Universidade de Brasília – UnB

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Engenharia de Software

Building Open Source Ecosystems - Collaboration Between Government, Industry, and Academia

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Monografia submetida ao curso de graduação em Engenharia de Software da Universidade de Brasília, como requisito parcial para obtenção do Título de Bacharel em Engenharia de Software.

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Abstract

Open Source Software (OSS) revolutionized software development with its principles of transparency, collaboration, and community-driven innovation. It plays a pivotal role in contemporary software development, leading to economic growth, innovation stimulation, and competitive advantage.

This paper explores the intricate dynamics of collaborative models within OSS ecosystems (OSSECO), with a focus on the role of government, industry, and academia. The goal is to examine the challenges, and lessons learned from practical experiences of OSSECO.

The research employs an Ethnographic Case Study approach, analyzing one innovation lab at the University of Brasília's involvement in three distinct projects: the Brazilian Public Software Portal (SPB), Salic Interactive Learning Technology (TAIS), and the ongoing Decidim Brasil community initiative. These projects exemplify the contributions of government, academia, and industry in driving innovation, diversifying resources, and engaging communities within the open-source landscape. Bringing lessons learned and three models with distinct resolutions showcase the behavior of a project utilizing open-source software, culminating in institutional solutions provided by the government and two other projects focused on building the OSS community concurrently with system development, going beyond the project's scope, emphasizing the development and perpetuation of OSS throughout the ecosystem.

Key-words: Open Source. Collaboration between industry and academia. Ecosystem.

Lista de ilustrações

Lista de abreviaturas e siglas

OSS	Open Source Software
SECO	Software Ecosystem
OSSEC	Open Source Software Ecosystem
UnB	University of Brasília
USP	University of São Paulo
OS2	Open Source and Public Sector Collaboration
LAPPIS	Software Production, Research, and Innovation Laboratory
UML	Unified Modeling Language
SPEM	Software Systems Process Engineering Metamodel Specification
SSN	Models such as the Software Supply Network
CI	Continuous Integration
CD	Continuous Deployment
TAIS	Salic Interactive Learning Technology
FLOSS	Free/Libre/Open Source Software
FOSS	free and open source software

Sumário

Introduction

Open Source Software (OSS) transformed the software industry in recent years, with its transparency, collaboration, and community-driven innovation shaping the industry. Several papers evidenced the multifaceted advantages of OSS adoption, encompassing economic progress, stimulation of innovation, and the cultivation of healthy competition (SáNCHEZ et al., 2020; HAUGE; AYALA; CONRADI, 2010; KATSAMAKAS; XIN, 2019; SILVA; COUTINHO; COSTA, 2023).

Software ecosystem (SECO) is widely use concept to characterize a software project infrastructure involving different stackholders and technology(BESTEN et al., 2020). For this paper we adopted the definition from Lungu et al. (LUNGU et al., 2010) where SECO is a "collection of software projects which are develop and evolve together in the same environment". It is a social-technical system that can also be guided by a OSS project. The OSS ecosystem (OSSECO) definition from Franco-Bedoya et al. (FRANCO-BEDOYA et al., 2017) can be synthesized by a "SECO placed in a heterogeneous environment whose boundary is a set of niche players and whose keystone player is an OSS community around a set of projects in an open-common platform."

Both OSS project and OSSECO highlight how the development process is decentralized and collaborative. Additionally, OSSECO emphasizes collaboration between entities to co-operate, co-create, co-evolve, and co-develop. These aspects would be challenging, if not impossible, to implement in proprietary SECO's (FRANCO-BEDOYA et al., 2017).

Those prefix "co-*" denotes the notion of competency and collaboration among diverse entities regarding a particular subject (FRANCO-BEDOYA et al., 2017). Through co-development, this collaboration is directed towards product development (CHESBROUGH; SCHWARTZ, 2007) (BÜYÜKÖZKAN; ARSENYAN, 2012), encompassing various models of collaborative software development. (KOURTESIS et al., 2012) (WEN et al., 2020). According to Kourtesis et al. (KOURTESIS et al., 2012), the benefits of this approach are "decreased software and business development costs, quicker time-to-market, improved focus, reduced complexity, and economic profit". The collaboration between entities is becoming a standard practice. One example is the development shared by several interested partners, close to OSSECO and in some contexts the platform has a central partner controlling access and contribution as SECO (KOURTESIS et al., 2012) or according to Manikas (MANIKAS, 2016a) "one of the most common differentiation of ecosystem types is the separation between ecosystems that are driven or supported by free and open source software (FOSS) and ecosystems that are driven or supported by proprietary software".

The collaboration within OSSECOs poses challenges stemming from their inherent complexity, traceability, and communication. Addressing these obstacles has led to the emergence of OSSECO modeling as a significant area of research. Previous studies have identified various techniques to describe these challenges in general. However, none of them fully encompass the scope of OSSECO. Therefore, there has been a need to develop new techniques, guidelines, and notations for modeling OSSECOs. (FRANCO-BEDOYA et al., 2017)

In the same time, an increasingly prominent model is Government-Community Collaboration, in which governments engage directly with the open-source community to develop software solutions tailored to meet governmental requirements (LINÅKER et al., 2023). Examples of this model include the United Kingdom[1], which employs standardized public procurement rules to prioritize open-source solutions when viable. This approach carefully weighs project-specific requirements, cost-efficiency, security considerations, and adaptability in alignment with governmental objectives. Likewise, Denmark's OS2 network brings together public entities with similar software requirements and private vendors in a collective effort to create and maintain open-source IT solutions (FREY, 2023a). These initiatives not only cost-effectively foster local economic sustainability but also nurture collaboration between the public sector and the local industry.

Incorporating OSS development and contributions into university technological courses has been a longstanding practice, and the mutual benefits for students and the OSS community in these collaborations are well-documented. In an environment where the cost of innovation in the market is notably high, the active engagement of a university setting in open-source communities, combined with its familiarity with the latest technologies and innovation methodologies, becomes an invaluable asset (WEN et al., 2020).

In this dynamic landscape, collaboration models among government, industry, and academia have emerged as pivotal mechanisms for fostering and expanding open-source ecosystems (MARIJAN; SEN, 2022). This paper delves into co-development models within the realm of OSS community development through an Ethnographic Case Study. In Section **??**, we lay the groundwork by introducing the concepts surrounding co-development and OSSECO, as well as the underlying rationale guiding our paper's decisions. We conclude this section by examining previous work and showcasing three instances of co-development. In Section 3, we present a comprehensive model designed to tackle the complexities, traceability issues, and communication challenges inherent in OSSECOs. Here, we elucidate the primary benefits and challenges encountered in each project. Finally, Section 4 encapsulates our findings, offering valuable insights that can serve as guiding principles for practitioners and government entities in the planning, evaluation,

[1] <https://www.gov.uk/government/publications/the-digital-data-and-technology-playbook/the-digital-data-and-technology-playbook>

and execution of collaboration models.

1 Background

1.1 Software co-development

The collaborative effort among diverse entities aimed at product development is referred to as co-development (FRANCO-BEDOYA et al., 2017) (CHESBROUGH; SCHWARTZ, 2007) (BÜYÜKÖZKAN; ARSENYAN, 2012). Co-development has been the subject of observation from various perspectives over the years, with collaborative projects often presenting challenges (WEN et al., 2020) (MARIJAN; GOTLIEB, 2020). Industry and academia (IA), for example, practitioners from industry's perspective believe that researchers work on outdated subjects or focus on futuristic theories, which contrasts with the rapid pace of production established by the industry (RUNESON; MINÖR; SVENÉR, 2014). Bern et al. (BERN, 2018) defends practitioners often encounter challenges in effectively utilizing the knowledge produced by academic researchers.

Furthermore, the collaboration between government and academia enables the development of innovative e-government projects that effectively address societal needs through their combined efforts. However, this collaboration encounters challenges, such as the disparity between the technologies hindered by bureaucratic processes and the reliance on traditional techniques favored by the government, as opposed to the disruptive innovation embraced by academia (WEN et al., 2020) . This discrepancy can stifle innovation due to the utilization of government-provided platforms and data.

Despite the challenges, academia can play a crucial role in this process by introducing new technologies and methodologies. Co-development offers the opportunity to create an environment conducive to innovation, allowing for early and frequent evidence provision, compelling opportunities, and incremental solution validation and improvement, as highlighted by Marijan (MARIJAN; GOTLIEB, 2020). As noted by Wen et al. (WEN et al., 2020), academic coordinators made three high-level decisions leading them to intuitively adopt nine FLOSS and agile best practices in the development process: (1) Use the system under development to develop the system itself. (2) Facilitate collaboration between government staff and the development team. (3) Organize development teams into priority fronts, with each front including at least one specialist hired from the IT market. This not only effectively results in a well-built project, but also consolidates the relationship between the entities involved.

1.2 Open Source Software Ecosystems

Software Ecosystem is a term used to understand the relationship between software projects, products, communities, and organizations. We adopt the definition of Lungu et al. (LUNGU et al., 2010) where SECO is a "collection of software projects which are develop and evolve together in the same environment". In this relation the Open-source software provides an environment that enables the creation of a software ecosystem through projects, communities, and external agents. The OSS ecosystem definition from Franco-Bedoya et al. (FRANCO-BEDOYA et al., 2017) can be synthesized by a "SECO placed in a heterogeneous environment whose boundary is a set of niche players and whose keystone player is an OSS community around a set of projects in an open-common platform."

OSSECO encompasses social-technical aspects and co-development through a collaboration between different communities and projects (LUNGU et al., 2010). Co-development using OSS fosters transparent communication and information sharing, while also providing investment in the OSS communities, ensuring their continuity beyond the lifespan of the original project.

Proprietary software ecosystems often prioritize organizational and business perspectives over collaborative processes (MANIKAS, 2016b). Nonetheless, commercial OSSECOs exist, blurring the line between purely commercial ecosystems and OSSECOs. These entities incorporate collaborative aspects from OSSECOs while integrating organizational and business perspectives from purely proprietary ecosystems. (BESTEN et al., 2020)

Additionally, modeling an OSSECO entails encountering specific challenges. While previous studies have identified various techniques to address these challenges in a general sense, none of them fully capture the breadth and complexity of OSSECOs. Consequently, there has been a pressing need to develop new techniques, guidelines, and notations tailored specifically for modeling OSSECOs. As a result, the study of OSSECO modeling has emerged as a significant and burgeoning area of research. (FRANCO-BEDOYA et al., 2017)

1.3 Previous Work

Projects involving multiple entities within the context of open-source projects are featured in various studies. For instance, Wen et al. (WEN et al., 2020) examined the Brazilian Public Software Portal project, a 30-month collaboration between government and academia, which included the University of Brasília (UnB), University of São Paulo (USP), and the Brazilian government. This project utilized Free/Libre/Open Source Software

(FLOSS) practices and agile methods for project management, showcasing the intricacies of co-development in e-government and how open-source software influences decision-making throughout the development process. They identified three high-level decisions supported by the adoption of nine best practices that improved the project performance and enabled professional training of the whole team.

Other works, such as OS2 (Danish term for Open Source and Public Sector Collaboration), demonstrate how public authorities and private vendors collaborate to develop and maintain IT projects (FREY, 2023b). This project emphasizes the importance of ensuring the success of projects within an ecosystem like this, outlining five key goals to initiate the development of an OS2 project.

In other project, an 8-year research-based innovation project in Norway, there was an in-depth discussion about an ecosystem involving multiple agents from a co-creation perspective. This project explored how collaboration between industry and academia can contribute to various innovations. The project identified 10 key findings to facilitate co-creation in this relationship, emphasizing an active process of participative knowledge generation aimed at producing more relevant results for all participants. (MARIJAN; GOTLIEB, 2020)

This paper sets itself apart from others by examining the collaboration between government, academia, and industry for developing a production-level solutions within the OSSECO context. It explores the case studies where we can identify the most effective decisions from each project. We analyze the decisions made in three projects based on LAPPIS, including the SPB project, Salic Interactive Learning Technology, and Brasil Participativo.

2 Study Design

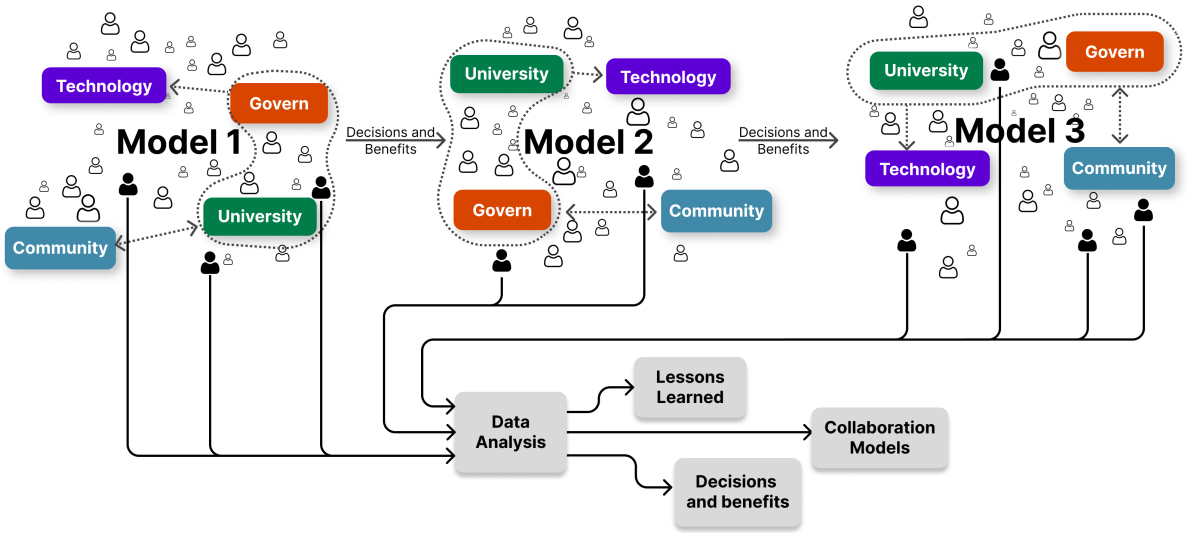

Figura 1 – The Ethnographic Case Study adopted in this research. Initially, the researchers, who are members of the community under analysis, conduct information gathering, followed by data comparison and discussion, culminating in the development of a collaboration model and identification of lessons learned.

2.1 Case Study Ethnographic

This research involved a deep immersion of the project team as active observers, actively participating in daily activities and interactions. This approach is known as Ethnographic Case Study(EDMONDS; KENNEDY, 2016; SHARP; DITTRICH; SOUZA, 2016), allowing us to observe the group, actively collect information, and conduct richer analyses. A Case Study is a research methodology that focuses on the detailed analysis of a specific situation embedded in a real-life context. Generally, this method investigates a particular case, such as a person, group, organization, or community, with the aim of understanding the principles and behaviors that influence it (YIN, 2018). Meanwhile, ethnography is a research method that seeks a deeper understanding of people, organizational culture, and social practices, especially in the context of software development. This approach focuses on understanding the perspectives, values, beliefs, and behaviors of individuals involved in software projects.

The ethnographic methodology focuses on the analysis of a real case within a specific cultural group, delimited by time, place, and environment (EDMONDS; KENNEDY, 2016). It is characterized by the intensive and holistic description of a specific social rea-

lity and is particularly suitable for investigations that seek to explore the activities of a group rather than just shared patterns of behavior.

This Ethnographic Case Study was conducted by members of a Software Production, Research, and Innovation Laboratory (LAPPIS)[1] at the University of Brasília (UnB)[2]. This laboratory specializes in open source development and research and collaborates with the government, as seen in the projects presented in the following section. These projects have in common their collaboration with the government, their focus on innovation using open-source software, and their explicit interest in fostering OSS communities in Brazil.

2.2 Data Sources

This research involved a deep immersion of the project team as active observers, effectively participating in daily activities and interactions.

In the SPB project, we explored research conducted throughout the project focusing on the analysis of methodologies used during its course. In these studies, data were collected through surveys, interviews, and data collection. The survey was completed by 45 undergraduate interns and IT professionals immersed in the project, and 2 interviews were conducted with government actors. Finally, they analyzed data from the central project repository, considering all the issues and commits. (WEN et al., 2018)

In the Tais project, we delved into the data available in the repository, as well as lectures and conducted research. Furthermore, we engaged researchers who were directly involved in the development process, retrieving the decisions made during the project.

For the Brasil Participativo, we collected data from documents and products generated during project execution. This approach allowed us not only to observe the group but also to actively participate, taking on leadership roles.

As a result of this active analysis and the data rescue, we were able to comprehensively describe the collaboration model developed within the project. Additionally, we discussed lessons learned based on our observations and available documentation. This combination of case study and ethnography provided a richer and deeper insight into the software development context and team dynamics, enabling us to gain valuable insights for future research and practice.

[1] <https://www.lappis.rocks>
[2] <https://unb.br>

3 Results

Amidst the complexity of SECO, prior research has explored diverse methodologies for formalizing the model strategy of these ecosystems. Models such as the Software Supply Network (SSN), Software Systems Process Engineering Metamodel Specification (SPEM), and Unified Modeling Language (UML) have been proposed to capture the intricacies of SECO (COUTINHO; VIANA; SANTOS, 2017). In the realm of OSSECO, challenges extend beyond complexity, traceability, and communication (FRANCO-BEDOYA et al., 2017). To address these challenges, the model presented here endeavors to encompass four key actors within OSSECO, comprehensively describing the intricate dynamics of these ecosystems. Our objective is to underscore the primary entities involved in the project and delve into the connections to discern the pivotal decisions guiding ecosystem outcomes.

- Governance: Responsible for designing roles, coordinating internal and external interactions, and orchestrating resource flows between other entities within the ecosystem. (DEDEHAYIR; MÄKINEN; ORTT, 2018)
- Platform: The technological foundation of projects, products, or services within the ecosystem. It serves as the catalyst for innovation, introducing disruptive technologies and fostering coopetition among participants. (BESTEN et al., 2020)
- Community: The cornerstone of the social-technical system surrounding open-source software (OSS). (BESTEN et al., 2020) This entity represents the heart of the ecosystem, comprising individuals and organizations focused on contributing to collective projects. It emphasizes transparency, collaboration, and community-driven initiatives.
- Support: Organizations, institutions, and corporations that provide infrastructure, personnel, data sources, and investment to bolster the platform and facilitate its operations within the ecosystem.

3.1 Model I - University controlling the project environment

Figure 2 presents the collaboration model of the SPB project. It shows that the University played a vital role in governance alongside the Brazilian government. This collaborative approach to governance decentralizes decision-making and grants universities the autonomy to manage and allocate resources. To organize these resources effectively, the strategy was to enlist IT professionals from the open-source projects such as Noosfero,

Colab and Mezuro, who were already well-versed in the project's technologies and requirements. Additionally, students and professors from free software laboratories at USP and UnB, with extensive experience in OSS project development and research, were included in the team.

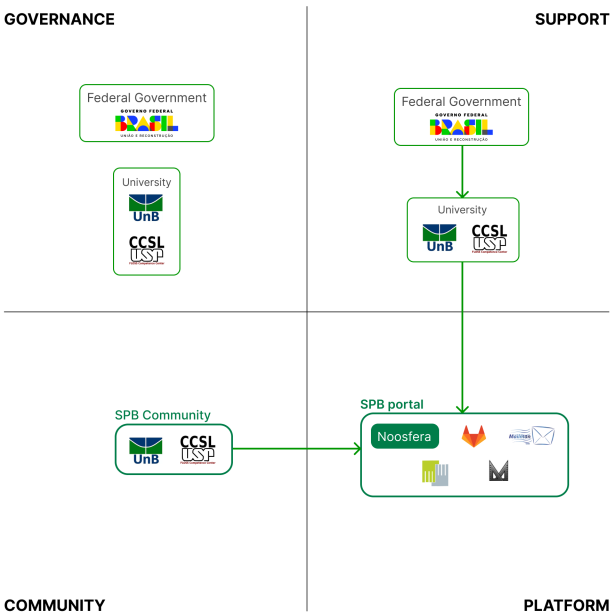

Figura 2 – SPB project described across four main topics related to open source community.

With the University orchestrating this entire ecosystem, one of the main benefits was improving communication between government stakeholders and the University. In this model, the government began to collaborate in the day-to-day running of the project, sharing a common understanding of the process, maintaining a high-level view of the project. In addition, the laboratories implement CI/CD, automation in the pipeline, improving productivity and quality of the product. These actions of bringing the government closer to academia overcame the government bias toward the low productivity of collaborative projects with academia that existed at that time (WEN et al., 2020; SIQUEIRA et al., 2018).

Engaging professionals from the open-source community provided instrumental in achieving rapid development progress and community engagement, particularly when government resources were readily available. However, this approach led to a project dependency on the University and its pool of developers, hindering efforts to expand the community, as underscored by (ARP et al., 2018). Finally, when government resources ceased, the community struggled to sustain itself due to a lack of diversity among vendors, clients, and collaborators, revealing the critical need for a more balanced ecosystem. Even though this project was a success, promoting an innovation linked to DevOps that simultaneously emerged and won over practitioners, there was a lack of investing in the

growth and diversity of the community, with the discontinuity of Noosfero and Mezuro communities in the following years.

3.2 Model II - University doing Innovation and community trainning

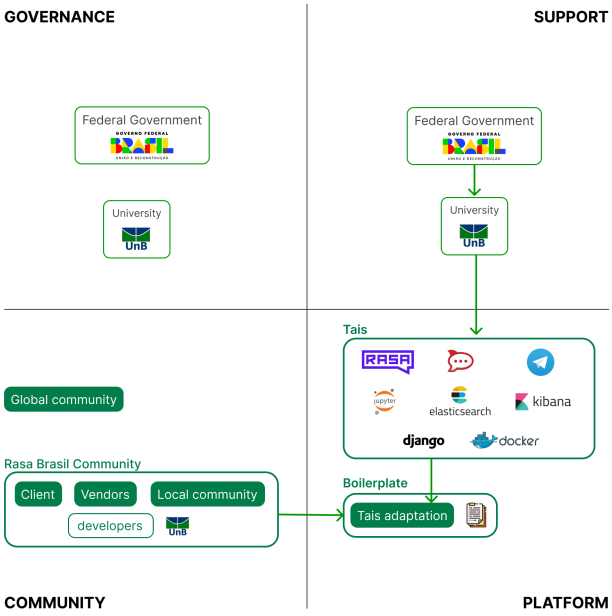

Figura 3 – Tais project described across four main topics related to open source community.

Salic Interactive Learning Technology (TAIS) is a chatbot designed to assist citizens in gaining a better understanding of the Cultural Incentive Law and to address frequently asked questions related to Brazil's primary cultural funding mechanism, the Rouanet Law. It also supports navigating the Access System to Cultural Incentive Laws (Salic) and accessing the Rouanet Law Portal. With a strong emphasis on research and technological innovation, this collaborative government-university project aimed to create a local community while developing features that cater to the needs of the federal government. Consequently, it fosters the growth of a Rasa Brasil community, boasting over 300 practitioners.

Figure 3 provides an overview of the project's ecosystem, which has yielded a boilerplate framework still in use by the community. The university shares project governance with the Federal Government as in the previous model. They collaboratively define product requirements, allocate resources, and promote community growth. Drawing from previous project experiences, this ecosystem endeavors to forge a community of stakeholders interested in the project, particularly those looking to utilize Rasa.

One of the project's core requirements was based on existing OSS, developed in partnership with government technical and non-technical staff who would later oversee the project's maintenance. Accordingly, a Rasa boilerplate was crafted on the technical front, implementing state-of-the-art NLP algorithms to bridge the research application gap. This technological advancement focuses on creating a boilerplate that promotes black-box reuse, empowering non-experts to quickly build mature FAQ chatbots in Portuguese, facilitated by comprehensive documentation, tutorials, and guidelines (LACERDA; AGUIAR, 2019). This approach has cultivated a local community comprising stakeholders, vendors, and clients.

The project's resources consist of government funding for development, along with a technical team comprising software engineers, journalists, and cultural law experts. Although initially lacking experience in chatbot development, the project's documentation, configurations, and automation were thoughtfully designed to expedite the team's learning curve, negating the need for chatbot specialists.

An incremental approach was adopted throughout the project's development, incorporating best practices from FLOSS, agile methodologies, and DevOps principles, with lessons learned from previous government-academia collaboration projects. As in the SPB project, using these techniques guaranteed improved collaboration and the relationship between the university and the government, which began to actively contribute to the day-to-day running of the project, having a broad view of the objectives and progress of the project.

However, due to its local development without a global community engagement, the project continues to be used without the broad reach needed for self-sustainability. Furthermore, the lack of interaction with the global community hinders the growth of the local community and prevents the product from being maintained and distributed to all Rasa enthusiasts. Consequently, during the project's development, various architectural decisions, such as MLOps and distinct pipelines for models and code, were implemented a few years later by the Rasa core. In this sense, if the project's governance was aligned with the Rasa core, the implementation made would also be applied to the Rasa core, avoiding rework of the core community, expanding the collaboration of the local community, and consequently gaining more strength to become sustainable without the government's contribution.

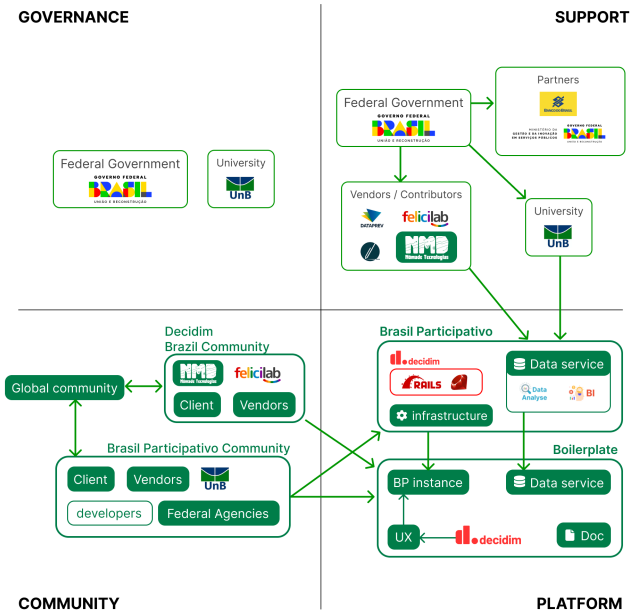

Figura 4 – Brasil Participativo project described across four main topics related to open source community.

3.3 Model III - University orchestrating the ecosystem

The Brazil Participativo[1] digital platform is a tailored version of Decidim[2], a product developed as OSS by the City of Barcelona, Spain. Decidim is a versatile tool that offers a range of customizable features for various participatory processes, spanning from soliciting ideas through to more intricate deliberation processes like Participatory Budgeting. This versatility empowers Brazil Participativo to function as a unified platform and aggregator for participatory initiatives across different federal government bodies. It leverages the gov.br[3] digital identity as the point of entry, ensuring both security and accessibility, effectively including participation in the array of digital services available to citizens.

In this model, the UnB plays a role in governance, actively collaborating with the Federal Government (see Figure 4). The university becomes the hub for scientific development and innovation of the platform's functionalities. Simultaneously, it brings a community-oriented perspective, promoting actions and directing resources for engagement and mobilization. Through incremental processes, technical support, product documentation, and conferences, the university enables scientific development and technology adoption by public organizations. It fosters the emergence of a Brazilian Decidim community aligned and connected with the Decidim core community.

1 <https://brasilparticipativo.presidencia.gov.br>
2 <https://decidim.org>
3 The "gov.br"is the domain used by the federal government of Brazil for its online presence and services.

As the Federal Government is the primary stakeholder and investor in this project, it actively supports the university's efforts in research and innovation, channeled through the university's laboratory. Another portion of the project's resources is directed towards engaging development companies like Nomade[4]. Nomade, which had already employed Decidim as a customizable element and offered it as Software as a Service (SaaS), was contracted to develop new features and manage maintenance. Furthermore, Dataprev[5], a government-owned entity responsible for Brasil Participativo's infrastructure, began to offer specialized infrastructure services for Decidim, solidifying its reputation in this context. This trend extends to other vendor and contributor companies interested in the solution. These initiatives are fundamental building blocks for nurturing a thriving community by stimulating the local market and encouraging vendor and contributor engagement.

Conversely, the university fosters the community by investing in the platform's utilization by the citizens, thus promoting the project in the local market. This can empower network with new practitioners and companies interested in the technology while encouraging community growth. The university also hosts workshops on technology to disseminate innovations to the local community and actively participates in meetings and events like Decidim Fest[6], linked to the global community, to align objectives and contributions.

Beyond active engagement with the global community, there are initiatives involving Brazilian companies and influencers who play a role in mobilizing the community to use and actively participate. The University of Brasília's innovation laboratory has hired mobilizers to work directly with the local community, promoting and empowering developers and individuals interested in the technology.

Ultimately, after years of experience, this model aims to create a community capable of boosting the local economy. What sets this project apart from previous ones is the diversity of actors and stakeholders interested in the developed technology, its direct connection to the global Decidim community and local user capable to modify and use the platform with Brazilian functionalities context. In case the federal government, the project's primary resource, reduces its support in the future, the community will sustain itself due to its existing local economy and a user base interested in the project. Moreover, it will remain actively connected and contribute to the Decidim core.

[4] <https://nomade.tec.br>

[5] <https://www.dataprev.gov.br>

[6] Conference by Decidim core community with the motto Democracy, Technology and Collective Intelligence.

4 Discussion and Conclusion

Effective management was paramount to ensure continuous deliveries. Establishing leadership roles and focal points for each technical area guaranteed that even though decisions were made collectively, the team had confidence in having support during delivery or challenging moments. Moreover, the diversity of leadership ensured that decisions were made with fewer biases from socially dominant groups. In summary:

In the Tais project, a significant outcome was the establishment of a development community for chatbots in Brazilian Portuguese. Following the conclusion of collaboration between the federal government and the university, the community persisted. The local industry adopted the technology, and to date, they continue to maintain the boilerplate, documentation, and community associated with it. However, the global community still no adopt the decisions and development made in the Brazilian local community, creating a bubble in this context that could be enriched involved other players.

Conversely, the SPB project did not cultivate a community around its initiatives, despite operating within an ecosystem rich in technology, processes, and stakeholders. The project's core developers and maintainers were exclusively funded by the government initiative, creating a dependency on the governance relationship between the university and the federal government. Consequently, following the conclusion of this funding, alternative sources were not secured, leading to limited adoption by new contributors and users.

Finally, Brasil Participativo fosters a community with two possible community scenarios: one comprised of developers who engage with the Decicim core community and the local industry, while another focused on usage within Brazilian public organizations. This approach provides a structure for community consolidation, spanning from the forefront of development to product utilization. Involving multiple player and enrich the ecosystem, create a consolidate scenario for a well growing community with different perspectives.

One significant lesson learned from our discussion is the importance of mitigating points of dependency within the ecosystem. The sustainability of the community is greatly enhanced by increasing the number and diversity of actors involved. In the case of Decidim, the presence of numerous stakeholders, including many companies interested in providing services to municipalities, underscores this point. Even if our university were to cease today, the ecosystem create a collaborative development to support and maintain the platform independently of federal government intervention. This highlights the resilience and self-sustaining nature of a diverse and inclusive community, emphasizing the value of fostering collaboration and broadening participation to ensure long-term success and

continuity. Additionally, we advocate for strengthening the connections proposed in the model and exploring new concepts to complement or replace existing ones. A particularly fruitful avenue for future research is the exploration of the various facets of OSSECO and its complexity.

Referências

ARP, L. G. et al. It takes a village: Open source software sustainability. 2018. Citado na página 24.

BERN, B. G. From theory to practice: experiences of industry-academia collaboration from a practitioner. In: *Proceedings of the 5th International Workshop on Software Engineering Research and Industrial Practice*. [S.l.: s.n.], 2018. p. 22–23. Citado na página 17.

BESTEN, M. D. et al. Collaboration and innovation dynamics in software ecosystems: A technology management research perspective. *IEEE Transactions on Engineering Management*, IEEE, v. 68, n. 5, p. 1532–1537, 2020. Citado 3 vezes nas páginas 13, 18 e 23.

BÜYÜKÖZKAN, G.; ARSENYAN, J. Collaborative product development: a literature overview. *Production Planning & Control*, Taylor & Francis, v. 23, n. 1, p. 47–66, 2012. Citado 2 vezes nas páginas 13 e 17.

CHESBROUGH, H.; SCHWARTZ, K. Innovating business models with co-development partnerships. *Research-Technology Management*, Taylor & Francis, v. 50, n. 1, p. 55–59, 2007. Citado 2 vezes nas páginas 13 e 17.

COUTINHO, E. F.; VIANA, D.; SANTOS, R. P. D. An exploratory study on the need for modeling software ecosystems: The case of solar seco. In: IEEE. *2017 IEEE/ACM 9th International Workshop on Modelling in Software Engineering (MiSE)*. [S.l.], 2017. p. 47–53. Citado na página 23.

DEDEHAYIR, O.; MÄKINEN, S. J.; ORTT, J. R. Roles during innovation ecosystem genesis: A literature review. *Technological Forecasting and Social Change*, Elsevier, v. 136, p. 18–29, 2018. Citado na página 23.

EDMONDS, W. A.; KENNEDY, T. D. *An applied guide to research designs: Quantitative, qualitative, and mixed methods*. [S.l.]: Sage Publications, 2016. Citado na página 21.

FRANCO-BEDOYA, O. et al. Open source software ecosystems: A systematic mapping. *Information and software technology*, Elsevier, v. 91, p. 160–185, 2017. Citado 5 vezes nas páginas 13, 14, 17, 18 e 23.

FREY, R. How we lead successful open-source collaborations in the danish public sector. *IEEE Software*, v. 40, n. 4, p. 19–24, 2023. Citado na página 14.

FREY, R. How we lead successful open-source collaborations in the danish public sector. *IEEE Software*, IEEE, v. 40, n. 4, p. 19–24, 2023. Citado na página 19.

HAUGE, Ø.; AYALA, C.; CONRADI, R. Adoption of open source software in software-intensive organizations–a systematic literature review. *Information and Software Technology*, Elsevier, v. 52, n. 11, p. 1133–1154, 2010. Citado na página 13.

KATSAMAKAS, E.; XIN, M. Open source adoption strategy. *Electronic Commerce Research and Applications*, Elsevier, v. 36, p. 100872, 2019. Citado na página 13.

KOURTESIS, D. et al. Software co-development in the era of cloud application platforms and ecosystems: the case of cast. In: SPRINGER. *Collaborative Networks in the Internet of Services: 13th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2012, Bournemouth, UK, October 1-3, 2012. Proceedings 13*. [S.l.], 2012. p. 196–204. Citado na página 13.

LACERDA, A. R. de; AGUIAR, C. S. Floss faq chatbot project reuse: how to allow nonexperts to develop a chatbot. In: *Proceedings of the 15th International Symposium on Open Collaboration*. [S.l.: s.n.], 2019. p. 1–8. Citado na página 26.

LINÅKER, J. et al. Open source software in the public sector: 25 years and still in its infancy. *IEEE Software*, IEEE, v. 40, n. 4, p. 39–44, 2023. Citado na página 14.

LUNGU, M. et al. The small project observatory: Visualizing software ecosystems. *Science of Computer Programming*, Elsevier, v. 75, n. 4, p. 264–275, 2010. Citado 2 vezes nas páginas 13 e 18.

MANIKAS, K. Revisiting software ecosystems research: A longitudinal literature study. *Journal of Systems and Software*, Elsevier, v. 117, p. 84–103, 2016. Citado na página 13.

MANIKAS, K. Supporting the evolution of research in software ecosystems: Reviewing the empirical literature. In: SPRINGER. *Software Business: 7th International Conference, ICSOB 2016, Ljubljana, Slovenia, June 13-14, 2016, Proceedings 7*. [S.l.], 2016. p. 63–78. Citado na página 18.

MARIJAN, D.; GOTLIEB, A. Lessons learned on research co-creation: making industry-academia collaboration work. In: IEEE. *2020 46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*. [S.l.], 2020. p. 272–275. Citado 2 vezes nas páginas 17 e 19.

MARIJAN, D.; SEN, S. Industry–academia research collaboration and knowledge co-creation: patterns and anti-patterns. *ACM Transactions on Software Engineering and Methodology (TOSEM)*, ACM New York, NY, v. 31, n. 3, p. 1–52, 2022. Citado na página 14.

RUNESON, P.; MINÖR, S.; SVENÉR, J. Get the cogs in synch: time horizon aspects of industry–academia collaboration. In: *Proceedings of the 2014 international workshop on Long-term industrial collaboration on software engineering*. [S.l.: s.n.], 2014. p. 25–28. Citado na página 17.

SHARP, H.; DITTRICH, Y.; SOUZA, C. R. D. The role of ethnographic studies in empirical software engineering. *IEEE Transactions on Software Engineering*, IEEE, v. 42, n. 8, p. 786–804, 2016. Citado na página 21.

SILVA, D. G.; COUTINHO, C.; COSTA, C. J. Factors influencing free and open-source software adoption in developing countries—an empirical study. *Journal of Open Innovation: Technology, Market, and Complexity*, Elsevier, v. 9, n. 1, p. 21–33, 2023. Citado na página 13.

SIQUEIRA, R. et al. Continuous delivery: Building trust in a large-scale, complex government organization. *IEEE Software*, IEEE, v. 35, n. 2, p. 38–43, 2018. Citado na página 24.

SáNCHEZ, V. R. et al. Open source adoption factors—a systematic literature review. *IEEE Access*, v. 8, p. 94594–94609, 2020. Citado na página 13.

WEN, M. et al. Floss project management in government-academia collaboration. In: SPRINGER. *Open Source Systems: Enterprise Software and Solutions: 14th IFIP WG 2.13 International Conference, OSS 2018, Athens, Greece, June 8-10, 2018, Proceedings 14*. [S.l.], 2018. p. 15–25. Citado na página 22.

WEN, M. et al. Leading successful government-academia collaborations using floss and agile values. *Journal of Systems and Software*, Elsevier, v. 164, p. 110548, 2020. Citado 5 vezes nas páginas 13, 14, 17, 18 e 24.

YIN, R. K. *Case study research and applications*. [S.l.]: Sage Thousand Oaks, CA, 2018. v. 6. Citado na página 21.