented reality gaming experience. Google Inc. proposed to craft augmented reality realm, by means of its investment in MagicLeap of over USD 500 million in October 2015. Microsoft is foreseen to expand its AR gaming devices 'Microsoft HoloLens' and its successor 'Microsoft HoloLens 2', which is a pair of mixed reality smart glasses.

Key market players on **Cloud mobile gaming** are focused on offering new products & solutions and adopting mergers & acquisitions, partnerships, and collaboration strategies to remain competitive in the market. For instance, in March 2020, Tencent signed a partnership with Huawei Technologies Co., Ltd. to set up a laboratory for developing a cloud gaming platform called GameMatrix in China. Through the partnership, the

company aims to leverage Huawei's computing power to build its gaming platform. In December 2019, Facebook, Inc. acquired Playgiga, a cloud gaming service provider. Through the acquisition, the company intended to launch cloud gaming services on its platform to increase user engagement. Furthermore, cloud game developers are focusing on developing gaming services that can be run on all PCs and laptops. For instance, in February 2020, Nvidia Corporation launched GeForce Now, a cloud gaming service that allows users to play games on all types of PCs and laptops. Factors such as, the rising investments in 5G technology and access to numerous games on cloud at affordable prices are also expected to contribute to the cloud gaming market growth. Furthermore, market players are observed partnering with telecom companies to deliver cloud gaming services globally. For instance, in January 2020, Microsoft Corporation partnered with SK Telecom Co., Ltd. to expand the reach of its Project xCloud Preview, a game streaming solution in South Korea.

3 Identifying ACCORDION Competitive advantage

3.1 ACCORDION Unique Selling Proposition

Based on the insights derived through the market analysis, the competitor analysis and considering the needs and requirements of targeted stakeholders, we can now identify ACCORDION true competitive advantage and the Unique Selling Propositions, which will highlight the specific benefits offered by the incorporation of well-established companies in their domains, for the creation and exploitation of an integrated cloud/edge resource provisioning solution.

We have identified the following Unique Selling Propositions:

- Integration of a large and diverse set of cloud and edge technologies in a single framework with a particular attention to the resource orchestration.
- Integration of QoS/QoE models to the services allowing adaptations of service parameters.
- Incorporating modern server architectures, including docker and individualized Unikernels for improved network performance.
- Facilitation of application deployment distributing it on cloud, edge and on-premises resources, allocating different micro services in different layers according to their requirements.
- Automated mitigation plan generation that extends from edge device to cloud servers and integrate multiple communication protocols.
- Implementation of secure execution environments addressing privacy and protection across different processing layers.
- KPI-based quality of service and quality of experience for low-latency, high bandwidth and adequate resource provisioning.
- AI-based decision mechanism for maintaining a robust edge/cloud continuum.

3.2 Value Proposition

A robust and impactful Value Proposition is essential for any business to effectively engage and connect with customers, partners and stakeholders by clearly identifying how it is different, better and worth purchasing from. The Value Proposition is central to the overall business model (as a preliminary version is provided in section 4.4) and should form the anchor for all decision-making, operations, and customer engagement.

The Value Proposition Canvas is a strategic tool that ensures that a product/service caters to customer needs. The Value Proposition Canvas illustrates the different advantages and values ACCORDION solution will deliver, the problems that targets to solve and the needs it aims to satisfy (Figure 3-1).

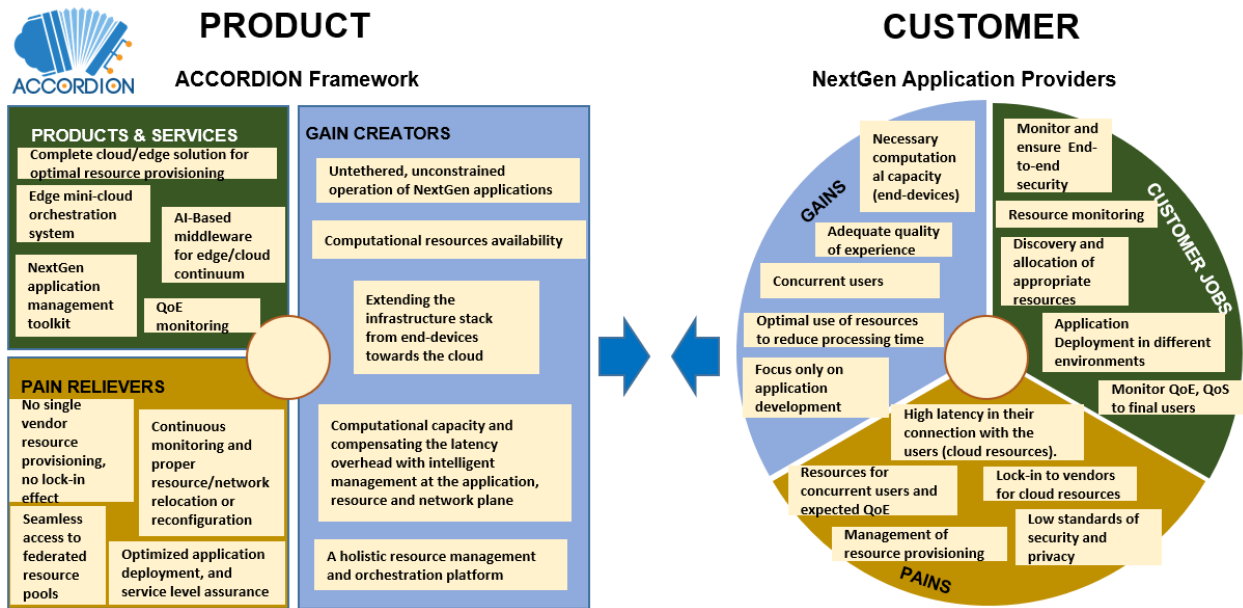


Figure 3-1: ACCORDION Value Proposition Canvas

The Customer Profile (right side of Value Proposition Canvas) concludes:

Customer Gains: the benefits which the customer expects and needs, what would delight customers, and the things which may increase the likelihood of adopting a value proposition. In specific, the first targeted market is the verticals of NextGen application providers (e.g., VR/AR, cloud mobile gaming industry) and a potential customer expects the optimal provision of the required computational resources, meeting the expected quality of experience for end-users, even in situations that many concurrent users are served. The service provider focuses only on the development of its application, relying on ACCORDION for the optimal use of the resources.

Customer Pains: the negative experiences, emotions and risks that the customer experiences in the process of getting the job done. NextGen application developers and service providers often suffer from lock-in effects from their cloud vendors and lower their expectations regarding the latency standards and the concurrent users that can serve simultaneously. In addition, weak security and privacy practices make the industry player vulnerable to security incidents.

Customer Jobs: the functional, social, and emotional tasks customers are trying to perform, problems they are trying to solve, and needs they wish to satisfy. In this context, various fragmentary and time-consuming processes must be executed by services providers own resources including the discovery, allocation and monitoring of the required resources, the monitoring of the quality of service to final users and the deployment of their applications in different environments. In response to customer needs and requirements, ACCORDION builds and demonstrates a novel and unified framework for the optimal resource provisioning of the demanding NextGen applications in terms of latency, bandwidth and QoE standards.

Gain Creators: An end-user will not accept a service they cannot control and enjoy as they desire. A mismatch of their expectations, which are increasing year by year, and the features/performance a service can offer will lead to a reduced user satisfaction. At a certain level, a user may decide to avoid using a service, especially

if there are high demands on the responsiveness of a service due to its interactivity. For fully serving the targeted customers, ACCORDION offers the operational environment for the untethered and unconstrained operation of NextGen applications and the high availability of the required computational resources, safeguarding the capacity and compensating the latency overhead by applying intelligent management of network and computational resources.

Pain Relievers: The ACCORDION platform ensures the business and technical requirements of NextGen application providers by offering automated and controlled resource/network relocation and reconfiguration based on real-time needs of these applications. The resource federated approach that ACCORDION adopts, promotes the seamless access to partners resources (federation), where and when needed, avoiding the vendor lock-in situations that many users face.

Products and Services: The consortium envisions to achieve the perfect fit between the value proposition and customer profile, by designing services which create gain and relieve pain, and which underpin the creation of value for the customer. In this context, ACCORDION offers a complete cloud/edge continuum paradigm for the optimal resource provisioning. The proposed offering includes an advanced mini-cloud orchestration system for the reservation of the resources where and when needed. The edge/cloud continuum is ensured by an advanced AI-based middleware that considers the QoE and QoS requirements of the applications that are served. Also, ACCORDION offers a complete NextGen application management toolkit to facilitate the underlying complexity of deploying NextGen applications on top of a volatile compute and network continuum and a QoE monitoring tool for measuring the quality of experience of NextGen applications.

The following impact KPIs verify the competitive advantage of ACCORDION compared to competitors and the value of ACCORDION offering to customers. These KPIs will be verified during the evaluation phase of the use cases' execution.

- More than 20% improvement in user experience across each use case compared to the current state
- More than 10 end-devices supporting interoperability and access via different VR/AR HMDs
- More than 20% increase in the average QoE by the end-users in VR/AR, gaming and content delivery domain
- More than 80% validation acceptance by end-users of the fully decentralized configuration of testbed in VR/AR, gaming and content delivery domain
- More than 5 different types of mobile devices to test ACCORDION offering in multiplayer gaming domain
- Less than 20ms the average latency for Collaborative VR applications, serving more than 15 concurrent users
- Less than 30ms the average latency for multiplayer mobile game, serving more than 100 concurrent users
- Less than 20ms average latency for content delivery for cloud gaming applications, serving more than 20 concurrent users

ACCORDION consortium recognizes that it is important to frequently validate and update the value proposition together with the customer. This establishes whether the proposition adds value to the customer’s business. Use cases execution and evaluation will validate the proposed approach and may be drive the potential alignment, or even the refinement, of the ACCORDION value proposition.

3.3 PEST Analysis

In today’s ever-changing global markets, being oblivious to the situations around may be quite detrimental to an organization. While formulating market strategies, organizations need proven analysis techniques to make informed decisions. The PEST (Political, Economic, Social, Technological) analysis is a strategic business tool to discover, evaluate, organize, and track macro-economic factors which can impact on ACCORDION outcomes now and in the future. The framework examines opportunities and threats due to Political, Economic, Social, and Technological forces and helps the consortium to get a comprehensive picture of the status and trends of important factors that are beyond its control but have an impact on the project.

The overall analysis of previous chapters regarding the market trends, drivers and constraints, help us to better understand the macroeconomic environment and the potentials of the ACCORDION project.

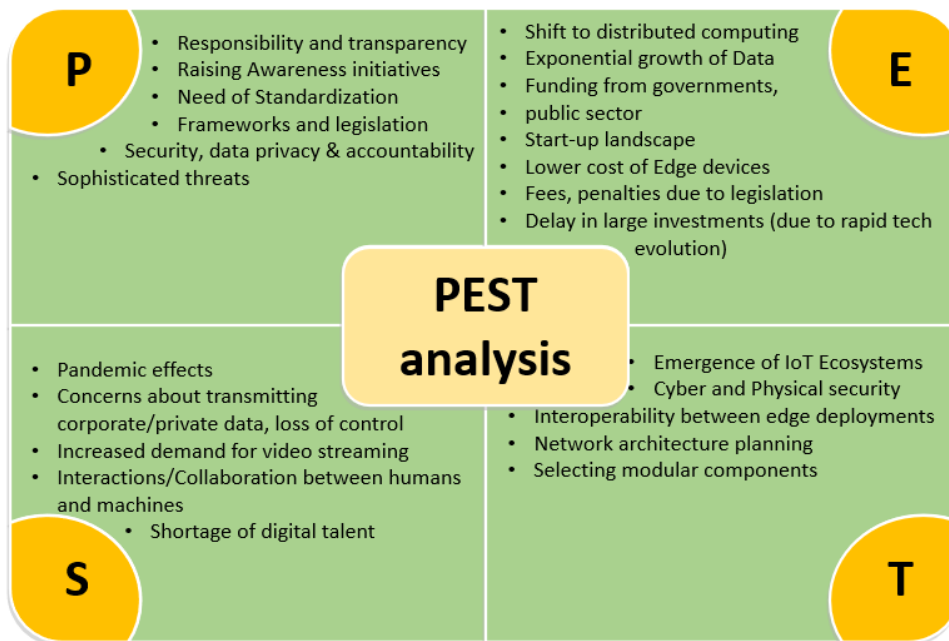


Figure 3-2: PEST Analysis

Summary of political factors:

Political factors include political stability, government policies, and activities of regulatory bodies and lobbying groups that may affect business through legislation, policies, rules, regulations and directives.

Political factors are closely tied to legal factors but are more focused on the underlying drivers and the political process eventually leading to binding legislation.

The main political concerns relating edge computing and next generation application market has to do with **responsibility and transparency issues**, a dimension that is highly connected with the lack of dominant framework and **standardization** schemes. For many businesses, customer experience is the key. In this context, they are willing to disguise cybersecurity and software procedures in order to deliver a ‘seamless customer experience’. Challenges arise when governments force through legislation and directives companies to be more transparent for their customers and internal processes. Whilst companies may be reluctant to police their users’ data, many are still willing to comply with regulatory and enforcement bodies to maintain safe online environments.

As the edge computing blurs the lines between data protection, security, safety and liability, current regulations may need to be adapted and aligned to match this change. Legislation has been designed without an integrated approach to these issues. The implementation of current and forthcoming **regulatory frameworks** will require more coordination and information sharing between the public agencies that monitor the adoption and enforcement of security by default measures.

With IoT and edge devices being attractive in industrial landscape, companies need to know the risks they are taking by bringing them into their production environment. It is the responsibility of both public institutions and private companies to **educate** and **aware** end users and companies in the security controls they should adopt. Service providers have a responsibility to protect user data but must also avoid becoming too intrusive when serving their customers. Public bodies and the private sector have a responsibility to ensure that only devices that adhere to ‘secure by default’ principles enter the market. In order to achieve this, governments might consider making ‘secure by default’ principles mandatory or adopt their own procurement policies that drive this.

In addition, the modern business environment contains increasingly **complex cyber threats** that the authorities struggle to identify in time or tackle. With low awareness level in cybercrime, it is unclear who will respond to it as it becomes more frequent and sophisticated. The cybercrime is everybody’s responsibility not just that of the governments, and industry should use their superior infrastructure and resources to supplement that of the security authorities.

Summary of economic factors

Economic factors include long-term trends of global economy as well as fast market fluctuations, costs and competition, as well as economic implications of political decisions, taxation and legislation. As already highlighted in the previous chapters the proliferation of IoT and edge devices, the expansion of 5G and the overall competitive landscape have significant impact of edge computing adaptation and the **shift to cloud/edge paradigm**. 5G and edge computing are two inextricably linked technologies, they are both poised to significantly improve the performance of applications and enable huge amounts of data to be processed in real-time.

Shifting to more distributed (including hybrid) **computing architectures** will impact business models, not only of cloud service providers, but millions of business adopters across every industry. Companies today

generate about 10% of their data outside a traditional data center or cloud, but Gartner¹⁵ expects that number will increase to 75% within just five years. Compounding this demand is the **exponential growth in data**, as pressures abound to actually use these data, both in real-time, and for longer-term strategic decision-making.

Shifting data processing to the edge of the network can help companies take advantage of the growing number of IoT edge devices, improve network speeds, and enhance customer experiences. The scalable nature of edge computing also makes it an ideal solution for fast-growing, agile companies, especially if they're already making use of colocation data centers and cloud infrastructure.

Private investment in the IoT has mostly been in the development of software for smart homes and buildings and venture capitalists predict the highest return on their investment in the short term. The same trend is valid for industrial set-up too. This focus on software has detracted attention from investment in hardware (a tougher and more expensive challenge), leading to a market containing higher volumes of cheap and insecure hardware that pose security risks.

Other influencing factors that are likely to shape the economic environment include:

- the desire for cost-effective solutions to expensive services, e.g., healthcare provision in remote areas
- the increasing funding from governments and the public sector for the development and exploitation of new technologies and business models that favor cybersecurity in service provisioning.
- the lower cost of IoT and edge devices, their usage and maintenance, improving the ROI of investing in edge computing.
- The market lure attracts new players and startups
- the delay in large investments due to rapid evolution in technology.
- The economic impact of no compliance with legislation, directives, and regulatory frameworks.

Summary of social factors

Social factors refer to the economic and social conditions of individuals or groups of the society. These are reflected in attitudes, preferences and trends that can influence market behavior and political decisions and eventually legislation. It is therefore important to understand how social factors may influence market demand, funding possibilities and legislation in order to determine how they may affect future business environment. The relevant social factors and the society of interest will depend on case to case. It is also good to note that the social factors may change quickly, for example, as employment or economic conditions change.

A major concern is the availability of skilled workforce. Based on estimations, Europe face a shortfall of 900.000 IT workers in 2020. Currently the European Commission estimates that 37 percent of Europe's labour workforce has insufficient digital skills¹⁶. Other factors include:

¹⁵ Gartner, <https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders/>
¹⁶ <https://ec.europa.eu/digital-single-market/en/digital-skills-and-jobs-coalition>

- Pandemic effect on work from office conditions and technical requirements regarding low-latency and high-bandwidth network capabilities.
- Increased demand for high-definition video streaming and video-on-demand services
- the lack of transparency regarding who has access to data, corporate or personal
- the willingness to share data with value in case of gaining a clear advantage by sharing them
- the co-existence of human factor and machines in production environments and vertical market that take advantage of NextGen applications.
- skepticism about data protection and the effectiveness of security solutions
- the unequal availability and access to edge computing between larger organizations and SMEs due to budget restrictions

Summary of technological factors

Our modern-day lives are overwhelmed with new digital developments and there is an expansion in the usage of AR tools like face filters, VR tools like voice assistants to **smart IoT devices** in all the industry verticals like healthcare, manufacturing, etc. The changes and growth of these devices entail lightning-fast speeds and huge volumes of data consumption which cannot be efficiently scaled for real-time processing and security by the cloud. While LTE networks brought about a degree of enterprise application improvements and added consumer benefits like better remote video streaming, 5G networks should eventually achieve speeds close to 100Gbps. With this powerful uptick in bandwidth capacity, and with the ability of businesses to create their own local, non-public 5G networks, the next-gen technology will be central to orchestrating infrastructure and being used for a variety of applications.

For any organization, **security** is the most challenging factor in edge computing architecture and deployments. On the other hand, data collected near the sensors or devices where it is created and used may also be vulnerable to cyber-attacks. Hence, building a strong end-to-end security and extending it all the way from remote devices, edge of the network to the data center is important to avoid security threats.

Organizations must ensure the level of **compatibility and interoperability** between different edge deployments while putting things into implementation. Various devices across the different network layers must be synchronized. In a nutshell, organizations will need an Edge Computing provider who offers end-to-end solution which can help the implementation of sensors network plugins to secure Cloud connection as well as huge gateways to seamlessly carry out remote operations whether on the server or virtualized.

It is necessary to develop a **network architecture** and element partitioning to fulfill the requirement of users and applications. It is important to be clear which portion of the system can run in the cloud and which can be executed at the edge. While partitioning can help distribute the application across the multiple peer nodes sharing the load, it is crucial the network architecture to meet the business and technical needs.

Different applications require different **hardware components** to equip on the edge nodes. Different components have different ability to perform based on their specific characteristics such as performance, programming algorithm, and memory storage level at the edge. Installing application-specific hardware components increases the interoperability between various modular components.

In any environment, IoT systems need to cooperate and coexist. This would lead towards them operating efficiently and productively. Data needs to be shared between various devices and platforms and as a result,

a proper **IoT ecosystem** is formed. These ecosystems are developing rapidly all around the world and major organizations are realizing that. Products and services need to be developed in such a way that they do not hinder the processes in any ecosystem and can be introduced to continuous updates.

3.4 SWOT Analysis

This section provides a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, listing the internal strengths and weaknesses of the ACCORDION solutions as well as the opportunities and threats faced by ACCORDION due to changes in the external environment. SWOT Analysis is a strategic planning tool for evaluating the above factors for a project or a business venture. This process allows ACCORDION to identify internal and external factors that are favorable and unfavorable to achieve its objectives. More specifically it provides the opportunity to:

- Evaluate the strengths of its situation
- Define the weaknesses, which the consortium will try to minimize later on
- Recognize the possible opportunities and threats and treat them in a planned and organized way

The following SWOT analysis diagram was derived from the results of the previous sections, supplemented by our vision of project's outcomes and the clear understanding of market potentials recognizing the strength and weaknesses of the consortium as a whole, as well as the opportunities and the threats of ACCORDION initiative.

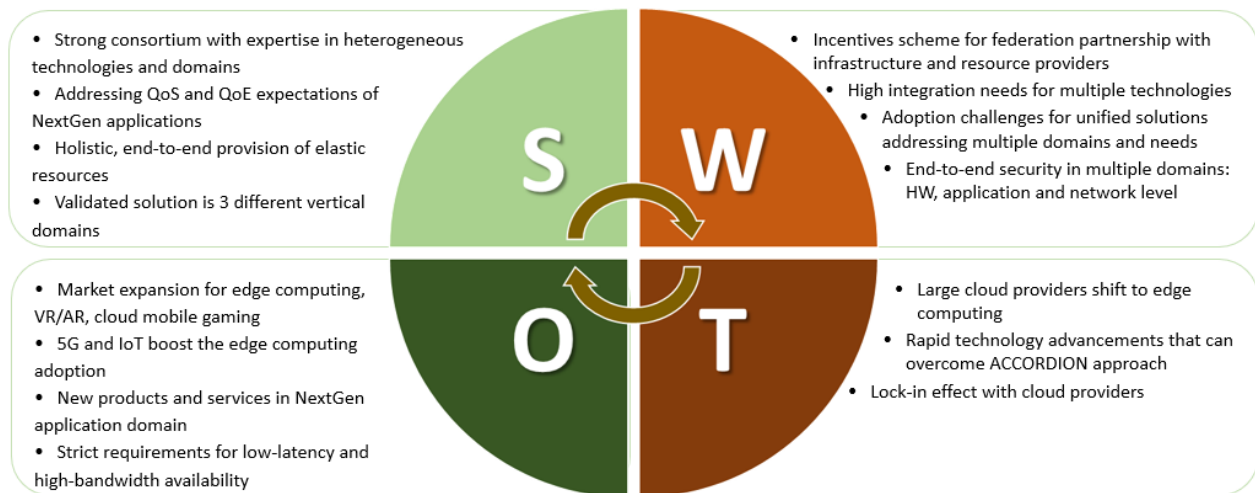


Figure 3-3: SWOT Analysis

4 Exploitation strategy

This section shows an update of the exploitation strategy proposed in Deliverable D7.1 and includes a preliminary business modelling.

4.1 Intellectual Properties (IP) and assets per partner

The following table lists the exploitable assets per consortium member, how these will evolve over the course of ACCORDION project and the current status during the first half of the project.

Table 1 Exploitable assets per partner

Partner	Background ¹⁷ Knowledge/Intellectual Properties	Foreground ¹⁸ Knowledge/Intellectual Properties	Current status (M1-M18) on Intellectual Properties
TID	<p>Weblog Privacy Analyzer (TRL 2): analyzes user weblogs and extracts the monetary value of users during their sessions. It can detect personal data leakage to advertisers via the real-time bidding and cookie synchronization protocols.</p> <p>Privacy-preserving AI (PPAI) Framework (TRL2) – This framework is designed to allow different Telefonica units to compute AI models across data sources, in a decentralized fashion, thus allowing better scalability and preservation of data sources’ privacy.</p>	<p>Weblog Privacy Analyzer will be used to assess value of users’ data (as extracted from delivered ads during their web browsing) at the edge, i.e., in a local device, without (or before) sharing data with the cloud/server (TRL 4).</p> <p>In ACCORDION, TID plans to further develop this framework, test its implementation across different devices, such as mobile and home devices, and improve its modelling capabilities for data processing, while also improving its privacy guarantees. Aiming to reach TRL 5.</p>	<p>The analyzer now has a variety of components that detect cookie synching, advertising protocol transactions such as for real time bidding and header bidding. We also looked into privacy leakage from the real-time bidding protocol, device or user fingerprinting, etc.</p> <p>We finally looked into categorization of news websites and their subdomains based on URL path and how that associates with their user tracking behavior. All these raise its status to TRL 3.</p>

¹⁷ Knowledge/IP available at the start of the project

¹⁸ Knowledge/IP produced during the project’s tenure

<p>NEC</p>	<p>Automated Unikernel Tool takes as input a target application, analyze its dependencies, and automatically creates a set of lean images, one per user-selected target platform, each containing the necessary application functionality (TRL 3).</p>	<p>NEC will use the Automated Unikernel Tool to generate images that it will deploy and test in test environments in order to derive performance numbers towards productization (TRL>=4).</p>	<p>The tool is now fully developed (available open source at github.com/unikraft) and a large and intensive batch of performance tests carried out as part of the Eurosys 2021 paper, which received the best paper award. For the latter, there's an accompanying repo that makes it simple to reproduce the results at https://github.com/unikraft/eurosys21-artifacts.</p>
<p>BSOFT</p>	<p>BlueSoft brings to the project its knowledge and many years of experience in the field of Information Technology (IT) systems integration, designing advanced digital IT solutions based on microservices and cloud computing technologies. We would like to use our own solution (Starboost) to manage microservices as one of the elements of Accordion platform. Starboost is a comprehensive microservices digital canvas which is boosting process of digital transformation from monolith to microservices and DevOps. Solution provides orchestration of services automating resource allocation to microservices and is ready for a cloud or on-premise deployment. An additional contribution will be our practical experience in the areas of DevOps and Agile driven by an experienced team of architects and</p>	<p>As part of the Accordion project, BlueSoft is going to enhance its knowledge and experience in the management of distributed applications based on micro-services. Additionally, we want to gain knowledge related to the practical use of microcomputers (Raspberry Pi, Arduino and others). Another area of our interest is the knowledge of real-time monitoring of applications and resources and prediction of potential problems and failures. The ACCORDION project will also be an excellent opportunity to develop the StarBoost platform towards supporting hybrid application deployment allowing simultaneous deployment in the cloud and on the edge.</p>	<p>During the project, we verified our original assumptions about using Starboost as part of the Accordion architecture. After analyzing requirements and discussions related to Accordion architecture, we decided to create a component responsible for DevOps process from scratch. This decision was based on a detailed analysis of the requirements defined by use case owners for the DevOps process and our experience in designing and implementing such procedures. Creating this component from scratch will allow for more effective implementation within Accordion, as well as for customization of the DevOps process to better fulfil the expectations of consortium members</p>

	<p>developers, ready to share their experience and knowledge with the other members of the consortium.</p>		
OVR	<p>OVR as one of the main Use-Case providers brings into the project the proprietary, gamified, multiuser VR software platform (MAGES SDK), which supports current and forthcoming Virtual Reality Head Mounted Displays (VR HMDs). The platform integrates a custom interpolation engine (Geometric Algebra Interpolation Engine) as part of the SDK offering network optimizations for reducing data transfer and compressing broadcasted values from ConCurrent Users (CCU's) following a client-server topology over the network based on Unity networking. Background IP is involved.</p>	<p>OVR will utilize the ACCORDION framework for managing the different data-services and available network resources (HMD, edge miniclouds and cloud resources) across the cloud continuum, and thus augment the processing capabilities of the end-devices while supporting the dynamic optimization of the interpolation engine based on the network characteristics. Foreground IP may be expected</p>	<p>During this period, OVR investigated on different available solutions for remote rendering and streaming and exploited the WebRTC framework that enables real-time communication for mobile devices. Experiments were also conducted in porting the MAGES SDK in linux to support containerization with docker. Though due to the inherent difficulties in supporting Unity and SteamVR in Linux the alternative of VM images was used.</p>
ORBK	<p>Innova engine multi: Innovative engine for online, cross-platform multiplayer gameplay for mobile games, along with a set of tools necessary for system testing, based on the Entity Component System (ECS). (TRL 4)</p>	<p>ORBK's multiplayer engine will be able to support up to 100 CCU's (concurrent users) and handle huge number of in-game events while performing full simulation of the game world and generate responses with minimal possible delay (<100ms). (TRL 6)</p>	<p>ORBK utilized "Innova engine multi" in order to build Game Server and Game Client applications. Initial versions of both applications are ready for first tests. ORBK prepared effective pipeline to create docker image of the server application. It is now ready for deployment testing.</p>

<p>PLEX</p>	<p>Traqus: A Plexus localization product using WiFi infrastructure, will become more sophisticated through AI techniques and the use of edge computing capacities.</p>	<p>Optimization of the content delivery path from cloud to low-end user devices, especially mobile devices. A typical scenario involves the generation of content at a centralized infrastructure and its streaming to the individual clients based on their own feedback/input.</p>	<p>During this period, PLEX developed an Edge application which performs content decisions based on the data obtained from probe requests. Furthermore, it has enhanced its digital signage solution Anblick by integrating it with the Edge application. Finally, a mobile augmented reality loyalty game has been developed which is ready for testing.</p>
<p>AEGIS</p>	<p>AEGIS brings into ACCORDION its cybersecurity expertise and the know-how for the development and deployment of security-enhanced applications for the identification of the security threats in edge/cloud environments as well as the implementation of privacy-preserving mechanisms for the early detection of potential leakage of sensitive data.</p>	<p>AEGIS expects to enrich the security know-how in federated environments with multimodal business and technical requirements, by investigating the tradeoffs between federated and pure peer-to-peer solutions, with respect to convergence, accuracy, and privacy</p>	<p>Knowledge gained from the security tools evaluation regarding static and dynamic application security testing, and container Image Security for the integration of security best practices within the DevOps process.</p>

4.2 Achieved exploitation activities

4.2.8 Individual exploitation activities

4.2.8.1 INDUSTRIAL PARTNERS

Table 2 Exploitation Plans per Business partner

Business Partner	Exploitation plan	Exploitation plan achievements
<p>TID</p>	<p>TID is the Research and Development (R&D) branch of Telefonica. Thus, TID has plans to introduce the results of the project to</p>	<p>We made significant efforts on the 1) Privacy-Preserving AI framework and also the 2) Weblog Privacy Analyzer.</p>

	<p>Telefónica Operating Businesses, by running demonstrators and trials and seeking to find applications within their businesses. Telefonica is currently developing and extending its next (fourth) generation platform that will make cognitive sense of a flow of data, also at the edge nodes, and will facilitate the discovery of new value-added propositions based on the insights from the project. Being part of a telecom operator, TID is especially interested in the novel edge/cloud data services and how they could be applicable in both fixed and mobile environments. TID is especially interested to tech-transfer results from the project to the ElevenPaths business unit of Telefonica that focused on cybersecurity B2B services. In addition, TID is interested in the deployment of technologies built within the project, in the future telco-edge infrastructure that Telefonica is investing. Also, the work done within the project (Weblog Privacy Analyzer) can provide guidelines for how to add value to the users' personal data and how they can be used in data services inside Telefonica and beyond. Furthermore, TID will make use of the Federated and other Privacy-Preserving Machine Learning services (Privacy-preserving AI Framework (PPAI)) to be built within the project for its upcoming fourth generation platform and how to compute machine learning models at the edge and at the same time use these models to improve applications and services depended on reliable data-driven insights relevant to Telefonica's business units.</p>	<p>The first one is being considered by different units internally (e.g., 4th platform, etc.) on how the data should be internally pre-processed before used by Telefonica units such as Smart Steps, to provide insights to the B2B customers.</p> <p>The second one leads to knowledge being transferred to an internal unit which performs investigations on advertisements that are privacy-preserving and do not require cookies or other PII. The insights from this unit are being fed to typical DSP units for ad-campaigns.</p>
<p>NEC</p>	<p>NEC will use the lightweight virtualization technology (automated unikernel generation tool), to apply unikernel technology to new markets. In particular, NEC has an existing and growing portfolio in the area of IoT platforms which would benefit from the unikernel systems that this project will develop. Another likely target is NEC's line of edge-based cloud computing services and</p>	<p>NEC have carried out extensive surveys and calls with potential clients to check market fit for the Unikraft technology. The feedback so far is encouraging, many potential clients are unhappy with the cost of their public infrastructure bills and this is an area where Unikraft could help. NEC is in the process of investigating what the next steps would be.</p>

	platforms and its line of cloud products and services.	
BSOFT	<p>BlueSoft expects its” Starboost” product to be strongly enhanced by ACCORDION with an opportunity for the hybrid approach for application orchestration - in the cloud and on-premise. This might bring additional benefits to our offer since many of the customers still have their own IT infrastructure up and running. Even though there is a trend to move towards the cloud services, customers would like to interplay between on-premise and cloud infrastructure with the priority to the first to fully utilize them and take the latter only when the top up is needed. Moreover, strong focus on the latency minimization and maximization of availability, reliability, security and performance at the various sites, will be specifically beneficial for the sectors such as fintech and telecommunication which are strategic businesses of BSOFT.</p>	<p>As part of the project work, and after consultation with consortium partners, it was decided that the Starboost application would not be used as a component within the Accordion project. Based on a detailed analysis of the requirements defined in the first phase of the Accordion project, as well as architectural considerations, we decided that the component responsible for managing the DevOps process will be created from scratch, which will allow us to more effectively meet the defined requirements. However, in the future we expect to adopt some of the solutions developed under the Accordion project in the Starboost product</p>
OVR	<p>The OVR VR software system has been the first-to-market psychomotor VR surgical Training solution. OVR will adopt the ACCORDION solution to develop and promote collaborative cloud VR training applications specially formulated for mobile systems, untethered HMDs. In addition, as OVR seeks solutions to support a higher number of CCUs, the ACCORDION framework will be adopted in current and upcoming products towards enhancing the training experience and moving into larger scale virtual classrooms. Finally, the adaptation of OVR’s networking layer to edge computing will optimize the current status of the cooperative mode, ensuring lower latency and higher performance on average network conditions.</p>	<p>The OVR software module has been redesigned to enable the migration of the application components in the minicloud following the full computation offloading paradigm. The cross-platform WebRTC framework has been exploited for streaming rendered content from the application component running on the mini-cloud to the HMD, and the Photon Networking solution for managing the communication among clients and offloading this functionality to dynamically allocated relay servers, while ACCORDION manages the deployment of the software components in the appropriate resources of the minicloud.</p> <p>Further improvements are foreseen in the next phase of the project for sharing of the same minicloud resource with more than one HMD and dynamically optimizing the transmission rate in the geometric algebra</p>

		interpolation engine via the developed QoE model of the platform.
ORBK	<p>As mobile game development studio, ORBK plans to use ACCORDION as a support for mobile multiplayer platform. ACCORDION enables ORBK to develop real-time multiplayer games which can give potential market advantage and the possibility of expanding the business beyond single player and turn-based multiplayer games. ACCORDION's NextGen application management toolkit will shorten and facilitate deployment process which will accelerate the production loop. Full automatization of deployment will allow more frequent publishing of patches and delivering new content to already published games without having to go through a complicated and lengthy manual publishing process. In the case of the success of the first real time game created using the ACCORDION's infrastructure, we plan, apart from creating consecutive games of this type, to use the system's ability to create an Augmented Reality (AR) game based on the user's geographical location.</p>	<p>ORBK is planning to utilize core functionality of the multiplayer engine developed based on "Innova multi engine" in future projects. The mechanism for synchronization of multiple game entities would be useful in an AR and VR collaborative applications. ORBK is also planning to utilize the multiplayer engine to create other multiplayer games in the following years. Multiplayer engine is still under intensive development.</p>
PLEX	<p>PLEX developed its platform TRAQUS which processes all data obtained from devices connected to a Wi-Fi network. It analyses real-time data of localization and then automatically delivers some key indicators to know customers better, to improve users experience and to increase sales, among other issues. Plexus objective in ACCORDION is the optimization of the content delivery path from cloud to low-end user devices, especially mobile devices. A typical scenario involves the generation of content at a centralized infrastructure and its streaming to the individual clients based on their own feedback/input. Thanks to ACCORDION, own current localization products by PLEXUS will become more sophisticated through AI techniques and the use of edge computing capacities. They will be able to offer different</p>	<p>Content delivery has been improved by adding content decision making on the Edge as part of the Accordion use case. Probe requests are being captured on the Edge and based on aggregated device characteristics a content decision is made. Allowing customers to receive more relevant content and improve its effectiveness.</p> <p>As part of the second phase of the Accordion project it's planned to develop an improved version allowing for more advanced content decision making.</p>

	<p>outputs almost in real time. This will improve decision making capacities. It will also provide the platform with information and event driven actions based on user location that will enable developers of games and applications gather position of multiples devices and have them available to develop gamification experiences. All this with very low client device requirements, high speed information and very low power consumption.</p>	
<p>AEGIS</p>	<p>AEGIS intends to transfer all knowledge gains through its participation in ACCORDION in order to enrich and specialize its offerings. We will enhance our cybersecurity expertise in complex federated environments in cloud and edge computing domains. Also, the ACCORDION project will enable AEGIS to better understand the real-world needs for our main market domains, namely digital investigations (forensics analysis), data visualization, and training & consultation services. Moreover, AEGIS will fully benefit from ACCORDION joint development in the field of data visualization in terms of monitoring, computational resource management, SLAs, and KPIs monitoring.</p>	<p>The existing service portfolio will be enriched with specialized consultation and training offerings on complex edge/cloud environments, especially targeted to potential customers that seek their digital transformation and their transition to cloud or hybrid environments. Moreover, the expertise gained in DevSecOps will be fully exploited in the development of our forensics and data visualization services.</p>

4.2.8.2 NON-PROFIT PARTNERS

HUA is exploring the creation of an open-source project and has contacted the Eclipse Foundation for that purpose. Furthermore, HUA started a PhD on ACCORDION topics (application models) and plans to start one more on a relevant topic. The preliminary results of ACCORDION have been presented in one lecture of a postgrad course and will be presented in the HPDC conference. Finally, a research proposal was put together and got funded (CHARITY) in which many challenges and approaches were identified in the frame of ACCORDION.

4.3 Preliminary business modelling

4.3.9 Business Model Canvas

This chapter is about investigate the potential systematic ways for ACCORDION to unlock long-term value for the project outcome while delivering valuable products and services. A business model includes the kind of

incentives it can create for its users, the distribution networks it is able to tap into and the key partnerships ACCORDION can leverage on. In short, a business model is a holistic framework to understand, define and design the positioning of ACCORDION in the marketplace.

Business model tools can be used in the phases of the business model generation in order to i) map the business model hypotheses ii) test these hypotheses with customers' feedback and iii) iterative this process in order to fine-tune and improve the business potentials and dynamics. The result will be an incremental development of a product/service that will reach a minimally viable version. The better the product based on customers' feedback and real-life pilots, the larger the audience it will reach.

The author of the Business Model Canvas¹⁹ defines the business model in the following way: "It describes the rationale of how an organization creates, delivers and captures value". The main objective of this idea is the joint of the business model development by all members of the organization in a simple and understandable way. The business model is a kind of a strategic scheme, to be introduced in the framework of structures, processes and systems in the enterprise. According to the concept of Business Model Canvas, the business model consists of nine fundamental elements that show the logic of developing profit for the company. These elements are Customer Segments, Value Proposition, Channels, Customer Relationships, Revenue Streams, Key Resources, Key Activities, Key Partners, Cost Structure. In order to facilitate the use of this method the special tool was developed. It shows all nine parts of the business model in an orderly fashion.

The business model of ACCORDION is a multi-sided one, meaning that there is more than one type of customers that have interest on the service provided. During the analysis of the business model canvas, we need to address each building block considering all the different types of customers that the developed platform needs to serve.

¹⁹ BMC, https://en.wikipedia.org/wiki/Business_Model_Canvas

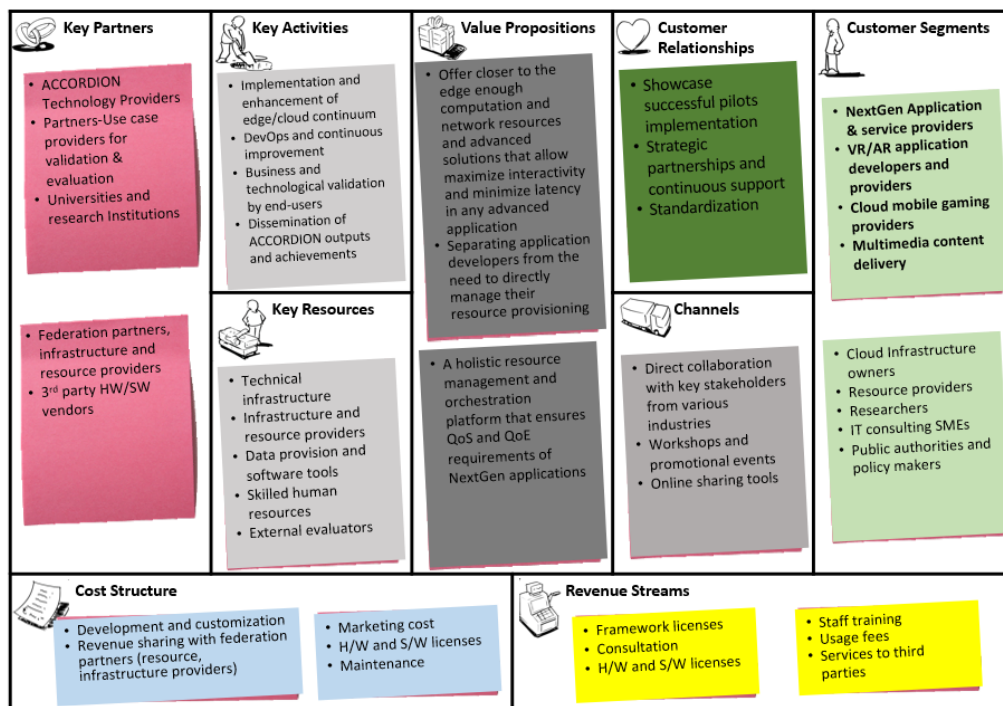


Figure 4-1: ACCORDION Business Model Canvas

Customer Segments: ACCORDION aims to reach and serve as customer segments all vertical industries that focus on NextGen applications and their specific technical requirements for low-latency and high-bandwidth availability for an adequate number of concurrent users. The experience gained from the use cases deployment in VR, multiplayer mobile gaming and multimedia content delivery will lead the further exploitation and targeting to similar organizations and markets. In addition, potential customer segments consist of community industry pioneers, research European including individual researchers, research centers and universities, providers and operators of cloud infrastructures and network resource providers, and potential investors interested in new technologies exploitation.

- **For whom are we creating value?** – We are creating value for the industry and the research community in various innovation-driven sectors such as edge computing, VR/AR industry, cloud mobile gaming and content delivery domain. With the implementation of ACCORDION, all potential users in need for elastic infrastructure, strict QoE and QoS requirements or for more mature innovative ideas will be able to contribute to ACCORDION approach and exploitation via the platform, while at the same time, industry and researchers will interact and share infrastructure, data and needs.
- **Who are our most important customers?** – Important customers will be the industry, especially from the targeted domains of VR/AR and cloud mobile gaming. The ideal customer profile of ACCORDION platform is companies in these domains recognize that the quality of experience expected by their end users cannot be met by traditional cloud providers and they seek a platform to optimum handling the resource provisioning of their service. Their acceptance, willingness and cooperation in using the platform will be fundamental. This collaboration will lead to the platform evolution and potential investors' attraction.

- **Where do they live?** ACCORDION will provide a framework able to be adjusted in various industry sectors and every research community worldwide.

Value Proposition: ACCORDION’s key competitive offering is the innovative and comprehensive framework for offering the required computational and network resources for maximizing interactivity and minimizing latency in NextGen applications where and when needed, as described in section 3.2.

- **What value do we deliver to customers?** ACCORDION aims to build a cloud/edge continuum framework through which numerous industries from a variety of fields will be able to exploit and enhance their services to end-users by focusing on the development of their applications, relying on ACCORDION for the resource provisioning. It will provide all interested stakeholders a comprehensive framework of tools, technologies, platforms and services through which they can manage the computational resource availability with trust and security. ACCORDION also helps market opportunity generation for industry partners, while the research community exploits an upgraded level of technological useful sources.
- **Which one of our customer’s problems are we solving?** NextGen applications are computationally- and data-intensive at the edge, latency- and QoE-sensitive, and scalable in nature. Their rollout is being held back by the limited network bandwidth that will guarantee a high-quality content delivery and the dependency on fixed local resources (e.g., for GPU-based processing) that constraints the physical presence of end users. In specific, these NextGen applications need to i) move to untethered operation, depending on consumer devices with constrained computational capacity and ii) support a theoretically unbounded number of collaborating users in real-time. To support both these requirements, computation offloading is required to shift its target towards infrastructures that combine low latency with (collectively) high computational capacity. At the same time, in order to meet the expected QoE standards, the application data flow model needs to be both decentralized and adaptive to the underlying mixed edge/cloud computing and network infrastructures. ACCORDION focuses on providing a platform which will combine the needs of the stakeholders aiming to meet these requirements and provide more complete and secure framework of operation. We will showcase our approach and technologies in the VR and gaming domain, but we expect upon completion of the project to attract further investments in order to perform wider testing of the platform in different industrial domains that are heavily dependent on QoE requirements.

Channels: Channels describe how a company communicates with and reaches its customers segments to deliver its value propositions. A company can deliver its value proposition to its targeted customers through different channels. Effective channels will distribute a company’s value proposition in ways that are fast, efficient and cost effective. An organization can reach its clients either through its own channels (store front), partner channels (major distributors), or a combination of both. For defining the channels, we would need to answer the following questions:

- **Through which channels do our customers want to be reached?** Direct collaboration with industry representatives and research community is one of the main channels. Building an integrated platform and online sharing tools that are easy-to-use will bring ACCORDION framework closer to independent stakeholders. The consortium will also organize workshops and seminars which will also contribute to the promotion of the project outcomes.

- **Which channels work best?** We intend to use a mix of channels in order to reach potential customers, however, we recognize that a detailed presentation and demonstration of ACCORDION platform can reveal the full potential of the project’s innovative offerings. In addition, we will use online channels (based on our dissemination and communication strategy) to promote the interest and keep the relationship with the individual stakeholders.
- **Which ones are the most cost-efficient?** Given the complex nature of the ACCORDION project, we have to use a combination of methods to reach the maximum potential market reach. We will monitor and evaluate the cost-effectiveness of each method in order to regularly refine our strategy.

Customer Relationship Management: ACCORDION aims to build its customer relationships based on strategic partnerships to reach the broader dissemination and exploitation channels possible. It will ensure long-term relationships, providing continuous support to evolving requirements of each targeted domain, by monitoring the new trends arising and the advancements in technology. Moreover, we will build upon customizations and refinements in order to meet the emerging resource provisioning needs of customers, offering consultation and training as well.

Revenue Streams: Sources of revenue will be created directly through selling the ACCORDION framework’s licenses and through usage fees that will be both subscription and on-demand fees. To promote the framework and engage service providers, especially start-ups and newcomers, the consortium will examine the viability of a Freemium offering, in which a basic version of the framework will be offered free-of-charge, considering the limited resource requirements at the early stage of new companies. Revenue streams will also be generated indirectly, i.e., by organizing consultation and training sessions for the users of the framework. During the business planning stage, the project will conduct a cost vs. benefit analysis to determine whether the proposed revenue model needs to be reconsidered. Financial figures and best estimates like the Return on Investment (ROI), net-present value (NPV), sales figures and alike will be provided during the project within the exploitation and innovation plan after a market analysis.

Key Resources: A strong partnership with research community and industry that will develop and run the framework across Europe is essential. The most important assets required to run the business are the technical infrastructure and a wide federation with infrastructure owners and resource providers for the high availability of resources when needed. The human capital is identified as the most significant resource for the success of this business plan, so every partner plays an important and integral role in the project. Finally, existing software tools provided by the ACCORDION partners are also key resources for the project’s success.

Key Activities: The key activities will be handled by the ACCORDION consortium are implementation of the framework, development & improvement and support of the framework operation, as well as maintain close relationships with the stakeholders and focus on promoting the framework and disseminating the results. Our partners are skilled in these processes and have a lot of experience in running and developing complex and innovative frameworks.

Key partnerships: The key partners are the ACCORDION technology providers and the use case providers for the validation of the project’s outputs. ACCORDION is a highly innovative project, so the contribution of academia and research institutions is essential for the success of the project. From a business perspective, the wide adaptation of our envision offerings requires a strong and effective federation partnership with

local infrastructure owners and resource providers for the scale-up needs of our end users. Project’s partners satisfy all the categories needed from research and industry community in various sectors.

Cost Structure: ACCORDION incurred costs to operate the business model are costs for the deployment in infrastructure management, software development and maintenance, and marketing. In addition, we must consider that based on the federation and business logic approach will follow, the revenue sharing scheme may be considered as an added cost for the provision of our service. Also, note that exact data is not provided as they would be purely based on rough estimates, because essential figures like total cost of ownership (TCO), are still unknown at this point of the project.

To ensure the success of the proposed Business Plan, the consortium has identified a robust set of means that will allow us to monitor of success, fine-tune offerings and driving sales:

Financial reports: Reports will be used to measure the profits and losses along with identifying whether the correct balance of revenue streams is being achieved to meet overheads and grow the business.

Self-awareness check: The consortium will regularly meet to discuss their ideas for the business. As a geographically dispersed consortium, ACCORDION understands that such face-to-face meetings are critical for ensuring the framework’s future matches the vision of the team.

4.3.10 Barriers to Adoption / Barriers to entry

Barriers to entry are referring to the barriers to digital innovation from start to implementation, as well as assessing the impact of facilitators of ICT innovation. Among the factors that act as a barrier are the following:

- Federated resources availability and weak incentive schemes
- Authenticity and traceability
- Security & privacy
- The complexity of standardization and regulation landscape.
- Lack of awareness about full benefits of edge computing
- Too many divergent interests among the stakeholders entail that digital innovation challenges the ability to cooperate.

Despite the high innovation nature of ACCORDION and the market momentum that strengthens our market adoption, there are factors that can hinder market penetration and jeopardize our commercialization strategy. These factors should be closely monitored, and partners should form a mitigation strategy to overcome them in case of their realization.

The distributed nature of ACCORDION, and the need for many edge devices to connect and interact, may pose several challenges to its widespread adoption. ACCORDION’s full potential can be exploited only after the establishment of an extended and strong federation scheme with infrastructure owners and resource providers. The IT corporations and Cloud suppliers/resource providers can join hands and allocate the resources through the ACCORDION federation. By selecting multiple providers in place of a single provider, the different computational obligations can be improved, and cost can be reduced. Maximizing performance, improving reliability, scalability, multi-location deployment for error tolerance and recovery, cost

minimization, less energy consumption and partnership with other providers are advantages of this federation. But, also, federation has many portability and interoperability issues and encounters many challenges in the deployment of the federation like Identity and Access Management. In order to build a strong federation, pricing and revenue sharing incentives should be available, but they can also jeopardize the overall competitive offering of ACCORDION, compared to the pricing of other alternative solutions.

Coordinating data exchange and sharing computational tasks between a potentially large number of computers or devices in a distributed edge computing network may pose a significant challenge. There may be difficulties if edge computers are working with a wide range of mobile devices that may not be consistently connected to the network. ACCORDION is actively trying to improve methods to monitor available computational resources, allocate them efficiently and recombine the results, highlighting that interoperability between devices – using standardized ways of communicating and executing tasks – is important for the full benefits of ACCORDION offerings to be exploited.

Securing data, improving operational reliability and efficiency, and driving application performance are all important factors. But while security is a top driver, it is also considered a top barrier, and this is an issue that needs to be addressed sooner rather than later. Security, reliability, and performance are critical to the success of ACCORDION system as they increasingly will be called upon to drive near real-time actions based on real-time analysis of data. In this scenario, the margin for error is slim, and the risk is high. There are concerns from end-users about the ability of a platform to provide these capabilities, particularly in the area of security and risk management.

Edge computing may offer some privacy advantages where personal data can be stored locally and processed or anonymized before being sent for external analysis. This may also allow organizations to better comply with data residency requirements. However, as data collecting devices are increasingly adopted by consumers, it may become more difficult to determine different stakeholders' responsibilities under data protection law and whether they are equipped to comply. Moreover, having central oversight and governance policies in place can help to ensure that local decisions made by edge computers are trustworthy, explainable and can be challenged if necessary. Ensuring that the sensor data feeding into edge computers is authentic and interpreted correctly is also important to maintain confidence in edge decisions.

Another important barrier to adopting an innovative solution such as ACCORDION is education and lack of awareness about new technologies and their benefits. There is simply a lack of knowledge on how to use edge computing and the best applications or use cases. Surprisingly, lack of Executive Management support and clear realization of edge computing benefits acts as barrier to further adoption. This is reinforced by both the distributed level of decisions from executive to middle management and the operational focus of Edge Computing.

Information technologies develop rapidly, and it is difficult to foresee their evolution, which may influence technical design decisions. Acting proactively to stay ahead of the state of the art and deliver a solution that will not sooner than later become obsolete, ACCORDION will be engaged in a continual technology watch effort by monitoring current research in similar projects and safeguard that the development process will comply with all related standards, will be designed to be flexible and that new requirements that may arise will be properly and timely gathered and processed.

5 Means & activities to raise Awareness of ACCORDION

In deliverable 7.1, we introduced tools, material and activities that we will realize within the ACCORDION dissemination and communication plan. In this section, we focus solely on dissemination activities relevant for the scientific community. This includes scientific and general publications (including those currently under submission) as well as organized and attended academic events

5.1 Dissemination and Communication Activities

All publication venues will be carefully selected based on their scientific excellence and impact privileging where possible open access publishing.

5.1.0 Publications

5.1.0.1 CONFERENCE PUBLICATIONS

Conference publications		
Partner	Title	Name of Venue
TID	Analysis of Anomaly detection	ICLR2020
TID	Detecting of differential tracking of online users when they browse Hyper-partisan news websites in USA	ACM WWW 2020
TID	Study of online tracking ecosystem before and after GDPR enforcement	ACM TMA 2020
ICCS	Next Position Prediction using LSTM Neural Networks	ACM SETN 2020
ICCS	Using LSTM Neural Networks as Resource Utilization Predictors: The case of training Deep Learning models on the Edge	GECON 2020
TID	Trade-off between utility of machine learning and privacy offered when differential privacy is applied in the ML pipeline	ACM CCSW 2020

TID	Federated Learning into various environments such as mobile devices, computing nodes, etc	ACM DistributedML 2020
TID	Privacy-preserving Federated Learning with Trusted Execution Environments	ACM Mobisys 2021
TUB	Quality enhancement of gaming content using generative adversarial networks	QoMEX2020
TUB	Assessing Interactive Gaming Quality of Experience Using a Crowdsourcing Approach	QoMEX2020
TUB	Quality estimation models for gaming video streaming services using perceptual video quality dimensions	MMSys2020
TUB	DEMI: Deep Video Quality Estimation Model using Perceptual Video Quality Dimensions	MMSP2020
TUB	A Large-scale Evaluation of the bitstream-based video-quality model ITU-T P.1204.3 on Gaming Content	MMSP2020
TUB	Delay Sensitivity Classification of Cloud Gaming Content	MMVE2020
TUB	Towards the Impact of Gamers Strategy and User Inputs on the Delay Sensitivity of Cloud Games	QoMEX2020
TUB	A latency compensation technique based on game characteristics to mitigate the influence of delay on cloud gaming quality of experience	MMSys2020
TUB	Towards the Influence of Audio Quality on Gaming Quality of Experience	QoMEX2021
TUB	Modeling and Understanding the Quality of Experience of Online Mobile Gaming Services	QoMEX2021

HPE	Inter-operability and Orchestration in Heterogeneous Cloud/Edge Resources: the ACCORDION vision	FRAME: 1st workshop on Flexible Resource and Application Management on the Edge
CNR	Latency Preserving Self-Optimizing Placement at the Edge	FRAME: 1st workshop on Flexible Resource and Application Management on the Edge
CNR	Collaborative visual environments for evidence taking in digital justice: a design concept	FRAME: 1st workshop on Flexible Resource and Application Management on the Edge
TID	Differential Tracking Across Topical Webpages of Indian News Media	ACM Webscience 2021
TID	The Rise and Fall of Fake News sites: A Traffic Analysis	ACM Webscience 2021
TID	User Tracking in the Post-cookie Era: How Websites Bypass GDPR Consent to Track Users	ACM WWW 2021
HUA	Inter-operability and Orchestration in Heterogeneous Cloud/Edge Resources: the ACCORDION vision	FRAME: 1st workshop on Flexible Resource and Application Management on the Edge
ICCS	Predicting Resource Usage in Edge Computing Infrastructures with CNN and a Hybrid Bayesian Particle Swarm Hyper-Parameter Optimization Model	Computing Conference 2021
TID	Hyper-partisan news websites in India and mobile vs. desktop tracking	AAAI ICWSM 2021

OVR	Inter-operability and Orchestration in Heterogeneous Cloud/Edge Resources: the ACCORDION vision	FRAME: 1st workshop on Flexible Resource and Application Management on the Edge
OVR	MAGES 3.0: Tying the knot of medical VR	ACM SIGGRAPH 2020
OVR	Covid-19 – VR Strikes Back: innovative medical VR training	ACM SIGGRAPH 2021
OVR	Scenior: An Immersive Visual Scripting system based on VR Software Design Patterns for Experiential Training	CGI 2020
TID	Analyzing the Real-Time Bidding Ad-protocol and cost that advertisements have to be delivered to users	ACM IMC 2021

5.1.0.2 JOURNAL PUBLICATIONS

Journal publications		
Partner	Title	Name of Venue
TUB	NDNetGaming - Development of a No-Reference Deep CNN for Gaming Video Quality Prediction	Multimedia Tools and Applications, 2020
AALTO	Toward using Reinforcement Learning for trigger selection in Network Slice Mobility,	IEEE JSAC
AALTO	AI-based network-aware Service Function Chain migration in 5G and beyond networks	IEEE TNSM

5.1.0.3 OTHER SCIENTIFIC PUBLICATIONS

Other scientific publications

Partner	Title	Name of Venue
TUB	ITU-T Standardization Activities Targeting Gaming Quality of Experience	ACM SIGMM Records
CNR	ACCORDION: Edge Computing for NextGen Applications	ERCIM News

5.1.1 Scientific events organised

Scientific events organised			
Partner	Place	Event name	Link
TUB	Montreal (Online)	Special Session of Interactive Applications and Games during the QoMEX 2021	https://qomex2021.itec.aau.at/special-session-5/
TUB	Montreal (Online)	TPC meeting main track of QoMEX 2021	https://qomex2021.itec.aau.at/
TUB	Montreal (Online)	TPC meeting short paper track of QoMEX 2021	https://qomex2021.itec.aau.at/
CNR	Stockholm (Online)	FRAME: 1st workshop on Flexible Resource and Application Management on the Edge	https://www.accordion-project.eu/frame2021/
TID	virtual	1st Workshop on Security and Privacy for Mobile AI (MAISP)	https://maisp.gitlab.io/
TID	virtual	1st Workshop on Serverless mobile networking for 6G Communications.	https://www.it.uc3m.es/mbsvless21/

5.1.0 Other events organised

Other events organised			
Partner	Place	Event name	Link
TUB	Berlin (Online)	Girl's Day	https://www.berlin.de/sen/frauen/bildung/girls-day/
HPE	Virtual	ACCORDION presentation to HPE Italy Pointnext Telco team	n/a
TUB	Montreal (online)	Qualinet Cost IC1003	http://qualinet.epfl.ch/
CNR	Online	Pervasive AI Lab Kick-off	n/a

5.1.1 ACCORDION Webinars

ACCORDION Webinars			
Speaker(s)	Month	Webinar name	Link (channel)
Patrizio Dazzi (CNR), Michael Dodis (ORama VR), Zbigniew Ledwon (Orbital Knight), Thomas Loven (Plexus)	March 2021	Introduction to Adaptive Edge/Cloud Compute & Network and NextGen Applications	https://www.youtube.com/channel/UC6YALa5A_nEo1VwyyUPhnDA
Prof. Massimo Villari, University of Messina (Italy)	April 2021	Looking beyond at Cloud Continuum: The Osmotic Computing paradigm	https://www.youtube.com/channel/UC6YALa5A_nEo1VwyyUPhnDA

Felipe Huici (NEC)	May 2021	Unikraft	https://www.youtube.com/channel/UC6YALa5A_nEo1VwyyUPhnDA
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5.1.2 Events attended

Other events (attended)		
Partner	Event name	Link
TUB	ITU SG12 meeting	https://www.itu.int/en/ITU-T/studygroups/2017-2020/12/Pages/default.aspx
TUB	VQEG 2020 meeting	https://www.its.bldrdoc.gov/vqeg/meetings/online-march-9-to-13-2020.aspx
TUB	ITU SG12 meeting	https://www.itu.int/en/ITU-T/studygroups/2017-2020/12/Pages/default.aspx
HUA	AI OpenLab (Eclipse & HUA)	n/a
HUA	H-Cloud: Technical Community Event	https://www.h-cloud.eu/event/h-cloud-technical-community-event/?instance_id=58
CNR	H-Cloud: Technical Community Event	https://www.h-cloud.eu/event/h-cloud-technical-community-event/?instance_id=58
HUA	Standard Performance Evaluation Corporation (SPEC) RG Cloud Working Group	https://research.spec.org/working-groups/rg-cloud.html
TID	Invited talk at Cloud NativeSecurity Day Europe 2021	n/a

CNR	ISTI Day	https://www.isti.cnr.it/en/research/isti-day-2020
CNR	Interview at the Radio (Punto Radio)	https://www.facebook.com/puntoradiofm/videos/4097333250348586

5.1.3 Conferences and workshops attended

Conference (attended)		
Partner	Place	Event name
TUB	Online	QoMEX2020
TUB	Online	MMSys2020
TUB	Online	ICASSP2020
TUB	Online	ICME2020
TUB	Online	QoMEX2021
TID	Online	NeurIPS2020
TID	Online	ICLR2021
TID	Online	WWW 2021
PLEX	Online	XR start up event
OVR	Online	SIGGRAPH 2020
OVR	Online	CGI 2020

CNR	Online	Horizon Cloud Summit 2020
CNR	Online	HPDC 2021

5.1.4 Info Days

ACCORDION wanted to organize a set of info days for the research community, potential technology end-users and the standardization communities. However, all onsite events have been postponed due to the covid-19 situation and have been proposed alternatives like online workshops or webinars. In spite of the existing limitations, ACCORDION started the planning of the organization of an infoday involving a set of research projects that face aspect that are synergistic to ACCORDION ones, that are the following:

- SoBigData++ Research Infrastructure (Research infrastructure)
- TEACHING H2020 RIA (Cyber-physical systems)
- RISE 6G (6G)
- SIFIS-HOME (Cybersecurity)

5.2 Social Media

To ensure the largest possible exposure of the project to a wide audience, and to build a community, different social media and networking tools have been used in the project, including LinkedIn, Facebook and Twitter. Considering the development of the Covid-19 pandemic, this early decision was quite beneficial and publishing on social media platforms has become even more important than anticipated. The project’s YouTube channel captures our three first webinars before summer break. Moreover, social media is considered of major relevance for the project to reach younger scientists who are in an early stage of their career. To improve the search engine ranking, all social media accounts are interconnected with the project website. The success of the social media presence of ACCORDION is continuously checked and evaluated by evaluating the types of comments received.

5.2.5 Twitter

The project is using Twitter as a key tool for communication. The Twitter channel can be accessed via:

https://twitter.com/accordion_h2020

Here, short comments, announcements, news, and other content relevant for a larger audience are shared. The engagement on the project’s Twitter channel is relatively high with 219 current followers. Some global and per month number are shown in Table 3. The goal for the rest of the project is to increase the number of followers with relevant content uploaded to the channel regularly and the number of followers. Furthermore, with the number of project results increasing due to advanced stages of the project implementation, the increase in the number of uploads is also expected.

Table 3 Twitter metrics

Twitter Metrics Per Month				
Month	Impressions	Visits	tweets	Followers
1	0	7	0	1
2	889	34	3	6
3	91	18	0	-1
4	1210	60	3	6
5	289	27	0	3
6	206	29	0	1
7	570	47	0	2
8	476	38	0	0
9	352	35	0	1
10	787	45	2	8
11	5747	151	14	6
12	4432	315	9	7
13	10900	736	21	90
14	17000	763	42	41
15	24700	1550	62	25
16	17200	773	45	10
17	10300	510	24	12
18	6289	805	19	1
Total	101438	5943	244	219

5.2.6 LinkedIn

A business channel on LinkedIn has been created under the following URL:

<https://www.linkedin.com/company/accordion-h2020/>

Here, news, events, and relevant information are shared on a regular basis targeting a professional audience. Similar to the Twitter channel of the project, the LinkedIn one also performs well in terms of engagement with 182 current followers. Some global and per month number are shown in Table 4. Therefore, for the remainder of the project the goal will be to keep on uploading the news regarding the ACCORDION project regularly and increase the number of followers and raise project awareness in general.

Table 4 LinkedIn metrics

LinkedIn Metrics Per Month			
Month	Posts	Impressions	Followers
1	0	0	0
2	1	113	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	1	168	0
11	5	886	0
12	4	539	0
13	10	687	0
14	34	3621	57
15	42	2894	48
16	26	3037	20
17	15	3441	47
18	21	1075	10
Total	159	16461	182

5.2.7 Facebook

A business channel on Facebook has been also created under the following URL:

<https://www.facebook.com/accordion.h2020>

Here, news, events, and relevant information are shared on a regular basis targeting both professional audience and scientific researchers. Like the Twitter and LinkedIn channel of the project, the Facebook channel also performs well in terms of engagement with 288 followers and 285 likes which shows that the news, videos, and other contents uploaded to this platform are mostly reaching the relevant users. Some numbers per month and their total are shown in Table 5. Therefore, for the remainder of the project the goal will be to keep on uploading the news regarding the ACCORDION project regularly and increase the number of followers and raise project awareness in general.

Table 5 Facebook metrics

Facebook Metrics Per Month			
Month	Posts	Impressions	Followers
1	0	0	0
2	0	0	0
3	0	0	0
4	2	281	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	6	244	0
11	17	856	0
12	8	268	0
13	22	609	0
14	66	2702	264
15	91	3325	10

16	76	3274	6
17	43	2426	3
18	35	1281	2
Total	366	15266	285

5.2.8 Youtube

The project’s YouTube channel called ACCORDION project is accessible via:

https://www.youtube.com/channel/UC6YALa5A_nEo1VwyyUPhnDA

The channel has just started showing the first three webinars' videos organized during the first half of the second year. Since the YouTube channel of the project has been used for sharing just the webinars, the goal for the rest of the project is to increase the number of videos and types of content to raise project awareness in general.

5.3 Key Performance Indicators

The following table provides a list of Key Performance Indicators (KPIs), a respective target values for dissemination and communication activities, and the current status.

Table 6 Impact Awareness Metrics and current status.

Impact Awareness Metrics (KPI's)				
	Tool	Target	Success Indicators	Status
Audience				
Online	ACCORDION Website	All	> 5000 access per year > 300 downloads	7642 unique visitors and 184 downloads for the period 9/2020 - 6/2021
	ACCORDION Videos		> 10	3 Webinars
	ACCORDION on Social Media		> 50 tweets/ month	Twitter: 219 followers Approximately 13/month(M1-m10) Approximately 30/month (M11-M18)

				LinkedIn: 182 followers Facebook: 285 likes 285 followers Blogs: 20 Blogposts
	ACCORDION e-newsletters		6 > 1000 recipients	4 55
Non Electronic	Press Echoes (From all over Europe)	All	> 10	3
	Journal Publications (Intl. Referred Journals)	Scientific Community	8	3
	Articles in printed and/or online form in magazines, newspapers etc	All	25	2
Interactive	ACCORDION participation in conferences and other events	Scientific community, vertical industries	> 20	41
	Organization of ACCORDION open events, info days	Scientific community, tech-providers, policy makers	> 2	8
	Co-operation with other initiatives, clusters	Scientific community, Vertical industries, policy makers	> 5	5
	Interaction with standardization groups	Scientific community, policy makers	> 4	7

	Participation in EU commission's consultation and other worldwide regulatory in the field of interest	Scientific community, policy makers	> 4	2
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6 Conclusions

The overall aim of this document has been to provide information on the ACCORDION project's dissemination and exploitation activities implemented throughout the first 18 months of the project. Moreover, a preliminary market analysis has been provided to raise the ACCORDION awareness in general. ACCORDION's communication, dissemination and exploitation plans have been described in D7.1. The tasks of communication, dissemination, and exploitation are of high importance to ACCORDION, as it is recognised that they are crucial elements to increase the impact of the project.

Fortunately, as it is visible from the results of the project so far, most of the activities (i.e., workshops, presentations) as well as the outputs (i.e., white papers, publications) are currently being implemented according to the project. More than 41 papers, 7 contributions to standards, and organization of multiple online scientific events, show the high implication of the project in the dissemination of achieved results.

Therefore, the aim to create synergies with the operational technologies players, communicating with the research community through scientific publications and presentations at scientific conferences and workshops, and communicating with the regulators and standardisation bodies in order to raise awareness of the project results is being successfully implemented. In the second part of the project, the consortium will take special efforts to follow the trends and latest news regarding the pandemic situation and keep on adapting to the changes in due time. For the time being, ACCORDION expects to organize the info days and other physical events provided that enough time remains after the pandemic is over.