A Lightweight Software Stack and Synergetic Meta-Orchestration Framework
for the Next Generation Compute Continuum

D8.2 Initial Dissemination, Communication, and Exploitation Activities Report

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List of Acronyms

Abbreviation / acronym	Description
5G	Fifth-generation technology standard for broadband cellular networks
AI	Artificial Intelligence
AIOTI WG	The Alliance for Internet of Things and Edge Computing Innovation Working Group
API	Application Programming Interface
AR	Augmented Reality
ATOS	Atos IT Solutions And Services Iberia SL, partner 4 of NEPHELE Consortium
AWS	Amazon Web Services
B2B	Business-to-Business
B2B2C	Business-to-Business-to-Consumer
BAS	Building Automation Systems
BFSI	Banking, financial services and insurance
BI	Business Intelligence
BPaaS	Business Process as a Service
CA	Consortium Agreement
CAGR	Compound Annual Growth Rate
CEI	Cloud-Edge-IoT
CEP	Complex Event Processing
CG	Communication Group
CI/CD	Continuous Integration, Continuous Deployment/Delivery
CNCF	Cloud Native Computing Foundation
CRM	Customer Relationship Management
CSA	Coordination and Support Action
DaaS	Desktop as a Service
DoA	Description of the Action
DT	Digital Twin
Dx.y	Deliverable number y belonging to WP x
EC	European Commission
ECL	Eclipse (NEPHELE partner)
EMS	Energy Management System
ERCIM	GEIE ERCIM, partner 16 of NEPHELE Consortium
ESN	Emergency Service Network
ETSI	European Telecommunications Standards Institute
EU	European Union
FBA	FundingBox Accelerator sp. zo.o., partner 7 of NEPHELE Consortium
FBC	FundingBox Communities SL, affiliated entity or linked third party of FBA in NEPHELE Consortium
FSTP	Financial Support of Third Parties (Open Calls)
FUN	Future Ubiquitous Networks
GA	Grant Agreement

GDPR	General Data Protection Regulation
GW	Gateway
HDA	Hyper Distributed Applications
HDAG	Hyper Distributed Applications Graph
HDAR	Hyper Distributed Applications Registry
HW	Hardware
IaaS	Infrastructure as a Service
IBM	IBM Ireland Limited, partner 13 of NEPHELE Consortium
ICOS	IoT-Cloud Operating System
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IG	Internet Group
IIoT	Industrial IoT
IM	Information Model
IoT	Internet of Things
IPCEI	Important Projects of Common European Interest
IPO	Initial Public Offering
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
KER	Key Exploitable Result
KPI	Key Performance Indicator
LTE	Long-Term Evolution, i.e., 4th generation of mobile networks
LPWAN	Low Power WAN
M2M	Machine-to-Machine
ML	Machine Learning
MRI	Magnetic Resonance Imaging
Mx	Month x of the project
NB-IoT	Narrow Band IoT
NFV	Network Function Virtualization
NGSI	Next Generation Service Interfaces
OMA	Open Mobile Alliance
OSM	Open Source Management and orchestration
OSPO	Open Source Program Offices
PaaS	Platform as a Service
PEST	Political, Economic, Social and Technological - refers to management method/analysis whereby an organisation can assess major external factors that influence its operation in order to become more competitive in the market
PPDR	Public Protection and Disaster Relief
QoS	Quality of Service
RAN	Radio Access Network
R&D	Research and Development
RFID	Radio Frequency Identification

ROS	Robotic Operating System
SaaS	Software-as-a-Service
SDN	Software-Defined Networks
SME	Small and Medium-sized Enterprise
SN	Social Networks
SNS-JU	Smart Networks and Services - Joint Undertaking
SoA	State of the Art
SW	Software
SWOT	Strengths, Weaknesses, Opportunities, and Threats - refers to a method for identifying and analysing internal strengths and weaknesses and external opportunities and threats that shape current and future business operations
TCO	Total Cost of Ownership
TETRA	TErrestrial Trunked RAdio
TRL	Technology Readiness Level
TSN	Time-Sensitive Networking
UAE	United Arab Emirates
UAV	Unmanned Aerial Vehicle
UC	Use Case
UN	United Nations
USD	US Dollar
VO	Virtual Object
VOs	Virtual Objects
VR	Virtual Reality
WAN	Wide-Area Network
W3C	World Wide Web Consortium
WG	Working Group
WoT	Web of Things
WP	Work Package
WWW	World Wide Web
ZHAW	Zürcher Hochschule fúr Angewandte Wissenschaften, partner 17 of NEPHELE Consortium

Executive Summary

In the present deliverable, we provide a detailed report on the progress towards the implementation of the dissemination, communication and exploitation strategies and plans presented in the deliverable D8.1 "Dissemination, Communication and Exploitation Plan". This document describes main KPIs and outcomes achieved during the current project period (until M18). A third update and final version of this deliverable will be produced at M36 in D8.3.

The major dissemination and communications means, channels and procedures that are used by NEPHELE have been thoroughly defined and described in the dissemination plan in D8.1. These include both "conventional" approaches, such as participation in events, publications, and creation of printed material, and web related activities. This deliverable reports on the results achieved so far in each of the activities. NEPHELE extensive use of online dissemination is also summarized together with KPIs, showing the use of both the NEPHELE website and the relevant social media channels.

The detailed project exploitation plan and strategy have been prepared and are outlined in the present deliverable, including the updated list of the NEPHELE exploitable outputs and the relevant exploitation plans of the involved partners. Several important relationships have been also established with related projects and initiatives also in the area of open-source community building, that can be used for dissemination purposes. Finally, an initial report on the standardization activities will be provided.

1 Introduction

1.1 Purpose of the document

This deliverable is a follow-up document of deliverable D8.1 "Dissemination, Communication and Exploitation Plan" where the strategy for dissemination, communication, standardisation, open-source communities, and exploitation, along with the implementation of the project website and social networks have been described.

The primary purpose of D8.2 - "Initial Dissemination, Communication, and Exploitation Activities Report" is to report on the Dissemination, Communication and Exploitation activities implemented in the first 18 months of the project to promote information and its outcomes to the defined target groups. The current deliverable provides a detailed account of the work carried out by NEPHELE in this domain, with particular emphasis on the fulfilment of the pre-defined key actions on the defined target audiences, adopting the pre-defined KPIs.

The document aims to:

- Follow up with the communication, dissemination, standardisation, exploitation, and open-source strategies and, in case needed, introduce enhancements and modifications.
- Report on communication, dissemination, standardisation, exploitation, and open-source activities performed by the partners.
- Report on the KPIs achieved to report the success of this WP.
- Report on synergies with other projects and initiatives.

1.2 Relation to other project work

The progress of the activities of WP8 tasks follows the progress of the results obtained in the other WPs, especially when it comes to dissemination and exploitation activities. Moreover, the activities in WP7 with the Open Calls are also strongly linked to the dissemination and communication results for the project.

1.3 Structure of the document

This document is structured in 7 major sections:

- **Section 2** presents the initial report on communication activities.
- **Section 3** presents the initial report on dissemination activities.
- **Section 4** presents the initial report on standardisation activities.
- **Section 5** presents the initial report on the exploitation activities.
- **Section 6** presents the initial report on the open-source, community building and sustainability activities.
- **Section 7** presents a status update and future roadmap for the KPIs.

2 Initial Report on Communication Activities

This section contains the updates related to NEPHELE website, the social network activity, marketing materials, videos, media coverage, and collaborations with other projects during this reported period.

2.1 Website

During the reported period, the website has been growing and was regularly updated with news and contents reflecting the consortium activities.

The main improvements during this period have been done in the News and Library sections.
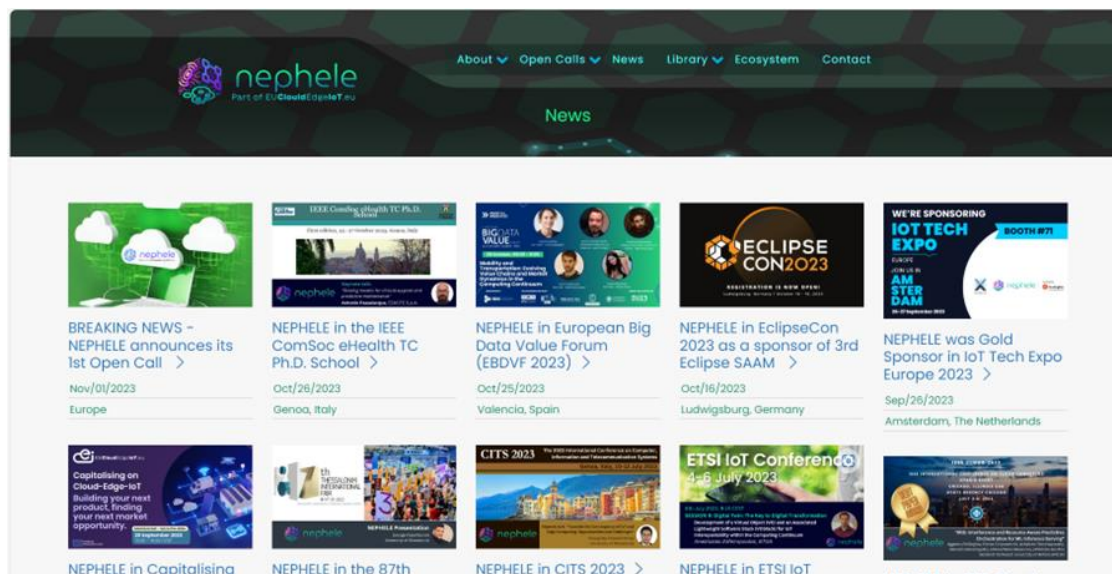
Figure 1: NEPHELE website - News section screenshot
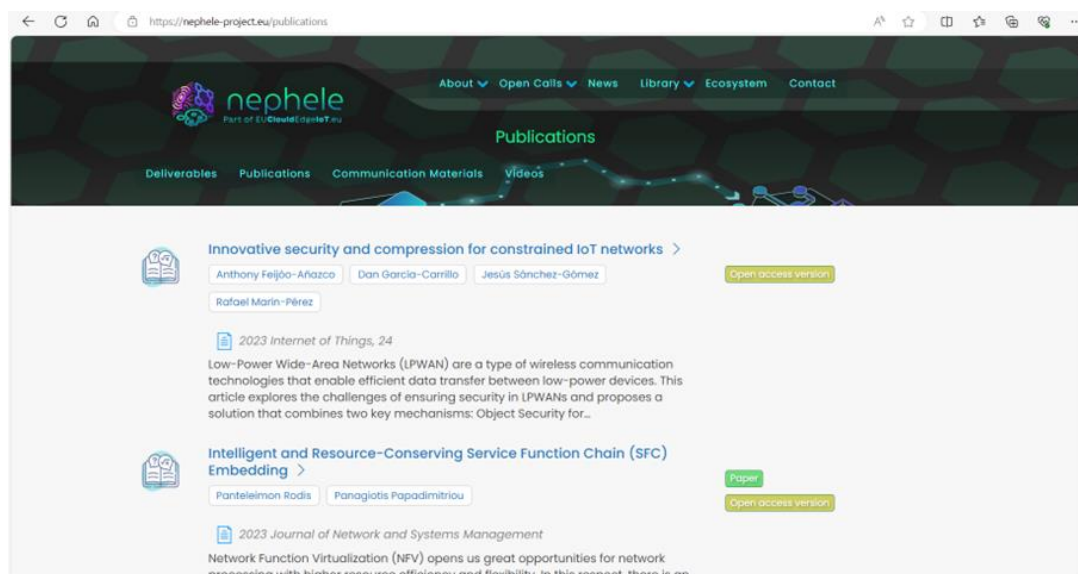
Figure 2: NEPHELE website - Library section/Publications screenshot

A section to promote NEPHELE Open Calls - which includes information about the call and a link to a page that provides support to participants, a Guide for Applicants, FAQ and contact email - has also been created.
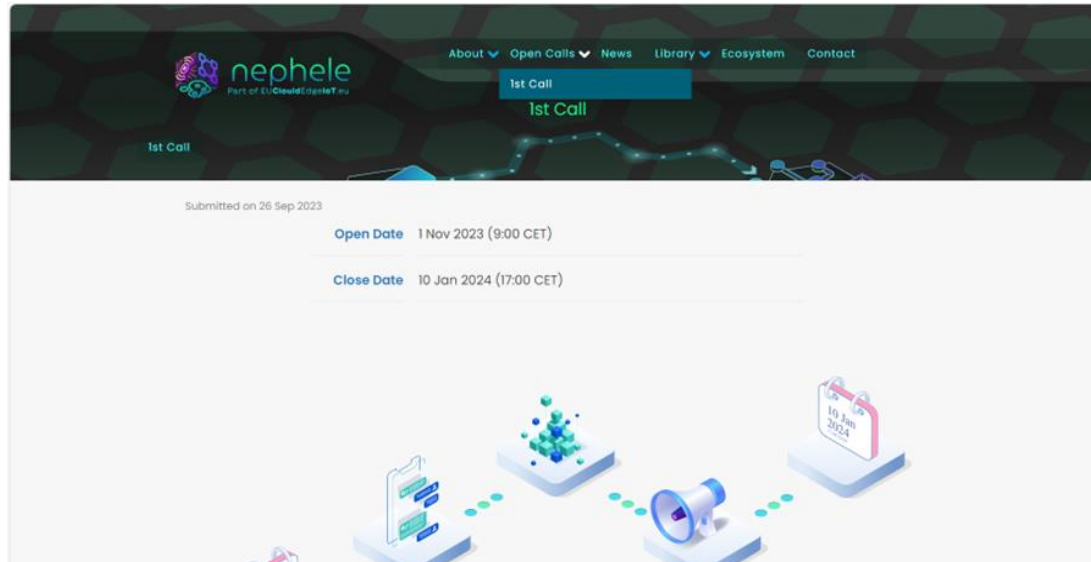
Figure 3: NEPHELE website – Open Calls section screenshot

Another section that is currently experiencing a notable transformation is Use Cases. Firstly, this section included a short description of the use cases as envisaged in the proposal in a single option of the main menu. The project is currently better defining the use cases requirements. New contents and diagrams are being provided for each use case and now each use case has its own section.

Figure 4: NEPHELE website – Open Calls section screenshot

2.1.1 Website statistics

During the first months, Google Analytics statistics were implemented in the NEPHELE website. However, in March 2022 Google had unexpectedly announced a change from UA (Universal Analytics) to GA4 (Google Analytics 4). Initially, we found that the new tool was very complete; it could be very practical for commercial websites, but the large amount of data offered was not easy to use for a research project. On the other hand, when the website visitors do not accept cookies, their data is not registered, so in May 2023 we noticed that the unique visitors count proved to be very inconsistent.

These are the unique visitors figures from the first months with GA4:

M1	M2	M3	M4	M5	M6	M7	M8	M9
Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
0	1	114	305	387	532	527	293	84

Figure 5: Google Analytics Statistics – results registered September2022- May 2023

To address this inconvenience and get more reliable figures, AWStats was implemented in the ATOS webserver from June 2023 (M10). These statistics can be found here:

https://newarisrv51.atosresearch.eu/awstats/awstats.pl?config=nephele-project.eu

AWStats is allowing us to have reliable figures about the unique visitors, seen as the average number of users visiting NEPHELE domain in the analysed period.

The following figure shows the summary of unique visitors, number of visits, pages, hits and bandwidth from 1st June 2023 to 19th February 2024, reported by year.

Summary					
Reported period	Year 2023				
First visit	01 Jun 2023 - 06:28				
Last visit	31 Dec 2023 - 23:46				
	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Viewed traffic *	<= 14,313 Exact value not available in 'Year' view	21,359 (1.49 visits/visitor)	66,531 (3.11 Pages/Visit)	243,051 (11.37 Hits/Visit)	8.47 GB (415.87 KB/Visit)
Not viewed traffic *			20,844	40,621	691.15 MB

* Not viewed traffic includes traffic generated by robots, worms, or replies with special HTTP status codes.

Summary					
Reported period	Year 2024				
First visit	01 Jan 2024 - 00:19				
Last visit	19 Feb 2024 - 09:18				
	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Viewed traffic *	<= 4,510 Exact value not available in 'Year' view	8,301 (1.84 visits/visitor)	26,228 (3.15 Pages/Visit)	83,954 (10.11 Hits/Visit)	5.10 GB (644.42 KB/Visit)
Not viewed traffic *			6,253	13,523	342.23 MB

* Not viewed traffic includes traffic generated by robots, worms, or replies with special HTTP status codes.

Figure 6: NEPHELE website statistics – Summary June - December 2023 and January - February 2024

The total sum of unique visitors at the end of this first reported period (on 19th February 2023, including the 2243 visitors registered with GA4) is 21066. Notice that this figure is more than **20 times greater than the initial target for this KPI** that was estimated at >1000 by M36.

The graph below shows the summary of unique visitors, number of visits, pages, hits and bandwidth from 1st June 2023 to 19th February 2024, reported by month.

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2023	0	0	0	0	0
Feb 2023	0	0	0	0	0
Mar 2023	0	0	0	0	0
Apr 2023	0	0	0	0	0
May 2023	0	0	0	0	0
Jun 2023	1,523	2,222	6,222	25,480	1.02 GB
Jul 2023	1,528	2,051	5,959	26,745	937.18 MB
Aug 2023	1,666	2,219	5,348	18,544	903.96 MB
Sep 2023	1,678	2,463	8,011	29,290	1.17 GB
Oct 2023	2,446	3,607	11,660	36,923	1.16 GB
Nov 2023	2,683	4,267	14,290	51,456	1.61 GB
Dec 2023	2,789	4,530	15,041	54,613	1.71 GB
Total	14,313	21,359	66,531	243,051	8.47 GB

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2024	3,087	5,455	17,281	57,231	1.91 GB
Feb 2024	1,423	2,846	8,947	26,723	3.19 GB
Mar 2024	0	0	0	0	0
Apr 2024	0	0	0	0	0
May 2024	0	0	0	0	0
Jun 2024	0	0	0	0	0
Jul 2024	0	0	0	0	0
Aug 2024	0	0	0	0	0
Sep 2024	0	0	0	0	0
Oct 2024	0	0	0	0	0
Nov 2024	0	0	0	0	0
Dec 2024	0	0	0	0	0
Total	4,510	8,301	26,228	83,954	5.10 GB

Figure 7: NEPHELE website statistics June - December 2023 and January - February 2024

With this implementation, we have detected that overall, the number of unique visitors by month has been progressively increasing from June 2023 (1523 unique visitors) to January 2024 (3087 unique visitors). Please notice that at the moment of closing this deliverable Section - 19th February 2024- last reporting month has not finished yet.

2.2   Social Media

2.2.1   X (formerly Twitter)

NEPHELE profile in the social network formerly known as Twitter (now X) started to be active in September 2022. Since then, we have an increasing number of followers until reaching 130 in February 2024. However, the following graph reveals that especially during the last months, since July 2024, the trend is that our number of followers is remaining almost stable, without experiencing a big increase.
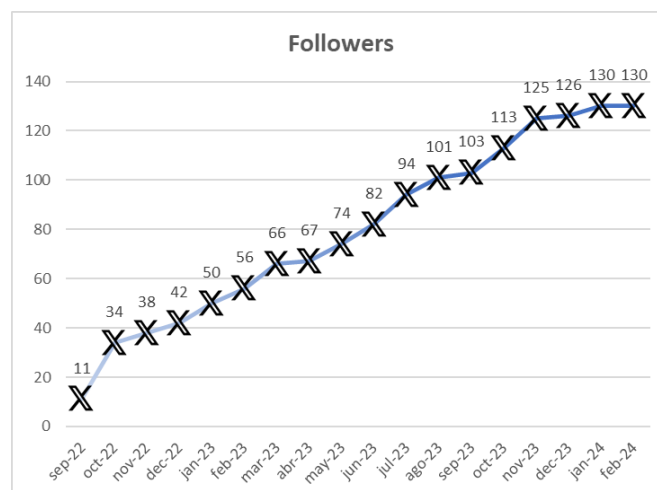
Figure 8: NEPHELE followers' evolution in X (September 2022 – February 2024)

This stability is good if we consider the big changes that Twitter/X has experienced during the last years. Elon Musk announced its deal to acquire Twitter and completed it in October 2022. Since then this

social network has experienced a rebranding, a change of name and policies. According to web analytics provider SimilarWeb [1] in September 2023, monthly active users for X/Twitter had dropped 15% worldwide. Forbes [2] also reflected that Twitter/X experienced an overall downward trend through 2023. However, SimilarWeb also showed in December 2023 a 6,06% traffic increase. General trends are not clear enough yet and we still do not know if we could reach our estimated KPI of 250 followers by month 36. Despite it, we consider that Twitter is still an interesting social network to disseminate our activity and results.

The following graph shows the number of NEPHELE published posts compared with the number of impressions on each month during the reported period. It is interesting to observe the rapid growth during the first months of activity, in December 2022- January 2023. It also reveals that the peak of 30 publications through April 2023 did not produce a proportional peak of impressions. We have changed our publications policy by increasing, when possible, the number of relevant tags.

The number of publications between 5 and 15 is estimated as optimum for getting enough impressions amongst our followers.
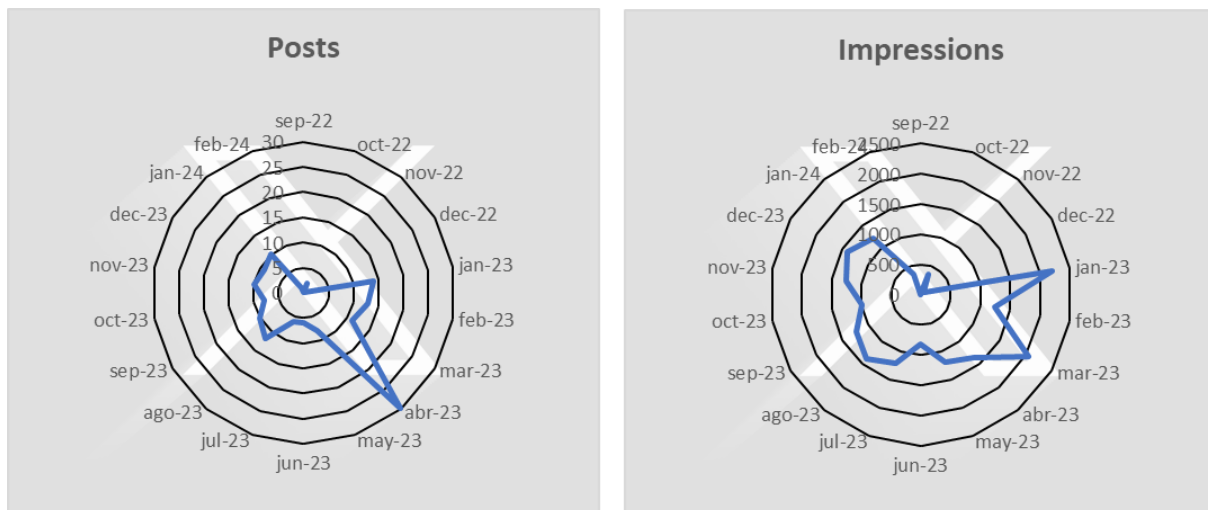
Figure 9: NEPHELE number of posts vs impressions on X (September 2022 – February 2024)

The trends previously described are also appreciated in the next graph which shows the engagement rate by month during the reported period. It is remarkable that we reached peaks of engagement (8-9%) in March, May and June 2023 and February 2024. But from July 2023, coincident with the changes in the social network, the media of the engagement rate is still increasing, but more stable and with lower peaks (7%)
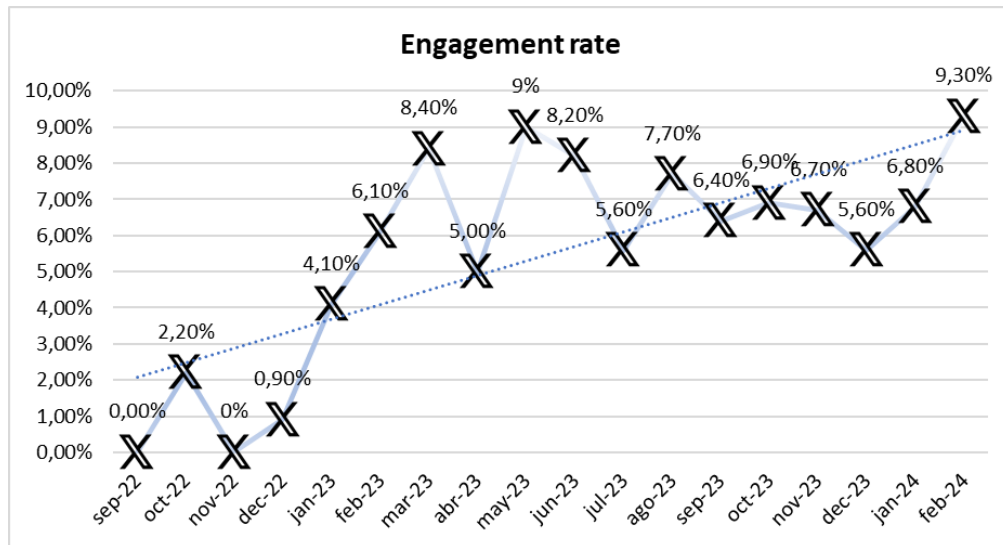
Figure 10: NEPHELE Engagement rate evolution in X. (September 2022 – February 2024)

2.2.2   LinkedIn

NEPHELE LinkedIn followers rose steadily, starting at around 23 followers in our first month of real activity (December 2023) and reaching 306 followers (on February 19, 2024).

The graph below shows that after a higher increase in the first effective two months (December 2022-January 2023), the increment of followers from month to month remained smoother until April 2023, with a increment peak on May 2023 and a notable increment of users from October 2023 to now. We think that is due to migration of users from X/Tweeter to our LinkedIn group.
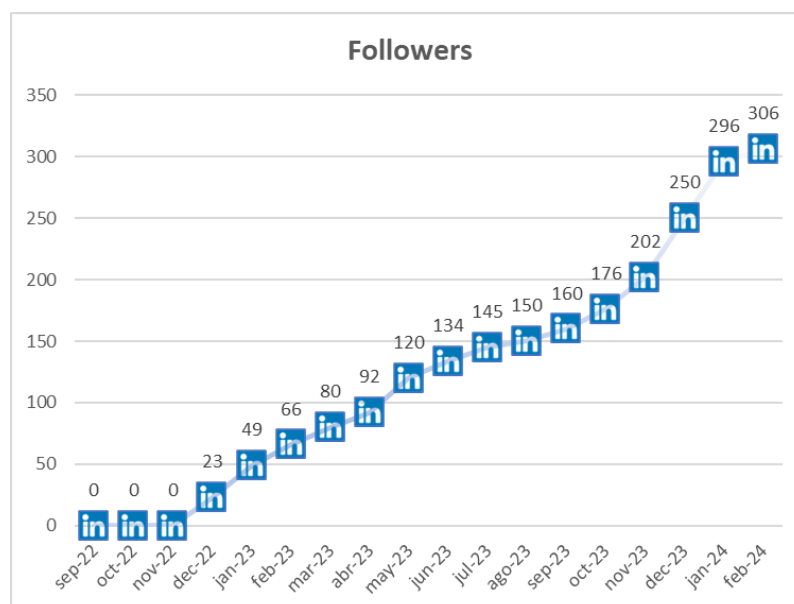
Figure 11: NEPHELE followers evolution in LinkedIn (September 2022 – February 2024)

The following graph shows the number of NEPHELE published LinkedIn posts compared with the number of impressions on each month during the reported period. It is interesting to notice that the peak of posts in February 2023 was not followed by a big number of impressions.

Besides that, we have tried to keep the number of posts by month between 7 and 12. The first peak of impressions appears in July 2023 (due to several posts related to videos and papers and to our attendance to several important events). From December 2023 to February 2024, we have reached a higher and remarkable number of impressions. In December 2023 and January 2024, we had a noticeable increase in the visitors probably related to our 1st Open Call; we have been also producing contents about the use cases and other specialised long posts that proved to be very attractive to our users.
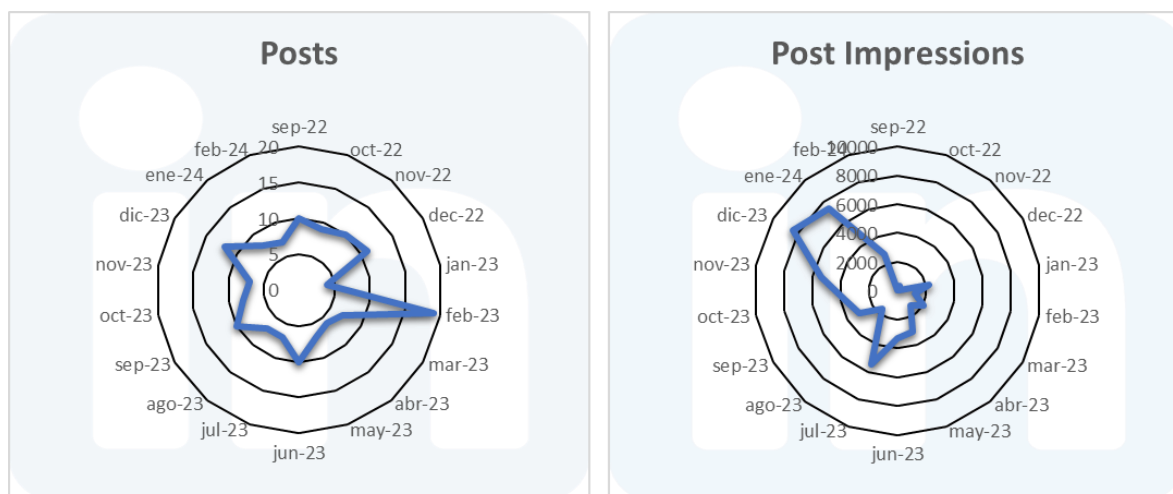
Figure 12: NEPHELE number of posts vs impressions on LinkedIn (September 2022 – February 2024)

The next graph shows the engagement rate by month during the reported period. The engagement rate had big peaks in March, May and September 2023, very similar to the engagement rate also detected in Twitter/X. From October 2023 the engagement rate oscillations have been reduced. (Figures from February 2024 cannot be considered, as fluctuations have been noticed especially at the end of each month).
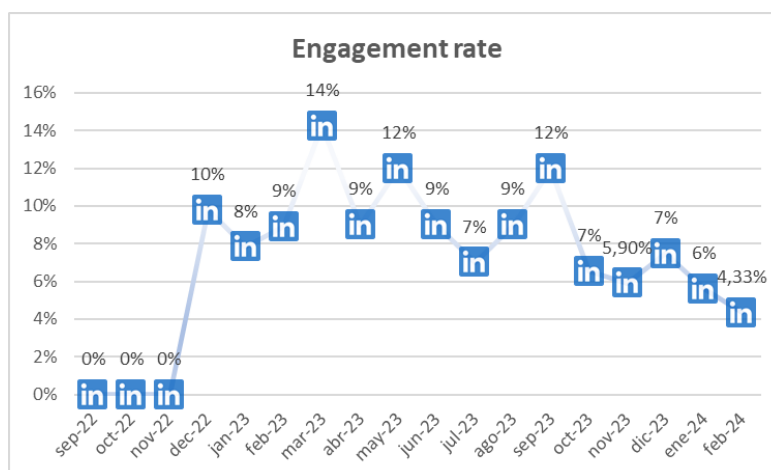
Figure 13: NEPHELE Engagement rate evolution on LinkedIn (September 2022 – February 2024)

2.2.3 YouTube Channel

Videos available in NEPHELE are not only available from our website; the videos recorded on our own are being uploaded to our NEPHELE YouTube Channel - which allow us to control the number of views for each video.

https://www.youtube.com/@nepheleproject6432
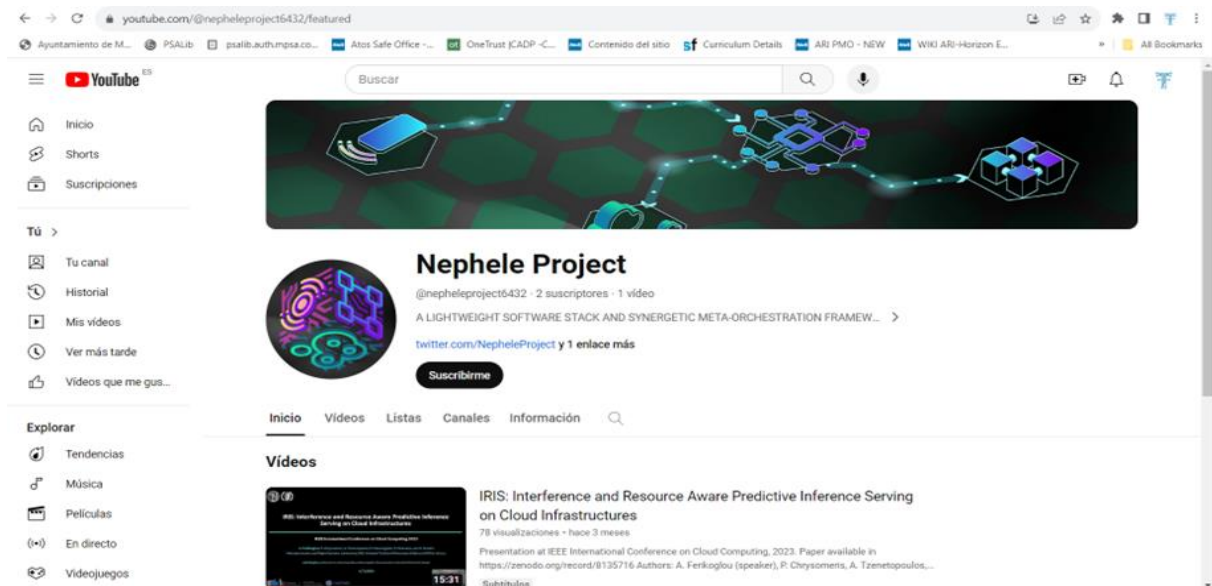
Figure 14: NEPHELE YouTube Channel

The total number of views of the available videos in our channel are now 203 (19th February 2024).
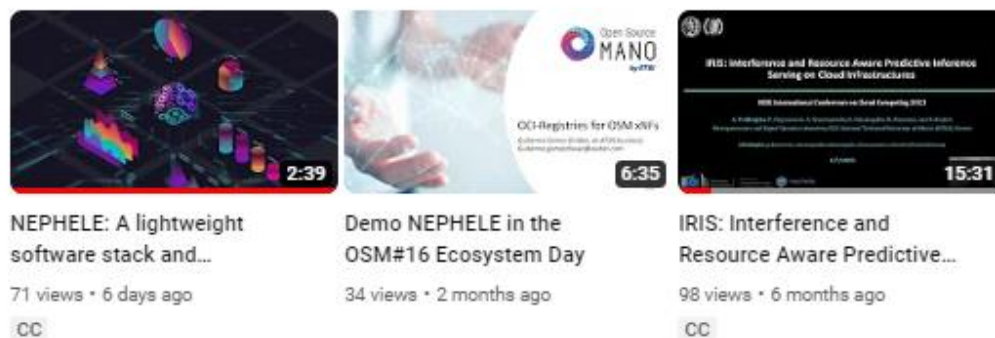
Figure 15: Videos and views in NEPHELE YouTube Channel

At the end of this reporting period, the first official NEPHELE video has been also produced. This video has 71 views in only 6 days (https://www.youtube.com/watch?v=yA_N2TvcH2s&t=158s).
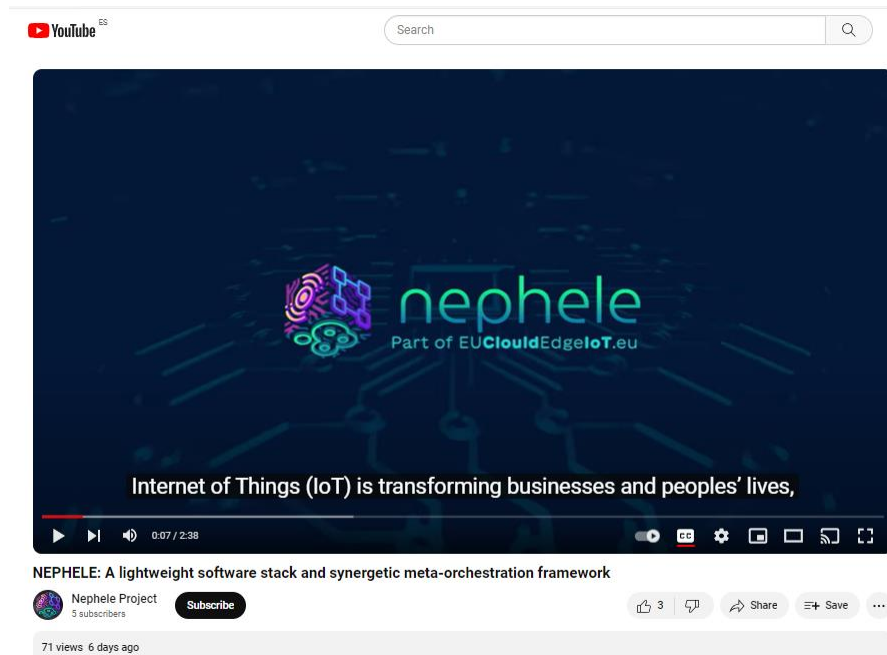
Figure 16: Official video in NEPHELE YouTube Channel

2.3 Marketing Materials

Our Library section includes four subsections: Deliverables, Publications, Communication Materials and Videos.

Deliverables

This section includes the title and description of NEPHELE project deliverables by work package. After approval by EC after the project reviews, NEPHELE public deliverables will be uploaded to this section to make them available to be downloaded and promoted in our social networks.
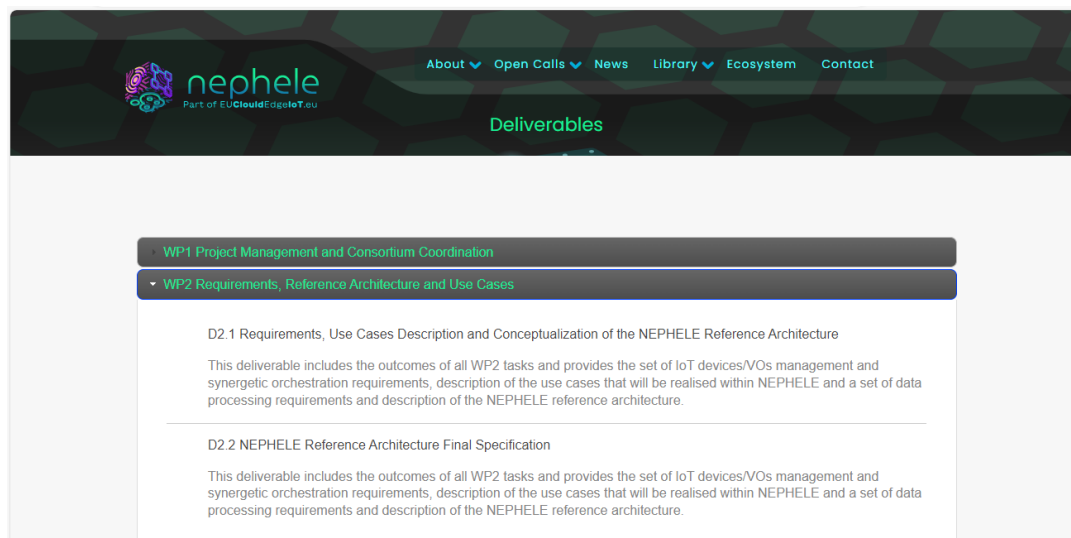
Figure 17: Deliverables section in NEPHELE website

Publications

This section offers access to the scientific publications related to NEPHELE produced by consortium members in conferences and journals. The button "Paper" is linked to the publication and the button "Open Access Version" is linked to our version of the same paper in Zenodo. You can also click in the name of any author to see all the papers about NEPHELE of that author.
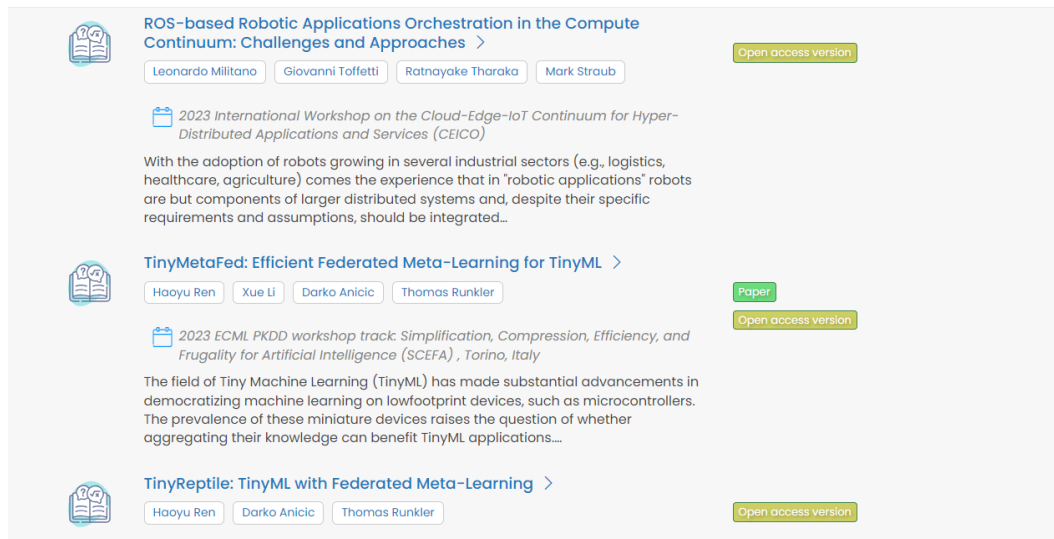
Figure 18: Publications section in NEPHELE website

Communication materials

This section offers the following materials to be downloaded:

- NEPHELE poster
- NEPHELE roll-up
- NEPHELE Project leaflet
- NEPHELE Newsletters: 2 newsletters have been produced during the reported period (M1-M18) and one more will be available in M19 (Newsletters are promoted in our social networks.)

Figure 19: Communication materials subsection

Videos

This website subsection includes not only our own videos that are in our YouTube channel but also those related to NEPHELE provided by other websites. In general, these videos contain presentations of our project and interviews to our partners related to our project and recorded during their participation in some dissemination events.
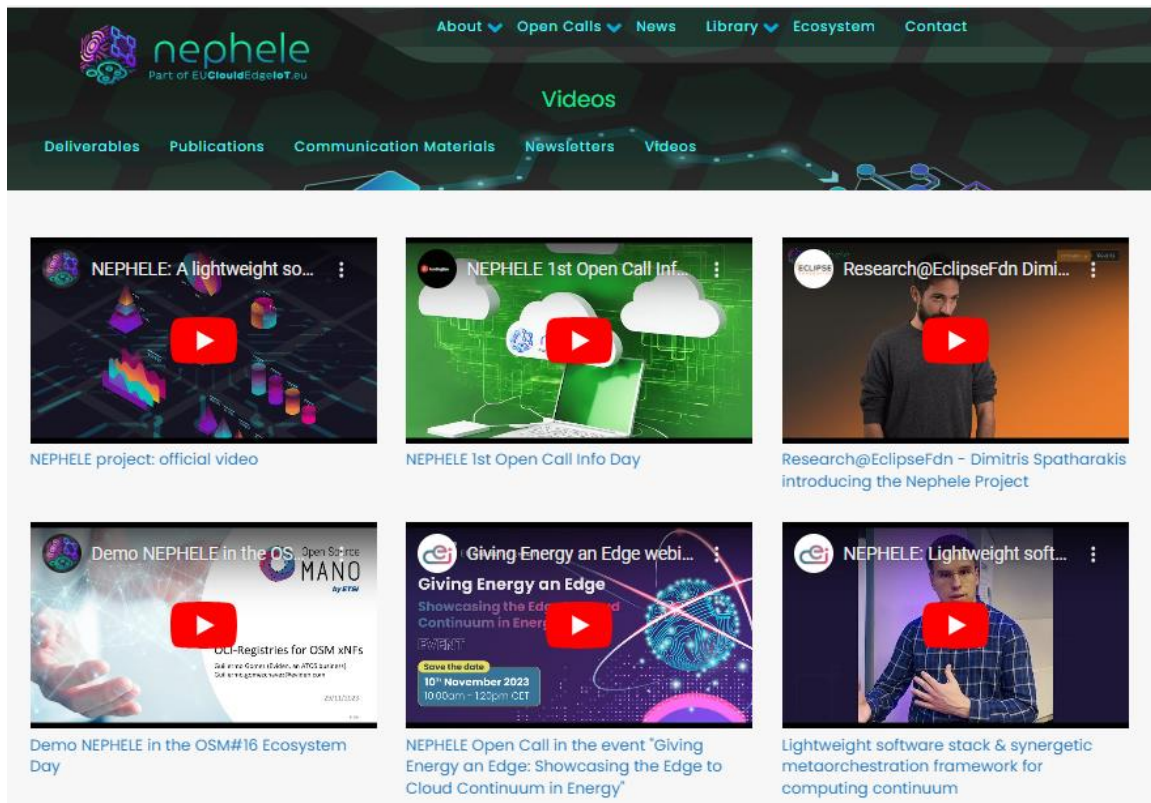
Figure 20: Video subsection in NEPHELE website

2.4 Media Coverage

A press release has been created for the announcement of our First Open Call.

This press release is available in our News section:

BREAKING NEWS - NEPHELE announces its 1st Open Call | Nephele (nephele-project.eu)

2.5 Collaboration with Other Projects in the Call

During this period, NEPHELE took part in several EUCloudEdgeIoT (AIOTI and Open Continuum and UNLOCK-CEI CSAs) events. This is a summary of the activities that have also been reflected in the entries of the News section of the NEPHELE website (https://nephele-project.eu/news) and our LinkedIn community (https://www.linkedin.com/company/nephele)

1. **AIOTI (Alliance for IoT and Edge Computing Innovation) webinar "IoT, Cloud, Edge Computing Continuum: from research to deployment" (30/11/2022).** Leonardo Militano, from ZHAW (Zurich University of Applied Sciences) presented NEPHELE's 1st Use Case:

"Emergency and Disaster Recovery". The webinar agenda included presentations from sibling EU projects AEROS, FLUIDOS, ICOS and NEMO, among other projects related to the topic.

2. **EUCloudEdgeIoT Task Force 2 and 3 Workshop - MetaOS project cluster: defining common open-source stacks** (18/01/2023). NEPHELE - represented by Anastasios Zafeiropoulos and Dimitris Soudris - reached out EUCloudEdgeIoT TF2 and TF3 for organising the first F2F meeting of all the six MetaOs projects (NEPHELE, AEROS, FLUIDOS, ICOS, NEBULOUS and NEMO) about standards in Toulouse (France). ECLIPSE (Marco Jahn) had a very important role in this meeting. This event established the initial relation with other MetaOS projects under the common interest of open source. It is also reflected in section 6 of this document.

3. **Workshop 2 - Task Force 5 "Market and Sectors"** (13/02/2023): This was the second workshop in a series focused on discussing how to develop market ready and sustainable Cloud-Edge-IoT use cases in several projects; our cluster has divided all use cases into smaller workshops according to different topics. On behalf of NEPHELE Leonardo Militano from ZHAW, and Nathalie Milton and Hazem Chaabi from INRIA attended the event. Hazem briefly presented NEPHELE Use Case 1. Commonalities and potential synergies with other use cases from other projects were widely discussed. Within the same workshop, Rudolf Susnik from ININ presented NEPHELE Use case 2 and Elena Torroglosa from ODINS presented NEPHELE Use Case 3.

4. **Common taxonomy for EU MetaOS workshop** (03/04/2023): One of the objectives of EUCloudEdgeIoT is to develop a shared taxonomy for European MetaOS projects. For this workshop, experts from NEPHELE, ICOS, aerOS, FluiDOS, NebulOuS and NEMO funded projects were invited to join the discussion about defining the terms to be included. Our technical coordinator Anastasios Tazeiropoulos from NTUA, and Panagiotis Papadimitriou, Ilias Sakellariou and Georgios Papathanail from UoM attended this meeting on behalf of NEPHELE.

5. **EC Concertation and Consultation Meeting on Computing Continuum Event: From Cloud to Edge to IoT** (Brussels, 10-11/05/2023): Several EC representatives, including project officers and directors, attended the event. A NEPHELE presentation and a rollup were prepared for this event, and Anastasios Zafeiropoulos (NTUA) represented our project. There was a "RIAs Guided Tour" session around the posters on the first day of the event, in which the EC representatives and other experts were guided across the project posters. A "RIAs Pitch Session" was held, in which we had the opportunity to briefly present its project goals, expectations and vision. And - last but not least - a "EUCEI Research Community Booklet" including relevant information about all the projects was made available for the event.

6. **IDC TF5 Online workshop for MetaOS projects "Cloud-Edge-IoT Skills Demands For Adoption"** (18/05/2023): NEPHELE and other MetaOS projects - NEMO PROJECT, aerOS Project and NebulOuS - attended this workshop organised by IDC in the framework of EUCloudEdgeIoT Task Force 5 activities for the MetaOS projects. Elena Torroglosa from Odin Solutions was in charge of leading Session 4, "Energy management in smart buildings and cities".

7. **AIOTI webinar: presenting Open Call Opportunities (07/06/2023):** This webinar listed Open Call Opportunities in European projects in the next months and explained how to present proposals. The agenda included a slot for Open Call Opportunities in the MetaOS projects. Diana Järve presented FundingBox.

8. **Webinar "Capitalising on Cloud-Edge-IoT: Building your next product, finding your next market opportunity" (20/09/2023):** This online event included information on the funding

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opportunities through open calls organised by the MetaOS projects, Diana Järve from FundingBox explained NEPHELE Open Call.

9. **AIOTI Innovative SME Showcase** **(06/11/2023):** This webinar presented IoT, cloud and edge computing funding opportunities for SMEs in European Commission, CEI and NGI (The Next Generation Internet) open calls. Other European project open calls like AEROS, ICOS, NebulOuS and TARGET-X were also introduced in the event.

10. **"Giving Energy an Edge: Showcasing the Edge to Cloud Continuum in Energy"** **(10/11/2023):** This event addressed innovations of the Cloud-Edge-IoT Continuum in Energy sector and critical challenges of energy infrastructure, adaptability, and electrification of heat and mobility and featured engaging presentations, interactive sessions, open calls and networking opportunities. Anastasios Zafeiropeoulos presented the NEPHELE open call opportunities for SMEs. Alejandro Arias from Odin Solutions presented the Energy Management in Smart Buildings/Cities use case in NEPHELE. Both participated in the breakout sessions.

11. **"Cloud-Edge-IoT Innovations in Agriculture and Crisis Management: Exploring Data Spaces, Value Chains, and Practical Applications"** **(20/02/2024)**: This UNLOCK-CEI webinar, part of the EUCloudEdgeIoT.eu initiative provided industry insights for the agriculture sector, with a specific focus on cloud-edge-IoT use cases. The event was co-organised with MetaOS projects and the AgriDataSpace project. On behalf of NEPHELE this event was attended by Leonardo Militano from ZHAW with a presentation related to disaster recovery. Leonardo also participated in a panel discussion with industry experts.

12. **ECS Brokerage Event 2024** **(20-21/02/2024)**: The ECS Brokerage Event in Brussels combined the brokerage activities of the industry associations AENEAS, EPoSS and INSIDE into one networking event dedicated to project proposals in the field of Electronic Components and Systems for the Chips JU Calls 2024 for the non-initiative part (ex KDT). This event gathered the ECS community around project ideas, allowing it to network, build consortia and start creating project proposals. Our Technical Coordinator Anastasios Tafeiropoulos from NTUA will showcase NEPHELE at this event. This event counted more than 400 participants and is expected to provide broad promotion and visibility for NEPHELE on the INSIDE Industry Association social media channels.

Also, NEPHELE collaborated with the following projects/events:

1. Open Source MANO (See OSM#16 Ecosystem Day in section 3.1.3 - 16)
2. aerOS: co-organiser - with NEPHELE - of a workshop in EBDVF 2023 (see section 3.1.3 -15)
3. EMERALDS: co-organiser - with NEPHELE - of a workshop in EBDVF 2023 (see section 3.1.3 -15)
4. GREEN.DAT.AI: co-organiser - with NEPHELE -of a workshop in EBDVF 2023 (see section 3.1.3 -15)
5. FLUIDOS: co-organiser - with NEPHELE - of a workshop in IEEE Future Networks World Forum (see section 3.1.3 -22)
6. OASEES: co-organiser - with NEPHELE - of a workshop in IEEE Future Networks World Forum (see section 3.1.3 - 22)
7. RIGOUROUS: co-organiser - with NEPHELE - of a workshop in IEEE Future Networks World Forum (see section 3.1.3 - 22)
8. HORSE: co-organiser - with NEPHELE - of a workshop in IEEE Future Networks World Forum (see section 3.1.3 – 22)
9. NEMO: co-sponsor - with NEPHELE - of TENSOR 2023 (see section 3.2)
10. CODECO: co-sponsor - with NEPHELE - of eSAAM 2023 (see section 3.2)

2.6 Other communication events, prizes and awards

NEPHELE participated in the "**RIAs Challenge 2024**" and was selected as one of the winners. Our project received an invitation to join and present our project to the ECS Brokerage Event 2024 (Brussels, 20-21 Feb 2024) and an interview that was published on issue #6 of **INSIDE Industry Association magazine**, a bi-yearly publication that counts 6500+ subscribers from the the field of Electronic Components and Systems community.
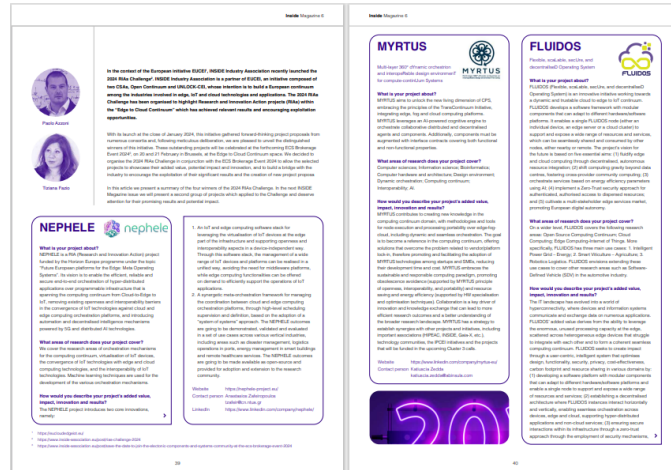
Figure 21: NEPHELE interview on INSIDE Industry Association Magazine - Issue 6, February 2024

It is also expected that this award will provide broad promotion and visibility of our project on the INSIDE Industry Association social media channels.

3 Initial Report on Dissemination Activities

In this section we cover in detail the dissemination activities which have taken place in the first 18 months of the project. Our dissemination strategy so far has laid good groundwork for ensuring impactful dissemination, as we look towards the second half of the project duration.

The channels that will be outlined in this section are:

- Scientific journal and conference papers;
- Technical demos and presentations;
- Technical workshops and project events;
- Open calls;
- Project deliverables.

3.1 Scientific journal and conference papers, technical demos and presentations

Several peer-reviewed scientific articles have been published by NEPHELE project partners until M18 of the project life. In the following subsections we list the journal papers, the conference and workshop papers, and technical demos and presentations published and presented by the NEPHELE partners. All publications at conferences and workshops listed in Section 3.1.2 were also presented by one of the NEPHELE partners. Zenodo allows us to have a control of the number of views and download of each NEPHELE paper. At this moment (19th February 2024) we have reached a total of 620 views and 665 downloads of papers with acknowledgement to NEPHELE in Zenodo.
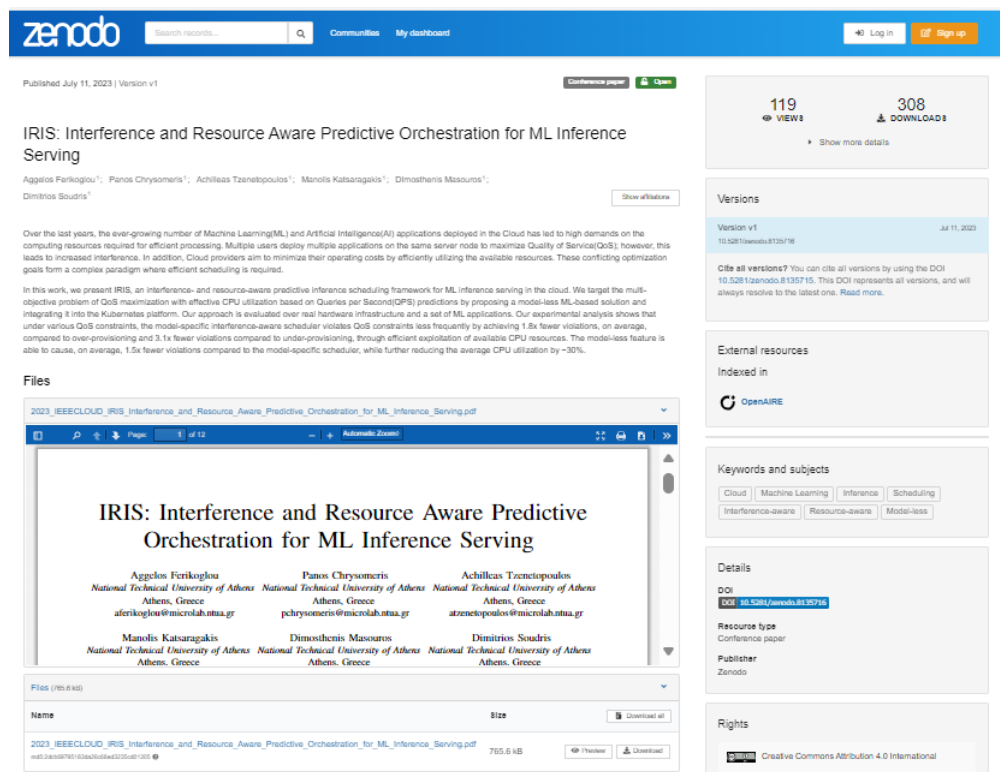
Figure 22: NEPHELE paper in Zenodo

Our most popular paper is Ferikoglou, A., Chrysomeris, P., Tzenetopoulos, A., Katsaragakis, M., Masouros, D., & Soudris, D. (2023, July). IRIS: Interference and Resource Aware Predictive

Orchestration for ML Inference Serving. In *2023 IEEE 16th International Conference on Cloud Computing (CLOUD)* (pp. 1-12). IEEE, doi: https://doi.org/10.5281/zenodo.8135715 with 119 views and 308 downloads (19th February 2024).

3.1.1　Journal Publications

1. Militano, L., Arteaga, A., Toffetti, G., & Mitton, N. (2023). The Cloud-to-Edge-to-IoT Continuum as an Enabler for Search and Rescue Operations. *Future Internet*, 15(2), 55, doi: https://doi.org/10.3390/fi15020055
2. Rodis, P., & Papadimitriou, P. (2023). Intelligent and Resource-Conserving Service Function Chain (SFC) Embedding. *Journal of Network and Systems Management*, 31(4), 81, doi: https://doi.org/10.1007/s10922-023-09771-y
3. Rodis, P., & Papadimitriou, P. (2023). Unsupervised Deep Learning for Distributed Service Function Chain Embedding. *IEEE Access,* vol. 11, pp. 91660-91672, 2023, doi: https://doi.org/10.1109/ACCESS.2023.3308492
4. Papadopoulos, K., Papadimitriou, P., & Papagianni, C. (2023). Deterministic and Probabilistic P4-Enabled Lightweight In-Band Network Telemetry. *IEEE Transactions on Network and Service Management,* vol. 20, no. 4, pp. 4909-4922, Dec. 2023, doi: https://doi.org/10.5281/zenodo.10522552
5. Feijoo-Añazco, A., Garcia-Carrillo, D., Sanchez-Gomez, J., & Marin-Perez, R. (2023). Innovative security and compression for constrained IoT networks. *Internet of Things*, *24,* 100899, https://doi.org/10.5281/zenodo.10638695
6. Filinis, N., Tzanettis, I., Spatharakis, D., Fotopoulou, E., Dimolitsas, I., Zafeiropoulos, A., Vassilakis, C., & Papavassiliou, S. (2024) Intent-driven orchestration of serverless applications in the computing continuum, *Future Generation Computer Systems*, Volume 154, Pages 72-86, ISSN 0167-739X, https://doi.org/10.5281/zenodo.10620887

3.1.2　Conference and Workshop Papers

7. Bolla, R., Bruschi, R., Lombardo, C., Mangialardi, S., Mohammadpour, A., Rabbani, R., & Siccardi, B. (2023, January). A Multi-Tenant System for 5/6G Testbed as-a-Service. In *2023 15th International Conference on COMmunication Systems & NETworkS (COMSNETS)* (pp. 768-773). IEEE, DOI: 10.5281/zenodo.10654015, https://doi.org/10.5281/zenodo.10654015
8. Gallego-Madrid, J.; Hermosilla, A.; Bernal-Escobedo, L., Asensio-Garriga, R., Pogo-Medina, A.; Diez-Revenga, J.S.; Sanchez-Iborra, R.; Skarmeta, A.F. Virtual On-board Unit Migration in a Multi-access Smart-Campus 5G Architecture. *IEEE Future Networks World Forum (FNWF),* https://doi.org/10.5281/zenodo.10625002
9. Katsaragakis, M., Masouros, D., Papadopoulos, L., Catthoor, F., & Soudris, D. (2023, May). On the Implications of Heterogeneous Memory Tiering on Spark In-Memory Analytics. In *2023 IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW)* (pp. 945-952). IEEE, doi https://doi.org/10.5281/zenodo.10683723
10. Papathanail, G., Mamatas, L., & Papadimitriou, P. (2023, June). Towards the Integration of TAPRIO-based Scheduling with Centralized TSN Control. In *2023 IFIP Networking Conference (IFIP Networking)* (pp. 1-6). IEEE, doi: https://doi.org/10.5281/zenodo.10077654
11. Spatharakis, D., Dimolitsas, I., Genovese, G., Tzanettis, I., Filinis, N., Fotopoulou, E., ... & Papavassiliou, S. (2023, June). A Lightweight Software Stack for IoT Interoperability within the Computing Continuum. In *2023 19th International Conference on Distributed Computing in Smart Systems and the Internet of Things (DCOSS-IoT)* (pp. 715-722). IEEE, doi: https://doi.org/10.5281/zenodo.10620911.
12. Zafeiropoulos, A., Fotopoulou, E., Vassilakis, C., Tzanettis, I., Lombardo, C., Carrega, A., & Bruschi, R. (2023, June). Intent-Driven Distributed Applications Management Over Compute and Network Resources in the Computing Continuum. In *2023 19th International Conference*

on Distributed Computing in Smart Systems and the Internet of Things (DCOSS-IoT) (pp. 429-436). IEEE, doi: https://doi.org/10.5281/zenodo.10620928.

13. Ren, H., Anicic, D. and Runkler, T.A., (June 2023). TinyReptile: TinyML with Federated Meta-Learning. In *2023 International Joint Conference on Neural Networks (IJCNN)* (pp. 1-9). IEEE, doi: https://zenodo.org/records/10263474

14. Ferikoglou, A., Chrysomeris, P., Tzenetopoulos, A., Katsaragakis, M., Masouros, D., & Soudris, D. (2023, July). IRIS: Interference and Resource Aware Predictive Orchestration for ML Inference Serving. In *2023 IEEE 16th International Conference on Cloud Computing (CLOUD)* (pp. 1-12). IEEE, doi: https://doi.org/10.5281/zenodo.8135715

15. Ren, H., Li, X., Anicic, D. and Runkler, T.A. ,(September 2023). *TinyMetaFed: Efficient Federated Meta-Learning for TinyML.* arXiv preprint arXiv:2307.06822, doi: https://zenodo.org/records/10263404

16. Toffetti, G., Militano, L., Tharaka, R., Straub, M., (2023, December) ROS-based Robotic Applications Orchestration in the Compute Continuum: Challenges and Approaches. *International Workshop on the Cloud-Edge-IoT Continuum for Hyper-Distributed Applications and Services (CEICO).* IEEE ACM, doi https://doi.org/10.5281/zenodo.10648949

17. Papathanail, G., Mamatas, L., Theodorou, T., Sakellariou, I., Papadimitriou, P., Filinis, N., Spatharakis, D., Fotopoulou, E., Zafeiropoulos, A. , Papavassiliou, S., A Virtual Object Stack for IoT-Enabled Applications Across the Compute Continuum, *International Workshop on the Cloud-Edge-IoT Continuum for Hyper-Distributed Applications and Services (CEICO).* IEEE ACM, doi: https://doi.org/10.5281/zenodo.10363418

3.1.3   Technical Demos and Presentations

1. HiPEAC poster presentation High Performance, Edge And Cloud Computing Conference (HiPEAC) 2023

   On behalf of NEPHELE, Dimitrios Soudris from NTUA, presented a NEPHELE poster in the STEM/Industrial poster session in Toulouse on January 17, 2023, in the HiPEAC 2023 parallel program. The objective was to share the NEPHELE vision with the HiPEAC participants, given that this conference is the premier European forum for experts in computer architecture, programming models, compilers and operating systems for general-purpose, embedded and cyber-physical systems. Further information is available here.

2. Mobile World Congress MWC 2023

   The Mobile World Congress (MWC) in Barcelona is the largest and most influential event for the connectivity ecosystem. Global mobile operators, device manufacturers, technology providers, vendors, content owners and people interested in the future of tech come together under one roof. Tens of thousands of senior executives from the top global companies, international governments and trailblazing tech businesses converge at this event. NEPHELE was represented at this event by UOM. Further information is available here.

3. Embedded World

   The Embedded World Exhibition & Conference provides a global platform and a place to meet for the entire embedded community, including leading experts, key players and industry associations. Panagiotis Papadimitriou from UOM gave a presentation of the NEPHELE project at the booth of Eclipse Foundation. Further information about the event can be found here.

4. EENA Conference & Exhibition 2023

   EENA conference is a yearly organised conference and exhibition aiming at presenting and learning on trends in the public safety industry, EU legislation updates, retaining staff, the well-

being of call-takers to real-life examples of new technology in use. The event is organised by EENA - the European Emergency Number Association, a non-governmental organisation whose mission is to contribute to improving people's safety & security. At the event, which took place 19. - 21. April 2023 in Ljubljana, ININ has presented certain parts of its NEPHELE related work, which is applicable to the fields covered by the EENA. The programme of the event is available here.

5. Concertation and Consultation on Computing Continuum: From Cloud to Edge to IoT

The Concertation and Consultation on Computing Continuum: From Cloud to Edge to IoT event was organized in Brussels, Belgium, the 10-11 May 2023 within the context of the European, Cloud, Edge and IoT Continuum initiative by the OpenContinuum consortium in close collaboration with the UNLOCK-CEI and SW Forum projects and guided by the European Commission DG CNECT E.2 and E.4 Units. The audience was mainly made by European Commission and EC projects involved stakeholders. In this event over 100 participants were reached and NEPHELE was presented. A short presentation was provided on behalf of the NEPHELE project by Anastasios Zafeiropoulos from NTUA during a pitch session, followed by a short discussion regarding the main challenges faced for the development of meta-orchestration solutions. Furthermore, a roll-up banner from NEPHELE was provided in the room of the session during both days, while a short video was produced where we highlighted the approach followed by NEPHELE. Further information is available here.

6. ETSI IoT Conference 2023 (ETSI IoT Week 2023)

The ETSI IoT Conference, in the framework of the ETSI IoT Week, offered attendees the opportunity to learn and share experiences related to IoT technologies, services, activities, requirements, looking at present and future standardization work. The 2023 edition included IoT demonstrations and offered keynote speeches, presentations, interactive panels, IoT demonstrations and many networking opportunities. NEPHELE was introduced in "SESSION 9 – Digital Twin: The Key to Digital Transformation" that took place on July 6, 2023. The technical manager of NEPHELE, Anastasios Zafeiropoulos from NTUA, gave a presentation of the project, titled "*Development of a Virtual Object (VO) and an Associated Lightweight SoftwareStack (VOStack) for IoT Interoperability within the Computing Continuum*". Further information is available at the conference website.

7. CITS 2023

Panagiotis Papadimitriou from UOM delivered a keynote talk in relation to NEPHELE project, titled "*Towards the Convergence of IoT and Edge Computing: Opportunities and Challenges*" at the IEEE International Conference on Computer, Information, and Telecommunication Systems (CITS 2023). This conference is an international forum for scientists, engineers, and practitioners to present their latest research and development results. The conference featured tutorials, technical paper presentations, and keynote talks. Further information is available at the conference website.

8. Path to the digitization of the economy and local communities

The workshop "Pot do digitalizacije gospodarstva in lokalnih skupnosti" (in English: "Path to the digitization of the economy and local communities"), taking place on 26. September 2023 in Ljubljana has been organised by the Agency for Communication Networks and Services of the Republic of Slovenia and supported by the Ministry of Digital Transformation and Ministry of the Economy, Tourism and Sport of the Republic of Slovenia. The main subject of the event was the introduction of radio spectrum available for non-public 5G networks in Slovenia and related forthcoming auction. Besides presenting potential benefits and some use cases targeting

industry and smart cities, certain solutions already available or under development have been presented at the exhibition part of the event. ININ has, among other achievements, presented its NEPHELE related work and its potential benefits for smart cities and industry applications. Link to the event information and ININ's dissemination post are here and here.

9. 87th Thessaloniki International Fair

George Papathanail from UOM showcased the NEPHELE project at the 87th Thessaloniki International Fair (TIF) in the booth of University of Macedonia. TIF constitutes an annual international trade fair held annually in Thessaloniki, Greece. It is one of the most significant events of its kind in Southeast Europe and serves as a platform for businesses, industries, and professionals to showcase their products and services. The fair typically features exhibitions from various sectors, including technology, industry, agriculture, commerce, and more. TIF attracts both Greek and international exhibitors and visitors. Further information about the 87th TIF is available here.

10. IoT Tech Expo 2023

The IoT Tech Expo 2023 in Amsterdam, a premier event for the latest advancements in Internet of Things technology, provided a dynamic platform for professionals to engage, collaborate and explore cutting-edge IoT innovations. On September 27th, the 1st Open Call of NEPHELE was presented by Urszula Sobek, the Senior Project Manager from FundingBox, during the "Get Public Funding for your Tech SME – A Quick and Easy Guide" presentation. Links to the Linkedin promotion can be found here, here and here.

11. European Researchers' Night

The CNIT team at the University Mediterranea of Reggio Calabria presented NEPHELE during the European Researchers' Night (24-29 September 2023) and showcased the innovative features and capabilities of NEPHELE, highlighting its potential to revolutionize the future of wireless communications, see link here.

12. EclipseCon

EclipseCon is the leading conference for developers, architects, and open-source business leaders, organized by ECL. ECL and NTUA showcased NEPHELE at the Eclipse Research booth which aims at establishing interaction between researchers and the open-source community. Over 400 participants from the open-source community were reached at EclipseCon2023 which was organized in Luwdisburg, Germany on October 17-19th, 2023. Furthermore, NTUA and SIEMENS participated in the IoT Working Group Community Day and discussed the way forward for the integration of VO Stack and Eclipse ThingWeb. Further information is available at the conference website.

13. EBDVF 2023

Dimitrios Spatarakis from NTUA presented NEPHELE in the workshop session "Mobility and Transportation: Evolving Value Chains and Market Dynamics in the Computing Continuum". The session explored the impact of Cloud-Edge-IoT applications on the transportation sector, covering topics such as autonomous vehicles, traffic management and green mobility. The session was co-organized by aerOS, NEPHELE, EMERALDS and GREEN.DAT.AI projects together with the EUCloudEdgeIoT.eu initiative as a part of the European Big Data Value Forum 2023, organised by the Big Data Value Association, in collaboration with various academic and research institutions, and has been granted with the Spanish Presidency auspice. The event was open to professionals and researchers interested in cloud, edge, IoT, and related

topics, including Artificial Intelligence and ICT security and was particularly relevant for those involved in the transportation and mobility sectors. The conference featured presentations on several mobility use cases and solutions, followed by a panel discussion with industry and R&D experts. Key topics included the impact of research projects on the future of the Computing Continuum and the current industry challenges such as energy shortages. A report of the event can be found here.

14. eHealth TC Ph.D. School IEEE "Sharing models for clinical support and predictive maintenance"

ESAOTE provided a presentation at this event presenting a concise introduction to medical ultrasound devices and how NEPHELE will support them. The focus of this presentation revolves around different projects related to connectivity. The presentation showcased how ultrasound devices are evolving to integrate seamlessly with modern connectivity solutions, enabling real-time data transmission, remote monitoring, and predictive maintenance capabilities. Some more information can be found on our website.

15. IEEE Future Networks World Forum

Antonio Skarmeta, Jorge Gallego and Ana Hermosilla from ODINS delivered a scientific paper in relation to the NEPHELE project, titled "Virtual On-board Unit Migration in a Multi-access Smart-Campus 5G Architecture" at the IEEE Future Networks World Forum (FNWF) - S07: Symposium on Future Networks for Connected and Automated Mobility (CAM) · 14 Nov. 2023. This conference is an international forum organized by IEEE for scientists, engineers, and researchers to present their latest research and innovation results. The conference featured scientific paper presentations, and keynote talks. The symposium also included the workshop "Beyond current 5G architectures for 6G services". This workshop was supported by NEPHELE and other projects (FLUIDOS, OASEES, RIGOUROUS, HORSE). Workshop co-chairs were Antonio Skarmeta, Diego R. López (Telefónica), Chen Tao (VTT Finland), Akis Kourtis (Demokritos, Greece), Slawomir Kuklinski (WUT, Poland), Symeon Papavassiliou (NTUA, Greece) and Pascal Bisson (Thales, France). See link to the program here.

16. OSM#16 Ecosystem Day

Open Source MANO (https://osm.etsi.org/) is an EU funded ETSI-hosted project to develop an Open Source NFV Management and Orchestration (MANO) software stack aligned with ETSI NFV. As a community-led project, OSM delivers a production-quality MANO stack that meets operators' requirements for commercial NFV deployments. On 29/11/2023, Guillermo Gómez presented the demo: "OCI-Registries for OSM xNFs -Novel storage and distribution approach for xNFs artefacts to improve interoperability of devs, xNF providers and MNOs, by leveraging commercial-grade implementations of the OCI specifications". Sessions are recorded and published in the YouTube channel of the OS Mano project and promoted in their social media. The agenda of the event is available here.

3.2 Project events and workshops

Technical workshops give NEPHELE the opportunity to share our research and findings with some of our key audiences. Until M18, three technical workshops have been organized by NEPHELE partners.

The first workshop "3rd International Workshop on Time-Sensitive and Deterministic Networking (TENSOR) 2023" was organized by UOM and Telefonica, as a joint activity between NEPHELE and

NEMO projects. TENSOR 2023 took place in Barcelona on June 12, 2023, and was attended by over 30 experts, researchers, and members of the Time-Sensitive Networking research community. The workshop offered an invaluable opportunity to network with our stakeholders, conduct two-way communication and gain useful feedback – particularly regarding the research being discussed. Proceedings available here.

The second workshop "International Workshop on the Cloud-Edge-IoT Continuum for Hyper-Distributed Applications and Services (CEICO) 2023" was a joint organization by NTUA and ZHAW (proceedings to be published soon). The workshop took place in Taormina on the 5th of December 2023 and was co-located with the 16th IEEE/ACM International Conference on Utility and Cloud Computing (UCC 2023). It was attended by over 30 researchers, and members of the Cloud-Edge-IoT continuum research community. Also, this workshop offered a great opportunity to network with peers and discuss ongoing research and innovation activities. Proceedings to be published soon.

The third one, eSAAM2023 - 3rd Eclipse Security, AI, Architecture and Modelling Conference on Cloud to Edge Continuum was co-organized by ECL, co-located with EclipseCon2023 and sponsored by NEPHELE (and EUCloudEdgeIoT, NEMO, and CODECO). The conference, orgnized in Ludwigsburg, Germany, brought together industry experts and researchers working on innovative software and systems solutions for the next generation of Cloud-to-Edge continuum, specifically focusing on Security and Privacy, Artificial Intelligence and Machine Learning, Systems and Software Architecture, Modelling, and related challenges. The event was attended by over 20 participants. Proceedings are published with ACM, see link.

3.3 Open Calls

3.3.1 Introduction

The NEPHELE project encompasses the initiation of two Open Calls aimed at fostering collaboration and innovation. The first Open Call is set to start on 1 November 2023 (M15) and end on 10 January 2024 (M17), while the second Open Call is aimed to launch in M24 and close in M25. The following subsections will give a brief overview of the dissemination activities that have been and will be conducted in the scope of the first Open Call.

In general, the dissemination activities, led by FundingBox (FBA, FBC), are structured around three stages:

1. Preparation stage;
2. Launch of the Open Call and dissemination activities to attract applicants;
3. Closing stage with a press release and infographics illustrating the main results of the Open Calls.

While composing this deliverable, the preparation stage and partly the launch phase have been implemented, the rest is yet to be implemented. See details about the stages in the following subchapters.

3.3.2 Preparation for the first Open Call

This preliminary phase entailed the groundwork essential for a successful call launch. Key tasks included the following tasks:

- Setting up the Open Call landing page,
- Launching the online community,
- Preparing the Dissemination Toolkit, and preparing for a social media campaign,
- Participation at online webinars as well as other events to communicate about the upcoming Open Call.

Landing page

The landing page for the first Open Call is accessible via the following link: https://nephele-1st-open-call.fundingbox.com/, and a snapshot of the page is presented in Figure 23.
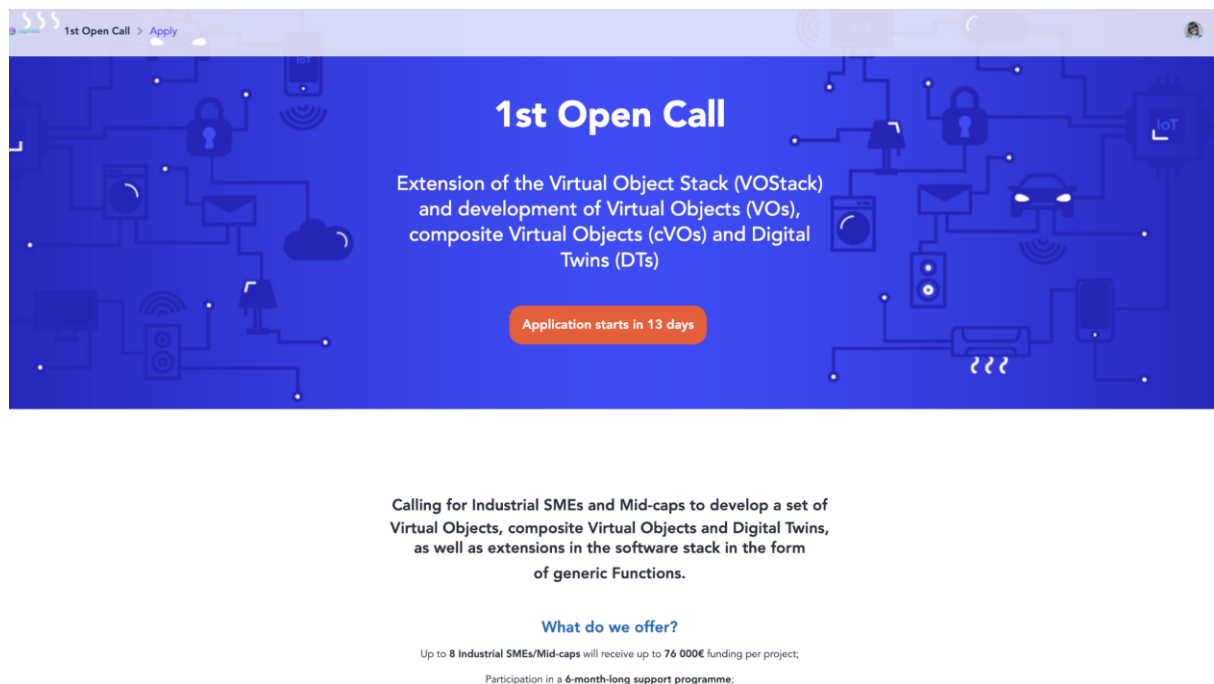
Figure 23: Snapshot of the Open Call website

The landing page is inviting SMEs and Mid-caps to submit proposals for developing Virtual Objects, composite Virtual Objects, Digital Twins, and extending the software stack with generic functions. The page informs that up to 8 selected projects will be awarded up to €76,000 each and will participate in a 6-month support program with technical mentoring. There is a clear outline of the focus areas eligible for funding, and the page provides access to supporting documents (e.g., the Guide for Applicants, the Frequently Asked Questions) for better understanding of the call. For further inquiries, there's also a link to the Helpdesk space in the IoT Community, and a dedicated email address for direct dissemination. This setup ensures that interested SMEs and Mid-caps have all the necessary information and support to participate in the Open Call effectively.

Finally, the page features an "Apply" button which, when clicked, leads applicants to a page where they can submit their application, ensuring a straightforward process for those interested in participating in this call.

Online Community

We have set up and launched (in M6) an online community for IoT stakeholders to foster the adoption of NEPHELE's outcomes and promote the advancement of IoT, Cloud, and Edge Computing technologies. This digital space is designed to offer support to the Open Call applicants during the application process, as well as to foster collaboration among professionals and innovators who share an enthusiasm for these technological domains. A snapshot of the community can be found in Figure 24.

Figure 24: Snapshot of the NEPHELE Helpdesk in the Community at Spaces

The online community encompasses a wide range of stakeholders, such as innovators and developers contacted through the Open Calls, as well as other individuals and organisations from industry, academia, and government who are interested in using NEPHELE's outcomes to improve their products, services and processes. The online community provides a platform for these stakeholders to connect with each other, share knowledge and experiences, and collaborate on projects.

To inform, inspire, and connect the online community, FundingBox, in collaboration with the Consortium, will curate a diverse and engaging content portfolio:

- News and articles interesting about the IoT industry.
- NEPHELE Open Calls and other funding opportunities information.
- Multimedia content such as images, videos and infographics.
- Events organised, but also other relevant events at the European level attended by the partners of the project.
- Other communities' information and access.
- Info about supportive partners of the project.
- Best practices and success stories to inspire innovative SMEs, organizations and researchers to build those solutions within the industry.
- Q&A sessions.

See an example of the post about various events in Figure 25.
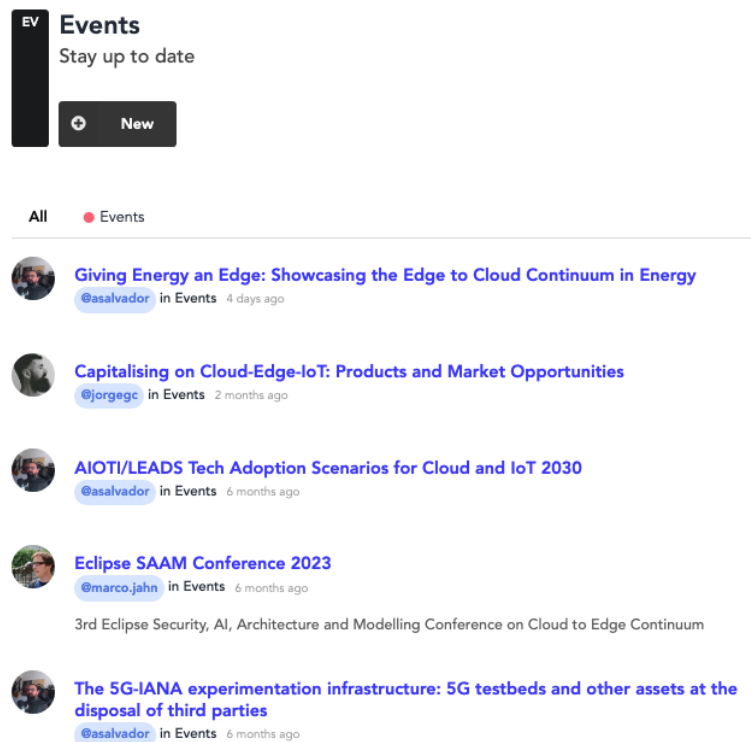
Figure 25: Posts about various events in the community

The community has been growing since the launch in M6, reaching 98 members and 65 companies in M15, see sign ups in the period from M6 until M15 in Figure 26. To ensure that community growth continues, we will engage in the following activities:

- Continue creating and posting relevant content.
- Onboard new users with a dedicated space in the community containing community guidelines.
- Continue invitations to the community through organic and paid channels.
- Launch the Ambassadors & Influencers Programme to increase the community and raise its awareness and visibility.
- Actively supporting Open Call applicants in the Helpdesk.
- Inviting and engaging other umbrella projects to the community.
- Cross-disseminating the community and the Open Call in online and presential cascade funding webinars and its social media networks.
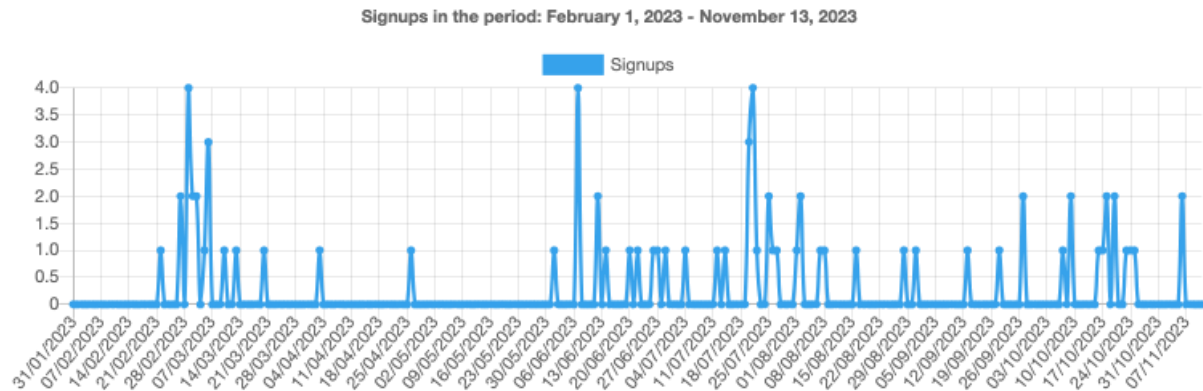
Figure 26: Sign ups between M6 until M15

Dissemination Toolkit and social media

The Open Call Dissemination Toolkit is a comprehensive resource intended to facilitate the promotion of and dissemination about the 1st Open Call. This toolkit comprises marketing materials, including press release templates, social media posts and email templates. This toolkit is curated to ensure the effective and precise dissemination of information about the 1st Open Call. See an abstract of the dissemination toolkit in Figure 27.

Figure 27: Screenshot of the Open Call dissemination toolkit

Participation at webinars and events

FundingBox participated in online webinars as well as one presential event, the IoT Expo Europe in Amsterdam, to communicate about the upcoming Open Call.

The webinars that FundingBox participated in were the following: AIOTI webinar: presenting Open Call Opportunities; BDVA workshop - Forum for SMEs/Startups matchmaking; RCC-Webinar Cascade; NOI: Webinar Cascade; Webinar: Funding opportunities in EUCEI and IRIS: Jornada de presentación de convocatorias cascade funding; and the AIOTI Innovative SME showcase.

This early participation in events has also given us the opportunity to build awareness and anticipation of the Open Call through social networks and newsletters from both FundingBox and the event organisers, an example of this cross-dissemination can be seen in Figure 28.

Figure 28: Example of cross-dissemination webinars

3.3.3 Launch of the first Open Call

Once the Open Call launched, the activities listed below took place:

- Social media campaigns;
- Online info day;
- Running the online helpdesk via email and the online community.

Social media campaigns

We launched social media campaigns to build project awareness, communicate about the Open Call, and aimed to engage a diverse and targeted audience to foster innovation. Below are the channels that were used:

- Newsletter: The campaign was disseminated through our email newsletter to reach our subscribers who are interested in technology and innovation. It included a compelling message along with a link to the application details of the Open Call.
- LinkedIn: We run a social media campaign using NEPHELE´s account targeting SMEs (including startups) and Midcaps.
- Reddit: We ran a paid campaign on Reddit adapting the messages to the target of this platform with a lighter tone and applying the use of compelling and funny images following the advice of the platform's workers with whom we checked the campaign.
- FundingBox Communities: We leveraged the FundingBox Communities, a platform focused on innovation and funding opportunities, to promote our Open Call. This was done by sharing the campaign on the network's platform to reach a broader audience.

By strategically disseminating the campaign through these channels and networks, we aimed to maximise its reach and engagement, ensuring that it reaches a diverse and highly targeted audience of potential participants and innovators.

Online info day/webinar

The info day/webinar is an essential component of our Open Call application process, designed to provide potential applicants with a deeper understanding of the application system and to address any questions or concerns they may have. This event (link to the event is here, and the screenshot is below) was organised to ensure that all interested parties have the opportunity to build a strong application and increase their chances of success. The info day was recorded and shared with the participants so that applicants can refer to it later if needed.
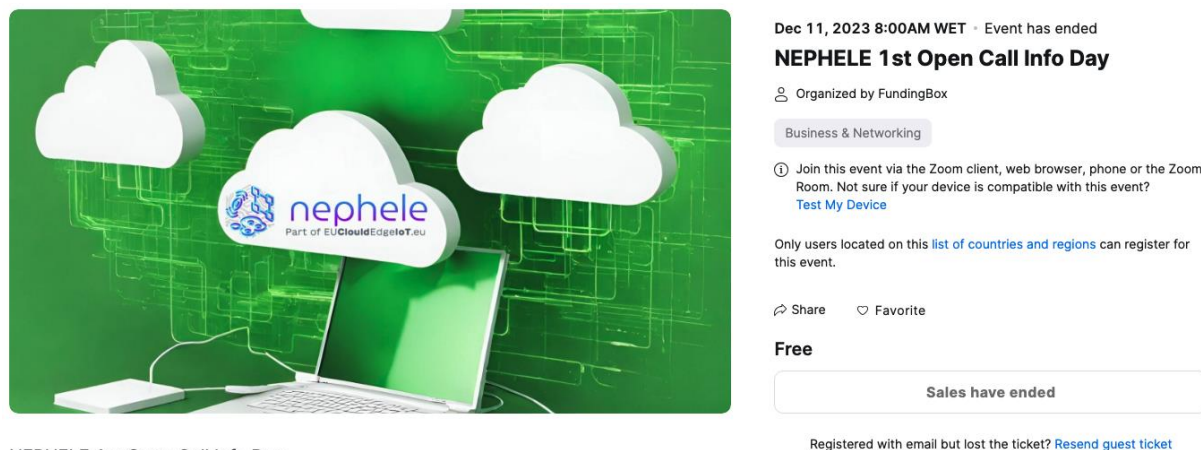
NEPHELE 1st Open Call Info Day

Join the NEPHELE 1st Open Call Info Day and learn how to get funding up to €76K for you Industrial SME or Mid-cap. More info at: https://nephele-1st-open-call.fundingbox.com/

In this session, the Project Coordinator will give a short presentation about the project and what the open call is targeting. The Open Calls Manager will then guide you on how to build a winning application. The session will end with a Q&A slot.

Figure 29: The online info day/webinar

Online helpdesk

A dedicated helpdesk space within the NEPHELE Community was available to potential applicants who were able to ask questions there, and the responses were visible to everyone visiting the space. Applicants were also able to send an email to a dedicated email address: nephelehelpdesk@fundingbox.com.

3.3.4 Closing of the First Open Call

Once the first Open Call closed, a press release with an infographic, see below, informing about the results and the number of submitted applications was published on the project's website, social media channels and the online community.

Additional planned communication and dissemination activities include featuring the most relevant/successful actions performed by external partners on the project's website, social media and the community (e.g., articles by influencers/ambassadors or publications in relevant media). Moreover, the first Open Call beneficiaries will act as success stories that will be featured in various project channels. A dedicated space for this purpose will be created on the project's website and the community. Furthermore, communication and dissemination materials will be created to feature the Open Call beneficiaries (e.g. short articles, testimonials etc.).

Besides the activities listed above, we will also utilise ambassadors/influencers for further communication and dissemination purposes. The planned launch of the NEPHELE Ambassadors Programme is in spring 2024.
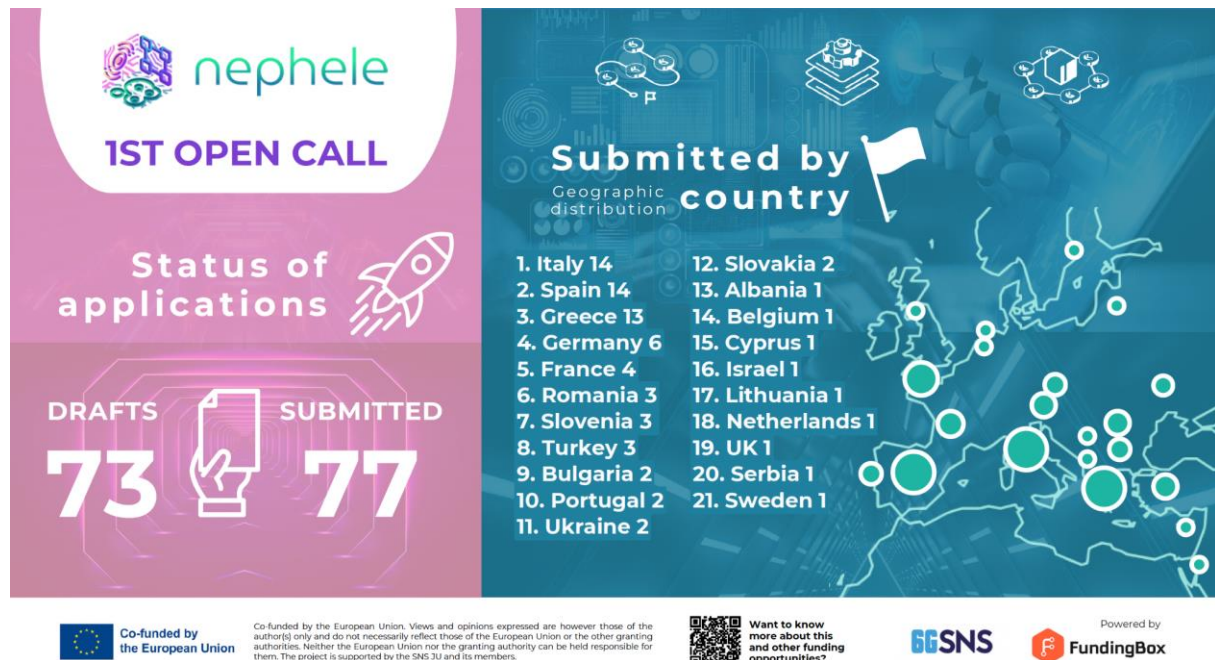
Figure 30: Infographic of the 1st Open Call

3.3.5 Summary and the Second Open Call

This Section presented an overview of the dissemination and communication activities that have been and will be conducted in the scope of the first Open Call. The performance of the activities will be monitored to refine the strategy and the effectiveness of the communication activities for the second Open Call, which is planned in M24-25. After the conclusion of the first Open Call, continuous dissemination of its results will be conducted through, for instance, showcasing the success stories of the selected beneficiaries. This approach not only highlights the impact and achievements of the first Open Call but also builds a narrative of progress and success that could attract more participants for the second Open Call. The communication and dissemination activities for the second Open Call will be elaborated on the final version of this deliverable (D8.3).

3.4 Deliverables

As reported in deliverable D8.1 "Dissemination, Communication and Exploitation Plan", the consortium has identified a list of public and open-access technical deliverables that will be published on the NEPHELE website after the review and acceptance of the European Commission. In Table 1 the list of them until M18 is reported.

Table 1: List of published technical deliverables on the NEPHELE website

No.	Deliverable name	WP	Leader	Type	Delivery date
D2.1	Requirements, Use Cases Description and Conceptualisation of the NEPHELE Reference Architecture	WP2	INRIA	Report	M09
D2.2	NEPHELE Reference Architecture Final Specification	WP2	NTUA	Report	M18
D3.1	Initial Release of VOStack Layers and Intelligence Mechanisms on IoT Devices	WP3	SIEMENS	Report & Other	M15
D4.1	Initial Release of Hyper-distributed Applications Synergetic Meta-Orchestration Framework, Development Environment and Repository	WP4	IBM	Report & Other	M15
D5.1	First Release of NEPHELE Platform, Dashboard and DevOps Environment Setup	WP5	AW	Report & Other	M18
D8.1	Dissemination, Communication and Exploitation Plan	WP8	ATOS	Report	M03
D8.2	Initial Dissemination, Communication and Exploitation Activities Report	WP8	ZHAW	Report	M18

4 Initial Report on Standardisation Activities

NEPHELE's contributions to standardisation bodies and working groups are primarily directed at the W3C Web of Things (WoT) Working Group. This group benefits from the strong involvement of consortium members, notably ERCIM (the European partner of W3C) and SIEMENS. These contributions focus on the project's architecture, particularly in developing Virtual Object specifications and semantic model specifications that align with the Web of Things Thing Description. Additionally, they encompass the development of features and libraries for the Web of Things Scripting API. Beyond participation in the W3C WoT Working Group, another key objective is disseminating results to other relevant standardisation bodies where our partners have active roles.

The strategy is built on the following actions:

- **Active Engagement in W3C WoT Working Group:** Prioritise active involvement in the W3C WoT Working Group by regularly attending meetings, contributing to discussions, and providing expert input on Virtual Object and semantic model specifications. Leverage the expertise of consortium members like ERCIM and SIEMENS for influential participation.
- **Contribution of Expertise and Research:** Share findings and developments from NEPHELE, particularly in areas of Virtual Object specifications and Web of Things Thing Description. Ensure that these contributions are practical, scalable, and align with current industry standards.
- **Collaboration and Networking:** Foster collaborative relationships within the W3C WoT Working Group to gain insights and influence in the standardisation process. Utilise the network of consortium members to facilitate broader engagement across different standardisation bodies.
- **Documentation and Publication:** Regularly document and publish NEPHELE's contributions and developments in relevant journals and at conferences. This ensures visibility and recognition of the work being done, and provides a reference for others in the field.
- **Expanding Influence to Other Bodies:** Identify and engage with other relevant standardisation bodies as defined within Section 4.1, where consortium partners are active. Share NEPHELE's advancements and seek opportunities to contribute to the broader standardisation efforts in related fields.
- **Feedback and Adaptation:** Continuously gather feedback from standardisation bodies and adjust NEPHELE's contributions accordingly. This adaptive approach ensures that the project remains relevant and in alignment with evolving standards.
- **Education and Training:** Offer workshops, seminars, and training sessions to both consortium members and external stakeholders on the latest developments and how they impact standardisation. This enhances understanding and supports the adoption of new standards. In the second year, NEPHELE plans to organise a cross-project workshop, either online or in-person, to discuss standardisation gaps and opportunities relevant to projects and initiatives with similar interests.

By following this strategy, NEPHELE can effectively contribute to and influence standardisation efforts in the realm of Web of Things and beyond.

4.1 Standardisation Bodies

The standardisation bodies relevant to the project, with which the project plans to interact or has already established connections, include:

- ETSI: NEPHELE is collaborating through ATOS with Open Source MANO, an ETSI-hosted project aligned with the ETSI NFV group. For further information can be found in Section 4.3.
- W3C: ERCIM is the European partner of ERCIM and as such a partner in the project. See also Section 4.3.

The project is also planning to contribute to IETF, ISO and CEN/CENELEC, as the project evolves.

Interaction with the AIOTI has been established by NTUA (see 4.3). As the project progresses, there are plans to continue actively in commercial and industrial standardisation bodies such as AIOTI.

4.2 Partner involvement

Which partners are involved or plan to contribute to SDOs and industry alliances etc.:

- ATOS: NEPHELE is collaborating with Open Source MANO, which is an EU funded ETSI-hosted project to develop an Open Source NFV Management and Orchestration (MANO) software stack aligned with the ETSI NFV group. As a community-led project, OSM is delivering a production-quality MANO stack that meets operators' requirements for commercial NFV deployments. As part of the advanced management of the network part of the compute continuum, NEPHELE is developing autonomic and ad-hoc functionalities covering Software-Defined Networks (SDN) and Network Function Virtualization (NFV) Management and Orchestration (MANO) systems. Additionally, NEPHELE is a using an OCI-Registry (Open Container Initiative) to store NFV and SDN artifacts (xNF) compatible with the Open Source MANO (OSM) software stack, which is the building block of a development environment that aims to optimize the developers' tasks and contribute to the interoperability of xNF providers and Mobile Network Operators (MNOs).

- ERCIM/W3C is actively working on various recommendations related to the Web of Things (WoT) and other aspects of the Internet of Things (IoT), integrating symbolic approaches to knowledge. Key areas of this work include WoT Architecture, WoT Thing Description (TD), security and privacy considerations, and other horizontal efforts related to accessibility, internationalization, privacy, and security. W3C actively participates in the Internet of Things (RP2023) Rolling Plan for ICT standardization. Additionally, W3C is managing the Web of Things Interest Group and the Web of Things Working Group. The Interest Group convenes stakeholders interested in the Web of Things to explore concepts before standardization, collaborating with standards development organizations (SDOs) and industry alliances. ERCIM/W3C is planning to propose a W3C workshop on NGSI-LD (Next Generation Service Interfaces - Linked Data) specification, WoT and RDF.

- NTUA is managing the development of the VOStack version that is aligned with the W3C WoT specifications. Continuous interaction is established with representatives from the W3C WoT working group, where exchange of ideas and promotion of the work done in NEPHELE is taking place. VOStack is included in the "WoT Software and Middleware" section at https://www.w3.org/WoT/developers/. Interaction with the AIOTI is also established where high-level contribution regarding the meta-orchestration approach followed in NEPHELE is provided[1]. Promotion of the work in VOStack is also provided towards ETSI, mainly through our participation in the ETSI IoT Conference 2023.

- SIEMENS is actively involved in and contributing to the W3C Web of Things standardisation activities, such as wot-py in cooperation with Eclipse, in both the related Working and Community Groups.

- SMILE is supporting the standardisation effort through the enforcement of QA DevOps and open source best practices over the project results. As such, SMILE is contributing to most VO and VOStack oriented results.

- ECLIPSE is supporting standardization activities by promoting the standardization-by-adoption approach, i.e.m supporting activities towards open source implementations of standards and trying to increase adoption. This is mainly done by leveraging the community interaction between NEPHELE and the Eclipse ThingWeb WebOfThings projects.

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[1]   https://publications.ait.ac.at/ws/portalfiles/portal/39646250/AIOTI-Report-EU-funded-research-projects-landscape-IoT-and-Edge-computing-R2-Final.pdf

4.3 Cross Project Coordination

There are plans to organise a cluster meeting aimed at coordinating standardisation efforts across related projects. The project is planning to organise a session on standardisation and architecture at the IoT Week, expected to be held in 2024[2]. If a workshop at the IoT week is not feasible, a meeting would be held in the second half of 2024 or the first half of 2025.

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[2] https://iotweek.org/ The date of the conference is still pending.

5 Initial report on Exploitation activities

5.1 Exploitation Plans

All partners of the project are committed to exploit outcomes of the project in the way which makes the most benefit for them. Since each partner has its own vision, their initial individual exploitation plans are presented below.

The project has also established a database where expected (key) exploitable results (KER) are tracked, being individual or joint. During the creation of a KER, some new intellectual property rights are usually identified, therefore Nephele's KER database also includes data on IPR related to KERs, i.e., foreground IPR. The latter helps track IPRs related to project's outcomes, especially when the outcome is a result of multiple partners' joint effort. Within KER database, following data are collected:
- **Name**: short name of the KER,
- **Description**: description of the KER,
- **What problem does KER address**: short description of main existing issues the KER will provide a solution for,
- **Partners involved in the KER development**: list of all partners involved,
- **Existing TRL**: Technology Readiness Level indicator at the beginning of the project,
- **TRL foreseen at the end of the project**,
- **Relation to NEPHELE**: list of relevant Nephele deliverables,
- **Type of KER**: type of the KER such as hardware, software, algorithm, product, service, demonstrator, know-how, etc.,
- **Expected exploitation routes**: some examples are further research, consultancy, selling own products/services, selling IP rights, standardisation activities, etc.,
- **Potential customers**: list of potential customers (if applicable and/or not business secret),
- **Expected benefits of KER**: what would be benefits of using/consuming the KER,
- **Market feedback**: if any feedback already received,
- **KER readiness time plan**: expected quarter/month of the year when the KER will be ready.

Further, following foreground IPR data are added next to each single KER recorded in the database:
- **Owner**: main owner of the foreground IPR,
- **Other beneficiaries**: list of beneficiaries of the foreground IPR,
- **Classification**: type of the foreground IPR, such as hardware, software, methodology, product, service, demonstrator, algorithm, scientific article, know-how, etc.,
- **Licence type**: foreground IPR's licence type, such as commercial licence, patent, copyright, trademark, open source, etc.,
- **Related Background IPR**: list of background IPR items, if any and if relevant (see following paragraph for further details on Nephele background IPRs).

Exploitation of the project outcomes are heavily related to the intellectual property brought into the project by each single partner, therefore NEPHELE project has established a database of intellectual property rights (background IPR) to be also able to track these kinds of contributions within the project's final outcomes. Within Background IPR database, following data are collected:
- **Name**: short name of the background IPR,
- **Description**: description of the background IPR,
- **Owner**: list of background IPR owners,
- **Classification**: type of the background IPR, such as hardware, software, methodology, product, service, demonstrator, algorithm, scientific article, know-how, etc.,
- **Licence type**: background IPR's licence type, such as commercial licence, patent, copyright, trademark, open source, etc.,

- **Conditions and limitations for implementation of the background IPR**: to fulfil in case any specific conditions and/or limitations apply to the background IPR by its owner(s),
- **Conditions and limitations for exploitation of the background IPR**: to fulfil in case any specific conditions and/or limitations apply to the background IPR by its owner(s).

5.1.1 NTUA

NTUA, as a polytechnic university, is highly engaged in the development of solutions that promote research activities in the domains of IoT, edge and cloud computing, as well as network management and machine learning. In NEPHELE, NTUA is managing the development of VOStack (in accordance with the W3C WoT specifications), leading to the release of an open-source software stack that can be adopted and further extended in the future. Various exploitation opportunities arise towards this direction, considering both pure research and business aspects, since various collaborations can be established for the development of advanced and/or customised solutions. Furthermore, research collaborations are envisaged in the area of meta-orchestration solutions, where state of the art mechanisms are under development under the domain of synergetic orchestration. Such collaboration may be targeted to upcoming research and innovation projects (e.g., based on EU or national funding), as well as industry-specific projects.

5.1.2 CNIT

CNIT, the inter-university consortium, is highly engaged in the development of solutions that promote research activities in the domain of IoT, edge, and cloud computing, as well as network management and machine learning.

In NEPHELE, CNIT is managing the development of VOStack supporting OMA-LwM2M standard and IoT interoperability, and the set of functions that are supported by different layers of VOStack including the IoT Device Virtualized Functions Layer and the Generic/Supportive Functions Layer. This work has been released as an open-source VOstack project that can be further extended in the future. Moreover, the VOstack concept and related results will be leveraged to improve the teaching offer at the University Mediterranea of Reggio Calabria and University of Calabria. Early results have been already leveraged within Master courses at both Universities (e.g., through a cycle of seminars).

In addition, research collaborations are envisaged in the area of the meta-orchestration solutions, where the development is focused on a set of interfaces and management functions per VO to make it compatible with the principles followed in the cloud-native computing domain. Such interfaces and management functions are specified by the "Orchestration Management Interfaces" layer of VOStack. This layer exposes a set of APIs to applications that require services from the VO (such APIs support the interconnection of IoT application graph components with VOs). These APIs consider two key factors enabling NEPHELE to support seamless orchestration of the cloud-edge continuum: 1. communication protocols 2. configurability. Communication protocols will define loose coupling possibilities between VOs and third-party applications or devices; configurability will allow for redefining configurations of feature coverage and its parameters. As such, VOs expose through their interfaces most of their configuration attributes.

Finally, the collaboration may be targeted to upcoming research and innovation projects (e.g., based on EU or national funding), as well as industry-specific projects.

5.1.3 SIEMENS

SIEMENS is a leading technology company that provides innovative solutions in the fields of industry, infrastructure, and transportation. As of 2021, SIEMENS has 293,000 employees worldwide. In the fiscal year 2021, SIEMENS generated a revenue of €58.4 billion.

SIEMENS Technology is a division of SIEMENS, which participates in the NEPHELE project. It focuses on research and development of new technologies, collaborating closely with internal and external customers and partners. Collaborating with other partners in EU projects allows SIEMENS

Technology to further develop its research expertise and capabilities, build relationships with potential customers and partners, and contribute to the society and environment positively.

In the NEPHELE project, SIEMENS aims to develop a solution to optimise Building Automation Systems (BAS) regarding energy efficiency and human well-being in buildings. Requirements for BAS change over time and thus need to be adapted accordingly. Adaptivity is especially important to ensure low energy consumption and efficient energy management in BAS. Specifically, SIEMENS focuses on:

- Customizable and intelligent IoT devices for BAS. The development and deployment of intelligent on-device functions, specifically Complex Event Processing (CEP) engine and Tiny Machine Learning (TinyML) engine, on resource-constraint IoT devices. SIEMENS's goal is to enable customisable thermostats to load and run a virtual function, provided in the form of CEP rule or a Neural Network. Developed on-device functions will be used to reduce energy consumption in buildings.
- Virtual Object representation for IoT devices with their virtualized on-device functions based on the W3C WoT standard, focusing on the interoperability between VOs with different standards, e.g., W3C WoT and NGSI-LD, and the orchestration of VOs from different providers. The new functions of IoT devices should be exposed with no effort over an existing VO of that device. The concept of the VO will in this regard maintain the reality in terms of functionalities available in virtualized environments and play the role of the digital twin in the edge part of the continuum.
- The validation of the techniques in the use case: energy management in smart buildings.
- Contribution to W3C Web of Things standardisation activities.

SIEMENS will provide solutions applicable to cost-efficient IoT devices. Intelligence of devices will be based on the developed technologies, which can run on small, low-powered microcontrollers and enable low-latency, low power, and low bandwidth operations. With this strategy, SIEMENS aims to enable the market for energy-efficient and reconfigurable BAS.

5.1.4 ATOS

Atos is a global leader in digital transformation with 107,000 employees and annual revenue of c. € 11 billion. European number one in cybersecurity, cloud and high-performance computing, the Group provides tailored end-to-end solutions for all industries in 69 countries.

Atos Research & Innovation Team, the one participating in this project, is for the organisation the source of innovative ideas coming from EU and national research funded projects. The results from this kind of project plays a vital role to boost the innovation process within the organisation and to enhance the portfolio of products and technologies offered to its customers.

Concretely, in Nephele, Atos is:

- Leading the definition of the Nephele **Hyper Distributed Applications** (HDA) **Graph** (HDAG), which is the Information Model (IM) that developers need to use to compose Nephele´s HDAs. The HDAG essentially describes a chain of services, how and where they need to be deployed and any other relevant related information.
- Developing the **HDA Registry** (HDAR), the storage, distribution, catalogue, and verification system for all services involved in a NEPHELE HDA. It provides the hosting of all repositories of all the artefacts involved in the deployment of an HAD.
- Developing the **HDA Development Environment**, a sandbox repository to assist developers with the creation, verification, and distribution of HDAs.

In this context, Atos foresees the following exploitation scenarios as the most suitable for each of these Key Exploitable Results:

- HDAG: further research and publications
- HDAR: further research, publications, contribution to standardisation, and potential enhancement of Atos portfolio.
- HDA Development Environment: further research and publications

All of them will be further explored during the project lifetime.

5.1.5   INRIA

Inria is the French national research institute for digital science and technology. World-class research, technological innovation and entrepreneurial risk are its DNA. It has 220 project teams, most of which are shared with major research universities. More than 3,900 researchers and engineers explore new paths, often in an interdisciplinary manner and in collaboration with industrial partners to meet ambitious challenges. With its regional centres, Inria has a presence at leading research university campuses, throughout the regions of France and the country's industrial and entrepreneurial ecosystems for digital technology.

The FUN project team, based at Inria centre of Lille University and which is involved in NEPHELE, investigates solutions to enhance programmability, adaptability and reachability of FUN (Future Ubiquitous Networks) composed of RFID, wireless sensor and robot networks. The objects that compose FUN are characterised by limited resources, high mobility and high security level in spite of an untrusted environment. They communicate in a wireless way. To be operational and efficient, such networks have to follow some self-organising rules. Indeed, components of FUN have to be able in a distributed and energy-efficient way to discover the network, self-deploy, communicate, and self-structure despite their hardware constraints while adapting the environment in which they evolve. These devices of FUN can include mobile edge servers allowing edge computing as well as multi-radio technologies enhancing flexibility and connectivity. In the context of NEPHELE, two key exploitation results (KER) have been identified: 1) A QoS-based communication interface selection solution allowing IoT devices to dynamically select the least expensive communication technology among several available with regards to expected QoS and 2) An autonomous multi-robot-based exploration and monitoring solution allowing autonomous and adaptive exploration of an unknown area with potentially no 5G connection. Both KERs are composed of algorithms and open-source software. Moreover, the exploitation plan of Inria includes dissemination activities promoting NEPHELE results in international scientific conferences and peer-reviewed journals as well as further exploitation of the results of the project through Ph.D. theses for future research activities.

5.1.6   UoM

University of Macedonia is a multi-disciplinary, research-oriented Academic Institution, located in Thessaloniki, Greece. The main role of UOM as an academic partner is primarily to advance the technology challenges beyond the state-of-the-art and provide important results and feedback in the area of advanced hyper distributed applications over the IoT-Edge-Cloud continuum, as an enabler for future services and applications in diverse domains. UOM will benefit from enhancing its knowledge mainly around the research topics of autonomic and ad-hoc networking, as well as software-defined network (SDN) management and AI/ML-assisted service orchestration across the compute continuum.

To this end, UOM will leverage and extend its expertise on SDN-based ad-hoc cloud network management, IEEE 802.1 Qbv-based time-sensitive networking (TSN) for the edge, and advanced techniques for synergetic orchestration and relevant experimentation platforms, positioning the university better for further industrial collaborations, with the long-term target of attracting more funding and potentially exploiting research outcomes for the creation of start-up/spin-off companies. In this respect, UOM's exploitation plan includes: (i) dissemination activities promoting the NEPHELE results in prestigious research venues, including establishing liaisons with relevant research projects and

research groups, (ii) open-source development activities that aim to reach a wider audience and create a community, and (iii) further exploitation of the project's results through Master/Ph.D. theses and advancements in relevant undergraduate and postgraduate courses to build a strong research base for future activities.

5.1.7 FBA

FundingBox Accelerator is a Polish non-profit private entity supporting, promoting, and launching technological & innovative 'scale-ups' (startups and tech SMEs) initiatives in Europe. FBA was created, in 2012, as the innovation and business accelerator arm of 'The FundingBox Group'. It drives innovation by bringing its understanding of economic and industrial challenges as well as its global connections to the smart ecosystems around entrepreneurship.

Fundingbox is not a technical partner, thus we are not exploiting the project results directly, but providing the services for NEPHELE partners and the community to foster the uptake of NEPHELE technology by SMEs and end-users. Successful creation of the SMEs and stakeholders' community around the NEPHELE project is what we exploit, aiming at gaining new members of our community and growing our ecosystem.

5.1.8 OdinS

OdinS is an ICT SME focused on developing and selling solutions and products that use the results obtained in R&D projects. OdinS exploitation plan include the demonstration of the innovation results of NEPHELE solution applied to different use cases, looking for the adoption of the NEPHELE outcomes to develop Virtual Objects, intelligent IoT devices and hyper-distributed industrial applications for the IoT-Edge-Cloud compute continuum. The integration of these NEPHELE innovations in concrete OdinS products/solutions will allow the commercialization of multiple solutions for Smart Cities or Smart Agriculture industry.

On the other hand, OdinS will exploit the know-how and innovations acquired in NEPHELE to open new opportunities for collaborating in future research and innovation projects in the Horizon Europe framework with international partners and external organisations. Moreover, the NEPHELE innovations will enrich OdinS research initiatives, by supporting own post-doctoral researchers and Ph.D. industrial students for extending the NEPHELE innovations to carry out excellent research in main scientific domains, whose outcomes will be reported in publications in major international conferences and journals in networking, security, cloud-edge computing or IoT areas.

5.1.9 SMILE

SMILE has been a pioneer of technology and the European expert in open-source solutions since 1991. With more than 30 years in existence, 2000 contributors in 17 different agencies, SMILE is the European leader in integration and open-source solutions. The company is organised around 4 offers to support customers through their digital transformation: Digital, Business Apps, Embedded & IOT, Infrastructure.

Within the Nephele project, SMILE is leading the NEPHELE Platform Integration, Testing and Refinement. SMILE will contribute to provide a Cloud Native approach for BI-based infrastructures management, introduced by the company as BIOps.

In this context, 3 objectives are tackled: semi-automated KPIs generation from system metrics analysis and transformation, and dynamic dashboards provisioning; 3D representation for heterogeneous metrics sets; automated time series analysis to provide continuous optimisation for microservices infrastructures.

To this end, SMILE aims to pinpoint prospects for the transfer of technology to the industrial sector, particularly emphasising the transfer of expertise in both system and software integration, for example, orchestrating the deployed microservices between the cloud and edge computing orchestration platforms ensuring self-healing, portability and elasticity.

SMILE also anticipates disseminating this solution to open-source communities and its clientele through the creation of customised packages. Additionally, we aim to leverage the innovations introduced by NEPHELE to enhance our forthcoming communication service, Cloud, Edge, and IoT related research endeavours and business.

5.1.10 ININ

INTERNET INSTITUTE Ltd. (ININ) is positioning itself as a highly innovative SME, specialised in 5G, IoT and cloud solutions. ININ is focusing on business opportunities within the area of critical communications, ports/logistics industry vertical, telecom operators, public safety organisations, Industry 4.0, infrastructure, and utilities. Within the NEPHELE project, ININ expects to acquire certain knowledge, aiming at obtaining a competitive advantage for future technological improvements of its products and of specific technologies built on those products. Next, ININ also aims to further develop its existing products brought into the project, in order to improve these products' support for cloud-edge-continuum environments. In terms of exploitation, the main focus is expected to be on the 5G system and IoT Gateway as main ININ's products addressing cloud-edge-continuum.

Both knowledge and product improvements are expected to be further exploited through dissemination activities (primarily targeting industry events), further research and development projects (including SNS-JU initiative), consulting businesses, developing product portfolios, and creating strategic partnerships with relevant industry and scientific stakeholders. The latter includes discussions with industrial partners (i.e., vendors) on their possible integration into existing products. So far, ININ's exploitation activities have been mainly limited to dissemination activities.

5.1.11 ECL

The Eclipse Foundation (ECL) is the leading European Open Source Foundation with 170 corporate members in Europe (330 worldwide), 900 European committers (1600 worldwide) and over 430 Open Source projects. ECL supports organisations in doing professional, vendor-neutral open source and fosters open collaboration among industries and academia alike. ECL hosts 2 very active communities in the open-source Cloud-to-Edge domain, namely the Eclipse IoT Working Group and the Eclipse EdgeNative Interest Group.

ECL will leverage these communities to promote, support and help to sustain the NEPHELE open-source outcomes during and after the end of the project. ECL will make these results available as professional, vendor-neutral open source to both the greater public and to the potential users and contributors from other domains. This will contribute to strengthening the Eclipse Foundations's position in the open-source Cloud-to-Edge ecosystem and eventually increase member retention and lead to further growth. One concrete path that has been kicked off is an integration between NEPHELE Virtual Object development by NTUA and the Eclipse ThingWeb project and community, which is part of the IoT Working Group.

5.1.12 WINGS

WINGS is an SME that delivers solutions (software and hardware) for various vertical sectors, namely, utilities (water, energy, gas), the environment (air-quality, food security/safety (aquaculture), transportation, health, and security. NEPHELE project enables WINGS to develop new models for route optimization and logistics management and enhance its WINGSPARK platform by adding new features. In particular, an image processing component will be added. It will be able to recognize vehicles and containers and identify free or occupied parking slots, as well as a model that can provide automated delivery route scheduling. In this way, WINGSPARK will provide complete solutions to the transportation industry.

Additionally, NEPHELE project enables WINGS to expand its network of stakeholders in the transportation and logistics domain, and that will improve commercialization activities and collaboration for future projects.

5.1.13 IBM

IBM (International Business Machines Corporation) is a prominent global player and technology innovator with a vast footprint in the information technology sector. As a key contributor in the NEPHELE project, IBM brings its extensive expertise to the table, aligning with the project's objectives. With a global network and a rich ecosystem, comprising a multitude of corporate partners and a global community of developers, IBM aims to advance open collaboration and drive innovation in the Cloud-to-Edge domain through the NEPHELE project.

IBM's exploitation plan focuses on delivering value not only to its own ecosystem but also to the broader technology community. To achieve this, IBM plans to integrate the project's advancements with IBM's existing technologies and frameworks, and more specifically, its cloud and edge computing offerings. This engagement is anticipated to strengthen IBM's presence in the Cloud-to-Edge ecosystem and reinforce IBM's standing as a leader in open-source initiatives. It is also aimed at fostering sustained growth and solidifying its position in the rapidly evolving landscape of Cloud-to-Edge computing.

5.1.14 ESAOTE

ESAOTE is a Biomedical Company focused on developing and selling solutions and products for Ultrasound and MRI equipment and Medical IT systems.
ESAOTE exploitation plan include the demonstration of the innovation results of NEPHELE solution applied to remote Ultrasound platform, looking for the adoption of the NEPHELE outcomes to develop Virtual Objects, Ultrasound IoT devices and hyper-distributed medical applications for the IoT-Edge-Cloud compute continuum. The integration of these NEPHELE innovations in concrete ESAOTE products/solutions will allow the commercialization of multiple solutions for customers (for example hospitals, private and public physicians).

The exploitation of the VOStack layers will allow to exchange data and resources among the physical components involved in the use case (e.g., acquisition hardware, monitors, potentially other interactive HW input devices such as keyboards) and provide the infrastructure for additional capabilities, such as distributed data management.

ESAOTE will exploit the know-how and innovations acquired in NEPHELE to provide a dematerialized and distributed solution for remote support during an ultrasound exam. The different modules can communicate with each other thanks to the Nephele platform and its Virtual Object Stack.

5.1.15   LK

Port of Koper is a multi-purpose deep-sea freight port located at the Northern end of the Adriatic Sea. Logistic and port services are provided by the company Luka Koper d. d. Port terminals are equipped with state-of-the-art transhipment and warehousing equipment, such as ship-to-shore cranes, reach-stackers, forklifts, utility tractor rigs, etc. Port of Koper has excellent connections to the road and railway network. Continuous monitoring and optimization of the traffic within the port poses a daily challenge (traffic congestions, unplanned road closures, etc.) which might be solved by the use of technologies such as IoT and cloud-edge-computing, thus the challenge is specifically addressed in the use case 2, however, the Port's requirements are also addressed within the overall NEPHELE development process.

Luka Koper's exploitation plan therefore focuses on new technologies and processes that will expectedly substitute today's business models. As a representative of large vertical industries, LK plans to take advantage of the novel hyper-distributed applications that will be developed and evaluated within the NEPHELE project, thus gaining a competitive advantage towards its competitors as already mentioned. Specific exploitation goals of LK therefore involve technological knowledge/know-how in the IoT and cloud-edge ecosystems, focusing on useful technologies and applications, as well as critical communications, with a clear potential for the seaports and multimodal hubs; customising existing business processes to future state-of-the-art technologies and business models by setting up the corresponding time-aligned approach; strategic partnerships with stakeholders, including in the research field in EU; to exploit opportunities for future commercial collaborations.

5.1.16   ERCIM

ERCIM is a pan European research organisation. ERCIM is the European partner for the World Wide Web Consortium, which focuses on standardisation in support of the Web. As such we are not developing assets. Instead, we are focusing on research on high level abstractions for the IoT, that could lead to stronger standards in relation to edge and cloud infrastructures, knowledge-based systems, privacy and data handling.

The individual exploitation plan leverages the following opportunities provided by the Nephele project::

- International Collaboration: ERCIM can expand its reach by fostering partnerships with research organisations in Europe, promoting cross-national research.
- Technological Advancements: Rapid advancements in IoT technologies provide opportunities for ERCIM to stay at the forefront of research in informatics and mathematics.
- Emerging Technologies: W3C can play a pivotal role in standardising emerging technologies and driving their adoption related to the Internet of Things, in the core of NEPHELE.
- Knowledge Transfer: ERCIM can enhance its impact by facilitating the transfer of research results to practical applications, benefiting society and industry.
- Global Outreach: As a global organisation, W3C can expand outreach to underserved regions and communities can help democratise Web technologies and foster global inclusivity.
- Education and Training: Providing resources and training materials can help bridge the knowledge gap and promote broader understanding of Web standards.

5.1.17   ZHAW

ZHAW as an academic and research partner is mainly interested in adopting the research exploitation model for project results that will be provided with an open licence, integrating them in their research and/or teaching activities and/or setting up future research projects further promoting the project results. ZHAW plans to further develop its expertise relating to cloud robotics system technologies in the Cloud-to-Edge-to-IoT continuum to facilitate the integration of hardware and software solutions in this environment. ZHAW will exploit this knowledge in several dimensions. Being primarily an educational institution, the advances regarding cloud robotics over the continuum will be incorporated into the curriculum. Since Fall 2021 a course is delivered which has a focus on Cloud Robotics. Also, dissemination activities of NEPHELE results in prestigious research venues, open-source development activities are part of ZHAW's exploitation plan. Moreover, ZHAW also performs collaborative projects

with local companies through the national Innosuisse collaborative framework. ZHAW helps local companies to exploit modern application design principles: it will promote the innovations devised in Nephele, particularly around advanced cloud robotics solutions to local companies with a view to technology transfer primarily through further Innosuisse collaborative projects. ZHAW believes that reinforcing its current leadership in this emerging technology in Switzerland could provide several technological transfers and possibly spin-off opportunities.

5.2 Market Analysis

Through the Market Analysis, we try to identify the market potential and market needs of the markets targeted by Nephele consortium partners, their exploitable results and markets addressed by the joint outcomes of the project. The Market Analysis presents state-of-the-art situations in the market, which is exercised through the description of the current situation in the market, identifying market potential and market needs, and identifying market players.

Next to the markets of potential interest, the overview of situation and potentials within open-source communities and standardisation organisations have also been added to this section, as, in scope of business planning described in the next subsection, certain insights and/or contributing to either open-source or/and standardisation may result in securing better potential when addressing specific market or markets.

Data collected through the analysis of each single market have further served as inputs for integral analysis of complete market segments relevant for Nephele, using PEST analysis, Porter's five forces analysis and SWOT analysis.

5.2.1 Application Developers

State of the Art

Cloud-native applications development is continuously evolving, incorporating various development paradigms including serverless computing, edge computing, adoption of service mesh technologies, adoption of observability and telemetry stacks and consideration of both stateless and stateful applications. Towards this direction, Gartner has announced the top strategic technology trends in software engineering for 2023 and beyond (see Figure 31). Focus is given on the developers enablement considering the adoption of open source strategies to proprietary code (InnerSource) and the improvement of the experience of developers based on their interaction with various tools; AI-augmented software engineering based on the adoption of AI to aid software engineering teams and to introduce innovative characteristics in software; and scaling aspects of software development for the management of distributed software provision approaches and the increase of the immunity of the overall system. Adoption of generative AI solutions is also highlighted, considering their emerging development and usage in the last period.
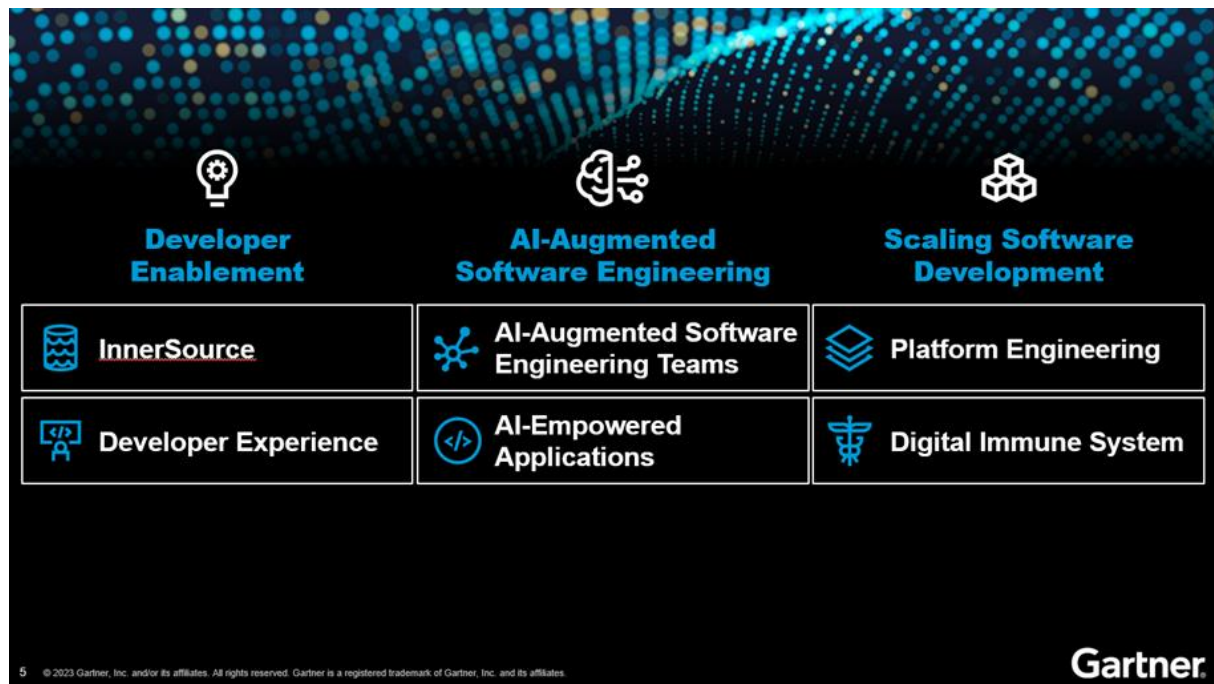
Figure 31: Top strategic technology trends in software engineering for 2023 and beyond[3]

Cloud native applications development is also impacted by the solutions that can support interoperability and/or convergence of IoT, edge and cloud computing technologies. This can be achieved through the advantages offered by containerization mechanisms in combination with intelligent orchestration mechanisms. Cloud-native functions/microservices can be developed in a form that can be part of an overall application graph, while deployed at any part of the infrastructure across the continuum.

Identification of market potential and market needs

According to the latest analysis by Virtue Market Research[4], Global cloud native platform market was valued at USD 9.77 Billion and is projected to reach a market size of USD 35 Billion by the end of 2030. Over the forecast period of 2024-2030, the market is projected to grow at a CAGR of 20%. Based on the Cloud Native Applications Market Research[5] for 2032, the global cloud native applications market was valued at $5.3 billion in 2022, and is projected to reach $48.8 billion by 2032, growing at a CAGR of 25.2% from 2023 to 2032.

Two of the key drivers (based on the report by marketsandmarkets[6]) regard:

- Shorter time to market deployment with the effective implementation of cloud native applications platform;
- Using containers, developers can write applications that run on devices from a smartphone to a mainframe without changing the code.

Such market trends regard the adoption of pure technological paradigms in software development and can be considered as part of the overall Software as a Service (SaaS) delivery mechanisms that are detailed in Section 5.2.2, where an extensive market analysis is detailed.

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[3] https://www.gartner.com/en/newsroom/press-releases/gartner-identifies-the-top-strategic-technology-trends-in-software-engineering-trends-for-2023

[4] https://www.linkedin.com/pulse/global-cloud-native-platform-market-projected-reach-0xhzc/

[5] https://www.alliedmarketresearch.com/cloud-native-applications-market-A210373

[6] https://www.marketsandmarkets.com/Market-Reports/cloud-native-applications-market-53431081.html

Market players

With regards to application development, the main stakeholders include initiatives and foundations that support the creation and maintenance of open-source communities, as well as the promotion and provision of open-source software repositories. Among others, these include Eclipse Foundation, Linux Foundation, and Cloud Native Computing Foundation. Emergence of technologies, such as Machine Learning techniques, Large Language Models (LLMs), and service meshes, along with their adoption and promotion by large vendors and software providers (e.g., IBM, Amazon, Google, Microsoft, VMware) significantly affect the dominant software development paradigms.

5.2.2   Application service/Software-as-a-Service providers

State of the Art

SaaS is a model of software delivery that differs from the traditional one because, in this case, the software is hosted on a provider's server and accessed by the user via the internet; in the traditional model, on the contrary, software is installed directly in the user's hardware.

On the other hand, traditional software is typically purchased through a one-time licence fee, and maintenance and/or support may incur additional costs. SaaS usually operates on a subscription basis, which means that users pay a recurring fee to use the software.

Examples of SaaS include tools like Google Workspace, Salesforce, or Dropbox; examples of traditional software are Microsoft Office (pre-Office 365) and Adobe Creative Suite (pre-Creative Cloud).

The evolution of SaaS has been remarkable over the past two decades. There are 3 main drivers that motivated this growth:
1. Increased availability of the Internet across the world.
2. Rapid digital transformation across industries, boosted by COVID-19, as organisations responded to a new business and social dynamic (i.e., shift to remote work, which brought the need of solutions that supported collaboration, communication, and other business functions in a virtual environment).
3. Recognition of the benefits of SaaS from the organisations.

Identification of market potential and market needs

Cloud computing is transforming how industries and customers work, moving away from the traditional on-premises services to the use of IT infrastructures, platforms, software, and applications via the Internet. Nowadays, organisations in all sectors and of all sizes are adopting cloud solutions. The shift from traditional on-premise services to the cloud has accelerated over the past few years. According to a report from Gartner Inc.[7],, more than half of enterprise IT spending in key market segments (application software, infrastructure software, business process services and system infrastructure markets) will shift to the cloud from traditional solutions by 2025.

As shown in Figure 32, the market of cloud services has grown significantly over the last few years, and it is expected to keep doing so in the next few years.

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[7] https://www.gartner.com/en/newsroom/press-releases/2022-02-09-gartner-says-more-than-half-of-enterprise-it-spending
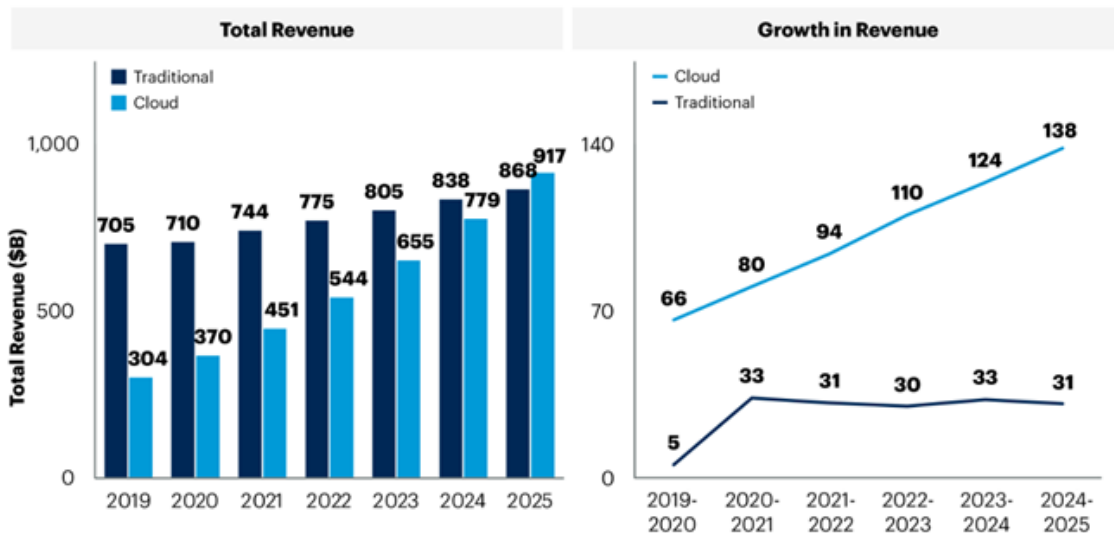
Source: Gartner, February 2022

Figure 32: Sizing Cloud Shift, Worldwide, 2019 – 2025 [7]

Table 2 shows the sustained growth experienced in all segments of the worldwide end-user spending on public cloud services year over year, something that will repeat in the coming years.

Cloud market segments	2019	2020	2021	2022	2023	2024
Platform as a Service (PaaS)	37,512	46,335	86,943	119,579	145,320	176,493
Software as a Service (SaaS)	102,064	102,798	152,184	174,416	205,221	243,991
Business Process as a Service, (BPaaS)	45,212	46,131	51,410	61,557	66,339	72,923
Desktop as a Service (DaaS)	616	1,220	2,072	2,430	2,784	3,161
Infrastructure as a service (IaaS)	44,457	59,225	91,642	120,333	143,927	182,222
Total Market	229,861	254,611	337,982	478,315	563,592	678,790

Table 2: Worldwide Public Cloud Services End-User Spending Forecast 2019-2024 (Billions of U.S. Dollars). Source: Gartner (November 2023)[8]

According to the latest report from Gartner Inc.[8], the worldwide end-user spending on public cloud services will grow 20.4% in 2024, from $563.6 billion in 2023 to $678.8 billion. End-user revenues are expected to exceed $1.1 trillion U.S. dollars in 2027, a five-year compound annual growth rate of 19.3%[9].

Numbers reflect the expansion of the SaaS market and the increase in adoption. As shown in Table 2, all segments of the cloud market are expected to see growth in 2024, including the SaaS industry. According to a report published by Verified Market Research[10], SaaS Market size is projected to reach USD 896.2 Billion by 2030, growing at a CAGR of 27.45% from 2023 to 2030.

Figure 33: Global SaaS Market. Source: Verified Market Research (September 2023)[10]

Based on Deployment Type (Public Cloud, Private Cloud, and Hybrid Cloud), the public cloud segment accounted for the highest revenue share of the Global SaaS Market in 2020 and is expected to keep dominating the market.

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[8] https://www.gartner.com/en/newsroom/press-releases/11-13-2023-gartner-forecasts-worldwide-public-cloud-end-user-spending-to-reach-679-billion-in-20240

[9] https://www.gartner.com/en/documents/4789331

[10] https://www.verifiedmarketresearch.com/product/software-as-a-service-saas-market/

GLOBAL SOFTWARE-AS-A-SERVICE (SAAS) MARKET, BY DEPLOYMENT TYPE (USD BILLION)
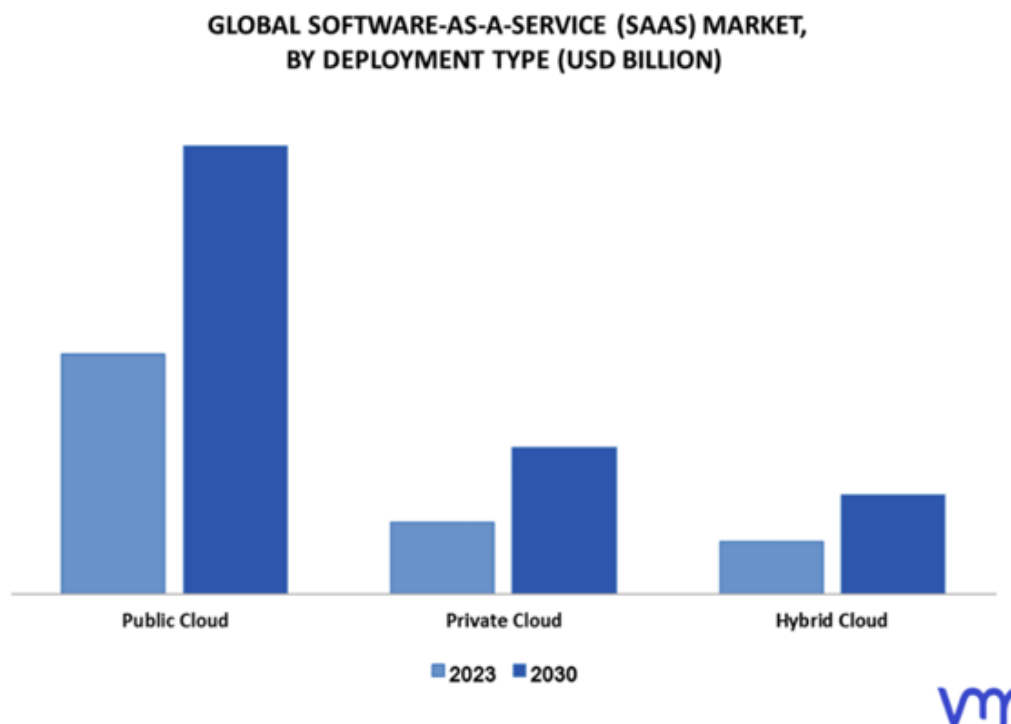
Figure 34: Global SaaS Market by deployment type. Source: Verified Market Research (September 2023)[10]

Based on Geography, North America accounted for the largest revenue share in the Global SaaS Market in 2020 and is expected to retain its dominance in the next future.

GLOBAL SOFTWARE-AS-A-SERVICE (SAAS) MARKET, BY GEOGRAPHY (USD BILLION)
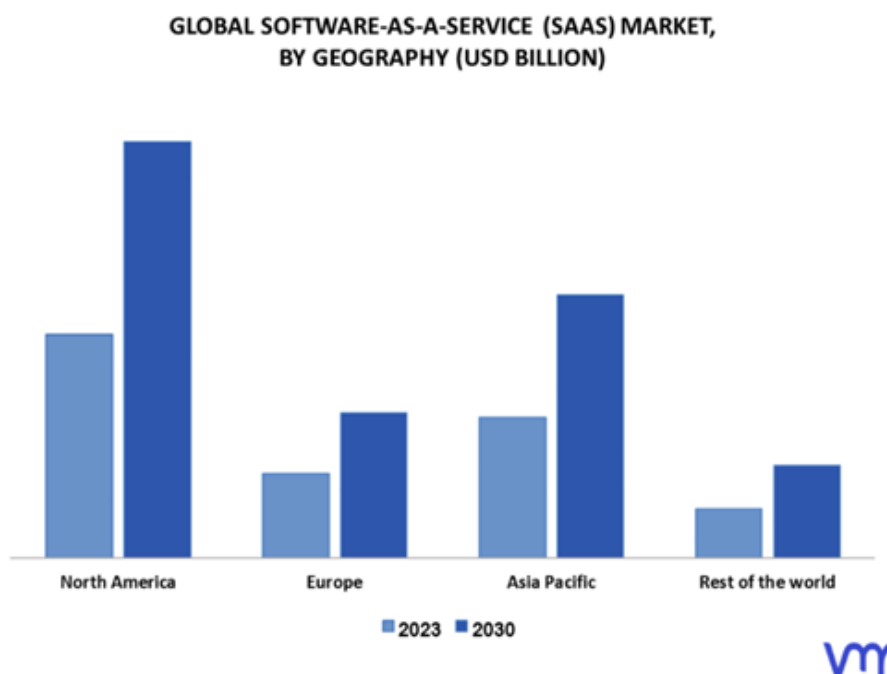
Figure 35: Global SaaS Market by geography. Source: Verified Market Research (September 2023)[10]

Around 70% of company software use is currently attributed to SaaS and, according to the predictions of BetterCloud[11], it will reach 85% by 2025.
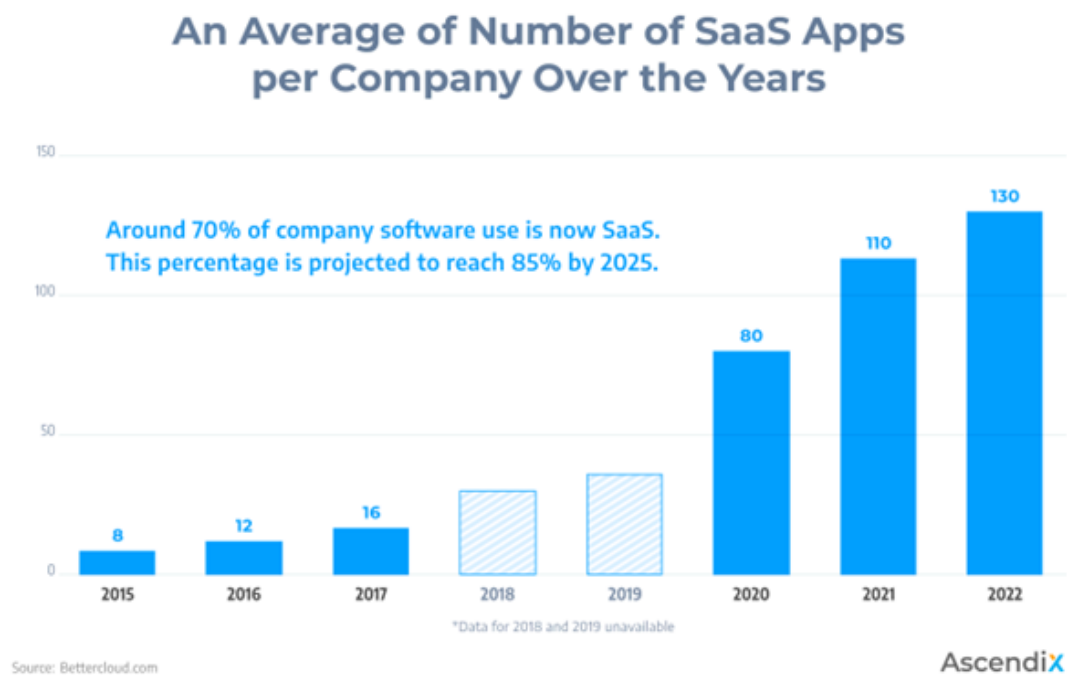
Figure 36: Average number of SaaS per company by year. Source: BetterCloud (Ascendix, 2023)[11]

According to BetterCloud, the average number of SaaS applications per company has increased over the years. In 2022, the average number of SaaS applications per company was 130. However, the number of SaaS apps used by organisations varies based on their size: companies with less than 50 employees use only 16 SaaS applications on average, companies with 50 to 99 employees use an average of 24 SaaS applications, organisations with 100 to 499 employees use almost double, 47, and larger organisations with over 1,000 employees use an average of 177 SaaS applications.

As stated in BetterCloud, many are the advantages that SaaS brings:
- **Easy and quick deploymen**t: The deployment process of SaaS solutions is usually quick and straightforward because the software is hosted on the cloud, requiring not just less time, but also less technical resources. Users can access it via a web browser or a lightweight client application, so there's no need for time-consuming installations on individual devices.
- **Accessibility and flexibility**: SaaS solutions are highly accessible as users can access their software any time, from anywhere, from any digital device with just an internet connection, making it a flexible choice for remote or distributed teams.
- **Lower costs**: SaaS usually resides in a shared environment where hardware and software costs are low in comparison to the traditional mode. There is also a reduced need for IT infrastructure and personnel.
- **Integration**: Many SaaS providers offer APIs and pre-built integrations with other popular SaaS applications, making it easier for businesses to create a cohesive software ecosystem.
- **Scalability**: Cloud-based SaaS enables organisations to expand with ease due to its inherent scalability.
- **Adaptability**: Due to the level of scalability, companies that use these solutions are more adaptable to potential and unforeseen organisational changes.

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[11] https://www.bettercloud.com

- **Convenient payment structure**: As businesses don't need to purchase either software or hardware, they have the option of sticking to pricing structured more suitable to them, usually subscription model with fixed fee (no surprises).
  - Out-of-the-box solutions as a basic package or more complex solutions for large organisations.
  - Access to customer service and support.
  - Subscriptions might potentially include maintenance, compliance, and security services.
- **Maintenance and updates**: SaaS providers handle all the maintenance tasks, including releasing updates, fixing bugs, and applying security patches. Businesses don't have to invest much time in this area of operation and users always have access to the latest, most secure version of the software without having to worry about maintenance.
- **User-friendly**: one of the reasons why SaaS is becoming more and more popular is the focus that software businesses have on user-friendliness.

But there are also some disadvantages to consider:
- **Data Security**: data are primarily located in off-premise servers, so security could potentially become an issue.
- **Interoperability**: Integrations with existing applications and services can be a concern since many SaaS apps are not designed for open integrations.
- **Customization**: SaaS services typically allow minimal customization for features, capabilities, and integrations.
- **Lack of control:** With a SaaS solution, businesses often must hand over ultimate control to the third-party service providers — giving them the keys to functionality, performance and even data.

The world of software delivery is not a one-size-fits-all landscape [6]. Choosing between SaaS and traditional software depends on a variety of factors, such as business's specific needs, resources, and strategic goals. The most important thing is to understand the key differences between SaaS and traditional software to make an informed decision. For businesses that value flexibility, low upfront costs, and ease of use, and are willing to trust a third-party provider with their data, then SaaS might be the right choice; if a business values control, customization, and long-term cost-effectiveness, and is willing to invest in the necessary infrastructure and expertise, then traditional software could be a better fit. In many cases, businesses may find a hybrid approach that allows them to take advantage of the benefits of both models, while mitigating their respective drawbacks.

According to datapine[12], these will be the top 12 SaaS Trends in 2024:

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[12] https://www.datapine.com/blog/saas-trends/
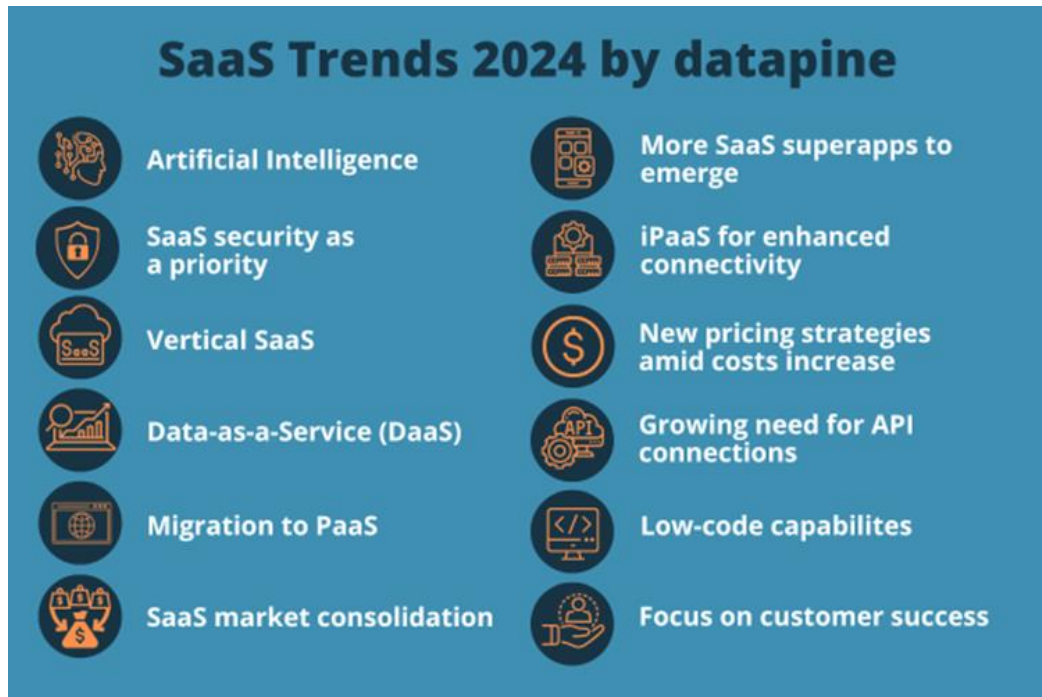
Figure 37: SaaS Trends 2024 Source: datapine (Jan. 2024)[12]

These industry trends are a promise of a progressive future for the industry. Many developments have spilled over from last year, while the others will bring for brand-new concepts that will evolve the SaaS industry even more.

Market players

A report by Statista[13] shows that there are around 30,000 SaaS companies around the world in 2023 serving millions of customers.

The leading country by number of SaaS companies is the United States with a staggering 17,000 SaaS companies and 59 billion customers globally, followed by the United Kingdom and Canada with approximately 2,000 SaaS companies each, while Germany, France, and India round off the top six with 1,000 SaaS companies each. These firms include established companies such as Dropbox and Adobe Creative Cloud, as well as small startups.

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[13] https://www.statista.com/statistics/1239046/top-saas-countries-list/
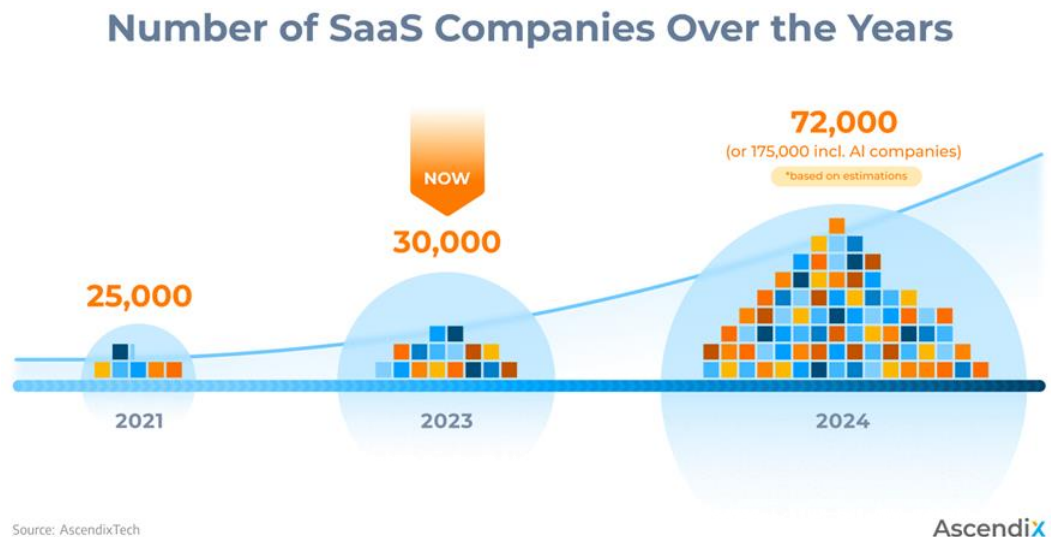
Figure 38: Number of SaaS Companies Over the Years. Source: Ascendix (May 2023)[14]

Figure 39: Number of SaaS Companies by country. Source: Ascendix (May 2023)[14]

Over time, there has been a general increase in the number of newly launched SaaS companies. This trend reflects the growing popularity of the SaaS business model and the increasing demand for cloud-

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[14] https://ascendixtech.com/number-saas-companies-statistics/

based software solutions. Note that the number of newly launched SaaS companies in 2020 is lower than in previous years due to the COVID-19 pandemic's impact on the economy and business activity.

Figure 40: New SaaS Startups Launched By Year- Source: Ascendix (May 2023)[14]

Attending to the SaaS categories, Ascendix Suggests[14] the following current distribution, with over 24,000 Productivity Tools and Collaboration Applications, about 17,000 companies like Salesforce in the Customer Service Solutions segment, 15,000 in Marketing Software, nearly 14,000 in E-commerce, and 12,000 in Data & Analytics. Sales come in at 11,500 companies (these estimations include AI companies).

Figure 41: SaaS Companies by Industry Source: Ascendix (May 2023)[14]

Regarding who the top SaaS providers are, we can say that the global market for SaaS was dominated by Microsoft in 2021, accounting for 10.9% of the market share. Other significant players in the industry were: Salesforce (10.9%), SAP (4.5%), Oracle (3.6%) and Google (3.4%). Although no single company has a monopoly in the SaaS market, these five largest SaaS firms collectively hold a market share of approximately 33.3% as of 2021.
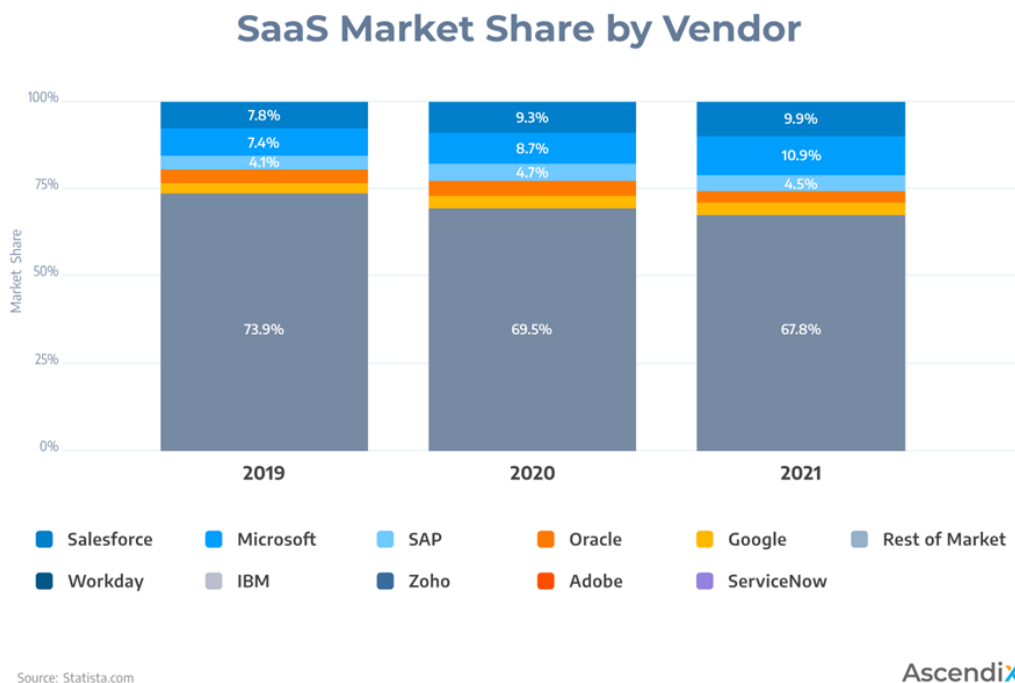
Figure 42: SaaS Companies by Industry Source: Ascendix (May 2023)[14]

5.2.3 IoT vendors and providers

State of the Art

The last few years have witnessed a remarkable surge in the number of connected devices, driven by the proliferation of the Internet of Things (IoT). This exponential growth in IoT deployments has revolutionised the form we interact with technology and has far-reaching implications across various sectors. Although it is complicated to measure the growth of connected devices — since each source categorises these devices differently — there is a common upwards trend. For instance, one study estimated that by the end of 2023 there would be 15.14 billion IoT devices connected, and the total number is expected to grow to 19.08 billion by 2025 and more than 29 billion in 2030[15].

The increase in the number of IoT devices, along with the current increase in urbanisation and globalisation, has boosted the growth of the IoT market. The global IoT market will grow from USD 5662.21 billion in 2023 to USD 3,353.97 billion by 2030[16]. The technology of the IoT serves as a worldwide infrastructure for the information society, facilitating the connection of advanced services and interconnecting objects through both established and developing communication technologies. Additionally, it provides interoperable information and the capacity for autonomous communication without the need for human intervention. The management of the data is one of the most critical aspects of IoT technology, as IoT accumulates immense amounts of data and information for processing.

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[15] https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/
[16] https://www.fortunebusinessinsights.com/industry-reports/internet-of-things-iot-market-100307

Identification of market potential and market needs

In terms of components, the market is divided into platforms (network management, cloud platform, and device management) and solutions/services (real-time streaming analytics, security, data management, remote monitoring, and network band management). Even though the platform is expected to grow at the highest Compound Annual Growth Rate (CAGR), the solutions and services are expected to dominate the market with the highest market share. On the other hand, in terms of end-use industry, the market is segmented into agriculture, BFSI, healthcare, government, retail, manufacturing, and others. The agriculture sector is expected to grow at the fastest CAGR, including smart farming or smart agriculture as major applications of the technology in this sector. However, the emergence of Industry 4.0 technologies has resulted in healthcare and manufacturing being projected to have the highest market share.

For an IoT device to work properly, the technology used in combination with the device must be advanced, otherwise, it would not be taking advantage and getting the maximum performance out of IoT devices. This is the case in many countries in Asia Pacific, Africa, and Latin America, where certain technologies, such as telecommunications, are not as advanced as in other parts of the world, e.g., China. This means that an initial investment of money must be made to overcome these restrictions, which results in the underdevelopment of the IoT market in these countries. On the other hand, the price of IoT devices has decreased significantly over the last decade. Whereas years ago, only a select group of industries could afford to adopt these technologies, nowadays all industries have access to such devices and technologies. As a result, there are great opportunities for organisations to deploy an interconnected network of sensors via the Internet to collect data for analysis and develop all types of data-driven solutions. A clear example of this could be the healthcare sector, where such implementations have started to emerge in recent years. It is worth mentioning that just because IoT devices are easy to acquire nowadays does not mean that they are easy to implement functionally and efficiently for their use. For this reason, industries or organisations need to invest in staff to make the most of these devices, as there may be cases where the full potential of these devices and technologies is not being exploited due to lack of knowledge.

Finally, in terms of regions, North America holds the largest market share for the year 2022, but Europe is anticipated to surpass North America soon, becoming the dominant force of the IoT market. The other regions, such as Africa and Middle East, are expected to grow, driven primarily by countries like Saudi Arabia and the UAE that have been actively involved in the development of smart cities, while the Asia-Pacific region is expected to exhibit the highest CAGR, attributed to the increasing number of smart city projects and growing initiatives in the region.

Market Players

There are many competitors in the growing sector of IoT such as Amazon Web Services (U.S), Intel (U.S), Microsoft (U.S), PTC (U.S), G.E (U.S), Cisco Systems (U.S), IBM (U.S), Oracle Corporation (U.S), SAP SE (Germany) and Siemens AG (Germany). These major key players are heavily investing in cutting-edge technologies like AI and cloud computing, among others. Well-established market players are directing significant investments toward startups and mid-scale companies to provide effective solutions across various sectors, including healthcare, manufacturing, retail, and more.

5.2.4   Infrastructure Providers and Operators

State of the art

Technology plays a pervasive role in contemporary business operations, influencing various facets ranging from individual employee tasks to overall organisational functions and the provision of goods and services. When seamlessly integrated within a robust network framework, technology becomes amenable to optimization, fostering enhanced communication, operational efficiencies, and heightened productivity.

An adaptable, reliable, and secure Information Technology (IT) infrastructure assumes paramount significance, as it constitutes a pivotal determinant in an enterprise's capacity to achieve its objectives and gain a competitive advantage within the marketplace. Conversely, inadequately implemented infrastructures can expose businesses to a spectrum of challenges, encompassing issues related to connectivity, productivity, and security, such as system disruptions and breaches. Consequently, the proficient deployment of an infrastructure emerges as a critical factor influencing the overall profitability of a business entity.

Within the realm of infrastructure, a company stands to achieve several strategic advantages, including the ability to ensure an uninterrupted and positive customer experience by providing continuous access to its website and online store. Furthermore, a well-established infrastructure facilitates the expeditious development and launch of solutions to market, enabling the organisation to respond promptly to dynamic market demands. Additionally, the real-time collection of data empowers the company to make informed decisions swiftly, contributing to strategic agility. Moreover, an effectively implemented infrastructure positively correlates with improved employee productivity, thereby reinforcing its pivotal role in organisational success.

The infrastructure encompasses three primary types: traditional infrastructure, cloud infrastructure, and hybrid infrastructure.

Traditional infrastructure comprises conventional hardware and software components, including facilities, data centres, servers, networking hardware, desktop computers, and enterprise application software solutions. This infrastructure model typically necessitates a substantial allocation of power, physical space, and financial resources compared to alternative infrastructure types. Its deployment conventionally occurs on-premises, designated for exclusive company or private use.

Cloud computing infrastructure shares similarities with traditional infrastructure. However, in this context, end users can access the infrastructure remotely via the internet, enabling the utilisation of computing resources without on-premises installation through virtualization. Virtualization facilitates the connection of physical servers maintained by a service provider at various geographical locations, subsequently partitioning and abstracting resources, such as storage, to render them accessible to users across diverse locations with an internet connection. Due to its predominantly public nature, this form of infrastructure is commonly referred to as a public cloud.

The hybrid cloud infrastructure paradigm involves the integration of locally available resources with cloud services to fortify or address existing deficiencies. This configuration allows for the establishment of an IT environment that amalgamates resources from diverse cloud service providers and on-premises data centres, thereby facilitating the efficient and cost-effective fulfilment of diverse operational requirements.

Infrastructure configurations exhibit variability based on the unique needs and objectives of businesses. However, certain objectives are universally applicable across enterprises. An optimal infrastructure is characterised by the provision of high-performance storage, a low-latency network, robust security measures, an efficiently optimised wide area network (WAN), virtualization capabilities, and the attainment of zero downtime.

High-performance storage systems are designed to store and backup data, incorporating a data recovery system to mitigate the impact of disasters.

Low-latency networks leverage enterprise-grade infrastructure components to minimise the latency in the flow of data.

Secure infrastructures encompass systems that govern information access and ensure data availability, effectively fortifying businesses against breaches and cyberattacks irrespective of data location, thereby upholding customer trust.

WANs function by managing network traffic, prioritising certain applications to allocate bandwidth according to their requirements.

Virtualization contributes to expedited server provisioning, heightened uptime, enhanced disaster recovery capabilities, and energy conservation.

The concept of zero downtime is geared towards minimising disruptions to business operations, eradicating system downtime, and thereby controlling costs while maximising profitability.

Identification of market potential and market needs

Optimising IT infrastructure is pivotal in furnishing organisations with systems characterised by high performance, minimal latency, and enhanced security measures. The enhancement of existing IT infrastructure can be achieved through a combination of traditional approaches and the integration of cloud services. For example, the utilisation of Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) represents a noteworthy strategy in this optimization process.

According to the estimations provided by Facts and Factors[17], the global digital infrastructure market, valued at USD 120.14 billion in 2022, is projected to exhibit substantial growth, reaching USD 655 billion by 2030. This anticipated expansion reflects a compound annual growth rate (CAGR) of 23.6%. Besides, the 2022 valuation of the global market for system infrastructure software reached USD 145.2 billion, with projections indicating a CAGR of 8.4% from the year 2022 to 2030 to reach USD 277.65 billion[18]. Moreover, the market for IT infrastructure services is anticipated to exhibit a CAGR of 11.2%, projecting a reach of USD 145 billion by the year 2030 within the forecast period (2022 - 2030)[19].

According to Pluralsight's 2023 State of Cloud report[20], 70% of entities indicate that more than half of their infrastructure is currently hosted in the cloud; 44% of organisations adopt the latest cloud products as soon as they're available; 65% of enterprises affirm their cloud environment is multicloud; 27% of leaders assert that their cloud strategies enable them to drive customer value. Numerous enterprises are actively seeking to modernise their antiquated infrastructure in order to harness the transformative capabilities offered by emerging technologies, including but not limited to artificial intelligence (AI), machine learning (ML), augmented reality/ virtual reality (AR/VR), 5G telecommunications, automation, and blockchain.

Although there are many key providers in the infrastructure market share, they tend to have 2 main business approaches:
- **Service oriented**: hardware is provided virtually through a service or private access.

- **Product oriented**: hardware is provided physically, most of the time intended to be integrated with other components.

Considering the IoT market share, the variety of providers, services and consumers tend to propose a fully fledged products catalogue, made of either devices, services or a mix of both (such as the smart appliances).

When Open Source is represented in the infrastructure domain, it is more than often under the Open Hardware consideration, where rather than the operating code, it is the product blueprint that is made available publicly.

Market players

The infrastructure market is currently characterised by a diverse range of providers and operators, each contributing to different segments of the industry. Notable players include:

- **Communication Service Providers/ Telecom operators**: Deutsche Telekom, Vodafone, Ericsson, Nokia, Orange, Telefónica, AT&T, Verizon, T-Mobile US, China Mobile, Huawei, China Unicom, NTT DOCOMO, LoRa Alliance, Equinix, Samsung, Fujitsu, NEC, SMILE.
- **Cloud-related Providers**: Amazon Web Services (AWS), Google Cloud Platform (GCP), Google Anthos, Microsoft Azure, Alibaba Cloud, Tencent Cloud, Huawei Cloud, IBM Cloud, VMware Tanzu, Red Hat OpenShift, Cisco (Catalyst SD-WAN), VMware (NSX), Rackspace Technology, OVH.
- **Edge Computing Providers**: Amazon Wavelength, Microsoft Azure Stack Edge, Google Cloud Distributed Cloud Edge, Cloudflare, Equinix, Lumen, Wind River, Xillinx.
- **IoT-related providers**: Arduino, Raspberry Pi, Qualcomm, Unabiz (Sigfox, Lorawan), SMILE (integration and support), Amazon (Alexa), Apple, Samsung.

5.2.5 Vertical industries

5.2.5.1 PPDR

State of the Art

Public Protection and Disaster Relief (PPDR) sector has for a long time relied on narrowband networks, which is still the case in many countries. These networks are mainly limited at providing mission-critical voice services and, in some cases, low-speed data services. Although analog systems are still in use for PPDR communications, digitalization is progressing with TETRA and TETRAPOL being most commonly used communication technologies across Europe (though narrowband). However, PPDR communication systems are for decades lagging several technological generations behind the commercial sector and are even today mostly unable to support up-to-date services already available in commercial networks, such as mission critical IoT devices support which is addressed within the NEPHELE Use Case #1.

Technologies able to address the needs of PPDR stakeholders' requirements, which include supporting mission critical data and video services, are LTE-Advanced systems and 5G as considered by International Telecommunication Union (ITU). Following this way, EC is supporting BroadMap, BroadWay and coming BroadNet projects/initiative, a procuring innovation activity to enable a pan-

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[17] https://www.fnfresearch.com/news/global-digital-infrastructure-market
[18] https://www.grandviewresearch.com/industry-analysis/system-infrastructure-software-market-report
[19] https://www.marketresearchfuture.com/reports/it-infrastructure-services-market-8639
[20] https://www.pluralsight.com/resource-center/state-of-cloud-2023

European broadband mobile system for PPDR, validated by sustainable test and evaluation capabilities[21]. So far, many nation-level broadband PPDR deployments hosted on the 4G and/or 5G networks are already operational or are in the process of being deployed, e.g., FirstNet in the US, Emergency Service Network (ESN) in the UK, SafeNet in South Korea.

Identification of the market potential and market needs

Despite slow pace in building a PPDR network infrastructure, many IoT solutions helping PPDR practitioners at their work are already there, although they utilise various network technologies and infrastructures which may not be considered PPDR-grade at all since they may, at least, potentially lack reliability and resilience, e.g., some examples include WiFi and similar unlicensed spectrum solutions (including ad-hoc networks), publicly available mobile networks, certain private networks, etc. On the other end, these IoT solutions, although not used within PPDR-grade networks, already exploit many advanced functionalities provided by cloud and cloud-edge-continuum technologies.

IoT products/services for PPDR (or Public Safety) therefore already exist, although its future is due to the infrastructure obstacles a bit unclear. However, once the infrastructure is ready, the opportunities should arise on both national and cross-country level. According to the Research and Market report "Internet of Things for Public Safety Market - Global Industry Size, Share, Trends, Opportunity, and Forecast, 2018-2028"[22] , global IoT for Public Safety market is valued at USD 2.7 Billion in 2022 and is anticipated to project robust growth in the forecast period with a CAGR of 15.3% through 2028. One of the important conclusions of the mentioned survey is also a finding that the "global IoT for Public Safety market is undergoing significant growth, driven by the transformative potential of IoT technologies in enhancing safety and security across various sectors". In that sense, Nephele based innovations may contribute to the market growth.

As the IoT market for Public Safety growth is somehow impacted by slow pace in building PPDR-grade network infrastructure, SNS Telecom & IT's report "The Public Safety LTE & 5G Market: 2022 – 2030 – Opportunities, Challenges, Strategies & Forecasts"[23] recognizes rapidly expanding ecosystem of public safety-grade LTE/5G devices, to which IoT devices contribute as well, as a complementary driver for further growth of PPDR-grade networks (i.e., LTE-Advanced and 5G) at a CAGR of approximately 13% between 2022 and 2025, accounting for more than USD 2.3 Billion by the end of 2025.

Market players

Based on the above-mentioned reports and our observations, we may identify the following companies as already being presented in the IoT for PPDR market or as have a potential to impact the market: Cisco, Huawei, Nokia, Motorola Solutions, Intel, Siemens, NEC, IBM, Microsoft, Honeywell International, Bosch Security Systems, Airbus, Thales, Frequentis, Leonardo. Some of the companies are directly contributing by providing IoT devices, products, services, etc., while some are contributing more in-directly by providing specific solutions, e.g., security solutions.

Next to big players, we may also mention European SMEs contributing to the market: Athonet, Internet Institute, Nemergent.

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[21] https://www.broadway-info.eu/broadnet-preparation/

[22] https://www.researchandmarkets.com/reports/5908407/internet-things-public-safety-market-global

[23] https://www.snstelecom.com/public-safety-lte

5.2.5.2   Logistics

State of the Art

Throughout history, ports have been key points in global trade and maritime transportation. Nowadays, more than half the value of goods imports to the EU and over 40% of goods exports from the EU go through ports. As within other industry verticals, also for ports the digitalisation is one of the key pressing needs required for the port to maintain its (global) competitiveness. In the process of digitalisation, where IoT plays a significant role, port evolves into so-called smart port where business processes are automated with the support of (wireless/mobile) network, various (smart) sensors and data centres as key infrastructural elements of a smart port. Main benefits of the digitalisation include operation efficiency, resource optimisation, safety and security, environmental sustainability, etc.

The digitalisation of ports, maritime transport in general, also includes the introduction of smart containers. The term refers to the containers equipped with an IoT device providing real-time tracking and monitoring of the container. This enables operators to increase containers' turn time, thus improving equipment availability, as well, it also allows beneficial cargo owners to understand location and status of their cargo in order to better control the entire supply chain. Visibility of cargo flows and container fleet management are among many factors driving the market growth as carriers are willing to invest in order to improve efficiency of their operations which are frequently disrupted by supply chain disruptions and port congestions.

Additionally, besides the above mentioned IoT technologies, the digitalisation of ports relies on other new technologies such as cloud and edge computing, mobile networks (e.g., 5G and future 6G networks), advanced analytics employing big data and artificial intelligence (AI), etc. Those technologies significantly contribute to digital transformation of maritime transport and ports, which have been somewhat slow at adopting digital solutions in the past but have boosted up after the COVID-19 pandemic ended.

Complete digitalisation of the port should include all business processes within the port, however, the digitalisation process usually advances gradually, therefore the level of the digitalisation is in some ports limited/isolated to certain business processes, while in some other cases the approach seems to be more holistic. Based on the experiences from Swedish ports, a digital three-step maturity model has been proposed. It accommodates the different situations for individual ports[24]. The so-called maturity model takes a formal digitalisation strategy/plan as the basis for informing actions on subsequent steps. The first step is achieved with a digitally connected infrastructure. Then, the second step is achieved with digital collaboration among the port actors, as well as having established communication interfaces to the 3rd parties. Finally, the third step is to have in place defined services and business models for digital business activity. The same source[24] reports only 20 % of the 4,900 ports in the world have established, or plan to establish, digital capabilities to assure transport chain connectivity.

It is also worth noting that in general, larger ports seem to be advancing with the digitalisation more thoroughly than middle and small ports [3].

Identification of the market potential and market needs

Ports' business processes involve many people and machines to work together. All actors being challenged by ensuring schedules are timely met, since any delay in the logistics/shipping process can finally cost millions or even billions to the industry. As described above, the IT industry, relying on

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[24] https://unctad.org/news/ports-tomorrow-measuring-digital-maturity-empower-sustainable-port-operations-and-business

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automation supported also by IoT and cloud-edge computing, can bring significant advantages in ensuring optimum port operations, boost productivity and develop profitable business relationships.

There are a plenty of challenges which IoT and related technologies can help to solve[25]. Particularly, Nephele UC#2 will tackle part of the container management challenges, which in general deals with handling and tracking containers in order to speed up the delivery, avoid misplacement and losses of containers, as well as help identify the container's contents in detail. Nephele UC#2's goal is optimization of the container delivery time within the port. This challenge inevitably involves management of port trucks fleet and traffic management within the port. The latter would in general not target port trucks and other vehicles within the port only, while it can extend to port cranes, ships, trains and trucks coming and leaving the port. Further, all gears controlled by the port operator(s) can be equipped with a solution providing predictive maintenance in order to lower number of failures, ensure faster repairs and other maintenance interventions whenever necessary, thus improving operational safety and reducing emissions, reducing downtime, avoid penalties, unnecessary expenses and overall improving quality of the service. Furthermore, safety of the port personnel and port area itself can be improved with video surveillance devices and relevant image detection software solutions. On the other end, port is expected to deal efficiently with hinterland demands requiring ever-more complex supply chains and increasing demands where IoT and other new technologies can help tracking cargo flows, improve traffic management in certain areas, ensuring compliance for the customers, as well as reducing time and costs for the business community.

Some of the above-described ports' needs have been also addressed in other EU funded projects such as 5G-Loginnov[26] and Vital-5G[27].

As it holds true for all industry verticals, it is also an accepted fact for the ports, logistics and maritime industry that investing in a technology which improves both efficiency and safety is crucial to remain competitive in the market. Therefore, we have seen an increase in ports digitalisation and involving smart technologies as a response to the supply chain crisis caused by COVID-19 pandemic and later war in Ukraine which, among other troubles, resulted in closing some ports and disrupted the flow of certain primary commodities [4].

Between 2022 and 2027, the global smart ports market is projected to increase from $1.9 billion to $5.7 billion[28]. On the other side, a report issued by Drewry estimates that by the end of 2021 around 3.6% of the global container equipment fleet was fitted with smart technology devices following growth of over 30% through the year. However, smart containers fleet is forecast to grow six-fold over the next five years and account for up to 30% of global box inventories by 2027[29].

Market players

Based on the above-mentioned reports and our observations, we may identify following companies as already being presented in the IoT for the smart ports market or as have a potential to impact the market: ABB, Accenture, Cavotec, IBM, ioCurrents, Kalmar, Konecranes, Navis, Microsoft, Siemens, Trelleborg.

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[25] https://www.searates.com/blog/post/how-iot-technology-can-enable-efficient-smart-port-operations

[26] https://5g-loginnov.eu/

[27] https://www.vital5g.eu/

[28] https://www.researchandmarkets.com/reports/5349698/global-smart-ports-market-by-technology-iot#product--tags

[29] https://container-mag.com/2023/07/13/drewry-smart-container-fleet-to-expand-six-fold-over-the-next-five-years/

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Most of the companies are directly contributing by providing IoT devices, products, services, etc., which mainly serve for digital support of their own products/solutions (already) utilised in the port environment, while some market players are contributing more in-directly by providing specific software solutions.

5.2.5.3   Energy Management

State of the Art

In 2022, the worldwide market size for energy management systems reached a value of USD 28.25 billion. This value is projected to grow from USD 55.03 billion in 2024 to USD 113.85 billion by 2029, reflecting a robust Compound Annual Growth Rate (CAGR) of 15.65% throughout the forecast period (2024-2029)[30]. Advancements in technology, such as network communications, are progressing quickly. In many domains of power consumption, such as electricity usage patterns and energy conservation at consumption premises, home area networks, bidirectional communication mediums, smart grids, information infrastructures, power conservation methodologies, and various strategies are undergoing a revolutionary change. One of the main reasons for this technological advance that is taking place is due to the global concerns to optimise renewable sources and reduce the carbon footprint.

The global business sector and government agencies have begun to increasingly prioritise energy efficiency. The world's electricity grids are reaching their capacity limits due to increased energy consumption caused by expanding economic activity. In response to this challenge, and due to government regulations, homes and industries have started to adopt energy-saving solutions. Notably, it is estimated that 30% of a building's energy is wasted. Other political reasons are also influencing the increase in energy management systems, such as the war between Russia and Ukraine. In this case, Russia is one of Europe's main sources of gas, and over the last year, due to this conflict, Russia has reduced the gas supplied to EU countries by 88%.

Due to all this, many governments and companies are investing heavily in the study of energy management, causing a technological breakthrough in energy management systems, including all kinds of smart devices such as smart sensors, smart metres, or any kind of IoT device that helps to maintain energy efficiency.

Identification of market potential and market needs

The technological advances that have been made in recent years in the field of IoT, not only in terms of hardware or software but also in communication technologies (5G, LPWAN, NB-IoT...), have enabled the collection of large amounts of data in different areas (buildings, agricultural fields, cities, factories, etc.) that can be monitored or analysed to improve energy saving systems. This data helps developers find where the energy is being wasted or where more energy could be saved, allowing developers to develop automated energy-saving systems that work based on the data collected by the various IoT devices and that will make the best decision to improve energy management, rather than having a person monitoring the data and making decisions on their own.

Digitalization has revolutionised industrial and commercial processes, notably in energy management, enhancing efficiency and value. The process involves connecting and coordinating networked equipment and devices, resulting in significant efficiency gains and enabling communication with smart power grids. Transformation in Energy Management Systems integrates energy and operational data, providing valuable insights for minimising downtime and enhancing equipment reliability. Overall, digitalizing energy processes has the potential to reshape energy management infrastructure.

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[30] https://www.mordorintelligence.com/industry-reports/energy-management-systems-market

Growing environmental concerns, including climate change, global warming, and the escalating occurrence of natural disasters, are encouraging both global and regional energy organisations to implement rigorous guidelines for the effective utilisation of energy. Consequently, governmental efforts to enhance energy consumption and management efficiency are ready to expand the overall market size for Energy Management Systems on a global scale.

In terms of market segmentation, the energy management market can be divided into:

- **System Type**: This segment categorises the market based on the different types of Energy Management Systems (EMS) or technologies that are being offered. This includes all types of EMS for homes (Home EMS), buildings (Building EMS) and industries (Industrial EMS). In this market segment, we can highlight the emergence of Industry 4.0, which has been a revolution in Industrial EMS in terms of interconnectivity, automatization, and real-time data. Thanks to these advances, this market segment is expected to grow during the following years. Related to home EMS and building EMS, this market segment is also expanding thanks to projects such as Smart Buildings or Smart Homes.

- **End User**: This segment categorises the market based on the types of users or organisations that utilise energy management solutions. The main difference with the previous market segment is that the System Type segment focuses on the energy management technology itself, while the End User segment focuses on the industries or sectors that deploy and use energy management systems. Therefore, this market segment is expected to grow thanks to the adoption of smart solutions in homes, buildings, and industries.

- **Application**: This segment categorises the market based on practical uses and purposes of EMS within various industries or settings. In this segment market, the automation sector (called e-mobility) is expected to witness a rapid CAGR due to the measures that are being taken (especially in the European Union) to stop selling petrol and diesel cars by 2035 to reduce CO2 emissions, thereby reducing pollution and climate change. Therefore, the electric car market is expected to grow during the following years.

- **Industry**: This segment categorises the market based on the industries or sectors that deploy and utilise energy management systems. The oil and gas market is one of the most powerful markets due to growing energy demand, making industries the major source of CO2, sulphur oxide (SOx), and nitrogen oxide (NOx) emissions. Due to this, governments around the world are imposing strict regulations on the oil and gas market, making industries adopt power management systems to increase energy savings and reduce carbon emissions. This is expected to boost the EMS market growth in the following years.

Market players

Key players in the market employ strategies such as introducing new products, engaging in collaborations, forming partnerships, and making acquisitions to stay competitive. Additionally, companies emphasise continuous improvement of their products by incorporating user-friendly features. This approach enables them to maintain competitiveness and enhance their brand value. Many industry participants allocate their resources to research and development efforts. Emerging players are also contributing to the market by providing advanced components, integrated systems, software, and services to strengthen their position in the industry. The most relevant key players/stakeholders for the Energy Management System are General Electric Company (U.S.), IBM Corporation (U.S.), Honeywell International Inc. (U.S.), Schneider Electric SE (France), Siemens AG (Germany), Eaton Corporation (Ireland), ABB Limited (Switzerland), Johnson Controls International PLC (U.S.), NEC Corporation (Japan), Emerson Electric Company (U.S.), C3 Energy (U.S.), Daikin Industries (Japan) and Elster Group (Germany).

5.2.5.4 Healthcare

State of the Art

Ultrasound imaging has been one of the fastest growing sectors compared to other imaging modalities. Over the last 25 years, the medical ultrasound imaging market has grown from €2.29B in 1998, to €7.77B in 2023 worldwide. That is a compound annual growth rate of over 5%.

The high growth rate made the ultrasound market very attractive. This is evident by looking at the history of the acquisitions especially in late 90s and early 2000s.

1998 – **Philips** acquired ATL ultrasound (market leader, 18% market share).

1998 – **GE** acquired Diasonics Vingmed.

2000 – **Siemens** acquired Acuson (14% market share).

2001 – **Philips** acquired Agilent Healthcare/HP medical (16% market share).

2001 – **GE** acquired Kretztechnik from Medison.

Over the years this trend continued as more players started to become interested in the ultrasound market and medical imaging in general:

2010 - **Samsung** acquired Medison.

2010 – **Hitachi** acquired Aloka.

2012 - **Fuji** acquired Sonosite.

2016 - **Canon** acquired Toshiba Medical.

2018 - A Chinese consortium acquired Esaote.

2021 - **GE** acquired BK Medical.

2021 - **Fuji** acquired Hitachi Diagnostics Imaging.

As the ultrasound market grew, the premium that big companies are willing to pay for gaining more market share has also increased:

1998 - **Philips** paid €0.73B for 18% market share (ATL acquisition).

2012 - **Fuji** paid €0.91B for 6% market share (Sonosite acquisition).

2021 - **GE** paid €1.33B for 2% market share (bk medical acquisition).*

*However, this could be considered cherry-picking, given that GE paid a high premium for BK Medical perhaps as an overreaction to Butterfly's valuation at the time or a big bet on BK's growth potential. For comparison, Fuji paid the same amount, in the same year, for 7% market share (Hitachi Diagnostics Imaging acquisition). A few years earlier, Esaote, which held a market share comparable to BK's, was also acquired for a quarter of BK's valuation.

Today, GE HealthCare dominates the medical ultrasound market, with over 30% market share. A position solidified through GE's strategic acquisitions, organic in-house developments, and strong leadership over the years. Philips holds the second spot, while Fuji has claimed the third place, after its recent acquisition of Hitachi Medical, positioning itself ahead of Canon.

By 2030, the medical ultrasound equipment market is anticipated to hit €10.97B. Given the influx of new entrants, especially in the handheld segment, and heightened competition among current players, it'll be interesting to observe the market dynamics and share distribution over time.

Identification of the market potential and market needs

Esaote's ultrasound devices will establish a distinctive competitive edge within the hospital segment, marked by substantial cost reductions and a unique emphasis on software, transducers, and high-parallel computing networks. This strategic positioning will yield compelling benefits across various fronts:

For Esaote
- **Cost Efficiency** - by eliminating plastics, mechanical components, boards, and spare parts, Esaote's approach would achieve dramatic cost reductions. This cost-conscious strategy will prioritise software, transducers, and high-parallel computing networks.
- **Transportation Savings** - the innovative design leads to a significant decrease in transport costs, streamlining logistics and contributing to enhanced operational efficiency.
- **Installation Efficiency** - Esaote's ultrasound devices would be engineered for easy and cost-effective installation, minimising the resources and time required for the setup process.
- **Service & Maintenance** - the emphasis on durability and simplicity will result in a substantial reduction in service and maintenance costs, ensuring a more sustainable and economically viable product lifecycle.
- **Environmental Impact** - with fewer materials and components, Esaote would actively contribute to a reduction in environmental impact, aligning with the increasing demand for eco-friendly technologies.

For the Hospital
- **Total Cost of Ownership**: Esaote's ultrasound devices will be able to offer an extended product life cycle, translating into a lower total cost of ownership for hospitals and contributing positively to overall financial performance.
- **Technological Advancements** - hospitals benefit from always up-to-date equipment with remote control and diagnosis capabilities, ensuring continuous access to the latest technological advancements without the need for frequent replacements.
- **Space Optimization** - the design of Esaote's devices facilitates efficient space reorganisation within hospitals, allowing for more effective resource utilisation and potentially freeing up valuable space for revenue-generating activities.
- **Market Revenue** - by offering a product that enhances operational efficiency and potentially increases patient throughput, Esaote's devices align with the market's need for solutions that contribute positively to revenue generation.

For the End-User
- **Intuitive Interface** - Esaote's user-friendly interface directly addresses the market's need for intuitive and accessible technology, ensuring that end-users can efficiently navigate the equipment to provide optimal patient care.
- **Efficient Reporting** - users experience a reduction in the time required for reporting, streamlining workflow processes and potentially leading to increased patient throughput and revenue generation.
- **Training Time Reduction** - Esaote's focus on minimising training time meets the market's need for user-friendly technology, enabling healthcare professionals to quickly and effectively adapt to new equipment and protocols.

In summary, Esaote's ultrasound devices not only meet the market's needs for cost-effective, environmentally friendly, and technologically advanced solutions but also align with the industry's demands for streamlined logistics, efficient installation, and space optimization, contributing to overall market satisfaction and success.

Market players

GE HealthCare maintained its position as market leader to the radiology ultrasound market in 2022, pulling away from Canon Medical, who is estimated to have lost market share. GE HealthCare performed well across the board and is estimated to have gained market share in all regions, even in China, where it is estimated to have overtaken Philips.

The market share GE HealthCare gained in China, the largest market for radiology ultrasound, was primarily taken from other international vendors including *Canon Medical*, Philips and Siemens Healthineers. As well as losing market share in China, Canon Medical was also estimated to have lost market share in Japan, to GE HealthCare and *Fujifilm Healthcare*.

Alongside GE HealthCare, *Mindray* was the other vendor estimated to have gained significant market share in 2022 and has overtaken Philips and Siemens Healthineers to become the third largest supplier to the radiology market in 2022. Whilst most of this market share was from the China market, Mindray is also increasing its presence internationally and is estimated to have gained market share in Europe. Mindray, alongside other Chinese vendors, was not as affected by the supply chain issues and so was able to offer systems to customers quicker than some of its Western peers. Mindray also prices its systems competitively which made it attractive to price conscious customers, or those with budget constraints in 2022.

Siemens Healthineers recently launched systems targeted at specific markets. Alongside the release of its Sequoia Crown system, which includes new features and tools, at the ECR 2023 conference, it unveiled the Sequoia Select, which only includes some of the new features included on the Sequoia Crown. Siemens Healthineers took a physician led approach to decide which features from the Sequoia Crown to include on the Sequoia Select, in a bid to target the system to the European market and offer more flexibility to customers. It is taking a similar approach in China, where it will release the Sequoia Silver, with features targeted for the China market included.

GE HealthCare remains the dominant market leader in the ABUS market. Competition is increasing in China, with local vendors entering the market. There is currently less competition outside of China.

5.2.5.5   Open-Source Communities

State of the Art

Across industry sectors, businesses of all sizes and at every stage of development are adopting open-source software. Open-source software now accounts for 80 to 90 percent of the code in a typical product, service, or application.[31] The remaining 10 to 20 percent comes from businesses that adopt open source and use it as a foundation to differentiate and add value for their customers. Many of these organisations also recognize the business benefits of participating in open-source software and communities. They understand that an effective open-source strategy goes well beyond simply consuming software. To realise the full business potential of open source, it's crucial to engage with, support, and contribute to the communities that produce the software. Community-driven open source is proven to be the best way to co-innovate on high-quality, scalable, and sustainable technologies that allow organisations to build better products faster, accelerate revenues, and create value. Collaborating with competitors on non-differentiating technologies frees scarce resources to focus on delivering value-

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[31] https://www.sonatype.com/hubfs/SSC/Software_Supply_Chain_Inforgraphic.pdf?t=1468857601884

added and differentiating features faster. Community members can pool development efforts on commodity and backend capabilities to reduce headcount expenses and development costs. At the same time, they can accelerate market adoption of technologies and standards to mitigate business risks.

Identification of market potential and market needs

In his study, "Learning by Contributing: Gaining Competitive Advantage Through Contribution to Crowdsourced Public Goods," Frank Nagle of Harvard Business School found that companies that contribute and give back to the community learn how to better use the open source software in their own environment, creating a competitive advantage.[32] According to Nagle, companies that pay employees to contribute to open source software can boost company productivity by up to 100 percent, compared with companies that simply use or consume the software. They can also improve their image and their ability to recruit top talent.

Industry scans show an increasing number of organisations at every stage of development - from startups to established global leaders - recognize the business value identified by Nagle. Results from the 2021 Open-Source Program Survey[33] reveal that:

- 75 percent of companies with 50 or fewer employees say their open-source program is very critical to their success.
- The number of companies saying their open-source program was extremely critical to the success of their engineering or product teams rose from 54 percent in 2020 to 63 percent in 2021.

Market players

To capitalise on all the benefits, open-source has to offer, companies of all sizes are actively collaborating and innovating in open-source ecosystems. Here are just a few examples of leading business-oriented open-source communities:

- The Eclipse IoT Working Group includes more than 40 members, ranging from major international players, such as Bosch.IO, Huawei, Intel, and SAP, to smaller industrial IoT (IIoT) specialists such as Aloxy, Cedalo, Eurotech, Kynetics, and ZettaScale.
- Industry leaders such as Arm, Broadcom, Ericsson, Red Hat, Renesas, and STMicroelectronics collaborate with open-source tools specialists, such as EclipseSource, Obeo, and TypeFox, in the Eclipse Cloud DevTools Working Group, a community that's focused on defining and building the future of web and cloud-based development tools.
- The Open Infrastructure Foundation comprises 500 companies supporting the development and promotion of the OpenStack platform and its community.
- The Cloud Native Computing Foundation was founded around Kubernetes which was contributed to the Linux Foundation by Google as a seed technology. Founding members include Google, CoreOS, Mesosphere, Red Hat, Twitter, Huawei, Intel, Cisco, IBM, Docker, Univa, and VMware. Today, CNCF is supported by over 450 members.

Active involvement also spans a broad spectrum of industries. The 2021 Open-Source Program Survey noted that while adoption of Open Source Program Offices (OSPOs) was still highest among technology companies, adoption by public sector, retail, education, financial services, and transportation organisations is on the rise.

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[32] https://hbswk.hbs.edu/item/the-hidden-benefit-of-giving-back-to-open-source-software, Harvard Business School, September 5, 2018.

[33] https://github.com/todogroup/osposurvey/tree/main/2021, GitHub, October 22, 2021.

5.2.6   Standardisation organisations

State of the Art

The current state of the art in the targeted market(s) of the NEPHELE consortium partners includes an exploration of the technological advancements, software packages, and open-source projects that are shaping the industry. Notably, the W3C Web of Things (WoT) specifications stand out as a significant development. These specifications have been widely adopted by numerous software packages and projects, facilitating Thing Description validation and construction, support for Thing runtimes, and Thing Description directories that enable discovery. Such advancements underscore the evolving landscape of the market and set the groundwork for further analysis.

Identification of Market Potential and Market Needs

The market potential and specific needs of standardisation bodies within these markets involve a detailed investigation into the practical applications of current technological advancements and how they align with the market's demands. The growing market adoption of the WoT, exemplified by products like SayWoT! and Desigo CC from Siemens, highlights a clear demand for solutions that leverage the WoT specifications. This trend not only illustrates the market's appetite for innovative WoT applications but also indicates the broad potential for projects and products that align with these standards.

Market Players

Various entities contribute to the advancement and adoption of standards like those developed by W3C. Additionally, the involvement of standardisation bodies such as ETSI, IEEE, ISO, and CEN/CENELEC is crucial. These organisations play a pivotal role in shaping the market by developing and endorsing standards that ensure interoperability, security, and reliability. Understanding the dynamics among these players and their influence on the market is essential for navigating the competitive environment and leveraging opportunities for collaboration and innovation.

In summary, the identified standardisation bodies and key players significantly influence the market. Contributions to and cooperation with these bodies will guide the project's strategic direction and ensure its outcomes are well-positioned to meet market demands and contribute to the broader ecosystem.

5.2.7   Integral Market Analysis

Within this section, multiple analytic tools have been utilised to facilitate specific markets analyses outcomes as inputs for integral/overall market analysis. The idea of these analysis is to highlight key consideration points potentially useful for defining further business strategies and making decisions for entering market(s) where the technology NEPHELE project is developing is in focus, i.e., IoT within cloud-edge continuum computing, including supportive technologies such as AI and 5G. Following analytic tools have been utilised: PEST analysis, Porter's Five Forces analysis and SWOT analysis.

PEST analysis

PEST analysis[34][35] is a management method which consists of assessing Political, Economic, Social, and Technological factors as being major (external) influences on the business environment. An organisation would apply for the analysis in order to become more competitive in the market. Besides assessing major influences that affect the market(s), the organisation is positioned in, or is planning to position in, the analysis can also facilitate an effective strategic planning. The planning, for example, can be undertaken to maximise the organisation's ability to capitalise on conditions as they exist, as well, it can help the

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[34] https://www.investopedia.com/terms/p/pest-analysis.asp

[35] https://en.wikipedia.org/wiki/PEST_analysis

organisation to better prepare itself for potential changes, thus allowing it to stay ahead of competitors. However, PEST analysis is believed to be, in general, more effective with larger organisations that are more likely to experience the effects of macro events. In scope of Nephele market analysis, outcomes of PEST analysis may, as other analyses, serve for Nephele partners to better recognize what business strategies might be applied and to help partners making better decisions whether they are already positioned within the targeted market(s) or whether they are planning to enter (new) market(s).

- **Political**: NEPHELE project's targeted technologies are presented in multiple markets, while dominated mainly by (big) non-EU actors, therefore it seems development of such technologies has political support in general. Due to the limitation to a few big players, multiple issues can be identified – from security, lack of data control, accessibility to market for smaller organisations, lagging in development of skills, etc. Although EU legislation strives for non-discrimination, some previous and recent attempts indicate tensions for limiting (big) monopolies, thus providing some potential opportunities for less-established and even smaller players and consortiums of them, which in turn, are in certain cases also encouraged through mechanisms such as IPCEI (Important Projects of Common European Interest). Further on, these technologies are significant contributors to the digital transformation and green transformation of the complete EU economy on one end, and are also, on the other end, contributors to solutions addressing climate changes, raising political tensions across the world and its threat to human rights and free trade, etc. It is more or less clear that digital and green transformation are necessary to keep the EU economy competitive and therefore it is of strategic importance to develop and adapt technologies for industry verticals such as public safety, agriculture, energy production/consumption, healthcare, maritime and ports, smart cities, etc. IoT technologies are also considered advanced in the sense they can overcome certain issues of less advanced telecommunication networks compared to their more contemporary counterparts, thus providing opportunity for fostering faster development also in states with less developed telecommunication infrastructure.
- **Economic**: Currently, certain tensions and political instability worldwide, as mentioned above, affect the economy as well, resulting in slower economic growth (incl. inflation and recession) as result of supply chain disruptions, increased costs of HW, and finally consumer spending power. Otherwise, the markets addressed by NEPHELE are all expected to grow in the future, therefore prognosticating good opportunities for entering the market and further business expansion, especially with innovative solutions. Various business models can be identified by the actors already active in specific markets, which also indicates there is room for new entrants to the market to position itself as best as possible. However, even completely new business models might be attractive for customers in the market, given the fact the value added by IoT and other NEPHELE technologies can contribute to shorter time to the market and for the end user to lower costs, enhance accessibility and flexibility of the services/product, contribute to digital and green transformation, etc. However, new technologies are in general easy to acquire but not easy to implement, therefore a workforce with specific skills is required, and as long as there is shortage of ICT experts, investment in staff might be necessary as well.
- **Social**: With an ageing society in the EU, future technological solutions will also need to address this specific fact, meaning certain business opportunities may be utilised by exploitation of the products/services adapted to specific needs of elderly people. Ageing society on the other hand also means potentially less workforce available and potentially higher costs of workforce and/or additional investments in gaining skills. Otherwise, IoT and other NEPHELE technologies have clear potential in addressing multiple social challenges (ageing and healthcare, energy efficiency, environmental and economic sustainability, etc.), this fact should contribute at achieving better public acceptance of these technologies in everyday life, as well as of its further development. After all, IoT and related technologies are one of key elements in enabling information society.
- **Technological**: highly innovative approach following latest technological achievements (while adding own unique ideas), skilled partners with the ability to develop required components and

integrate them into the prototype, provide excellent prospects for building future-proof products and services which may also affect further development of IoT technologies globally. This approach, of course, should last in case market players would like to remain competitive. Current technological trends related to IoT involve cloud-native software deployments, virtualized environments, and AI/ML support utilised within interconnected networks of sensors, where low latency, high performance, zero downtime, enhanced security measures and assured quality of service are achievable. However, potential drawbacks of technological advancement might be inability to address current and near future requests from the market due to the slow pace of adopting technologies, targeted by NEPHELE, in specific markets.

Porter's five forces analysis

Porter's five forces analysis[36] [37] is a tool used for assessing the competitive landscape of an industry, thus directly applicable to market analysis. It set out five, so-called, forces which play key roles in any given industry/market: internal competition, the potential for new entrants, the negotiating power of suppliers, the negotiating power of customers, and the ability of customers to find substitutes. The analysis is aimed at helping organisations to better understand where power lies within the industry, also trying to address real-world situations where competitors are not always just rivals as it is usually assumed by "perfectly competitive" business models. Five forces determine industry in terms of profitability, i.e., what profits would be generally expected, and may also help identify whether there might be any potential sources that could serve to increase the profitability. The analysis was first introduced in a 1979 article published in the Harvard Business Review.

- **Competition**: in each market analysed within the NEPHELE project, actors of different sizes are present. Established big players tend to be dominant and powerful especially within the cloud services market and markets which are significantly regulated (e.g., PPDR, healthcare, infrastructure). On the other hand, smaller players cover more niche segments of all markets and are, benefiting out of their considerable flexibility over bigger organisations, able to take a certain part of market share while the market is not yet fully matured and while certain niches are appearing. In such a situation, first adopters may already require solutions bigger players are not able to provide, thus giving opportunity to smaller providers. However, in many cases, smaller companies are therefore acquired by bigger ones. Market competition may also improve in favour of smaller companies by introducing more open technological standards as may be observed in IT industry, as well as in telco industry, e.g., recent Open RAN initiative.
- **Potential for New Entrants**: various entrance barriers have been identified during the analysis of the markets of interest, ranging from those with relatively low barriers (e.g., application development market) to those with higher barriers (e.g., highly regulated markets, infrastructure-dependent markets). Bigger NEPHELE partners with capabilities of providing mass products/services will likely rely on economy of scale which will incur higher costs for market entrance than for smaller partners which may still count on lower market entrance costs providing highly customised and niche solutions for specific customers who may have specific interest in adopting new (IoT) technologies. Opposite to the latter, it is expected the customers which are not yet urgently forced to switch from their existing technologies to new technologies (e.g., PPDR, energy management) will not be willing to cooperate extensively, thus representing higher entrance barriers. As well, in cases where compliance to standards and local regulations is required, entrance barriers may be lowered by introducing more open technological standards (including IoT and 5G) which can be, for example, facilitated by active participation in standardisation organisations.
- **Power of Suppliers**: as it holds in general, it also turns out in analysed markets that in those markets, dominated by big players with (many) large deployments of services and products,

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[36] https://www.investopedia.com/terms/p/porter.asp
[37] https://en.wikipedia.org/wiki/Porter%27s_five_forces_analysis

suppliers have significant power due to considerable switching costs for the customer. Similarly, small players' power is moderate unless they provide specific and/or highly customised solutions. Since analysed markets are growing and market niches are appearing, innovative suppliers may become powerful if addressing prospective niches.

- **Power of Customers**: customers targeted within analysed markets could be private organisations, end consumers, as well as public or private-public partnership organisations (e.g., healthcare, PPDR, infrastructure, smart cities) backed by local/regional/state authorities. In general, it can be observed that markets are growing, thus demand is relatively high, giving service/product providers more power while negotiating prices. As it may be expected B2B type of transactions will be most likely (and in some cases B2B2C as well) for most of the NEPHELE services/products, customers' requirements of purchase sizes may be significantly large, thus affecting prices on one hand, while potentially raising switching costs for the customer on the other hand. Additionally, in markets where customers are not yet urgently forced to switch from their existing technologies to new technologies (e.g., PPDR, energy management), the power of customers is larger as well.
- **Threat of Substitutes**: based on the fact that digitisation is in progress and targeted markets are growing, there is low risk for the addressed technologies to be substituted in general. However, particular solutions can be more easily substituted, which mainly depends on their specific flexibility they can provide in terms of relevant techno-economic parameters. Given the NEPHELE project goals are oriented on providing high flexibility of the outcomes, the threat of substitutes would present low risk for the actors exploiting their results in the market.

SWOT analysis

SWOT analysis is a strategic planning and strategic management technique used to help a person or organisation identify Strengths, Weaknesses, Opportunities, and Threats which are further used to evaluate an organisation's competitive position and to develop (strategic) project planning[38] [39]. It is necessary for the organisation to keep the analysis updated and accurate, focusing on relevant context. Within the analysis, performance, competition, risk, business potential and similar indicators are assessed through analysing internal (strengths, weaknesses) and external factors (opportunities, strengths):

- **Strengths**: characteristics of the business or project that give it an advantage over others.
- **Weaknesses**: characteristics that place the business or project at a disadvantage relative to others.
- **Opportunities**: elements in the environment that the business or project could exploit to its advantage.
- **Threats**: elements in the environment that could cause trouble for the business or project.

Although the SWOT analysis will not solve an organisation's every major concern by itself, it can provide multiple useful outcomes that may make decision-making (a bit) easier. With this in mind, Nephele market SWOT analysis points to many topics that need to be considered by partners to make better decisions whether they are already positioned within the targeted market(s) or whether they are planning to enter (new) market(s).

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[38] https://en.wikipedia.org/wiki/SWOT_analysis

[39] https://www.investopedia.com/terms/s/swot.asp

Table 3: Market SWOT Analysis.

Strengths (internal factors)	Weaknesses (internal factors)
Flexibility and scalability of the solution(s), Orchestrated solution(s), Support of cutting-edge technologies and approaches (cloud-native, AI, CI/CD, digital twins, etc.), Integrated cybersecurity and trust management mechanisms, Adapted to high network dynamics (links fluctuation, mobility), Supporting heterogeneous devices Domain knowledge of certain industry verticals (healthcare, energy management, logistics, PPDR), Supported by open-source communities, Availability of testbed facilities	- Maturity of solutions (TRL), - Potential delays in development, - Availability of special devices required for certain use cases implementation, - Maintenance of the product/service - Providing HW resources, - Lack of extensive field tests
Opportunities (external factors)	**Threats** (external factors)
- Growing markets (CAGR between 10% and 30% - depending on specific market), - Various business models available, - Digitisation is in high demand, - NEPHELE technologies are able to address social challenges such as climate changes, etc., - Ability of influencing standardisation process, - Ability of influencing open-source communities	- Not all potential users may be yet ready and/or willing to adopt new technologies, - Certain legislation limitations may require additional time to adapt to possibilities available by utilising new approaches provided by IoT technologies, - Market entrance barriers such as certifications and compliance to specific standards, - Slow pace of adopting new (IoT) technologies and their integration into existing networks and business processes, - Non-acceptance of new technologies from certain publics (e.g., anti-AI, anti-5G movements), - Existing market players

5.3   Business Plan

NEPHELE project's goal, among others, is also to increase European autonomy in data processing which requires support for future hyper-distributed applications by building open platforms and an open edge ecosystem. Businesswise, increasing European autonomy in the field, includes development of business models. Therefore, this deliverable, as previously indicated in D8.1, proposes initial steps towards business models and plans which will be finalised by the end of the project and presented in deliverable D8.3.

Initial work on business planning of NEPHELE project has been so far focused on creating Business Model Canvases, as a strategic management tool aimed at visualising and assessing the business idea. The Business Model Canvas therefore presents a business model by graphically providing different core elements of the (planned) business.

Use cases brought into the project have a clear vision of its business/market potential, since there are certain business partners involved in each of them. Similarly, business/market potential has been envisioned for the NEPHELE platform as one of its objectives is to contribute to increasing European autonomy in data processing. Therefore, initial work on business planning includes Business Model Canvases for NEPHELE's use cases and platform, presented in the following subsections.

5.3.1   Business Model Canvas

The business model canvas was developed by Alex Osterwalder and Yves Pigneur [5] and serves as a visual framework for planning, developing and testing the business model(s) of an organisation. Through visually representing all key elements of the business model, it provides a comprehensive perspective, enabling organisation's team members at facilitating effective collaboration and thus achieving an alignment on the model.

The canvas consists of nine fields which, in general, focuses on the value proposition, infrastructure, customers, and financial aspects of the business (e.g., product or service, etc.). As mentioned before, the objective of the Business Models Canvas is analysis of the business idea in terms of how it can generate profitability.

Canvas fields are divided into right and left side and one middle field:

-        the right side of the canvas: focuses on external factors that are not under the control of the business owner, i.e., the customer or the market,

-        the left side of the canvas: focuses on internal factors that are mostly under the control of business owner such as costs and business activities,

-        the middle – Value Proposition: the value propositions that represent the exchange of value between the (analysed) business and the customers.

The tool itself is versatile and customizable and can be adjusted to suit the specific requirements of any company, regardless of its size or business/industry. As well, it enables a methodical approach for investigating opportunities and experimenting with new concepts, thus fostering creativity and innovation[40].

Following figure presents Business Model Canvas template:

Table 4: Business Model Canvas.

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
	Key Resources		Channels	
Cost Structure			Revenue Streams	

Meaning of the fields in the Business Model Canvas are as follows[41]:

-        **Key Partners**: To make a business model canvas, identify the key partners needed to make your business model work. Think about suppliers, distributors, or other entities that could help your business run more smoothly or effectively. Consider the nature of these partnerships, how they benefit your business, and how you'll maintain those relationships over time.

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[40] https://creately.com/guides/business-model-canvas-explained/

[41] https://miro.com/strategic-planning/what-is-a-bmc/

-    **Key Activities**: The key activities section of a business model canvas lists what your business needs to do to deliver value to your customers. Think about the core activities required to create your product or service, plus any supporting functions like marketing or accounting. When completing this section, focus on high-level activities and avoid getting bogged down in the details.

-    **Key Resources**: This section of a business model canvas refers to the assets of your business. These might include physical resources like equipment and inventory or intangible assets like intellectual property or human capital. Consider which resources are critical to your business success and how you can best leverage them to achieve your goals.

-    **Value Proposition**: The value propositions section of a business model canvas describes your business's value proposition. Think about what benefits your product or service provides customers. Then think about how it differs from what's already on the market. This section allows you to differentiate yourself from competitors and position your business for success.

-    **Customer Relationships**: Identify how your business interacts with its customers in the customer relationship section. This section could include direct communication channels like email or social media. Also consider indirect customer loyalty programs. When completing this section, think about building trust and maintaining a positive relationship with your customers throughout each stage of the customer journey.

-    **Channels**: The channels section of a business model canvas describes how customers will interact with your business. It also describes the sale channels for your product or service. Think about online and offline channels and how each channel is used at different stages of the customer journey. When completing this section, focus on the channels that'll be most effective for your target audience.

-    **Customer Segments**: The different groups of customers your business serves are described in the customer segments section. Think about each segment's needs or problems and how your product or service can address those needs. When completing this section, clearly define your target audience and consider potential future segments.

-    **Cost Structure**: The cost structure section of a business model canvas lists expenses your business has. These include materials, labour, marketing, or technology. Consider fixed and variable costs and how your business can spend efficiently to maximise efficiency.

-    **Revenue Streams**: If you have a business, you need to figure out how it makes money. Think about how you'll make money from your product or service. Your revenue streams may change over time as your business evolves.

Use case's initial business canvases presented in the following subsections are based on the previous work done by Nephele use cases within The European Cloud, Edge and IoT Continuum Initiative Task Force 4 "Market and Sectors" (EUCloudEdgeIoT.eu), where the initial ideas have been presented and discussed with other similar use cases.

5.3.2   Business Model Canvas of Use case 1 – Post-disaster in a container terminal

Business Model Canvas, and subsequently the business model, presented in this subsection can be applied to first responders and disaster responder services which seek to enhance situational awareness using technological solutions to guarantee safe operations, to mitigate damages, and ensure rapid rescue operations. Other stakeholders in this use case may include the operator of the port, the city government and insurance companies.

Table 5: Business Model Canvas of Nephele Use Case 1.

Key partners	Key activities	Value Proposition	Customer Relationships	Customer Segments
- Application developers - First responders - IoT vendors - Insurance companies - Port operators - Partners with mission-critical tasks knowledge	- Integration of IoT nodes, robots, drones, and multi-technology gateways to deploy a network infrastructure in the disaster area - Robots-based exploring and mapping applications - Victim detection and injury assessment - Risk prediction in post-disaster scenarios	- Enhanced situational awareness to first responders - Increased victim-locating capabilities - Improved injury assessment - Improved emergency operations management based on risk	- Co-creation and collaboration relationships during test and demo phase	- First responders - Port operators - Insurance companies - Public Safety Answering Points - Local government
	Key resources - ICT expertise for IoT-based network deployment, service development and integration - ICT expertise in robots and drones controlling - Mission-critical tasks knowledge - Knowledge in risk assessments in post-disaster scenarios		**Channels** - Test and trials campaigns - Dissemination at fairs and other industry events - European Emergency Number Association website and newsletter - Web and social media promotion - Dissemination in international conferences and peer reviewed journals	

Cost Structure	Revenue Streams
- R&D costs - IoT devices, drones and robots costs -Demonstration and test costs - Service deployment and integration costs - Administrative and legal costs (e.g., to address potential GDPR and data confidentiality issues) - Marketing/sales costs	- EU funding to support the initial development - Services usage and/or licensing fees when open licensing is not available

5.3.3 Business Model Canvas of Use case 2 – Containers routing optimization in the port

Business Model Canvas, and subsequently business model, presented in this subsection can be applied to the operator of a (sea) port which seeks for its business opportunity, including cost optimization and improved quality of service provided to the customers, by approach of optimising routing of containers within the port.

Table 6: Business Model Canvas of Nephele Use Case 2.

Key partners	Key activities	Value Proposition	Customer Relationships	Customer Segments
- Application developers - Service providers - IoT vendors - Infrastructure providers and operators - Research institute or partner with logistics domain knowledge	- Integration of IoT devices and video cameras to port facilities - Integration of services with existing port information system - Marketing activities - Training sessions for the customer	- Improved forklifts utilisation - Improved workforce utilisation - Improved delivery time - Reduced delivery errors - Less traffic congestions - Improved port services - Cost optimization - CO_2 and noise reduction	- Co-creation and collaboration relationships during test and demo phase - Foster the adoption of the tools and services beyond the end of the project	- Port operator - Freight forwarder - Local government
	Key resources - ICT expertise for the development and integration of services - Logistics processes expertise		**Channels** - Test and trials campaigns - Web and social media promotion - Dissemination at fairs and other industry events	

Cost Structure	Revenue Streams
- R&D costs - IoT devices and video cameras costs - Service deployment and integration costs - Administrative and legal costs (e.g., to address potential GDPR and data confidentiality issues) - Marketing/sales costs	- EU funding to support the initial development - Services usage and/or licensing fees - Cost savings related to optimised processes within the customer

5.3.4   Business Model Canvas of Use case 3 - Energy management in smart buildings/cities

Business Model Canvas, and subsequently business model, presented in this subsection can be applied to local governments, citizens, or building managers and administrators who seek to improve energy efficiency in their facilities and therefore reduce costs and improve well-being.

Table 7: Business Model Canvas of Nephele Use Case 3.

Key partners	Key activities	Value Proposition	Customer Relationships	Customer Segments
- Application developers - City administrators - Smart building owners/operators - IoT vendors - Infrastructure providers and operators - Research institute or partner with logistics domain	- Design, development, production, and marketing of smart energy solutions - Deployment and orchestration of applications on the VOStack - Continuous improvement and optimization of applications	- Intelligent monitoring and remote energy management - Improved well-being and comfort - Improved latency and reliability - Secure group communication protocols - Distributed	- Continuous support and updates for deployed applications - Collaboration with customers for customization and optimization - Regular training sessions for users and administrators	- Smart Building Owners/Operators - City administrators - Energy Service Providers - IoT Device Manufacturers

	Key resources	complex decision-	**Channels**	
knowledge	- ICT expertise for IoT-based network deployment, service development and integration - Knowledge in energy management	making - Distributed authorization scenarios - Object/Person detection with IA - Communication radio offloading for battery-powered devices	- Direct sales to Smart Building Owners/Operators and City Administrators - Test and trials campaigns - Web and social media promotion - Dissemination at fairs and other industry events - Partnership with Energy Service Providers	

Cost Structure	**Revenue Streams**
- R&D for advanced applications - Infrastructure costs for IoT and Edge/Cloud Computing - Marketing and sales expenses - Support and maintenance costs	- Sales of Smart Energy Applications and Services - Licensing and subscription fees - Maintenance and support contracts

5.3.5 Business Model Canvas of Use case 4 - Ambulance in a Rural Environment

Business Model Canvas, and subsequently business model, presented in this subsection can be applied to ambulance operators that must ask for support towards hospital high-skill operators in different geographical locations. The solution promotes local health even in rural areas to all EU citizens.

Table 8: Business Model Canvas of Nephele Use Case 4.

Key partners	**Key activities**	**Value Proposition**	**Customer Relationships**	**Customer Segments**
- Application developers - Infrastructure providers and operators - Research institute or partner with ultrasound domain knowledge - Hospitals	- Design, development, production, and marketing of ultrasound solutions - Deployment and orchestration of applications on the VOStack - Continuous improvement and optimization of applications	- Ultrasound solution scalability - Remote ultrasound training - Remote ultrasound demo - Ultrasound Exam remote support and second opinion	- Continuous support and updates for deployed applications - Collaboration with customers for customization and optimization - Training sessions for users	- Ultrasound Operator - Sonographer - Physician
	Key resources - ICT expertise for IoT-based network deployment, service development and integration - Knowledge in Ultrasound Management		**Channels** - Test and trials campaigns - European Ultrasound Association and Emergency Association website and newsletter	

| | | | - Web and social media promotion
- Dissemination in international conferences and peer reviewed journals | |

Cost Structure	**Revenue Streams**
- R&D for advanced applications - Infrastructure costs for IoT and Edge/Cloud Computing - Marketing and sales expenses - Support and maintenance costs	- Sales of Ultrasound - Licensing and subscription fees - Maintenance and support contracts

5.3.6 Business Model Canvas of the NEPHELE platform

The following business model canvas refers to the overall solution provided by NEPHELE and regards the open-source software stack for virtualization of IoT devices and the Meta-orchestration platform. It is targeted to IoT vendors and IoT application developers that can take advantage of the virtualization of IoT devices and the provision of IoT virtual functions at the edge part of the infrastructure, Edge and Cloud computing application providers that can deploy and manage distributed applications across multi-cluster infrastructure in the computing continuum, Network providers that can support the deployment of efficient network management mechanisms to satisfy QoS needs of the applications, and application developers that can develop microservices-based applications considering the desired intent and including -where required- Virtual Objects (VOs) as parts of their application graphs.

Table 9: Business Model Canvas of Nephele Platform.

Key partners	Key activities	Value Proposition	Customer Relationships	Customer Segments
- Edge/Cloud Application Providers - Edge/Cloud/IoT Infrastructure Providers - Network Providers - Edge/Cloud/IoT Application Developers - IoT Vendors	- Virtualization of IoT devices and functions through VOStack - Development of distributed applications with integrated IoT functionalities - Development of Digital Twins - Orchestration of distributed applications across multiple clusters - Intent-driven orchestration	- Software stack for virtualization of IoT devices, interoperability of IoT technologies and convergence with edge/cloud computing technologies - Synergetic orchestration framework for intent-driven multi-cluster management of compute and network resources	- Promotion of the added value introduced by the NEPHELE artefacts in events, social media, workshops - Creation and maintenance of an open-source community - Continuous interaction with standardisation bodies - Support of partners in the open calls	- Cloud/Edge Application Providers, Software Houses - Cloud/Edge/IoT Infrastructure Providers - IoT Vendors
	Key resources - Software repositories with pool of existing components and VOs - Compute and		**Channels** - Website - Social media - Participation at events, workshops, conferences - Clustering events	

	network resources across the computing continuum - Researchers with expertise in IoT, Edge/Cloud and 5G/6G networking technologies - Software development teams		- Industrial exhibitions	

Cost Structure	Revenue Streams
- Operation and management of the NEPHELE platform - Lease/ownership of compute and network infrastructure across the continuum - Software development expenses for customised or industry-specific solutions	- Offering for usage of the NEPHELE platform for intent-driven multi-cluster orchestration of distributed applications - Lease of IoT infrastructure and VOs, cVOs, Digital Twins (DTs) - Custom development of VOs, cVOs, DTs

6 Initial report on Open source, community building and sustainability activities

NEPHELE implements an open source and community building strategy to maximise up-take and achieve sustainability of project results beyond the project lifetime and contribute to a sovereign, open European IoT-Edge-Cloud Continuum.

6.1 Open Source and Community Building Strategy

The detailed description of the NEPHELE Open Source and Community Building Strategy can be found in Deliverable D8.1.

The following sections report on the progress and activities performed, looking at the four key aspects of the open source and community building strategy:

- to create an environment that allows for open collaboration and implementation of open source best practices right from the start (Section 6.2),
- to draw and keep track of the open source landscape of the project (Section 6.3),
- to implement sufficient IP management (Section 6.3), and
- to lay out measures for community building, sustainability and long-term governance (Section 6.4)

6.2 Eclipse Research Labs: Implementing Open Source Best Practices

Eclipse Research Labs is a combination of infrastructure (GitLab), processes and training to implement open-source best practices right from the start and increase the chances of delivering high-quality, professional open-source results.

Eclipse Research Labs aims at gradually and continuously preparing research results to become proper open-source projects during the research project lifetime.

Repositories

In M2, the NEPHELE Research Labs GitLab was provisioned and by the date of writing 27 developers signed the Contributor Agreement and joined the NEPHELE GitLab. The repositories are structured according to the components of the NEPHELE Open Source Platform (see Figure 43).
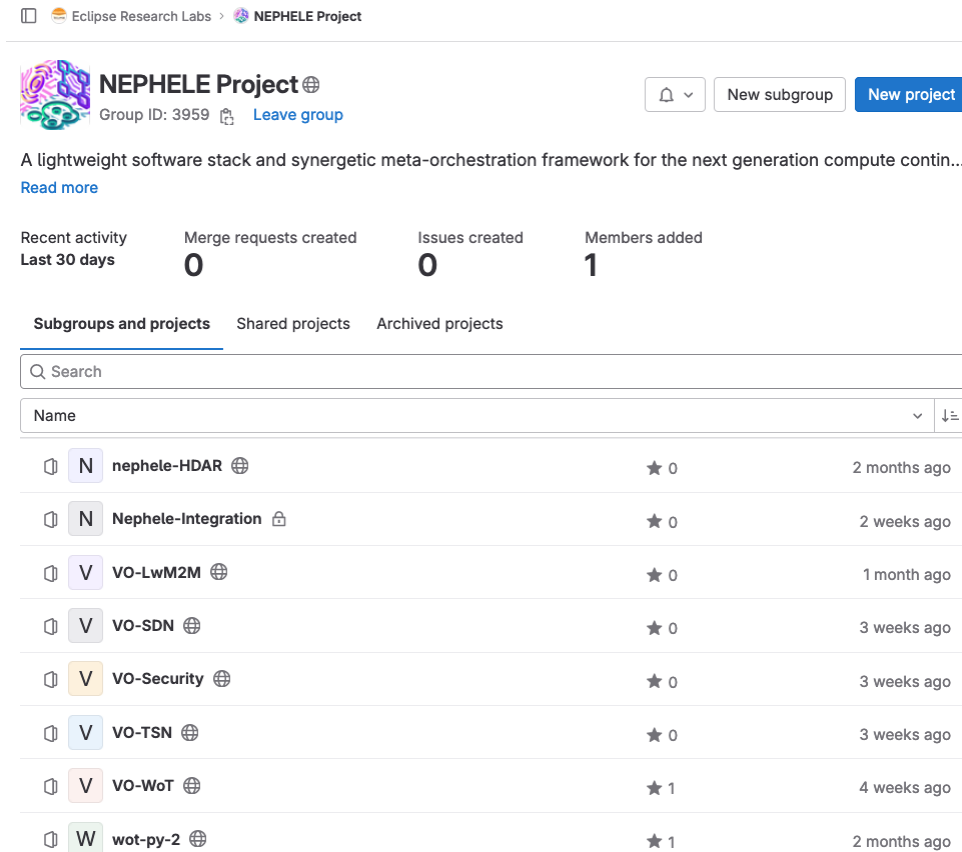
Figure 43: Repository GitLab for the components of the NEPHELE Open Source Platform.

Open-Source Licences

IP and license management is an important part of open-source software development. Two steps need to be considered:

1. The license(s) under which the NEPHELE Open Source components will be made available
2. Compatibility with the licences of third-party libraries used by NEPHELE components.

The basic agreement for NEPHELE open source is that it will be licensed under a permissive or weak copyleft licence. By default, this includes Apache-2-0, MIT, and BSD-3-Clause, and EPL-2.0. Use of other licences will be decided based on prior discussion among the consortium members. Respective **copyright headers** will be added to all relevant files in the repositories accordingly. Copyright headers for NEPHELE will follow the Eclipse Foundation recommendations as described in the Eclipse Foundation Project Handbook[42] and depicted in Figure 44.

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[42] https://www.eclipse.org/projects/handbook/#ip-copyright-headers

```
/**********************************************************************
 * Copyright (c) {year} {owner}[ and others] ①
 *
 * This program and the accompanying materials are made available under the ②
 * terms of the Eclipse Public License 2.0 which is available at
 * http://www.eclipse.org/legal/epl-2.0.
 *
 * SPDX-License-Identifier: EPL-2.0 ③
 *
 * Contributors: ④
 *   {name} - initial API and implementation
 **********************************************************************/
```

Figure 44: Copyright headers for NEPHELE

1) Name of the initial copyright owner (this must be a legal entity); other organisations that have contributed are either listed individually or grouped together by appending "and others". The year is expressed either as a single year or a range spanning the year of the initial creation and that of the most recent change.

2) Declared project licences described in human readable form.

3) Declared project licences indicated using SPDX codes and expressions.

4) The names of the contributors and the nature of their contribution (this section may be excluded).

3rd-party licence compliance will be checked semi-automatically on a regular basis, using the Eclipse Dash License Tool[43] (short: Dash Licence). Dash License identifies the licences of content. It is intended primarily for use by Eclipse committers to vet third party content used by their Eclipse open-source project. The Eclipse Dash License Tool does not identify dependencies (at least not in general). Rather, the value it provides starts after the list of dependencies are identified by build tools. That is, the tool works on the list of dependencies with which it is provided. Ultimately, the tool is only as good as the input with which it is provided, and it is up to the committee to ensure that the input provided is correct. That means, dependencies that are not automatically discovered by build tools must be vetted manually.

For any licence-incompatible library found, the developer of the respective NEPHELE component is asked to exchange it, i.e., look for a library providing similar functionality under a compatible licence.

6.3   NEPHELE Open Source Platform

The NEPHELE Open Source Platform comprises the following software components/projects which are accessible via the project's public GitLab repository https://gitlab.eclipse.org/eclipse-research-labs/nephele-project.

Hyper-Distributed Application Registry and Development Environment: Nephele-HDAR

The NEPHELE Hyper-Distributed Application Registry (HDAR) is the common storage, distribution and verification system for all the artifacts involved in the deployment of HDA via the NEPHELE Synergetic Meta-Orchestration framework. The HDAR is an implementation of the Open Container Initiative (OCI) distribution specification to harmonise how artefacts are managed in the compute continuum. HDAR also includes a development sandbox repository and a Command Line Interface (CLI) utility to assist developers on the creation, verification and distribution of the artifacts related to the HDAs. HDAR is released as open source under the Apache-2.0 License.

Synergetic Meta Orchestration - Network Management and Interfaces:

---

[43] https://github.com/eclipse/dash-licenses

Open Source MANO SDN/NFV

As part of the advanced management of the network part of the compute continuum, NEPHELE will develop autonomic and ad-hoc functionalities covering Software-Defined Networks (SDN) and Network Function Virtualization (NFV) Management and Orchestration (MANO) systems. Additionally, NEPHELE is using an OCI-Registry (Open Container Initiative) to store NFV and SDN artifacts (xNF) compatible with the Open Source MANO (OSM) software stack. As a community-led project, OSM delivers a production-quality MANO stack that meets operators' requirements for commercial NFV deployments. NEPHELE developments will contribute to this community.

VO-Networking: VO-SDN, VO-TSN

The networking functionalities supported by the Virtual Object (VO) are accommodated within the Physical Convergence layer of the VOStack. These functionalities are organised as two distinct elements: Time-Sensitive Networking (TSN) Control Plane and Reactive Routing. By utilising TSN, we ensure low latency and jitter in the communication between IoT devices and their associated VOs. The TSN control plane encompasses a Schedule Engine for the computation of TSN schedules based on flow requirements and a Gate Control List (GCL) controller for the computation of time intervals on the GCL. Communication with TSN bridges is established using NETCONF and YANG. On the other hand, Reactive Routing maintains network connectivity between wireless IoT nodes and the IoT, irrespective of mobility or other connectivity implications. The Reactive Routing control plane supports topology discovery, path computation, and clustering at the c(VO) level. Communication with IoT nodes is established using a technology-specific API, following the principles of software-defined networking (SDN). VO-TSN and VO-SDN are released as open source under the MIT License.

Security Functionality: VO-Security

For the Southbound interface (VO-to-Device), security measures will be robustly implemented through the utilization of MQTT with TLS (Transport Layer Security) and CoAP with OSCORE. For the Northbound interface (VO-to-cVO, VO-to-App and cVO-to-App), the architecture is based on the utilization of Holder, Verifier, Issuer and PEP-Proxy components. These components are deployed within Kubernetes on every element (Applications, cVOs, and VOs) and will be released as open source under the Apache-2.0 license.

VO-Stack Implementations: OMA-LwM2M, W3C Web of Things

VO-LwM2M is a VO-Stack implementation based on the OMA-LwM2M standard which enables scalability and semantic standardization. VO-LwM2M is released as open source under the MIT License and it builds using modern Java framework and storage solutions for time-series data in order to extend the physical device capabilities (i.e. computational and storage) into the VO-Stack space. It implements interfaces for service orchestration, virtual function integration and multiprotocol communication interfaces. VO CoAP core leverage on open-source Eclipse Leshan project.

VO-WoT is a VO-Stack implementation based on the W3C Web of Things (WoT) standard. It builds on the wot-py Python implementation of WoT, extending it with VO-Stack features such as VO storage space, composite VO, implementation of orchestration interfaces, and concepts of virtual functions. VO-WoT is released as open source under the MIT License and collaboration with the Eclipse ThingWeb open-source community has been established to align developments and contributions. The goal is to make relevant contributions to this community.

Table 10 provides an overview of the currently available open-source components of NEPHELE.

Table 10: Open-source components of NEPHELE.

Name	Link	Lead	License	Full description
nephele-HDAR	https://gitlab.eclipse.org/eclipse-research-labs/nephele-project/nephele-hdar	ATOS	Apache-2.0	D4.1, Chapter 4
VO-Security	https://gitlab.eclipse.org/eclipse-research-labs/nephele-project/vo-security	ODINS	Apache-2.0	D3.1, Chapter 6
VO-SDN	https://gitlab.eclipse.org/eclipse-research-labs/nephele-project/vo-sdn	UOM	MIT	D3.1, Chapter 5
VO-TSN	https://gitlab.eclipse.org/eclipse-research-labs/nephele-project/vo-tsn	UOM	MIT	D3.1, Chapter 5
VO-WoT	https://gitlab.eclipse.org/eclipse-research-labs/nephele-project/vo-wot	NTUA	MIT	D3.1, Chapter 6
VO-LwM2M	https://gitlab.eclipse.org/eclipse-research-labs/nephele-project/vo-lwm2m	CNIT	MIT	D3.1, Chapter 6

6.4 Community Building Activities

During the first six months of the project, a set of high-priority communities who are relevant in terms of open source have been identified. In the following we briefly describe each community and their relevance for NEPHELE's open-source ambitions and the activities performed to establish relationships between these communities and NEPHELE.

Eclipse IoT Working Group - https://iot.eclipse.org

The Eclipse IoT Working Group enables collaboration on the development of open source implementations of IoT standards and protocols, frameworks and services used by IoT solutions, and tools for IoT developers for commercial-grade IoT. Currently, the Eclipse IoT Working Group comprises around 50 member companies who collaborate on more than 40 open-source projects that help building professional applications for the Edge-Cloud Continuum.

Relevance: the Eclipse IoT community provides a wide range of commercial-grade open source tools for developing applications in the cloud-to-edge continuum. We are monitoring the technologies and developments to assess their fit, either for adoption in NEPHELE applications, but also as a base technology for the VO-Stack (such as Eclipse Thingweb).

Eclipse Thingweb (Web of Things) - https://www.thingweb.io

Eclipse Thingweb™ offers components for making IoT solutions interoperable at scale by leveraging the W3C WoT standards, no matter if improving an existing solution or building a new one:

- Describe devices: information, capabilities, and data schemas in a standardised format.
- Integrate devices: connectivity via various IoT protocols under a uniform interface.
- Validate device descriptions: consistent metadata for your devices and across directories.
- Develop applications: Web browser-like runtime for (headless) portable IoT apps.

Each component within the Eclipse Thingweb™ project is designed to be used independently from each other while working harmoniously together. This gives developers the flexibility to choose the specific tools they need for their IoT solution without sacrificing interoperability.

Relevance: The Eclipse Thingweb™ node-wot is the official reference implementation of the Web of Things (WoT) Scripting API written in the official specification. NEPHELE is taking upon the wot-py implementation and extending it with VO-Stack features. Collaboration between NEPHELE developers and Eclipse Thingweb community has been established during the first months of the project and meetings between both are held on a regular basis to keep track and discuss the way forward.

ETSI Open Source MANO (OSM) community - https://osm.etsi.org

Open Source MANO is an EU funded ETSI-hosted project to develop an Open Source NFV Management and Orchestration (MANO) software stack aligned with ETSI NFV. As a community-led project, OSM delivers a production-quality MANO stack that meets operators' requirements for commercial NFV deployments.

Relevance: as part of the E2E orchestration of HDA in the compute continuum, the NEPHELE's synergetic orchestration framework will leverage the OSM stack following a system of system approach. OSM will handle the Network Functions and overall network management part when using resources from a Mobile Network Operator as part of the HDA.

EUCloudEdgeIoT and MetaOS projects

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. The EUCloudEdgeIoT.eu initiative offers a set of cooperation mechanisms with the community of research projects in the Cloud, Edge, IoT and related domains in the form of six individual task forces.

The aim of these task forces is to assist in the coordination and dissemination with stakeholders from the Cloud, Edge and IoT ecosystems, such as research projects, coordination projects, the European Commission, and other organisations. The EUCloudEdgeIoT.eu task forces avoid overlap of work between projects, enable project amplification, and allow the identification of potential areas of collaboration and conflict.

Relevance: while NEPHELE is active in all of the six task forces, in the scope of open source activities we are dealing with TF2 - Open Source Engagement. Naturally, from the NEPHELE side we provide the requested input to contribute to the whitepapers and overviews produced by EUCloudEdgeIoT. But we are also aiming to gain knowledge on commonalities with the other MetaOS projects. Here we are looking for interesting open source technologies or related activities that could be of relevance for the VO-Stack.

NEPHELE Online Community - Open Calls

To leverage the network of innovators and developers that will be contacted through the Open Calls (WP7), FundingBox has launched an online community for IoT stakeholders to offer support to the Open Call applicants and to foster the adoption of NEPHELE's outcomes. The full description of the online community is available in Chapter 3.3.1.

Relevance: the Open Calls are a great opportunity for NEPHELE to gain attraction by first adopters from highly relevant industries. Therefore, the online community built around the Open Calls is a means to attract developers and adopters alike. It allows us to get early feedback on our open-source solutions and benefit from the development done by the Open Calls participants. It is a requirement for all software developed in the Open Calls to be open source and part of the NEPHELE ecosystem.

The following activities have been performed to establish relationships between NEPHELE and these open-source communities.

Table 11: Relationship activities between NEPHELE and open source communities.

Name	Description	Partners involved	Impact	Date
EUCloudEdgeIoT Task Force 2 and 3 Workshop	Workshop between all MetaOS projects to draw a first open source landscape.	ECL, NTUA	Established initial relation with other MetaOS under the common interest of open source	Jan 18. 2023
Embedded World 2023	NEPHELE booth at the Eclipse Foundation booth and presentation about NEPHELE.	ECL, UOM	Presentation to a broad audience. Established contact with Eclipse Zenoh project leaders.	Mar 13. - 15. 2023
Eclipse Con 2023	EclipseCon is the leading conference for developers, architects, and open source business leaders. NEPHELE at the Eclipse Research Booth. Participation in the IoT Working Group community day meeting.	ECL, NTUA	Established contact with Eclipse Thingweb project lead. Meeting to discuss integration. Opportunity to present NEPHELE to the global Eclipse open source community. NEPHELE (VO-Stack) listed on Web of Things developers adoption site: https://www.w3.org/WoT/developers/	Oct. 16. - 19. 2023
OSM#16 Ecosystem Day	The OSM Ecosystem Day allows organisations in the OSM Ecosystem to share about their Open Source MANO experience and how OSM is helping them to achieve their goals.	ATOS	Demo: OCI-Registries for OSM xNFs -Novel storage and distribution approach for xNFs artefacts to improve interoperability of devs, xNF providers and MNOs, by leveraging commercial-grade implementations of the OCI specifications.)	Nov. 29. 2023

7 Status update and future roadmap for Key Performance Indicators (KPIs)

7.1 Communication KPIs

Table 12 reports on the communication KPIs achieved during the first 18 months of the project and compares them to the initially defined target values estimated for the end of the project. Some indicators exceeded our expectations even at the halfway: at this point we have 20 times more unique visitors on our website and 3 times more followers on LinkedIn than the expected target values. Twitter is progressing a bit slower, but still the respective KPI values are more than 50% of the KPI targets halfway through the project. Collaborations with other projects and participants in the open call have also exceeded our expectations. This attests the interest of the scientific community in our project and the involvement of the consortium partners in the communication activities. Further details are reported in Section 2. In the second half of the project, we expect these values to continue growing and we anticipate that we will eventually reach the communication KPI targets.

Table 12: NEPHELE Communication KPIs (as of February 19, 2023)

Type	KPI	Target by M36	Current Value
Website	Unique web visits	> 1000	21066
Twitter	Tweets	300	178
	Followers	250	130
LinkedIn	Post Impressions	3500	54501
	Followers	100	306
Marketing Material	PPT project presentation	1	1
	Brochure	1	1
	Videos	1	3
	Open Call Infographics (2)-FBA	2	1
Media Coverage	Tweets and Linkedin posts, editorials and clippings and blog posts	100	265

Events	Workshops/webinars organised (2 for FSTP/support programmes; 3 scientific and technical workshops)	5	4
	Webinars (1 per open call)	2	1
	Number of webinars and workshop participants	300	30 (Info Day)
	No. of attendees/recipients of information campaigns, webinars, peer networking events	>1000	144 (Info Day)
Collaboration with other projects in the call	Collaboration activities	>10	22
Community	Size of the community (incl. Twitter followers, mailing list subscribers, bloggers)	>1000	533
	No. of Companies involved	>50	65
Open calls	No. of SMEs and start-ups reached	Around 1000	>2000
	No. of SMEs and start-ups participating in Open Calls	At least 80	150 applications (incl. 73 drafts and 77 submitted)

7.2   Dissemination KPIs

In Table 13 we report on the dissemination KPIs achieved during the first 18 months of the project and compare them to the target values that were defined until the end of the project. As we can observe, the results are significant already halfway the project as for all three identified KPIs the goals set have already been achieved at this point in time. This attests to a very successful involvement of the consortium partners in the dissemination activities. The details about the exact publications and event participations are reported in Section 3. In the second half of the project, we expect these values to continue growing, as we will pursue additional dissemination activities.

Table 13: NEPHELE Dissemination KPIs

Type	KPI	Target by M36	Current Value
Scientific Dissemination	Scientific/technical publications in high impact conference and journals	> 15	17
	Conference presentations	> 20	27
	Number of event participants in scientific events	200	> 3400

7.3 Standardisation KPIs

As outlined in 4.3, the NEPHELE project demonstrates an extensive engagement with standardisation activities, spanning several organisations and focusing on critical areas of IoT and WoT. The project's efforts are not only directed towards contributing to the development of new standards but also towards ensuring interoperability, security, and privacy within the IoT ecosystem. The variety of contributions, from direct involvement in Working Groups to the promotion of standards through workshops and conferences, showcases the project's commitment to advancing the IoT standardisation landscape. In the second half of the project, as the use cases begin to yield results, the project will make an effort to further engage with commercial and industrial standardisation bodies.

Table 14: NEPHELE Standardisation KPIs

Type	KPI	Target by M36	Current Value
Standardisation	Number of contributions to standardisation bodies	>3	2 (W3C, ETSI)
	Number of contributions in commercial and industrial bodies	>4	1 (AIOTI)

8 References

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