Exploration of Wide-spectrum Resource-Awareness: a Preliminary Local Study*

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Abstract

Software and systems have become common actors in every economy and society, as well as in everyday life all around the world. Accordingly, they became the main resource consumers. In a conventional sense, one can observe resource (e.g. processor or memory) utilization while they are executed and used. However, many kinds of emerging resources and their utilization may be observed all around the software and system life cycle, not only used by them but by subjects included in the related processes such as education and training, research, administration, policy-making, etc. Awareness of this wide range of resources by various stakeholders across sectors is currently questionable, especially in regions with young, but fast-growing, system and software industries. One such region is the Autonomous Province of Vojvodina (APV), north of Serbia. In this study, we examined the use of wide-spectrum resources as a potential for collaboration between sectors, primarily between academia and (software) industry. We conducted a survey-based investigation localized in APV, with a future goal of adapting the survey based on the lessons learned and repeating the study across a wider geographical region. The final goal is to identify the open space for advanced resource optimization towards sustainability with additional awareness of not-so-obvious but still significant resources. The preliminary study concluded that: (1) awareness of basic resources is not much higher than the other ones; (2) the most used additional resources are Network bandwidth, safety, security, time limits, and quality and quantity of data; (3) there are interests and ideas concerning collaboration between sectors. Finally, we have found a connection between higher resource awareness and existing dedicated departments and training in the organization.

Keywords

Academia-industry collaborations, resource-awareness, preliminary study

1. Introduction

The software industry has become an indispensable component of every modern economy, and software systems are fully integrated into everyday life, connecting, and maintaining the continuity of all social and business processes. Another component of all processes is resources, among which energy, people and data stand out - which are always the focus of stakeholders (e.g., for management). Other resources such as infrastructure, space, time, effort, or skills are often neglected and cause unexpected costs, as well as damage to the natural and social environment.

Collaborations between the private and public sectors form a broad spectrum of objectives, where the objectives of the respective participants are based on differing drives to collaborate [1]. The type of collaboration is usually chosen in accordance with the purpose and extent of the complementary information or resources that are needed to accomplish the purpose of cooperation.

The Autonomous Province of Vojvodina (APV), north of Serbia, is a specific region with rapid development of IT (Information Technology) and accompanying sectors. As a result of such fast development and rapid processes, resource awareness might be lowered, which may have significant consequences in the future. Here, it is interesting to observe resource awareness as an open space for strengthening cross-sectorial collaboration towards higher sustainability. However, APV is not an isolated region. Having many international companies present there, especially in the IT domain, it is becoming interesting to investigate resource awareness within the interconnected regions and broader. The future overall observation will be devoted to discovering subject-related similarities and differences between geographical regions, disciplines, domains, and sectors, to identify strengths and weaknesses concerning resource utilization and to enable learning among each other towards balanced resource usage.

The final goal is to extend the research across Europe, and broader, towards better coordination and consolidation of teaching, training, research, and innovations for meeting the UN Sustainable Development Goals [2].

Having described short- and long-term goals in mind, this paper focuses only on APV and local resource awareness as a possible space for collaboration between sectors, primarily academia and industry, as preliminary research.

Observed locally in APV and currently, there is insufficient awareness of all the possible capacities that actors from the academic community and (software) industry can offer each other to improve cooperation in general, and hence in the field of resource utilization, as well. The aim of this preliminary research is to determine the level of awareness about resources and their adequate use in APV. Based on the results as our future goal, a platform will be created for a stronger connection of subjects between and within the two sectors. We tend to identify which principles for resource identification are stated and supported by a sophisticated checklist that will identify opportunities for cooperation and compatible subjects for cooperation based on the identified resources.

We start from an initial list of characteristic resources used in the (software) industry, and then divide them into two general groups:

- basic resources commonly involved in every business process: classical, proven and well explored such as personnel,
- additional resources commonly of interest of software and system life cycles such as energy, time,

3rd workshop on Resource AWareness of Systems and Society (RAW 2024)

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or data. Here, some emerging and not-so-obvious resources may appear such as human effort or employed tools.

Following the goals of CERCIRAS Cost Action CA19135 [3], dedicated to coordinating research efforts around resources and raising awareness of their impact, the goal of this research is to understand:

a) how industry and academia use resources,
b) how are actors from different sectors and domains aware of various resources, and
c) whether there are needs and open space for cooperation towards their more efficient utilization.

To carry out the research we used an online survey. The survey was first sent to a limited group of respondents (pilot survey) for testing. Afterwards, it was improved based on perceived deficiencies.

Answers to these questions will be a key step towards understanding the problem: "What resources (with an emphasis on the non-obvious ones) can be important for improving cooperation between (software) industry/business and academia?" More precisely, through targeted and specialized interviews and surveys, we should arrive at answers with a focus on:

1) identification of characteristic categories of actors (e.g., companies, their products, related parties, and products...) in the local software industry, the academic community, and the wider environment,
2) identification of resources of interest and associated costs,
3) identification of the professional staff that comes into contact with the identified resources, their competence and their awareness of the resources and their roles, and
4) identification of opportunities for connecting characteristic subjects from science and industry, as well as within these two sectors, to improve the use of resources.

The main contributions of this study are lessons learned about the survey structure and the abilities of respondents to be clear when answering specific questions. Another contribution is a better picture of resource awareness in a specific localized developing economy with the IT sector in expansion.

The following section reviews a brief state of the art and the related work. Further, we present the methodology used. Section 4 then presents the main results of the study. Lastly, Section 5 outlines the conclusion of the presented research and potential future directions.

2. Field Overview and Related Work

This section outlines available studies and conclusions related to the three main points of this study: (1) reviews and surveys on wide-range resource awareness (2) choice of research method design and the data collection approach, and (3) academia-industry collaboration and impact.

Based on the preliminary investigation, many (systematic) literature reviews (SLR) and surveys have been conducted related to resources, their usage and its optimisation. However, all of these are focused on specific categories of systems such as cloud computing [4, 5], edge-/fog-computing [6, 7], or high-performance computing [8, 9]. Alternatively, they are conducted in a scope of a specific domain such as medical systems (with a special focus on privacy and security) [10]. However, we have not identified any wide-range survey on resource awareness across disciplines, domains, sectors, and regions. This situation in the literature gives us a preliminary picture of selective resource-awareness depending on domain and discipline

According to [11] an online survey collects information from people who respond to a form or instrument that is distributed through internet channels. Online surveys have several advantages:

- They are easy to conduct using free platforms such as Google Forms [12], SurveyMonkey [13], Jotform [14], Typeform [15], etc.
- They can be quickly created and distributed,
- There are free online survey solutions,
- The analysis is generally easy to carry out on the same platform on which the survey was conducted.

Finally, we are coming to collaboration across sectors, primarily having in mind industry-academia collaboration, knowledge transfer and innovations.

In [16], authors synthesize up-to-date findings (from 239 articles indexed in Web of Science and Scopus databases), outline the intellectual structure of Open Innovation within the manufacturing research domain, and suggest a future research agenda. Another research on the impact of academia and industry is given by Perkmann and Walsh [17], where they explore the diffusion and characteristics of collaborative relationships between universities and industry.

One of the fundamental roles in the economic development of a country is cooperation in research, development and innovation (RD&I) between universities or research institutes and industry. In [18], authors present a systematic review with the aim to identify the barriers and facilitators of university-industry collaboration and analyze them using bibliometric tools.

Farah et al. [19] propose a model for the desired assimilation of the industry and university, leading to more efficient working of the two.

3. Method

The research process usually begins with the need to understand the subject ("phenomenon") being researched, which is the case in our research subject. Typically the best research mechanism for learning about a phenomenon is a survey (similar mechanisms intended to assess the current situation in the area under investigation). Modern online tools make basic data analysis easy and fast.

In this section, we present the methodology used in our research. First, we discuss, what are the resources, that we have observed in our study. Next, we present our survey and its dissemination.

3.1. Resources

We discussed the initial list of characteristic resources used in the software industry and broader with the youth engineers and several managers, and came to the following division:

- Basic resources:
  - personnel,

  - education/expertise,
  - specialized expertise,
  - narrowly specialized resources,
  - physical space,
  - various other types of infrastructure.
- Additional resources:
  - energy and efficiency of its use,
  - energy autonomy,
  - local and global data bandwidth,
  - capacities for security and safety of software,
  - quantity and quality of data,
  - time and time limits,
  - more specialized software tools,
  - tools that allow download of ready-made solutions in source code.

3.2. Survey Design

The pilot process was used to identify any confusing or leading questions [20]. Participants in the pilot also helped us populate survey items where we asked survey participants to choose between multiple options. The last version of the survey was conducted through Google Forms [12].

Following this piloting process, the questionnaire was structured into the following sections:

- Information about the organization
- Information about the respondent
- Awareness of the resources we have identified
- Awareness of the other resources
- Possibilities for awareness improvements through collaboration within the organization among teams and organization units
- Possibilities for awareness improvements through collaboration with external subject

The questionnaire is available as a Google Form in Serbian [21]. The next version, for the global study, will be shared in English.

3.3. Dissemination

We did not use any other recruitment channel, like social media or recruiting platforms, but sent emails to former students and other contacts who work in industry. 43 people responded to the survey. In addition, in private communication, 15 persons, representatives of organizations, replied that they do not deal with the issues from the survey at all.

4. Results

In this section, we are going to summarize the collected results by survey sections as described in Section 3.2.

4.1. Profiles of respondents and organisations

The distribution among sectors that the organization is engaged in is given in Table 1. Our sample equally covers the educational/academic and industrial organizations, 21 organizations from each sector and only one from public administration.

Table 1
Type of organization

Type of organization	Number of responses
Academy and other educational institutions	21
Industry	21
Public administration /administration	1

The chart in Figure 1 illustrates distribution across fields within these sectors. Only 7 organizations deal with two or more fields, while 36 are specialized in only one. Education, which most often appears as the field that the respondents deal with, represents 1/3 of all potential fields. We believe that the listed fields represent a good sample of potential fields of interest having in mind the structure of organizations from APV, so we consider their answers representative.

The relation that the organizations have with various kinds of software is given in Table 2. 22 organizations are software users, 14 develop/maintain software for others, 14 for themselves, and only one organization is involved in all these relations. One respondent has not specified it, however.

Table 2
Activities that the organization is engaged in

Activities that the organization is engaged in	Number of responses
They use third party software	22
They develop/maintain the system for others	14
They develop/maintain their system	14
All of the above	1
Unknown	1

4.2. Importance of resources in the opinion of respondents

Here we show how the respondents evaluated the significance of the resources in both categories, basic and additional ones, as described in Section 3.1.

Most organizations (their representative respondents) consider that, for their business and activities, the most important (ratings from 3 to 5), basic resources are: Education/expertise, Personnel, and then Infrastructure (40, 36, 36 answers). If we observe only the highest rating 5, then the most important for 25 organizations is Education/expertise, followed by Personnel in 20 organizations. On the opposite side, physical space is the most important basic resource only for 8 organizations, observing only the rating 5, and observing ratings 3,4, and 5 it is still in last place (26 answers). All results are shown in Table **??** and illustrated by the chart in Figure 2.

Figure 3 shows that most of the organizations/respondents believe that, out of additional resources, Security and Integrity, Network Bandwidth and Specialized Tools are of the greatest importance to them (importance grades 3 to 5 in 38, 37, 37 answers respectively) and least of them consider Energy autonomy as important (20).

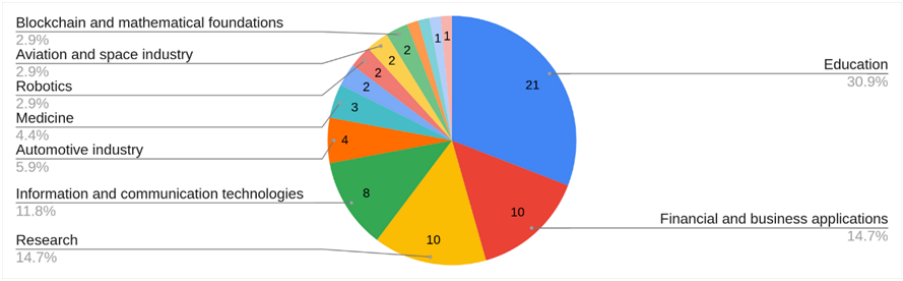

Figure 1: Fields that the organization deals with.

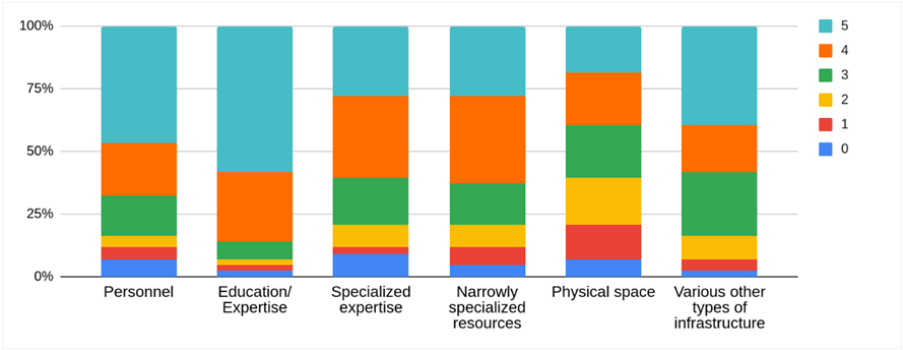

Figure 2: Importance of basic resources in the opinion of respondents.

Observing only the grade 5, Capacities for security and safety of software and Time and time limits are the most important to the highest number of respondents (20).

We can notice that there is a high awareness of the importance of additional resources among the respondents, only slightly less compared to the awareness of basic resources (if we also included those mentioned 15 who refused the survey because they did not deal with additional resources, the situation is worse).

Data Flow, Safety and Security, Time and Time Limits, and Data Quantity and Quality (Figure 4) are used significantly more than the others, followed by Specialized platforms/-tools in almost all phases of software development.

Prior knowledge, where present, (Figure 5) was acquired through appropriate studies (18 cases), work experience (12 cases) and specialized courses (10 cases). The additional resources mentioned in the previous question also have the most appearances here, with the exception being here now appears and using tools to download ready-made solutions in source code - but judging by the response to the previous question it is insufficient even though there is prior knowledge.

The use and efficiency of additional resources, when measured (Figure 6), is measured by specialized tools (13 cases), analysis (12 cases), testing (3) and specialized teams (3).

For most of the resources, asking about the existence of the special department dedicated to additional resources, we got a positive answer in around one-fourth and fewer cases (Figure 7). Here, the situation is different for the Bandwidth of local and global networks, Security and safety and Quantity and quality of data, where the ratio is half-and-half.

Organizations generally do not offer their own courses (Figure 8), except (increasingly) for Bandwidth of local and global networks, Security and safety, and Quantity and quality of data. However, we haven't identify high awareness of missing training or courses on these topics (Figure 9).

About half of the respondents think that other sectors in the organization can help (Figure 10), and if they cannot, then it is because there is no available corresponding speciality or expertise, or all the activities are performed within the same unit where software is developed or used.

In two cases, there are more concrete ideas than no ideas for cooperation (Figure 11 and Table 3):

- with the industry (13 organizations from the industry and 15 from academic/educational institutions have concrete ideas) and,
- with academia (11 organizations from business and 16 from educational institutions have concrete ideas).

In the other two cases (cooperation with the public administration and with other organizations), the majority do not have a concrete idea.

5. Conclusion and future work

To make resource-usage trade-offs at specification, design, implementation, and run-time requires profound awareness of the local and global impacts. We conducted a survey to learn about resource awareness in organizations in APV. The study aimed to examine how the academy and the (software) industry use additional resources.

Based on the results of the survey, the following can be concluded:

a) Awareness of the importance of additional resources is only slightly lower than awareness of the importance of basic resources, which is positive,
b) There is significant interest in cooperation on specific ideas in this area and the organizations have concrete

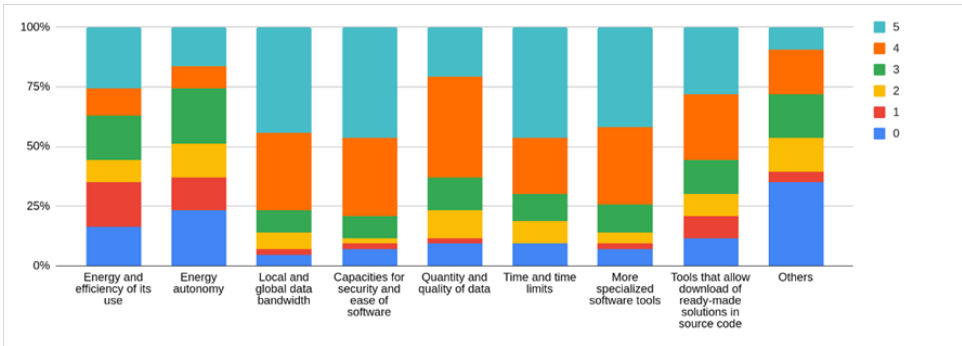

Figure 3: Importance of additional resources in the opinion of respondents.

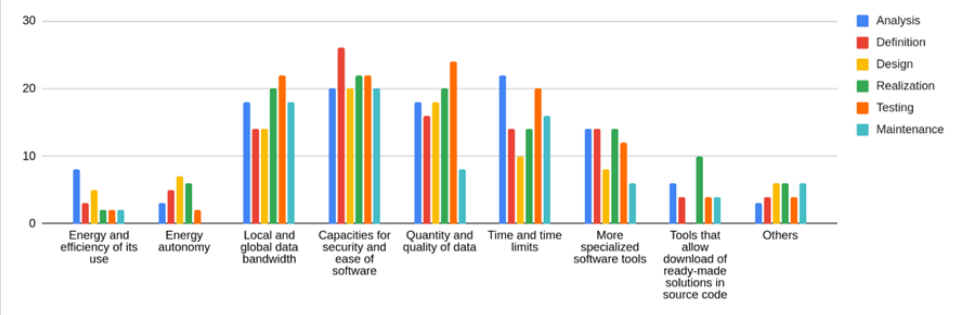

Figure 4: Use of additional resources by stages of software development.

ideas and intentions to cooperate with industry and academia. Besides, we haven't identified any significant correlation between other parameters (e.g. the field the organization deals with, its expertise concerning other additional resources, the existence of a specialized sector ... concerning the desire for cooperation.)

c) Network bandwidth, Safety and security, Time and time limits, and Quantity and quality of data clearly stand out as the most used additional resources.

We identified a correlation between the expressed importance of the team resources, the existence of dedicated units for those resources, offering own courses, large prior knowledge, and a small need for additional courses. Namely, the greater the importance expressed by an organization/respondent for some of these 4 resources, the greater the prob-

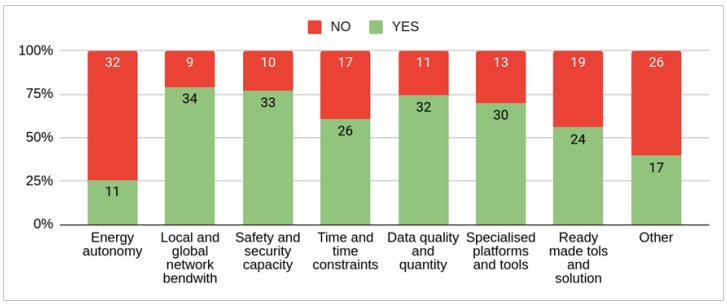

Figure 5: Prior knowledge of using additional resources.

Table 3
Existing ideas about specific cooperation with other organizations

Cooperation	With industry	With academia	With public administration	Security, safety
Yes	28: 13 from industry 15 from academy/ education	27: 11 from industry 16 from academy/ education	17: 11 from industry 8 from academy/ education	15: 4 from industry 11 from academy/ education
No	15	16	26	28

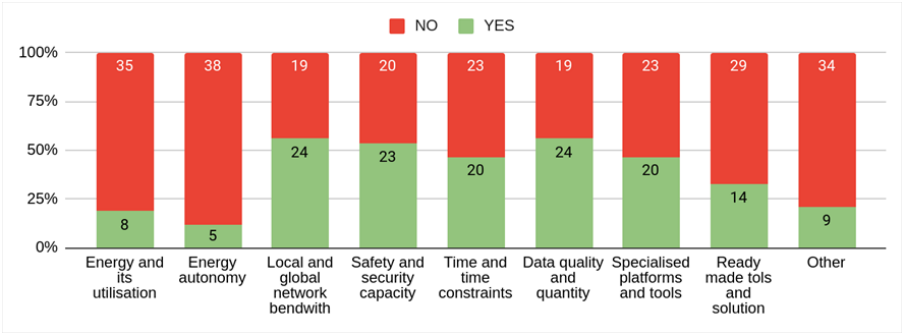

Figure 6: If the use of additional resources is measured.

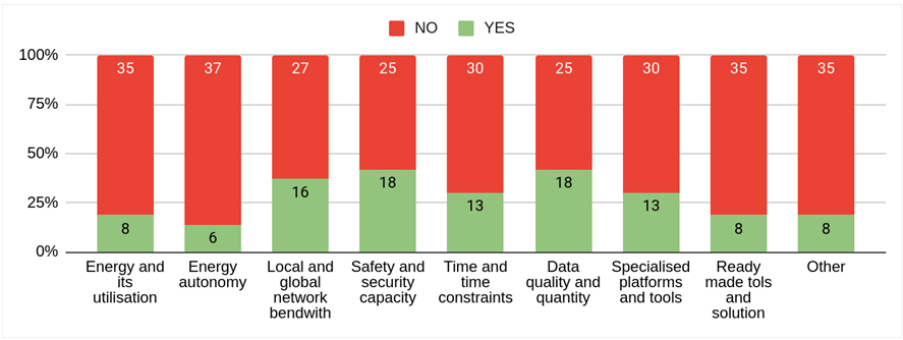

Figure 7: Existence of a special department dedicated to additional resources.

ability that in the organization there exists a specialized department, that it offers its courses, and that there is one within the organization with appropriate prior knowledge.

From this point, there are several research directions among which we highlight: (1) potential extension of the study and conducting it globally, and (2) deeper investigation of discovered ideas for collaboration, towards their implementation.

Acknowledgments

This research was partially funded by Short-term APV project 142-451-2036/2022 “Exploring the use of wide-spectrum resources as a potential for collaboration between academia and (software) industry in the Autonomous Province of Vojvodina” and Cost Action CA19135 - CERCIRAS: Connecting Education and Research Communities for an Innovative Resource Aware Society funded by COST Association.

References

[1] P. M. Abuja, T. Carapina, M. de Kort, M. Raess, C. Tieken, N. Wagstaff, Corbel industry collaboration best practice guide, 2019. URL: https://doi.org/10.5281/zenodo.2615365.

[2] UN SDG, accesible on 15.6.2024. URL: https://sdgs.un.org/goals.

[3] CERCIRAS CA19135, accesible on 15.6.2024. URL: https://www.cerciras.org/.

[4] A. Hameed, A. Khoshkbarforoushha, R. Ranjan, P. P. Jayaraman, J. Kolodziej, P. Balaji, S. Zeadally, Q. M. Malluhi, N. Tziritas, A. Vishnu, S. U. Khan, A. Zomaya, A survey and taxonomy on energy efficient resource

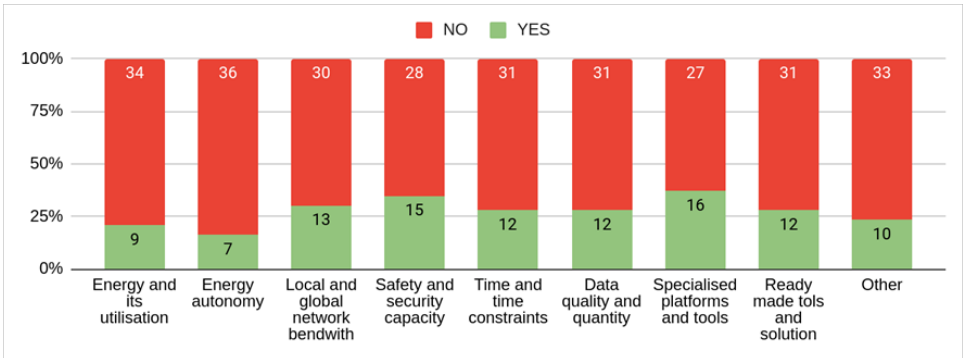

Figure 8: If organizations offer their own courses.

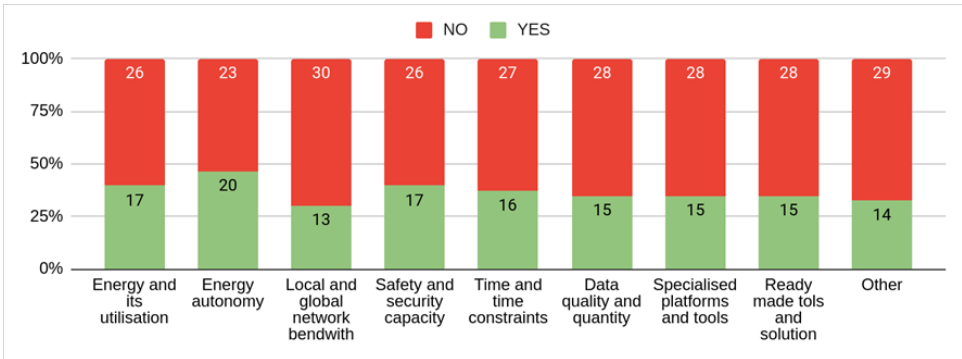

Figure 9: Are some training/courses missing?

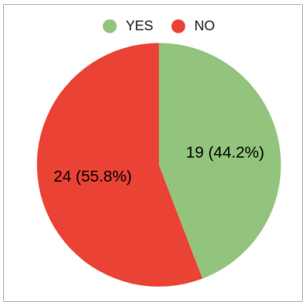

Figure 10: Can other sectors within the organization help?

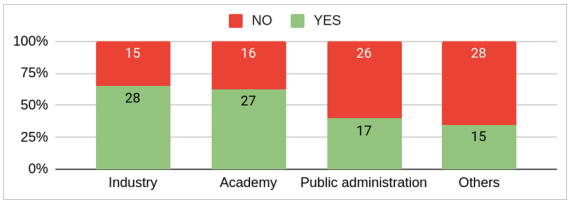

Figure 11: Existing idea about specific cooperation with other organizations.

allocation techniques for cloud computing systems, Computing 98 (2014) 751–774. URL: http://dx.doi.org/10.1007/s00607-014-0407-8.

[5] S. Singh, I. Chana, Qos-aware autonomic resource management in cloud computing: A systematic review, ACM Computing Surveys 48 (2015) 1–46. URL: http://dx.doi.org/10.1145/2843889.

[6] C.-H. Hong, B. Varghese, Resource management in fog/edge computing: A survey on architectures, infrastructure, and algorithms, ACM Computing Surveys 52 (2019) 1–37. URL: http://dx.doi.org/10.1145/3326066.

[7] Q. Luo, S. Hu, C. Li, G. Li, W. Shi, Resource scheduling in edge computing: A survey, IEEE Communications Surveys Tutorials 23 (2021) 2131–2165. doi:10.1109/COMST.2021.3106401.

[8] H. Hussain, S. U. R. Malik, A. Hameed, S. U. Khan, G. Bickler, N. Min-Allah, M. B. Qureshi, L. Zhang, W. Yongji, N. Ghani, J. Kolodziej, A. Y. Zomaya, C.-Z. Xu, P. Balaji, A. Vishnu, F. Pinel, J. E. Pecero, D. Kliazovich, P. Bouvry, H. Li, L. Wang, D. Chen, A. Rayes, A survey on resource allocation in high performance distributed computing systems, Parallel Computing 39 (2013) 709–736. URL: https://www.sciencedirect.com/science/article/pii/S016781911300121X.

[9] P. Czarnul, J. Proficz, A. Krzywaniak, Energy-aware high-performance computing: Survey of state-of-the-art tools, techniques, and environments, Scientific Programming 2019 (2019) 8348791. URL: https://onlinelibrary.wiley.com/doi/abs/10.1155/2019/8348791.

[10] T. Jabeen, H. Ashraf, A. Ullah, A survey on healthcare data security in wireless body area networks, Journal of Ambient Intelligence and Humanized Computing 12 (2021) 9841–9854. URL: http://dx.doi.org/10.1007/s12652-020-02728-y.

[11] C. Andrade, The limitations of online surveys, Indian Journal of Psychological Medicine 42 (2020) 575–576. URL: http://dx.doi.org/10.1177/0253717620957496.

[12] Google Forms, accesible on 15.6.2024. URL: https://www.google.com/forms/about/.

[13] SurveyMonkey, accesible on 15.6.2024. URL: https://www.surveymonkey.com/.

[14] Jotform, accesible on 15.6.2024. URL: https://www.jotform.com/.

[15] Typeform, accesible on 15.6.2024. URL: https://www.typeform.com/.

[16] T. Obradović, B. Vlačić, M. Dabić, Open innovation in the manufacturing industry: A review and research agenda, Technovation 102 (2021) 102221.

[17] M. Perkmann, K. Walsh, University–industry relationships and open innovation: Towards a research agenda, International journal of management reviews 9 (2007) 259–280.

[18] A. L. Rossoni, E. P. G. de Vasconcellos, R. L. de Castilho Rossoni, Barriers and facilitators of university-industry collaboration for research, development and innovation: a systematic review, Management Review Quarterly (2023) 1–37.

[19] F. Ahmed, M. T. Fattani, S. R. Ali, R. N. Enam, Strengthening the bridge between academic and the industry through the academia-industry collaboration plan design model, Frontiers in Psychology 13 (2022) 875940.

[20] E. Van Teijlingen, V. Hundley, The importance of pilot studies, Nursing Standard (through 2013) 16 (2002) 33.

[21] Questionnaire (Ser), accesible on 15.6.2024. URL: https://forms.gle/W5U4gs21RemahSqEA.