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CHARITY
Cloud for Holography and Augmented RealITY

Cloud for Holography and Cross Reality

D5.4: Final report on dissemination, communication and standardisation

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Abstract

This final report is a compilation of dissemination, communication and standardisation activities performed by the CHARITY project consortium during the CHARITY project life cycle.

In the scope of CHARITY dissemination and communication, such activities follow the Communication and Dissemination Strategy defined for the entire project. This strategy has been improved and refined with complementary actions to ensure the accomplishment of the objectives committed by the project consortium.

Document revision history

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v0.2	13/06/2024	Elaboration of content for several sections	Ignacio Salceda (PLEXUS)
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Executive Summary

The CHARITY project aspires to leverage the benefits of intelligent, autonomous orchestration of cloud, edge, and network resources, to create a symbiotic relationship between low and high latency infrastructures that will facilitate the needs of emerging applications.

To maximise the value of the project results, a dedicated Work Package (WP5) defines and supports an impact creation strategy that covers all the tasks and activities needed for this purpose. Such impact can be assessed by the project's innovations, i.e. any result that, by being used, delivers a benefit not only economic but also societal, research, environmental, or educational.

Within the context of WP5, partners are reflecting on how to make society aware of the project and its benefits (**communication**), how to discuss with the scientific community about the project results and collect their feedback (**dissemination, collaboration**) and how to foster industry adoption of its features (**standardization**).

This deliverable reports on the activities conducted in WP5 during the entire life cycle of the project, namely T5.1, T5.2 and T5.4 (activities under T5.3 are gathered in deliverable D5.5). The consortium has actively participated towards its goal throughout the project by creating CHARITY's visual identity and website, the main communication channel used by the project to deliver relevant content to external audiences. In addition, the project's social media accounts on LinkedIn, Twitter and Facebook have been used for promotional purposes and to promote interactions among key target audiences. A CHARITY YouTube channel has also been created to present the progress of the technical development and its results visually. CHARITY project partners have produced different types of communication material (posters, social media banners, newsletters, videos), which have been used at events for increasing project visibility.

Generating impact and disseminating the project's findings and results among research and academic communities have been mainly done through the active development of papers and their posterior presentation and publication at important conferences and in journals. In addition, CHARITY project partners have also participated in external events and have organised events/webinars.

CHARITY project closely monitors standardisation activities and fosters collaboration with standardisation bodies to assist with forming strategies and ensure that the project's objectives are met. CHARITY project partners recognise open-source communities as essential pillars to ensure the sustainability of the project results and uptake by third parties.

This document aims at providing an impact assessment on Communication, Dissemination and Standardisation activities carried out throughout the project, comparing it with the Strategy defined at the beginning of the journey and showing an update on the work done after the issuing of D5.2.

Table of Contents

List of Figures

List of Tables

Abbreviations

3D	Three dimensional
AR	Augmented Reality
E2E	End-to-end
GA	Grant Agreement
IoT	Internet of Things
KPI	Key performance indicator
MEC	Multi-access Edge Computing
NGN	Next-generation Network
QoE	Quality of experience
SEO	Search Engine Optimization
SDN	Software defined network
SME	Small and Medium size enterprise
VNF	Virtual network function
VR	Virtual Reality
WP	Work Package
XaaS	Anything as a service. Most popular terms are SaaS - Software, PaaS - Platform, IaaS - Infrastructure as a service
XR	Extended Reality
ZSM	Zero Touch Network and Service Management

1 Introduction

1.1 Purpose of this document

The WP5 objective is to maximise the project's impact, engage relevant stakeholder groups and provide visibility of the project goals, facilitating the adoption of its results. This deliverable reports the various communication, dissemination and standardization activities that CHARITY partners are conducting and is an update of D5.2. Such activities follow the strategy described in D5.1, to ensure that the project findings and results reach the target audience and influence the relevant community and the relevant standards.

1.2 Rationale of content

The first three sections provide an overview of the communication, dissemination and standardisation activities performed during the entire project life cycle. Then, a section follows where this effort is evaluated in light of the committed key performance indicators (KPI) established in the underlying Grant Agreement. Finally, the final report's conclusions aim at extracting the essence of the presented content.

1.3 Methodology

The deliverable D5.1 (Dissemination and Communication Strategy, M06) defined suitable methods to ensure that the project research and practical outcomes are widely disseminated to the appropriate target audiences. The previously defined approaches have been applied and, whenever needed they were adapted in order to maintain the project on track. It is worth highlighting the following key approaches that were followed in this work package:

- Monthly WP5 meetings to synchronise the partner's efforts in terms of communication, dissemination and standardisation allowing to detect project risks in advance to further design and implement mitigation actions.
- Dedicated *ad-hoc* meetings: whenever it is required (e.g., for event participation, webinar organisation, standardisation activities, etc.) - the partners set up a dedicated online meeting to focus and make progress on specific items. Thanks to the minutes, partners (specially the absentees) can catch up with the discussed topics and provide their view and/or contribution, if needed, off-line.
- Only Office Tool: a common working space allows to share and edit online documents fostering collaboration and reducing administrative overhead making a more efficient use of the available resources.
- Tracker Tool: this tool allows partners to create and manage communication and dissemination items so that Task Leaders and WP leaders can perform a proper follow up of these items.
- Joint weekly meetings, WP2-3-4-5, especially important during this last integration phase of the project, in which interrelated issues across the various WPs can be discussed and solved.

2 Communication and Dissemination activities

Communication and dissemination activities represent an essential effort of the project to raise awareness and maximise the visibility of the project results and progress among industry, key stakeholders potentially interested in adopting the technologies and solutions developed within the CHARITY project, and among a wide range of general audiences to demonstrate the commitment and interest of the European Commission to boost European innovation.

CHARITY project considers an efficient and complementary set of dissemination and communication activities. The first one refers to the public disclosure of the results to various stakeholders such as research peers, industry, potential end-users, policy-makers, standardisation bodies, and others that could adopt and integrate the results in their work. On the other hand, communication activities cover the promotion of the action and results to many audiences, including media and the public to build strong relationships and reach society.

This deliverable presents the report of communication and dissemination activities done by the Consortium partners.

The following sections describe and report the specific activities achieved.

2.1 CHARITY Website (KPI 01)

The project website (https://www.charity-project.eu/) was created on M01 considering various SEO best practices and requirements for enhancing the organic positioning on search engines, such as the monitoring and analysis of keywords, increasing the number of internal and external links, and fulfilling accessibility requirements to offer valuable content to visitors regardless of the type of device they use to visit the website.

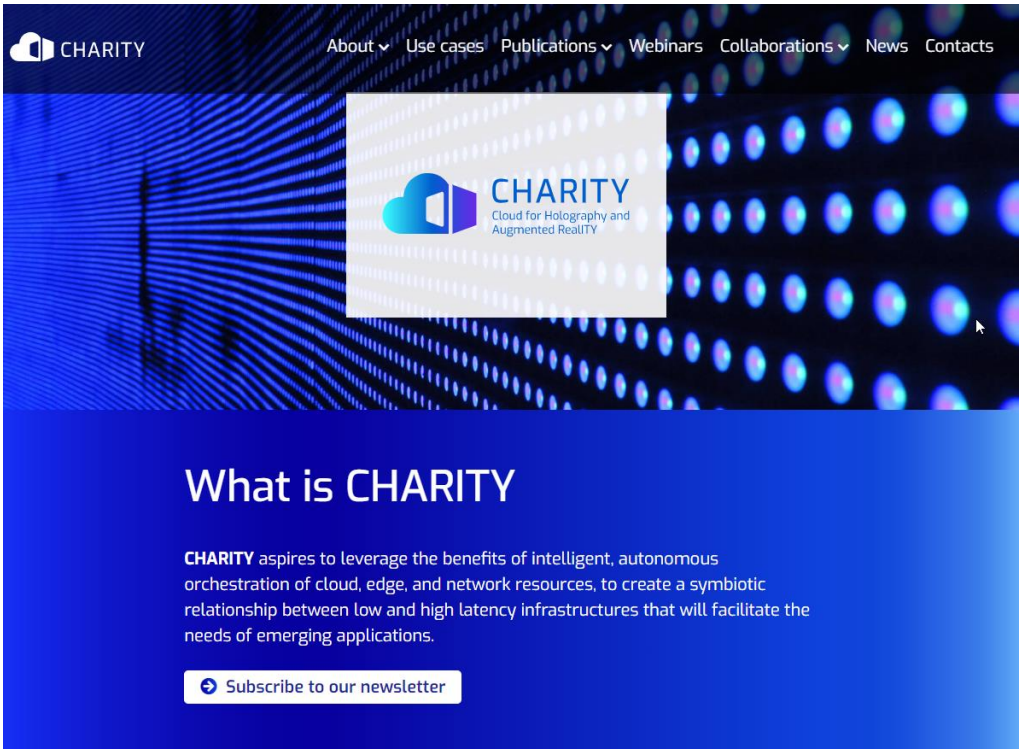


Figure 1: Homepage of http://www.charity-project.eu.

The website is the main communication channel used by the project to communicate with external audiences about motivation, progress, knowledge and various activities aiming to raise awareness and increase the visibility of the project.

All the new content uploaded to the website is highly promoted through the project and partners' social media accounts to maximise the reach, inform followers and interested parties, and then drive traffic to the website where visitors can get more information about a specific topic.

We use Google Analytics to monitor and measure relevant metrics that indicate the traffic of the website to understand if the content provided is well received by visitors. Figure 2 presents data on the number of users, rebound percentage and average duration per visit.

Figure 2: CHARITY project website, Google Analytics data.

According to the data presented, over the last natural year of the project (June 2023 to June 2024), there were 2,100 users who have initiated at least one session of the website. This number is a good indicator that we have met the objective of increasing the visibility of the project and raising awareness about its objectives and expected results.

What is even more impressive is the data regarding user interaction with the website. As a technical innovation project, we realized earlier in the journey that awareness can't be only measured on quantity, but also quality. It is only by reaching the people who are genuinely interested in the project that we would be successful in communicating what the CHARITY project's outcomes are, to the actual people that both care and understand and that can go on and benefit from that knowledge in the future.

Regarding this, we have identified two key indicators that this mission has been successful: event count per user and average session duration. Regarding the first one, we can observe that during the last 12 months, each user has in average created almost 9 events (i.e. interactions such as clicks, scrolls…) in the website. This is a good indicator that users are actively navigating through the website to look for information, and not just staying at the home page and going away.

In terms of the **duration of each session**, the website sits at an impressive average of **2 min 50 s**. To make a comparison, the average in the industry is as low as 52 seconds (**x3,26**), while Google Analytics itself lists a 2-4 min duration as a very good figure. Also, this metric has improved dramatically (**265%)** since the figure we listed in D5.2, which was already above average for an informative website at 1 minute and 4 seconds.

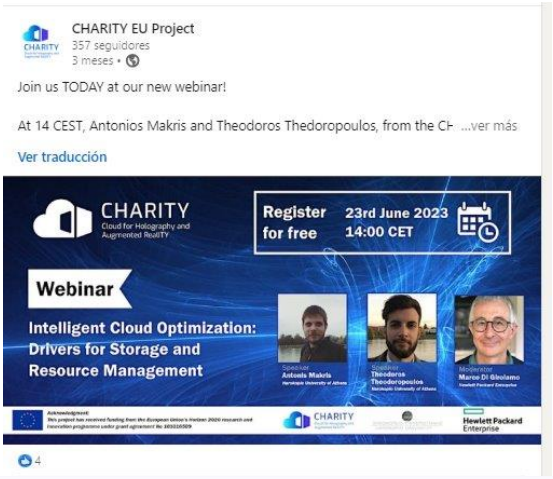
Almost half of the traffic (47.38%) comes from direct search, which means visitors that entered the site address in the browser, accessed through a saved tab, or clicked on a specific link containing the website address. This is a result of the link-building strategy - publications on external websites that are adding information about the project, and with reference to the website. At this stage of the

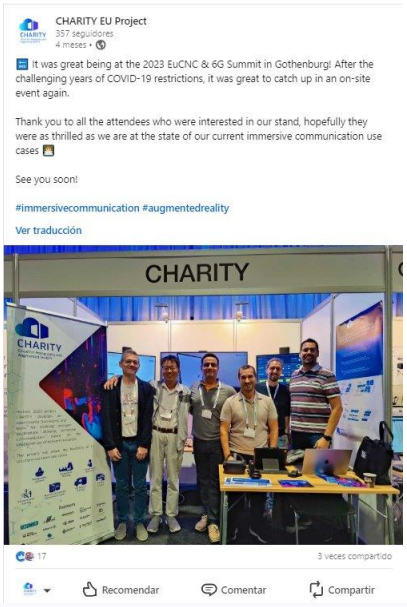
project, this is also due to users acquired in the past through social media, that are already familiar with the address of the website and are now regulars to the site.

The **organic search** (36.38%) is the traffic coming from unpaid search results on search engines such as Google, Yahoo, or Bing. This is directly related to the SEO positioning thanks to the monitoring and use of relevant keywords in the content provided, following accessibility guidelines and having a strong link-building strategy. These is also due to communication collaborations with other important initiatives like EUCloudEdgeIoT, whose website is the number one source of visits after search engines and social media platforms.

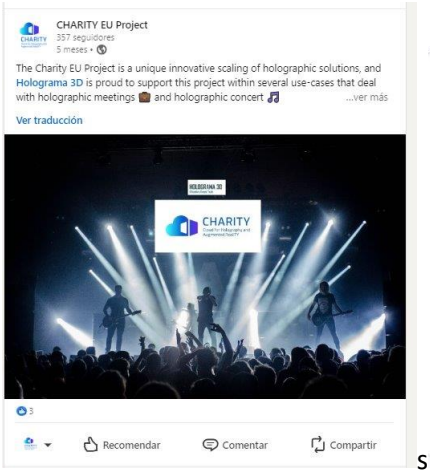
Finally, the **social traffic** (8,6%) reflects that still a good portion of visitors is coming from the publications made on social networks of the project, project partners and 3rd parties, especially on LinkedIn, which is the main platform of interest for interested profiles.

In its interesting to note that there is a clear correlation between social network posting on the project and new visits to the website, clear indicator that there is a community of 'CHARITY followers' already engaged with the evolution of the project, as can be seen in the following examples:




CHARITY EU Project
357 seguidores
4 meses •
It was great being at the 2023 EuCNC & 6G Summit in Gothenburg! After the challenging years of COVID-19 restrictions, it was great to catch up in an on-site event again.
Thank you to all the attendees who were interested in our stand, hopefully they were as thrilled as we are at the state of our current immersive communication use cases
See you soon!
#immersivecommunication #augmentedreality
Ver traducción
CHARITY
17
3 veces compartido
Recomendar
Comentar
Compartir


Users
1.9K
New users
1.8K
Average engagement time
0m 38s
Total revenue
€0.00
50
40
30
20
10
0
Thu 15 Jun
Users 42
01 Jan
01 Feb
01 Mar
01 Apr
01 May
01 Jun
01 Jul
01 Aug
01 Sept
01 Oct


CHARITY EU Project
357 seguidores
5 meses •
The Charity EU Project is a unique innovative scaling of holographic solutions, and Hologrma 3D is proud to support this project within several use-cases that deal with holographic meetings and holographic concert
...ver más
Ver traducción
CHARITY
3
Recomendar
Comentar
Compartir


Users
1.9K
New users
1.8K
Average engagement time
0m 38s
Total revenue
€0.00
50
40
30
20
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Thu 11 May
Users 35
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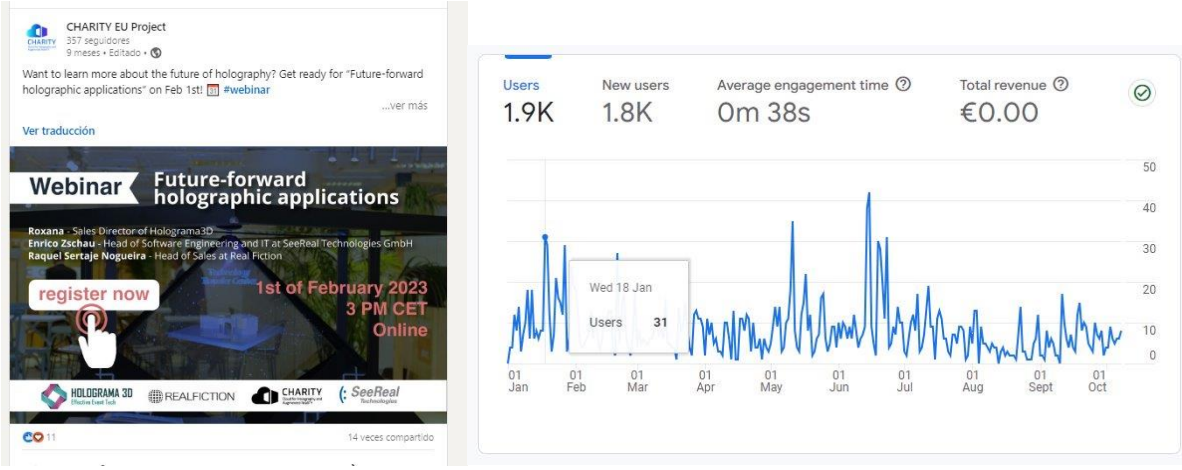


Figure 3: Analytics dashboards showing website users on specific days of social media posting.

It is interesting to see in Figure 4: Users analysis by country for the period of January 2023 to June 2024. that there are visitors from most EU countries and from non-EU countries such as the United States and China. Most of the visits come from countries where a project partner has its headquarters, but there are visits from users based in other EU countries, which means that the content and work done by the project partners is reaching other territories, driving innovation and research activities in the fields addressed by the CHARITY project.

Figure 4: Users analysis by country for the period of January 2023 to June 2024.

2.2 Social Media (KPI 02)

Social media accounts of the project on LinkedIn, Twitter and Facebook have been used to promote and give visibility to advancements and relevant information not only about the CHARITY project but about XR as a whole, leveraging the public interest in these technologies. Efforts have been made to identify related accounts, specifically other H2020 profiles, in order to reach a beneficial return in engagement and interactions among key shared target audiences, always with the goal of boosting the visibility and positioning of the project. Main posts are shared between these three platforms (LinkedIn, Twitter and Facebook), to multiply the reach of each specific update of the project, but each platform has a very different return. Twitter and LinkedIn are the main focuses of the project, while Facebook acts as a mirroring platform.

In addition, a YouTube channel has been set up dedicated to videos produced by the CHARITY consortium.

2.2.1 LinkedIn

CHARITY's company page on LinkedIn (CHARITY EU Project) is an essential part of the communication and dissemination strategy designed and outlined in D5.1 (M06). This social network targets more professional and technical audiences and connects the project with specialized profiles that could be potentially interested in the project results. In this case, what matters are the rates and metrics indicating reactions from followers, which indicate if the content is well received by followers.

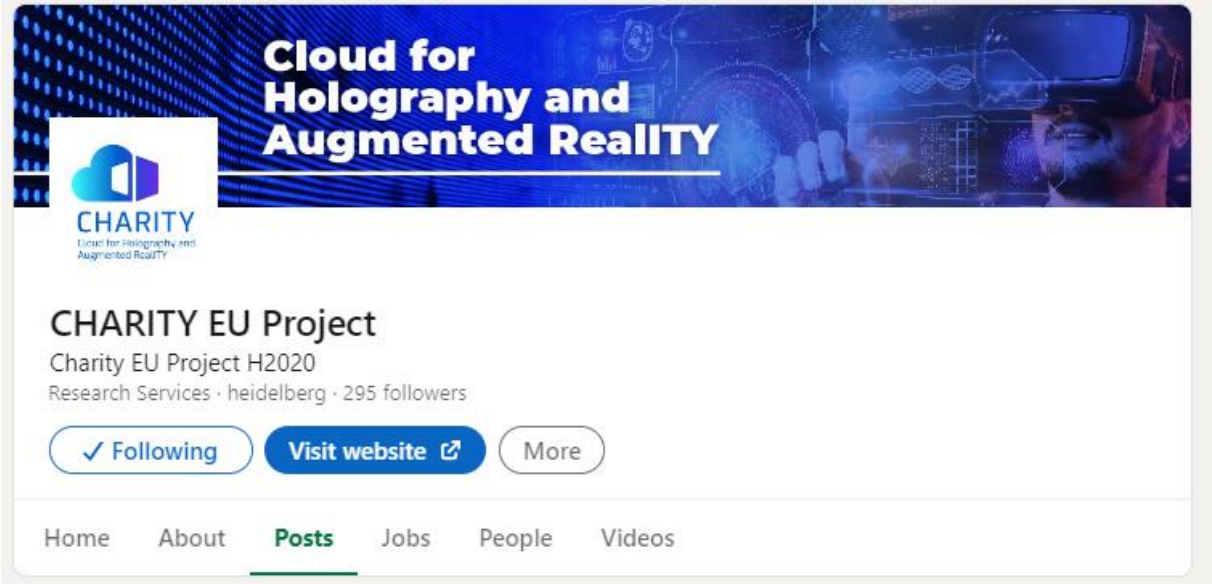


Figure 5: The company page of the CHARITY project partners "CHARITY EU Project".

For this purpose, the engagement rate is the main focus of analysis. The reactions percentage demonstrates that the project partners are providing quality content on LinkedIn that followers and visitors are interacting with. We have had an average engagement rate of 6,7% in the last year, reaching a peak of around 12% which happened around last November. This is a really good indicator that the posts have had meaningful interactions among those already interested in the topics developed in the project, especially when interesting deliverables or pieces of content have been published.

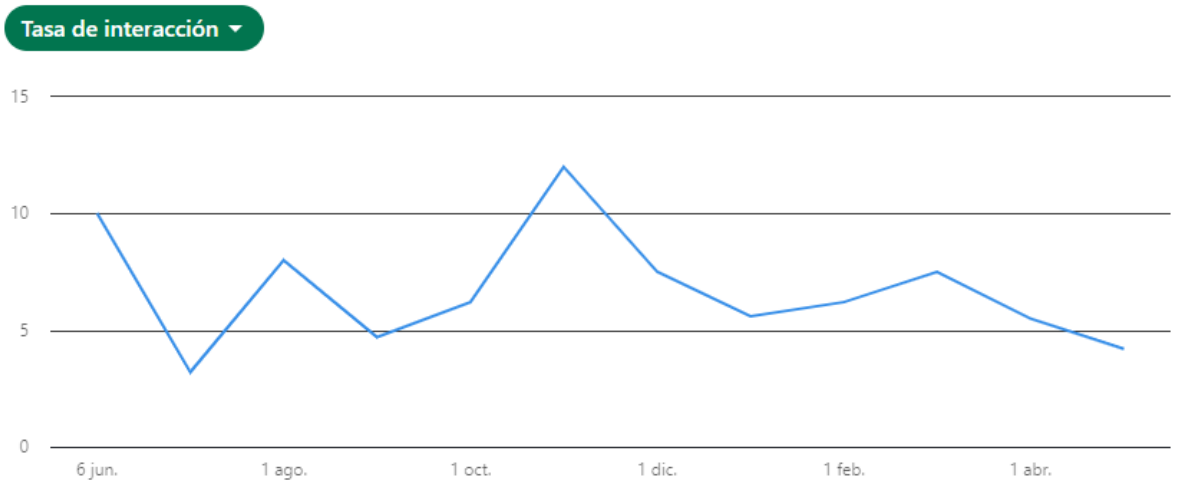


Figure 6: Metrics - Engagement rate of the last 12 months of the CHARITY account on LinkedIn.

This assessment is only evaluating interaction, but we are also interested in where that interaction is coming from. Figure exposes the type of professional profiles is interested in the content provided by the CHARITY project account on LinkedIn. **Around 42% of the audience comes from a technical and engineering background** (Engineering, Research, Education and Information Technology), which can be evaluated as considering the key topics of the CHARITY project. However, as the project has progressed, there is another profile of visitors that has incremented from a business development, marketing or project management background that is also relevant to the project as the CHARITY project reaches its end product.

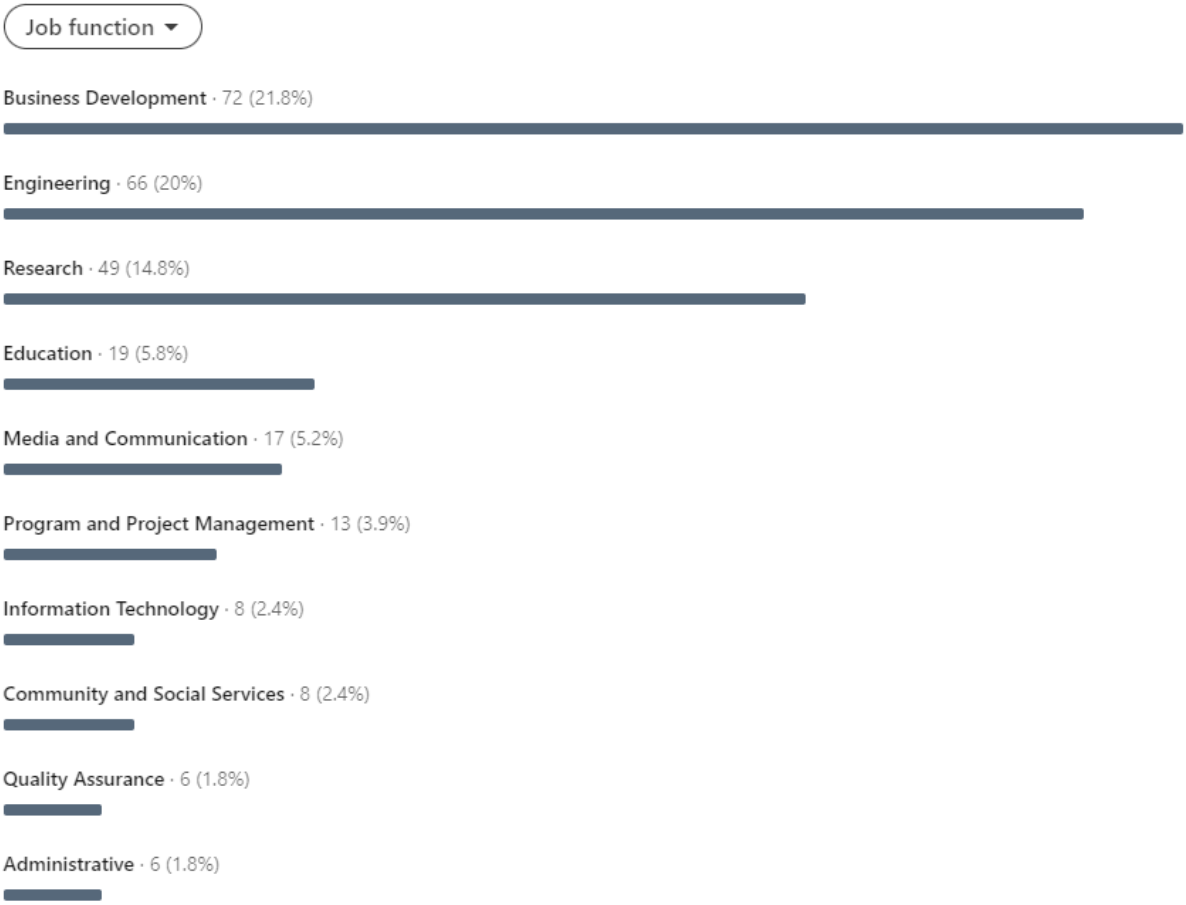


Figure 7: Visitors demographic background of the CHARITY account on LinkedIn.

In general, the performance on this social network has been very good throughout the whole lifecycle of the project. Analytics cites LinkedIn as the #2 website in terms of traffic acquisition for the CHARITY EU project website, with Google Search being the first one. LinkedIn has also helped target a specific qualified audience that ensures a good interaction rate, conversion rate and also helps the interaction with the website.

As shown in Figure 8, it is demonstrated how the account has been getting followers at a steady pace throughout the whole project, expanding its audience while also targeting quality audience in the process. The account is just about to reach 400 followers just at the end of the project journey.

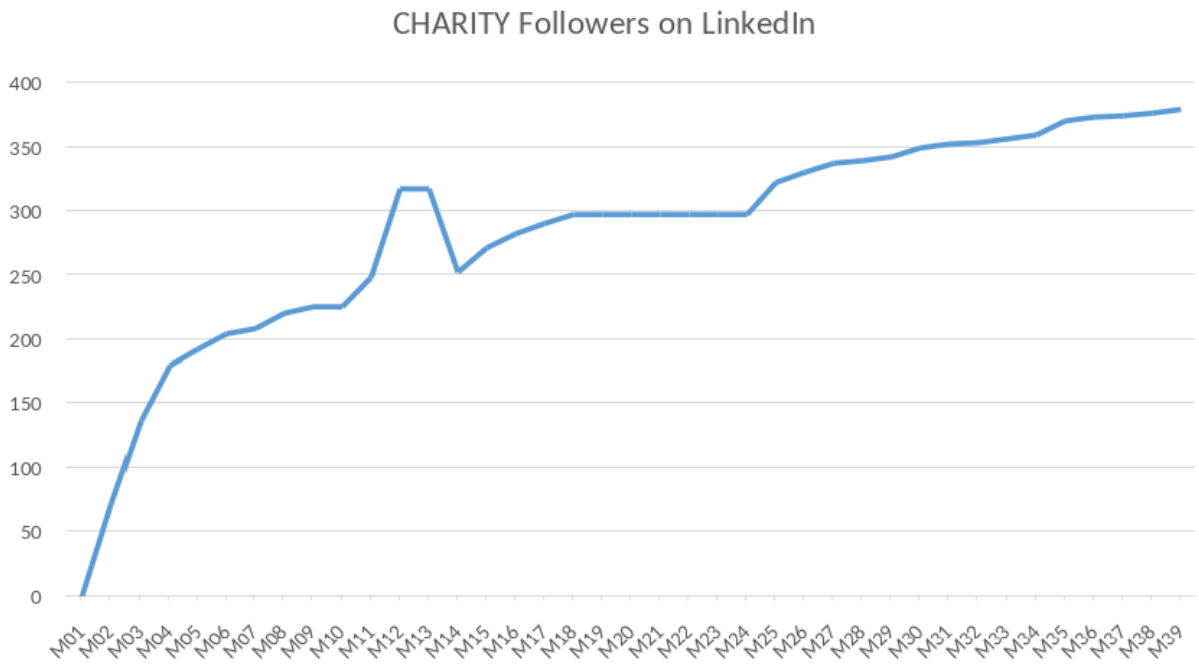


Figure 8: Followers performance of the CHARITY project account on LinkedIn (M01-M39).

2.2.2 Twitter/X

The Twitter/X account (@CHARITYproj) is specifically aimed at interacting and establishing a relationship with other related projects, either interested in XR or part of the H2020 ecosystem.

Content is posted regularly to provide followers with relevant information about topics related to the project. Also, information posted by other accounts is interacted with to generate relation with key accounts while also amplifying the scope of the content offered by CHARITY.

Over the past year, we have successfully fulfilled the objectives we set for our Twitter/X strategy. Here's a summary of our accomplishments:

- We have effectively monitored accounts of events, projects, thought leaders, and organizations that work on similar topics or have shown interest in adopting our project's results. This proactive engagement has expanded our network and increased our visibility.

- Our campaigns have been meticulously planned around specific topics in advance, ensuring a diverse range of content. We have maximized communication opportunities arising from our partners' activities, leading to a dynamic and engaging Twitter feed.

- Our posts shifted to short publications with clear calls-to-action, successfully driving traffic from our social media accounts to our project's website. This strategic approach has significantly increased the number of unique visitors. We have identified which kind of publications were successful in this social network and have adapted accordingly.

Overall, our strategic efforts have paid off, demonstrating the impact of our well-planned and executed Twitter strategy. Figure 9 shows the overall follower performance of the CHARITY project account on Twitter from M13 to M43.

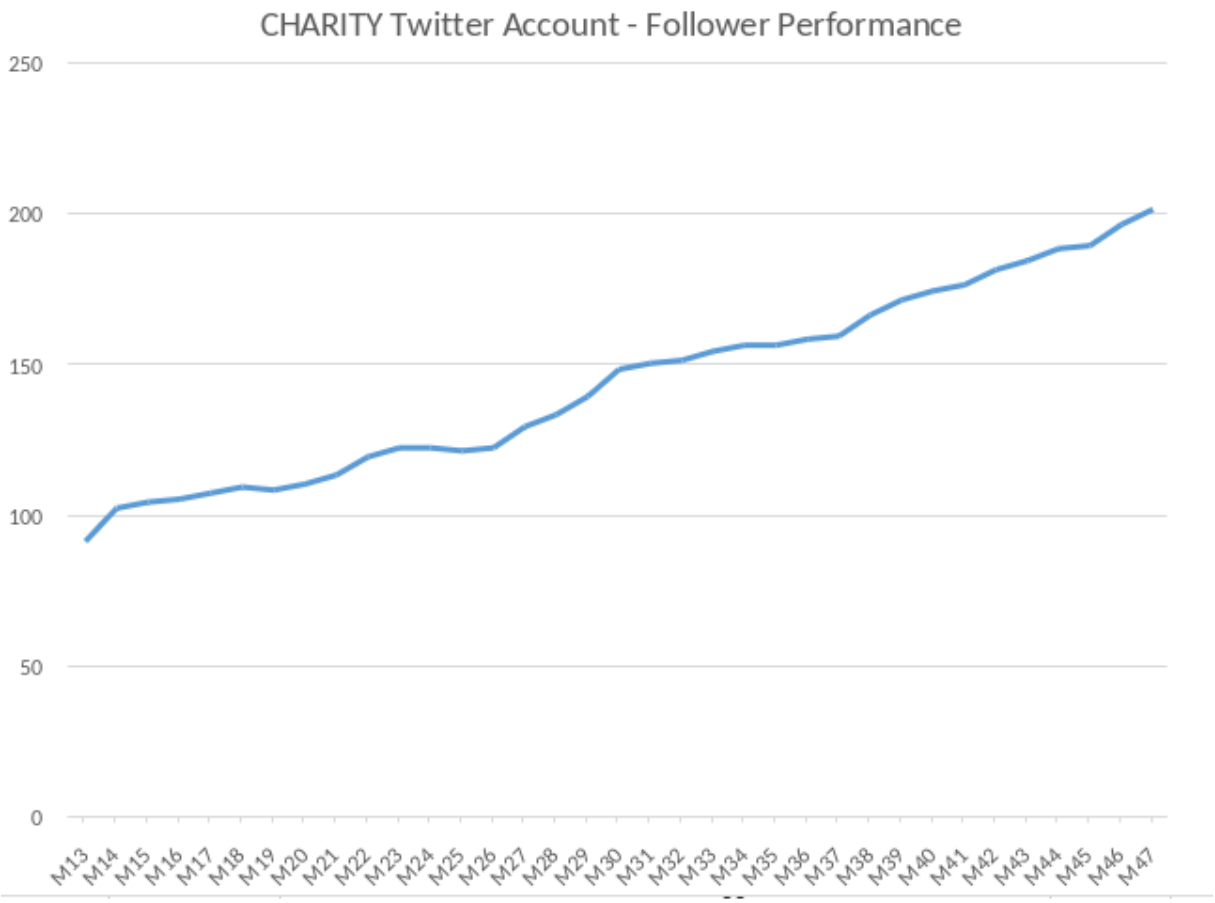


Figure 9: Followers performance of the CHARITY project account on Twitter/X (M13-M47).

2.2.3 Facebook

CHARITY project's Facebook account (@CharityEUProject) has been set-up. While LinkedIn covers the area of professional/technical audience and Twitter has the ability to reach a great amount of projects and relevant people through its platform and algorithm, Facebook targets a wider less informed audience.

Figure 10: CHARITY project's Facebook account @CharityEUProject.

We have identified that, as we developed the use cases and the core content of the project shifted to be more technical, Facebook made less sense than LinkedIn or Twitter for our purpose. Both LinkedIn and Twitter guaranteed us a more loyal audience, and better interaction numbers as the traffic flew to the website, as they were probably more prepared to understand what we were doing at CHARITY.

In spite of this, we can see in Figure 11 that over the last 17 months we have surpassed the 2.2K impression mark on Facebook,

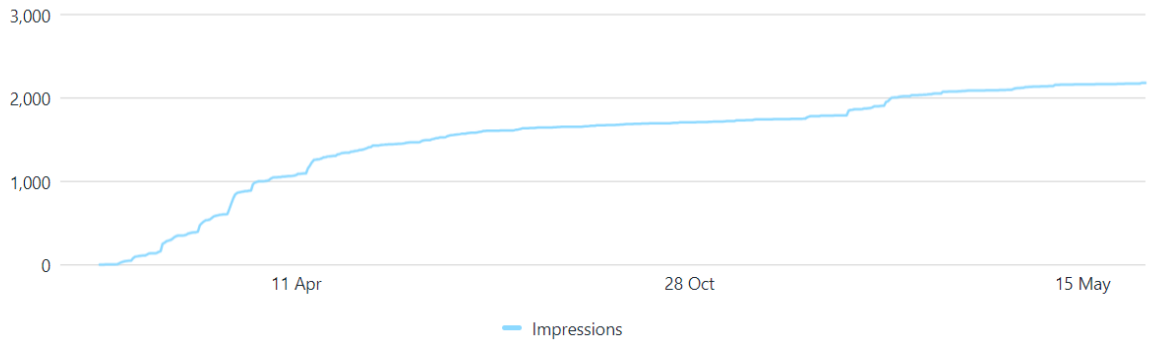


Figure 11: Cumulative impressions of the CHARITY project account on Facebook (January 2023 to May 2024).

2.2.4 YouTube

A YouTube channel dedicated to the CHARITY project was created on M09 to upload different types of videos such as interviews with partners presenting and explaining the project Use Cases and recordings of webinars produced by the project partners to present the progress of the technical development and its results in a visual way. Since the beginning of the project, a lot of the other social media platforms we use have shifted towards more video-related content, which has meant that YouTube has been used less often.

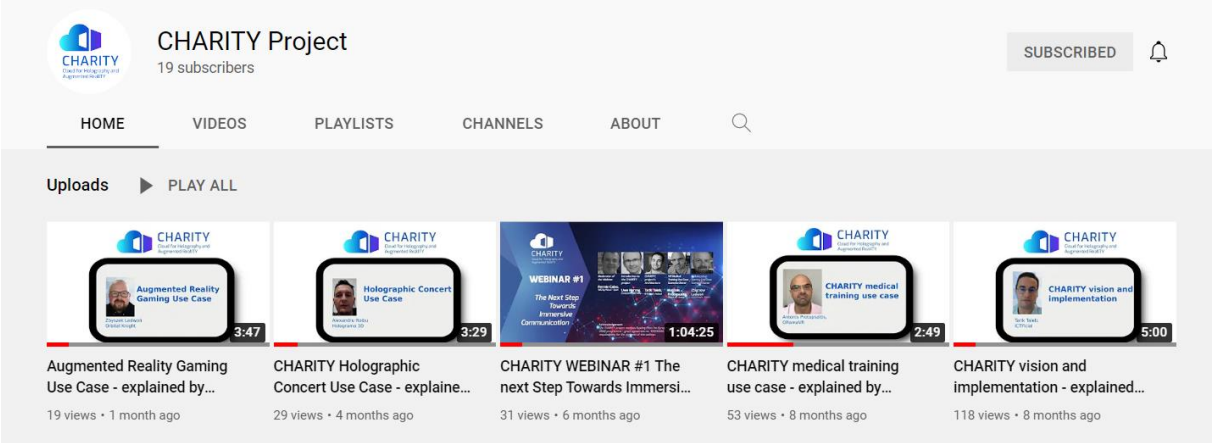


Figure 12: YouTube channel of the CHARITY project.

It is important to notice that this content is quite technical and with longer durations in time than typical clips on social media. Anyhow, 30 subscribers are following the evolution of CHARITY project.

2.3 Communication Materials (KPI 03)

The CHARITY project consortium produced several communication materials about the CHARITY main goals and achievements of the project, such as Newsletters, Posters or Roll-ups. Table 1 presents an overview of such communication materials produced up to M42.

Table 1 - Summary of Communication Materials

Item	Description	Estimated # persons reached
Website	www.charity-project.eu	7.621 visitors[2]
Use-Case Mini sites	https://www.charity-project.eu/en/use-cases	7 UC mini-sites, 665 visitors
Website Blog Posts	Posts on Website about CHARITY Research and Developments (https://www.charity-project.eu/en/blog)	16 blog entries, 427 views[3]
Newsletters	CHARITY Newsletters: (https://www.charity-project.eu/en/newsletters) Contributions to third-party newsletters: (https://www.h-cloud.eu/news/charity-project-towards-achieving-immersive-communication/)	12 newsletters: 29 subscribers[4], 166 views (CHARITY) 506 subscribers (H-Cloud)
Flyer 2	Shaping the future of XR: Innovations in Multi-Domain Orchestration	100 persons
Leaflet	The Next Step Towards Immersive Communication. Creating new business opportunities for the European Industry (https://www.charity-project.eu/en/brochures-flyers).	300 persons
Roll-up	CHARITY Roll-up (https://www.charity-project.eu/en/brochures-flyers)	300 persons
Poster 1	Project Overview (https://www.charity-project.eu/en/brochures-flyers)	200 persons
Poster 2	CHARITY Project Architecture (https://www.charity-project.eu/en/brochures-flyers)	300 persons
Poster 3	CHARITY Use Cases Presentation (https://www.charity-project.eu/en/brochures-flyers)	300 persons
Poster 4	LLO Architecture (https://www.charity-project.eu/en/brochures-flyers)	100 persons

[2] The number of CHARITY website visitors were extracted through Google Analytics.

[3] The website blog post figures encompass the aggregated data for all blog posts.

[4] For the newsletter figures, we considered both the number of subscribed users at the time of release and the total views up to M42.

Poster 5	Recording and replaying psychomotor user actions in VR (SIGGRAPH)(https://doi.org/10.1145/3532719.3543253)	11700 persons
Press Release	CHARITY Press Release (https://www.charity-project.eu/en/news/charity-press-release-march-2021)	3800 followers 55 website views
CHARITY Videos	CHARITY published videos (https://www.youtube.com/@charityproject9759) (https://www.charity-project.eu/en/videos)	175 Website Views, 536 Youtube views[5]
Banner	Banner used in emails and on partner websites	200 views

The communication activities performed over the course of the project are described in more detail in the following sections.

2.3.1 CHARITY Website and Blog

The blog section of the CHARITY project website played a crucial role in fostering engagement and dissemination of CHARITY outcomes among its stakeholders. The CHARITY project used the blog (cf. Figure 12) to raise awareness about important topics and inspire community involvement. Moreover, the blog allows for sharing best practices and innovative solutions (c.f. Figure 13 and 14), thereby contributing to a broader discourse on CHARITY work. The blog complements other communication materials, such as newsletters, social media updates, and official reports, providing a broader narrative. CHARITY has delivered 16 insightful blog entries, collectively attracting 427 views. Such an engagement underscores the blog role in connecting with and informing the community about the project's activities.

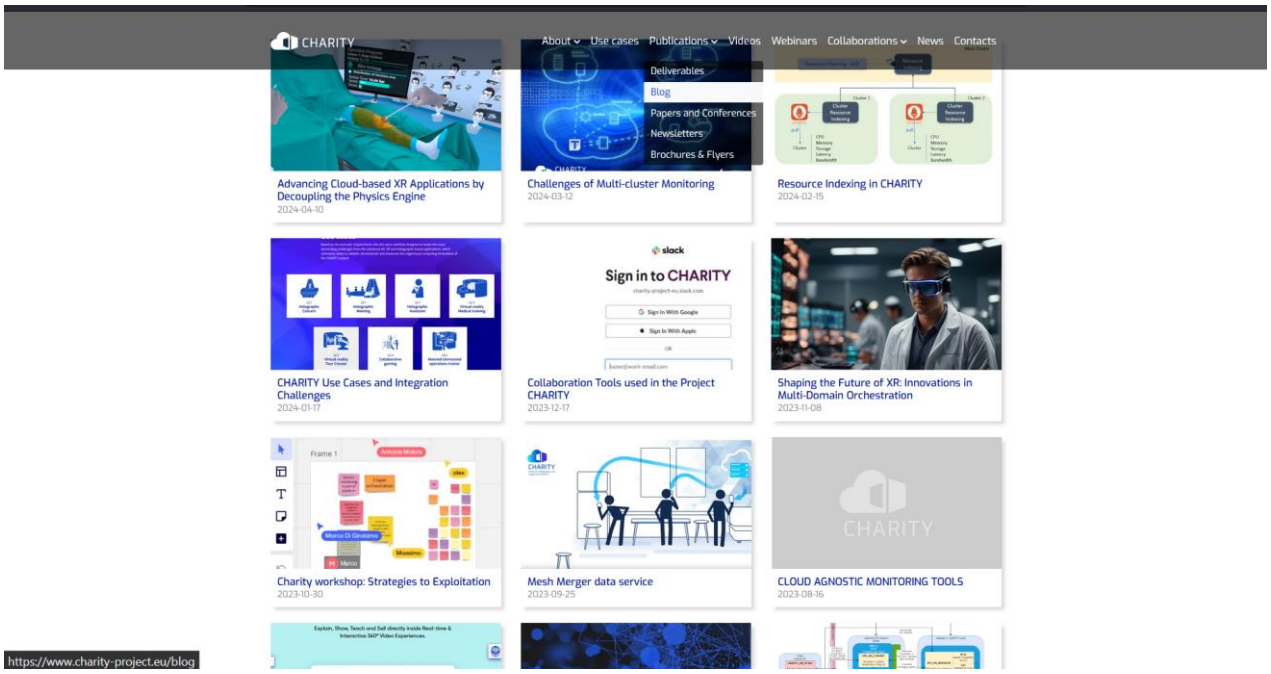
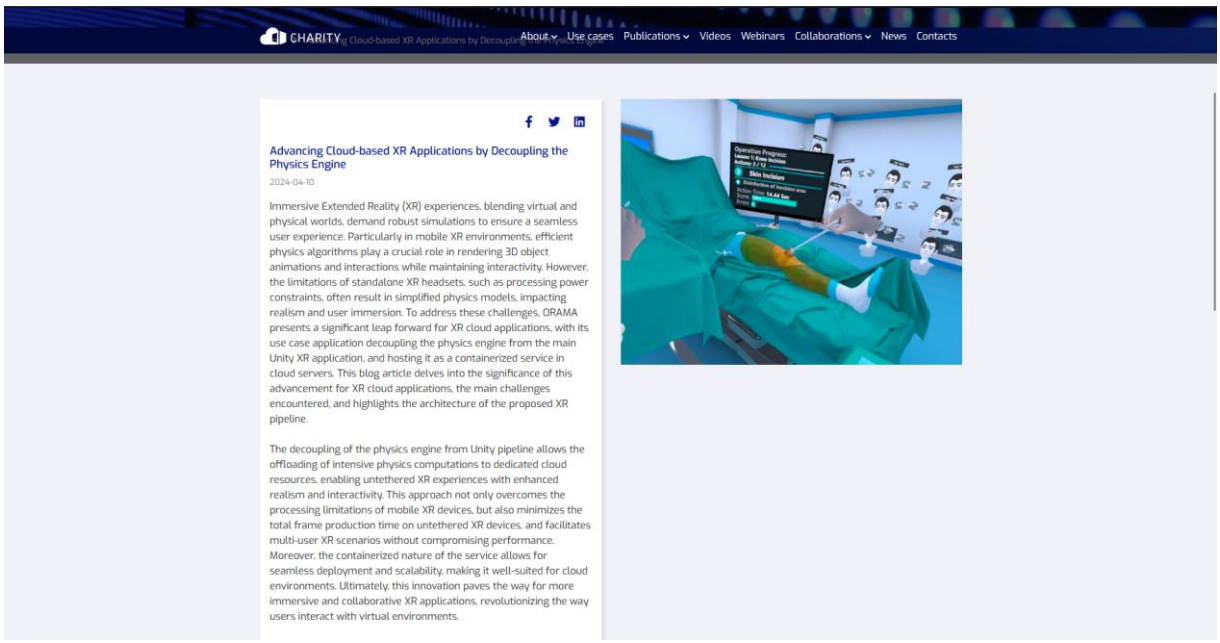


Figure 12 - CHARITY Blog Posts webpage

[5] For the video figures, we considered both the number of views on Youtube and the number of views and the total website views up to M42.



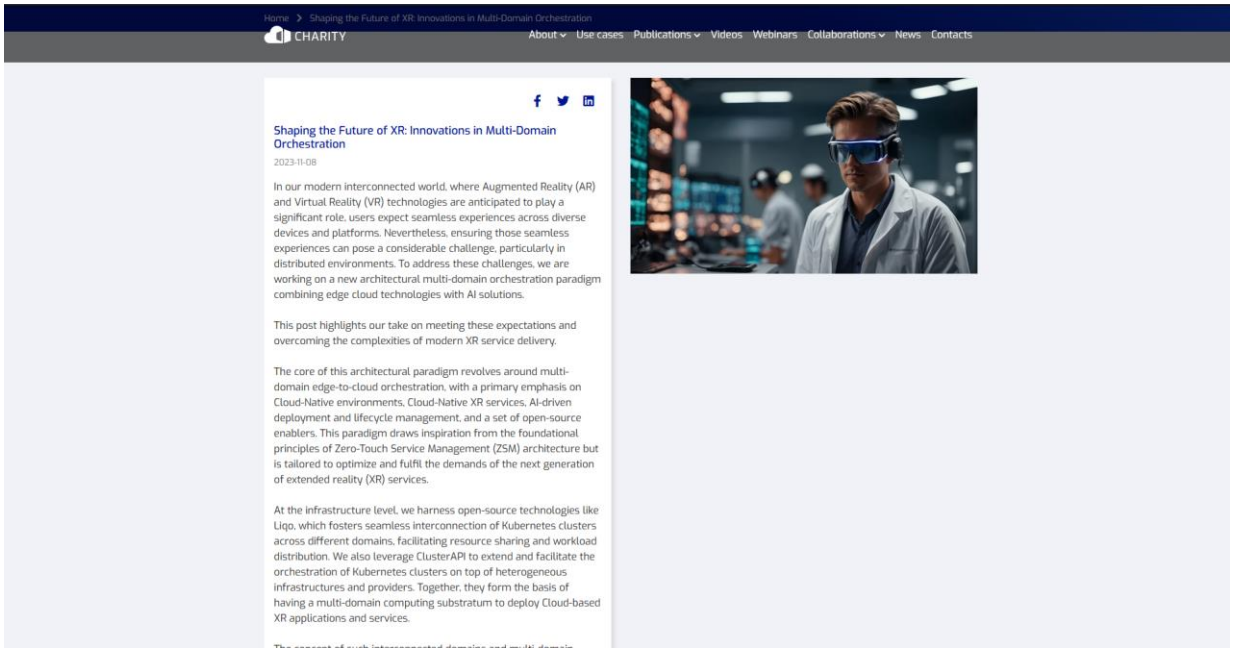


Figure 13 and 14 - Advancing Cloud-based XR Applications by Decoupling the Physics Engine and Shaping the Future of XR: Innovations in Multi-Domain Orchestration

2.3.2 Newsletter releases

The project partners committed to 4 newsletter releases per year. During the course of the project, 11 newsletters were produced along with a contribution to the Horizon Cloud newsletter to bring the total to 12. Newsletters were made available to visitors through the CHARITY website's Newsletter dedicated section presented in Figure 14.

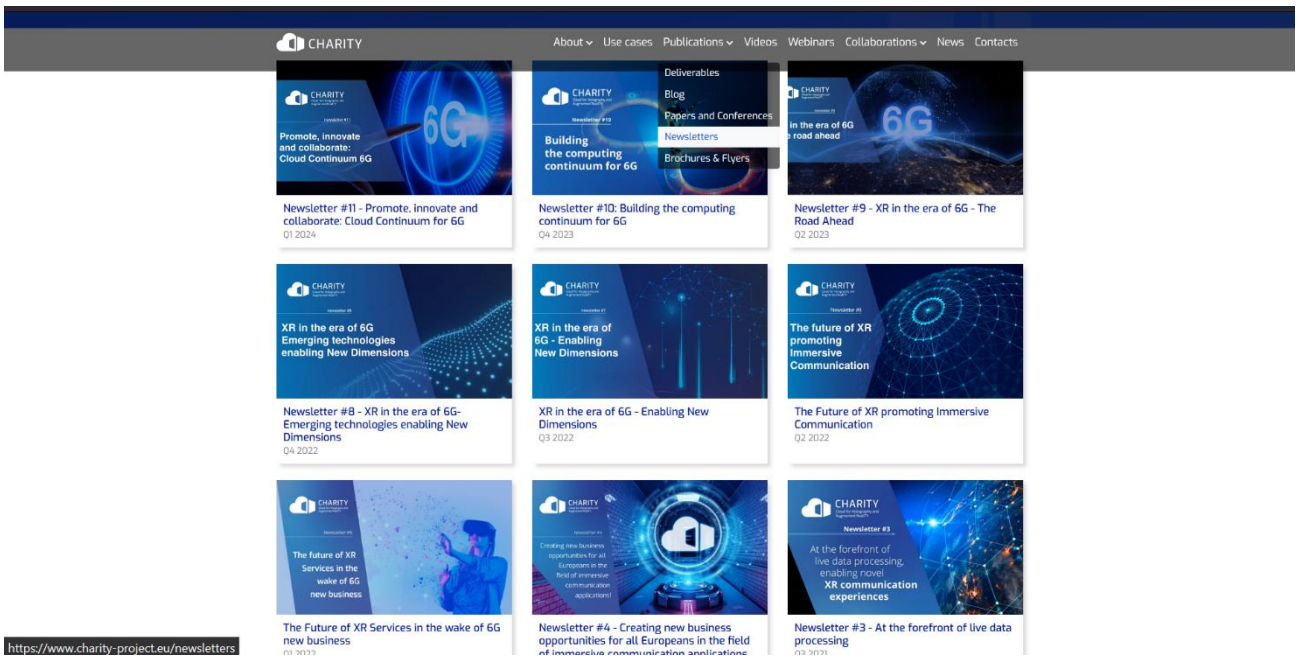


Figure 14: CHARITY project website with dedicated Newsletter section.

Figure 15: Call to action for newsletter subscription.

A call to action on the homepage (Figure 17) and a dedicated site are available for new visitors so they can easily subscribe to the newsletter as well as manage their subscription. Newsletters played a crucial role in maintaining ongoing communication about project events and outcomes, reaching 29 unique subscribers and achieving 166 views.

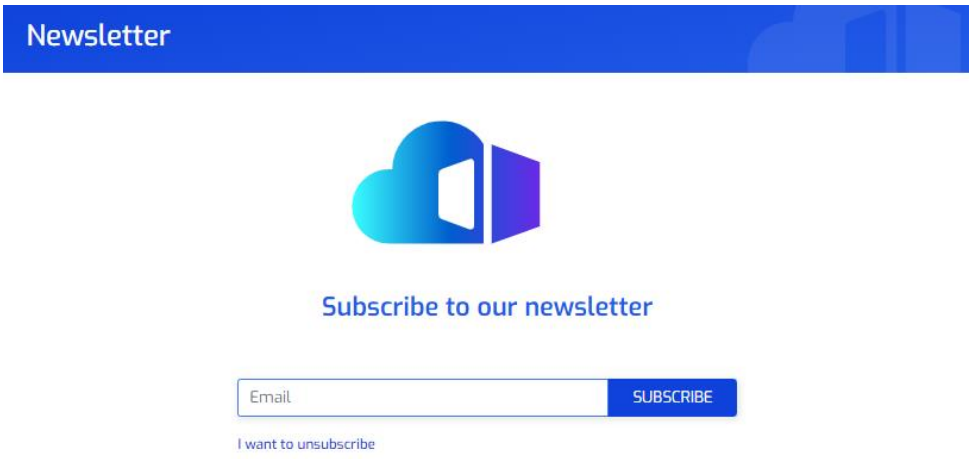


Figure 16: Dedicated site to easy subscription to the newsletter for interested visitors.

Figure 18 and Figure 18 present the H-Cloud newsletter for which CHARITY contributed, reaching additional and broader audience.

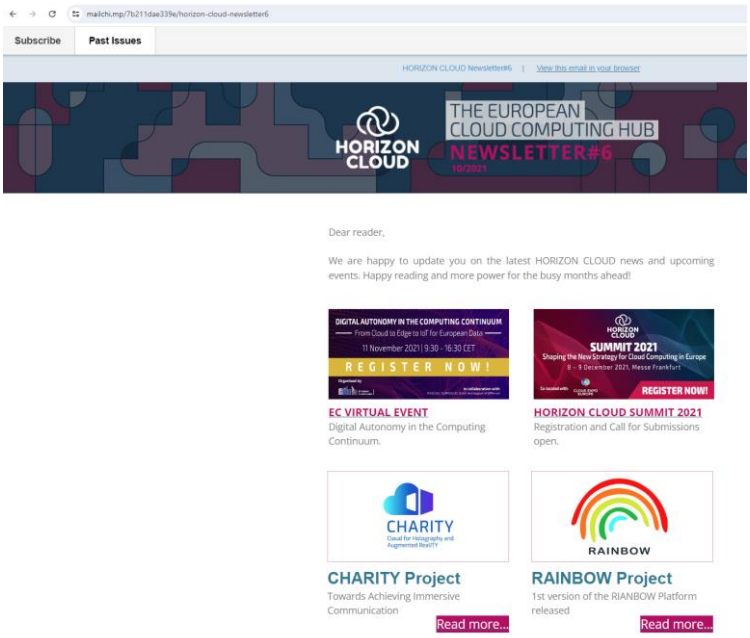


Figure 17 - CHARITY contribution to H-Cloud Newsletter (1/2)

Figure 18 - CHARITY contribution to H-Cloud Newsletter (2/2)

Table 2 provides a detailed breakdown of the KPIs for each newsletter produced.

Table 2 - Newsletter Individual KPIs

Item	Description	Estimated # persons reached
Newsletter #1	The Next Step Towards Immersive Communication (https://www.charity-project.eu/en/newsletters/newsletter1)	7 subscribers 3 Website Views
Newsletter #2	Innovating in the field of next-gen applications (https://www.charity-project.eu/en/newsletters/newsletter2)	11 subscribers 5 Website Views
Newsletter #3	At the forefront of live data processing (https://www.charity-project.eu/en/newsletters/newsletter3)	12 subscribers 33 Website Views
Newsletter #4	Creating new business opportunities for all Europeans in the field of immersive communication applications (https://www.charity-project.eu/en/newsletters/newsletter4)	15 subscribers 3 Website Views

Newsletter #5	The Future of XR Services in the wake of 6G new business (https://www.charity-project.eu/en/newsletters/newsletter5)	17 subscribers 11 Website Views
Newsletter #6	The Future of XR promoting Immersive Communication (https://www.charity-project.eu/en/newsletters/newsletter6)	20 subscribers 12 Website Views
Newsletter #7	XR in the era of 6G - Enabling New Dimensions (https://www.charity-project.eu/en/newsletters/newsletter7)	21 subscribers 12 Website Views
Newsletter #8	XR in the era of 6G-Emerging technologies enabling New Dimensions (https://www.charity-project.eu/en/newsletters/newsletter8)	21 subscribers 25 Website Views
Newsletter #9	XR in the era of 6G - The Road Ahead (https://www.charity-project.eu/en/newsletters/newsletter9)	26 subscribers 15 Website Views
Newsletter #10	Building the computing continuum for 6G (https://www.charity-project.eu/en/newsletters/newsletter10)	28 subscribers 34 Website Views
Newsletter #11	Promote, innovate and collaborate: Cloud Continuum for 6G (https://www.charity-project.eu/en/newsletters/newsletter11)	29 subscribers 16 Website Views
H-CLOUD Newsletter contribution	H-CLOUD Newsletter contribution, October 2021 release https://www.h-cloud.eu/news/charity-project-towards-achieving-immersive-communication/	506 subscribers

2.3.3 Press release

A press release was published during the first months of the project life cycle at a consortium level in order to present the project to the community and start creating awareness about the potential results which can arise from the research activities to be conducted by the project partners in the scope of the CHARITY project.

This press release was sent to several media by each partner. The press release was published on the Cluster TIC Galicia website as news item. This organisation is followed by more than 3.800 followers (only on LinkedIn) by the time of the release. In addition, this content was made available on the CHARITY website (News section) and published on all project social media accounts.

2.3.4 Posters and Leaflets

2.3.4.1 Poster 1 (Project Presentation)

Figure 19: Poster 1 of the CHARITY project - General Project presentation.

A concise project presentation depicted on a poster is a visual aid to use while the work is being presented and a way to guide the audience through the project.

This poster is available on the project website for download and can be used any time by the partners for presentation on on-site events or sent as promotional material via online channels.

At the beginning of the project this poster was used several times to underline social media content.

As shown in Figure 19 several sections are available on the poster:

- Project Logo
- Image that communicates the idea of immersive communication using headsets
- EC logo
- Consortium presentation
- Partner logos
- Links to online website and accounts
- EC acknowledgement

2.3.4.2 Poster 2 (CHARITY project architecture)

The CHARITY platform has its basis on the innovative CHARITY architecture, whose 5 layers are explained in this dedicated poster.

This poster is available on the project website for download and can be used any time by the partners for presentation at on-site events or sent as promotional material via online channels.

Figure 20 Poster 1 of the CHARITY architecture

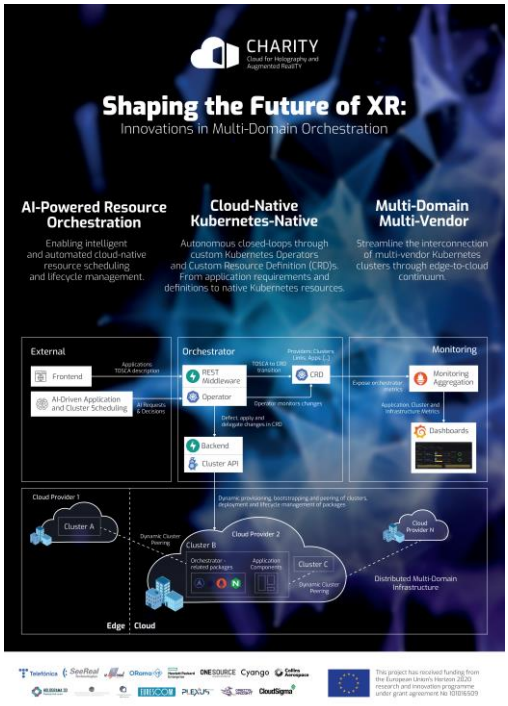
2.3.4.3 Poster 3 (CHARITY Use Cases Presentation)

The presentation of the Use Cases of the CHARITY project can be seen in the Poster 3 (Figure XX). The poster delineates four distinct use cases specific to the fields of Augmented Reality (AR), Virtual Reality (VR) and Holography. This poster is [available on the project website](#) for download.

Figure 21: Poster 1 of the CHARITY architecture

2.3.4.4 Poster 4 (LLO Architecture Poster)

Through a joint effort, OneSource and ICT-FI, the partners responsible for the Low-level orchestrator, which is a core component of the CHARITY framework, designed a poster focused on the architecture and underlying technical aspects of the Low-level orchestrator. This poster was showcased in **EUCnC & 6G Summit 2024** and is [available to download in the project's website](#).



As shown in Figure 22 several sections are available on the poster:

- Project Logo
- 3 Bullet Texts highlighting features and focus of CHARITY platform
- Image representing the LLO Architecture and other relevant CHARITY components
- EC logo
- Consortium presentation
- Partner logos
- EC acknowledgement

Figure 22 - Poster 3 - LLO Architecture

2.3.4.5 Poster 5 (Recording and replaying psychomotor user actions in VR)

The poster titled "Novel Recording of Low-Dimensional UX Data in VR Allows Immersive Full Session Replay from Any Perspective and Point in Time," presented by Manos Kamarianakis at SIGGRAPH 2022 (c.f. 25, https://doi.org/10.1145/3532719.3543253), showcases an innovative approach for recording and replaying psychomotor user actions in virtual reality (VR). This method, developed by the FORTH Institute of Computer Science in collaboration with ORAMAVR, enables the capture and playback of VR sessions, allowing novices to learn VR operations effectively and evaluators to assess learning outcomes. This poster also references related works that enhance VR learning through similar methodologies, further establishing the significance and innovation of this research.

Figure 23 - Poster 5 - Recording and replaying psychomotor user actions in VR

2.3.4.6 Flyer 1 - Project Overview Leaflet

The project Flyer and Leaflet (Figure 26) are available for download on the project website. These communication items can be used by partners to introduce the project briefly to other interested parties (online and off-line). They are used on several social media posts to raise awareness about the project.

Figure 24: Project Flyer available for download on the project website.

2.3.4.7 Flyer 2 – Low Level Orchestrator (LLO)

An additional flyer (Figure 27) was designed by OneSource and ICT-FI, featuring the Low Level Orchestrator (LLO) as part of CHARITY framework. This flyer was used as a communication material at **EuCNC & 6G Summit 2024** to allow a thoughtful discussion of LLO technical details, including the integration with AI-algorithms, the Cloud and Kubernetes-nativeness and the multi-domain orchestration aspects. The leaflet is available for download on the project's website.

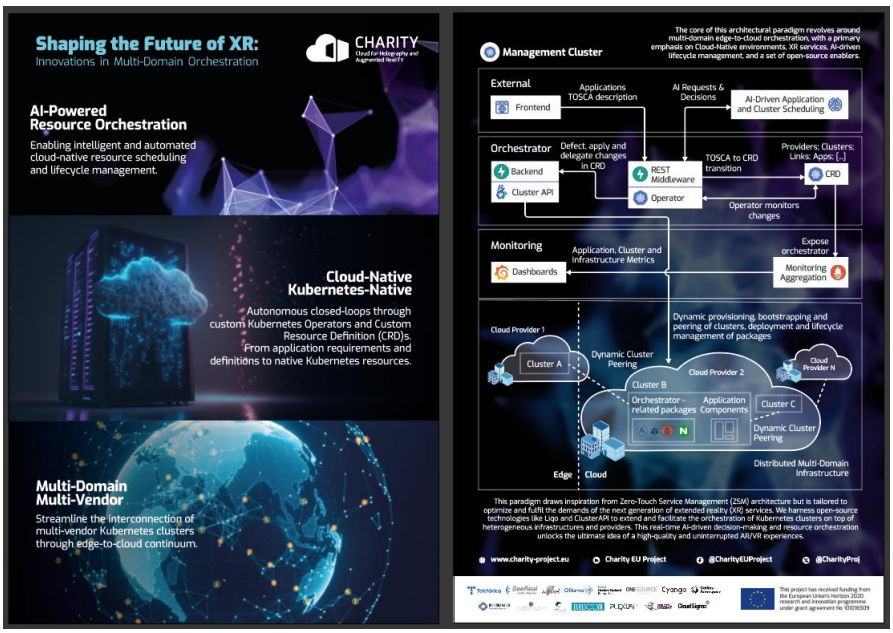


Figure 25 Flyer 2 - Low Level Orchestrator (LLO)

2.3.4.8 Roll-up

Figure 26 - Project Roll-up

The project partners designed a roll-up to be used on events which is [available for download on the project website](). This advertising displays are composed of a canvas, on which the design is printed, which is rolled up at the base of the structure. They are self-sustaining objects, which means that thanks to their structure they remain upright and stable without the need for any other accessory. They are a very versatile and functional advertising tool for any type of event or fair due to their easy transport and assembly. They have a great power in attracting attention of visitors.

As shown in Figure 28 several sections are available on the roll-up:

- Project Logo
- Image whose main objective is to reflect the idea of immersive communication
- Summary of the planned project outcome and its goal
- Use Case icons
- Partner logos
- EC funding acknowledgement

This roll-up provides a high-level overview of CHARITY project vision, use cases and partners. It was produced for the EuCNC & 6G Summit (Grenoble, France) which took place on June 2022.

2.3.5 Partner Interviews, Webinars and additional videos

Several interviews have been conducted to present different aspects and areas of the CHARITY project during the project:

- CHARITY vision and implementation - explained by Tarik Taleb
- CHARITY medical training use case - explained by Antonis Protopsaltis
- Holographic Concert Use Case - explained by Alex Roibu (Holo3D)
- Augmented Reality Gaming Use Case - explained by Zbyszek Ledwon (ORBK)

The interviews embedded in the project website as news items and available on the project Youtube channel (cf. Figure 27 and Figure 28).

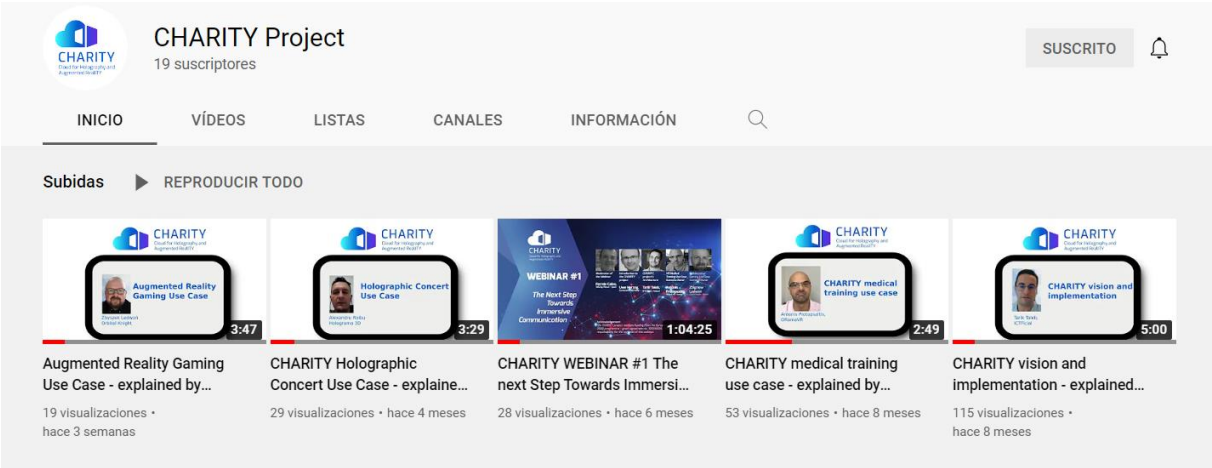


Figure 27: YouTube channel with interviews of CHARITY project partners.

Moreover, since COVID-19 restrictions we also strengthened our dissemination and communication strategy by focusing on webinars in addition to local workshops. Section 2.5 details the performed webinars. Webinars are conceived not only for real-time interaction with the audience but also for continued engagement through post-webinar follow-ups and discussions.

Furthermore, we published additional informative videos demonstrating the CHARITY concept and capabilities (cf. *Figure 28*, *Table 3*), including a video for explaining the notion of multi-cluster distribution and connectivity and service migration.

Table 3 - CHARITY Interviews and additional videos

Item	Description	Estimated # persons reached
CHARITY Video	Virtual Tour UC Overview (https://www.youtube.com/watch?v=RhhP-slWIB4)	30 views[6]
CHARITY Video	Multi-Cluster Connectivity (https://youtu.be/7OSafcaBx4Y)	32 views
CHARITY Video	Multi-Cluster Service Migration (https://youtu.be/JIwpicwLoLs)	44 views

[6] The video views were extracted from Youtube analytics.

CHARITY Video	Mesh Merger component initial version demonstration (https://www.youtube.com/watch?v=1WlJjOyM7EU)	17 views
CHARITY Interviews	Augmented Reality Gaming Use Case - explained by Zbyszek Ledwoń (https://youtu.be/m_ohJvrH5BE)	28 views
CHARITY Interviews	CHARITY Holographic Concert Use Case - explained by Alexandru Roibu (https://youtu.be/-Z5U4wGCLo0)	50 views
CHARITY Interviews	CHARITY vision and implementation - explained by Tarik Taleb	188 views
CHARITY Interviews	CHARITY medical training use case - explained by Antonis Protopsaltis	75 views

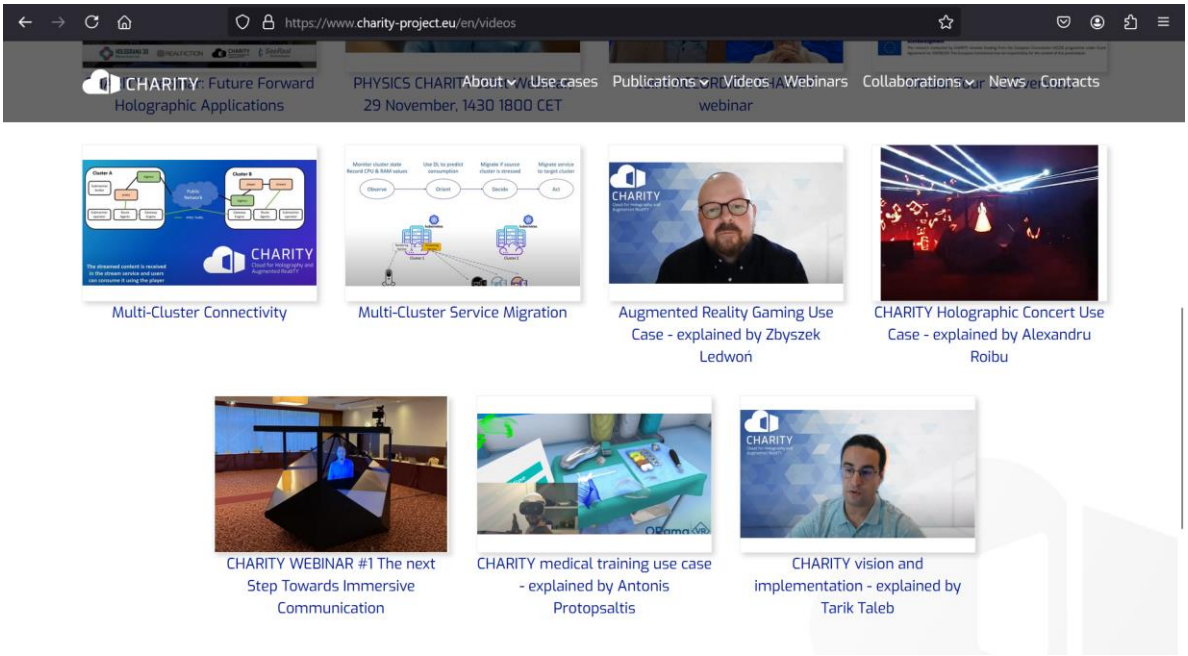


Figure 28 - CHARITY Videos

2.3.6 Banner

A project's brand represents who it is and what it does. After all, it goes far more than just a logo or graphic element. Therefore, it is essential for branding to be used and displayed correctly in every possible medium, including corporate email. Corporate email is often a medium where branding goes amiss, despite being the most common business communication method. Consistent branding is important. This is from your project logo to the colour palette and font size. Standing out from the crowd is critical in today's marketplace, particularly over email. In the context of email, CHARITY project identity needs to stand out in crowded inboxes to have any impact. An email that conforms to a project's brand guidelines has a much higher chance of doing so.

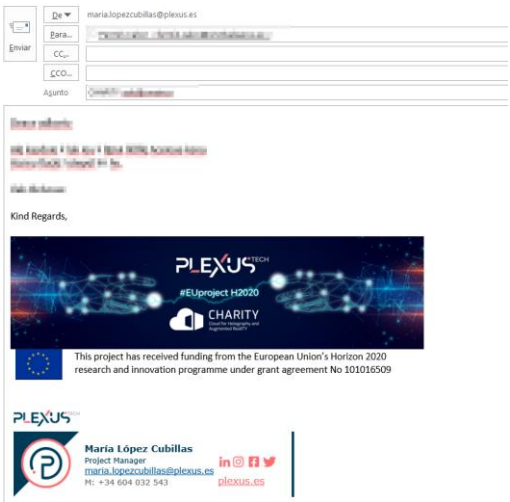


Figure 29: Banner to be used within email exchanges with externals.

A consistent and clear identity lets externals know what to expect when they interact with CHARITY project partners. There is no uncertainty, which is key. Branded email signatures create a sense of trust. If the recipient of an email recognizes a brand, they're more likely to reply or engage. Figure 29 showsFigure 29: Banner to be used within email exchanges with externals. an example of how the project banner is being used for email exchanges with external recipients.

In addition, and whenever the company policy allows it, project partners use the banner within their website to promote the CHARITY project. Figure 30 shows the banner within ORBK's website.

Figure 30: Banner used in partner website to promote the CHARITY project.

2.4 Participation on 3rd party events (KPI 04)

The participation in third party events which may be co-located within bigger and renowned venues has contributed to raising awareness of the project, increasing visibility of the work that is being done and to potentially engage with key stakeholders. The latter is a key benefit that so far, we haven't had the chance to experience at its fullest since most of the events where the project has been presented had been online.

Online events are great in terms of reaching a wide audience located anywhere in the world, while physical events have only limited number of attendees. Moreover, the availability of the recording of the sessions allows the project to reuse these contents to promote them on the website and social media channels and increase the impact and reach after the participation of the event. However, online events don't foster great engagement as people are more used to joining them to receive a talk on a specific topic, rather than connecting to establish meaningful connections on virtual booths. For this purpose, CHARITY project aims at promoting its participation in physical events whenever it is possible to foster new and relevant connections with participants and attendees that could be beneficial for the dissemination of the project's results.

The following tables present a list of **36 events where CHARITY project partners participated during the course of the project, reaching over 16700 persons (estimated[7]**) of different role and background such as researchers, academics, industry, standardisation body, among others. Participation and format have varied from presentations, invited talks, booth, demo sessions, etc. All events have been uploaded to the website as news items and highly promoted on social media channels.

[7] This figure was calculated based on the sum of the estimated reached persons of Y1, Y2, Y3 and Y4.

During the first year of the project life cycle (until M12) CHARITY project partners participated in the events shown in Table 4.

Table 4 - Event participation along Y1.

#Y	Event Name	Venue	Date	Type of Participation	Description	Estimated # of persons reached[8]	Link
Y1	XR Start-Up Connect: European Kick-Off	online	30/03/2021	Presentation	Yago Rozas (PLEXUS) presented in a keynote the relationship between edge computing and the XR environment.	38	https://www.vdc-fellbach.de/termine/2021/03/30/xr-start-up-connect-european-kick-off/
Y1	Web Summit Lisbon 2021	Lisbon, Portugal	01/11/2021	Booth	Joao Ferreira and Ariaan Spronk (DOTES) presented their use case on a booth.	70	https://websummit.com/
Y1	IEEE International Conference on Cloud (Cloud Net 2021)	online	08/11/2021 - 10/11/2021	Presentation	Antonis Makris (HUA) presented a joint paper ("Cloud for Holography and Augmented Reality").	25	https://cloudnet2021.ieee-cloudnet.org/
Y1	ISTI Day	Pisa, Italy	16/11/2021	Presentation	Massimiliano Corsini (CNR) presented the CHARITY project.	100	https://www.isti.cnr.it/en/research/isti-day-2021
Y1	International Symposium on 6G Networking 2021 (6G Net 2021)	Lisbon, Portugal	22/11/2021	Invited Talk	Luis Cordeiro (ONE) presented in the future of XR Services, their upcoming network and	30	http://6g-net.org/

[8] The number of people reached at each event was estimated by the participants of the event.

					computing challenges and the role of 6G in addressing them.		
Y1	Conference on emerging Networking EXperiments and Technologies (CoNEXT)	online	01/12/2021 - 03/12/2021	Presentation	Aravindh Raman (TID) presented paper "Exploring content moderation in the decentralised web: the pleroma case"	50	https://www.sigcomm.org/events/conext-conference
Y1	Horizon Cloud Summit 2021	online	09/12/2021	Presentation	CHARITY's Holographic Assistant Use Case presented by Uwe Herzog, Project Coordinator, in section "Success Stories and Use Cases from the European Cloud Community"	60	https://www.h-cloud.eu/event/horizon-cloud-summit-2021/

During the second year (M13-M24) CHARITY project partners participated in the events shown in Table 5:

Table 5 - Event participation along Y2

#Y	Event Name	Venue	Date	Type of Participation	Description	Estimated # of persons reached	Link
Y2	7th International XR Conference	Lisbon, Portugal	28/04/2022	Keynote presentation	Joao Rodrigues (DOTES) presented Cyango and the role of CHARITY project	30	https://arvrconference.wixsite.com/arvrconference
Y2	ARETE & iv4XR workshop: Second workshop on the future of XR: Current ecosystem and upcoming opportunities	online	11/05/2022	Presentation	Fermin Calvo (PLEXUS/SM2) presented the highlights of the project developments.	20	n/a

Y2	EXPO Dubai 2020	Dubai, United Arab Emirates	22/02/2022	Presentation	George Papagiannakis (ORAMA) presented “Let's Accelerate World's Transition to Medical VR Training”	100	https://www.expo2020dubai.com/en
Y2	European Conference on Networks and Communications (EuCNC) and the 6G Summit	Grenoble, France	07/06/2022 - 10/06/2022	Booth Poster Roll up Video presentation	Adriaan Sponk (DOTES), Alex Roibu (HOLO3D), Luis Rosa (ONE) and Uwe Herzog (EURES) present the CHARITY project and showcase 2 use cases.	80	https://www.eucnc.eu/
Y2	ACM Web Conference (WWW)	online	25/04/2022 - 29/04/2022	Presentation	Aravindh Raman (TID) presented paper “Jettisoning Junk Messaging in the Era of End-to-End Encryption: A Case Study of WhatsApp”.	50	https://www2022.thewebconf.org/accepted-papers/
Y2	SIGGRAPH 2022	Vancouver, Canada	08/08/2022 - 10/08/2022	Poster Presentation	ORAMA presented the paper “Recording and replaying psychomotor user actions in VR”	11700	https://s2022.sigraph.org/
Y2	EGI Conference 2022	Prague, Cz.Republ	19/09/2022 - 23/09/2022	Invited talk In-person outreach	HUA presented paper “An Efficient Distributed Storage Solution for Edge Computing Environments”	60	https://www.egi.eu/event/egi2022/
Y2	ACM Special Interest Group on Data Communication (SIGCOMM)	Amsterdam, Netherlands	22/08/2022 - 26/08/2022	Conference contribution	TID presented accepted paper “Experiences from the IPFS Network: Deployment and Performance”.	100	https://conferences.sigcomm.org/sigcomm/2022/
Y2	International Conference on Mobile Systems,	Portland, USA	27/06/2022 - 01/07/2022	Conference contribution	TID presented published paper “Global Mobile Network Aggregators: Taxonomy,	40	https://www.sigmobile.org/mobisys/2022/

	Applications, and Services (ACM MOBISYS 2022)				Roaming Performance and Optimization"		
Y2	Seminar at the Distributed, Parallel and Secure Systems group, University of Lisbon	Lisbon, Portugal	15/02/2022-18/02/2022	Invited talk	TID presented the paper "EqualNet: A Secure and Practical Defense for Long-term Network Topology Obfuscation"	100	https://www.dpss.inesc-id.pt/
Y2	BTL Tourism Event 2022	Lisbon, Portugal	16/03/2022-20/03/2022	Exhibition Demo Booth	DOTES showcased and promoted Cyango platform using CHARITY platform in BTL, a tourism event	50	https://btl.fil.pt/
Y2	Hotel 4.0	Évora, Portugal	05/04/2022	Invited talk	DOTES's talk about the future of hotels and the advantage of using Cyango and the power of CHARITY to leverage the innovation of the business	30	https://www.facebook.com/cyango1/posts/pfbid0QJLYngkNMpoiLuhZsfwuuKrqABw92ZM9Dtspihw87gnRraecVWRBqTarVopX5m6hl
Y2	The Network and Distributed System Security	San Diego, California	24/04/2022 – 28/04/2022	Conference contribution	TID presented the paper "EqualNet: A Secure and Practical Defense for Long-term Network Topology Obfuscation"	100	https://www.ndss-symposium.org/ndss2022/accepted-papers/
Y2	Internet Measurement Conference (IMC)	Nice, France	25/10/2022-27/10/2022	Conference contribution	TID presented the paper "A Browser-side View of Starlink Connectivity"	40	https://conferences.sigcomm.org/imc/2022/

Y2	ACSAC '22: Proceedings of the 38th Annual Computer Security Applications Conference	Austin, Texas	05/12/2022 – 05/01/2023	Conference contribution	TID presented "Heimdallr: Fingerprinting SD-WAN Control-Plane Architecture via Encrypted Control Traffic"	1000	https://www.acsac.org/

During the third year (M25-M36) CHARITY project partners participated in the events shown in Table 6:

Table 6 - Event participation along Y3

#Y	Event Name	Venue	Date	Type of Participation	Description	Estimated # of persons reached	Link
Y3	European Conference on Networks and Communications (EuCNC) and the 6G Summit	Gothenburg, Sweden	06/06/2023 – 09/06/2023	Booth Poster Roll up Video presentation	ONESOURCE, DOTES, HPE and CNR presented and demonstrated the CHARITY framework.	100	https://www.eucnc.eu/2022/www.eucnc.eu/index.html
Y3	FRAME: 3rd workshop on Flexible Resource and Application Management on the Edge	Orlando, USA	20/06/2023	Conference contribution	HUA presented the paper "Real-time Monitoring and Analysis of Edge and Cloud Resources"	100	https://www.accordion-project.eu/frame2023/
Y3	FRAME: 3rd workshop on Flexible Resource and Application Management on the Edge	Orlando, USA	20/06/2023	Conference contribution	HUA presented the paper "Multi-Agent Deep Reinforcement Learning for Weighted Multi-Path Routing"	100	https://www.accordion-project.eu/frame2023/

Y3	IEEE CLOUD 2023	Chicago, IL, USA	02/07/2023-08/07/2023	Conference contribution	HUA and CNR presented the paper “GNOSIS: Proactive Image Placement Using Graph Neural Networks & Deep Reinforcement Learning”	100	https://conferences.computer.org/cloud/2023/
Y3	IEEE IEDGE SYMPOSIUM ON INTELLIGENT EDGE COMPUTING AND COMMUNICATIONS	Online	01/05/2023-12/07/2023	Conference contribution	ICT-FICIAL, HUA, ONESOURCE, DOTES, HPE presented the paper “Intelligent Multi-Domain Edge Orchestration for Highly Distributed Immersive Services: An Immersive Virtual Touring Use Case”	10	https://conferences.computer.org/edge/2023/symposium/
Y3	IEEE International Conference on Service-Oriented System Engineering	Greece	17/07/2023-20/07/2023	Conference contribution	HUA presented the paper “GreenKube: Towards Greener Container Orchestration using Artificial Intelligence”	20	https://ieeesose.com/
Y3	IEEE International Conference on Service-Oriented System Engineering	Greece	17/07/2023-20/07/2023	Conference contribution	HUA presented the paper “Multi-Service Demand Forecasting using Graph Neural Networks”	20	https://ieeesose.com/
Y3	IEEE International Conference on Joint Cloud Computing (JCC)	Greece	17/07/2023-20/07/2023	Moderation	HUA moderated the IEEE International Conference on Joint Cloud Computing (JCC) 2023 forum for researchers and practitioners	500	https://ieeesose.com/
Y3	ACM SIGGRAPH 2023	Los Angeles USA	06/08/2023-10/08/2023	Presentation	ORAMA presented a talk regarding “Computational Medical XR: Spatial, Neural	400	https://s2023.sigraph.org/

					and Wearable Computing Converging to Transform Healthcare"		
Y3	SIGGRAPH 2023	Los Angeles Convention Center, USA	06/08/2023-10/08/2023	Presentation	ORAMA provided a workshop regarding computational medical XR	1000	https://s2023.siggraph.org/
Y3	IEEE CLOUDNET (THE WORKSHOP ON INTELLIGENT CLOUD CONTINUUM FOR B5G SERVICES)	New York Area, USA	01/07/2023-20/08/2023	Conference contribution	HUA presented the paper "A Brief Review of Population-based Methods for Task Offloading in Cloud-to-Edge Continuum"	20	https://cloudnet2023.ieee-cloudnet.org/
Y3	Capgemini Portugal	-	26/09/2023 - 26/09/2023	Invited talk	Presenting Cyango to Capgemini Portugal	12	N.A.
Y3	ESOCC 2023 - 10th European Conference On Service-Oriented And Cloud Computing	Larnaca, Cyprus	02/07/2023 - 26/10/2023	Conference contribution	HUA presented the conference paper "Streamlining XR Application Deployment with a Localized Docker Registry at the Edge"	100	https://cyprusconferences.org/esocc2023/
Y3	Cyango Cloud Studio Presentation	-	02/07/2023-31/12/2023	Presentation	A pitch deck presentation DOTES have been doing to several events. Like present to investors meetings, present to potential clients and present do telcos like NOS in Portugal	15	N.A.

During the fourth year (M37-M42) CHARITY project partners participated in the events shown in Table 7:

Table 7 - Event participation along Y4

#Y	Event Name	Venue	Date	Type of Participation	Description	Estimated # of persons reached	Link
Y4	8th Annual Virtual Reality and Healthcare Global Symposium	Sarasota - Tampa Florida USA	29/02/2024 - 03/03/2024	Invited talk	ORAMA's talk focusing on "Generative AI for Authoring Medical XR Training Applications"	250	https://health24.ivrha.org/
Y4	FRAME: 4th workshop on Flexible Resource and Application Management on the Edge	Pisa, Italy	04/06/2024 - 04/06/2024	Proceeding	HUA and CNR presented the paper "Optimizing Resource Allocation in the Edge: A Minimum Weighted Vertex Cover Approach"	30	https://www.accordion-project.eu/frame2024/
Y4	EuCNC Conference & 6G Summit 2024	Anthwerp Belgium	03/06/2024 - 06/06/2024	Exhibition Demo Booth	ONESOURCE, ICTFICIAL, HPE and DOTES presented and demonstrated the CHARITY framework and showcased one use case	30	https://www.eucnc.eu/
Y4	IEEE International Conference on Communications 2024	Denver, USA	01/03/2024	Conference Contribution	HUA presented the paper "A New Approach for Evaluating the Performance of Distributed Latency-Sensitive Services"	20	n/a

2.5 Organisation of local workshops (KPI 05)

Due to the pandemic, the organisation of face-to-face meetings during 2021 (Y1 of the project) had a very limited possibility of gathering participants. Therefore, the consortium decided to organise a series of online Webinars, which neutralized the barrier of Covid-19 restrictions. The following tables present a list of **17 events** (combining webinars and in-person workshops) where CHARITY project partners participated during the course of the project, reaching over **671 persons (**estimated[9]).

Table 8: Webinars organised by CHARITY project partners in Y1.

#Y	Event Name	Venue	Date	Persons reached	Link
Y1	CHARITY - Webinar #1: The Next Step Towards Immersive Communication	Online	30/11/2021	23	https://www.charity-project.eu/en/webinars/charity-project-webinar-1-the-next-step-towards-immersive-communication

The event was recorded and made available for reproduction on CHARITY's Youtube channel. In addition, this video was embedded in a news item created on the project website and used for further communication activities on social media and newsletters releases.

Figure 31: Overview of Webinar #1 organised by CHARITY partners.

Additional webinars were organized and performed as detailed the following tables.

[9] The webinar's reach was determined by analyzing both the video views from YouTube Analytics and the number of attendees present during the online session.

Table 9: Webinars organised by CHARITY project partners.

#Y	Event Name	Venue	Date	Persons Reached	Link
Y2	Second workshop on the future of XR: Current ecosystem and upcoming opportunities	Online	11/05/2022	20	N.A.
Y2	FRAME 2022: The 2nd Workshop on Flexible Resource and Application Management on the Edge, USA, Minneapolis, Minnesota	Minnessota, USA	27/06/2022 - 01/07/2022	20	https://dl.acm.org/doi/proceedings/10.1145/3526059#issue-downloads
Y2	CHARITY - Webinar #2: Cloud-Edge Continuum Resource Management and Application Steering (Joint webinar between CHARITY & ACCORDION)	Online	10/11/2022	80	https://www.charity-project.eu/en/webinars/charity-project-webinar-2-cloud-edge-continuum-resource-management-and-application-steering
Y2	CHARITY - Webinar #3: Opening up the Cloud Edge Continuum to new generations of applications (Joint CHARITY-PHYSICS webinar)	Online	29/11/2022	53	https://www.charity-project.eu/en/webinars/charity-project-webinar-3-opening-up-the-cloud-edge-continuum-to-new-generations-of-applications

Table 10 - Webinars organised by CHARITY project partners in Y3

#Y	Event Name	Venue	Date	Persons Reached	Link
Y3	CHARITY - Webinar #4: Future Forward Holographic Applications	Online	17/01/2023	50	https://www.charity-project.eu/en/webinars/charity-project-webinar-4-future-forward-holographic-applications
Y3	CHARITY - Webinar #5: Securing the Future: Challenges ahead of XR Services and Serverless Computing	Online	05/04/2023	50	https://www.charity-project.eu/en/webinars/charity-project-webinar-5-securing-the-future-challenges-ahead-of-xr-services-

					and-serverless-computing
Y3	CHARITY - Webinar #6: Architecting Collaborative Experiences: A Journey in MR Applications Development	Online	17/05/2023	50	https://www.charity-project.eu/en/webinars/charity-project-webinar-6-architecting-collaborative-experiences-a-journey-in-mr-applications-development
Y3	FRAME : 3rd Workshop on Flexible Resource and Application Management on the Edge	Orlando, FL, USA	20/06/2023	40	https://www.accordion-project.eu/frame2023/
Y3	CHARITY - Webinar #7 - Intelligent Cloud Optimization: Drivers for Storage and Resource Management	Online	23/06/2023	40	https://www.charity-project.eu/webinars/charity-project-webinar-7-intelligent-cloud-optimization-drivers-for-storage-and-resource-management
Y3	CHARITY - Webinar #8: Shaping the Future of XR: CHARITY New Multi-Domain Orchestration Paradigm	Online	18/12/2023	35	https://www.charity-project.eu/en/webinars/shaping-the-future-of-xr-charity-new-multi-domain-orchestration-paradigm

Table 11 - Webinars organised by CHARITY project partners in Y4

#Y	Event Name	Venue	Date	Persons Reached	Link
Y4	CHARITY - Webinar #9 - How to create Virtual Reality Experiences with Cyango Cloud Studio	Online	21/05/2024	50	https://www.charity-project.eu/en/webinars/how-to-create-virtual-reality-experiences-with-

					cyango-cloud-studio-7886
Y4	Exploring the Frontier: Highlights from the Cognitive Cloud Infrastructure Webinar	Online	26/03/2024	30	https://eucloudedgeiot.eu/exploring-the-frontier-highlights-from-the-cognitive-cloud-infrastructure-webinar/
Y4	How to create VR Experiences with Cloud	Startup Lisboa	24/05/2024	30	https://www.eventbrite.com/e/bilhetes-how-to-create-virtual-reality-experiences-with-cyango-cloud-studio-901360582767?aff=oddtdtcreator
Y4	FRAME: 4th workshop on Flexible Resource and Application Management on the Edge	Pisa, Italy	04/06/2024	30	https://www.accordion-project.eu/Frame2024/
Y4	FRAME: 4th workshop on Flexible Resource and Application Management on the Edge - Industrial Exploitation of Continuum Platforms – experience and outcomes of the CHARITY project for XR-AR enabling of the Continuum	Pisa, Italy	04/06/2024	30	https://www.accordion-project.eu/frame2024/
Y4	WS-12: 2nd International Workshop on Intelligent Cloud Continuum for B5G Services	Denver, Colorado, USA	09/06/2024 - 13/06/2024	40	https://6g-cloud-continuum-workshop.net/icc2024/

Some of the performed webinars were done in collaboration with other H2020 projects, providing not only a wider perspective of the presented content but also aimed at reaching a broader audience which benefits all involved parties while boosting awareness and impact generation.

Figure 33 and Figure 32 illustrate the first two editions of the in-person workshop entitled “International Workshop on Intelligent Cloud Continuum for B5G Services” organized by CHARITY in

collaboration with other research projects. Figure 34 depicts the FRAME workshop organized by CNR, also within the scope of CHARITY.

Figure 32 - ICC2024: 2nd International Workshop on Intelligent Cloud Continuum for B5G Services

Figure 33 - IEEE CLOUDNET 2023: 1st International Workshop on Intelligent Cloud Continuum for B5G Services

Figure 34: FRAME workshop website: https://www.accordion-project.eu/frame-2nd-workshop-on-flexible-resource-and-application-management-on-the-edge/

2.6 Collaboration with other H2020 projects (KPI 06)

The consortium has made important efforts in terms of identifying concrete opportunities and performing collaborative activities with other H2020 projects.

The consortium has conducted several joint activities with following H2020 funded projects, which are listed on the project website (Collaborations > H2020 Collaborations).

In Table 12 the collaboration activities conducted since the first year of the project life cycle (2021) are presented.

Table 12: Collaboration with other H2020 projects since Y1 / 2021.

#Y	Event Name	Collaboration areas
Y1	H-CLOUD project https://www.h-cloud.eu/	– Participation on monthly Communication Task Meetings (exchanging with up to 10 other European funded projects the current work status, upcoming events and collaboration opportunities) – Participation at H-CLOUD Summit 2021 – Contribution to periodic H-CLOUD Newsletter releases (Oct 2021 - 301 subscr., Jan 2022 - 410 subscr., June/July 2022 - 506 subscr. so far) – Social Media promotion of events and activities
Y1	ACCORDION project https://www.accordion-project.eu/	– Contribution to CHARITY Newsletter – Social Media promotion of events and activities
Y1	SWforum.eu project	– Hosting of CHARITY project minisite within Project Hub Section, https://swforum.eu/project-hub/cloud-holography-and-augmented-reality – Social Media promotion of events and activities

		– Promotion of CHARITY Webinar #1: https://swforum.eu/events/charity-project-webinar-1-next-step-towards-immersive-communication

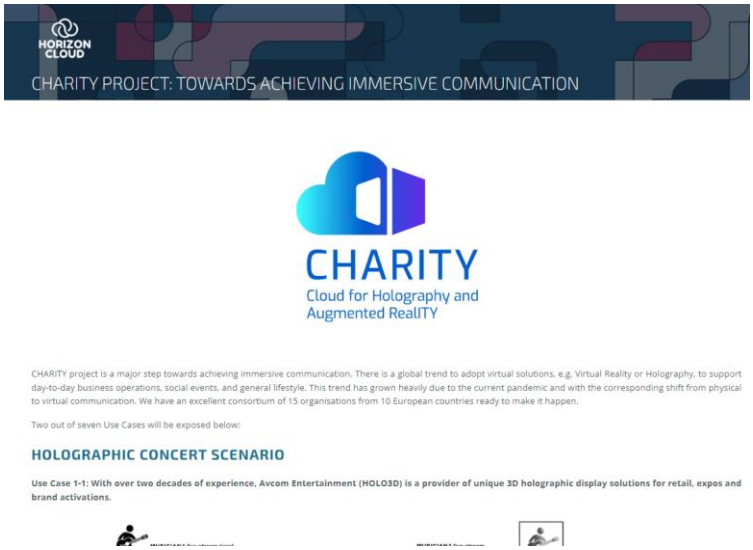


Figure 35: CHARITY project contribution to October 2021 H-CLOUD newsletter release.

In Table 12 the collaboration activities conducted since the second year of the project life cycle (2022) are presented.

Table 13: Collaboration with other H2020 projects since Y2 / 2022.

#Y	Event Name	Collaboration areas
Y2	ARETE project, https://www.areteproject.eu/	– Participation at workshop organised by ARETE &iv4XR projects. – Social Media promotion of events and activities – Project contribution for CHARITY Newsletter #5 release
Y2	iv4XR project, https://iv4xr-project.eu/	– Participation at workshop organised by ARETE &iv4XR projects. – Social Media promotion of events and activities Planned activities: joint Webinar between CHARITY and iv4XR projects in the field of VR applications.
Y2	ARtwin project, https://artwin-project.eu/	– Collaboration areas to be defined along June / July.
Y2	PHYSICS project, https://physics-faas.eu/	– Collaboration areas to be defined along June / July.
Y2	HUB4CLOUD project, https://www.h-cloud.eu/ict_40-projects/hub4cloud/ Project start: Sept 2022	– Collaboration areas to be defined from September. HUB4CLOUD takes on the baton from H-CLOUD to extend and build upon its activities and outreach to foster the European Cloud Computing ecosystem

Figure 36: Social Media posting about the CHARITY project participation at the workshop organised by the ARETE & iv4XR projects.

2.7 Participation on EC Events (KPI 07)

#Y	Event Name	Venue	Date	Type of Participation	Description	Estimated # of persons reached	Link
Y2	European Conference on Networks and Communications (EuCNC) and the 6G Summit	Grenoble, France	07/06/2022 - 10/06/2022	Booth Poster Roll up Video presentation	DOTES, HOLO3D, ONE and EURES present the CHARITY project and showcase 2 use cases.	80	https://www.eucnc.eu/
Y3	European Conference on Networks and Communications (EuCNC) and the 6G Summit	Gothenburg, Sweden	06/06/2023 – 09/06/2023	Booth Poster Roll up Video presentation	ONESOURCE, DOTES, HPE and CNR presented and demonstrated the CHARITY framework.	100	https://www.eucnc.eu/
Y4	European Conference on Networks and Communications (EuCNC) and the 6G Summit	Antwerp, Belgium	03/06/2024 - 16/06/2024	Booth Poster Roll up Video presentation	ONESOURCE, ICTFICIAL, HPE and DOTES presented and demonstrated the CHARITY framework and showcased one use case	30	https://www.eucnc.eu/

As highlight of the EuCNC & 6G Summit participation it can be mentioned that Mr. Pearse O'Donohue visited the CHARITY booth at EuCNC & 6G Summit (Figure 39) experiencing first-hand the selected use cases explained by the CHARITY project partners.

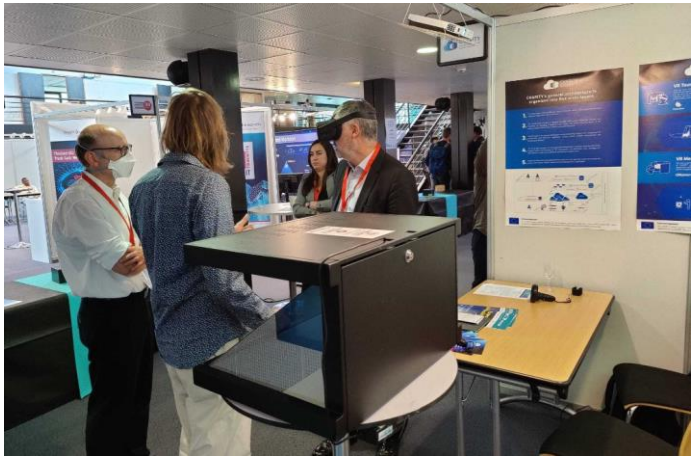



Figure 37: Mr. Pearse O'Donohue visiting the CHARITY project booth at EuCNC & 6G Summit 2022.

Pearse O'Donohue is Director for the Future Networks Directorate of DG CONNECT at the European Commission, dealing with policy development and research supporting the Digital Single Market in the areas 5G networks, IoT, cloud and data flows.

It is also worth mentioning, during both the EUCnC & 6G Summit 2023 and 2024 booth exhibitions, two members of the CHARITY advisory board Dr. Richard Li and Dr. Zarrar Yousaf visited the CHARITY booth respectively (cf. Figure 38), experienced the CHARITY platform's features and provided their valuable feedback.

Figure 38 - EUCnC 2024 Booth Exhibition

Figure 39 - EUCnC 2023 Booth Exhibition

2.8 Publications (KPI 08)

Generating impact and disseminating the project's findings and results among research and academic communities has been mainly done through the active development of papers and its posterior presentation and publication at important conferences and journals.

All papers are uploaded to the project website (Publications > Papers & Conferences) whenever the PDF becomes available at the respective conferences' proceedings or publication of the journal. Moreover, this content is promoted through social media and included in the project' newsletters. The following tables (Table 14) present the published publications during the course of the project:

Table 14: Publications generated by CHARITY project partners during Y1

Type	Title of the Journal/ Conference/ Magazine	Title of the publication	Authors	Date	Status	Confid. level	Link
Journal	IEEE Communications Surveys & Tutorials	Federated Machine Learning: Survey, Multi-Level Classification, Desirable Criteria and Future Directions in Communication and Networking Systems	Tarik Taleb (ICT-FI)	Feb-21	public	published	https://www.researchgate.net/publication/349194533_Federated_Machine_Learning_Survey_Multi-Level_Classification_Desirable_Criteria_and_Future_Directions_in_Communication_and_Networking_Systems
Magazine	IEEE Network Magazine	AI-based Resource Management in Beyond 5G Cloud Native Environment	Tarik Taleb (ICT-FI)	Mar-21	public	published	https://www.charity-project.eu/api/download/1664812847_4td5XtPmY0Y9tJjDfU5w
Magazine	IEEE Network Magazine	Asynchronous Time-Sensitive Networking for 5G Backhauling	Tarik Taleb (ICT-FI)	Mar-21	public	published	https://www.charity-project.eu/api/download/1664812695_0BTnfsm3fLdWzND6gtpp
Magazine	IEEE Network Magazine	Immersive Services over 5G and Beyond Mobile Systems	Tarik Taleb (ICT-FI)	Aug-21	public	accepted	https://www.charity-project.eu/api/download/1634729079_KbKKbtquSSeGhNLNLstF

Conference	IEEE International Conference on Big Data Computing Service and Machine Learning Applications	An Encoder-Decoder Deep Learning Approach for Multistep Service Traffic Prediction	Theodoros Theodoropoulos (HUA), Angelos-Christos Maroudis (HUA), John Violos (HUA), Konstantinos Tserpes (HUA)	Aug-21	public	published	https://www.charity-project.eu/api/download/1664813111_TylFJPMwWA5xrkVlrdri
Conference	IEEE International Conference on Cloud Networking (CloudNet)	Cloud for Holography and Augmented Reality	Antonios Makris (HUA), Abderrahmane Boudi (ICT-FI), Massimo Coppola (CNR), Luís Cordeiro (ONE), Massimiliano Corsini (CNR), Patrizio Dazzi (CNR), Ferran Diego Andilla (TID), Yago Gonzalez Rozas (PLEXUS), Manos Kamarianakis (ORAMA), Maria Pateraki (ORAMA), Thu Le Pham (CAI), Antonis Protopsaltis (ORAMA), Aravindh Raman (TID), Alessandro Romussi (HPE), Luís Rosa (ONE), Elena Spatafora (HPE), Tarik Taleb (ICT-FI), Theodoros Theodoropoulos (HUA), Konstantinos Tserpes (HUA), Enrico Zschau (SRT), Uwe Herzog (EURES)	Oct-21	public	accepted	https://www.charity-project.eu/api/download/1664813232_Ave9oyjigswBiNV3mdSi
Conference	CoNEXT '21: International Conference on emerging Networking EXperiments	Exploring content moderation in the decentralised web: the pleroma case	Aravindh Raman (ICT-FI)	Dec-21	public	published	https://www.charity-project.eu/api/download/1664893212_bIREvbi1eb1feAVY4g0e

Table 15: Publications generated by CHARITY project partners during Y2

Type	Title of the Journal/ Conference/ Magazine	Title	Authors	Date	Status	Confid. level	Link
Journal	IEEE Transactions on Network and Service Management	Deterministic Latency/Jitter-aware Service Function Chaining over Beyond 5G Edge Fabric	Tarik Taleb (ICT-FI)	Feb-22	public	accepted	https://www.charity-project.eu/api/download/1646302917_Sega7OzksbRKpTSNySWm
Journal	Journal of Networking and Networking Applications	Cloud-based XR Services: A Survey on Relevant Challenges and Enabling Technologies	Theodoros Theodoropoulos (HUA), Antonios Makris (HUA), Abderrahmane Boudi (ICT-FI), Tarik Taleb (ICT-FI), Uwe Herzog (EURES), Luís Rosa (ONE), Luís Cordeiro (ONE), Konstantinos Tserpes (HUA), Elena Spatafora (HPE), Alessandro Romussi (HPE), Enrico Zschau (SRT), Manos Kamarianakis (ORAMA), Antonis Protopsaltis (ORAMA), George Papagiannakis (ORAMA), Patrizio Dazzi (CNR)	Feb-22	public	published	https://iecscience.org/jpapers/100
Journal	IEEE Transactions on Network and Service Management	DSM-MoC as Baseline: Reliability Assurance via Redundant Cellular Connectivity in Connected Cars	Aravindh Raman (TID)	Feb-22	public	published	https://www.charity-project.eu/api/download/1664813410_dXJJ7P0q9dI8g9Eeww9l
Journal	ITU Journal on Future and	Intelligent Proactive Fault Tolerance at the	Theodoros Theodoropoulos (HUA)	Feb-22	non-public	accepted	https://www.researchgate.

	Evolving Technologies	Edge through Resource Usage Prediction					net/publication/366194381_Intelligent_proactive_fault_tolerance_at_the_edge_through_resource_usage_prediction
Journal	Open Research Europe	Transition from monolithic to microservice-based applications. Challenges from the developer perspective	Antonios Makris (HUA) Konstantinos Tserpes (HUA)	Feb-22	public	published	https://www.semanticscholar.org/paper/Transition-from-monolithic-to-microservice-based-Makris-Tserpes/5e3157edd175f9bcce7d8532a301c19f596dc7ec
Journal	Computer Networks	Intelligent Horizontal Autoscaling in Edge Computing using a Double Tower Neural Network	Theodoros Theodoropoulos (HUA)	Mar-22	public	published	https://www.sciencedirect.com/science/article/abs/pii/S1389128622003735
Magazine	IEEE Network Magazine	Collaborative Cross System AI: Towards 5G System and Beyond	Tarik Taleb (ICT-FI)	Apr-22	public	published	https://www.charity-project.eu/api/download/1664812537_sTl31gbLhbg1ORkOcR3I
Journal	IEEE Transactions on Network and Service Management	AI-based network-aware Service Function Chain migration in 5G and beyond networks	Tarik Taleb (ICT-FI)	Apr-22	public	published	https://www.charity-project.eu/api/download/1665130440_PJVF7Uv2trUKh4hRWAiQ
Conference	WWW '22: The ACM Web Conference 2022	Jettisoning Junk Messaging in the Era of End-to-End Encryption: A Case Study of WhatsApp	Aravindh Raman (TID)	Apr-22	public	published	https://www.charity-project.eu/api/download/1664813727_VMifQZbbVHyTg6E5xBuZ

Journal	IEEE Network Magazine	AI-based Autonomic & Scalable Security Management Architecture for Secure Network Slicing in B5G	Tarik Taleb (ICT-FI)	May-22	public	accepted	https://www.charity-project.eu/api/download/1653984641_m8Hb1AdEX5xMkUpuU7i8
Magazine	Comunications of the ACM	Privacy-Preserving AI for Future Networks	- Eduard Marin Fabregas (TID)	Apr-22	public	published	https://zenodo.org/record/7456821
Conference contribution	The Network and Distributed System Security	EqualNet: A Secure and Practical Defense for Long-term Network Topology Obfuscation	- Eduard Marin Fabregas (TID)	Apr-22	non-public	accepted	https://www.ndss-symposium.org/wp-content/uploads/2022-154-paper.pdf
Journal	IEEE Journal on Selected Areas in Communications	Toward Using Reinforcement Learning for Trigger Selection in Network Slice Mobility	Tarik Taleb (ICT-FI)	May-22	public	published	https://www.charity-project.eu/api/download/1664812953_tPTy5oNzbRJQkajeMsCb
Magazine	IEEE Communications Standards Magazine	Extremely-interactive and low latency services in 5G and beyond mobile systems	Tarik Taleb (ICT-FI)	Jun-22	public	published	https://www.charity-project.eu/api/download/1664812370_lZWrcY6jAcxNU1ZOrcXg
Conference	FRAME '22: 2nd Workshop on Flexible Resource and Application Management on the Edge	Towards a Distributed Storage Framework for Edge Computing Infrastructures	Antonios Makris (HUA), Evangelos Psomakelis (HUA), Theodoros Theodoropoulos (HUA), Konstantinos Tserpes (HUA)	Jun-22	public	accepted	https://zenodo.org/record/6967216#.YxsXqnbMJPa
Conference	FRAME '22: 2nd Workshop on Flexible Resource and Application	An Automated Pipeline for Advanced Fault Tolerance in Edge	Theodoros Theodoropoulos (HUA), Antonios Makris (HUA),	Jun-22	public	accepted	https://zenodo.org/record/6967334#.YxsYF3bMJPZ

	Management on the Edge	Computing Infrastructures	John Violos (HUA), Konstantinos Tserpes (HUA)				
Conference	MobiSys '22: 20th Annual International Conference on Mobile Systems, Applications and Services	Global Mobile Network Aggregators: Taxonomy, Roaming Performance and Optimization	Aravindh Raman (TID)	Jun-22	public	accepted	https://aravindhr.am/publications/marin2022global.pdf
Journal	IEEE Transactions on Mobile Computing	Optimization of Flow Allocation in Asynchronous Deterministic 5G Transport Networks by Leveraging Data Analytics	Tarik Taleb (ICT-FI)	Jul-22	public	published	https://www.charity-project.eu/api/download/1664812899_4trOZdY7ApA2G41uhqat
Journal	International Journal of Information Management Data Insights	Graph Neural Networks for Representing Multivariate Resource Usage: a Multiplayer Mobile Gaming Case-study	Theodoros Theodoropoulos (HUA), Antonios Makris (HUA), Ioannis Kontopoulos (HUA), John Violos (HUA), Zbyszek Ledwoń (ORBITAL), Przemysław Tarkowski (ORBITAL), Patrizio Dazzi (CNR), Konstantinos Tserpes (HUA)	Jun-22	public	published	https://www.sciencedirect.com/science/article/pii/S2667096823000058
Conference	SIGGRAPH 2022	Recording and replaying psychomotor user actions in VR	George Papagiannakis (ORAMA), Manos Kamarianakis (ORAMA)	Aug-22	public	accepted	https://www.charity-project.eu/api/download/1665051939_NFYxV1IUuoLlIAZ7zFFN
Conference	ACM SIGCOMM 2022	Experiences from the IPFS Network: Deployment and Performance	Aravindh Raman (TID)	Aug-22	public	accepted	https://arxiv.org/pdf/2208.05877.pdf

Journal	Applied Sciences	Performance Analysis of Storage Systems in Edge Computing Infrastructures	Antonios Makris (HUA), Ioannis Kontopoulos (HUA), Evangelos Psomakelis (HUA), Stylianos Nektarios Xyalis (HUA), Theodoros Theodoropoulos (HUA), Konstantinos Tserpes (HUA)	Sep-22	public	published	https://www.mdpi.com/2076-3417/12/17/8923
Journal Magazine	IEEE Network Magazine	AR-based Remote Command and Control Service: Self-driving Vehicles Use Case	Tarik Taleb (ICT-FI)	Sep-22	public	accepted	https://ieeexplore.ieee.org/document/9910350
Conference contribution	Internet Measurement Conference (IMC)	A Browser-side View of Starlink Connectivity	- Aravindh Raman (TID)	Oct-22	non-public	published	https://nishrs.github.io/pdf/2022/Starlink_Measurements-IMC.pdf
Proceeding	IEEE Global Communications Conference (GLOBECOM) '22	Near-optimal Cloud-Network Integrated Resource Allocation for Latency-Sensitive B5G	- Tarik Taleb (ICT-FI)	Dec-22	public	accepted	https://ieeexplore.ieee.org/document/10001109
Proceeding	IEEE Global Communications Conference (GLOBECOM) '22	Deep Reinforcement Learning for Dependency-aware Microservice Deployment in Edge Computing	- Tarik Taleb (ICT-FI)	Dec-22	public	accepted	https://ieeexplore.ieee.org/document/10000818
Magazine	EURESCOM Message	5G-Enabled XR Medical Training 4.0 Using XR to effectively educate healthcare personnel	- Antonis Protopsaltis (ORAMA) - Manos Kamarianakis (ORAMA) - Maria Pateraki (ORAMA)	Dec-22	public	accepted	https://www.eurescom.eu/eurescom-messages/summer-2022/5g-enabled-xr-medical-training-4-0/

Table 16 - Publications generated by CHARITY project partners during Y3

Type	Title of the Journal/ Conference/ Magazine	Title	Authors	Date	Status	Confid. level	Link
Journal	IEEE Trans. Vehicular Technology	H. Masuda, O. El-Marai, M. Tsukada, T. Taleb, and H. Esaki, "Feature-based Vehicle Identification Framework for Optimization of Collective Perception Messages in Vehicular Networks," in IEEE TVT	- Tarik Taleb (ICT-FI)	Jan-23	public	accepted	http://mosaic-lab.org/uploads/papers/b2b203b0-f779-487c-adba-8a13f5abd1a0.pdf
Journal	IEEE Transactions on Network and Service Management	An Aggressive Migration Strategy for Network Slices in Core Cloud	- Tarik Taleb (ICT-FI)	Jan-23	public	accepted	http://www.mosaic-lab.org/uploads/papers/45c59025-fa0b-4ed5-8687-04e5f492481f.pdf
Journal	Journal of Cloud Computing	Serverless computing: a security perspective	- Eduard Marin Fabregas (TID)	Jan-23	public	published	https://journalofcloudcomputing.springeropen.com/articles/10.1186/s13677-022-00347-w
Journal	IEEE IoT Journal	Toward Supporting XR Services: Architecture and Enablers	- Luís Rosa (ONESOURCE) - Luís Cordeiro (ONESOURCE) - Theodoros Theodoropoulos (HUA) - Konstantinos Tserpes (HUA) - Abderrahmane Boudi (ICT-FI)	Feb-23	public	published	http://mosaic-lab.org/uploads/papers/95be65ad-7e26-4960-aec8-7d312210d14b.pdf

Journal	Journal of Cybersecurity and Privacy	Security in Cloud-Native Services: A Survey on Key Features	- Theodoros Theodoropoulos (HUA) - Luís Rosa (ONESOURCE) - Chafika Benzaid (chafika.benzaid@oulu.fi) - Peter Gray (CLOUDSIGMA) - Eduard Marin Fabregas (TID) - Antonios Makris (HUA) - Luís Cordeiro (ONESOURCE) - Ferran Diego Andilla (TID) - Pavel Sorokin (CLOUDSIGMA) - Marco Di Girolamo (HPE) - Paolo Barone (HPE) - Tarik Taleb (ICT-FI) - Konstantinos Tserpes (HUA)	Jun-23	public	published	https://www.mdpi.com/2624-800X/3/4/34
Conference contribution	FRAME: 3rd workshop on Flexible Resource and Application Management on the Edge	Real-time Monitoring and Analysis of Edge and Cloud Resources	- Ioannis Korontanis (HUA) - Antonios Makris (HUA) - Theodoros Theodoropoulos (HUA) - Konstantinos Tserpes (HUA)	Jun-23	public	published	https://dl.acm.org/doi/abs/10.1145/3589010.3594892
Conference contribution	FRAME: 3rd workshop on Flexible Resource and Application Management on the Edge	Multi-Agent Deep Reinforcement Learning for Weighted Multi-Path Routing	- Theodoros Theodoropoulos (HUA) - Dimitrios Kafetzis (HUA) - John Violos (HUA) - Antonios Makris (HUA) - Konstantinos Tserpes (HUA)	Jun-23	public	published	https://dl.acm.org/doi/abs/10.1145/3589010.3594888
Magazine	IEEE Network Magazine	Cross Kubernetes Cluster Networking to Support XR Services: Challenges, Solutions and Performance Evaluation	- Theodoros Theodoropoulos (HUA) - Luís Rosa (ONESOURCE) - Abderrahmane Boudi (ICT-FI) - Tarik Zakaria Benmerar (ICT-FI) - Antonios Makris (HUA) - Tarik Taleb (ICT-FI)	Jun-23	non-public	submitted	

			- Luís Cordeiro (ONESOURCE) - Konstantinos Tserpes (HUA)				
Journal	IEEE Transactions on Network and Service Management	Leveraging Graph Neural Networks for SLA Violation Prediction in Cloud Computing	- Angelos-Christos Maroudis (HUA) - Theodoros Theodoropoulos (HUA) - John Violos (HUA) - Konstantinos Tserpes (HUA)	Jul-23	non-public	published	https://ieeexplore.ieee.org/abstract/document/10173672
Conference contribution	IEEE CLOUD 2023	GNOSIS: Proactive Image Placement Using Graph Neural Networks & Deep Reinforcement Learning	- Theodoros Theodoropoulos (HUA) - Antonios Makris (HUA) - Evangelos Psomakelis (HUA) - Emanuele Carlini (CNR) - Matteo Mordacchini (CNR) - Patrizio Dazzi (CNR) - Konstantinos Tserpes (HUA)	Jul-23	non-public	published	https://openportal.isti.cnr.it/data/2023/487364/2023_487364.postprint.pdf?id=people_____%3A%3A0dc1c4d6e0ea589550f276c3e6583224
Conference contribution	IEEE IEDGE SYMPOSIUM ON INTELLIGENT EDGE COMPUTING AND COMMUNICATIONS	Intelligent Multi-Domain Edge Orchestration for Highly Distributed Immersive Services: An Immersive Virtual Touring Use Case	- Tarik Zakaria Benmerar (ICT-FI) - Theodoros Theodoropoulos (HUA) - Luís Rosa (ONESOURCE) - João Rodrigues (DOTES) - Tarik Taleb (ICT-FI) - Paolo Barone (HPE) - Konstantinos Tserpes (HUA) - Luís Cordeiro (ONESOURCE)	Jul-23	non-public	accepted	http://www.mosaic-lab.org/uploads/papers/b97cefa0-1fe0-4900-b431-dbe0d7cb72c6.pdf
Conference contribution	IEEE International Conference on Service-Oriented System Engineering	GreenKube: Towards Greener Container Orchestration using Artificial Intelligence	- Theodoros Theodoropoulos (HUA) - Antonios Makris (HUA) - Ioannis Korontanis (HUA) - Konstantinos Tserpes (HUA)	Jul-23	non-public	published	https://ieeexplore.ieee.org/abstract/document/10254745
Conference contribution	IEEE International Conference on Service-Oriented System Engineering	Multi-Service Demand Forecasting using Graph Neural Networks	- Theodoros Theodoropoulos (HUA) - Antonios Makris (HUA) - Ioannis Kontopoulos (HUA) - Angelos-Christos Maroudis	Jul-23	non-public	published	https://ieeexplore.ieee.org/abstract/document/10254749

			(HUA) - Konstantinos Tserpes (HUA)				
Conference contribution	IEEE CLOUDNET (THE WORKSHOP ON INTELLIGENT CLOUD CONTINUUM FOR B5G SERVICES)	A Brief Review of Population-based Methods for Task Offloading in Cloud-to-Edge Continuum	- Theodoros Theodoropoulos (HUA)	Aug-23	public	accepted	https://ieeexplore.ieee.org/abstract/document/10490076
Conference contribution	ESOCC 2023	Streamlining XR Application Deployment with a Localized Docker Registry at the Edge	- Antonios Makris (HUA) - Evangelos Psomakelis (HUA) - Ioannis Korontanis (HUA) - Theodoros Theodoropoulos (HUA) - Antonis Protopsaltis (ORAMA) - Maria Pateraki (ORAMA) - Zbyszek Ledwoń (ORBITAL) - Christos Diou (HUA) - Dimosthenis Anagnostopoulos (HUA) - Konstantinos Tserpes (HUA)	Oct-23	public	published	https://link.springer.com/chapter/10.1007/978-3-031-46235-1_12
Journal	Software Impacts	A Lightweight Storage Framework for Edge Computing Infrastructures / EdgePersist	- Antonios Makris (HUA) - Evangelos Psomakelis (HUA) - Konstantinos Tserpes (HUA) - Maria Pateraki (ORAMA)	Nov-23	public	published	https://www.sciencedirect.com/science/article/pii/S2665963823000866

Table 17 - Publications generated by CHARITY project partners during Y4

Type	Title of the Journal/ Conference/ Magazine	Title	Authors	Date	Status	Confid. level	Link

Journal Proceeding	Applied Sciences	A Survey on Modeling Languages for Applications Hosted on Cloud-Edge Computing Environments	- Ioannis Korontanis (HUA) - Antonios Makris (HUA) - Konstantinos Tserpes (HUA)	Mar-24	public	published	https://www.mdpi.com/2076-3417/14/6/2311
Journal	Future Generation Computer Systems	Pro-active component image placement in Edge computing environments	- Antonios Makris (HUA) - Evangelos Psomakelis (HUA) - Emanuele Carlini (CNR) - Matteo Mordacchini (CNR) - Patrizio Dazzi (CNR) - Theodoros Theodoropoulos (HUA) - Konstantinos Tserpes (HUA)	Apr-24	public	published	https://www.sciencedirect.com/science/article/pii/S0167739X24001353?dgcid=author
Journal	Cross-Cluster Networking to Support Extended Reality Services	Cross-Cluster Networking to Support Extended Reality Services	- Theodoros Theodoropoulos (HUA) - Luís Rosa (ONESOURCE) - Tarik Taleb (ICT-FI) - Luís Cordeiro (ONESOURCE) - Tarik Zakaria Benmerar (ICT-FI) - Abderrahmane Boudi (ICT-FI) - Antonios Makris (HUA) - Konstantinos Tserpes (HUA)	May-24	public	accepted	https://arxiv.org/abs/2405.00558
Journal Proceeding	SoftwareX	EdgeCloud Mon: A lightweight monitoring stack for K3s clusters	- Ioannis Korontanis (HUA) - Antonios Makris (HUA) - Konstantinos Tserpes (HUA)	May-24	public	published	https://www.sciencedirect.com/science/article/pii/S2352711024000463?via%3Dihub

Proceeding	FRAME: 4th workshop on Flexible Resource and Application Management on the Edge	Optimizing Resource Allocation in the Edge: A Minimum Weighted Vertex Cover Approach	- Antonios Makris (HUA) - Emmanouil Maragkoudakis (HUA) - Ioannis Kontopoulos (HUA) - Theodoros Theodoropoulos (HUA) - Ioannis Korontanis (HUA) - Emanuele Carlini (CNR) - Matteo Mordacchini (CNR) - Patrizio Dazzi (CNR)	Jun-24	public	accepted	
Journal	SoftwareX	StreamK3s: A K3s-Based Data Stream Processing Platform for Simplifying Pipeline Creation, Deployment, and Scaling	- Ioannis Korontanis (HUA) - Antonios Makris (HUA) - Alexandros Kontogiannis (HUA) - Iraklis Varlamis (HUA) - Konstantinos Tserpes (HUA)	Jun-24	public	published	https://www.sciencedirect.com/science/article/pii/S2352711024001572
Journal	IEEE Computer Graphics and Applications	MAGES 4.0: Accelerating the world's transition to VR training and democratizing the authoring of the medical metaverse	- Antonis Protopsaltis (ORAMA) - Maria Pateraki (ORAMA) - Manos Kamarianakis (ORAMA) - George Papagiannakis (ORAMA)	Jun-24	public	published	https://ieeexplore.ieee.org/document/10038619
Conference Contribution	IEEE International Conference on Communications 2024	A New Approach for Evaluating the Performance of Distributed Latency-Sensitive Services	Theodoros Theodoropoulos (HUA)	Mar-01	public	accepted	n/a

Journal	Elsevier Computer Communications	GraphOpticon: A Semantics-based Proactive Horizontal Autoscaler for Reduced Resource Consumption	Theodoros Theodoropoulos (HUA)	May-01	public	submitted	n/a
Journal	IEEE IoT Journal	WEST GCN-LSTM: Weighted Stacked Spatio-Temporal Graph Neural Networks for Regional Traffic Forecasting	Theodoros Theodoropoulos (HUA)	Mar-01	public	submitted	n/a

2.9 Contribution to Open-Source Software repositories (KPI 09)

CHARITY is actively contributing to the open-source software community, both in the form of contributions to already existing open-source projects to be used in the project and by means of making finalized software components developed in the project publicly available.

Table 18 outlines the achieved contributions to ongoing open-source projects and contributions of full systems until M18.

Table 18: Contribution to open-source repositories by CHARITY project partners until M18.

Type (Ongoing, Full)	Title / Topic	Link	Date	Partner	Names
Full	An-Encoder-Decoder-Deep-Learning-Approach-for-Multistep-Service-Traffic-Prediction: Deep Learning models which were developed in the context of the paper named "An Encoder-Decoder Deep Learning Approach for Multistep" Service Traffic Prediction"	https://github.com/Efficient-Computing-Lab/Encoder_Decoder-DL	01/06/2021	HUA	Theodoros Theodoropoulos, Konstantinos Tserpes
Full	d-LOOK - A deep learning toolkit; d-LOOK is an automated way to execute various supervised deep learning models	https://github.com/Efficient-Computing-Lab/d-LOOK	23/09/2021	HUA	Antonios Makris, Konstantinos Tserpes
Full	Dynamic Lifecycle Framework: Dynamic Lifecycle Framework for dynamic volume provisioning in K3s	https://github.com/AntonisMakris/datashim	05/12/2021	HUA	Antonios Makris, Konstantinos Tserpes
Full	useElapsedTimeXR React hook: React hook to measure elapsed time using requestAnimationFrame	https://github.com/cyango/use-elapsed-time-xr	23/10/2023	DOTES	Eduarda Ferreira

Full	TRISECT (Time-seRIeS forECasting Toolkit): Simple and automated way to execute various deep learning models for time-series forecasting	https://github.com/Efficient-Computing-Lab/TRISECT	12/04/2024	HUA	Antonios Makris, Konstantinos Tserpes
Full	PACE-Edge: Pro-active Component Image Placement in Edge Computing Environments	https://github.com/Efficient-Computing-Lab/PACE-Edge	12/04/2024	HUA	Antonios Makris, Konstantinos Tserpes
Full	EdgePersist: Package of components that enables edge storage for IoT and smart device edge networks	https://github.com/Efficient-Computing-Lab/EdgePersist	12/04/2024	HUA	Antonios Makris, Konstantinos Tserpes
Full	LoDESS: Locust-Driven Performance Evaluation of Storage Systems - Orchestrates simulated user behaviour to conduct performance tests focusing on read and write operations	https://github.com/Efficient-Computing-Lab/LoDESS	12/04/2024	HUA	Antonios Makris, Konstantinos Tserpes
Full	MinimumVertexCoverAlgorithms: Algorithms for solving the Minimum Vertex Cover Problem	https://github.com/AntonisMakris/MinimumVertexCoverAlgorithms	12/04/2024	HUA	Antonios Makris, Konstantinos Tserpes
Full	SP-FaaS (StreamK3s): A stream-processing Function as a Service (FaaS) solution	https://github.com/Efficient-Computing-Lab/SP-FaaS	12/04/2024	HUA	Antonios Makris, Konstantinos Tserpes
Full	GNOSIS: Learning approach that addresses the Minimum Vertex Cover problem through the combination of Graph Neural Networks and Deep	https://github.com/Efficient-Computing-Lab/GNOSIS	12/04/2024	HUA	Antonios Makris, Konstantinos Tserpes

	Reinforcement Learning.				
Full	EdgeCloud-Mon: Lightweight monitoring tool designed to oversee K3s clusters	https://github.com/Efficient-Computing-Lab/EdgeCloud-Mon	12/04/2024	HUA	Antonios Makris, Konstantinos Tserpes
Full	LLO Operator	https://github.com/OneSourceConsult/llo-operator	2024	ONE, ICT-FI	ONE, ICT-FI
Full	Custom Backend of LLO	https://github.com/OneSourceConsult/llo-backend	2024	ONE, ICT-FI	ONE, ICT-FI
Full	Mesh Merger	https://gitlab.charity-project.eu/ponchio/meshmerger.git	2024	CNR	CNR
Full	HLO	N.A.	N.A.	CNR	CNR
Full	HSPF (Network Traffic Collector,Injection Mechanism, Reporting Interface)	https://github.com/OneSourceConsult/injection-mechanism https://github.com/OneSourceConsult/network-traffic-collector https://github.com/OneSourceConsult/reporting-interface	2024	ONE	ONE

2.10 Advanced Training (KPI 10)

CHARITY project partner support advanced training activities, providing support for MSc and PhD research thesis directly related with the project topics and promoting the use of the CHARITY concept and tools in specialized training courses provided by the academic and public research institutions involved (with the support of the other members of CHARITY consortium), such as advanced master courses.

Table 19 outlines the performed support activities related to advanced training during the duration of the project.

Table 19: Support activities for advanced training by CHARITY project partners until M18.

Y#	Type (MSc, PhD, Training Program)	Title / Dissertation Topic	Start Date	End Date	Partner

Y1	MsC	MSc. Interactive Media	Jun-21	Dec-21	CAI
Y2	MsC	Smart Orchestration on Cloud-Native Environments	Sep-21	Jun-22	ONE
Y2	MsC	Resource Allocation	-	end of Y2	TID
Y2	PhD	Middleware development for the optimal replica placement in distributed key-value stores	-	end of Y2	HUA
Y2	PhD	Identification and modeling of behavioral factors for policy making support	-	end of Y2	HUA
Y3	MsC	Smart Orchestration on Cloud-Native Environments	Sep-15	Sep-9	ONE
Y4	MsC	Smart Orchestration on Cloud-Native Environments	Sep-23	Jun-24	ONE

2.11 Community Building (KPI 11)

Table 20: List of communities in the scope of the CHARITY project. provides an overview of the already formalized communities.

Table 20: List of communities in the scope of the CHARITY project.

Y#	Type	Title / Description	Start Date	Current status	Partner
Y1	Facebook Group	Cyango Virtual Storytelling (https://www.facebook.com/groups/storytellingvirtualtours)	Jan-21	Ongoing	DOTES

2.12 Summary of dissemination and communication activities

Overall, dissemination and communication activities performed by the CHARITY project partners have been successful during the course of the project. The different number of activities established, the participation on events, the submission of papers, and the increasing digital visibility indicate that the project as a whole fulfilled the project objectives and raised awareness among the target audience. Those activities where the project partners actively engaged with key stakeholders by reaching out to potentially interested end-users/adopters of the results of the project and involve them in activities were pivotal to support exploitation and business modelling activities. Table 21 presents the KPIs established to measure the success and effectiveness of the strategy presented in D5.1, which have been closely monitored on a monthly basis to identify any deviations in time or determine if any other actions should be executed to guarantee the effective accomplishment of the committed figures.

Table 21 - Project Dissemination KPIs Comparison

KPI #	Description	KPI to achieve by M42	KPI achieved by M42	Section
KPI 01	Website	6200	7621	2.1
KPI 02	Social Media	900 followers	380 f. Linkedin 193 f. Twitter 45 f. Facebook	2.2
KPI 03	Promotional Materials	12 newsletters released	12# Newsletters released 7 Videos 1 Website 1100 Social Media Post 4 Promotion Interview 5 Promotion Posters 1 Press Releases	2.3.2
KPI 04	Participation in Conferences and other 3rd party events	Research events >= 21 Industry events >= 10 Demos >= 6	36 participations	2.4
KPI 06	Collaboration with other H2020 projects	Reached projects: >= 27	8 Project collaborations	2.6
KPI 08	Publications	Research papers: 27 Other publications: 16	63 papers	2.8

KPI #	Description	KPI to achieve by M42	KPI achieved by M42	Section
KPI 05	Org. of local workshops and int. seminars	500 participants reached	9 Webinars 671 part. reached	2.5
KPI 07	EC Dissemination Mechanisms	Total events = > 6	3	2.7
KPI 09	Open-Source repositories	Contribution to ongoing open-source projects => 6 Contribution of full system =>10	Full Systems: 19	2.9
KPI 10	Advanced Training	Concluded Thesis MSc = > 24 Concluded Thesis PhD = > 6 Impacted training programs => 3	MsC: 5 PhD: 2	2.10
KPI 11	Community Building	# of members > 50	1700	2.11

3 Exploitation

All Exploitation related content and a resume of the activities performed in T5.3 is detailed in Deliverable D5.5.

4 Standardization

The objective of the standardization activities was to investigate the relevant activities from which CHARITY can benefit and ideally to contribute. The most tangible expectation in terms of successful activities, is to identify the standards that would resolve certain CHARITY challenges and adopt them and/or contribute to their further development.

4.1 Performed Activities

Already, at the proposal phase, the consortium had identified several standardization bodies that were relevant to the work that we were planning to conduct. Some missing standardization bodies have been also identified by the consortium during the realization of the Task 5.4. Those bodies and standards are presented in **Erro! A origem da referência não foi encontrada.**. Based on our experience, a contribution to a standard normally takes longer than a project duration and a stronger commitment than that normally feasible in the frame of a collaborative project. As such, we started with a preliminary analysis of technical contributions that the project is inevitably focusing on with its corresponding standards. The objective of this analysis was to identify the contributions that could potentially benefit standard bodies.

Erro! A origem da referência não foi encontrada.

Relevant body (and standardization)		**Applicable CHARITY functionalities**
3GPP	SA4	Specifications of speech, audio, video, graphics and other media codecs for the CHARITY use cases.
	RAN1	Communication of XR devices and other components in the XR service deployment plane.
MPEG	MPEG_MAR	Mixed and Augmented Reality Reference Models established to define required modules, minimal functionalities and the associated information content.
	G-PCC	Includes the procedure to include 3D points structure in a lossless manner by using an octree approach. The use case Holographic Assistant, suitable point cloud formats as like as its real time capable generation, compression and decompression are a strong requirement.
	OMF	Omnidirectional Media Format supports three degrees of freedom which enables omnidirectional media applications - 360° video, images and audio.
IETF	detnet	To facilitate synchronization of specific traffic flows and enable to end-to-end latency.
	dinrg	Decentralized infrastructure for XR service deployments and distributed store management via blockchain.

ITU-T	SG-12	Contribution to quality assessment methods for XR applications.
	SG-13	Contribution to design aspects of network virtualization supported by the CHARITY use case
	Network 2030	To guarantee low end-to-end latency and near-optimal utilization of the available bandwidth for holographic applications
ETSI	ISG MEC	leverage the benefits of deploying service and enabling service migration across MEC hosts/cloud domains
	ISG ZSM	Orchestration across multi-domain XR service ecosystem within a cloud native environment
	ISG NFV	For creating self-managed end-to-end network slices and implementation of the reference architecture of Open-source MANO.
	ARF	Augmented reality framework for interoperation in the highly heterogeneous ecosystem of providers for an AR-related use cases.
Khronos Group	OpenXR	To establish connection between XR devices and the processing engines.
	gITF	Efficient transmission and rendering of 3D scenes and models created by the holographic applications.
EUROCAE, RTCA		Aviation related standards for especially for supporting use case 3

4.1.1 3GPP

3GPP (3rd Generation Partnership Project) is a worldwide consortium of organizations focused on development and maintenance of mobile standards. Ensuring the compatibility in the heterogeneity of the network is the main goal of both 3GPP standard bodies and CHARITY.

5G End-to-End Network Slicing is a recurrent topic addressed in CHARITY WP1 and investigated in WP2. This topic is also present in the different projects developed during the latest three frozen releases (Release 15, 16 and 17). This property of the 5G Systems allows to use multiple types of services and apply them to different network requirements (latency, priority, type of users, etc.) at the same time. This feature is important for the design and implementation of the Charity architecture, and also for the interoperability between operators and service providers.

Moreover, CHARITY project has three main fields of uses cases: virtual reality, extended reality, and cloud gaming. One of them, Extended reality, is also present in the studies of Release 17 by evaluating firstly the performance of XR in terms of power consumption, capacity, mobility and coverage. Therefore, the outcome of CHARITY use cases could help on providing more insights on new Releases.

4.1.1.1 CHARITY support of 3GPP Media Streaming

3GPP media streaming focuses on Release 16 centres on a one-way download and thus envisages frame buffering (on the client and potentially at the edge) as a core component; whereas CHARITY tackles a different problem that focuses on streaming media to a user who has no interactive role in composing that media. However, there are a number of interesting characteristics and design attributes in the 3GPP architecture that can prove useful for CHARITY.

CHARITY aims to be deployable on heterogeneous cloud data networks – whether on the public clouds of hyperscalers or private clouds of enterprises – and optimize media delivery either directly to the 5G User Plane Function or to the specialized 5G Media Streaming downlink (5GMSd) Application Server. New features of the CHARITY media streaming infrastructure spanning the edge and cloud will be considered to support 3GPP Media Streaming.

4.1.2 MPEG

4.1.2.1 Mixed and Augmented Reality (MAR)

The MAR Standard is a reference model established to define required modules, minimal functionalities and the associated information content and models for applications, components, systems, services that must claim compliance with MAR systems. This reference model is agnostic to platforms, used devices and algorithm, and does not specify how MAR applications should be designed, developed, and implemented. The main objective of MAR reference model is to establish a principled way (definitions, main concepts, and architecture overview) needed to create mixed and augmented reality systems or applications as need in CHARITY use cases.

Therefore, CHARITY may contribute an extension to this XR standard in the direction of AR streaming services over 5G cellular systems since the MPEG-MAR XR standard drove the design of the CHARITY platform to suit accordingly the AR (and possibly Holographic) use cases.

4.1.2.2 Geometric Based Point Cloud Compression (G-PCC)

Especially for the CHARITY use case “Holographic Assistant”, suitable point cloud formats with the support of real time capable generation, compression and decompression are a strong requirement. This type of content representation is the ideal input for generating high quality 3D holograms to be presented on holographic 3D display devices based on diffraction and interference of light. Currently, the existing 3D Point Cloud Standards, i.e., G-PCC, are not 100% compatible with CHARITY requirements. Real time capability / high performance and compatibility with holographic 3D are some of the key requirements; hence some extensions or a simplified solution developed and optimized for operation in the CHARITY cloud could be potentially impact the standard.

4.1.2.3 Omnidirectional Media Format (OMF)

OMF is a virtual reality system standard developed by the Moving Picture Experts Group (MPEG to enable omnidirectional media applications - 360° video, images, audio and timed text (text media synchronised with other media).

For CHARITY, especially for the Virtual Reality use case topic, several publicly available implementations compatible with OMF v2 must be evaluated since OMAF v2 fully supports three degrees of freedom (3DOF) at the time of writing this deliverable. The support for six degrees of freedom (6DOF) is still progressing, and will allow for transitional user movement to prompt the rendering of overlays and for multiple viewpoints. The evaluation of these implementations could improve further versions of the OMF standards related to CHARITY use cases.

4.1.3 IETF Detnet and ITU-T Network 2030

Deterministic Networking (DetNet) provides a capability to carry specified unicast or multicast data flows for real-time applications with extremely low data loss rates and bounded latency within a network domain.

CHARITY aims to leverage the DetNet paradigm, as well as get inspired from the design of New IP, initiative which was introduced by the ITU-T Network 2030 Focus group, in order to provide guarantees regarding the network's ability to keep up with the established QoS requirements. Towards this goal, it is essential for a data flow template to be established. This template shall entail information regarding the source, the destination and the desired upper bound of latency. There are two distinct classes of time-sensitive flows that CHARITY aims to facilitate. The first class is indicative of data flows that require extremely low end-to-end latency in the form of the aforementioned upper bounds of latency. This requirement is associated with time-sensitive data flows and more specifically with real-time applications. The second one is associated with the need to properly facilitate the various temporal correlations which are established among some specific data flows. The upper bound of latency which is provided by the next-gen developer will be regarded as a time-stamp which dictates the exact moment that each traffic flow has to arrive at its perspective destination node. The ability of each DetNet flow to arrive at its destination node at a specific moment is guaranteed via the use of Cyclic Queuing and Forwarding protocols like the ones which were examined above. The priority of each traffic flow is established based on its latency-sensitive it is. This type flow prioritization will be leveraged by a Deep Reinforcement mechanism which will be in charge of formulating optimal routing strategies in accordance to the upper bounds of latency. Furthermore, a Traffic Predictions mechanism will be providing estimates regarding the traffic which is expected to take place in the near future. Alongside the information provided by the data flow template, it is essential to offer information about the topology of the network in order to implement centralized configurations in regards to routing and scheduling. These configurations are established via the SDN paradigm which is capable of configuring schedules on the hosts and the forwarding tables of the switches. The contributions on these mechanisms done in WP2 will improve the techniques used in Detnet: 1) reserving data plane resources for individual (or aggregated) DetNet flows in some or all of the intermediate nodes along the path of the flow; 2) providing explicit routes for DetNet flows that do not immediately change with the network topology; and 3) distributing data from DetNet flow packets over time and/or space to ensure delivery of each packet's data in spite of the loss of a path.

4.1.4 ITU-T SG13

ITU-T Study Group 13 works on next-generation networks and now caters to the evolution of NGNs, while focusing on future networks and network aspects of mobile telecommunications.

Cloud computing is an important part of SG13 work, and the group develops standards that detail requirements and functional architectures of the cloud computing ecosystem, covering inter- and intra-cloud computing and technologies supporting XaaS (X as a Service). This work includes infrastructure and networking aspects of cloud computing models, as well as deployment considerations and requirements for interoperability and data portability. Given that cloud computing relies on the interplay of a variety of telecom and IT infrastructure resources, SG13 develops standards enabling consistent end-to-end, multi-cloud management and monitoring of services exposed by and across different service providers' domains and technologies.

An SG13 recommendation focuses largely on inter-cloud and in particular its functional architecture. There is a direct analogy between the inter-cloud relationships and the functionality that one provides to another, and the CHARITY cross domain concept. Even though the specification is complete and rather inactive since 2017, the decision is to keep studying the specification and adapt as many elements as possible.

4.1.5 ETSI Multi-Access Edge Computing AND ISG Network Functions Virtualization

Multi-access Edge Computing (MEC) offers application developers and content providers cloud-computing capabilities and an IT service environment at the edge of the network. This environment is characterized by ultra-low latency and high bandwidth as well as real-time access to radio network information that can be leveraged by applications. In concept this appears as the right answer to the CHARITY application demands.

MEC is largely dependent on ETSI ISG NFV, a group that is charged with developing requirements and architecture for virtualization for various functions within telecoms networks. The NFV Evolution and Ecosystem (EVE) define management and orchestration aspects of a VNF focusing on a new set of management functions about the creation and lifecycle management of the needed virtualized resources for the VNF. VNF Management functions are responsible for the VNF's lifecycle management including operations such as

- Instantiate VNF (create a VNF using the VNF on-boarding artefacts).
- Scale VNF (increase or reduce the capacity of the VNF).
- Update and/or Upgrade VNF (support VNF software and/or configuration changes of various complexity).
- Terminate VNF (release VNF-associated NFVI resources and return it to NFVI resource pool).

Moreover, three main categories of use cases and applications have been already identified as part of the MEC specification: Consumer-oriented services (e.g., augmented and assisted reality, and cognitive assistance), Operator and third party services (e.g., active device location tracking, big data, security and safety, and enterprise services) and last but not least Network performance and QoE improvements (content/DNS caching, performance optimization or video optimization). In the scope of CHARITY, these scenarios will be further researched to understand how they align with the envisioned next generation of distributed AR/VR and Holography-based applications.

Similar in spirit to MEC, CHARITY intends to leverage the benefits of deploying services (i.e., the next generation applications) across the edge/cloud and enabling service migration across MEC hosts/cloud domains - when needed. The previous and extensive MEC work of identifying relevant use cases and architectural solutions is of vital importance to understand the requirements and challenges of these scenarios, i.e., how to decouple these use cases into multiple services and how specific components can be leveraged to manage them. All of these work can be used to better understand, identify the components and tailor the CHARITY architecture to XR services. Moreover, the multi-domain problematic, a key topic already part of the MEC specification, can be seen as a foundational research towards the service orchestration across different domains developed on WP2 and could easily contribute on both standards.

4.1.6 ETSI Zero touch network & Service Management (ZSM)

ISG ZSM from ETSI was formed to discuss relevant use cases, requirements, and specify an E2E management reference architecture that allows such end-to-end service deployments. First, ZSM Management Services, exposed through specific endpoints, allow a more consistent and standardized way to expose different management capabilities across the overall deployment. This is an important factor given the discussed scenarios comprise services spanning over different domains. Second, the ZSM framework specifies an E2E Service Management Domain. Among others, the E2E Service Management domain is responsible by end-to-end orchestration across different domains, E2E closed loop management, E2E analytics, and data collection.

More than E2E deployments, the underlying idea of ZSM is to achieve a level of automation where closed-loop processes and algorithms (e.g., machine learning based orchestration mechanisms) can drive more efficient and flexible scenarios (e.g., a self-monitoring and optimization of the network) and ultimately reduce (or eliminate) the need for human intervention. Indeed, the concept of Closed Loops can occur at both Management Domain and E2E Domain levels.

This ZSM specification is of utmost importance towards the standardization of how applications and services spanning across multiple domains can be fully realized. Such specification includes the definition of how common orchestration functions could be implemented and how the different components can communicate. Inspired by that, CHARITY framework was conceived to achieve such notion of E2E orchestration across multiple domains which will be used to support the deployment of next-generation applications (i.e., the XR services) within a cloud native environment in WP2. Moreover, CHARITY also leverages the notion of closed loops as a structured approach to enable the deployment of both service related orchestration functions and XR specific mechanisms (e.g., adaptive video streaming, to allow applications to adjust to network conditions based on the metrics collected in the real-time or to implement a given security function).

4.1.7 ETSI Augmented Reality Framework

ETSI, as part of its standardization efforts, is currently specifying an Augmented Reality Framework (ARF) whose objective is to provide a transparent architecture for interoperation in the highly heterogeneous ecosystem of providers and technologies that stimulate developers. A reference AR functional architecture was also specified in the same document by the ISG AR group. This architecture targets both fully embedded AR systems and implementations spread over IP networks (e.g. edge/cloud environments).

ETSI specifies relevant components and interfaces required for an AR solution through a set of six use cases centred in industry, whose objective is reducing costs using virtual prototypes and decreasing time-frames of procedures. Each use case contains a description of how their functional steps map into the proposed AR architecture. For some of them, it was stressed the benefits of having different functions running on local, edge or cloud, which ultimately allows a better resource exploitation. T

This use case description and specification is a key aspect explored in CHARITY, but it should be evaluated with the Virtual Reality use cases or whether a unified approach for Mixed Reality Scenarios can be devised.

4.1.8 Khronos group

4.1.8.1 OpenXR

OpenXR is an open standard to connect XR devices and game engines with each other. The goal is to eliminate the various specific implementations to support an XR-device X in game engine Y on platform Z by providing a generic, cross platform application interface to any supported XR device within any supported game engine on multiple

Use case owners planning for using well-known 2D stereo based HMDs within their CHARITY applications could basically make use of OpenXR to increase the bandwidth of supported end user devices. Hence, the various game engines and OpenXR core libraries can access and control the holographic 3D end user device.

4.1.8.2 GL Transmission Format

glTF™ (GL Transmission Format) is a royalty-free specification for the efficient transmission and loading of 3D scenes and models by engines and applications. glTF minimizes the size of 3D assets, and the runtime processing needed to unpack and use them. glTF defines an extensible, publishing format that streamlines authoring workflows and interactive services by enabling the interoperable use of 3D content across the industry.

4.2 Activities performed

As indicated in D2.2, CHARITY conducted an extensive analysis of the actual standards and the work conducted during the duration of the project. Figure 42 summarizes all the standards related to CHARITY.

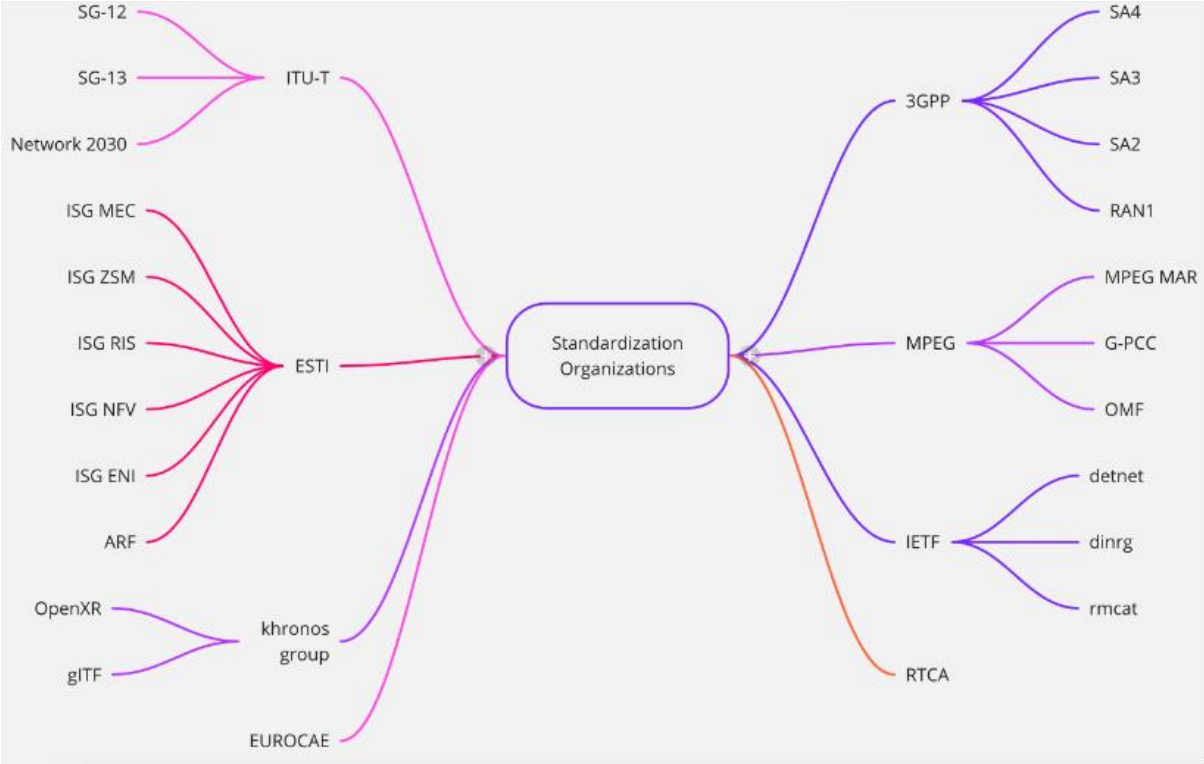


Figure 40: Standardization bodies related to CHARITY

4.2.1 ESTI Standard

After the analysis of the standards, CHARITY decided to focus just on two standards, ESTI ISG MEC and ESTI ARF. Thanks to HPE, CHARITY was able to discuss CHARITY project with the vicepresident Prof. Dr. Dario Sabella. Prof. Sabella was able to go through Deliverable D1.3 and pointed out *"Actually in figure 5, the interconnection between MEC systems is done via MEC Federator (I guess the deliverable didn't consider the last MEC architecture v3.1.1, published in 2022; no issues, let me share the link here)".* However, the architecture of CHARITY was published in Deliverable D1.3 at the beginning of 2023, and not able to include the last advances in the interconnection between MEC systems. Moreover, Prof. Dr. Sabella told us that there was a good opportunity to influence MEC standard, e.g. at least by checking at the requirements in MEC 002, and verifying if you foresee further XR requirements to MEC, or enhancements for any MEC entities. However, CHARITY was not able to find any further generic XR requirement that could influence MEC standard in the next phase. Finally, we decided to have a follow up meeting in a dedicated slot at the f2f MEC. However, our intents to contact ETSI ARF was not fruitful due to the lack of responds to the chair of the ESTI ARF.

4.2.2 InterPlanetary File System (IPFS)

CHARITY contributed to the InterPlanetary File System (IPFS) project. IPFS aims to achieve an entirely decentralized content-addressable media object storage and retrieval platform. IPFS is a community-driven, open source effort, which is vital for ensuring community buy-in and creating an open platform for design innovation. IPFS covers 176 git repositories, across which there have been 60.4 k commits by 1185 code contributors, covering 400+ organizations including universities, start-ups and large corporations.

CHARITY contribution was published in IPFS academic papers since several data collection methodologies was used to evaluate the deployment footprint of IPFS. We find that IPFS infrastructure has been deployed in over 2700 Autonomous Systems, across 464k IP addresses. This covers 152 countries, with the majority hosted in the US and China. We further observe widespread usage by clients with 7.1 million content retrievals seen from a single vantage point on one day alone.

Further, our contribution shows that, although content retrievals in IPFS are slower than direct HTTP access, delays are still reasonable for a number of use cases. For example, 3/4 of retrievals from Europe are under 2 seconds. This includes looking up the content host and fetching a 0.5 MB file. To improve performance, we show how the introduction of gateway caching can substantially reduce retrieval latency with 76 % of requests being served in under 250 ms. While this can form a good use-case for delay-torrent applications, CHARITY conjectured that the current deployment of IPFS will not be able to serve delay-sensitive XR applications.

4.2.3 OASIS TOSCA

CHARITY has developed an Application Management Framework (AMF) component of the CHARITY architecture to define XR applications blueprints, allowing high-level and low-level orchestrators to find and execute the best deployment configuration for different XR application constituents. The AMF is a self-consistent asset that can be reused in contexts different from CHARITY by customizing REST APIS and interfacing with other platform components.

The AMF addresses two main requirements: providing a user-friendly tool for XR application developers to define their services by defining constituent micro-services and specifying their interlinking and communication paths. It also defines a flexible, standards-based representation model for XR services that can be understood by orchestration services to deploy the specified XR service and manage its life-cycle during the workload running lifetime.

To satisfy the first functional requirement, CHARITY has developed a Blueprint Editor, part of a web portal based on a micro-frontend architecture pattern. This modern design allows for flexibility and extensibility, enabling independent development teams to add features and services in full autonomous multi-tenant mode. The editing environment ensures proper isolation of different tenants and access control to the database of generated XR service blueprints.

The XR application blueprint modelling is based on the TOSCA specification, a well-recognized standard for describing orchestrated applications and services, which has been properly extended and customized to define the characteristics specific to the Charity XR applications domain. The model includes design-time specified components and parameters, as well as run-time parameters that are actualized at service instance provisioning time. The AMF is a complete tool for supporting application

developers, particularly XR developers, and has received positive feedback from XR developers within the CHARITY consortium.

To summarize, CHARITY implemented some extensions to the common standard TOSCA language, customizations defined to add specific information instrumental to orchestration of VR/AR/XR class applications and services.

4.2.4 SWForum.eu

SWForum.eu aims to create a self-sustainable online forum that facilitates and encourages both researchers and practitioners as well as projects in software, digital infrastructure and cybersecurity to create intersections of expertise and a multidisciplinary approach to research and innovation. This forum seeks to set in place the European research roadmap and offer cross-fertilisation of competencies to all other research and innovation areas. Morever, SWForum.eu works to enhance the visibility and increase the competitiveness of research and innovation in the field of software technologies, digital infrastructure and cybersecurity, especially European funded Research and Innovation Action (RIA) projects. Moreover, the project aims to introduce best practices and technology transfer opportunities to cross-synergise European excellence.

SWForum invited CHARITY to online webinar "Software Technologies and Standards: Enabling Interoperability and Innovation" on February 21, 2023. The idea of the webinar is to provide an overview and key insights on how software technologies and standards are enabling interoperability and innovation in Europe. Figure shows the advertisement of the webinar and also CHARITY provided some feedback to SWForum Deliverable about the standardization strategies that were performed in CHARITY.

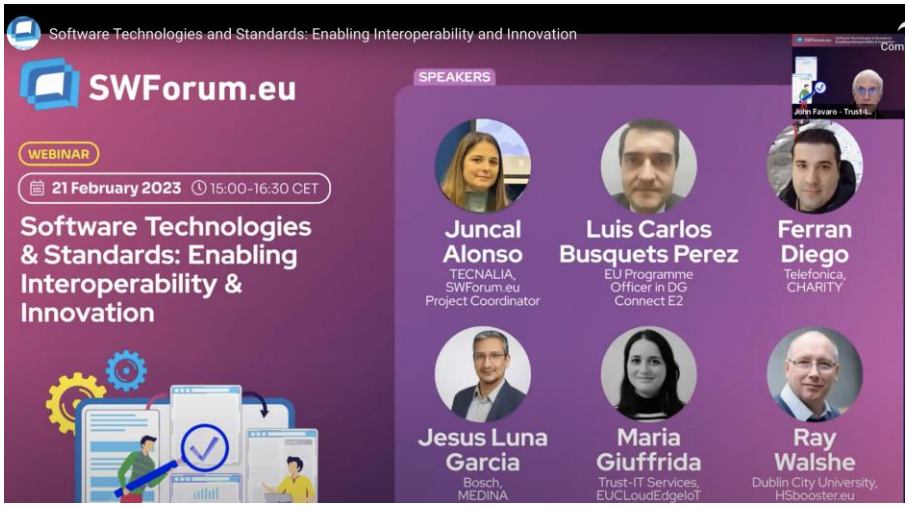


Figure 41: Webinar advertisement.

4.2.5 EUCloudEdgeIoT.eu

The EUCloudEdgeIoT.eu initiative aims to realise a pathway for the understanding and development of the Cloud, Edge and IoT (CEI) Continuum by promoting cooperation between a wide range of research projects, developers and suppliers, business users and potential adopters of this new technological paradigm.

CHARITY played an active role in Task Force 3 – Architecture that focus on three main aspects: (i) enable the architectural discussion among projects around IoT/Edge and Cloud to create a continuum, (ii) identification of the thematic areas and building blocks, and (iii) understanding the contribution of

each project to the thematic areas. Specifically, CHARITY attended several meetings of the working group 5 about the reference architecture of the orchestration. The WG5 minutes show a direct reference of the HighLevel and Low-level orchestrator as shown in Figure .

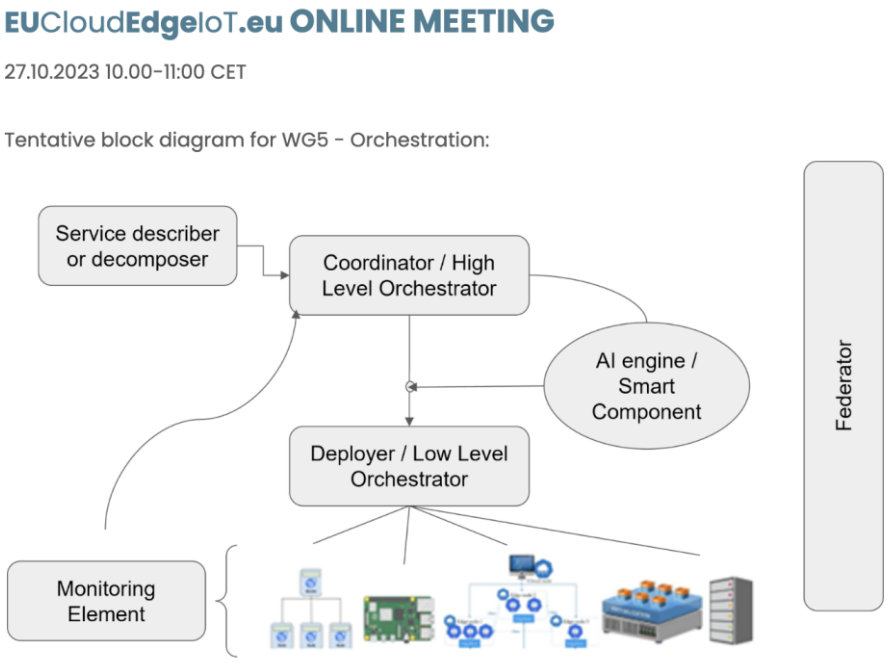


Figure 42: Screenshot from WG5 minutes about reference orchestrator.

5 Conclusions

This deliverable provided a detailed overview of the WP5 activities of the project in its last 12 months of the project life cycle and, moreover, a resume of all the work done within CHARITY project in terms of communication, dissemination and standardization activities (Exploitation activities are treated in D5.5 deliverable, as it was stated previously in this document).

CHARITY project have worked heavily in generating impact on different audiences and stakeholders and in this document we have resumed this effort.

In general we can say that the CHARITY project consortium has made excellent dissemination progress and achieved almost all important KPIs. And more important, a community of CHARITY followers was created and is active in being aware of the project and its results.

From a WP5 perspective, partners have joint efforts to support the planned technical activities as well as participating in relevant events by developing communication items and dissemination activities to reach the target audience.

In addition, all communication material is available on the website and was disseminated widely via social media accounts, both through the various project accounts and H2020 projects CHARITY is collaborating with. CHARITY project partners have organized/participated in many webinars in different areas such as Cloud/Edge and XR together with other H2020 projects, widening the target audience and with the aim of boosting CHARITY project impact on the scientific and societal ecosystem within Europe.