Empirical Software Engineering (2025) 30:40
https://doi.org/10.1007/s10664-024-10588-9

Why do companies create and how do they succeed with a vendor-led open source foundation

Elçin Yenişen Yavuz[1] · **Dirk Riehle**[1] · **Ankita Mehrotra**[2]

Accepted: 24 October 2024

Abstract
Vendor-led open source foundations are open source foundations led by software vendors rather than individual developers or end-user organizations. Our research investigates why vendors create or join such foundations, and how these foundations succeed. We conducted exploratory single-case study research, with the LF Edge foundation as our case. We collected qualitative data in the form of interviews and text documents, and performed qualitative data analysis for building our theory. We identified 18 motives of vendors' participation in vendor-led open source foundations regarding four aspects: revenue, competition, productivity and innovation, and reputation. To understand how vendor-led open source foundations succeed, we investigated good practices followed by LF Edge applied as preventions for potential problems or solutions for encountered problems. We determined 52 good practices in 20 different contexts, focusing on three dimensions: governance, efficiency and productivity, and sustainability.

Keywords Open source foundations · Open source projects · Best practices · Governance problems · Coopetition · Linux Foundation · Edge foundation

1 Introduction

Open source foundations are non-profit organizations that provide neutral platforms for open-source software (OSS) projects. They play a pivotal role in the collection and distribution of funds to support these projects, safeguarding the rights of project members

Communicated by: Klaas-Jan Stol

✉ Elçin Yenişen Yavuz
elcin.yenisen@fau.de

Dirk Riehle
dirk@riehle.org

Ankita Mehrotra
ankita.mehrotra@fau.de

[1] Computer Science Department, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

[2] Erlangen, Germany

Published online: 13 December 2024

and contributors by providing a legal framework. Furthermore, they can offer governance support to their members (Riehle and Berschneider 2012; Eckert et al. 2019; Izquierdo and Cabot 2020).

In our research, we identified three types of open source (OS) foundations based on the roles their participants play: (1) Community-led OS foundations, (2) vendor-led OS foundations, and (3) user-led OS foundations. A community-led OS foundation is an open source foundation in which projects are led by individuals. These individuals can be both developers and users of the software they contribute to. Software developers contributing to community-led OS projects can be volunteers or paid employees of companies. Two examples of these types of foundations are the Apache Software Foundation (ASF) and The Document Foundation (LibreOffice).

The second type are vendor-led OS foundations. In vendor-led OS foundations, the leading participants are information technology (IT) companies. They collaborate with the goal of developing open-source software components (Schaarschmidt et al. 2011; Riehle and Berschneider 2012). Two examples of this type of foundation are the OpenInfra Foundation (formerly known as the OpenStack Foundation) and the LF Edge foundation. As of June 2024, the OpenInfra Foundation has a variety of member organizations, including AntGroup, Ericsson, Huawei, and Microsoft (OpenInfra Foundation n.d.). Members of the LF Edge foundation include Intel, IBM, Red Hat, Zededa, and Dianomic.

The third type are user-led OS foundations. In user-led OS foundations, leading members are the end-user organizations, mostly from non-software industries. They collaborate on OSS development to use the software for their internal processes (Yenişen Yavuz et al. 2022). The leading members of these foundations are corporate entities (organizations), not individual software developers. Two examples of this type of foundation are the Apereo Foundation and the Open Logistics Foundation. The Apereo Foundation has members from the higher education sector, such as the University of Michigan, Indiana University, Stanford University, and the Massachusetts Institute of Technology (MIT) (Apereo Community Blog n.d.). The Open Logistics Foundation has members from the logistics industry such as Rhenus Logistics, Duisport, Dachser Intelligent Logistics, and DB Schenker (Open Logistics Foundation n.d.).

In both vendor-led and user-led OS foundations, members focus on competitively undifferentiated OSS development projects. Organizations work collaboratively in OSS projects, which would be beneficial for all the involved parties, but do not provide a competitive advantage among each other. Vendor-led and user-led OS foundations tend to have somewhat different goals, though. In our research, we observed that most of the vendor-led OS foundations focus on developing software components to use in their products, and user-led OS foundations focus on developing software applications to use for their internal business processes. In Fig. 1, we present the classification of open source foundations.

In this research, we focus on vendor-led OS foundations. Vendors have a longstanding history of active involvement in OSS projects and communities, employing diverse strategies for engagement. One strategy involves hiring or assigning employees to contribute to specific OSS projects. For instance, in a 2021 statement, Intel shared that their software engineers contribute to more than 100 OSS projects, including the Linux Kernel, Chromium, and TensorFlow (Intel Corporation 2021; Business Wire 2022). Another strategy of vendors is open-sourcing their proprietary software and fostering a community around it. For instance, in 2015, Microsoft open-sourced a source-code editor, Visual Studio Code (VS Code), under a permissive MIT license (Microsoft n.d. a). While still retaining ownership of the software, Microsoft created a community around the tool (Microsoft n.d.b). According to Stack Overflow surveys, VS Code was the most popular development tool

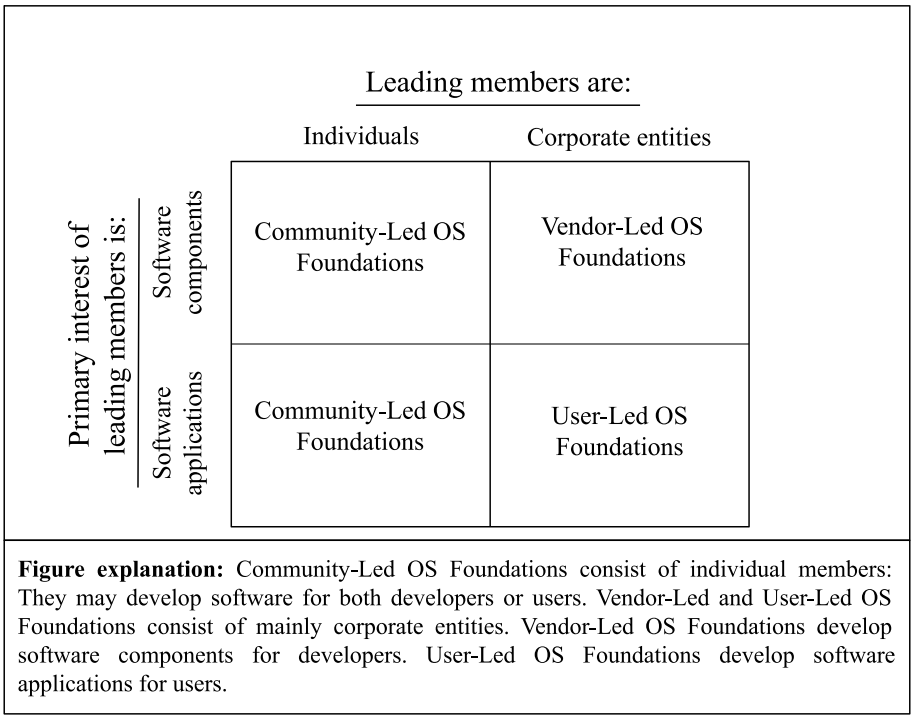


Figure explanation: Community-Led OS Foundations consist of individual members: They may develop software for both developers or users. Vendor-Led and User-Led OS Foundations consist of mainly corporate entities. Vendor-Led OS Foundations develop software components for developers. User-Led OS Foundations develop software applications for users.

Fig. 1 Classification of Open Source Foundations

among developers in 2023 (Stack Overflow 2023). Another strategy for vendor involvement in OSS projects involves collaboration with other companies in a multi-vendor approach. For instance, the Kubernetes[1] project is a multi-vendor initiative hosted by the Cloud Native Computing Foundation (CNCF), in which Google, IBM, Microsoft, and VMware collaborate (Cloud Native Computing Foundation 2015).

We investigate (1) the motives for organizations' participation in vendor-led OS foundations and (2) the practices that lead to success of vendor-led open source foundations. To understand success, we look into the problems encountered in a vendor-led OS foundation and the solutions implemented to address them. Furthermore, we identify the practices they follow to mitigate potential problems and empower successful collaboration. Our research questions are:

RQ1. Why do organizations participate in vendor-led open source foundations?
RQ2. How do vendor-led open source foundations become successful?

To gain a comprehensive understanding of this phenomenon in its natural context, we perform a single-case study following Yin's (2018) case study methodology. Our case is the "LF Edge" foundation. LF Edge is a vendor-led OS foundation that sponsors and leads

[1] https://www.cncf.io/projects/kubernetes/

multiple open source projects in the domain of Internet of Things (IoT) and edge devices. LF Edge is hosted by the Linux Foundation, which provides administrative, technical, and legal services to LF Edge. Some examples of these services are establishing governance models, offering access to essential infrastructure for development and deployment of projects such as code repositories, and providing operational support such as organizing events, and community building activities. We perform this research by conducting interviews with key informants and analyzing publicly available documents, including textual meeting minutes.

The contributions of this research are:

1. A comprehensive synthesis of existing literature about the reasons for vendor involvement in OSS projects
2. The development of a theory about the reasons for vendor involvement in vendor-led open source foundations
3. Identification and presentation of 52 good practices across 20 contexts within a vendor-led open source foundation

The rest of this paper is structured as follows: We present related work in Section 2. In Section 3 we describe the research method and provide background information about the case of LF Edge. Section 4 presents the results of our research. The discussion about our findings is presented in Section 5, while Section 6 covers the limitations. We conclude this research with a conclusion section.

2 Related Work

Vendors' involvement in OSS projects has been investigated in the literature regarding various aspects. Some of the topics discussed in the literature are vendors' engagement practices in community-led OSS initiatives (e.g. Butler et al. 2019), the effects of vendors' involvement on retention in OSS communities (e.g. Zhou et al. 2016), conflicts that may arise between vendors and OSS communities (e.g. Schaarschmidt and Stol 2018), as well as the merits and challenges of open-sourcing proprietary software such as establishing new communities (e.g. Pinto et al. 2018). An additional area of investigation within this body of work is the dynamics of multi-vendor involvement within the same OSS projects (e.g. Teixeira et al. 2016).

Despite the richness of research in this domain, a noticeable gap exists in the literature regarding vendor-led OS foundations, where multiple vendors collaboratively contribute not only to one specific project, but to several OSS projects. Our research, presented in the next Section, fills this gap.

To understand vendor motives and the risks of engagement in OSS projects, we reviewed literature focusing on vendor behaviors, such as sponsoring established OS communities, donating code and building a community around it, and collaborating with other vendors in OSS projects (multi-vendor OSS projects). The literature lacks clear terminology regarding vendor-led OS foundations. In this section, we aim to provide a comprehensive set of findings by synthesizing the literature and categorizing the results into key themes.

In Section 2.1, we present a literature review of vendor motives for joining OSS projects, followed by organizations' reasons for joining umbrella open source foundations in

Section 2.2. In Section 2.3, we review the literature on the potential risks faced by vendors involved in OSS projects.

To our knowledge, good practices or success factors of vendor-led OS foundations have not been addressed in the literature, yet. In a broader context, we reviewed the literature about success factors of user-led OS foundations and coopetition. We present the results in Section 2.4.

2.1 Vendor Motives for Participating in Open Source Projects

By synthesizing our findings from the literature, categorize vendor motives for engaging in OSS projects into four key groups: (1) Revenue, (2) competition, (3) productivity and innovation, and (4) reputation. In this section, we discuss these categories in detail and provide an overview in Table 1.

Revenue One of the motives of vendors to open source their software is the opportunity of ***generating revenue*** by offering complementary products and services related to that software (Grand et al. 2004; West and Gallagher 2006; Schaarschmidt et al. 2011; Teixeira et al. 2016; Zhang et al. 2020, 2021). Companies can create new markets using open source to sell products built on it. Furthermore, by open sourcing their software, companies aim to accelerate the adoption of the software, increase its user base and ***gain a dominant position*** in the market (Grand et al. 2004; West and Gallagher 2006; Joo et al. 2012).

Companies can ***reduce software development costs*** by collaborating with other companies in OSS projects, since they share resources and experiences (Shaikh and Cornford 2010; Riehle 2010; Teixeira et al. 2016). Moreover, OSS allows companies to utilize the source code and develop complementary products. Companies that open source their software can gain more suppliers and service providers for the open-sourced software (Ågerfalk and Fitzgerald 2008; Linåker and Regnell 2020). Having alternative suppliers helps companies to ***reduce maintenance costs*** (Linåker and Regnell 2020).

Competition Vendors can use open-sourcing as a strategy to ***compete with dominant competitors***. An approach of this is offering substitute open-source software to compute with a dominant proprietary software. By this way, vendors can increase the adoption of their substitute product and gain the support of the developer community (West and Gallagher 2006; Joo et al. 2012). For instance, Joo et al. (2012) gives the example of IBM's donation of a programming platform, VisualAge Micro Edition, to the Eclipse Foundation to create a substitute for the dominant Microsoft's programming platform. Besides donating the codes alone, vendors can also collaborate to create a common platform against a dominant competitor by contributing to OSS projects (Teixeira et al. 2016; Weikert et al. 2019).

A further motive for vendors for donating source code or joining OSS communities is ***establishing de facto standards*** (West and Gallagher 2006; Riehle 2010; Schaarschmidt et al. 2011; Teixeira et al. 2016; Linåker and Regnell 2020). Establishing standards provides ***first-mover advantages***, and eases influence on a community or industry (Linåker and Regnell 2020).

Productivity and Innovation Open source involvement enables companies to ***access external resources*** such as developers (Grand et al. 2004; West and Gallagher 2006; Ågerfalk and Fitzgerald 2008; Shaikh and Cornford 2010). Furthermore, when companies collaborate

Table 1 Vendors' Motives to Participate OSS Projects Based on Related Literature

Category	Motives	References
Revenue	Generating revenue by offering complementary products and services	Grand et al. 2004; West and Gallagher 2006; Schaarschmidt et al. 2011; Teixeira et al. 2016; Zhang et al. 2020; Zhang et al. 2021
Revenue	Expanding the market and gaining a dominant position	West and Gallagher 2006; Joo et al. 2012
Revenue	Reducing development costs	Shaikh and Cornford 2010; Riehle 2010; Teixeira et al. 2016
Revenue	Gaining more suppliers and reducing maintenance costs	Ågerfalk and Fitzgerald 2008; Linåker and Regnell 2020
Competition	Competing with dominant competitors	West and Gallagher 2006; Joo et al. 2012; Teixeira et al. 2016; Weikert et al. 2019
Competition	Establishing de facto standards	West and Gallagher 2006; Riehle 2010; Schaarschmidt et al. 2011; Teixeira et al. 2016; Linåker and Regnell 2020
Competition	Gaining first mover advantage	Linåker and Regnell 2020
Productivity & Innovation	Accessing external resources and gathering experience	Grand et al. 2004; West and Gallagher 2006; Ågerfalk and Fitzgerald 2008; Shaikh and Cornford 2010; Schaarschmidt et al. 2011; Teixeira et al. 2016; Zhang et al. 2020
Productivity & Innovation	Collecting realistic feedback	Grand et al. 2004; Iivari et al. 2008
Productivity & Innovation	Collecting innovative ideas & receiving support from the community	Shaikh and Cornford 2010; Teixeira et al. 2016; Linåker and Regnell 2020
Productivity & Innovation	Developing new products and services	Linåker and Regnell 2020
Reputation	Improving credibility of companies from customer sight	West and Gallagher 2006; Ågerfalk and Fitzgerald 2008; Linåker and Regnell 2020
Reputation	Increasing employee satisfaction	Shaikh and Cornford 2010; Linåker and Regnell 2020
Reputation	Attracting potential employees	Grand et al. 2004; Linåker and Regnell 2020
Reputation	Involving in a high-quality product development	Shaikh and Cornford 2010; Teixeira et al. 2016

in OSS projects with other companies, they share and ***gather knowledge and experience*** (Schaarschmidt et al. 2011; Teixeira et al. 2016; Zhang et al. 2020).

A further benefit of open source is the early ***collection of realistic user feedback,*** ultimately aiding in the reduction of software development time (Grand et al. 2004; Iivari et al. 2008). By decreasing software development time and costs, organizations can redirect internal resources towards more value-added and differentiating activities, such as user interface design (Iivari et al. 2008; Linåker and Regnell 2020). Moreover, companies can benefit from open-source communities by collecting ***innovative ideas*** about requirements and features, as well as receiving support with testing and quality assurance (Shaikh and Cornford 2010; Teixeira et al. 2016; Linåker and Regnell 2020). By this way, products can better align with the expectation of customers (Grand et al. 2004; Linåker and Regnell 2020). Furthermore, the data collected from OSS projects contribute to the ***development of new products and services*** (Linåker and Regnell 2020). All these benefits contribute to accelerating the pace of innovation.

Reputation Involvement in OSS projects helps to ***improve credibility of companies*** from the sight of customers, ***increase employee satisfaction*** and ***attract potential employees*** (Grand et al. 2004; West and Gallagher 2006; Ågerfalk and Fitzgerald 2008; Shaikh and Cornford 2010; Linåker and Regnell 2020).

Participation of various companies in OSS projects enhance projects' appeal to other vendors. It is regarded as a sign of a healthy community with a ***high-quality product*** (Shaikh and Cornford 2010; Teixeira et al. 2016).

2.2 Organizations' Motives for Joining Umbrella Open Source Foundations

Organizations can collaborate on OSS projects by either establishing their own independent foundations or joining an already established umbrella foundation. Umbrella foundations host other foundations or consortia and offer structures for these foundations to adapt and use in their creation and legal processes (Izquierdo and Cabot 2020). The Linux Foundation and Eclipse Foundation are examples of umbrella foundations which simplify the establishment process by providing governance guidelines, legal structures, and by-laws.

We summarize our findings from the literature about the motives of organizations to join umbrella foundations using three aspects: (1) Cost sharing, (2) productivity, and (3) reputation.

Cost Sharing Umbrella foundations host various communities. Working with umbrella foundations for OSS projects helps organizations to reduce overhead expenses. These expenses can be in the form of bookkeeping, or donation handling (Eckert et al. 2019).

Productivity Umbrella foundations have already proven and tested services, structures, processes, and existing bylaws. Member organizations can use these established structures, save from administrative work, and focus on their core activities (Hunter and Walli 2013; Eckert et al. 2019; Izquierdo und Cabot 2020; Yenişen Yavuz et al. 2022). Since different communities operate under the same umbrella, these foundations provide ecosystems that facilitate collaboration among the hosted communities (Izquierdo und Cabot 2020).

Reputation OSS communities can benefit from the visibility and reputation of umbrella foundations. They can gain recognition and attract new contributors (Eckert et al. 2019).

2.3 Vendor Risks of Engaging in Open Source Projects

We categorize the risks outlined in the literature into two groups: (1) Conflict of interest and (2) competition. We explain the details in this section and present an overview in Table 2.

Conflict of Interest In OSS projects, companies and communities may prioritize software functionality differently. If a company ***forces its own agenda*** without considering the expectations of the involved OSS community, or attempts to ***dominate the development process*** by allocating an excessive work force, it triggers resistance within the community (Grand et al. 2004; Ågerfalk and Fitzgerald 2008; Shaikh and Cornford 2010; Schaarschmidt et al. 2011; Schaarschmidt and Stol 2018). The sustainability of OSS projects is at risk when one company dominates, as the project's activity can decline if this dominant company withdraws or reduces its involvement (Zhang et al. 2022b). There should be a balance between the dominant company's requirements and communities' expectations (Ågerfalk and Fitzgerald 2008).

A similar issue arises in the context of multi-vendor OSS projects. When stakeholders in OSS projects ***have misaligned agendas***, it poses the risk of steering the direction different from what some organizations anticipate (Linåker and Regnell 2020; Zhang et al. 2022a). This situation is risky in particular for those organizations which offer value propositions closely related to OSS (Linåker and Regnell 2020). A misalignment of expected development direction might affect the internal operations, as well (Linåker and Regnell 2020). Moreover, if vendors ***prioritize their individual interests*** over the collective interest of the foundation, it may result in conflicts among its members. This is particularly evident when competing companies target the same users and markets, leading to the potential for such conflicts (Weikert et al. 2019).

Competition From an intellectual property standpoint, there is a risk of ***losing competitive advantage*** for the parties involved in OSS development (Grand et al. 2004; Linåker and Regnell 2020). The suggested approach to overcome this challenge is separating commodity and differentiating functionality using a modular architecture and contributing frameworks and libraries (Linåker and Regnell 2020). Additionally, companies actively contributing to the development also cultivate internal expertise and competence that may not be attainable by other organizations (Grand et al. 2004).

Companies face an additional risk of ***potential developer attrition*** in OSS development projects. Developers may choose to establish their own ventures or transition to other companies within the same ecosystem (Teixeira et al. 2016; Schaarschmidt and Stol 2018; Zhang et al. 2022a).

2.4 Success Factors of Coopetition

Coopetition is a strategy that involves a combination of cooperation and competition. Competitive companies can collaborate, for example, by creating a more valuable market together and compete individually to get more share from that market (Brandenburger and

Table 2 Vendors' Risks to Participate in OSS Projects Based on Related Literature

Category	Risk	References
Conflict of interests	Domination of one company	Grand et al. 2004; Ågerfalk and Fitzgerald 2008; Shaikh and Cornford 2010; Schaarschmidt et al. 2011; Schaarschmidt and Stol 2018; Zhang et al. 2022b
Conflict of interests	Misaligned agendas within the same project	Weikert et al. 2019; Linåker and Regnell 2020; Zhang et al. 2022a
Competition	Losing competitive advantage	Grand et al. 2004; Linåker and Regnell 2020
Competition	Developer attrition	Teixeira et al. 2016; Schaarschmidt and Stol 2018; Zhang et al. 2022a

Nalebuff 1996). In vendor-led OS foundations, most of the companies are rivals to each other, but collaborate in the development of undifferentiated OSS projects.

Teixeira and Lin (2014) coined the term "open-coopetition" to define the collaboration of rival companies in OSS projects. Teixeira and Lin (2014) and Teixeira et al. (2016) investigated this collaboration structure focusing on the interaction of developers employed in rival companies and working in the same OSS projects. In this study, we focus on company-level interaction between members.

Germonprez et al. (2013) called the collaboration of competitors in the same OSS ecosystem "community of competitors." They define this structure considering company-level involvement, without differentiating vendor-led or user-led characteristics. They focus on the structure of the foundations, but not on the governance practices or success factors for collaboration.

Coopetition can also take place in user-led OS foundations. Yenişen Yavuz et al. (2022) focused on user-led OS foundations, and presented the success factors of a user-led OS consortium, the openMDM consortium. They categorize success factors into four categories: (1) Consortium management, (2) process management, (3) user management, and (4) external factors. Success factors in the consortium management category are: *Clearly defined rules and boundaries*, *collective prioritization*, *openness and transparency*, *shared resources and equality*, *commitment of members*, *inheriting established governance rules and legal structures*, *periodic communication*, *organizing events*, and *promoting hosted projects.* User-led OS foundations foster collaboration among users, where users can also be competing companies, but collaborate on OSS projects to improve their internal processes. In vendor-led OS foundations, members have more revenue and market-oriented goals.

In economics literature, Chin et al. (2008) and Petter et al. (2014) investigated success factors of coopetition by performing systematic reviews. Kumar et al. (2020) focused on the success factors of coopetition in relation to corporate social responsibility and sustainability by performing an interview study. They concentrate on both inter-company relationships and intra-company factors. In this study, our focus is the success factors of inter-company relationships. According to their results, *trustworthy partnership* is one of the most important factors for successful collaboration. *Having common goals*, *sharing the roles and responsibilities*, and *building a mutual organization culture* have influence on building trustworthy relationships and success of collaborations (Petter et al. 2014; Chin et al. 2008; Kumar et al. 2020). *Long-term commitment* is an important factor for achieving common goals and enables continuity of a coopetition (Petter et al. 2014; Chin et al. 2008; Kumar et al. 2020). *Having long-term agreements, periodic reviews of collaboration outcomes*, *accepting collective gains as opportunities* are some of the success factors which are also related to long-term commitment factors (Chin et al. 2008; Kumar et al. 2020). *Knowledge sharing, risk sharing,* and *experience sharing* help both improve the trustful relationships and productivity in the collaboration (Petter et al. 2014; Chin et al. 2008). Having *a management and control mechanism*, *formalization of governance and relationship* among companies, *managing conflicts and different expectations* are governance related success factors (Petter et al. 2014; Chin et al. 2008). Furthermore, Kumar et al. (2020) highlights the importance of *efficient, transparent and fair decision-making*.

Although these studies offer valuable insights, there is a lack in the literature about how competitive companies successfully collaborate in vendor-led OS foundations. In our research, we focus on collaboration practices which can be employed by the governance bodies to manage inter-company relations in the foundation and increase the success of the collaboration.

3 Research Design

In this section, we detail our methodology, case selection, data collection, and data analysis processes.

3.1 Methodology

We conducted an exploratory single-case study following the guidelines of Yin (2018). Our goal was to understand the motives behind vendors' participation in vendor-led OS foundations, the problems encountered in these foundations, and the solutions applied to these problems. Furthermore, we sought to identify good practices for creating and governing successful open source foundations. To achieve this goal, we investigated a real case in its natural setting considering real-life events.

As recommended by Yin (2018) and Guion (2011), we aimed to triangulate our research data by using multiple sources of evidence. We used three main data sources: key informant interviews, textual meeting minutes of governing bodies, and official documents shared by the consortium.

Key informant interviews provided insights into the foundation, including members' expectations and experiences. Textual meeting minutes offered an objective view of the concerns and discussions within the foundation. Official documents detailed the requirements for membership and project admissions, as well as specifications about programs of the foundation.

Together, these data sources provided us with a comprehensive understanding of the foundation's ecosystem and dynamics.

3.2 Case Selection

To define our case, we followed six steps. We present the summary of this process in Fig. 2, and details in the text.

In the first step, we searched for open source foundations, and in the second step we identified vendor-led OS foundations among these foundations. To accomplish these steps, we used three sources: A list of open source foundations created by Izquierdo and Cabot (2020), a list of OSS consortia on the Eclipse Foundation website, and a list of OSS projects on the Linux Foundation website.

Izquierdo and Cabot (2020) listed 101 different open source foundations. We manually searched the websites of these foundations and investigated their governance and membership structure. Regarding our investigation, we identified three vendor-led OS foundations on this list. These were the Cloud Foundry Foundation, the JS Foundation, and the OpenInfra Foundation.

Following this search, we focused on the consortia hosted by the Eclipse Foundation. On the Eclipse Foundation Working Group (WG) website, we identified 17 WGs supporting different OSS projects, four of which were vendor-led OS consortia. These were the Adoptium WG, Eclipse IoT WG, OpenADx WG, and Edge Native WG.

As the final step of the vendor-led OS foundation identification process, we investigated the projects listed on the Linux Foundation website using a list we created in 2020. This list comprised 115 projects. We examined the details of each project, focusing on their governance structure and the foundations hosting them. This analysis led us to identify seven vendor-led OS foundations: the Cloud Foundry Foundation, the Cloud Native Computing

Step 1: Searching for open source consortia	**Source:** A list of open source foundations from the literature	**Source:** Working Groups hosted in the Eclipse Foundation	**Source:** Projects & Consortia listed in the Linux Foundation website
Step 2: Classifying vendor-led OS consortia as potential cases	**3 consortia:** Cloud Foundry Foundation, JS Foundation, OpenInfra Foundation	**4 consortia:** The Adoptium Working Group, The Eclipse IoT Working Group, The OpenADx Working Group, and The Edge Native Working Group	**6 consortia:** Cloud Foundry Foundation, Cloud Native Computing Foundation (CNCF), Diamon Workgroup, LF Edge, Open JS Foundation, and Tars Foundation
Step 3: Aggregation of potential cases	**11 consortia:** OpenInfra Foundation, The Adoptium Working Group, The Eclipse IoT Working Group, The OpenADx Working Group, The Edge Native Working Group, Cloud Foundry Foundation, Cloud Native Computing Foundation (CNCF), Diamon Workgroup, LF Edge, Open JS Foundation, and Tars Foundation		
Step 4: Investigating the specifications of consortia	**5 consortia:** OpenInfra Foundation, The Eclipse IoT Working Group, The OpenADx Working Group, Cloud Native Computing Foundation (CNCF), LF Edge		
Step 5: Reaching to consortia members	**3 consortia:** OpenInfra Foundation, Cloud Native Computing Foundation (CNCF), LF Edge		
Step 6: Choosing the case	**LF Edge**		

Fig. 2 Case Selection Process

Foundation (CNCF), the Diamon Workgroup, LF Edge, the Open JS Foundation, and the TARS Foundation.

Following this step, we consolidated the results and removed any duplicates, leaving us with a list of 11 foundations.

In the fourth step, we focused on the size, goals, and objectives of these foundations, as well as the number and use cases of their projects. Our final metric was the maturity of the foundations, which we defined using four levels: (1) Initial, (2) developing, (3) established, and (4) advanced. These levels were based on the initiation year, funding sources (regarding supporting institutions), number of existing projects, and surrounding communities.

After investigating the details of these 11 foundations based on our criteria, we eliminated six of them. We explain the details of the elimination process in Appendix E. As a result, we were left with five foundations as potential cases to investigate. We sent emails and LinkedIn messages to the members of these foundations and requested interviews. We received responses from one member of the OpenInfra Foundation, one member of CNCF, and four members of LF Edge. After conducting interviews with all respondents, we decided to continue our research by focusing solely on LF Edge.

LF Edge is a vendor-led OS foundation, hosted by the Linux Foundation. The mission of LF Edge is outlined in their charter document as “to raise, budget and spend funds in support of various open source projects relating to development of an edge computing software stack”. It was established in 2019 with the involvement of 60 companies. Our goal was to identify a case with a diversity of members, so we could observe different viewpoints and dynamics in the foundation. The founding members of LF Edge include both startups and established leaders in the software industry. According to our metrics, LF Edge is a developing foundation. We aimed to investigate a case which has already accomplished the initial phase, experienced some problems and has already solved them. Although it is a developing foundation, LF Edge hosts a variety of projects (as of June 2023, 11 projects) with distinct use cases. We aimed to find a case focusing on diverse use cases, as this would give the case a higher probability of being generalizable compared to

an edge case. Furthermore, LF Edge provides valuable documentation, including publicly accessible meeting minutes, which increases transparency for our research. As a result, we chose LF Edge as our case. We present the summary of metrics in Table 3.

3.3 Data Collection

We followed Yin's (2018) guidelines and used multiple sources of evidence. We collected our research data in two iterative phases. Initial phase involved conducting semi-structured interviews with key informants of LF Edge. We aimed to obtain firsthand insights about the foundation. Second phase involved collecting and analyzing publicly available documents related to LF Edge. These documents include official charter documents, textual meeting minutes, meeting presentations, and project-specific documents. We share the details of our interviewing and document collection process in the following subsections.

3.3.1 Semi-Structured Interviews

We conducted four semi-structured interviews between January 2023 and June 2023. The interviews were conducted online in English. Each interview session lasted approximately 45 to 60 min. Table 4 presents an overview of the interview sessions with the corresponding identifiers we assigned.

Semi-structured interviews comprise open-ended, in-depth questions. The interviewer prepares the questions in advance, but during the interview, the sequence or content of these questions may change. This flexibility allows the interview to flow naturally in a dialogue format (Bryman 2016).

As recommended by Roberts (2020), we prepared an initial set of questions prior to the interviews. Since asking irrelevant or leading interview questions reduces the credibility of the findings (Roberts 2020), we created our questions in alignment with our research questions. We focused on "how" and "why" inquiries, and tried to avoid "yes/no'' questions. By this approach, we aimed to encourage interviewees to share their insights freely and avoid manipulation.

Before starting the interview process, we created an interview protocol including an initial list of questions, the research topic, case name and interview type. For each interview, we updated the interview protocol by adding the interviewee's name, interviewer, meeting date, and marked the questions asked to each interviewee. We present the content of the four interview protocols in a consolidated form in Appendix A, in Yenişen Yavuz et al. (2024).

We began each interview with introduction and transition questions to get an understanding of our interviewee partners and their organization. After the initial questions, we continued with key questions focused on our research topics. Interviews concluded with the opportunity for interviewees to add any final comments. The sequence and wording of questions varied during interviews. We asked twelve questions to Interviewees 1, 2 and 4, and thirteen questions to Interviewee 3. Following each interview, we transcribed interviews, and subsequently shared the transcriptions with the respective interviewees for their review.

We present the list of our key questions, and our goal to address these questions in Table 5, focusing on our research objectives. The full list is presented in Appendix A.

Table 3 Sampling Metrics for LF Edge

Dimension	Explanation	Results for the LF Edge
Size	The number of members	60
Extent	The variety of member companies	Both startup companies and large companies
Focus	The goal of the foundation	Accelerating the deployment and adoption of edge computing solutions
Project size	The number of projects hosted in the consortium	11
Project use cases	The application areas of projects	IoT and smart devices, telecommunication and 5G, smart cities, industrial IoT, retail and customer engagement, healthcare, autonomous vehicles, content delivery networks
Maturity level	The phases of "initial, developing, established, advanced, transformative" considering the establishment year, governance rules, funding sources, existed projects, and communities	Developing (founded in 2019, have established governance rules and structures, have secured funding sources, have initial projects)

Table 4 Interviewees and Identifiers

Identifier	Organization	Project	Responsibility	Interview date (YYYY-MM-DD)	Question count
I1	Linux Foundation		LF Edge-Executive Director	2023–01–27	12
I2	IBM	Open Horizon	LF Edge-Chair: Technical Advisory Council	2023–01–31	12
I3	Aveva	Fledge	LF Edge-Vice-Chair: Technical Advisory Council	2023–02–01	13
I4	ZEDEDA	Project EVE	LF Edge-Founding Member	2023–06–27	12

Table 5 Key Questions in Interviews

Question type	Addressed research questions	Question number	Question
Key Question	RQ1. Understanding the reasons of organizations involvement	Q5	Why did you choose to be a part of an existing foundation or not create one of your own?
Key Question	RQ1. Understanding the reasons of organizations involvement	Q6	Why are companies joining this consortium?
Key Question	RQ1. Understanding the reasons of organizations involvement	Q7	What were the reasons behind joining a consortium?
Key Question	RQ2. Understanding the problems and applied solutions in the foundation	Q8	What kind of challenges did you encounter in the consortium and how did you handle it?
Key Question	RQ2. Understanding the problems and applied solutions in the foundation	Q9	Did any conflicts arise between the interests and priorities of member organizations? / What conflicts have arisen between the interests and priorities of driver members?
Key Question	RQ2. Understanding the solutions and success factors in the foundation	Q10	How do you handle conflicts inside the consortium?
Key Question	RQ2. Understanding the success factors in the foundation	Q11	Which success factors would you attribute to this? / What kind of success factors are followed in this consortium?
Key Question	RQ2. Understanding the solutions and success factors in the foundation	Q12	How much power or freedom do you have as a member in the consortium, and is it sufficient?
Key Question	RQ2. Understanding the solutions and success factors in the foundation	Q13	As a member of this consortium, would you suggest some changes in the member rights or membership structure?
Key Question	RQ2. Understanding the solutions and success factors in the foundation	Q14	How do you manage to get the competitive advantage for your company when most of the things are open and transparent?
Key Question	RQ2. Understanding the success factors in the foundation	Q15	How do you manage the development process? Do you have volunteer developers working on projects, or are companies allocating developers to work on projects?

3.3.2 Documents

In the second phase of the data collection process, we collected data from the websites of the Linux Foundation and LF Edge. We gathered corporate announcements, official charter documents, textual meeting minutes, meeting presentations, project requirements documents, project proposals, project progress reviews, workgroup or program-specific documents, corporate publications such as white paper and progress reports, and corporate blog posts. In total, we collected 128 documents published between January 2019 and April 2023.

We present a summary of our data sources along with the unique identifiers we devised to categorize them in our research in Table 6. We use these identifiers in the results section of this paper to clearly attribute the sources of our findings. We present a full list of documents with access links in Appendix B (Yenişen Yavuz et al. 2024).

3.4 Data Analysis

We performed qualitative data analysis using the coding paradigm of grounded theory, as defined by Strauss and Corbin (1990). We did not perform grounded theory (we performed case study research), but simply used its data analysis technique. We used MaxQDA[2] as our data analysis tool.

We initiated the coding process by analyzing interviews, and subsequently proceeded to code the collected documents. We systematically compiled the collected documents, and organized them chronologically from oldest to the newest. Our goal was to analyze these documents chronologically to get an understanding of issues, discussions and solutions emerging sequentially in their natural context.

Our data analysis method, the coding paradigm of grounded theory (Strauss and Corbin 1990), involves three main steps: open, axial, and selective coding. The analysis process was accompanied by continuous peer debriefing with experienced colleagues.

The qualitative data analysis of our research is based on the three phases of coding within grounded theory (GT), open, axial and selective coding (Strauss and Corbin 1990). However, while grounded theory would follow a fully inductive approach to theory building, we followed a hybrid approach of both inductive and deductive reasoning and limited our use of the grounded theory methodology to the coding method as described in the following paragraphs. The analysis process was accompanied by continuous peer debriefing with experienced colleagues.

During the open coding stage, we identified events and actions to create a basis for the understanding of the foundation structure, members' motivation on involvement into the foundation, the problems they encountered, and solutions they applied to solve these problems. The focus on these categories of constructs was guided by our research questions, however we also remained open to other aspects that emerged as particularly important to our case. We started by creating conceptual labels. During the identification of new theoretical constructs, we made sure to compare the data the construct emerged from with the data gathered and analyzed in previous iterations of our process.

In the axial coding stage, we compared the events and actions we defined in the open coding stage with each other and grouped them into subcategories and categories.

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

Table 6 Data Sources and Identifiers

Document type	Identifier (ID)	Document	Document date (YYYY-MM-DD)	Count	Word count (overall)	Word count (average per each data source)
Textual interview transcript	I1, I2, I3, I4	Key informant interviews	from 2023–01–27 to 2023–06–27	4	16,506	4126
Corporate announcement	A1	Linux Announcements—The Linux Foundation Launches New LF Edge to Establish a Unified Open Source Framework for the Edge	2019–01–24	1	1277	1277
Official charter document	LF-0	LF Edge Foundation Charter Document	2021–05–25	1	2990	2990
Textual meeting minute	L1 to L35	LF Edge Technical Advisory Council (TAC) Meeting Minutes	from 2019–01–30 to 2019–12–18	35	39,984	1142
Textual meeting minute	L36 to L55	LF Edge Technical Advisory Council (TAC) Meeting Minutes	from 2020–01–15 to 2020–12–16	20	29,066	1453
Textual meeting minute	L56 to L75	LF Edge Technical Advisory Council (TAC) Meeting Minutes	from 2021–01–13 to 2021–12–01	20	19,114	955
Textual meeting minute	L76 to L94	LF Edge Technical Advisory Council (TAC) Meeting Minutes	from 2022–01–12 to 2022–12–14	19	3168	167
Project requirements document	LP-0	LF Edge Technical Advisory Council (TAC) Project Proposal Requirements	2022–08–10	1	823	823
Project requirements document	LG-0	LF Edge Technical Advisory Council (TAC) Technical Project Getting Started Checklist	2022–04–20	1	1441	1441

Table 6 (continued)

Document type	Identifier (ID)	Document	Document date (YYYY-MM-DD)	Count	Word count (overall)	Word count (average per each data source)
Project requirements document	LP-6	LF Edge Technical Advisory Council (TAC) Project Stages: Definitions and Expectations	2023–04–13	1	2143	2143
Project proposal review	LP-1, LP-2, LP-3, LP-4, LP-5	LF Edge TAC Subgroup Reviews	from 2019–06–04 to 2021–01–26	5	6448	1289
Project progress review	LA-0	LF Edge Technical Advisory Council (TAC) Project annual reviews	2020–07–07	1	708	708
Meeting presentation	LO-1, LO-2	LF Edge Outreach Committee Presentations	on 2021–08–26 and 2021–09–09	2	3867	1933
Official charter document	LE-0	LF Edge End User Solutions Group Charter Document	2021–02–23	1	1180	1180
Meeting presentation	LE-1	LF Edge End User (Vertical) Solutions Group Presentation	2020–10–01	1	1843	1843
Work Group / Program specific document	LI-0	LF Edge Industry Solutions Showcase Objectives Document	2022–11–03	1	497	497
Textual meeting minute	LI-1, LI-2, LI-3, LI-4, LI-5	LF Edge Industry Solutions Showcase Meeting Minutes	from 2022–06–10 to 2022–10–21	5	1705	341
Work Group / Program specific document	LM-0	LF Edge Mentorship Program Proposal Document	2022–07–25	1	305	305
Work Group / Program specific document	LL-0	LF Edge Shared Community Lab Overview	2022–07–01	1	334	334

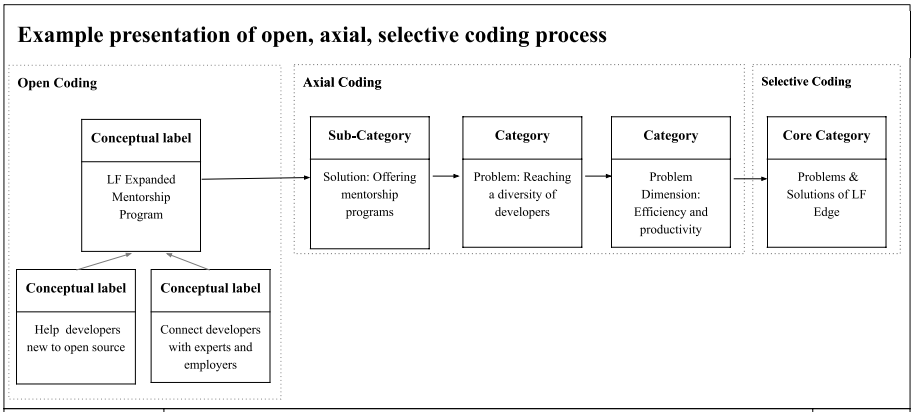
Table 6 (continued)

Document type	Identifier (ID)	Document	Document date (YYYY-MM-DD)	Count	Word count (overall)	Word count (average per each data source)
Corporate publication (White Paper)	LW-1	LF Edge Foundation—Sharpening the Edge White Paper II: Diving Deeper into the LF Edge Taxonomy and Projects	2022	1	17,738	17,738
Corporate publication (Report)	LR-1, LR-2	LF Edge Foundation—State of Edge Report	2021 and 2022	2	66,704	33,352
Corporate blog post	B1 to B4	Leaders in LF Edge Interviews—Blog Post	from 2022–11–04 to 2023–04–27	4	4577	1144

Conceptual labels and subcategories are linked to overarching categories. Axial coding laid the foundation for creating categories that provide deeper insights into the governance structure of LF Edge, the motives of member organizations, the details of hosted or candidate projects, the discussed issues in the meetings, the suggested solutions, and the actions taken within the foundation. Further relationships between the identified concepts and categories were documented in code memos. Memo writing was an integral part of our analysis process.

In the selective coding stage, core categories were defined, representing the central phenomena of the study. Different from a strict GT approach, the core categories did not emerge from the data but were derived from the research questions. During selective coding, all other identified constructs were evaluated regarding their fit to the core categories and modified or removed accordingly. The resulting core categories are related to organizational engagement reasons, problems encountered, applied solutions, and good practices. The categories which emerged in the axial coding step represent the strategies (event and actions), and conditions of the core categories. These finalized categories were crucial in shaping and defining the outcomes of this research and aligning the analysis result with our research questions.

We illustrated the coding process with examples of conceptual labels, subcategories and categories in Fig. 3. For instance, in the meeting minutes, we read the details of the "expanded mentorship program". We asked: "Why is the goal of this program?" We labeled two of the answers to this question as: "To help developers new to open source" and "To connect developers with experts and employers". We positioned the "expanded



Code	Exemplary coded segment	Data sources
Help developers new to open source	"LF Expanded Mentorship Program ■ Helping developers new to open source: ● experiment, learn, and contribute to open source communities, ● econnect with experts & employers"	L50
Connect developers with experts and employers	"The Program is intended to provide a formal structure to connect mentors and student developers from around the globe to contribute their enthusiasm, time, and experience toward building sustainable LF Edge communities"	LM-0
Offering mentorship programs	in order to help achieve that, … we've started creating mentorship and internship opportunities, both with early career professionals in the company and in the context of high school students and college students"	I2
Problem: Reaching a diversity of developers	"I think it's critical that you have diversity in your developer community. The enterprise developers to commercial developers, setting all of them involved in the community and making sure they're all standing on equal footing in relation to each other"	I2

Fig. 3 Qualitative Data Analysis Steps with Examples

mentorship program" as a subcategory of solutions to specific problems of LF Edge. To create the main category, we asked the following question: "How can LF Edge benefit from this program?" The answer was "reaching a diversity of developers," which was a problem for the LF Edge. During the axial coding phase, we categorized this problem into the "efficiency and productivity" dimension. In the selective coding phase, we positioned this category into the "problems and solutions of LF Edge" core category.

We performed data triangulation (Guion 2011) by utilizing multiple data sources (interviews, textual meeting minutes, meeting presentations, official and corporate documents) to construct our theory. During the analysis process, we created a codebook and continuously updated it as new codes emerged. This codebook contains a list of final codes and explanations of the themes. We present this codebook in Appendix C (Yenişen Yavuz et al. 2024). We showed a prolonged engagement in the research process. Performing interviews, collecting related data, and analyzing the results took place between January 2023 and February 2024.

4 Research Results

We address our first research question in Section 4.1, and our second research question in Section 4.2.

4.1 Vendor Motives for Participating in Vendor-Led Open Source Foundations

In this section, we elaborate on why vendors participate in open source foundations. In the light of our qualitative data analysis, we grouped vendors' motives for creating or joining a vendor-led OS foundation focusing into four key dimensions: (1) Revenue, (2) competition, (3) productivity and innovation, and (4) reputation.

We aimed to map and validate our findings with the literature. We used the same set of themes both in the related work section and in the results section. Table 7 presents the overview of motives we found from the case study research, and references in literature that support our findings.

Revenue In LF Edge, vendors work collaboratively on competitively undifferentiated and generic features in OSS projects (I1, I3). Companies can ***reduce their development costs*** by reaching out to and working with developers outside of their organizations (I1).

> Interviewee 1 explained this approach with the following words: *"Explain to these companies right by simply saying, hey, if you're working on a project that has four hundred engineers globally working on it, you are only supplying three to four or maybe ten. The rest is coming from the outside. So, you're working on a product that you're not paying for, so, look at the R&D efficiencies internally, so that's kind of the first part of it, cost savings internally."*

Companies individually develop unique proprietary components for their businesses on top of collaboratively developed OSS. Following this approach, vendors aim to ***generate revenue*** from the product built using the OSS components (I1, I3, I4).

Table 7 Companies' Motives for Participating Vendor-Led Open Source Foundations

Dimension	Motive	Sources of evidence	References in literature that support our findings, if any
Revenue	Generating revenue from the product built using the OSS components	I1, I3, I4	Zhang et al. 2020
Revenue	Preventing vendor lock-in	I1, I2, B4	Ågerfalk and Fitzgerald 2008; Linåker and Regnell 2020
Revenue	Reducing development and maintenance costs	I1, I3	Shaikh and Cornford 2010; Riehle 2010; Teixeira et al. 2016
Competition	Establishing open standards	I2, B3	West and Gallagher 2006; Riehle 2010; Schaarschmidt et al. 2011; Teixeira et al. 2016; Linåker and Regnell 2020
Competition	Influencing the market and becoming the leader	I1, I4, L43	Linåker and Regnell 2020
Competition	Experiencing peer pressure	I1, I3, I4	West and Gallagher 2006
Productivity & Innovation	Collaborating with a diversity of organizations	I1, I2, I4	
Productivity & Innovation	Gaining insights from diverse viewpoints (from members)	I1, I2	Shaikh and Cornford 2010; Teixeira et al. 2016; Linåker and Regnell 2020
Productivity & Innovation	Reaching a diversity of adopters	I2	Grand et al. 2004; West and Gallagher 2006; Joo et al. 2012
Productivity & Innovation	Solving common problems by focusing on generic features	I1, I2, I3, I4	West and Gallagher 2006; Schaarschmidt et al. 2011; Teixeira et al. 2016
Productivity & Innovation	Increasing the pace of innovation in the industry	I1, I2, I3, L43	Linåker and Regnell 2020
Productivity & Innovation	Reaching talent globally	I1, I2, B4	Grand et al. 2004; West and Gallagher 2006; Ågerfalk and Fitzgerald 2008; Linåker and Regnell 2020
Productivity & Innovation	Receiving feedback and support of a large community	I2	Grand et al. 2004; Iivari et al. 2008; Shaikh and Cornford 2010; Teixeira et al. 2016; Linåker and Regnell 2020
Productivity & Innovation	Having more secure code	I1	
Productivity & Innovation	Reduced complexity of establishing partnerships	I2	Hunter and Walli 2013; Eckert et al. 2019; Izquierdo und Cabot 2020; Yenişen Yavuz et al. 2022
Productivity & Innovation	Learning from other groups' experiences	I2	Izquierdo und Cabot 2020
Reputation	Increasing outreach opportunities	I1, I4	
Reputation	Gaining recognition among other companies	I4	

> Interviewee 3 explained this approach with the following words: *"When people open source projects, they do not always open-source everything. The collaboration happens at a level where there are generic features that everybody can benefit from."*

Moreover, establishing open standards collectively with other organizations helps to ***prevent vendor lock-in*** (I1, I2, B4). This, in turn, provides companies with greater flexibility in choosing maintainers for their products. Vendors aim to gain economic advantage for instance by ***reduced development and maintenance costs*** (I1, I2).

Competition Companies work on ***establishing open standards*** (I2, B3), and aim to benefit from the OSS projects they contribute by ***influencing the market and becoming the leader*** (I1, I4, L43) in the industry.

> Interviewee 1 explained this approach with the following words: *"As a leader, you get 75% more value, in terms of influencing the market, right? And you create the market yourself, right? So, and then people followed. Look at Kubernetes or you look at all of these things. It actually happened when they, when you know they started changing the game by adding you know to open-sourcing and getting the developer velocity out."*

A further reason for participation in vendor-led OS foundations is ***peer pressure*** (I1, I3, I4). When companies witness their competitors' engagement in OSS projects and consortia, they experience pressure to participate in these initiatives to safeguard their competitive edge.

Productivity and Innovation One of the motives of companies' participation in OS foundations is the opportunity of ***collaborating with a diversity of organizations*** (I1, I2, I4). This enables ***gaining insights from diverse viewpoints*** (I1, I2) and ***reaching more adopters*** (I2). Furthermore, diversity in the member organizations reduces the risk of the consortium being dominated by one or two powerful companies (I2).

Vendor-led OS foundations encompass competitive companies among their members that work collaboratively focusing on undifferentiated software and generic features (I1, I3, I4). It is vital that member organizations share common goals and a unified vision. By aligning their vision, they can focus on ***solving the common problems*** and seek solutions collaboratively with other members of the foundation (I1, I2, I3, I4). They can employ the same frameworks for interoperability and testing purposes (I1). By working collaboratively to solve common problems, and using open standards, companies save time and resources and ***increase the pace of innovation*** in the industry (I1, I2, I3, L43).

> Interviewee 1 explained this approach with the following words: *"[...]the 5G implementation happened much faster because of open source. And the reason for that is when you have competitors and end-users all in the open source foundation like LF Networking, they would by default use the same frameworks to interoperate and test in the open. So, then you don't have to spend a couple of years testing and interoperating, it gives you that same testing and interoperability right from day one, that's kind of the other reason, which is the speed of innovation."*

Participation in vendor-led OSS projects increases the possibility to ***reach the talent globally*** (I1, I2, B4). Developers contributing to OSS projects have various backgrounds, including employees of different companies, volunteer developers, or students (I2). This diversity in the community enables receiving ***feedback and support from a larger community*** (I1, I2). Since the source code is open, potential malicious code can be detected easily which enables projects to ***have more secure code*** (I1).

Furthermore, working with an established umbrella foundation that hosts various consortia attracts companies, as it ***simplifies the process of establishing new partnerships*** and streamlines operations by enabling them to ***learn from the experiences of other groups*** (I2).

> Interviewee 2 explained this aspect with these words: *"We were able to liberally borrow in the process from a lot of other groups like the Cloud Native Computing Foundation, or LF Network and learn from their mistakes and their success."*

Reputation By joining OS foundations, companies gain access to the consortium's ***outreach opportunities*** (I1, I4). For instance, they can showcase projects in various events and conferences (I4). Startup companies can ***gain recognition*** by joining a consortium, as it allows them to be noticed by other companies involved in the same consortium (I4). These connections help companies to establish collaborative relationships alongside open source projects (I4).

> Interviewee 4 explained this benefit with these words: *"Getting our name recognized by the big industrial players, like, IBM, Microsoft, that was extremely successful, because these are the same players that are part of the consortium. So they are kind of forced to know what you are doing. They are kind of forced to meet you and get to know you. So later on, when we started to do a commercial relationship with some of these companies, it was much easier."*

4.2 Success of Vendor-Led Open Source Foundations

To address our second research question, firstly we investigated the governance structure and projects of the LF Edge foundation. After gaining an overview about the structure, we investigated the problems that emerged and solutions implemented within LF Edge. Furthermore, we collected the practices applied to mitigate potential problems in advance and strengthen the collaboration success.

We focused on the problems, and solutions that emerged in LF Edge in three dimensions: (1) Governance, (2) efficiency and productivity, and (3) sustainability. We explain the implemented (or proposed) solutions to address both experienced and potential problems. We present our results by aggregating these (potential) problems and solutions into context and good practices in Tables 8, 9, and 10 along with their sources of evidence. We assigned IDs to each of these contexts, problems, and solutions. These IDs consist of abbreviations such as C1.P and C1.S, in which "C" stands for Context, "P" stands for Problem, and "S" stands for Solution.

Table 8 Good Practices in Governance dDimension

Dimension: Governance		
Category: Management conflicts		
ID	**Definition**	**Sources of evidence**
Context C1	Mitigating (potential) management conflicts	I2
Practice C1.S1	• Establishing bounding rules	I2, I4, LF-0
Practice C1.S2	• Separating governance and technical responsibilities	I2, I4, L2, L3, L5, L6, LF-0
Practice C1.S3	• Managing meetings professionally and ensuring transparency	I1, I2, L5, L6, L34
Context C2	Mitigating concerns on the influence of political factors	I3, L13, L15
Practice C2.S1	• Applying same set of evaluation criteria to all projects	L6
Practice C2.S2	• Investigating cases in depth before decision-making	L13, L44, LP-3
Practice C2.S3	• Being transparent about reasoning the decisions	I3, L45
Context C3	Solving disagreements about the project lifecycle criteria	L28, L45, L46
Practice C3.S1	• Creating a subgroup dedicated to work on improvement suggestions	L3, L5, L15, L26
Practice C3.S2	• Improving and updating the criteria based on lessons learned	I2
Context C4	Creating guidelines	L28
Practice C4.S1	• Crafting guidelines and documents	L03, L11, L13, L29, L31
Practice C4.S2	• Revising documents as needed	I2, L45, L51
Category: Llegal conflicts		
ID	**Definition**	**Sources of evidence**
Context C5	Mitigating (potential) legal conflicts among members	I1
Practice C5.S1	• Adhering to antitrust policies	I1
Context C6	Solving disagreements about the voting rights of the members	I2, I4
Practice C6.S1	• Openly discussing and identifying areas for compromise	I2
Practice C6.S2	• Updating charter and applying same rules to all members in the same situation	L30, LF-0
Category: Dialog among the members		
ID	**Definition**	**Sources of evidence**
Context C7	Empowering dialog among members	I2

Table 8 (continued)

Practice C7.S1	• Providing an open environment	I2
Practice C7.S2	• Organizing face-to-face meetings	I1, L30
Context C8	Finding a balance among members' expectations	I2, I3, I4
Practice C8.S1	• Being transparent about reasons of concerns or requests	I3
Practice C8.S2	• Convincing others about the benefits of requested changes	I3
Practice C8.S3	• Building positive relationships	I3
Practice C8.S4	• Balancing the number of startups and big players in the foundation	I4

Table 9 Good Practices in Eefficiency and Productivity Dimension

Dimension: Efficiency and Productivity		
Category: Ccollaborative wwork		
ID	**Definition**	**Sources of evidence**
Context C9	Competition among overlapping projects	I2, I3, L15
Practice C9.S1	• Promoting collaborative work among projects	I2, L45
Practice C9.S2	• Finding potential areas for harmonization	L14, L15, L16
Context C10	Enhancing cross-project collaboration	I4, L8, L27, L31
Practice C10.S1	• Establishing cross-project subgroup focusing on harmonization areas	L30, L31, L35
Practice C10.S2	• Clarifying use cases and target markets of each project	L30, L31
Practice C10.S3	• Creating a catalog of services across multiple projects	L52
Practice C10.S4	• Creating cross-project demos	L31, L35, L37, L53
Context C11	Focusing on specific topics in depth	L2, L15
Practice C11.S1	• Establishing voluntary-based subgroups	L3, L16, L19, L37, L43, L44
Practice C11.S2	• Performing surveys	L35, L78
Context C12	Sharing knowledge and experience among projects	L70
Practice C12.S1	• Enabling experience share among projects	L70, L71
Practice C12.S2	• Mentoring hosted projects	L17
Practice C12.S3	• Mentoring candidate projects	I2, L40, L63, LP-0
Context C13	Sharing hardware resources among members	L54, L55
Practice C13.S1	• Creating a pool of resources	L40, L52, LL-0
Context C14	Aligning joint efforts with other foundations	I4
Practice C14.S1	• Assigning representatives to other foundations	L70
Practice C14.S2	• Inviting representatives from different foundations	L70
Category: End-user insights		
ID	**Definition**	**Sources of evidence**
Context C15	Getting end-user insights	I2, I3, L2
Practice C15.S1	• Creating a program focusing on end-user expectations	L50, L61, LE-0

Table 9 (continued)

Practice C15.S2	• Collaborating with a user-led OS consortium	I3
Category: Developer community		
ID	**Definition**	**Sources of evidence**
Context C16	Increasing the diversity in the developer community	I2
Practice C16.S1	• Looking at the enterprise developer market	I2
Practice C16.S2	• Targeting developers who create their own projects	I2
Practice C16.S3	• Offering mentorship programs and internship opportunities	I2, L50, L56, LM-0
Practice C16.S4	• Organizing hackathon events	L23, L24, L26

Table 10 Good Practices in Sustainability Dimension

Dimension: Sustainability		
Category: Financial continuity		
ID	**Definition**	**Sources of evidence**
Context C17	Sustaining financial continuity	I2
Practice C17.S1	• Convincing member companies to involve and invest more	I2
Practice C17.S2	• Attracting more members and projects	I2, I4
Context C18	Expanding outreach	I2, I4
Practice C18.S1	• Creating a taxonomy to show the coverage area of the projects	L5, L14
Practice C18.S2	• Crafting publications about projects	I2, L30, L35, L37, L38, L43, LW-1
Practice C18.S3	• Publishing annual reports on the industry and the foundation	L47, L51, LR-1, LR-2
Practice C18.S4	• Participating in sector-specific events	L13, L15, L22, L36, L53, L63
Context C19	Persuading decision makers to engage	I1, I2, I3, I4
Practice C19.S1	• Explaining benefits of involvement	I1, I2, I3
Practice C19.S2	• Offering trainings about open source and legal aspects	I1, I4
Practice C19.S3	• Highlighting the involvement of competitors in the projects	I1
Category: Projects' health**rojects' health**		
ID	**Definition**	**Sources of evidence**
Context C20	Improving projects' health	LA-0, L58, L71
Practice C20.S1	• Providing projects with a self-evaluation checklist	L41, L58, LG-0
Practice C20.S2	• Having annual review cycles for projects	L35, L42, L43, L44, L45, LA-0
Practice C20.S3	• Facilitating projects to address security issues	L70, L71
Practice C20.S4	• Ensuring independence of projects	L45, L46, L57

4.2.1 Governance Structure and Projects of LF Edge

LF Edge has three membership categories: (1) Premium membership, (2) general membership, and (3) associate membership. The influence of members on the governance of the foundation is structured according to their membership category, with premium members exerting the greatest influence (LF-0).

The governance of LF Edge is overseen by the Governing Board. The Governing Board consists of representatives from premium members, selected representatives from general members, and one representative from the Technical Advisory Council (TAC). Premium members have the right to appoint one representative to the Governing Board and any other committee within the foundation (LF-0). Every ten general members can appoint one representative to the Governing Board, while associate members do not have the right to appoint any representatives (LF-0). The Governing Board is supported by the outreach committee, legal committee, budget committee, and technical advisory board (council) (LF-0).

LF Edge provides governance and marketing support to the projects it hosts (I4) and facilitates collaboration possibilities among different projects (L2, L43). The Foundation is not directly involved in the development process of projects, or the features and functionalities of the open-source software (I4). Each project maintains autonomy with its own technical steering committees, goals and roadmaps (L2, L41). Figure 4 illustrates the governance structure of the LF Edge foundation.

LF Edge was founded with five OSS projects. Three of these projects (Akraino Edge Stack, EdgeX Foundry, Open Glossary of Edge Computing) were formerly stand-alone projects of the Linux Foundation. Two projects, HomeEdge and Project EVE, contributed their seed code during the establishment process of LF Edge (A1). Over the span of four years, from 2019 to 2023, LF Edge experienced a growth in the number of hosted projects, reaching a total of 11. We present the projects hosted by the LF Edge as of June 2023 in Appendix F.

Projects within LF Edge have access to varying degrees of marketing support based on their lifecycle stage (LO-1). There are three lifecycle stages that determine the level of marketing support: Stage 1 (At Large), Stage 2 (Growth), and Stage 3 (Impact) (LO-1).

Projects are categorized into these stages based on their maturity levels. Stage 1 is the entry stage, where new projects apply for acceptance into the foundation. for projects. After

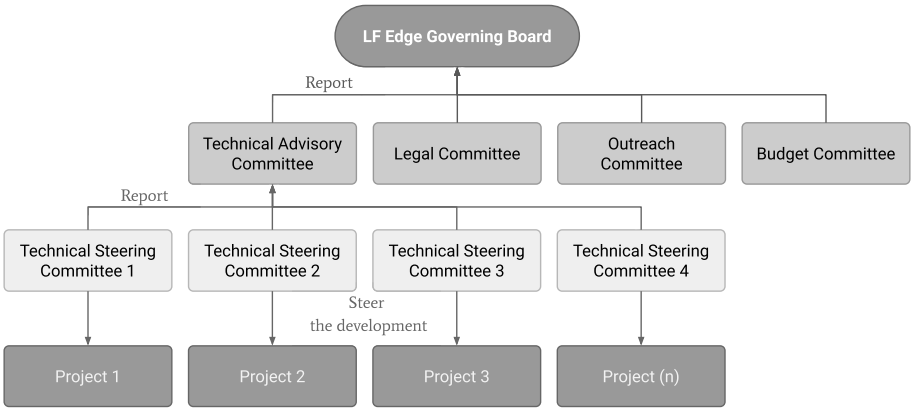


Fig. 4 Governance Structure of LF Edge

acceptance, they can apply for higher stages (L16, LP-0, LP-6). Stage 2 is the growth stage. It requires projects to have a growth plan with a roadmap, an active community of contributors, regular Technical Steering Committee (TSC) meetings, and project documentation. These projects receive mentorship from TAC members and have access to increased marketing support compared to Stage 1 projects (LP-5, LP-6). Stage 3 is the highest project level where projects are expected to maintain a "self-sustaining cycle of development, maintenance, and long-term support" (LP-6). Criteria for Stage 3 include having at least five members in the governing body, committers from at least two organizations, publicly accessible documentation on the governance processes, and established security processes (LP-6). Stage 3 projects receive the highest priority for marketing support from the Foundation (LO-1). Additionally, there is Stage 4, known as the Emeritus stage. Projects that have reached the end of their lifecycle and do not plan to release major versions in the future are classified as being in this stage. Projects in this stage do not receive resource allocation from the foundation (LP-6).

Acceptance criteria for different project lifecycle stages are created by the TAC (L2, L5), and approval is subject to votes by the TAC and the Governance Board/Strategic Planning Committee (L30). Projects must demonstrate that they meet the requirements for the desired stages. Project representatives present their progress at TAC meetings. Requirements are reviewed by the TAC subcommittee for the candidate projects. This subcommittee provides recommendations on accepting or rejecting the project proposals. Following this step, the TAC voting process begins. If the TAC accepts the proposal, it undergoes a subsequent vote by the Governance Board (L12).

4.2.2 Problems, Solutions, and Good Practices in the Governance Dimension

We present the practices related to the establishment and regulations of the foundation's ecosystem, focusing on member relations within the governance dimension. We categorized the governance dimension into three categories: management conflicts, legal conflicts, and dialog among members.

Management Conflicts

Context C1: Mitigating (potential) management conflicts

(Potential) Problem C1.P: LF Edge was established with 60 initial member organizations in 2019 (A1). Member organizations have a diversity from larger enterprise companies to smaller start-ups (I2). Due to different expectations and needs, there can be tension within the foundation (I2).

Solution C1.S: LF Edge has a set of bylaws that all members are required to adhere to. For instance, the charter document of the foundation outlines the membership rules and responsibilities (LF-0). Each candidate must acknowledge that they will adhere to these rules and guidelines to become a member of the foundation. ***Establishing bounding rules*** serves to mitigate conflicts and discourage unnecessary discussions within the foundation (I2, I4).

In LF Edge, ***responsibilities of the governing board differ from those of the technical committee*** (I4). The Governing Board comprises representatives from different membership categories (LF-0). Foundation-wide issues are discussed and solved at that level (I4). Projects have autonomy and they maintain their own technical steering committees (L2). Projects have their own charters and the flexibility to update the rules when needed (I2). Project members solve technical conflicts in their technical steering committees (I4).

Between the Governing Board and the projects, the Technical Advisory Council (TAC) serves as a bridge. Members discuss foundation-wide issues and project related subtopics in the Technical Advisory Council (TAC) meetings (L5). The goals of the Council, the roadmaps to achieve these goals, the status of the hosted projects, and the evaluation of the upcoming project proposals are some of the discussion topics of the TAC meetings. Additionally, participants discuss upcoming conferences and outreach opportunities. TAC relates budget requests of the projects (from technical steering committee of projects) to the governing board (L2, L3), and informs about projects' status to the governing board (L6). Furthermore, TAC facilitates communication and collaboration among the projects hosted in the foundation (L2).

TAC holds periodic meetings. In 2019, these meetings were held weekly, from 2020 onwards, they transitioned to a biweekly schedule (L5, L6, L34). These meetings are ***managed professionally***. Meeting minutes and recordings are published at the end of each session. Everyone can access these documents and familiarize themselves with the discussions. This accessibility ***ensures transparency***. Professional program managers lead these meetings and guide participants toward solutions (I1, I2).

Establishing bounding rules for every member, separating governance and technical responsibilities, performing periodic meetings, governing meetings professionally, and ensuring transparency enable the foundation to mitigate conflicts, and empowers the governance process in the foundation.

Context C2: Mitigating concerns about the influence of political factors on decision-making

Problem C2.P: TAC members review candidate projects, cast votes on their acceptance into the foundation, and determine their lifecycle stages (L12). The allocation of funds to hosted projects depends on their lifecycle stages, making the maturity level of projects crucial (L6, LO-1, LP-5). During the acceptance and subsequent stage upgrade process of one of the projects (formerly named FogLAMP, later changed to Fledge), some members of the TAC raised concerns regarding the perceived unfairness in the project evaluation. The reason for this concern was that this project had overlapping functions with another project of the foundation (named EdgeX Foundry) (I3, L13, L15).

Solutions C2.S: A solution to this concern is to consistently ***apply the same set of evaluation criteria*** to all projects. Following this approach, the foundation seeks to mitigate potential conflicts of interest among member organizations in relation to the projects they are overseeing (L6).

In this specific case, TAC members established a subgroup to ***investigate the project's application in depth*** to the foundation (L13). The subgroup mapped the overlapping areas and differences between these two competitive projects (L15, LP-3). During the evaluation meeting, project leaders aligned the project's features with the acceptance criteria, resulting in the project being accepted into the foundation (L16).

A year later, the same project sought an upgrade to Stage 2 (L44). A new subgroup was formed to evaluate the project's adherence to lifecycle criteria (L44, LP-4, LP-5). ***Being transparent about the decisions*** is crucial for fostering positive relationships among members (I3). The subgroup presented both the positive aspects and areas of concern, along with recommended steps for improvement (L45). Following the project team's commitment to implementing the subgroup's recommendations, the project successfully advanced to Stage 2 (L47, LP-5)..

Context C3: Solving disagreements about the project lifecycle criteria

Problem C3.P: Budget allocation for projects is designed based on their lifecycle stages (L6, LO-1). Projects receive more funding and marketing support as their maturity level increases (LP-5).

Lifecycle stages of projects are determined based on predefined criteria by TAC (L2, L5). In 2019, disagreements emerged among TAC members about the evaluation criteria for project stages. In particular, during the Akraino Project's lifecycle stage evaluation process, some TAC members expressed concerns about the vagueness of the Stage 3 criteria (L28). The Akraino Project was not a single project; it hosted different projects. Since it has a different structure, some members suggested changing the evaluation criteria for this project. However, the majority decided that it would be unfair to apply new criteria for a project during the evaluation phase (L28).

Solutions C3.S: To prevent further problems, TAC members created ***a voluntary subgroup dedicated to developing improvement suggestions*** for new project evaluations (L3, L5, L15, L26). After the subgroup finalized their work on improvement suggestions (L30, L31, L32, L33, L34), TAC performed a survey among the TAC members to assess the necessity for an update on the criteria (L35). Results indicated that the majority of the survey respondents were opposed to implementing any changes on the project lifecycle criteria (L37). As a result, suggestions were not considered and the first attempt at improvement was canceled (L37). The subgroup's members expressed frustration about the general refusal to implement change after expending efforts to make a suggestion (L37).

However, concerns about the ambiguity of the project lifecycle criteria continued after this decision (L45, L46). Discussions on this matter extended throughout 2022 (L83, L86, L87, L92). Drawing from experiences and lessons learned, TAC approved the modifications to the project lifecycle criteria (I2). These criteria were subsequently updated at the outset of 2023.

Interviewee 2 explained the solution with the following words:

> *"We wanted to be able to look at situations on a case-by-case basis and evaluate them on their individual merits. But that can also, at times, make it very hard to judge, if a project meets these criteria and there is room for disagreement on this point. So that could be an area where people strongly disagree and for good reasons. That's why it's really important for us to revisit those."*

Context C4: Creating guidelines

Problem C4.P: LF Edge has already established management rules in their charter document (LF-0). However, in some cases, unforeseen problems did occur that were not anticipated or clarified in the previous documentation (L28).

Solution C4.S: When TAC members reach a consensus on a particular topic, they collaborate on ***crafting guidelines and documents*** to serve as a reference for similar cases in the future. Some examples of these documents are instructions on how to submit new project proposals (L11, L13), project induction guidelines (L03), project lifecycle document (PLD) (L03), and documenting APIs (L29, L31).

Furthermore, the foundation ***revises its documents as needed*** based on lessons learned and changes in processes (I2, L45). For instance, following the discussions about project lifecycle criteria in 2023, members integrated revisions in the PLD, based on the

outcomes of discussions and lessons learned (I2). Another example is about project-based documents. TAC created the "Open Glossary of Edge Computing" to identify the terminology about edge technology. The glossary acts as a formulated consensus and reference of a common vocabulary. Members of the foundation were asked to update existing documents and apply the vocabulary consistently for easier and more efficient communication (L51).

Legal Conflicts

Context C5: Mitigating (potential) legal conflicts among members

(Potential) Problem C5.P: The members of LF Edge operate in the IT industry, with some members directly competing with each other (I1).

Solutions C5.S: Given the competitive nature among most of the members of the foundation, it is essential for them to ***adhere to antitrust policies***. This ensures proactive measures to prevent potential legal conflicts (I1). In accordance with these policies, members are advised against discussing products, market differentiation, and pricing (I1).

Context C6: Solving disagreements about the voting rights of the members

Problem C6.P: The Governing Board holds the authority to make decisions regarding the foundation and the status of projects. Membership category determines one's eligibility for involvement in the Governing Board. Each premium member is entitled to one vote in the decision-making process (LF-0). A problem about the voting rights of companies emerged when a premium member (IBM) acquired another company (Red Hat) which was also a premium member of the LF Edge. Possessing two voting rights by one organization caused disagreements among the members (I2, I4).

Solutions C6.S: To solve this problem, the Governing Board ***led a discussion*** and members ***reached a compromise***. Under this compromise, the foundation would accept the two voting rights (one for the acquiring company and one for its subsidiary) only in cases where the acquiring company owns less than 50% of the subsidiary company's shares (I2, LF-0). This rule is applicable to all members with similar situations in the LF Edge. After the conclusion, the results are documented and the ***charter is updated*** including the statements about voting rights of subsidiaries (L30, LF-0).

> Interviewee 2 explained how they addressed this problem: *"I think any good resolution what you end up doing as a compromise where the larger company, that appeared to have two votes, had to give up some of the privileges that come with that and likewise the other companies that don't want to be overwhelmed by the larger enterprises need to compromise a little bit as well. What we came up with was an equitable in-between solution, where in certain situations, if a company has a subsidiary where they own X percentage of it, they only get one vote in the certain situation."*

Dialog Among Members

Context C7: Empowering dialog among members

(Potential) Problem C7.P: LF Edge includes a large number of members from diverse types of companies. Given that different people have different perspectives and viewpoints, disagreements within the foundation are possible (I2).

Solution C7.S: ***Providing an open environment*** which enables everyone to speak and share their opinions openly is important to show members different perspectives (I2).

Organizing face-to-face meetings helps members from different organizations to know each other and create a community (I1). An example for this is the in-person meeting of some of the Akraino Team and EdgeX project members to discuss collaboration opportunities (L30).

Context C8: Finding a balance among members' expectations

Problem C8.P: LF Edge encompasses a diverse range of organizations, including small startups and large industry players of various sizes (I4). The presence of diverse organizational types brings both benefits and challenges. As a benefit, large industry players can allocate greater resources to the foundation and projects, while small startups can act faster (I4). However, due to the varying expectations and needs of these distinct types of companies, disparities emerge, giving rise to disagreements between members, such as in the realm of budget decision-making (I2, I3, I4). Allocating higher resources to the foundation allows members to have more influence on the decisions. To secure approval for their requests, project members should persuade decision makers (I3).

Solutions C8.S: Some of the solutions implemented are ***being transparent*** about reasons of concerns or requests (I3), ***convincing others about the benefits of requested changes*** (I3), and ***building positive relationships*** (I3). Furthermore, having a balanced distribution of startups and established industry players (e.g. 50% startups and 50% large corporations) would help to ***create a balance in the consortium*** (I4).

> Interviewee 4 explained some of the discussions about spreading marketing funds: *"There was some tension back and forth in terms of how to spend marketing dollars. Because Edge is so diverse, even picking the conferences where the LF Edge has to be represented was a big discussion, because some companies wanted network related conferences, some companies wanted embedded and industrial conferences. But the budgeting for the foundation was reasonable."*

4.2.3 Problems, Solutions, and Good Practices in the Efficiency and Productivity Dimension

We categorized the problems and solutions that have influence on the project-level outcomes in the productivity and efficiency dimension. In this dimension, we defined three categories: collaborative work, end-user insights, and developer community.

Collaborative Work

Context C9. Competition among overlapping projects

Problem C9.P1: As of June 2023, LF Edge hosts 11 projects. Some of these hosted projects address similar use cases (L15). LF Edge allowed working on the same solutions by different projects to enhance competition and innovation (I2, I3). However, this approach led to inefficient use of resources and tension within the foundation (I2, I3).

Solutions C.9.S: To solve this problem, LF Edge considered focusing on the value to be offered to adopters. LF Edge ***promoted collaborative work among projects*** by searching for different areas to offer distinctive solutions, and developing solutions which will supplement with other projects (I2, L45). To understand the differences and similarities of projects, TAC members decided to ***craft a taxonomy*** (L14). Furthermore, a TAC subgroup

has been established to review the overlaps between projects and find ***potential areas for harmonization*** (L15, L16).

> Interviewee 2 explained this solution with the following words: *"What that does, is that allows us to begin to look at that potential competition to decide:"are there areas where we actually provide a unique distinctive solution different from the other project" and "are there ways in which it might make sense to take those distinctive and use it to supplement the other project". Because fundamentally, we are trying to build a more comprehensive framework."*

Context C10. Enhancing cross-project collaboration

Problem C10.P: One of the mission statements of LF Edge is to "seek to facilitate harmonization across Edge projects" (L8, L27). LF Edge is hosting diverse projects with various use cases. Members are leading different projects. One of the concerns about the foundation is being too diverse and having members with different focuses (I4). The enhancement of harmonization across projects is a point of discussion for the foundation members (L31).

> Interviewee 4 explained this problem with the following words: *"Edge ended up being way too diverse. Different players basically had very particular interests. But because the Edge is so diverse, those interests didn't really overlap enough to create a common collaborative environment for different players. So it ended up being like, everybody did their own thing, under this huge umbrella. But not necessarily collaborating with each other, not because of some ill will. [...] There's basically a lot of business to be done in there, for a lot of different companies. So, I guess, not finding that commonality was one of the big challenges."*

Solutions to C10.S: Enhancing cross-project collaboration was a focus area for TAC members in 2020 and 2021 (L27, L31). The Governance Board and TAC worked on a number of ideas to solve this problem. One of the applied practices is to ***establish a cross-project subgroup*** compromising members from diverse projects to explore potential collaboration opportunities (L30, L31, L35). This subgroup has a specific focus of clarifying which projects target ***distinct use cases and markets*** (L30, L31). Another approach is ***crafting a white paper*** on how projects can collaborate to address key issues (L30). With this work it is aimed to clarify how all projects fit together (L31). A ***catalog of edge based services*** which could run across multiple projects is a further idea to improve cross project collaboration (L52). Another strategy to increase the harmony between the projects is ***creating cross-project demos*** (L31, L35). These demos consist of at least two projects linked together for specific use cases (L31). These demos have two functions. One is promoting collaboration between the projects, encouraging them to explore the collaboration opportunities together (L31, L35). The other function is expanding outreach by showcasing these demos at sector-specific events (L37). The FLIR camera demo which was created collaboratively by EVE and Fledge Projects is an example of this cross-project collaboration (L37, L53).

Context C11. Focusing specific topics in depth.

(Potential) Problem C11.P: In TAC meetings, some of the discussed issues couldn't be resolved directly. In order to solve disagreements and come to a decision, members needed detailed information (L2, L15).

Solution C11.S: When TAC requires detailed information and focused attention on particular topics, it ***establishes subgroups*** dedicated to exploring these topics in detail. These subgroups comprise TAC members who have volunteered for participation (L3). Following their work on assigned topics, subgroups deliver reports to offer insights into the respective subjects. Some of the specific topics these subgroups addressed are the review of new project submissions (L16), the annual review process for projects (L19, L43, L44), and project lifecycle document (L37).

Performing surveys among community members is another approach to collect ideas and improvement suggestions about specific topics (L35, L78). An example survey is about the priority of outreach committee activities (LO-1).

Context C12. Sharing knowledge and experience among members

(Potential) Problem C12.P: One of the focuses of TAC meetings is the progress of hosted projects. Representatives from these projects provide updates on their progress and discuss any challenges they encounter. In some cases, different projects experience similar problems (L70).

Solution C12.S: Projects can learn from each other's ***shared experiences***. For instance, when a project emphasized its security challenges, other projects shared their strategies for addressing similar issues (L70, L71). Discussing these issues in the TAC meetings and sharing experiences help other members to have a better understanding of the potential solutions.

An additional strategy involves ***providing mentorship to projects***. To apply for advancement to a higher lifecycle stage, projects are required to be sponsored by at least two TAC members. These sponsors guide and mentor projects, facilitating their readiness to progress to the next stages (L17).

Extending ***mentorship to candidate projects*** is another approach (LP-0). This approach serves as a model for candidate projects to comprehend the foundation's structure, rules, and expectations (I2, L40, L63). Notably, one candidate project (Open Horizon) collaborated with an existing LF Edge project (EdgeX Foundry) before submitting their proposal (L40). Through mutual learning among projects, the evaluation process becomes more streamlined, enhancing overall efficiency.

Context C13. Sharing hardware resources among members

(Potential) Problem C13.P: In some cases, different projects hosted in the LF Edge may benefit from the similar hardware (L54, L55). Spending the budget on the same resources would lead to inefficiency.

Solution C13.S: ***Creating a pool of hardware resources*** for the use of members enhances the efficient utilization of the foundation budget (L61). For instance, LF Edge projects share hardware resources through their Community Lab (LL-0). In 2020, Akraino project has made its Community Lab available for use by all members (LL-0, L40). This lab accepts donations from the Linux Foundation and other organizations, making these resources available for use of projects (LL-0, L52).

Context C14. Aligning joint efforts with other foundations.

Problem C14.P: LF Edge considered to collaborate with other consortia (I4).

Solution C14.S: A suggested practice is to ***assign volunteers to represent LF Edge*** in other foundations' or consortia's meetings. Some of these foundations are hosted in the Linux Foundation, such as the LF AI&Data and the LF Networking. Another example is the Eclipse Edge Native Working Group that works on the edge technologies, as well. By

following this approach, LF Edge aims to enhance communication with other foundations, stay abreast of external developments, align joint efforts, and ensure compatibility with standards and specifications (L70). Another practice to reach the same goal is ***inviting representatives from other foundations***, encouraging their attendance at LF Edge TAC meetings to introduce and share insights about their respective organizations. This approach would allow the LF Edge to gain deeper insights into diverse organizations and assess potential collaboration opportunities (L70).

End-User Insights

Context C15. Getting end-user insights

Problem C15.P: LF Edge comprises vendor organizations that collaborate to develop generic frameworks for edge computing. However, members address end users. As a result, they need to understand users' expectations to offer them appropriate solutions. The absence of end-user companies and their insights leads to discrepancies between products and user requirements (I3). Failing to reach a diverse range of adopters is a further problem that contributes to the absence of end-user insights (I2).

Understanding end users' needs was a consideration point for the TAC from the beginning (L2). For a while the discussions about this issue were postponed (L3), and later excluded from the TAC's scope and assigned to a higher-level committee, the Strategic Planning Committee (L26, L27, L28, L29, L30, L31, L41).

Solutions C15.S: To solve this problem, in the third quarter of 2020, LF Edge started "Vertical Solutions—End User Community" (I2, L50). In the second quarter of 2021, ***End-User Solutions Group*** was launched (L61, LE-0). The goal was to understand the expectations and concerns of users, and provide end-user perspective on the value and usability of the LF Edge projects (L61, LE-0). However, this attempt did not continue (I2).

On the other hand, interviewee 3 explained their own solution to this problem as ***joining a user-led open source consortium*** (LF Energy) which is driven by end users and focusing on their needs and expectations (I3).

Developer Community

Context C16. Increasing the diversity in the developer community

Problem C16.P: One of the motives for vendors to engage in open source projects is accessing a diversity of contributors (I1, I2, B4). Lack of diversity in the community is one of the problems of the LF Edge (I2).

Solutions C16.S: To solve this problem, various approaches are employed by the member organizations. Two of these approaches are ***examining the enterprise developer market*** and targeting ***developers who create their own projects*** (I2). Another approach is ***offering mentorship programs and internship opportunities*** to students from various education institutions (I2, L50, L56, LM-0). A further approach is ***organizing hackathon events*** (L23, L24, L26).

> Interviewee 2 explained their approach with these words: *"We've started creating mentorship and internship opportunities, both with early career professionals in the company and in the context of high school students and college students. So, towards that there is a program called P-TECH that targets high schools too and helps them. IBM has a program called JumpStart for early career professionals to teach them new areas and help up their skills."*

4.2.4 Problems, Solutions, and Good Practices in the Sustainability Dimension

We present the practices which are about the continuity of the foundation in the sustainability dimension. In this research, we categorized sustainability into two categories: sustaining financial continuity and projects' health.

Financial Continuity

Context C17. Sustaining financial continuity

Problem C17.P: LF Edge is a non-profit organization and it depends on membership fees (I2). Foundation must consistently safeguard its funds.

Solution C17.S: A solution for this problem is convincing its member companies to ***involve and invest more*** in the hosted projects (I2). In order to ensure the continuity of companies' involvement, consortia and projects should bring value to the member organizations. Budget allocation and activities should be in line with the member organizations' expectations (I2). Another way is ***attracting new members*** and projects to become a part of the foundation (I2, I4). Having more members increases the diversity in the consortia, contribution, and the financial support for the projects (I2).

Context C18: Expanding outreach

Problem C18.P: Attracting new members and projects is a practice to safeguard foundation's funds (I2, I4). To reach potential members, LF Edge searched for different strategies.

Solution C18.S: One of the strategies LF Edge employs involves promoting projects by emphasizing their missions, use cases, and the interconnection between these projects (L37). As a tool for this strategy, the Foundation ***created a taxonomy*** of edge projects. The goal of the taxonomy is to highlight the covered areas, identify gaps, and explore potential collaboration areas between projects (L5, L14).

Furthermore, the LF Edge foundation ***crafted a white paper*** (L30, L35, L37, L38). This paper elucidates edge definitions and abstractions, presents the created taxonomy, and defines market verticals (I2, L43). The initial release of this white paper occurred in 2020, followed by an updated version in 2022 (LW-1).

Another strategy to raise awareness involves ***publishing annual reports on industry*** that explores news related to the state of critical infrastructure, networks, hardware, and software (L47, L51). Additionally, the report showcases use cases of edge computing and provides updates on LF Edge Projects (L51). "State of the Edge" report has been released on an annual basis since 2020. The reports for 2021 and 2022 are publicly available (e.g. LR-1, LR-2).

A further approach involves ***participating in sector-specific events***. During each TAC meeting, project members deliberate on upcoming conferences and events related to edge computing and open source environment. Project representatives decide on which conferences to attend (L13, L15, L22, L36, L63). Project members present demos in these events with the goal of capturing the attention of other organizations or developers (L53).

Context C19: Persuading decision makers to engage

Problem C19.P: OSS projects are often misperceived as being cost-free and devoid of benefits for the parties involved (I1, I2, I3). The prejudices affect decision makers when they think about joining OSS projects. Licensing terms in some of the standards obstruct organizations to involve in OSS development and end users to use it (I3, I4).

Solution C19.S: Some of the solutions to apply are ***explaining the benefits of involvement*** and ***highlighting how innovation could bring value to their company***, offering

training about open source and its legal aspects, and highlighting the ***involvement of competitors*** in open source projects (I1, I2, I3, I4).

Projects' Health

Context C20: Improving projects' health

Problem C20.P: One of the functions of LF Edge is providing governance support to the projects it hosts (LF-0). To ensure the health of projects, TAC needed to implement some measures (LA-0, L58, L71).

Solution C20.S: TAC works on creating guidance documents that are beneficial for all projects. One of these is the "getting started checklist", which is a ***self-evaluation checklist*** for projects (L41, LG-0). The goal is to "define, refine and enhance" the project management approach of existing and new established projects (L41, L58).

LF Edge conducts an ***annual review cycle*** of its hosted projects, following the evaluation criteria developed by the TAC (LA-0). With this practice TAC and project members assess the project status, and determine whether the projects are in the correct lifecycle stages (L35). If there are any misalignments about the stages of these projects, TAC provides guidance and recommendations to address project stage level expectations (L42, L43, L44, L45). If projects intend to apply for a higher-level stage, this annual review cycle helps them to understand the requirements and how to progress towards acceptance (L45). Results of these reviews are being transparently published on LF Edge wiki pages (L45). LF Edge uses these reviews to improve and ensure the health of projects (L45).

One of the concerns of LF Edge is the ***security issues*** for projects. Projects have different processes to handle their security issues and they are free to decide how to do it. TAC enables members to share their insights about the approaches they follow to assist other projects (L70, L71). Some of the approaches in different projects followed are: providing an email address for public reports about vulnerability; identifying Security Issue Review (SIR) team to read and act on reported vulnerabilities; having a security subcommittee; applying automated vulnerability scanning & PEN testing and generating reports on regular basis; having a threat model to define vulnerabilities and search for solutions (L70, L71).

To enhance the sustainability chances of projects, LF Edge highlights the importance of ***ensuring independence of projects*** from supporting companies. They encourage projects to prevent the dominance of one or two companies and foster a healthy community around projects (L45, L46, L57).

5 Discussion

In the previous section, we addressed our research questions "RQ1. Why do organizations participate in vendor-led open source foundations?" and "RQ2. How do vendor-led open source foundations become successful?" based on our findings from a single-case study.

This section embeds these findings in a larger context of the current consensus of academic literature. By carving out the alignment and the differences to the current body of knowledge we discuss the contributions of this study. In Section 5.1, we discuss the motives of vendors for engaging in vendor-led OS foundations, and in Section 5.2 we explore the problems they encounter, and practices they apply.

5.1 Motives for Engaging in Vendor-Led Open Source Foundations

To identify vendors' motives for engaging in vendor-led open source foundations, we reviewed literature, created themes for the literature findings and synthesized the findings in Table 1. While literature provides an overall framework, we present a close-up picture to useful patterns that can work in specific contexts. We compare and contrast findings from the literature with our findings from this case study. Our findings show similarities with companies' motivations for participating in open source projects and communities. However, there are also some differences.

One of the motives for vendors to engage in OSS projects is ***generating revenue***. In the literature, the most frequently discussed method for generating income through OSS involvement revolves around selling supplementary services and products (Grand et al. 2004; West and Gallagher 2006; Schaarschmidt et al. 2011; Teixeira et al. 2016; Zhang et al. 2020). Zhang et al. (2021) investigated the companies' contributions to open source projects in the OpenStack focusing on commercial incentives of the companies. According to Zhang et al. (2021)'s research, one of the incentives of the companies is to provide commercial solutions based on the open source software they contribute. Similar to Zhang et al. (2021), we identified that companies work collaboratively to produce commercial products based on the open source software they work on. In our case, we found that companies contribute to undifferentiated, generic features of OSS projects. They collaboratively work on solving common problems. One of the motives behind this action is to build commercial components on the undifferentiated part and generate revenue.

The other motive is to ***increase the pace of innovation***. Collaborating to address common industry challenges enables companies to accelerate innovation within that sector. Rather than individually tackling the same issues, they work together to solve them, allowing each company to concentrate on differentiating features independently. Companies can increase productivity by accessing external resources. By open source involvement, companies access external knowledge which is being produced outside their organization. As discussed in the literature, by working with communities, companies gain the knowledge produced by the developers, collect innovative ideas and feedback from users (Grand et al. 2004; West and Gallagher 2006; Ågerfalk and Fitzgerald 2008; Shaikh and Cornford 2010). When multiple organizations engage in OSS projects such as in vendor-led OS foundations, companies get the opportunity to access the resources of each other, as well. They exchange experiences not only regarding technical matters, but also concerning administrative and procedural processes. Moreover, by working with an *umbrella foundation*, companies also obtain the opportunity to acquire experience from other foundations and projects hosted within the same organizational umbrella.

Furthermore, our findings support the literature that companies target to reduce development costs by pooling resources. Gaining more suppliers and reducing vendor dependency are additional objectives that align with the literature.

Gaining a competitive advantage is a further motive for companies to involve in vendor-led OS foundations. Our findings show that establishing open standards provides companies the opportunity to influence the market. Furthermore, open standards in the industry increase the flexibility of companies and reduce maintenance costs by ***preventing vendor lock-in.*** In the existing literature, companies aspire to gain a competitive advantage by setting their proprietary standards accepted within the industry (West and Gallagher 2006; Riehle 2010; Schaarschmidt et al. 2011; Teixeira et al. 2016; Linåker and Regnell 2020).

Based on our findings, companies seek to establish industry-wide open standards through collaborative efforts.

A further motive from the competition aspect is ***safeguarding competitive edge*** by handling peer-pressure. When key industry leaders engage in such collaborations, outsider companies face the pressure of potentially missing out on the opportunity to shape the industry's future and gain a competitive advantage. This pressure also becomes a motive for them to join such foundations. In the literature, competitive advantage of OSS involvement is related to creating a competitive product or platform against an already existing competition (Teixeira et al. 2016; Weikert et al. 2019). In the case of LF Edge, vendors aspire to assert industry dominance through open standards, seeking to gain a competitive edge ahead of other companies.

In the literature, reputation dimension is handled from the sight of employees, developers, and customers (e.g. Ågerfalk and Fitzgerald 2008; Shaikh and Cornford 2010; Linåker and Regnell 2020). In our research, we identified that ***gaining recognition*** among other vendors and companies is also an important motive in particular for start-up companies.

5.2 Problems, Solutions and Good Practices in a Vendor-Led Open Source Foundation

One focus of this research is identifying good practices applied in vendor-led open source foundations for successful collaboration. We determined 52 practices in 20 contexts focusing on three dimensions: governance, efficiency and productivity, and sustainability.

We identified practices in the **governance** dimension considering the goals of mitigating management and legal conflicts among members, empowering dialog among members, and guiding members. Establishing bounding rules is a practice to mitigate management conflicts among members which we also encountered in the literature (e.g. Yenişen Yavuz et al. 2022). Kumar et al. (2020) present transparent and fair decision-making governance as a success factor. Having established bounding rules and applying these rules to every member is a practice of fair decision-making. Managing meetings professionally, publishing meeting minutes or recordings are practices to mitigate management conflicts by increasing transparency.

LF Edge hosts concurrent projects, leading a sense of competition among vendors for the resources. Additionally, an unequal distribution of influence power among members presents a problem, as powerful members may tend to favor their own projects. In the literature, Weikert et al. (2019) highlights a similar problem about having conflict between members when they target the same markets and users. Practices to overcome these concerns are being transparent, openly discussing and communicating issues, finding potential areas for harmonization, building positive relationships and applying the same rules for all projects in the foundation.

Since members of vendor-led OS foundations are rival companies, they need to adhere to antitrust rules to mitigate legal conflicts. Yenişen Yavuz et al. (2022) highlights that transparency in OSS projects also helps competitive companies to adhere to antitrust compliance. In the literature, building trust is listed as one of the most important success factors for coopetition (Petter et al. 2014; Kumar et al. 2020). Providing an open environment for members and organizing face-to-face meetings help to empower dialog among members. This approach can be counted as a basis for building trust among members. Documenting processes and providing guidelines for instance for newcomer developers is an established

practice applied in open source communities (Yenişen Yavuz et al. 2022). In our case, this practice is employed to guide member companies about project governance practices.

For increasing **efficiency and productivity**, foundations can focus on improving collaboration among hosted projects within the foundation and fostering collaborative initiatives between the foundation and external organizations. To increase the interaction and collaboration between projects, foundation members apply a number of practices, such as creating a taxonomy, presenting an overview of collaboration areas and promoting cross-project demo production. Since we couldn't find literature about vendors working in the same consortium but focusing on different projects, we did not encounter this problem presented in the literature.

Project participants and members of the foundation can learn from each other by experience and knowledge sharing. These findings are parallel with the literature in which exchange of experience, learning and knowledge is defined as one of the success factors of coopetitions (Petter et al. 2014; Chin et al. 2008). Another practice to increase productivity is focusing on specific topics by assigning subgroups to work in detail and performing surveys to collect ideas and feedback from the members.

One of the problems in the productivity and efficiency context is absence of end-user insights. A considered solution for this problem is establishing an end-user group to understand end-user requirements and expectations. Another solution which is applied by one of the companies uniquely is participating in an user-led OS foundation. A further problem is absence of diversity in the developer community. Hosted projects individually address this problem by creating mentorship programs, offering scholarships, and reaching directly to talented developers.

The last dimension is **sustainability**. Sustaining financial continuity and improving projects' health are two of the main goals we defined in our research.

Since open source foundations are non-profit organizations, attracting new members is an important objective for their sustainability. However, attracting new members is a challenge. Some strategies to attract new members are explaining the benefits of involvement and showing how to handle legal problems. Demonstrating the existence of competitors within open source projects serves as an additional incentive to attract companies that may be hesitant to participate in open source endeavors. Promoting the foundation and projects by using publications about the industry and showing the coverage areas of projects hosted in the foundation are other practices we highlighted in this research. Promoting the projects by participating in (sector-specific) events is a practice performed by other open source foundations, as well (Yenişen Yavuz et al. 2022).

We explained that performing periodic reviews is an important practice to improve projects' health. Kumar et al. (2021) highlights the importance of setting short-term achievable goals and periodic reviews of the outcomes for sustainability of coopetition. Chin et al. (2008) considers the periodic reviews as a part of long-term commitment. Ensuring independence of projects from one or two dominant companies is a measure to protect the OSS communities. As stated in the open source literature, dominance of one company in a project triggers resistance within the community (Grand et al. 2004; Ågerfalk and Fitzgerald 2008; Shaikh and Cornford 2010; Schaarschmidt et al. 2011; Schaarschmidt and Stol 2018). Furthermore, when a project only depends on a dominant company, the absence of the company can lead to inactivation of the project (Zhang et al. 2022b). Expanding outreach helps to attract more members and developers to join the foundation and the projects. In business literature we did not encounter any success factors about promoting the coopetition.

Although the practices we determined are based on a vendor-led open source foundation, these results can be applicable to other open source foundations which are led by

organizations. Our research contributes literature and offers practical value to practitioners by elucidating potential problems, providing solutions, and highlighting good practices that can be applied in various situations.

6 Limitations

We took an exploratory single-case study approach (Yin 2018). For our qualitative, theory-building research, we use Guba's (1981) trustworthiness criteria to evaluate our research. These criteria are credibility, transferability, dependability, and confirmability.

Credibility refers to the truth of research findings. We used two techniques to improve credibility: prolonged engagement and data triangulation. We focused on data collection and the investigation process for one year. At first, we conducted interviews with the key persons from the LF Edge foundation, who are responsible for different projects. Two authors coded the same four interviews and compared their results by following two different guidelines. The third author followed the thematic analysis approach by following Braun and Clarke's (2006) guideline. First step of this approach is reading the documents and getting an understanding about the content. The lead author preferred the coding paradigm of the grounded theory approach, considering analysis of other documents besides the interview transcriptions. After performing analysis on interview transcriptions, two authors agreed on the first set of the codes. Following this step, the lead author continued analysis of collected publicly available documents (such as textual meeting minutes) about LF Edge Foundation dated between January 2019 and December 2022. The lead author read and qualitatively analyzed 128 documents. This approach enabled data triangulation.

Transferability concerns the applicability of the research findings in other contexts**.** A limitation of this study is that the results are based on one vendor-led open source foundation. To mitigate this limitation, we chose a representative case rather than an edge example. As stated in Yin (2018)'s *Case Study Research* book, choosing a "common case" for single-case study research is a valid approach to collect insights. Working on a single-case allowed us to focus, explore, and understand in depth the consortium structure, problems and issues, and practices they employ in its natural context. Furthermore, we compared our results with the findings of existing research. Table 7 shows our findings about the motivations with the results we found from literature review. Our findings about problems differentiate from the risks existed in the literature about vendors' engagement with open source communities. Since we could not find best practices or success factors of vendor-led open source foundations, we included the literature for success factors in the user-led open source foundations and coopetition. We called our practices "good practices" since best practices could be reached by comparing these practices among other cases. Our study serves as an exploratory investigation, offering a foundation for future research that may include multiple cases or broader surveys.

Dependability concerns the traceability and reliability of research findings. We used publicly available documents and interviews. We share the list of documents in Appendix B, and interview protocol in Appendix A (Yenişen Yavuz et al. 2024). We performed qualitative data analysis and used a codebook. Codebook is presented in Appendix C and the code-segments of our results in Appendix D (Yenişen Yavuz et al. 2024). We presented our findings with the identifier of the source of evidence. These identifiers enable the traceability of our findings by leading to related publicly available documents. Due to privacy concerns, we did not publish the interview transcripts. However, we used quotations from the interviews to support our

findings. Using these instruments, we aimed to increase traceability and dependability of our findings.

Confirmability refers to objectivity. To avoid researcher bias, we used interview protocol. Two authors analyzed the interview transcripts and reached similar results. We present each of our results, providing the corresponding data sources from which these findings originate. We share the list of documents in Appendix B with accessible website links, and our codebook in Appendix C for the examination of external reviewers (Yenişen Yavuz et al. 2024).

7 Conclusion

The focus of this research is vendor-led OS foundations. We investigated the motives for vendors' engagement in vendor-led OS foundations, the problems experienced in these foundations, implemented solutions, and good practices applied. We performed a single-case study by investigating the LF Edge.

To address our first research question, we synthesized the findings from the literature and compared and contrasted them with the results of our case study. As a result, we grouped the reasons for engagement considering four aspects:(1) Revenue, (2) competition, (3) productivity and innovation, and (4) reputation. We explained 16 motives considering these four categories. Some of these reasons are generating revenue from the product built using the OSS components, increasing the pace of innovation in the field, establishing open standards, influencing the market, and preventing vendor lock-in.

We addressed our second research question by investigating the problems that emerged in a vendor-led OS foundation, the solutions applied or considered, and the resulting leading good practices. We identified 52 good practices in 20 different contexts, considering three dimensions: governance, productivity and efficiency, and sustainability. In the governance dimension, some of the good practices are establishing bounding rules, separating governance and technical responsibilities, providing an open environment, and crafting guidelines and documents. Efficiency and productivity dimension relates to project-level outcomes. Some of the good practices in this dimension involve promoting collaborative work, enabling experience sharing among projects, mentoring projects, and establishing voluntary-based subgroups. The sustainability dimension consists of financial continuity and project health categories. Some practices in this dimension include creating a taxonomy to illustrate the coverage areas of projects, crafting publications about projects, publishing annual reports on the industry and the foundation, providing projects with a self-evaluation checklist, conducting annual review cycles for projects, and ensuring independence of projects.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10664-024-10588-9.

Acknowledgements We thank our interview partners for their valuable time and insights. We also thank Andreas Kaufmann, Julia Mucha, and Georg Schwarz for their invaluable feedback. This research has been supported with the fundings by the German Research Foundation (Deutsche Forschungsgemeinschaft). The project number of the fund is 506460878 and GZ:RI 2147/11-1.

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

Data Availability In this research, we used two types of data: interview transcripts and publicly available documents. Interview transcripts are not shared to preserve our interview partners' privacy. However, we

share the interview protocol in Appendix A to ensure transparency. We present the list of documents we analyzed with their access links in Appendix B, the codebook we created during our analysis in Appendix C, and the list of code segments supporting our results in Appendix D. Appendices of this study are accessible from this link: https://faubox.rrze.uni-erlangen.de/getlink/fiUGvjNoXvGJ8acKJDfBMt/

Declarations

Conflicts of Interests All authors certify that they have no affiliations with the investigated case involving the LF Edge foundation, and the Linux Foundation.
The authors have no competing interests to disclose.

References

Ågerfalk PJ, Fitzgerald B (2008) Outsourcing to an unknown workforce: exploring opensourcing as a global sourcing strategy. MIS Q:385–409. https://doi.org/10.2307/25148845
Apereo Community Blog (n.d.) *About Apereo.* Retrieved June 20, 2024, from https://apereo.github.io/about/
Brandenburger AM, Nalebuff BJ (1996) Co-opetition, doubleday currency, New York, NY
Braun V, Clarke V (2006) Using thematic analysis in psychology. Qual Res Psychol 3(2):77–101
Bryman A (2016) Social research methods. Oxford university press
Business Wire (2022) Intel accelerates developer innovation with open software-first approach. Business Wire. Retrieved June 20, 2024, from https://www.businesswire.com/news/home/20220928005326/en/Intel-Accelerates-Developer-Innovation-with-Open-Software-First-Approach
Butler S, Gamalielsson J, Lundell B, Brax C, Sjöberg J, Mattsson A, Gustavsson T, Feist, Lönroth E (2019) On company contributions to community open source software projects. IEEE Trans Softw Eng 47(7):1381–1401
Chin KS, Chan BL, Lam PK (2008) Identifying and prioritizing critical success factors for coopetition strategy. Ind Manag Data Syst 108(4):437–454
Cloud Native Computing Foundation (2015) New Cloud Native Computing Foundation to drive alignment among container technologies. Retrieved June 20, 2024, from https://www.cncf.io/announcements/2015/06/21/new-cloud-native-computing-foundation-to-drive-alignment-among-container-technologies/
Eckert R, Stuermer M, Myrach T (2019) Alone or Together? Inter-organizational affiliations of open source communities. J Syst Softw 149:250–262
Germonprez M, Allen JP, Warner B, Hill J, McClements G (2013) Open source communities of competitors. Interactions 20(6):54–59
Grand S, Von Krogh G, Leonard D, Swap W (2004) Resource allocation beyond firm boundaries: a multilevel model for open source innovation. Long Range Plan 37(6):591–610
Guba EG (1981) Criteria for assessing the trustworthiness of naturalistic inquiries. Ectj 29(2):75–91
Guion RM (2011) Assessment, measurement, and prediction for personnel decisions. Taylor & Francis. https://doi.org/10.4324/9780203836767
Hunter P, Walli S (2013) The rise and evolution of the open source software foundation. IFOSS l Rev 5:31
Iivari N, Hedberg H, Kirves T (2008) Usability in company open source software context-Initial findings from an empirical case study. IFIP international conference on open source systems. Springer US, Boston, pp 359–365
Intel Corporation (2021) Open source software: fact sheet. Intel Corporation. Retrieved June 20, 2024, from https://download.intel.com/newsroom/2021/client-computing/OSS-Fact-sheet.pdf
Izquierdo JLC, Cabot J (2020) A survey of software foundations in open source. *arXiv preprint arXiv:2005.10063*
Joo C, Kang H, Lee H (2012) Anatomy of open source software projects: evolving dynamics of innovation landscape in open source software ecology. The 5th International Conference on Communications, Computers and Applications (MIC-CCA2012), Istanbul. IEEE. pp 96–100
Kumar A, Connell J, Bhattacharyya A (2021) Co-opetition for corporate social responsibility and sustainability: drivers and success factors. Sustainability Accounting, Management and Policy Journal 12(6):1208–1238
Linåker J, Regnell B (2020) What to share, when, and where: balancing the objectives and complexities of open source software contributions. Empir Softw Eng 25:3799–3840
Microsoft (n.d.a) Visual Studio Code license and privacy statement. Retrieved June 20, 2024, from https://code.visualstudio.com/license

Microsoft (n.d.b) Visual Studio Code [Repository]. GitHub. Retrieved June 20, 2024, from https://github.com/microsoft/vscode

Open Logistics Foundation (n.d.) Mission | Rethinking open source for logistics. Joining forces. Retrieved June 20, 2024, from https://openlogisticsfoundation.org/about/mission/

OpenInfra Foundation (n.d.) Organizations supporting the OpenInfra Foundation. Retrieved June 20, 2024, from https://openinfra.dev/members/

Petter RRH, Resende LM, de Andrade Júnior PP, Horst DJ (2014) Systematic review: an analysis model for measuring the coopetitive performance in horizontal cooperation networks mapping the critical success factors and their variables. Ann Reg Sci 53:157–178

Pinto G, Steinmacher I, Dias LF, Gerosa M (2018) On the challenges of open-sourcing proprietary software projects. Empir Softw Eng 23:3221–3247

Riehle D (2010) The economic case for open source foundations. Computer 43(01):86–90

Riehle D, Berschneider S (2012) A model of open source developer foundations. IFIP international conference on open source systems. Springer Berlin Heidelberg, Berlin, pp 15–28

Roberts RE (2020) Qualitative interview questions: guidance for novice researchers. Qual Rep 25(9). https://doi.org/10.46743/2160-3715/2020.4640

Schaarschmidt M, Stol K-J (2018) 'Company soldiers and gone-natives: role conflict and career ambition among firm-employed open source developers', forthcoming conference, ICIS 2018, San Francisco, 13–16 December

Schaarschmidt M, Bertram M, von Kortzfleisch HF (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.

Shaikh M, Cornford T (2010) 'Letting go of control to embrace open source: implications for company and community. In: 2010 43rd Hawaii international conference on system sciences. IEEE, pp 1–10. https://doi.org/10.1109/HICSS.2010.1

Stack Overflow (2023) Stack overflow developer survey 2023: most popular technologies - Integrated development environment. Retrieved June 20, 2024, from https://survey.stackoverflow.co/2023/#section-most-popular-technologies-integrated-development-environment

Strauss A, Corbin J (1990) Basics of qualitative research. Sage Publications, Thousand Oaks

Teixeira J, Lin T (2014) Collaboration in the open-source arena: the webkit case. In: Proceedings of the 52nd ACM conference on Computers and people research. pp 121–129. https://doi.org/10.1145/2599990.2600009

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

Weikert F, Riehle D, Barcomb A (2019) Managing commercial conflicts of interest in open source foundations. International conference on software business. Springer International Publishing, Cham, pp 130–144

West J, Gallagher S (2006) Challenges of open innovation: the paradox of firm investment in open-source software. R&D Manag 36(3):319–331

YenişenYavuz E, Barcomb A, Riehle D (2022) Problems, solutions, and success factors in the openMDM user-led open source consortium. Commun Assoc Inf Syst 51(1):13

Yenişen Yavuz E, Riehle D, Mehrotra A (2024) Why do companies create and how do they succeed with a vendor-led open source foundation (External Appendix) [Online]. Available: https://faubox.rrze.uni-erlangen.de/getlink/fiUGvjNoXvGJ8acKJDfBMt/

Yin RK (2018) Case study research and applications. Sage Publications, Thousand Oaks

Zhang Y, Zhou M, Mockus A, Jin Z (2021) Companies' participation in OSS development–an empirical study of openstack. IEEE Trans Software Eng 47(10):2242–2259

Zhang Y, Liu H, Tan X, Zhou M, Jin Z, Zhu J (2022a) Turnover of companies in OpenStack: prevalence and rationale. ACM Trans Softw Eng Methodol (TOSEM) 31(4):1–24

Zhang Y, Zhou M, Stol KJ, Wu J, Jin Z (2020) 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. https://doi.org/10.1145/3377811.3380376

Zhang Y, Stol KJ, Liu H, Zhou M (2022b) Corporate dominance in open source ecosystems: a case study of OpenStack. In: Proceedings of the 30th ACM joint european software engineering conference and symposium on the foundations of software engineering. pp 1048–1060. https://doi.org/10.1145/3540250.3549117

Zhou M, Mockus A, Ma X, Zhang L, Mei H (2016) Inflow and retention in oss communities with commercial involvement: a case study of three hybrid projects. ACM Trans Softw Eng Methodol (TOSEM) 25(2):1–29

Elçin Yenişen Yavuz is a researcher and doctoral student at the Professorship for Open Source Software at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany. She received her master's degree in International Information Systems from FAU, Germany. Before joining academia, she led various projects in the automotive, healthcare, and pharmaceutical industries. Her research interests include open innovation, open source foundations, open source software communities, collaborative software development, and digital transformation.

Dirk Riehle is a professor of computer science at University of Erlangen. They are also the CEO of Bayave GmbH, a training and consulting firm. Their work helps companies succeed in and through software, with a specialization in open source, inner source, and product strategy. Before joining academia, Prof. Riehle led the open source research group at SAP Labs in Palo Alto, California (Silicon Valley). They also worked for software startups and large corporations in Boston, MA and Zurich, Switzerland, as a software developer, architect, and engineering manager. Riehle holds a Ph.D. in computer science from ETH Zurich and an M.B.A. from Stanford Graduate School of Business. They welcome email at dirk@riehle.org, blog at https://dirkriehle.com, and tweet as @dirkriehle.

Ankita Mehrotra is a change manager at Siemens HealthineersForchheim, Germany. She received her master's degree in International Information Systems from FAU, Germany and Bachelor of Technology (Computer Science Engineering) from India. Before joining her master's program, she worked in roles of IT Analyst and System Engineer in the IT industry for around 6 years. Her areas of interest are change management (process and product), service innovation, and digitalization in the workplace.