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to grow a sustainable and comprehensive ecosystem

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Abstract

This deliverable has a threefold goal. First, it presents the methodology followed for the research roadmap. Secondly, it presents the results from the different consultations and finally, the final prioritisation of research topics on Cloud computing in Europe.

Keywords:

Document Revision History

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V1.0	05/10/2022	First compiled version	Enrique Areizaga (TECNALIA)
V1.2	10/10/2022	Including Revision comments from MARTEL	Enrique Areizaga (TECNALIA)

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* *R: Document, report (excluding the periodic and final reports)*
DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc

EXECUTIVE SUMMARY

This deliverable describes the findings on the key topics tackled up to M21 by HUB4CLOUD in support of ECC roadmap. This document will also indicate how other CSAs will take over road mapping activities after the end of HUB4CLOUD.

This document develops a scoring and a classification and scoring of topics established in D1.5 and will end with a set of recommendations and prioritizations for the European Commission to include in the upcoming work program.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	3
TABLE OF CONTENTS	4
LIST OF FIGURES	5
ABBREVIATIONS	6
1 INTRODUCTION	7
2 ROADMAPING APPROACH AND METHODOLOGY	8
2.1 Introduction	8
2.2 Methodology	8
3 RESULTS OF CLOUD COMPUTING RESEARCH TOPICS PRIORITISATION	10
4 CLOUD COMPUTING RESEARCH TOPICS UPDATED ROADMAP	17
5 CONCLUSIONS	18

LIST OF FIGURES

Figure 1. Multi source analysis in Task 1.3.....	8
Figure 2. Methodology followed in Task 1.3	8
Figure 3. Multi-factor scoring methodology phases	9
Figure 4 HUB4CLOUD multi-factor scoring methodology.....	10
Figure 5 Cloud computing R&D ranking	11
Figure 6 LinkedIn consultation on Cloud Computing R&D topics	11
Figure 7 Results from LinkedIn consultation on Cloud Computing R&D topics	12
Figure 8 EUSurvey consultation on Cloud Computing R&D topics.....	13
Figure 9 Results from EUSurvey consultation on Cloud Computing R&D topics.....	13
Figure 10 Results from LinkedIn consultation on Cloud Computing Skills gap	14
Figure 11 EUSurvey consultation on Cloud Computing Skills gap	15
Figure 12 Results from EUSurvey consultation on Cloud Computing skills gap	16
Figure 13 Cloud Computing R%D topics final roadmap	17

ABBREVIATIONS

B2B	Business to Business
B2C	Business to Consumer
B2G	Business to Government
BIM	Building Information modelling
CTO	Chief Technology Officer
ECC	European Cloud Computing
eIDAS	electronic IDentification, Authentication and trust Services
EU	European Union
EUCS	European Union Cloud Services Scheme
G2C	Government to Consumer
GDPR	General Data Protection Regulation
IDSA	International Data Spaces Association
IoT	Internet of Things
IP	Internet Protocol
IT	Information Technologies
MCDA	Multi Criteria Decision Analysis
MPC	Multi Party Computing
RIA	Research and Innovation Action
SME	Small and Medium Enterprise
TCP	Transmission Control Protocol
TRL	Technology Readiness Level

1 INTRODUCTION

This document is the third in the series of three documents that aim to present the proposal for a research roadmap in the domain of cloud computing continuum. HUB4CLOUD partners ran some open consultations, gathering content from relevant stakeholders such as existing RIA projects as well to the general scientific community. The main goal was to come up with a list of research challenges and topics classified, scored, and prioritized.

The document is structured as follows.

Section 2 presents the consultation and prioritisation methodology followed for the elucidation of the research roadmap.

Section 3 presents the results of Cloud computing research topics prioritisation.

Section 4 contains the updated roadmap for European Cloud Computing R&D topics

2 ROADMAPPING APPROACH AND METHODOLOGY

2.1 Introduction

This report is the third outcome of task “*T1.3 Road mapping and policy recommendation*” with the main objective to contribute to the ECC research roadmap and policy recommendations aligning the view from different stakeholders (research, industry, users). In order to achieve this objective Task 1.3 proposes a multi-source analysis (see Figure 1) considering different sources to gather the input from the different types of stakeholders: academia, practitioners, industry and users. The result of this analysis started in D1.4 (M9), part of the findings and results were reported in D1.5 (M17) and is further developed and finalised with priorities and recommendations in this deliverable, D1.6 (M21).



Figure 1. Multi source analysis in Task 1.3.

2.2 Methodology

The proposed methodology stands over 3 main pillars (Figure 2). The methodology is similar to the one already presented in D3.5 but tailored for the domain at hand. This demonstrates the repeatability and the scientific soundness of the approach:

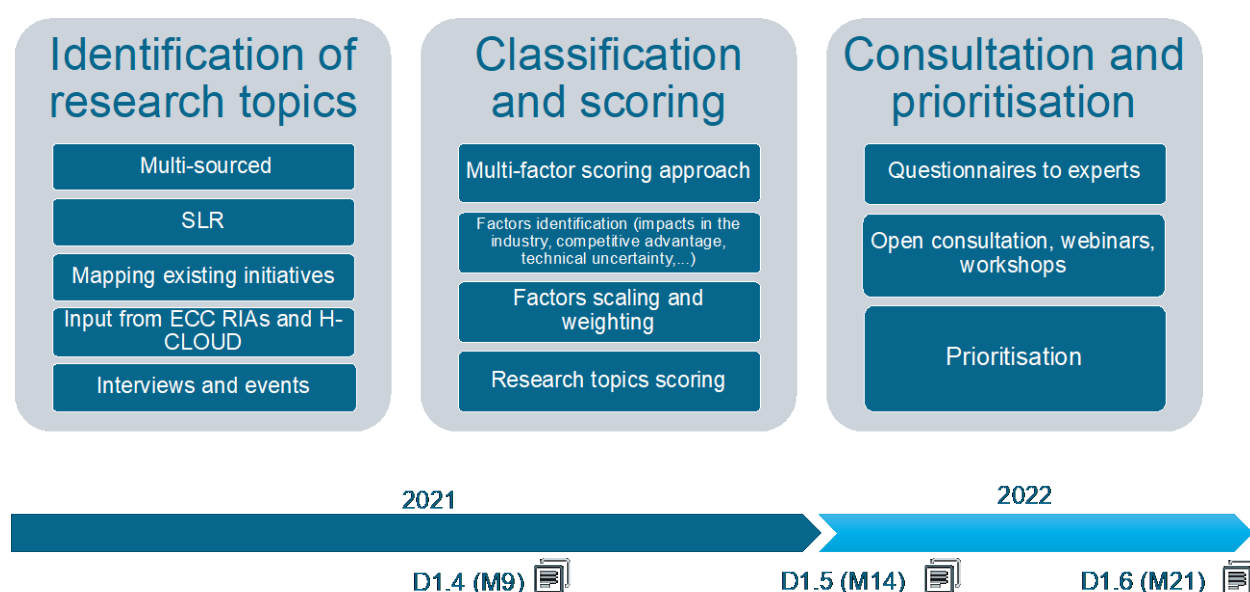


Figure 2. Methodology followed in Task 1.3

1. Identification of research topics from diverse sources: Included in D1.4
2. Classification and scoring (Figure 3): Once the inputs are gathered an initial list of research topics will be created. This list will be classified and scored using a set of factors (i.e. impact in the industry, competitive advantage, technical uncertainty, etc). Included in D1.5
3. Consultation and prioritization: The initial classification performed by HUB4CLOUD will be shared with the community through different channels (workshops, interviews) and as a result the final prioritization of the topics will be performed.

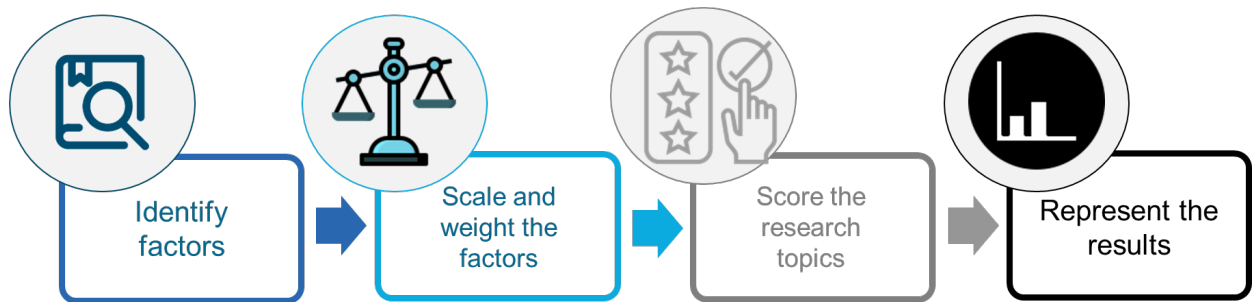


Figure 3. Multi-factor scoring methodology phases

This deliverable (D1.6) reports the work done for the third pillar in Figure 2.

3 RESULTS OF CLOUD COMPUTING RESEARCH TOPICS PRIORITISATION

The method selected to establish a ranking and prioritisation of the seven research challenges was based on Multi-Criteria Decision Analysis, or MCDA. The three main factors are technical, business, and sectoral (Figure 4 HUB4CLOUD multi-factor scoring methodology). Each of the factors is composed of different criteria that include a set of questions to facilitate their individual scoring. This method, as well as the weight assigned to each factor, was agreed within the HUB4CLOUD consortium. The methodology is documented within deliverable D1.5.

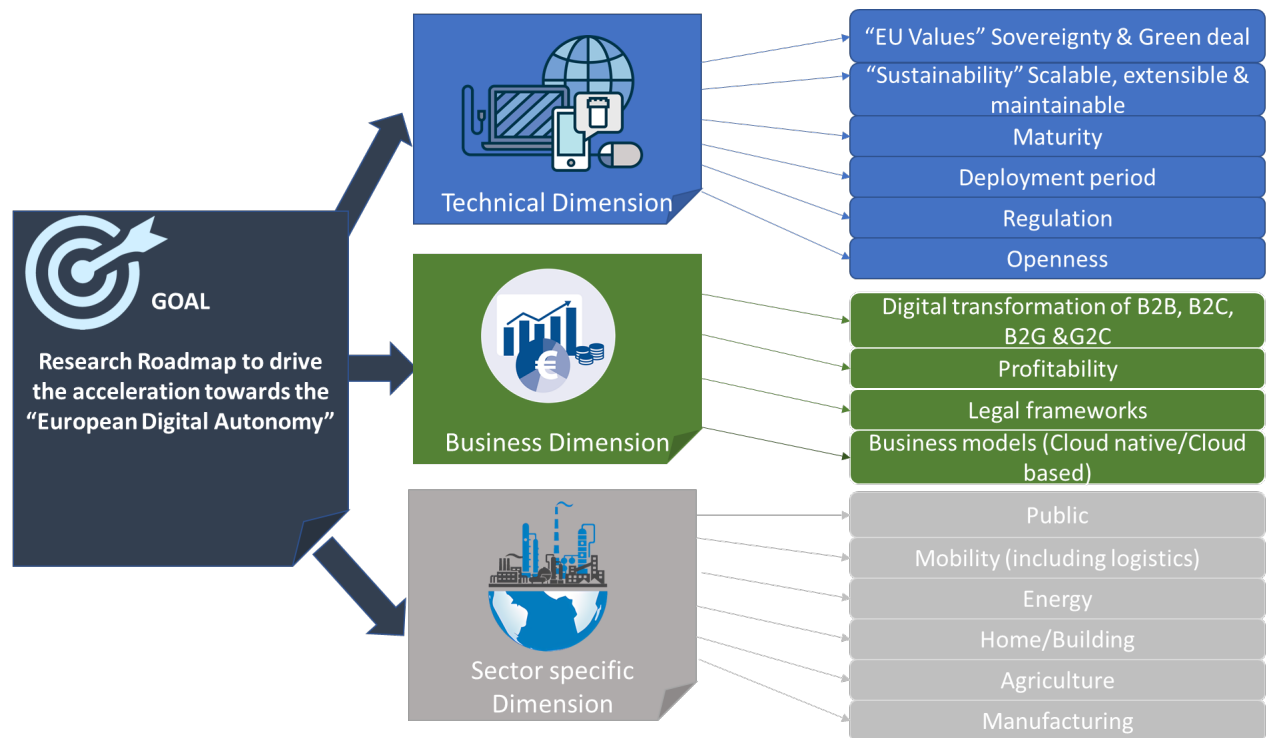


Figure 4 HUB4CLOUD multi-factor scoring methodology

The results obtained are summarised in Figure 5 Cloud computing R&D ranking showing the scores obtained per challenge and factor.

Considering the different dimensions, the three most important research topics are:

- **Technical:** "Data Governance", followed by "Compliance as Code" and "Cloud Federation".
- **Business:** "Cloud Federation" followed by "Data Governance" and "Compliance as Code"
- **Sectors,** the one that stands out by far is "Security". This is followed by "Data Governance", which shows that the industry is very sensitive to privacy and security.

Considering the scores obtained in all the factors, the four challenges shown above once again stand out, with “Data Governance” as the highest priority, followed by “Federation of Cloud”, “Compliance as Code” and “Security”, with very little difference between them.

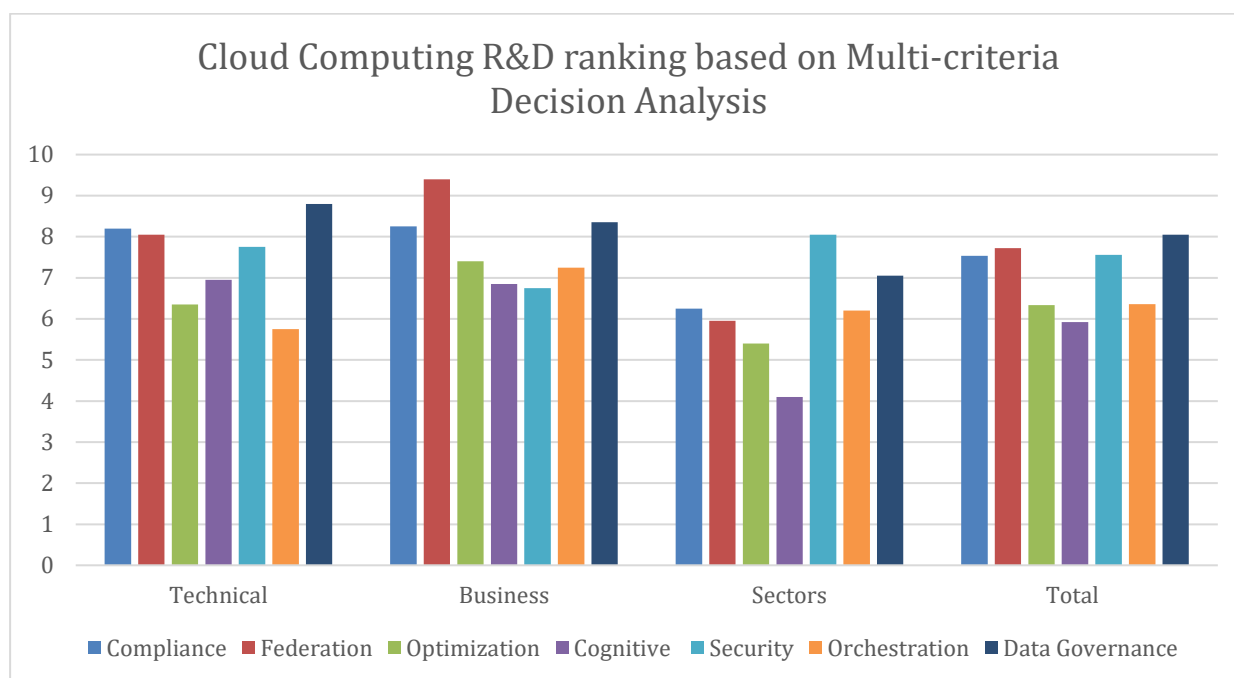


Figure 5 Cloud computing R&D ranking

From the results obtained during the classification and scoring public consultations have been conducted to confront the results obtained with the different sensitivities in the cloud computing ecosystem.

In order to get feedback from a wide audience, a simple consultation was carried out through **LinkedIn** including the 4 main R&D research topics for Cloud Computing

Which of the cloud computing research topics should Europe prioritise in order to achieve "digital autonomy" by 2025?

You can see how people vote. [Learn more](#)

Data Governance frameworks

Federation of Clouds

Compliance as code in Clouds

Security in Federated Clouds

Figure 6 LinkedIn consultation on Cloud Computing R&D topics

Though the consultation reached 947 impressions, the level of participation was quite low. The classification obtained from the poll is shown in Figure 7 Results from LinkedIn consultation on Cloud Computing R&D topics.



Figure 7 Results from LinkedIn consultation on Cloud Computing R&D topics

A similar consultation was done using the EUSurvey platform.

Cloud Computing Research Topics Roadmap			
dac69563-0462-b873-4c59-60ba87e57f5c			
Created	29/08/2022	Owner	nareizen
Start date	Not specified	Expiry date	Not specified
Replies	5	Translations	EN

Help us create the European Cloud Computing research topics roadmap for the digital decade. Please take the following survey.

Out of the different options for meeting the current industry demand for cloud computing expertise, please rank the following options from most to least important.

Thank you!

Note: Information about the R&D topics can be downloaded from <https://www.h-cloud.eu/deliverables/#1612856408665-c027dbdb-3a1e> (D1.5 EUROPEAN CLOUD COMPUTING ROADMAP AND POLICY RECOMMENDATIONS Q1-2022)

Use drag&drop or the up/down buttons to change the order or *accept the initial order*.

⌵ ⬆ ⬆ Data Governance frameworks
⌵ ⬆ ⬆ Federation of Clouds
⌵ ⬆ ⬆ Compliance as code in cloud security certification
⌵ ⬆ ⬆ (Federated) Security mechanisms
⌵ ⬆ ⬆ Dynamic configuration, provisioning, and orchestration in the cloud continuum
⌵ ⬆ ⬆ Optimization techniques for non-functional characteristics of the cloud continuum such as energy consumption, resource selection, reliability, performance, latency minimization, ...
⌵ ⬆ ⬆ Cognitive, self-healing, self-learning (programmable) infrastructures, services and applications

Figure 8 EUSurvey consultation on Cloud Computing R&D topics

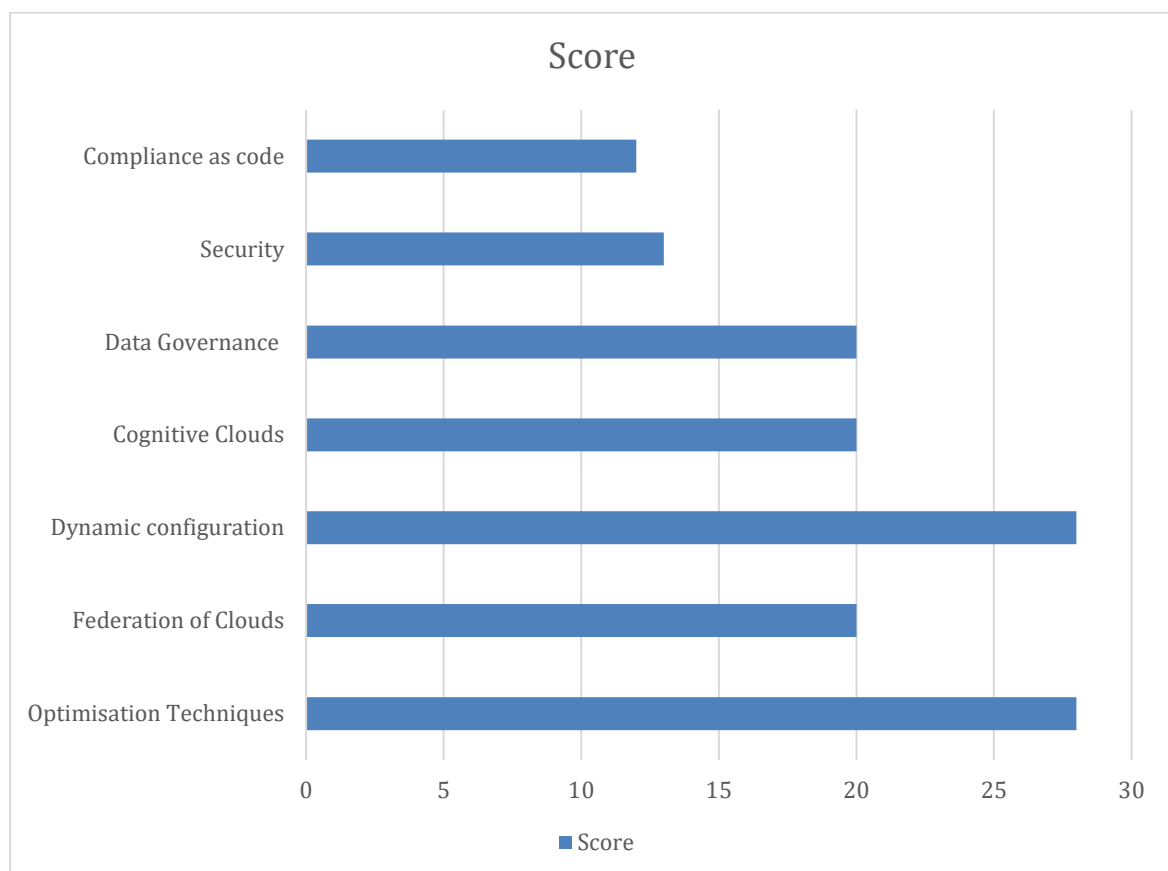


Figure 9 Results from EUSurvey consultation on Cloud Computing R&D topics

EUSurvey was shared among all ICT40 project coordinators, and it got 5 contributions. The TOP 4 results include “Optimisation Techniques”, “Dynamic configuration”, “Federation of Clouds” and “Data Governance”.

Compiling all the results obtained from the ranking and queries, only two remain on the high priority list, **Cloud Federation** and **Data Governance**.

The other two TOP topics identified during the Classification and scoring phase **Compliance as code** and **(Federated) security** have not received the expected support in the public consultations.

Note: It is important to mention that the number of responses obtained during the public consultations is not high enough to conclude that the results are conclusive.

Once the European Cloud Computing research topics were classified, two more surveys were conducted to identify how the industry was coping with the skills required to cope with the demand.

A new specific consultation on ECC was done through LinkedIn with 590 impressions a bit more successful in the number of contributions (Figure 10 Results from LinkedIn consultation on Cloud Computing Skills gap).

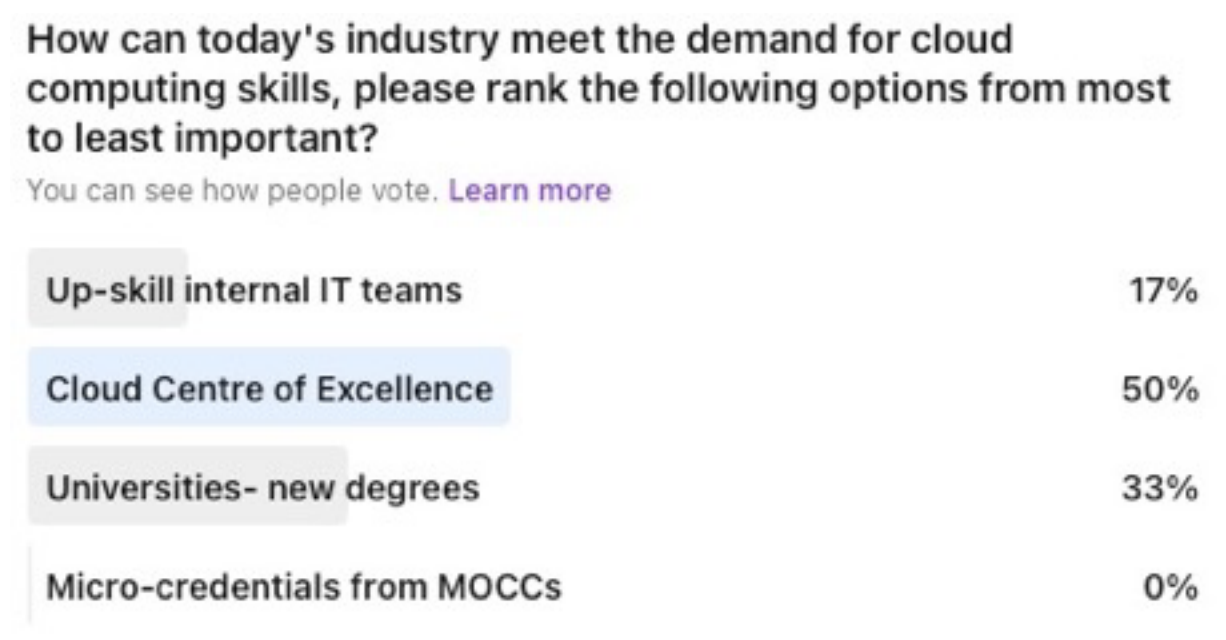


Figure 10 Results from LinkedIn consultation on Cloud Computing Skills gap

A similar consultation has also been carried out through EUSurvey.

Cloud Computing Skills gap Survey

2857f463-1e60-126d-5001-48cf62c670cf

Published

Created	31/08/2022	Owner	nareizen
Start date	Not specified	Expiry date	Not specified

In Europe, 31% of IT decision-makers struggle to find the right people to keep pace with evolving technology needs. This is a concern because organisations have invested heavily in cloud software and services and are in need of architects, administrators, and other cloud experts to ensure those investments pay off.

Of the different options for meeting the current industry demand for cloud computing expertise, could you rank the following options from most to least important?

Use drag&drop or the up/down buttons to change the order or [accept the initial order](#).

::
↑ ↓
Ad-hoc training courses to upskill internal IT teams

::
↑ ↓
Cloud Computing Centre of Excellence

::
↑ ↓
Universities and alternative educational models (i.e. the 42 method)

::
↑ ↓
Digital innovation hubs and platforms

::
↑ ↓
Micro-credentials from Massive Online Open courses

Figure 11 EUSurvey consultation on Cloud Computing Skills gap

The results obtained are shown in the graph below

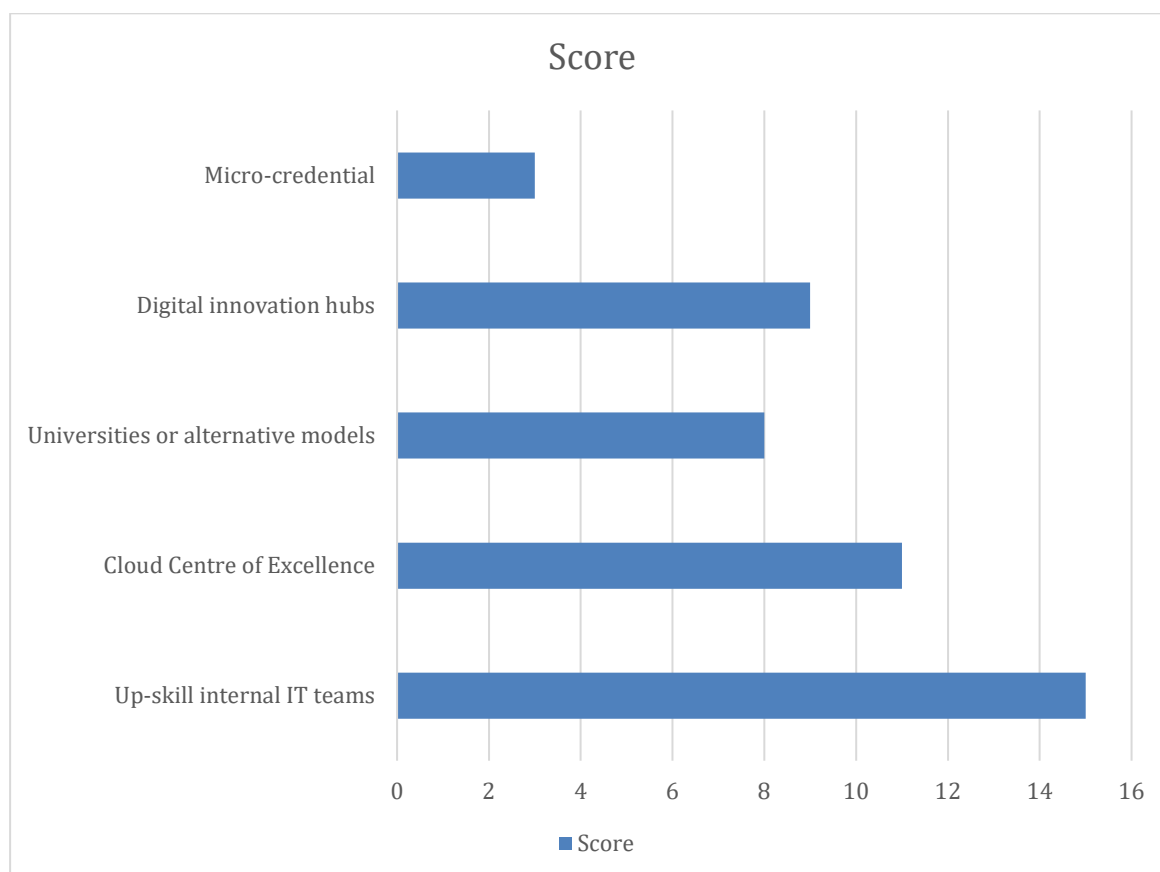


Figure 12 Results from EUSurvey consultation on Cloud Computing skills gap

The results of the surveys show that the most preferred option is the “Up-skill of internal IT Teams”, followed by the “Cloud Centre of excellence”. Details can be found in deliverable D3.6.

The EU is promoting through initiatives like “European Schoolnet¹” to cope with the skills gap in Cloud computing.

¹ <http://www.eun.org>

4 CLOUD COMPUTING RESEARCH TOPICS UPDATED ROADMAP

After compiling the results of comparing the R&D topics on Cloud Computing with various scientific communities, the list of the most relevant topics has been updated according to their prioritisation.

The topics identified as higher priority are put as more urgent (and therefore with closer time periods). Those identified as lower priority are moved to 5–8-year timeframes.

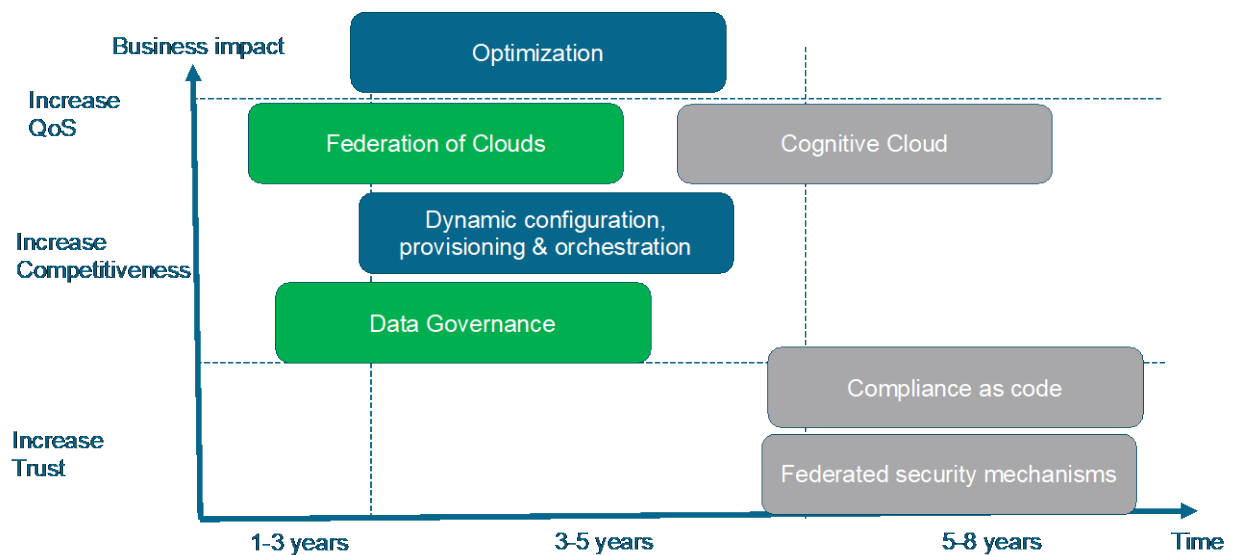


Figure 13 Cloud Computing R&D topics final roadmap

5 CONCLUSIONS

HUB4CLOUD has followed a methodological procedure, previously agreed upon, in order to identify the most relevant research topics within Cloud Computing.

Starting from an exhaustive task of academic exploration, followed by a contrast with current initiatives and interviews with representatives from different sectors of the industry, a first approximation of the different topics was presented, together with a first prioritisation and a time mapping to indicate the effort that, according to HUB4CLOUD's criteria, should be made to respond to the different challenges.

This first approximation was later contrasted in different conferences specialised in the subject of Cloud Computing (both online and in person) in which the results obtained were presented and the collaboration of the attendees was requested to know their opinions. We also contacted important representatives of organisations involved in the subject (i.e. GAIA-X) and cloud service providers.

With all the information obtained, the almost definitive version was subjected to public consultations through different surveys, some more open oriented to a more generic professional public and others more targeted to the environment related to the world of R&D.

The result has been presented in chapter 4 of this document in a very summarised form with the idea of having a visual representation of the topics and the suggested roadmap based on the results obtained during the project.