Why and How Do Organizations Create User-Led Open Source Consortia? A Systematic Literature Review.

Elçin Yenişen Yavuz[1]
elcin.yenisen@fau.de, ORCID: 0000-0002-3760-0515
Computer Science Department, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Dirk Riehle
dirk@riehle.org, ORCID: 0000-0002-8139-5600
Computer Science Department, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Context: User-led open source (OS) consortia (foundations) consist of organizations from industries beyond the software industry collaborating to create open-source software solutions for their internal processes. Initially pioneered by higher education organizations in the 2000s, this concept has gained traction in recent years across various industries.

Objective: This study has two research objectives. The first objective is to provide an overview of the current state of the art in this field by identifying previously studied topics and gathering examples from different industries. The second objective is to understand the structure of user-led OS consortia and the motivations of organizations for participating in such consortia.

Method: To gain a comprehensive understanding of this phenomenon, we conducted a systematic literature review, covering the years 2000 to 2023. Furthermore, we performed thematic analysis on 43 selected studies to identify and examine the key characteristics, ecosystems, and the benefits organizations gain from involvement in user-led OS consortia.

Results: We identified 43 unique papers on user-led OS consortia and provided details on 14 sample user-led OS consortia projects. We defined 19 characteristics of user-led OS consortia and 16 benefits for organizations' involvement. Additionally, we outlined the key actors and their roles in user-led OS consortia.

Conclusion: We provided an overview of the current state of the art in this field. We identified the structure of user-led OS consortia and organizations' motivations for participating in such consortia.

[1] Friedrich-Alexander-Universität Erlangen-Nürnberg, Professur für Open-Source-Software, Martensstr. 3, 91058 Erlangen

Keywords: Open source foundations; User-led open source consortia; Collaborative software development; Open-source software projects; User-driven open-source software development; Community-source software development; Coopetition; SLR; systematic literature review

1 Introduction

Open-source software (OSS) development is a development approach where source code is openly shared, allowing developers and software engineers to use, modify, and contribute to it while collaborating on the development process—all without charge. Initially, OSS development projects were primarily driven by individual contributors; however, over time, corporate organizations began participating actively (Fitzgerald, 2006).

One strategy for corporate involvement in OSS is to release proprietary software as open-source code and foster a community around it (West & O'Mahony, 2005; Dahlander & Magnusson, 2005; Dahlander, 2007; Harutyunyan et al., 2020). This strategy enables companies to establish widely recognized standards, drive innovation, develop markets for complementary products and services, and build positive relationships with their target audience (West & Mahony, 2005).

Another strategy is to engage in OSS development in collaboration with other corporate entities. These collaborations typically occur under legal entities such as foundations or consortia. We classify the collaborative OSS development approaches of organizations into two categories: vendor-led open source foundations (or consortia) and user-led open source foundations (or consortia).

In vendor-led open source (OS) consortia, collaborative efforts are primarily driven by software vendor organizations aiming to develop software components for use in their products (Schaarschmidt et al., 2011; Riehle & Berschneider, 2012; Yenişen Yavuz et al., 2025). In contrast, in user-led open source (OS) consortia, development efforts are steered by organizations from non-software industries with the goal of developing software tailored to their specific internal needs (Yenişen Yavuz et al., 2022; Yenişen Yavuz et al., 2025). The common characteristic of these two types of consortia is that their leading members are organizations rather than individuals.

OSS projects steered by companies, rather than individuals, are becoming increasingly common in practice. However, the literature on these types of foundations and projects remains limited. Few studies have focused on vendors' involvement in such projects (e.g., Teixeira et al., 2016; Yenişen Yavuz et al., 2025). On the other hand, the literature lacks a clear explanation of the definition and structure of "user-led OS consortia." In OSS literature, "users" are primarily defined as volunteer developers who are often the end users of the software they contribute to. However, the involvement of user organizations in OSS development and their collaborative efforts with other organizations have not been systematically investigated.

The first examples of user-led OS consortia emerged in higher education in the early 2000s, pioneered by universities in the United States. This expansion was driven by the growing demand for customized software solutions and the need for independence from vendors. Since then, user-led OS consortia have gained significant traction and popularity across various industries.

Current literature on user-led OS consortia primarily focuses on specific project examples, with most of the investigated projects originating in the education sector. However, a comprehensive explanation of the structure of this model across different industries is lacking.

In this research, we have two research objectives (RO): Our first RO is to provide an overview of the current state of the literature on user-led OS consortia. Our second RO is to identify the general structure of user-led OS consortia and define the motivations of organizations for engaging in these consortia.

To achieve our first RO, we formulated three research questions (RQ). These are:

RQ.1.1. What is the current state of the art in the literature on user-led open source consortia?

RQ.1.2. Which user-led open source consortia have been investigated in the literature?

RQ.1.3. Which research topics about user-led open source consortia does the literature address?

To achieve our second RO, we have three additional RQs:

RQ.2.1. What are the defining characteristics of user-led open source consortia?

RQ.2.2. How do organizations engage with user-led open source consortia?

RQ.2.3. Why do user organizations create user-led open source consortia?

To address these research questions, we conducted a systematic literature review (SLR) by following the guidelines of Kitchenham (2004) and Kitchenham & Brereton (2013). We analyzed the relevant literature qualitatively using thematic analysis (Braun & Clarke, 2012).

As a result of our analysis, we contribute to the literature with the following key findings:

- We identify *43 unique papers* on user-led OS consortia and *synthesize information* they provided on different topics. With this contribution, we aim to provide a literature list for researchers working on this topic, and for practitioners, considering involvement in OS consortia projects.
- We present *14 sample user-led OS consortia projects* from the 44 papers we reviewed. We collected and presented information about these projects, including their industry, initiation goal, initiation year, and status as of May 2024. This contribution proves that this approach is applicable across different industries and captures the attention of various stakeholders.
- We identify *19 defining characteristics* of user-led OS consortia based on three key features: being led by user organizations, following collaborative software development approaches, and offering the developed software as open source. Furthermore, we present *key actors and their roles within the ecosystem* of user-led OS consortia. These contributions are beneficial for establishing governance practices around such consortia. They serve as the first steps to provide an understanding about their structure and management.
- We define *16 motivations* behind organizations' participation in user-led OS consortia by comparing the benefits of this approach with alternative options. This contribution is beneficial for practitioners to better understand these motives, communicate the benefits to others, and attract more members to their projects.

The structure of this paper is as follows: In Section 2, we present related work on open source foundations and user-led OS consortia definitions. In Section 3, we describe the methodology we employed in this study. We present the obtained results in Section 4, and discussion in Section 5. In Section 6, we outline the limitations of our study. Lastly, in Section 7 we provide the conclusion of this study.

2 Related Work

In Section 2.1, we provide an overview of open source foundations, while in Section 2.2, we present the definitions of user-led open-source consortia used in the literature.

2.1 Open Source Foundations

Open source (software) foundations are non-profit organizations that serve as impartial platforms for open-source software (OSS) projects. They play a crucial role in managing and distributing funds to support these initiatives, while also protecting the rights of project members and contributors through a legal framework. Additionally, they often provide governance support to their members (Riehle & Berschneider, 2012; Eckert et al., 2019; Izquierdo & Cabot, 2020).

The origins of free and open-source software (OSS) can be traced back to the Free Software Foundation (FSF), established by Richard Stallman in 1985. Stallman is credited with introducing the concepts of 'copyleft'—an alternative to copyright— and the 'General Public License' (von Hippel & von Krogh, 2003). The FSF is a non-profit organization that collects and distributes funds for early software development projects, most notably the GNU Project, which aimed to develop a completely free operating system (Stallman, 2003).

Other early examples of open source foundations include the Apache Software Foundation, the Linux Foundation, and the Eclipse Foundation. The Apache Software Foundation was established in 1999 to ensure the continuity of original HTTP Project and subsequent projects (Hunter and Walli, 2013). The collaborative approach, meritocratic governance structure and community development process of ASF became a blueprint for other open source foundations[2].

With the increased adoption of Linux operating systems, the popularity of Linux-kernel projects grew. As the scope, complexity, and number of contributors to the Linux-kernel project grew, support for its expanding community was required. To address this need, the Linux Foundation was established in 2000 (Perlow, 2020; Hunter and Walli, 2013). Similarly, the Eclipse Foundation was founded in 2004 to support the Eclipse IDE project (Hunter and Walli, 2013).

All of these foundations were initially established to support community-led OSS projects. Community-led OSS projects are initiated and managed by individual developers (Yenişen Yavuz et al., 2025). These projects follow a meritocratic governance model, where contributors gain governance roles based on the consistency and quality of their contributions (Riehle & Berschneider, 2012; Weikert et al., 2019). In most community-led OS foundations, corporate entities are not formally recognized as members. However, they can support hosted OSS projects by funding individual contributors, offering infrastructure resources, or sponsoring project-related events (Shaikh & Cornford, 2010).

The Apache Foundations has continued in this direction, accepting only individual members. To support community-led OS projects, it accepts sponsorship from organizations, but does not allow institutions to be the members of the projects.[3] On the other hand, the Linux Foundation and the Eclipse Foundation accept both individual and institutional members. They have expanded their OSS project portfolios to include community-led OS projects, vendor-led OS consortia projects, and user-led OS consortia projects.

Vendors participate in collaborative open-source development projects to help establish industry standards, accelerate innovation within the field, and enhance productivity through resource sharing (Schaarschmidt et al., 2011; Teixeira et al., 2016; Zhang et al., 2020; Yenişen Yavuz et al., 2025). Furthermore, vendors may offer complementary hardware, software, or services related to the open-source projects they support (Teixeira et al., 2016; Zhang et al., 2020). Developers working on these projects are mostly paid employees of member companies (Schaarschmidt et al., 2011). However, volunteer contributors are also welcome to these projects. Some examples of vendor-led OS consortia hosted by the Linux Foundation are LF Edge[4], and the Cloud Native Computing Foundation[5]. Examples from the Eclipse Foundation include Eclipse IoT Working Group[6] and the Adoptium Working Group[7] (Yenişen Yavuz et al., 2025).

User-led OS consortia involve end-user organizations that steer OSS development by providing requirements and financial incentives. These organizations are the primary consumers of the OSS

[2] https://www.apache.org/foundation/how-it-works/
[3] https://www.apache.org/foundation/governance/
[4] https://lfedge.org/
[5] https://www.cncf.io/
[6] https://iot.eclipse.org/
[7] https://adoptium.net/

being developed. IT service providers primarily act as development partners that implement the specifications and develop the software (Yenişen Yavuz et al., 2022).

We use the terms foundation and consortium synonymously in this article. Riehle & Berschneider (2012) explain the distinction between these terms based on their goals—whether they serve their members or the public—, and their jurisdiction of incorporation, which depends on the country in which they are established. However, rather than focusing on the legal distinctions between these collaborations, we emphasize their structure and objectives in relation to software development efforts.

2.2 Definition of User-led Open Source Consortia

The first examples of user-led open source consortia were observed in higher education. Courant & Griffith (2006) used the term “directed open source” to describe this model. Wheeler (2007a) and Liu et al. (2007) investigated examples in higher education and referred to this approach as “community-source software development”.

Chesbrough & Appleyard (2007) and Perr et al. (2010) classified “community-source software development” as an open source business model and explored the benefits of involvement in these collaborations from the perspective of software vendors. Chesbrough & Appleyard (2007) referred to this business model as “self-service”, defining it as “consortia of end-user organizations”.

Riehle (2019) classified OSS foundations into two categories: developer foundations and user foundations. Developer foundations are those that are steered by software vendors or individual developers. In contrast, user foundations are founded and managed by user organizations—rather than software vendors—with the goal of developing OSS for their own use.

Almigheerbi et al. (2020) proposed implementing this model in Libyan higher education organizations, focusing on the development of ERP packages. They referred to this model as “Collaboratively-Developed Enterprise Resource Planning (CD-ERP)”.

Schwab et al. (2020) and Yenişen Yavuz et al. (2022) referred to this model as “user-led open source consortia”. Yenişen Yavuz et al. (2022) highlighted the potential for confusion when referring to the model employed in higher education projects as "community-source software development," as this term may mistakenly imply a similarity to open source projects led solely by developers without organizational involvement—commonly referred to as community-led open source development.

As this research constitutes a literature review, we employ diverse terminology to explore relevant findings. However, we call this phenomenon “user-led open source foundations” and “user-led open source consortia”. In the rest of the paper, we use the term “user-led OS consortia” to explain this phenomenon.

3 Methodology

We chose to perform a systematic literature review (SLR) for this research. An SLR is a form of secondary study that focuses on “identifying, evaluating and interpreting all available research relevant to a particular research question, topic area, or phenomenon of interest” (Kitchenham, 2004). An SLR is a method for adopting an Evidence-Based Software Engineering (EBSE) research approach. Inspired by evidence-based medicine, EBSE aims to support software development decisions by synthesizing insights from high-quality research studies (Kitchenham et al., 2009).

The potential contributions of SLRs can be categorized as “backward-oriented”, which involves synthesizing existing knowledge or aggregating evidence from previous studies, and “forward-oriented”, which focuses on theory building or identifying research gaps for future exploration (Diaz et al., 2024). Our research focuses on both backward and forward orientations. Our

first objective is to synthesize existing knowledge by investigating literature on user-led OS consortia. Our second objective is to develop a theory based on the information we have collected.

We employed the methodologies proposed by Kitchenham (2004) and Kitchenham & Brereton (2013) in conducting this systematic literature review. In the initial step, we investigated existing systematic literature reviews on user-led OS consortia; however, we did not find any. In the second step, we developed a literature review protocol outlining our research goals and rationale for the literature review, our search strategy, paper selection criteria, and data extraction strategy. We adhered to this protocol. In the third step, we conducted the review and documented the results. Finally, in the fourth step, we report the review process and its result in this paper. In the following section, we describe the details of the third step: "conducting the review".

3.1 Search Strategy

In the search strategy step, we defined the keywords, specified the timeframe, and selected the digital libraries for the search.

We identified four sets of keyword lists. We began with terms commonly used in the literature to define this model, such as "community source", "directed open source", and "user-led OS consortia." The second set includes terms related to the structure of the software development process, such as collaborative OSS development, intercompany OSS development, and sponsored OSS development.

User-led open source consortia can take different organizational forms, such as foundations, working groups, or consortia. Organizations can initiate their own foundations, or alternatively, they can operate under an established umbrella foundation. In our third set of keywords, we included prominent umbrella foundations for user-led OS consortia, namely the Apereo Foundation and the Eclipse Foundation (Working Groups).

During our prior research (Yenişen Yavuz et al., 2022), we encountered notable user-led OS projects and consortia, including Kuali, Sakai, openKonsequenz, openMAMA, and the Academy Software Foundation. We utilized these terms as the fourth set of keywords, which we continuously updated as we discovered new projects or consortia.

In Table 1, we provide a detailed keyword list and its corresponding search results.

> **Set 1:** Terms which are used in the literature to define user-led OS consortia such as "community source", "directed open source", "user-led open source consortia", and "user-led open source foundations"
> **Set 2:** Terms which are used to define organizational involvement in open-source software development such as "collaborative open-source software development", "intercompany OSS development", and "sponsored OSS development".
> **Set 3:** Terms which present umbrella foundations, such as "Eclipse Foundation", and "Apereo Foundation"
> **Set 4:** Terms which present known examples of user-led OS consortia or their projects such as "Kuali", "Sakai", "openKonsequenz", "openMAMA", "Academy Software Foundation", "Nordic Institute for Interoperability Solutions" and "samvera"

We specified our keywords to generate a list of related papers published between 2000 and 2023. We set the initial year for our search as 2000 because the user-led OS consortia phenomenon began with the Sakai project, which was initiated in 2003 through a collaboration among the University of Michigan, Indiana University, Stanford University, and the Massachusetts Institute of Technology in the United States (Severance, 2011). We conducted our keyword search in the electronic databases of Google Scholar, Web of Science, the ACM Digital Library, IEEE Xplore, and Scopus.

3.2 Search and Selection Process

To streamline our search process, we defined inclusion and exclusion criteria, and created a data extraction table to document and monitor all obtained results.

We formulated three inclusion criteria based on the publication year, focus, and type of the study to be included. These criteria are as follows:

- **Publication year:** The studies should have been published between 2000 and 2023.
- **Focus:** The study should focus on a user-led open source consortium, a project, or the overall model itself.
- **Type of study:** The study should fall into one of the following categories:
    - Empirical research papers
    - Discussion or opinion papers
    - Experience-sharing papers authored by individuals who are or were participants of any user-led OS consortium or project

We established four exclusion criteria. Any results that meet these criteria are to be eliminated during the selection process. These criteria are as follows:

- **Language:** Studies that are not written in English.
- **Duplicates**: Search results that are duplicates.
- **Non-concurrent manuscripts:** Search results that do not consist of complete manuscripts, such as conference agendas, journal announcements, interview scripts, lecture notes, presentations, or editorials.
- **Student theses:** Bachelor's theses, master's theses, and dissertations.

To collect studies published between 2000 and 2023, we searched each defined keyword individually using the specified search engines. For example, we searched for a keyword on Google Scholar and recorded all results by noting the author's first name, publication year, and the first word of the title. Additionally, we saved the URL of each study for further review. During this process, we identified and marked studies that were not written in English or were duplicates.

After this initial exclusion process, we focused on the type and content of the papers. We reviewed their abstracts and, when necessary, the full manuscripts. In some cases, to better understand the structure of the projects mentioned in the studies and to determine the inclusion or exclusion of these papers, we conducted additional internet searches to gather more information about the projects.

Figure 1 illustrates the sequential steps of the paper search and selection process, along with the corresponding results.

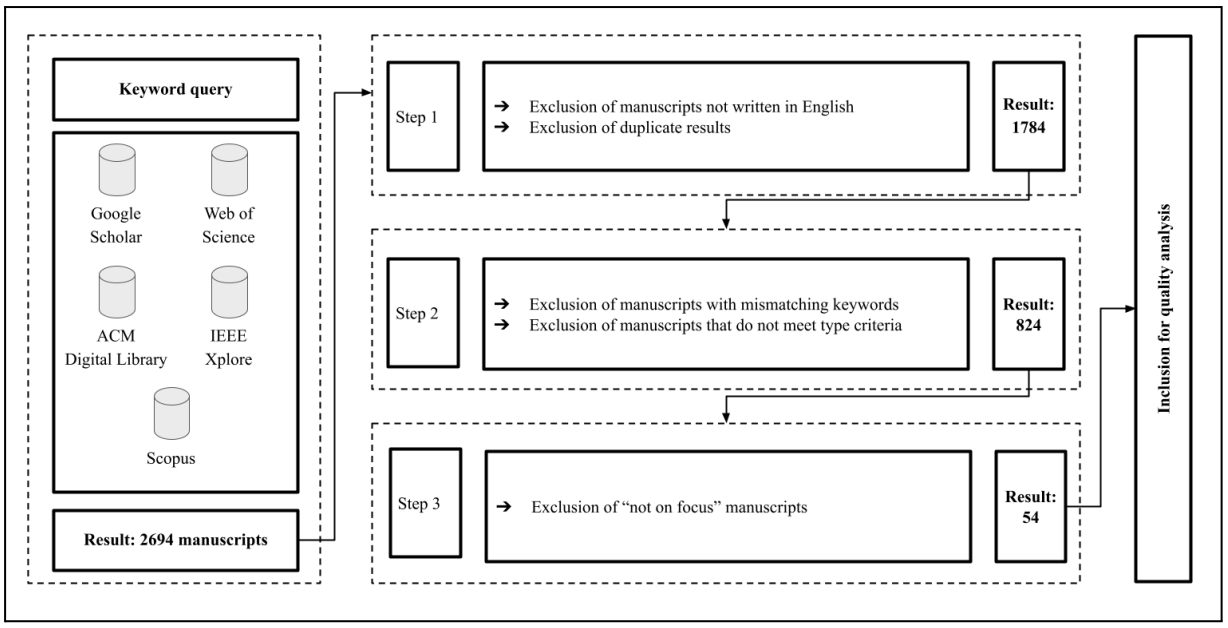

Figure 1. Search and Selection Process

Our literature search returned a total of 2694 results. We did not restrict our search to any specific section of the studies; instead, we searched "all fields" within the search engines used for the query. The inclusion and exclusion process was conducted through three distinct steps.

In the first step, we excluded search results that were not in English and removed duplicate papers, resulting in a total of 1784 manuscripts.

In the second step, we conducted a thorough content scan and searched for the presence of our designated keywords within the papers. Whenever we found that the keywords did not align with the intended meaning we were seeking, we categorized these papers as "keyword mismatch" and subsequently excluded them from further consideration. For instance, there were cases where the term "community-source" yielded incorrect outcomes, such as references to the "Sun Community Source License." Similarly, when searching for "Sakai," we encountered research papers in which the term appeared as the author's name, despite not being directly related to the Sakai project itself. In this step we excluded 668 papers due to incorrect keyword matches. Furthermore, we eliminated manuscripts that did not meet our inclusion criteria based on the type of study. This entailed excluding materials such as conference agendas, journal announcements, interview scripts, lecture notes, and editorials. Additionally, we made a deliberate decision to exclude bachelor's theses, master's theses, and dissertations. As a result, 292 papers that did not align with the desired study type were eliminated. After this step, we were left with 824 papers.

In the third step, we thoroughly reviewed the titles, abstracts, and bodies of the manuscripts, carefully evaluating their content and its relevance to user-led OS consortia. During this process, we eliminated studies that did not align with the focus of our research. For instance, if a manuscript discussed the use of the "Sakai" quiz tool for student evaluation, we excluded it from our final selection of articles. Another example includes manuscripts that focused on authors' experiences using software developed by a user-led OS consortium or comparing it with other alternatives in the market to decide on implementations; these were categorized as "not on focus". At the end of this step, we excluded 770 studies that did not align with the focus for our research.

Conversely, manuscripts that focused on the creation, governance, or structure of user-led open source consortia or foundations in general, as well as projects associated with these consortia, were

labeled as "related" and designated for the quality analysis step. Thus, we collected a total of 54 manuscripts directly relevant to the user-led OS consortia topic.

Table 1 presents the keywords used for the search along with the corresponding results, while the full list of papers is available in (Yenişen Yavuz & Riehle, 2025: Appendix A).

Table 1. List of Keywords and Search Results

Classification	KEYWORD	Search results	After 1st step	After 2nd step	After 3rd step
Set 1: Definition	community source AND open source	1323	1067	352	40
	directed open source	23	19	2	1
	User led open source consortia	0	0	0	0
	User led open source consortium	0	0	0	0
	User-led open source consortia	1	0	0	0
	User-led open source consortium	0	0	0	0
	User-led open source foundation	11	1	1	1
Set 2: Open source development approach	collaborative open-source software development	99	82	56	0
	collaborative OSS development	33	28	24	0
	company led open-source software development	0	0	0	0
	company led OSS	4	4	3	0
	company led OSS development	0	0	0	0
	company-led open-source software development	0	0	0	0
	company-led OSS development	0	0	0	0
	inter-company open-source software development	0	0	0	0
	inter-company OSS development	0	0	0	0
	intercompany open-source software development	0	0	0	0
	intercompany OSS development	0	0	0	0
	open source cooperative projects	0	0	0	0
	sponsored open-source software development	6	6	3	0
	sponsored OSS development	2	2	1	0
	user led open source cooperative	0	0	0	0
	user-led open source cooperative	0	0	0	0
	user-sponsored OSS development	0	0	0	0
Set 3: Umbrella Foundatio	Apereo Foundation	223	172	113	0
	Eclipse Foundation AND industry working groups	7	7	4	0

Classification	KEYWORD	Search results	After 1st step	After 2nd step	After 3rd step
n					
Set 4: User-led OS Consortium or Project Names	Academy Software Foundation	58	42	27	2
	Kuali AND community source	207	23	16	2
	Nordic Institute for Interoperability Solutions	94	70	51	1
	open source AND openMAMA	40	23	19	3
	openKonsequenz	45	25	23	3
	openPASS AND Eclipse Working Group	21	19	15	0
	Sakai AND community source	403	108	48	0
	samvera AND open source AND governance	94	86	66	1
	RESULTS	**2694**	**1784**	**824**	**54**

3.3 Quality Assessment

To assess the quality of the 54 selected papers, we focused on the reporting of results, rigor of the studies, and the credibility of results. We adapted the quality criteria used by Dybå et al. (2007) and Kitchenham & Brereton (2013) to develop a quality model. We present the list of questions and corresponding answer options we used in our quality model in Table 2.

We began by gaining an understanding of the overall structure of the papers. Our first set of questions concerns defining the research type and determination of the research methods applied in these studies. Dybå et al. (2007) excluded the discussion papers from their systematic literature review; however, we did not follow this approach. Like Kitchenham & Brereton (2013), we included research papers, discussion papers, and experience papers. Since this research topic impacts both academic research and practical applications in different fields, we did not want to overlook the perspectives of experts involved in user-led open source consortia projects or its implication in the industry. Considering their type, we applied different evaluation criteria to papers in different categories.

The second set of questions includes the criteria for reporting these studies. The third set focuses on the rigor and trustworthiness of results, while the fourth set addresses the credibility of findings. Dybå et al. (2007) and Kitchenham & Brereton (2013) apply credibility criteria primarily considering quantitative studies. In addition, we included assessment criteria for qualitative studies. However, we did not include “methods’ appropriateness to the goals of studies” and “relevance criteria as the value of the study for research or practice”, since we aimed to minimize subjective interpretation as much as possible.

Table 2. Question List for the Quality Assessment of Collected Papers

Category	Number	Question	Answer options & Scoring points
Overview about the study	Q1	What is the type of the study?	Research paper, discussion/opinion paper, experience paper
	Q2	What is the type of research? (applied to research papers)	Qualitative, quantitative, mixed-method, mathematical and simulation models, software tool article, not applicable
	Q3.a	What research method is used in the study? (authors' claim)	Experiment, Quasi-Experiment, Case study, Qualitative survey (Interview Study), Quantitative survey, Grounded theory research, (Systematic) literature review, Observation study, Action research, Experience sharing, Lessons learned, Game-theoretical model, Statistical analysis, Not applicable, None
	Q3.b	What research method is used in the study? (our observation)	Experiment, Quasi-Experiment, Case study, Qualitative survey (Interview Study), Quantitative survey, Grounded theory research, (Systematic) literature review, Observation study, Action research, Experience sharing, Lessons learned, Game-theoretical model, Statistical analysis, Not applicable, None
Reporting	Q4	Is there a clear statement of the aims of the study?	Yes (1) / Partly (0.5) / No (0) / Not applicable
	Q5	Is there an adequate description of the context in which the research or observation was carried out?	Yes (1) / Partly (0.5) / No (0) / Not applicable
	Q6	Is there a clear statement about findings?	Yes (1) / Partly (0.5) / No (0) / Not applicable
Rigor and trustworthiness	Q7	Is the description of the sample and the sample selection process explained in detail?	Yes (1) / Partly (0.5) / No (0) / Not applicable
	Q8	Is the data collection process explained in detail?	Yes (1) / Partly (0.5) / No (0) / Not applicable

Category	Number	Question	Answer options & Scoring points
	Q9	Is the data analysis process explained in detail?	Yes (1) / Partly (0.5) / No (0) / Not applicable
Credibility	Q10	Is there a limitation or credibility section in the research?	Yes (1) / Partly (0.5) / No (0) / Not applicable
	Q11	If the type of research is qualitative: Are any quality practices such as member checking, prolonged engagement, triangulation, peer debriefing used in the research process?	Yes (1) / Partly (0.5) / No (0) / Not applicable
	Q12	If the type of the research is quantitative: are any methods used to compare results (such as control groups in experiments)?	Yes (1) / Partly (0.5) / No (0) / Not applicable
	Q13	For experience papers: Are one of the authors involved in the discussed project or consortium?	Yes (1) / Partly (0.5) / No (0) / Not applicable

Both authors actively reviewed the articles to decide on their inclusion or exclusion. The first author manually evaluated the quality of each article using our quality model. Our primary focus during the quality evaluation of the articles was on the reporting process, the rigor and trustworthiness of findings, and the credibility of results. The first author then used the quality evaluation to suggest a decision regarding inclusion or exclusion.

Our exclusion criteria for manual assessment were as follows:

- If a paper does not provide final results (findings) or only partially provide results, it will be excluded.
- If a research paper does not provide detailed information about the sample AND data collection AND data analysis, it will be excluded.
- If a research paper does not define its research method AND we are unable to determine it, it will be excluded.
- If a research paper has a published extended version with almost the same content, the first version of the paper will be excluded.
- If an experience-sharing paper does not have an author involved in the sample project being discussed, it will be excluded.

The second author developed a scoring function to assign a quality score to each article. The scoring function uses the distance metric (square root of sum of squares) to calculate a quality score over the questions of Q4 to Q13 of the model. We adjusted the cut-off value—where articles with a higher score were included, articles with a lower score were excluded—based on the maximum alignment with our qualitative assessment. The cut-off value, on the scale of 0 to 1, was set at 0.69.

The second author compared the quality score results with the first author's manual assessment and identified ten problematic cases of disagreement, categorized as follows:

- Articles that were marked for inclusion based on the first author's manual evaluation but received a low score from the scoring function.
- Articles that were marked for exclusion based on the first author's manual evaluation but received a high score from the scoring function.
- Articles that fell into the middle range of 0.65 to 0.75.

The second author reviewed these problematic articles and suggested their re-evaluation. The first and second authors then collaboratively decided on the inclusion or exclusion of each article. As a result, the first and second author created a joint assessment, leading to the inclusion of 42 papers in the systematic review.

We excluded nine articles, since they did not meet our quality criteria. Furthermore, we excluded three articles of good quality that contained similar text to other three articles but were published in different venues with extended content. In these cases, we included only the updated version of each article. Although one paper (e.g., Courant & Griffiths, 2006) was published as a report rather than in a traditional research publication, we included it in our research and analysis due to its relevance.

We present the list of included studies in the results section of this paper (in Section 4), and results of our quality assessment in (Yenişen Yavuz & Riehle, 2025: Appendix B).

3.4 Snowballing

As the third step in our data collection process, we conducted forward (Felizardo et al., 2016) and backward snowballing (Wohlin, 2014) using the 42 papers resulting from the quality assessment process.

For the forward snowballing process, we used Google Scholar. We searched each of the collected papers and recorded the names and URLs of the papers that cited them using the "cited by" function. This process was repeated for each paper, except for Chesbrough & Appleyard (2007). Since the primary focus of Chesbrough & Appleyard (2007) is on "open innovation," it had an overwhelming number of citations (2364). To narrow the search, we employed an automated data collection tool, Publish or Perish[8], and restricted our search using the keywords "open innovation and strategy" and "self-service." The term "open innovation strategy" is the title of the paper, while "self-service" is the term Chesbrough & Appleyard (2007) used to describe the user-led OS consortia concept. After compiling the list of papers and removing duplicates, we obtained a total of 617 papers.

Next, we excluded duplicates, papers not written in English, papers that were inaccessible, papers published after 2023, and papers that did not meet our inclusion criteria based on their type. This process left us with 221 papers. We reviewed the abstracts of these papers and, when necessary, the full manuscripts. From this review, we identified three potentially relevant papers; however, these papers did not meet our quality standards based on the selection criteria outlined in Section 3.3. As a result, we were unable to include any additional papers following the forward snowballing analysis.

For the backward snowballing process, we compiled all references listed in the included papers. Nine of the papers did not provide reference lists. From the remaining 33 papers, we gathered a total of 1223 references. After removing duplicates, papers not written in English, inaccessible papers, papers published before 2000, and those that did not meet our inclusion criteria, 740 papers remained for further review. We reviewed the abstracts of these papers and, when necessary, the full manuscripts. From this review, we identified one relevant paper, which was subsequently included in our results.

We provide the list of snowballing results in (Yenişen Yavuz & Riehle, 2025: Appendix G).

[8] https://harzing.com/resources/publish-or-perish

In Table 3, we provide a comprehensive list of the related literature along with their unique identifiers (IDs) used in this research.

Table 3. Related Literature and Identifier (IDs) Codes

ID	Reference	ID	Reference	ID	Reference
S1	Baecker, 2005	S16	Levy & Germonprez, 2015	S31	Robles et al., 2019
S2	Baron et al., 2010	S17	Liu et al., 2010	S32	Sabin & Leone, 2009
S3	Brooks, 2004	S18	Liu et al., 2012	S33	Samuel et al., 2022
S4	Bulushi, 2019	S19	Liu et al., 2014a	S34	Schwab et al., 2020
S5	Chesbrough & Appleyard 2007	S20	Liu et al., 2014b	S35	Severance, 2007
S6	Courant & Griffiths, 2006	S21	Liu et al., 2017	S36	Severance, 2011
S7	Farmer & Dolphin, 2005	S22	Liu et al., 2020	S37	Walker et al., 2020
S8	Foutty, 2010	S23	Liu et al., 2021	S38	Wheeler & DeStefano, 2007
S9	Germonprez et al., 2013	S24	Mackie, 2008	S39	Wheeler, 2007a
S10	Germonprez et al., 2020	S25	Morris & Leonard, 2020	S40	Wheeler, 2007b
S11	Goering et al., 2017	S26	Nidy & Kwok, 2005	S41	Wheeler & Hilton, 2012
S12	Hancock, 2010	S27	Perr et al., 2010	S42	Winkler, 2018
S13	Heckenberg et al., 2019	S28	Provan & Lemaire, 2015	S43	Yenişen Yavuz et al., 2022
S14	Henttonen et al., 2017	S29	Rankin & Baecker, 2007		
S15	Ketterl et al., 2010	S30	Riehle, 2019		

3.5 Data Extraction and Synthesis of the Extracted Data

Once we identified the related papers for our research, we extracted and documented key information from each publication, including the “publication title”, “authors of the publication”, “publication year”, “publication type”, “published venue”, and if applicable, “project studied in the paper”. To maintain clarity and traceability, we assigned unique identifiers (IDs) to each paper, which we then utilized in the results section to attribute the extracted information to its respective source.

To address our research questions, we conducted a qualitative data analysis following the six steps of the thematic analysis procedure proposed by Braun & Clarke (2012).

In the first step, we familiarized ourselves with the data by taking notes on the content of each paper during the literature selection process. In the second step, we started creating initial codes. Using a qualitative data analysis tool (MaxQDA)[9], we generated codes by reading the full manuscripts

[9] https://www.maxqda.com/

of each paper. At this stage, we started developing a codebook in a Google Spreadsheet based on the initial codes.

In the third step, we refined our coding scheme by consolidating and clustering the initial codes into sub-themes and main themes. We created a category for codes that did not fit into any of the themes or were not directly related to our research questions, with the intention of revisiting them again. At this point, our approach diverged from Braun and Clarke's (2012) methodology. While Braun and Clarke recommend using thematic maps in this step—described as a less detailed but similar alternative to a codebook—we chose to continue developing and refining our codebook instead.

In the fourth step, we revisited each of the relevant papers, carefully examining our codes and their associations with the emerging themes. We continuously revised and updated the codes and themes as needed, eliminating any codes that did not fit into a category or were unrelated to our research questions.

By the time we reached the fifth step, we had developed a clear set of themes and codes. We established precise definitions for the themes and incorporated the most relevant quotes corresponding to each code into the codebook.

The final step of thematic analysis involves producing a report. We present our coding list and themes in our final codebook (Yenişen Yavuz & Riehle, 2025: Appendix C) and showcase the results of our data analysis in the Results section of this paper. The process of creating codes and themes, along with supporting examples, is depicted in Figure 2.

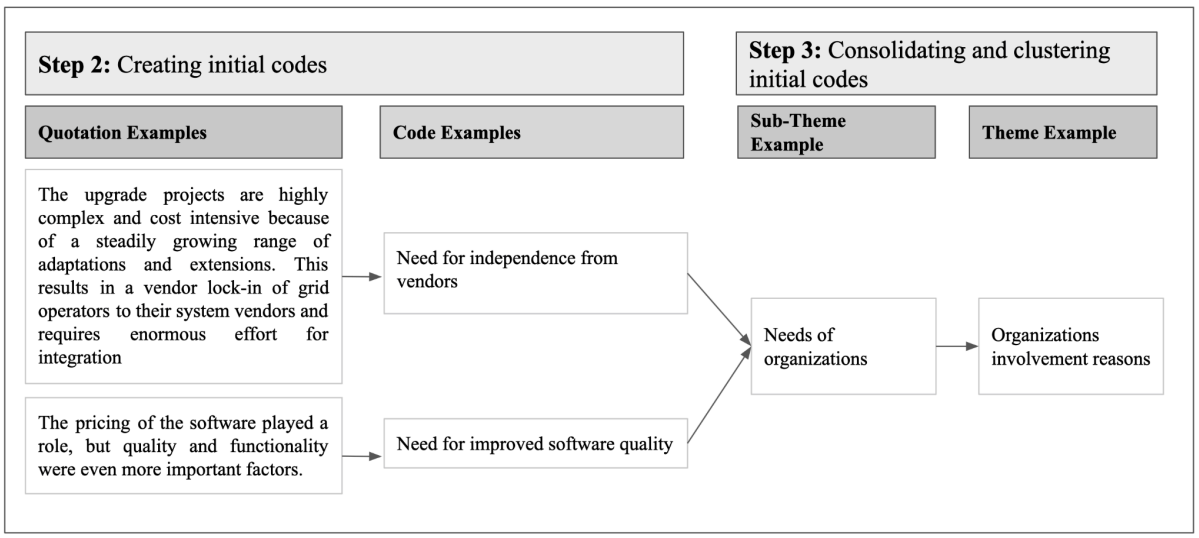

Figure 2. Steps 2 and 3 of the Data Analysis Process

4 Results

In this section, we present the research findings related to our two research objectives. Each objective will be further explored through subsections addressing related research questions.

4.1 RO. 1. Identification of the State of the Art in User-Led Open Source Consortia Literature

As a result of our literature search and selection process, we collected 43 related papers. We present a sample of search results in Table 4, and the full list in (Yenişen Yavuz & Riehle, 2025: Appendix D). Descriptive statistics on the distribution of the included studies are provided in Section

4.1.1, details on user-led OS projects investigated in the literature are discussed in Section 4.1.2, and key concepts explored in the literature are outlined in Section 4.1.3.

Table 4. Sample Search Results Examining the Topic of User-Led Open Source Consortia

ID	Title	Author(s)	Year	Type	Venue	Sample	Industry
S10	Tapestries of Innovation: Structures of Contemporary Open Source Project Engagements	Germonprez, M., Levy, M., Kendall, J. E., & Kendall, K. E.	2020	Research paper	Journal of the Association for Information Systems	open-MAMA	Finance

4.1.1 RQ.1.1. What is the current state of the art in the literature on user-led open source consortia?

To address RQ1.1, we analyzed the distribution of studies focusing on three aspects: study type, publication venue, and publication year.

Among the 43 manuscripts we collected, 19 (44%) are peer-reviewed research papers, 13 (30%) are experience papers, and 11 (26%) are opinion papers. Figure 3 illustrates the type distribution of the collected studies.

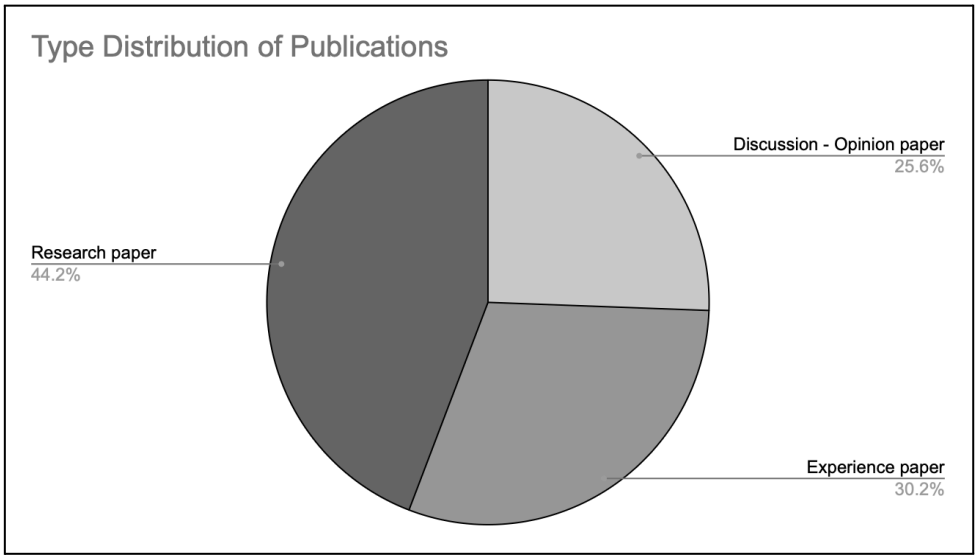

Figure 3. Distribution of Study Types in User-Led Open Source Consortia Research

Studies focusing on user-led OS consortia were published in various venues. Of the 43 studies collected in this research, 18 (42%) were published in journals, 13 (30%) in conference proceedings (including congress and symposiums), and eight (19%) in industry specific magazines. Furthermore, we included in our analysis three book chapters and one report (9 %).

The majority of the *research papers* (17 out of 19) were published in journals and conference proceedings. The remaining two research papers were published in Communications of the ACM Magazine and Organization for Open-Source Software Study Report. *Experience papers* were written by founders or members of different user-led OS consortia. Of these, 69% were published in journals and conference proceedings, while the remaining 31% appeared in magazines and books. *Discussion*

(or opinion) papers focused on the general structure of user-led OS consortia. The authors of these papers were either founders of different user-led OS consortia or sector professionals. Of the discussion papers, 45% were published in industry-specific magazines, while the remaining papers were published in journals, conference proceedings, and one book.

We present the type and publication venue distribution of the studies we collected in Figure 4.

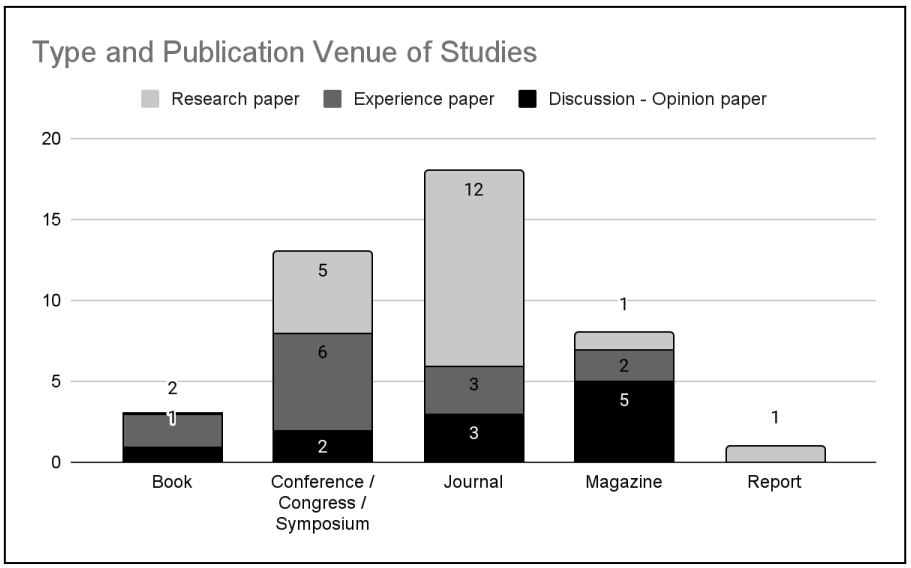

Figure 4. Distribution of Study Types and Publication Venues in User-Led Open Source Consortia Research

The first examples of user-led OS consortia projects were initiated at the beginning of 2000s by higher education institutions. From 2004 to 2023, 67% of the published papers had a focus on user-led OS consortia or projects from higher education. The first paper in a different industry beyond higher education was published in 2013. From 2013 to 2023, 29% of papers were focused on consortia from other industries beyond higher education. A further 4% of the papers explained the general structure of the user-led OS consortia without focusing on any industry. The years 2007, 2010, and 2020 stand out as being particularly significant in terms of numbers of papers published. Figure 5 illustrates the distribution of the literature based on the published year.

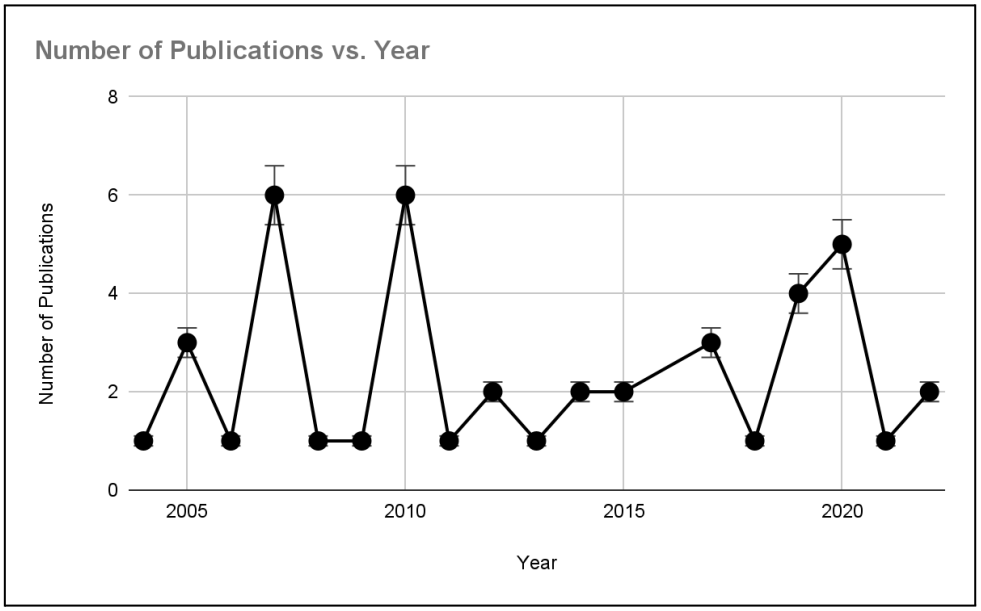

Figure 5. Distribution of Publication Years in User-Led Open Source Consortia Research

4.1.2 RQ.1.2. Which user-led open source consortia and projects have been investigated in the literature?

Nearly half (47%) of the identified projects and their associated consortia in the literature originate from the higher education industry. The Kuali Foundation and the Apereo Foundation are two umbrella organizations that host user-led open-source (OS) projects in higher education.

The Kuali Foundation was established in 2004 by a group of universities and colleges in the United States [S8]. Its initial focus was to ensure financial sustainability and coordination for the Kuali Financial Systems (KFS) project, a user-led open-source consortium project [S8]. Following the success of KFS, the Foundation expanded its open-source initiatives to include a research administration system (Kuali Coeus), a student information system (Kuali Student), a library system (Kuali OLE), and middleware applications (Rice) [S8]. In 2014, the Kuali Foundation created a for-profit company, KualiCo, with the goal of "sustaining community" [S4]. KualiCo focuses on a cloud-based software-as-a-service (SaaS) model, offering paid cloud services for Kuali products [S4]. As of September 2023, the Kuali Foundation has been dissolved as a legal entity and transitioned into a for-profit Kuali company (Kuali Foundation, n.d.).

The Apereo Foundation was established in 2012 through the merger of two organizations: Ja-Sig and the Sakai Foundation (Apereo, n.d.; Apereo Community Blog, n.d.). The Sakai Foundation, incorporated in 2005, aimed to sustain the Sakai Learning Management System (LMS) project and its community [S35, S36, S40]. Following the merger, ownership of the Sakai LMS project was transferred to the Apereo Foundation. In addition to Sakai, the Apereo Foundation also hosts other projects discussed in the literature, including Open Source Portfolio (OSP) and OpenCast.

ePresence was an in-house developed streaming tool at the University of Toronto. In 2005, the university decided to open-source the project and create a consortium around it [S29]. Initially, the consortium followed a dual-license approach. After two years (in 2007), the members decided to adopt a single open-source license (BSD) for all versions [S29]. However, the open-source version of ePresence is no longer actively maintained.

Two projects, FOLIO and Hyku for Consortia, originate from the library industry. FOLIO was hosted by the Kuali Foundation from 2010 to 2016, during which it was known as the Kuali OLE project. In 2016, following the establishment of KualiCo, the members of the Kuali OLE project decided to leave the foundation and started a non-profit organization: the Open Library Foundation (OLF) [S42]. Since then, the FOLIO project has been hosted by the OLF.

Hyku for Consortia is a collaborative project initiated in 2018 by the Pennsylvania Academic Library Consortium (PALC) and the Private Academic Library Network of Indiana (PALNI). The project aims to build an open-source institutional repository (IR) on the Hyku platform and make it available for use by libraries [S25].

Other projects and consortia discussed in the literature originate from the automotive, energy, finance, entertainment, and geospatial industries.

openMDM is a consortium of companies in the automotive industry. Initiated by Audi in 2012, it became an open-source consortium in 2014 under the umbrella of the Eclipse Foundation [S43].

openKonsequenz is a consortium of energy providers focused on software development for energy grid operation management. It was initiated in 2013 in Germany [S11].

openMAMA is a consortium in the finance industry. Its main project is a data transfer platform that supports standardized data formats and is used by financial institutions [S9].

The Academy Software Foundation (ASWF) is a consortium of motion picture and visual effects organizations. Established in 2018, its goal is to support OSS development within the motion picture

content creation industry [S13]. OpenColorIO is one of the projects hosted by ASWF [S37]. As of August 2023, both openMAMA and the Academy Software Foundation are hosted under the umbrella of the Linux Foundation.

Two projects, Oskari and X-Road, are publicly funded and led by governmental organizations. Oskari is a geospatial software project initiated by the National Land Survey of Finland (NLSF) in 2008 [S14, Oskari, n.d.]. In 2011, the NLSF released its source code openly, and in 2014, a community of organizations called the Joint Development Group was established around this project (Oskari, n.d.). Since 2017, Oskari has been an incubation project under the umbrella foundation of OSGeo [S14, Oskari, n.d.].

X-Road is a data exchange platform developed by the Nordic Institute for Interoperability Solutions (NIIS), a consortium formed by governmental organizations from Estonia and Finland [S31]. X-Road is used in both the public and private sectors. In the public sector, it supports systems such as population registers, health insurance registers, and vehicle registration systems. In the private sector, it is utilized by energy, telecom, and banking institutions [S31].

We present the sample distribution of user-led OS consortia studies in a matrix format in Table 5.

Table 5. Sample Distribution of User-Led Open Source Consortia Studies

	Umbrella Foundation	Apereo Foundation			Kuali Foundation			Open Library Foundation	Hyku Partners	Eclipse Foundation	openKonsequenz	Linux Foundation	ASWF		Oskari Community	NIIS	None	
	Focus (Projects or General)	Sakai LMS	OpenCast	OSP	Kuali Financial Systems	Kuali Rice	Kuali Foundation	OLE project - FOLIO	Hyku for consortia	openMDM	openKonsequenz	openMAMA	OpenColorIO	ASWF	Oskari	X-Road	ePresence	General
ID	Study																	
S1	Baecker, 2005																x	
S2	Baron et al., 2010	x																
S3	Brooks, 2004																	x
S4	Bulushi, 2019						x											
S5	Chesbrough & Appleyard, 2007																	x
S6	Courant & Griffiths, 2006																	x
S7	Farmer & Dolphin, 2005	x																
S8	Foutty, 2010						x											
S9	Germonprez et al., 2013											x						
S10	Germonprez et al., 2020											x						
S11	Goering et al., 2017										x							
S12	Hancock, 2010		x															
S13	Heckenberg et al., 2019													x				
S14	Henttonen et al., 2017														x			
S15	Ketterl et al., 2010		x															
S16	Levy & Germonprez, 2015											x						
S17	Liu et al., 2010				x													
S18	Liu et al., 2012	x				x												
S19	Liu et al., 2014a						x											
S20	Liu et al., 2014b						x											
S21	Liu et al., 2017						x											
S22	Liu et al., 2020						x											
S23	Liu et al., 2021						x											
S24	Mackie, 2008																	x
S25	Morris & Leonard, 2020								x									
S26	Nidy & Kwok, 2005	x		x														x
S27	Perr et al., 2010																	x
S28	Provan & Lemaire, 2015				x													
S29	Rankin & Baecker, 2007																x	
S30	Riehle, 2019																	x
S31	Robles et al., 2019															x		
S32	Sabin & Leone, 2009	x			x													
S33	Samuel et al., 2022					x												
S34	Schwab et al., 2020										x							
S35	Severance, 2007	x																
S36	Severance, 2011	x																
S37	Walker et al., 2020												x					
S38	Wheeler & DeStefano, 2007																	x
S39	Wheeler, 2007a	x		x	x		x											x
S40	Wheeler, 2007b	x																
S41	Wheeler & Hilton, 2012																	x
S42	Winkler, 2018							x										
S43	Yenişen Yavuz et al., 2022	x								x								

Beyond extracting data from the literature, we conducted an online search to gather additional information about these projects. We focused on the use cases, industry, foundations, and active years of these projects. We present the details of each project in Table 6.

It is noteworthy that we identified numerous additional projects developed by user-led OS consortia; however, no existing studies were found about these consortia.

Table 6. User-led Open Source Consortia Projects Identified in the Literature

Project Name	Industry	Goal	Initiation Year	Status in May 2024	Foundation/ Initiative
Sakai LMS Project	Higher Education	Developing an online collaboration and learning environment for managing, delivering, and	2003	Continues as a user-led OS project	Apereo Foundation

Project Name	Industry	Goal	Initiation Year	Status in May 2024	Foundation/ Initiative
		assessing student learning			
Open Source Portfolio	Higher Education	Developing an online e-portfolio for personal representation, teaching, learning, assessment and accreditation	2003	Since 2005 it is a part of Sakai Project	Apereo Foundation
Kuali Financial Systems Project	Higher Education	Developing a financial services system specifically for colleges and universities	2004	Since 2014 it is a commercial product	Kuali Company (prior structure: Foundation)
ePresence	Higher Education	Developing a web-based streaming and collaboration tool for large-scale broadcast of events over the Internet	2005	inactive	None
Opencast (prior name: Opencast Matterhorn)	Higher Education	Developing an open source video recording and management system to use for lectures	2008	Continues as a user-led OS project	Apereo Foundation
openMAMA	Finance	Building an open platform to publish market data from multiple sources and multiple vendors in a standardized format	2010	Continues as a user-led OS project	Linux Foundation
Oskari	Geospatial	Developing a software to view, visualize, analyze and edit spatial data	2011	Continued as a user-led OS project	Oskari Joint Development Forum
openKonsequenz	Energy	Building software systems that are used in energy grid operation management	2013	Continue as a user-led OS project	openKonsequenz Cooperative
openMDM	Automotive		2014	Continue as a user-led OS project	Eclipse Foundation
FOLIO (prior name: Kuali OLE)	Library	Developing an open source platform for libraries	2016	Continues as a user-led OS project	Open Library Foundation
X-road	Neutral	Building a data exchange layer solution which ensures confidentiality, integrity and interoperability between data exchange parties	2017	Continues as a user-led OS project	Nordic Institute for Interoperability Solutions (NIIS)
OpenColorIO	Entertainment	Setting standards for color management in visual effects industry	2018	Continues as a user-led OS project	Academy Software Foundation (ASWF)
Hyku for Consortia	Library	Building a collaborative institutional repository based on Hyku Software	2019	Continues as a user-led OS project	Hyku Partners

4.1.3 RQ.1.3. Which research topics about user-led open source consortia does the literature address?

To address RQ.1.3, we conducted thematic analysis (Braun & Clarke, 2012) and applied the concept-matrix approach for presentation (Webster & Watson, 2002). We synthesized the individual topics from primary studies into a concept hierarchy across all studies. The top-level (root) concepts are referred to as key concepts. We identified five key concepts across all studies, which are:

1. General structure of user-led OS consortia
2. Governance of user-led OS consortia
3. Ecosystems of user-led OS consortia
4. Creation of a specific user-led OS consortium
5. Development process of a specific user-led OS project

In this section, we provide detailed explanations of each concept, along with the studies classified under these concept categories. The concept matrix is presented in Table 7, and the distribution of subconcepts shown in Table 8.

Table 7. Distribution of Research Concepts on User-led Open Source Consortia Addressed in the Literature

			Key Concepts				
			General structure of user-led OS consortia	Governance of user-led OS consortia	Ecosystem of user-led OS consortia	Creation of a specific user-led OS consortium / foundation	Development process of a specific user-led OS project
ID	**Reference**	**Study type**					
S1	Baecker, 2005	Experience paper					x
S2	Baron et al., 2010	Discussion - Opinion paper	x				
S3	Brooks, 2004	Discussion - Opinion paper	x				
S4	Bulushi, 2019	Research paper		x			
S5	Chesbrough & Appleyard, 2007	Discussion - Opinion paper	x				
S6	Courant & Griffiths, 2006	Research paper	x				
S7	Farmer & Dolphin, 2005	Experience paper					x
S8	Foutty, 2010	Experience paper				x	
S9	Germonprez et al., 2013	Discussion - Opinion paper	x				
S10	Germonprez et al., 2020	Research paper	x				
S11	Goering et al., 2017	Research paper					x
S12	Hancock, 2010	Experience paper					x
S13	Heckenberg et al., 2019	Experience paper				x	
S14	Henttonen et al., 2017	Research paper		x			
S15	Ketterl et al., 2010	Experience paper					x
S16	Levy & Germonprez, 2015	Research paper	x				
S17	Liu et al., 2010	Research paper		x			
S18	Liu et al., 2012	Research paper		x			
S19	Liu et al., 2014a	Research paper			x		
S20	Liu et al., 2014b	Research paper			x		
S21	Liu et al., 2017	Research paper			x		
S22	Liu et al., 2020	Research paper		x			
S23	Liu et al., 2021	Research paper		x			
S24	Mackie, 2008	Discussion - Opinion paper	x				
S25	Morris & Leonard, 2020	Experience paper					x
S26	Nidy & Kwok, 2005	Discussion - Opinion paper	x				
S27	Perr et al., 2010	Research paper	x				
S28	Provan & Lemaire, 2015	Research paper			x		
S29	Rankin & Baecker, 2007	Experience paper					x
S30	Riehle, 2019	Discussion - Opinion paper	x				
S31	Robles et al., 2019	Research paper					x
S32	Sabin & Leone, 2009	Discussion - Opinion paper	x				
S33	Samuel et al., 2022	Research paper			x		
S34	Schwab et al., 2020	Research paper			x		
S35	Severance, 2007	Experience paper					x
S36	Severance, 2011	Experience paper					x
S37	Walker et al., 2020	Research paper					x
S38	Wheeler & DeStefano, 2007	Discussion - Opinion paper	x				
S39	Wheeler, 2007a	Discussion - Opinion paper	x				
S40	Wheeler, 2007b	Experience paper					x
S41	Wheeler & Hilton, 2012	Discussion - Opinion paper	x				
S42	Winkler, 2018	Experience paper					x
S43	Yenişen Yavuz et al., 2022	Research paper		x			

4.1.3.1 General structure of user-led open source consortia

In this category, we collected studies focusing on the overall structure of the user-led OS consortia model and its impact across different areas.

User-led OS consortia concept is explained as a category of business model enabled by OSS [S5, S27, S30]. This model is defined as “consortia of end-user organizations jointly developing applications to be used by all” [S5, S27]. Since the users of the software develop it to meet their own needs, it is referred to as “self-service” [S5]. The goal is to create value through shared resources and to increase flexibility and innovation potential [S19]. Targeting vertical, enterprise, or back-office applications, this model focuses on a specific market segment [S27]. The user-led OS consortia concept represents one of the innovations of open source in the business model category [S30]. It is a type of open source foundation, which could be referred to as a “user foundation” [S30].

The user-led OSS development approach provides enrichments to involved institutions by shared experiences and best practices [S3]. Key components of user-led OS projects, particularly in the educational sector, include finding stakeholders which have similar problems to solve, identifying development partners which would provide technical support [S3, S26], securing financial support for the projects [S3, S26], coordinating resources [S26], and ensuring institutional commitment to the sustainability of the projects [S24]. Institutional involvement in user-led OS consortia projects requires aligned goals, sufficient resources, and shared values [S41].

The collaborative OSS development approach among for-profit companies enables them to spare time and resources in developing basic functionalities. This allows them to focus on differentiating their products based on feasibility, unique features, and advancing their own strategy [S9, S10, S16]. Open source communities offer a platform for strategic innovation to for-profit companies [S10, S16].

User-led OS consortia model originated in higher education under the name “community source”. Studies examining the general structure of this model, particularly in the context of higher education, are primarily experience or opinion papers authored by university members.

International collaboration and OSS movement play a significant role in resource creation for higher education [S2]. Various models and technologies have been applied in the Information Technology (IT) education community [S32]. One such approach is the user-led OS consortia model, with early examples including the Kuali and Sakai projects [S32, S39]. Contributions from user organizations to OSS projects are considered more reliable for mission critical projects and complex systems [S6]. Collaborating on user-led OS consortia projects helps mitigate the risks associated with proprietary software systems in higher education institutions [S38, S39]. These risks include misalignment with the institution’s operating model, implementation complexities, high implementation costs, and dependency on vendor behavior [S38, S39].

4.1.3.2 Governance of user-led open source consortia

We classified studies that focus on governance policies, governance practices, challenges and solutions of user-led OS consortia under the category of “governance of user-led OS consortia”.

The challenges faced by the user-led OS consortia projects include managing developers, finding high-quality developers, high turnover rates among developers, and ensuring the sustainability of projects [S17]. “Outsourcing developers” is one proposed solution to these challenges [S17].

When outsourcing the development process, a potential problem is the division of software development responsibilities among different vendors without a consortium-wide authority [S43]. To address this issue, the development process should be monitored through regular assessments and clearly defined milestones. Additionally, a dedicated project manager, supported by a consistent team of developers, should oversee the process, to ensure its success [S43].

Some of the other challenges are a low number of leading members, insufficient financial resources to sustain projects, delayed project releases, slow return on investment, turnover among service provider members and knowledge loss, a small user base, and lack of awareness about the projects [S43]. On the other hand, factors that can help overcome these challenges and achieve success include having clearly defined rules and boundaries, collective prioritization, openness and transparency, shared resources and equality, member commitment, established governance rules and legal structures, periodic communication, organizing events, and promoting hosted projects [S43].

Another challenge is sustaining continuity in such collaborations [S22]. Specific challenges in this area include community governance, defining the roles of commercial affiliates, maintaining a family-like atmosphere, sharing cross-project knowledge, and coordinating projects [S22]. One proposed solution to these issues is implementing a modular organizational design [S22, S23].

Addressing the diverse requirements of member organizations poses another challenge. Proposed solutions include achieving technological flexibility and customization [S18]. For example, in the Kuali Rice System project, five levels of customization are implemented: label customization, modification and addition of document types, workflow customization, code modification, and the addition of new modules [S18]. Similarly, in the Sakai project, the architecture is designed to enable both flexibility for use and flexibility for development [S18].

Focusing on the Kuali example, three phases of the governance process have been identified: 1) creating the community, 2) balancing the interests, and 3) sustaining the community [S4]. In the first phase (2004–2006), the focus was on supporting the OSS development process. During the second phase (2006–2014), the foundation prioritized meeting the diverse interests of stakeholders by creating customizable features. In the third phase (since 2014), the governance strategy shifted toward establishing a commercial company, KualiCo, to offer paid cloud-based services. With this strategy, the Kuali community aimed to create a hybrid model combining OSS principles with commercial market concepts [S4].

To address management challenges faced by OSS consortia in public sector organizations, a framework for community-based lifecycle planning has been proposed [S14]. This framework offers guidance on defining what needs to be managed, who should manage it, how it should be managed, and how to finance the management and development process. Implementing this framework impacts product acceptance and quality, resource pooling, and project sustainability processes [S14].

4.1.3.3 Ecosystem of user-led open source consortia

Papers discussing topics related to the actors in user-led OS consortia and their relationships are categorized under the "ecosystem of user-led OS consortia" category.

The ecosystem of the openKonsequenz consortium is examined in the literature [S34]. This consortium comprises three types of members. The first type includes energy company providers, specifically distribution system operators, who take the lead role in driving the development direction. These members provide the necessary financial investment and human resources and are referred to as the driver members. The second type consists of software vendors, who contribute to the development process with the long-term goal of spreading their technology and strengthening their future market position. The third type includes consultants, who aim to profit from consulting projects, and research groups, which benefit from the data generated by the project [S34].

Motivations for user organizations to participate in OSS consortia include cost reduction, independence from vendors, and options for system customization [S19, S34]. Additionally, developer training—both in terms of gaining system expertise and building strong social bonds through community involvement—is another key incentive [S19]. The size, financial power, and IT capabilities of individual institutions significantly influence decisions to join such consortia [S20]. Other institutional factors impacting these decisions include established norms, monitoring mechanisms, institutional similarity, availability of external funding, vendor behaviours, and the role of information technology [S21]. Furthermore, individual factors such as personal motives, opportunities for learning, and levels of trust have influence on decision-makers within institutions [S21].

Another topic explored in the literature is the interaction between participants in multi-organizational software development consortia [e.g., S28, S33]. Participants who supervise processes or provide functional advice tend to have the highest positional embeddedness, which correlates with the time they dedicate weekly and their level of influence [S28]. Those who invest significant hours in the projects gain recognition from others, enhancing their embeddedness within the network. Strong connections within the network are advantageous, as they increase participants'

ability to influence project outcomes. Additionally, participants seeking greater involvement in projects often choose to collaborate with individuals who hold influential roles in project decision-making [S28].

Project participants who work within the same organization tend to communicate more frequently compared to those from different organizations [S28, S33]. While this tendency can strengthen intra-organizational collaboration, it may also limit knowledge flow and reduce overall project effectiveness [S28]. Additionally, factors such as task assignments, clarity regarding task timelines, and the criticality of tasks significantly influence developers' actions and their interactions with one another [S33].

4.1.3.4 Creation of a specific user-led open source consortium

We categorized papers primarily focused on explaining the functionalities of user-led OS consortia (foundations) under the "creation of a specific user-led OS consortium" category. This category includes two papers.

The first, authored by the executive director of the Kuali Foundation in 2010, discusses the status of the foundation as of that year [S8]. The second paper examines the structure of the Technical Advisory Board of the Academy Software Foundation (ASWF) and outlines its goals for 2018–2019 [S13].

4.1.3.5 Development process of a specific user-led open source consortium project

We categorized papers discussing the initiation and development processes of specific user-led OS projects under the "development process of a specific user-led OS project" category. Most of these papers are based on the experiences of the initiators of these projects. The projects examined include ePresence, Sakai LMS, Open Library Environment, X-Road, Hyku for Consortia, OpenCast Matterhorn, OpenColorIO, and openKonsequenz.

ePresence was initially developed as an in-house streaming tool by the University of Toronto. In 2005, the university decided to open-source the project and establish a consortium around it [S29]. The primary motivation for this decision was to provide users with the flexibility to tailor the system to their specific needs. The project faced several challenges, including developing high-quality software with distributed development teams, sustaining an active community, identifying a suitable license, and establishing a revenue model [S1]. To address the challenge of generating revenue from the OSS product, the consortium adopted a "dual license" approach. However, this strategy proved unsuccessful. A major issue with the dual-license model was the need to maintain two separate but interrelated software packages, requiring the consortium to duplicate efforts during each release process. This approach not only consumed significant time but also led to usability problems [S29]. Ultimately, the consortium decided to simplify the licensing strategy by offering ePresence under a single open-source license, the BSD license [S29].

The history of the Sakai LMS project, along with its governance structure and the challenges faced during its establishment, is detailed by the project's founders [S35, S36, S40].

The history of the Open Library Environment (OLE) project and its transformation into the FOLIO project is documented in the literature [S42]. From 2010 to 2016, the OLE project was hosted by the Kuali Foundation. However, in 2015, OLE partners decided to leave the foundation and establish their own independent foundation. The primary reason for this decision was the shift in the Kuali Foundation's open-source policies. In 2014, the foundation created a for-profit corporation, KualiCo, to act as a service provider for the open-source products developed under the Kuali Foundation. Another contributing factor was the Kuali Foundation's decision to discontinue support for the Kuali Rice component, which served as the foundational framework for Kuali OLE [S42].

The literature provides insights into various aspects of notable user-led OS projects, including the organizational structure, contributors, and stakeholder-perceived challenges of the X-Road project [S31]; the creation and management process of the Hyku for Consortia project [S25]; the history and technical specifications of the Opencast Matterhorn project [S12, S15]; the details of the OpenColorIO project [S37], and development process and reference architecture of the openKonsequenz platform [S11].

Table 8. Distribution of Subconcepts on User-led Open Source Consortia Addressed in the Literature

Key Concepts	Subconcepts	Literature ID	Count
General structure of user-led OS consortia	Business models in OSS development	S5, S27, S30	3
	Collaboration of organizations in OSS development	S9, S10, S16	3
	Values/ Advantages of community source development	S3, S38	2
	Community source model in higher education	S2, S6, S24, S26, S32, S39, S41	7
Governance of user-led OS consortia	Problems and solutions	S17, S22, S43	3
	Achieving goals and sustainability	S18, S23	2
	Governance practices	S4	1
	Lifecycle management	S14	1
Ecosystems of user-led OS consortia	Ecosystem of a user-led OS consortium	S34	1
	Motivations to join community source projects	S19, S20, S21	3
	Interaction between participants in user-led OS projects	S28, S33	2
Creation of a specific user-led OS consortium / foundation	ASWF	S13	1
	Kuali Foundation	S8	1
Development of a specific user-led OS project	ePresence	S1, S29	2
	Hyku for consortia	S25	1
	OLE project	S42	1
	OpenCast	S12, S15	2
	OpenColorIO	S37	1
	openKonsequenz platform	S11	1
	Sakai LMS	S7, S35, S36, S40	4
	X-Road	S31	1

4.2 RO.2. Identification of the Structure of User-Led Open Source Consortia and Motivations of Organizations for Participation

To explore our second research objective, we formulated three research questions and conducted thematic analysis to address them.

To address RQ.2.1, we searched for defining characteristics of user-led OS consortia and categorized them in three main themes, which are presented in Section 4.2.1. We addressed RQ.2.2 by identifying the actors involved in user-led OS consortia, along with their roles, and goals. We explain our findings in Section 4.2.2. To address RQ.2.3, we examined the benefits of involvement, with the results presented in Section 4.2.3.

4.2.1 RQ.2.1. What are the defining characteristics of user-led open source consortia?

A user-led open source consortium is a community of user organizations and software vendors, working collaboratively to develop OSS for the specific needs of user organizations.

As a result of our thematic analysis, we identified key characteristics of user-led OS consortia, focusing on three dimensions: governance, goal, and work result. Within the governance dimension, we identified the theme of “being led by user organizations”. The goal of the consortia is “collaborative software development” to meet their own needs, and their work results in “open-source software”.

In this section, we explain the details of each characteristic and present a summary in Figure 6. The mapping of each characteristic with data sources and related user-led OS consortia is provided in (Yenişen Yavuz & Riehle, 2025: Appendix E).

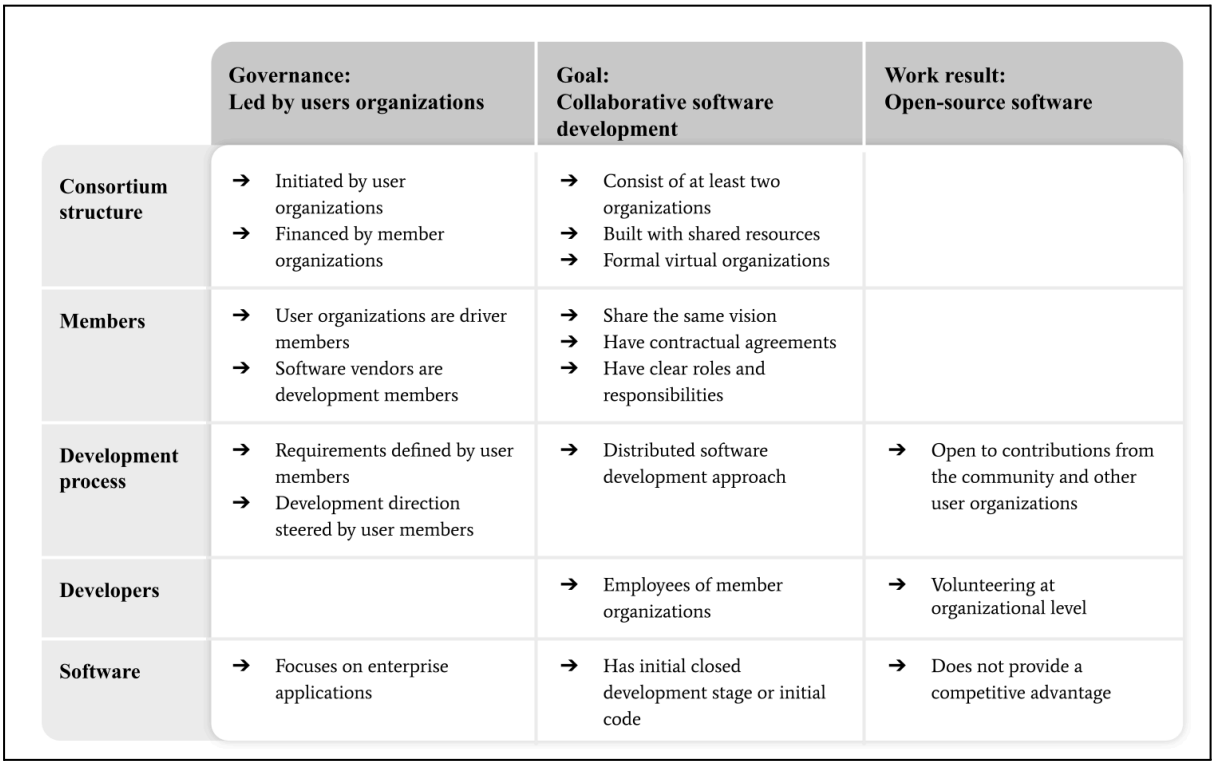

Figure 6. Defining Characteristics of User-led Open Source Consortia

4.2.1.1 Governance: Led by user organizations

User-led OS consortia are **initiated, financed, and led by user organizations,** whose primary function is not software development. However, these organizations engage in software development efforts to support their internal processes [S2, S5, S6, S8, S11, S16, S18, S19, S25, S34, S38, S42, S43]. For example, two universities in the USA—Indiana University and the University of Hawaii—initiated the Kuali Financial Systems project. Their goal was to develop software to support their internal finance management processes. With the involvement of other universities with similar needs, they built a consortium around this project [S18].

In user-led OS consortia, user organizations are the drivers of the software development process. They **define requirements** [S2, S6, S11, S16, S21, S25, S31, S43] and **steer the development direction** [S2, S11, S14, S16, S19, S24, S31, S38, S43]. Although external funding options may be available in some cases, the development process is primarily **financed by member organizations** [S8, S14, S15, S25, S26, S31, S34, S40]. In contrast to software vendor companies, user organizations do not focus on developing generic software, but tailor-made **enterprise applications** which are required to fill functionality gaps in related industries [S18].

4.2.1.2 Goal: Collaborative software development

User-led OS consortia **consist of multiple partner organizations** [S6, S11, S17, S18, S19, S25, S26, S32, S35, S37, S39, S40, S42, S43]. Organizations collaborate by **focusing on a common goal** and sharing the same vision about it [S1, S12, S19, S23, S24, S26, S34, S37, S40, S42, S43]. To ensure the sustainability of projects, partner organizations create non-profit legal entities. This can be a consortium, a foundation, or an initiation. These legal entities may have different legal structures based on the country they are initiated, but from the governance perspective, they follow similar

approaches. They create the boundaries and rules of collaborative working. A key principle in establishing the consortium is the use of **formal, contractual agreements** [S14, S25, S28, S32, S41, S43]. In these formal agreements—most often in the form of consortium charters—**membership structures, roles, and responsibilities** of member organizations are outlined. All partners are required to sign these agreements to join the consortium [S14, S18, S22, S39, S43].

Member organizations collaboratively focus on OSS development by **sharing resources** [S5, S6, S12, S14, S17, S18, S19, S20, S21, S22, S25, S27, S34, S39, S43]. In user-led OS consortia projects, the majority of project participants are **employees of member organizations** [S11, S16, S17, S18, S19, S20, S22, S24, S25, S26, S28, S33, S35, S39, S42, S43]. They can be employees of user organizations, development partners within the consortia, or both [S11, S16, S18, S25, S26, S35, S39, S40, S42, S43]. In some cases, project management and coordination tasks are executed by paid staff which are employed by the legal entities, such as foundations [S14, S35, S42, S43].

User-led OS consortia are built as **virtual organizations** [S14, S17, S18, S19, S20, S22, S24, S28] that follow **distributed software development** approaches [S8, S18, S28, S33, S39].

4.2.1.3 Work Result: Open-source software

Work results of user-led OS consortia projects are open-source software. However, in most cases these projects have an initial **closed code development stage**. User-led OS consortia can evolve around an already developed closed-source software such as in the examples of openMAMA, openMDM, and openColorIO [S16, S37, S43]. The other approach is that partner companies can work to develop the software initially at a closed stage such as in the case of the Sakai project [S36]. In these cases, after software reaches a satisfactory maturity level, it is offered as OSS for the use and contribution of other organizations [S24, S28, S32, S39]. The resulting software **does not provide a competitive advantage or differentiation** for the user member organizations [S3, S6, S9, S16, S21, S34].

OSS offers **flexibility in adaptation** for users [S18, S31, S35]. User organizations can adjust the functionality of the software based on their specific needs. Although the software is **open to any contributions** from individuals or organizations [S16, S24, S31, S32, S37], the **volunteering mostly takes place at the organizational level** [S16, S24, S26, S39].

4.2.2 RQ.2.2. How do organizations engage with user-led open source consortia?

To understand the organizations' engagement with user-led OS consortia, we identified the key actors and their roles within these environments. Based on our thematic analysis, we grouped the key actors into five categories: driver members, development partners (software vendors), user (adopter) members, non-profit organizations, and a legal entity—most often a foundation. In this section, we explain the roles of each actor and present the summary in Figure 7 and Figure 8.

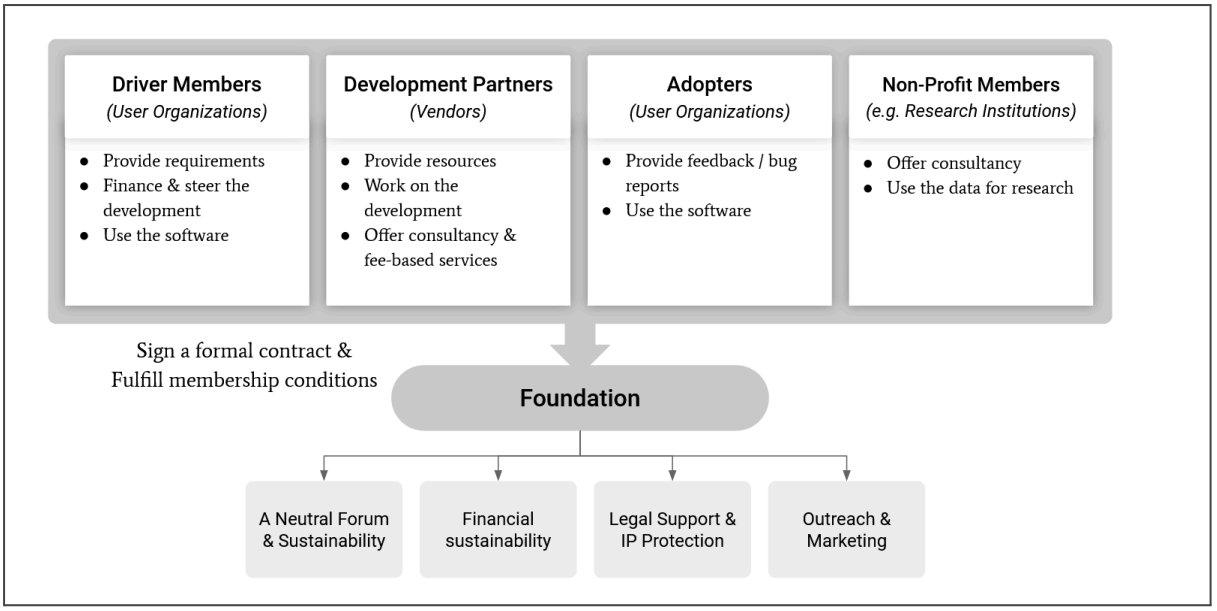

Figure 7. Actors and Their Roles in a User-Led Open Source Consortium

4.2.2.1 Driver members.

Driver members (or organizations) are primarily **user organizations** that need software with specific requirements to fulfill their internal business processes [S8]. The end users of the required software are stakeholders within these organizations, who are typically average computer users rather than software developers [S26].

Driver members engage with user-led OS consortia by financing software projects through **monetary support** and/or **staff resources** [S18, S21, S22, S33, S34, S35, S42, S43]. They define technical requirements [S11, S15] and influence the direction of the software development [S11, S21, S19, S14, S28, S33].

4.2.2.2 Development partners.

Development partners (or members) are **software suppliers or vendors** that are involved in consortia [S4, S21, S31, S42, S43]. They work on the software development process based on the requirements defined by driver members [S11, S16, S18, S35, S39, S40]. Since they have expertise in software development, they ease the development process [S3].

Development partners engage with user-led OS consortia by paying a membership fee or offering manpower to the consortia for the development work. In return for their contributions, development partners anticipate providing user organizations with **complementary fee-based services** for software implementation [S3, S8, S21, S22, S28, S31, S40]. Being a development partner in a user-led OS consortium enhances suppliers' reputation as **a trusted vendor** and enables them to **spread their technology** in the market [S34].

4.2.2.3 Adopters (User members).

Adopters or user members are user organizations that **do not have any direct influence on the development process**, but use the software developed [S11, S34, S35, S43]. Like other member organizations, they sign a contractual agreement, but they do not financially contribute to the project as much as driver members. They can contribute projects by providing feedback, bug reports or merging additional functionalities they create for their own needs [S11, S35]. Having user

organizations **increases the use of the platform** and helps consortia to **set standards** in the industry [S34].

4.2.2.4 Non-profit members.

Non-profit members include **research organizations** or **universities** (not user organizations) working with the consortium [S11, S43]. They can contribute to the project and benefit from the research data [S34].

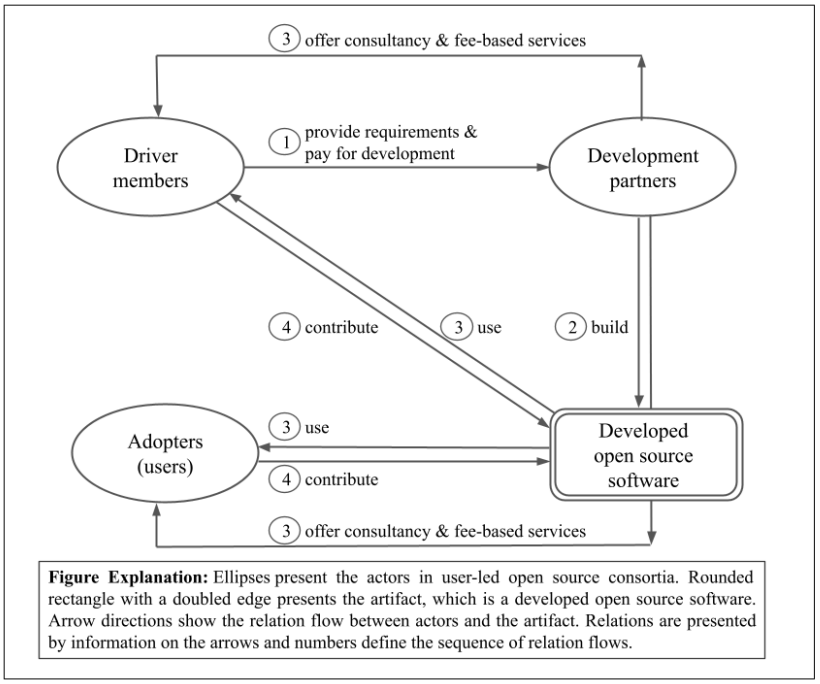

Figure 8. Relationships Among Actors in a User-Led Open Source Consortium

4.2.2.5 Foundation.

User-led OS collaboration members either build their own foundations or join an already established umbrella foundation.

Foundations offer **independent, neutral forums** for member organizations [S13, S16, S39]. As neutral platforms, foundations **protect members' rights** [S41] and **intellectual property** (IP) of the consortium by having the ownership of IP [S13, S16, S28, S39]. Members do not have special rights on the ownership of the software [S40].

Members pay a specific amount of membership fee to join foundations. These fees are centrally collected and distributed to project expenses. In this way, foundations help user-led OS consortia to **ensure financial sustainability** by leveraging financial and staff resources [S4, S8, S15, S35].

(Umbrella) Foundations offer **governance support**, **technical support**, and **support in quality assurance**. As a part of governance support, they provide a clear path for participation and contribution [S13]. They can facilitate collaboration among involved organizations [S4, S16].

Furthermore, umbrella foundations can provide technology platforms [S16], and development (and test) infrastructures for collaborators to work on collectively [S13, S16, S37]. They can set the properties of the OSS code [S4] and offer easy integration with other OS projects [S11]. Foundations can ensure transparency in the requirement process, offer quality assurance in process [S35], and help to increase quality and quantity of contributions [S13].

Furthermore, foundations help **community development** and **community management** by increasing recognition. In order to reach prospective members, foundations organize conferences and meetings [S35, S39] and provide marketing support [S16]. Foundations can assist choosing the right

members into a consortium in terms of culture fit [S35]. They help structuring the community [S4] and building a community of expertise with developers and user organizations [S8]. They keep the community together by coordinating work and projects, and member activities [S4, S8, S35, S37, S39].

4.2.3 RQ.2.3. Why do user organizations create user-led open source consortia?

Organizations that decide to create or join user-led OS consortia often share similar needs, such as an improved version of their existing systems [S11, S21, S34], reduced system complexity [S11], improved software quality [S11, S34], and reduced vendor dependency [S11, S39, S42].

From the literature we reviewed, we found that organizations primarily consider ***control, cost, sustainability,*** and ***productivity*** dimensions by their decisions on developing or buying software. Organizations perform this comparison by evaluating options of *upgrading their existing software*, *purchasing proprietary software*, *developing in-house software*, *using a community-led OSS*, or *joining in a user-led OS consortium*.

In this section, we present the reasons for choosing user-led OS consortia by highlighting the drawbacks of these alternatives and benefits of involvement in a user-led OS consortium. In Figure 9, we present the benefits of user-led OS consortia involvement considering these four dimensions and the defining features of user-led OS consortia. In (Yenişen Yavuz & Riehle, 2025: Appendix F), we present a mapping of each benefit with data sources and related user-led OS consortia.

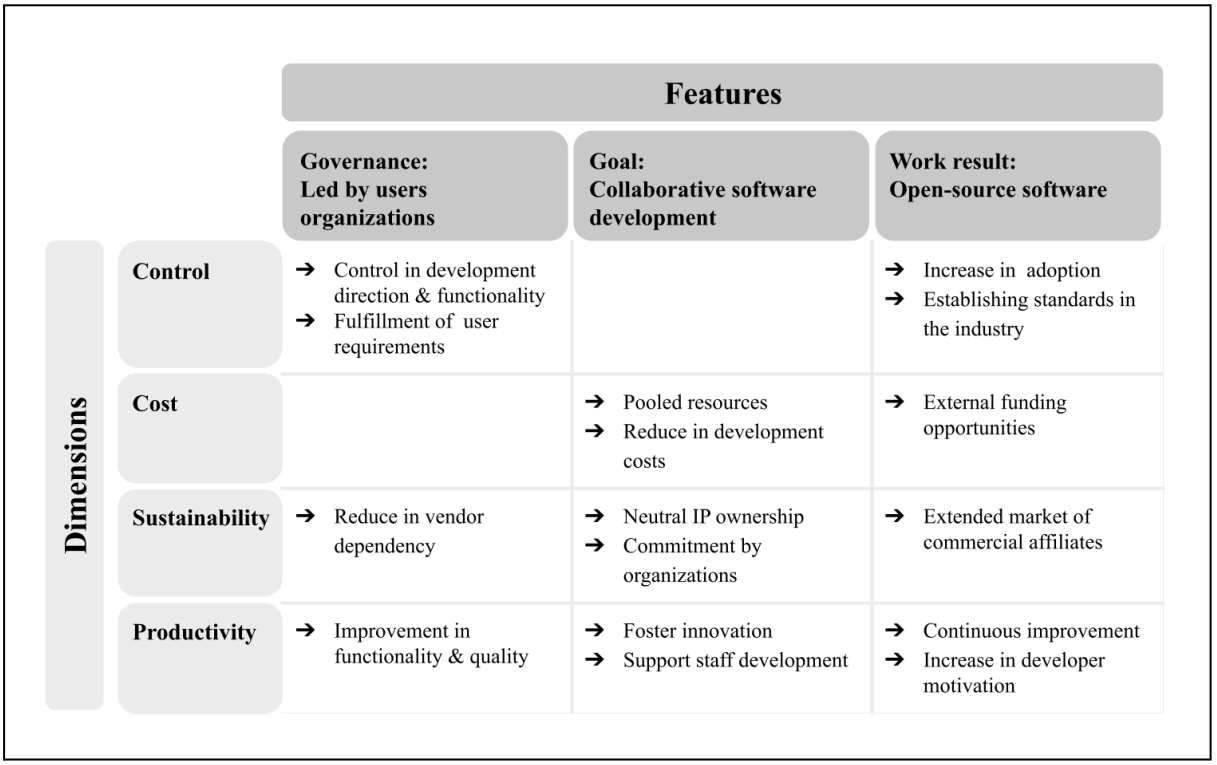

Figure 9. Benefits of Involvement in User-Led Open Source Consortia for User Organizations

4.2.3.1 Control Dimension.

When *proprietary software* is not developed for a specific industry, it may lack the critical functionalities required within that industry [S6, S8, S21, S35]. The literature indicates that most proprietary software products lack specificity to particular sectors, are inflexible in functionality, and are difficult to customize [S6, S12, S18, S20, S21]. Furthermore, upgrades to these products may cause disruptive changes in other connected systems [S6, S8, S21, S38]. A further complaint of the

user organizations about proprietary software is its limited capacity for innovation [S12, S26]. When user organizations request improvements for the proprietary software they use, they may experience a reduced ability to control timing of updates [S8], while software vendors often demonstrate a slow pace in implementing new features [S15, S26].

The other option, *in-house software development*, presents the challenge of keeping up with the pace of innovation in the field [S15, S39].

An alternative to proprietary software and in-house software development is the *use of community-led open-source software* (OSS). However, this software may lack the expected functionality [S6, S15, S35]. Dependence on volunteer developers and the risk of insufficient support are further problems [S12]. Other drawbacks of using community-led OSS for organizations include inconsistent governance models, multiple versions of libraries, siloed development, and varying licensing models [S6, S13].

In ***user-led OS consortia***, user organizations are organizations that work within the same industries, and collaborate with the aim of fulfilling **common needs** and software functionality requirements in their field [S2, S6, S12, S15, S25, S34]. Driver members, which mostly consist of user organizations, have the privilege to **define the functionality requirements** of software, prioritize tasks, and **lead the development direction** [S2, S14, S17, S19, S20, S21, S25, S28, S33, S43]. Since user organizations have control over the development process, they can prioritize their needs and **foster movement** for required functionalities [S3, S11, S21, S31, S37].

The software developed by user-led OS consortia is open source and offered to the community with various OSS licenses chosen by each consortium. This approach increases **the adoption of the software** among organizations with similar needs [S2, S31, S35]. An increase in the number of software users enhances the possibility of **establishing standards in related industry** [S11]

4.2.3.2 Cost Dimension.

Proprietary software products entail high entry costs [S6, S8, S12, S18, S21, S23] and licensing fees [S15, S26, S21]. On the other hand, developing *in-house software systems* without collaboration requires significant investment and maintenance costs for organizations [S21, S26, S28].

In ***user-led OS consortia***, organizations **pool their technical, personnel, and/or financial resources** [S6, S12, S14, S17, S20, S25, S39, S43]. By adopting this collaborative approach, organizations can significantly **reduce software development costs** compared to purchasing proprietary software or developing their in-house solutions [S3, S6, S8, S12, S14, S16, S18, S19, S20, S21, S22, S25, S34, S41]. In addition, organizations benefit from **reduced maintenance and operational costs** [S11, S21, S25, S34].

Since the developed end product is offered as OSS, some user-led OS consortia projects have the opportunity to receive **external funds** from funding organizations [S3, S12, S14, S18, S20, S21, S25, S26, S41, S42]. In examples from the higher education industry, some user-led OS consortia projects received funds from the Andrew W. Mellon Foundation during their early phases (e.g. Sakai, Kuali) [S18, S20, S41]. Later, to sustain development efforts, project participants established legal entities such as foundations, and began collecting fees from member organizations. For library and governmental projects, a similar funding approach can be observed, as seen in initiatives such as Hyku for Consortia and Oskari. For instance, the Hyku for Consortia project received partial funding from the Institute of Museum and Library Services [S25]. Similarly, the National Land Survey of Finland provided funds for the Oskari project during its early development phases [S14].

4.2.3.3 Sustainability Dimension.

Sustainability of *proprietary software* products depends on their developer companies (software vendors). One of the biggest concerns of user organizations regarding the sustainability of software

products is the risk of vendor lock-in [S2, S6, S11, S21, S26, S34]. There is always a risk that vendors or systems may disappear [S8]. Furthermore, working with uncooperative vendors can result in a lack of support [S21, S26].

Alternatively, developing *in-house software systems* presents challenges in keeping the system functionalities up-to-date and ensuring long-term sustainability [S18]. Adding new functionalities to these systems can be cost-intensive [S11, S34].

User-led OS consortia projects **reduce dependence on vendors** compared to proprietary software systems, as these projects are led and financed by user organizations [S2, S6, S11, S34]. Offering the work results as OSS helps **extend the market to more vendors** [S11, S26, S34, S38] and **improve the quality of support services** through competition [S2].

In user-led OS consortia, the owner of the software is neither a vendor nor one of the driver organizations. In general, the **IP ownership** belongs to legal entities (e.g., foundations) representing user-led OS consortia (e.g., S28, S39, S40). These legal entities provide a neutral forum, ensuring the independence and reliability of projects. Another key factor in the sustainability of user-led OS consortia is the **commitment of member organizations** to the consortia and their projects. Organizations sign agreements with the consortia to become members, acknowledging their commitment to working on a project for a defined period. They also commit to regularly investing their resources—whether in the form of human capital or financial contributions—thereby enhancing project sustainability [S6, S14, S21, S24, S43].

4.2.3.4 Productivity Dimension.

Since the member organizations in ***user-led OS consortia*** aim to achieve the same functionality in the end product, they follow a **stronger product vision** [S12]. They can focus on the continuous **improvement of software functionality and quality** [S6, S11, S16, S24, S38, S43].

Member organizations and their employees **share knowledge** and experience with each other regarding projects [S14, S25, S33]. This approach **fosters innovation** in projects [S2, S3, S6, S14, S16**,** S17, S19, S22, S31, S37, S38, S39]. Collaboration helps organizations **build expertise** [S8] and supports **staff development** [S8, S33, S39].

Since the work result is OSS, user-led OS consortia **benefit from the contributions of the community** [S1, S6, S37, S39, S35]. These contributions can take the form of innovative ideas [S2, S9, S14, S39], expert or technical insights [S37, S39], collaboration on future research and development [S1], as well as improvement suggestions and bug fixes [S1, S35].

Working on OSS development has a positive influence on **developer motivation** in user-led OS consortia projects [35, S34]. For instance, Samuel et al. (2022) highlight that working collaboratively with other organizations on the Kuali Rice project motivates developers to help each other more, as developers seek to enhance both their organizations' and their own reputations through expertise in software development and contributions to the project [S33].

5 Discussion

In this section, we discuss the results of our study, its contributions, and future research areas.

5.1 The State of the Art in User-Led Open Source Consortia Literature

Our first objective was the identification of the state of the art in user-led OS consortia literature. Our SLR results show that 35% of the published papers focus on the structure of specific user-led OS consortia or projects. The majority of these papers (12 out of 15) were experience papers. On the other

hand, only 16% of the papers have the focus on governance practices of user-led OS consortia. Existing research on governance primarily examines individual aspects, highlighting a lack of empirical studies on comprehensive governance approaches in user-led OS consortia.

Our analysis reveals that 70% of studies on user-led OS consortia projects focus on higher education, with nearly half of the projects (6 out of 14) originating in this sector. This dominance may stem from early user-led OS consortia projects, such as Sakai and Kuali, being initiated in higher education. Additionally, many authors of these papers are project creators who discuss their experiences. Another contributing factor might be the project creators' familiarity with academic research and publishing.

Only 26% of the studies focus on industries outside higher education, such as automotive, energy, finance, library, and entertainment. These studies emerged from 2013 onward. Expending the research effort across different industries will enable a more comprehensive understanding of the characteristics and benefits of user-led OS consortia. Extended research could offer practitioners valuable insights into the possibilities of open-source collaboration.

5.2 The Structure of User-Led Open Source Consortia

Our second objective was identification of the structure of user-led OS consortia and projects, the ecosystem of user-led OS consortia, and the motivations of organizations for participation.

User-led OS consortia projects are led by user organizations, rather than individual volunteer developers or software vendors. For example, in higher education, the leading partners of user-led OS consortia projects (e.g., Sakai, Kuali) are universities, while in the energy industry (e.g., openKonsequenz) they are energy providers. These consortia emerge to address functionalities unique to related industries or business areas. The structure of user-led OS consortia offers organizations the opportunity to define requirements based on their expectations and to influence the development direction of the required software.

In most user-led OS consortia projects, the underlying code is initially developed as closed source code, and subsequently made available to the public as open source after the initial release. This approach enables other organizations in the same industry to use the software and contribute to its improvements. For example, in the Sakai case, University of Lleida in Spain used the beta release of Sakai 1.0. version and translated the user interfaces into Catalan. They later contributed to the Sakai project by incorporating translation capabilities into the subsequent versions of the software. With the help of the community, the functionality of the Sakai project improved, and its user base grew (Severance, 2011).

It is expected that the resulting software does not provide a competitive advantage to any of the user members. Brooks (2004) highlights that since a user-led OS consortium does not lead to a loss of income and each organization benefits from the collaboration, it attracts more organizations. Working on non-differentiated software encourages even computing companies to cooperate on OSS projects, allowing them to focus on unique features with the time saved (Germonprez et al., 2013; Germonprez et al., 2020; Levy & Germonprez, 2015). These results can provide insight to practitioners considering involvement in open-source projects but who are concerned about protecting their competitive advantage.

Another contribution of this research is the presentation of the actors involved in user-led OS consortia. Umbrella foundations such as the Linux Foundation (LF) and the Eclipse Foundation (EF) define actors in user-led OS consortia environments using different terms. The status and voting rights of members are determined by the membership fees they pay. Organizations that aim to steer the development direction pay the highest membership fees and gain voting rights. The ASWF, hosted by

the LF, categorizes its members as Premier, General, Associate Members.[10] Another user-led OS consortium, openMDM, hosted by the EF, defines five types of membership: driver members, user members, application vendor members, service provider members, and guests.[11] Through this research, we defined the actors based on organizations' roles in consortia and the development process to provide clarity. We identified five main actors: driver members (organizations), development partners, adopters (users), non-profit organizations, and (umbrella) foundations.

Foundations provide a neutral forum for members and legal protection, help to ensure financial sustainability by collecting membership fees, offer governance support, technical support, and quality assurance. Furthermore, foundations can also support community development and management by organizing conferences, supporting marketing activities, helping member selection, and member activities. Wheeler (2007) highlights that working with a foundation helps the organizations to focus on software development, instead of directing their efforts to back-office support.

Some projects lead to the establishment of their own foundations, such as the Kuali Foundation, which originated from the Kuali Financial Systems Project, and the Apereo Foundation, which stemmed from the Sakai Project. Other projects chose to join already established umbrella foundations, such as the LF or the EF. For instance, the LF supports the openMAMA community by offering a governance framework, technology platform, marketing assistance, and IP protection (Levy & Germonprez, 2015). In this research, we presented example projects that follow either of the two approaches. Each approach has its own benefits and drawbacks. Investigating these approaches could be a valuable topic for future research, providing useful insights for decision-makers involved in the establishment of such projects.

5.3 Motivations of Organizations for Participation in User-Led Open Source Consortia

Organizations have diverse motives to participate in user-led OS consortia. User organizations are driven by the need for specific or complex functions that are lacking in proprietary software systems. For instance, when the first user-led OS consortia projects emerged, the commercial software available to educational institutions was often adapted from other industries and failed to provide the functionalities needed for educational processes (Courant & Griffiths, 2006). Indiana University and the University of Hawaii initiated the Kuali Financial Systems project in 2004 with the aim of transitioning their financial information systems to a web-based open-source platform (Liu et al., 2020). Liu et al. (2012) elaborate that even with commercial software, universities still need to build 15% of the necessary functions for financial transactions. Consequently, a project dedicated to meeting the fiscal data management and process needs of universities gained traction, leading to a growing number of member universities from 2005 onwards.

Use of proprietary software systems mostly leads to dependence on vendor companies. User organizations can address this challenge effectively by engaging in user-led OS consortia, where they define software functionalities, steer development direction, and cultivate a culture of movement and innovation. An example is openKonsequenz. In 2013 a number of Distribution System Operators (DSOs) of Germany initiated openKonsequenz consortia (Goering et al., 2016). DSOs required to update their software systems regarding external legal regulations. Being dependent on vendors was restricting their quality expectations, schedules and price negotiations. As a result, some of the DSOs collaborated to develop the undifferentiated parts of the software they required to break vendor lock-in (Goering et al., 2016, Schwab et al., 2020).

[10] https://cdn.platform.linuxfoundation.org/agreements/aswf.pdf
[11] https://www.eclipse.org/org/workinggroups/mdmwg_charter.php

For the proprietary software systems, there is a risk of disappearance of vendors or disappearance of systems. On the other hand, in user-led OS consortia, software projects are financed and led by user organizations, the continuity of projects depends on collaborative decisions of member organizations. The ownership of the IP does not belong to one organization, but to the general group (in most cases to the legal identity of the consortia). This approach increases the sustainability chance of software developed by a user-led OS consortium compared to proprietary software or community-led OSS.

A further characteristic of user-led OS consortia is that software is developed collaboratively. Collaborative software development enables reducing costs, and increasing productivity. Driver members finance projects by pooling resources and sharing development costs. This approach allows involved members to avoid the expenses associated with proprietary software licenses, or expenses involved in building or improving software themselves. In a collaborative development environment, participants share knowledge and ideas, learn from each other, and foster innovation through joint creation. Involved organizations benefit from this collaborative approach by building expertise and supporting staff development. Open Color IO (OCIO), an open-source color management library, is an example of the impact of this approach on shaping a project's future. Walker et al. (2020) explain that the OCIO project was initially developed by Sony Pictures Imageworks, and open sourced in 2010. While the project successfully established de facto standards for color management in visual effects, community engagement declined for a few years. The revival of the project occurred in 2020 when it was adopted by the Academy Software Foundation. Since this library is valuable to the industry and its member organizations, they provide both financial and intellectual support to ensure the project's long-term sustainability.

In user-led OS consortia projects, the resulting software is open source. This enhances the likelihood of the adoption by other organizations with similar needs. As the user community expands, they can offer feedback and contribute to the code. Another advantage of open sourcing the software is the increased potential for a wider range of vendor options. Moreover, it positively impacts developer motivation.

We provided a list of studies, including their focus and project information, and detailed the user-led OS consortia projects studied in the literature. Furthermore, we synthesized the characteristics of user-led OS consortia, the actors involved in these types of consortia, and the reasons user organizations participate in them. We believe this research will be beneficial for researchers interested in investigating this phenomenon in detail, and it will offer guidance to practitioners interested in creating and developing user-led OS consortia. In our future research, we plan to continue exploring this topic and develop a best practices handbook for practitioners, providing insights into the problems and solutions involved in establishing user-led OS consortia.

6 Limitations

We performed an SLR by following Kitchenham (2004) and Kitchenham & Brereton (2013) methodology. We adopt Guba's (1981) trustworthiness criteria, including credibility, confirmability, transferability, and dependability to discuss the limitations of our research.

Credibility is about the truth of the research findings. Our first concern of credibility was about selecting the relevant studies. To perform the selection process effectively, we used prolonged engagement practice. We conducted the study collection and selection process iteratively from August 2020 to March 2024 to extend the time frame of the papers published and include most up-to-date literature. We used Google Scholar and four other digital libraries to cover as many as possible studies and examined each of the resulting studies with great attention. The second concern of credibility was about the application of qualitative analysis and the results. We performed qualitative analysis by following Braun & Clarke (2012)'s thematic analysis guideline. We used peer debriefing practice to

ensure the credibility of the results. Although the first author performed the analysis, the method application procedures and results were discussed by periodic meetings with the second author. Furthermore, in a writer's workshop session, we shared the manuscript with our colleagues, and improved it with the feedback we received.

Confirmability is about objectivity. During the research period, the first author evaluated the relevance of each literature at least two times, and checked the data analysis results. While performing qualitative data analysis, we created a codebook and updated it regularly based on our findings. We present the codebook and sample codes in (Yenişen Yavuz & Riehle, 2025: Appendix C) for external auditors to examine the analysis we performed.

Transferability concerns establishing context-relevant statements. We addressed our research questions by analyzing related literature about user-led OS consortia. The majority of our findings show similarities in different projects from different industries. We present the mapping of our findings with related projects and consortia in (Yenişen Yavuz & Riehle, 2025: Appendix E and F). Although we believe that our findings can be generalizable for user-led OS consortia, it remains for future research to determine whether our findings can be applied to other user-led OS consortia projects.

Dependability refers to having reliable and traceable research findings. To address this concern, we provide the data of our research in the appendix. We present the data of included and excluded literature with details in (Yenişen Yavuz & Riehle, 2025: Appendix A), and the list of final literature in (Yenişen Yavuz & Riehle, 2025: Appendix D).

7 Conclusion

This research aimed to achieve two primary objectives: understanding the current state of literature on user-led open-source (OS) consortia and identifying their defining characteristics, key actors, and the motivations for user organizations to create and engage in such consortia.

To address our objectives, we conducted a systematic literature review (SLR) covering the years 2000 to 2023, identifying 43 unique papers directly related to user-led open-source (OS) consortia. Notably, the majority of these studies originate from the higher education sector, with papers addressing projects in other industries emerging only after 2013. This pattern highlights a significant gap in research on user-led OS consortia outside the higher education domain. We categorized the literature into five key concepts: the general structure, governance, ecosystem, creation of specific consortia, development processes of user-led OS projects. Our findings reveal gaps in literature addressing governance practices and ecosystem dynamics of these consortia, indicating areas for further exploration.

For the second objective, we conducted thematic data analysis to identify the defining characteristics of user-led OS consortia. We grouped these characteristics into three themes: led by user organizations, collaborative software development, and offering open-source software. Examining the roles within these ecosystems, we identified categories such as driver members, development partners, adopters (users), non-profit members, and foundations. Our analysis also shed light on the motivations for forming and participating in user-led OS consortia. Key benefits include greater control over development processes and functionality, enhanced sustainability, cost sharing, and improved productivity through collaboration.

This study provides a comprehensive overview of the current research on user-led OS consortia, identifies critical gaps in the literature, and highlights the defining characteristics and benefits of this model. These findings lay the groundwork for future research and practical exploration of user-led OS consortia across industries.

Acknowledgements

We thank our reviewers for their comments and suggestions for improvement. We would also like to express our gratitude to Ann Barcomb, Andreas Bauer, Stefan Buchner, Philip Heltweg, Andreas Kaufmann, Julia Mucha, Felix Quast, Georg Schwarz, and Özgür Yavuz for their valuable feedback on this research.

Declaration of Generative AI in Scientific Writing

During the writing process of this work the authors used ChatGPT in order to improve and rephrase written paragraphs. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Funding

This research has been funded by the German Research Foundation (Deutsche Forschungsgemeinschaft). The project number of the fund is 506460878 and GZ:RI 2147/11-1.

Data Availability

Data used and produced during this research is presented in the Appendix A, B, C, D, E, F, and G which are available at: https://faubox.rrze.uni-erlangen.de/getlink/fiWwX5LtjBRnm6qU67BuUW/

REFERENCES

Apereo. (n.d.). *About the Apereo Foundation* Retrieved June 5, 2024, from https://www.apereo.org/about

Apereo Community Blog (n.d.). *About Apereo.* Retrieved June 5, 2024, from https://apereo.github.io/about/

Baecker, R. (2005, June). Open source strategies for educational multimedia. In EdMedia+ Innovate Learning (pp. 133-137). Association for the Advancement of Computing in Education (AACE).

Baron, J., Willis, J., & Lee, R. A. (2010). Creating higher education academic and information technology resources in an international context. Computers in the Schools, 27(3-4), 288-308.

Braun, V., & Clarke, V. (2012). Thematic analysis. American Psychological Association.

Brooks, L. (2004). Values of community source development. Syllabus, September.

Al Bulushi, W. (2019, February). Governing University-Specific Open Source ERP: How Open is Open Enough?. In 4th FREE & Open-source software CONFERENCE (FOSSC'2019-OMAN) (Vol. 10, p. 18).

Chesbrough, H. W., & Appleyard, M. M. (2007). Open innovation and strategy. California management review, 50(1), 57-76.

Courant, P. N., & Griffiths, R. J. (2006). Software and collaboration in higher education: A study of open-source software. Organization for Open-source software Study.

Dahlander, L., & Magnusson, M. G. (2005). Relationships between open-source software companies and communities: Observations from Nordic firms. Research Policy, 34(4), 481-493.

Dahlander, L. (2007). Penguin in a new suit: A tale of how de novo entrants emerged to harness free and open-source software communities. Industrial and Corporate Change, 16(5), 913-943.

Díaz, O., Genero, M., Contell, J. P., & Piattini, M. (2024). Adding relevance to rigor: Assessing the contributions of SLRs in Software Engineering through Citation Context Analysis. *Computer Science Review*, *53*, 100649.

Dybå, T., Dingsoyr, T., & Hanssen, G. K. (2007, September). Applying systematic reviews to diverse study types: An experience report. In *First international symposium on empirical software engineering and measurement (ESEM 2007)* (pp. 225-234). IEEE.

Eckert, R., Stuermer, M., & Myrach, T. (2019). Alone or Together? Inter-organizational affiliations of open source communities. *Journal of systems and software*, *149*, 250-262.

Farmer, J., Dolphin, I., 2005. Sakai: eLearning and more. In: Proceedings of the 11th European University Information Systems, Manchester, UK.

Felizardo, K. R., Mendes, E., Kalinowski, M., Souza, É. F., & Vijaykumar, N. L. (2016, September). Using forward snowballing to update systematic reviews in software engineering. In *Proceedings of the 10th ACM/IEEE International Symposium on Empirical Software Engineering and Measurement* (pp. 1-6).

Fitzgerald, B. (2006). The transformation of open source software. *MIS quarterly*, 587-598.

Foutty, J. (2010) Kuali Foundation Delivers Open-source software. University Information Systems, 33.

Germonprez, M., Allen, J. P., Warner, B., Hill, J., & McClements, G. (2013). Open source communities of competitors. interactions, 20(6), 54-59.

Germonprez, M., Levy, M., Kendall, J. E., & Kendall, K. E. (2020). Tapestries of innovation: Structures of contemporary open source project engagements. Journal of the Association for Information Systems, 21(3), 5.

Goering, A., Meister, J., Lehnhoff, S., Herdt, P., Jung, M., & Rohr, M. (2017). Reference architecture for open, maintainable and secure software for the operation of energy networks. CIRED-Open Access Proceedings Journal, 2017(1), 1410-1413.

Hancock, M. (2010). Partner for More: Creating and Sustaining Collaboration to Support Campus-Based Rich Media. Continuing Higher Education Review, 74, 73-80.

Heckenberg, D., Panisset, J. F., & Olin, E. (2019). ASWF technical advisory committee: how to enable an open source community. In Proceedings of the 2019 Digital Production Symposium (pp. 1-2).

Harutyunyan, N., Riehle, D., & Sathya, G. (2020). Industry best practices for corporate open sourcing. In Proceedings of the 53rd Hawaii International Conference on System Sciences.

Henttonen, K., Kääriäinen, J., & Kylmäaho, J. (2017). Lifecycle management in government-driven open source projects–practical framework. International Journal of Information Systems and Project Management, 5(3), 23-41.

Hunter, P., & Walli, S. (2013). The rise and evolution of the open source software foundation. *IFOSS L. Rev.*, *5*, 31.

Izquierdo, J. L. C., & Cabot, J. (2020). A Survey of Software Foundations in Open Source. *arXiv preprint arXiv:2005.10063*.

Ketterl, M., Schulte, O. A., & Hochman, A. (2010). Opencast Matterhorn: A community‐driven

open-source software project for producing, managing, and distributing academic video. Interactive Technology and Smart Education, 7(3), 168-180.

Kitchenham, B. (2004). Procedures for performing systematic reviews. Keele, UK, Keele University, 33(2004), 1-26.

Kitchenham, B., Brereton, O. P., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009). Systematic literature reviews in software engineering–a systematic literature review. *Information and software technology*, *51*(1), 7-15.

Kitchenham, B., & Brereton, P. (2013). A systematic review of systematic review process research in software engineering. *Information and software technology*, *55*(12), 2049-2075.

Kuali. (n.d.). *Our Story* Retrieved June 5, 2024, from https://www.kuali.co/community/ourstory

Kuali Foundation. (n.d.). Retrieved June 5, 2024, from https://www.kuali.org/

Levy, M., & Germonprez, M. (2015). Is it egalitarianism or enterprise strategy? Exploring a new method of innovation in open source. In the 21st Americas Conference on Information Systems, AMCIS.

Liu, M., Wu, X., Zhao, J. L., & Zhu, L. (2010). Outsourcing of community source: identifying motivations and benefits. Journal of Global Information Management (JGIM), 18(4), 36-52.

Liu, M., Wang, H. J., & Zhao, J. L. (2012). Technology flexibility as enabler of robust application development in community source: The case of Kuali and Sakai. Journal of Systems and Software, 85(12), 2921-2928.

Liu, M., Hansen, S., & Tu, Q. (2014a). The community source approach to software development and the Kuali experience. Communications of the ACM, 57(5), 88-96.

Liu, M., Zeng, D. D., & Zhao, J. L. (2014b). Cooperative investment decisions in community source development. International Journal of Information Technology & Decision Making, 13(01), 5-28.

Liu, M., Hull, C. E., & Hung, Y. T. C. (2017). Starting open source collaborative innovation: the antecedents of network formation in community source. Information Systems Journal, 27(5), 643-670.

Liu, M., Hansen, S., & Tu, Q. (2020). Keeping the family together: Sustainability and modularity in community source development. Information and Organization, 30(1), 100274.

Liu, M., Hansen, S., & Tu, Q. (2021). Sustaining collaborative software development through strategic consortium. *The Journal of Strategic Information Systems*, *30*(3), 101671.

Mackie, C. J. (2008). Open source in open education: Promises and challenges. Opening up education: The collective advancement of education through open technology, open content and open knowledge, 119-131.

Morris, J., & Leonard, K. (2020). Collaborating Across Consortial Boundaries. Collaborative Librarianship, 11(4).

Nidy, D. R., & Kwok, F. (2005). Community source development: an emerging model with new opportunities. In CHI'05 Extended Abstracts on Human Factors in Computing Systems (pp. 1697-1700).

Perlow, J. (2020): The Linux Foundation: It's not just the Linux operating system. Retrieved December 1, 2024 from: https://www.linuxfoundation.org/blog/blog/the-linux-foundation-its-not-just-the-linux-operating-system

Perr, J., Appleyard, M. M., & Patrick, P. (2010). Open for business: emerging business models in open-source software. International Journal of Technology Management, 52(3/4), 432-456.

Provan, K. G., & Lemaire, R. H. (2015). Positional embeddedness in a community source software development project network: the importance of relationship intensity. R&D Management, 45(5), 440-457.

Rankin, K., & Baecker, R. (2007). Evolution of an Open Source Strategy. Open Source Business Resource.

Riehle, D. (2019). The innovations of open source. Computer, 52(4), 59-63.

Riehle, D., & Berschneider, S. (2012). A model of open source developer foundations. In IFIP International Conference on Open Source Systems

Robles, G., Gamalielsson, J., & Lundell, B. (2019). Setting up government 3.0 solutions based on open-source software: the case of X-road. In Electronic Government: 18th IFIP WG 8.5 International Conference, EGOV 2019, San Benedetto Del Tronto, Italy, September 2–4, 2019, Proceedings 18 (pp. 69-81). Springer International Publishing.

Sabin, M., & Leone, J. (2009). IT education 2.0. In Proceedings of the 10th ACM conference on SIG-information technology education (pp. 91-99).

Samuel, B. M., Bala, H., Daniel, S. L., & Ramesh, V. (2022). Deconstructing the nature of collaboration in organizations open-source software development: The impact of developer and task characteristics. *IEEE Transactions on Software Engineering*, *48*(10), 3969-3987.

Schaarschmidt, M., Bertram, M., & von Kortzfleisch, H. F. (2011). Exposing differences of governance approaches in single and multi vendor open-source software development. In IFIP International Working Conference on Governance and Sustainability in Information Systems-Managing the Transfer and Diffusion of IT.

Schwab, B., Riehle, D., Barcomb, A., & Harutyunyan, N. (2020). The Ecosystem of openKONSEQUENZ, A User-Led Open Source Foundation. In Open Source Systems: 16th IFIP WG 2.13 International Conference, OSS 2020, Innopolis, Russia, May 12–14, 2020, Proceedings 16 (pp. 1-13). Springer International Publishing.

Severance, C. (2007). Pushing the Boundaries of Innovation through Community Source.

Severance, C. (2011). Sakai: Building an Open Source Community.

Shaikh, M., & Cornford, T. (2010, January). 'Letting go of Control to Embrace Open Source: Implications for Company and Community. In *2010 43rd Hawaii International Conference on System Sciences* (pp. 1-10). IEEE.

Stallman, R. (2003). Free software foundation (fsf). In *Encyclopedia of Computer Science* (pp. 732-733).

Oskari. (n.d.) *Community behind the software* Retrieved June 5, 2024, from https://oskari.org/community/oskari_community

Teixeira, J., Mian, S., & Hytti, U. (2016). Cooperation among competitors in the open-source arena: The case of OpenStack. *arXiv preprint arXiv:1612.09462*

Walker, D., Dolan, M., & Hodoul, P. (2020). The ASWF Takes OpenColorIO to the Next Level. In The Digital Production Symposium (pp. 1-10).

Weikert, F., Riehle, D., & Barcomb, A. (2019, October). Managing commercial conflicts of interest in open source foundations. In *International Conference on Software Business* (pp. 130-144). Cham: Springer International Publishing.

West, J., & O'Mahony, S. (2005, January). Contrasting community building in sponsored and community founded open source projects. In *Proceedings of the 38th Annual Hawaii International Conference on System Sciences* (pp. 196c-196c). IEEE.

Wheeler, B. & DeStefano, J.(2007). Mitigating the Risks of Big Systems.

Wheeler, B. (2007) (a). Open source 2010: Reflections on 2007. Educause Review, 42(1), 49-52.

Wheeler, B. (2007) (b). Sakai: a case study in sustainability.

Winkler M., (2018) Governance Case Studies: Open Library Environment (OLE). In Arp, L. G., & Forbes, M. (2018) It Takes a Village: Open-source software Sustainability (pp. 17-18). LYRASIS

Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. In *Proceedings of the 18th international conference on evaluation and assessment in software engineering* (pp. 1-10).

von Hippel E., & von Krogh G., (2003). Open-source software and the "Private-Collective" Innovation Model: Issues for Organization Science. Organization Science 14(2):209-223.

Yenişen Yavuz, E., Barcomb, A., & Riehle, D. (2022). Problems, Solutions, and Success Factors in the openMDM User-Led Open Source Consortium. Communications of the Association for Information Systems, 51(1), 13.

Yenişen Yavuz, E., Riehle, D., & Mehrotra, A. (2025). Why do companies create and how do they succeed with a vendor-led open source foundation. *Empirical Software Engineering*, *30*(1), 1-49.

Yenişen Yavuz, E., & Riehle, D. (2025). External appendixes: Why and How Do Organizations Create User-Led Open Source Consortia? A Systematic Literature Review. https://faubox.rrze.uni-erlangen.de/getlink/fiWwX5LtjBRnm6qU67BuUW/

Zhang, Y., Zhou, M., Stol, K. J., Wu, J., & Jin, Z. (2020, June). How do companies collaborate in open source ecosystems? an empirical study of openstack. In *Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering* (pp. 1196-1208).