



The crosscutting impact of the AOSD Brazilian research community

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ABSTRACT

Background: Aspect-Oriented Software Development (AOSD) is a paradigm that promotes advanced separation of concerns and modularity throughout the software development lifecycle, with a distinctive emphasis on modular structures that cut across traditional abstraction boundaries. In the last 15 years, research on AOSD has boosted around the world. The AOSD-BR research community (AOSD-BR stands for AOSD in Brazil) emerged in the last decade, and has provided different contributions in a variety of topics. However, despite some evidence in terms of the number and quality of its outcomes, there is no organized characterization of the AOSD-BR community that positions it against the international AOSD Research community and the Software Engineering Research community in Brazil.

Aims: In this paper, our main goal is to characterize the AOSD-BR community with respect to the research developed in the last decade, confronting it with the AOSD international community and the Brazilian Software Engineering community.

Method: Data collection, validation and analysis were performed in collaboration with several researchers of the AOSD-BR community. The characterization was presented from three different perspectives: (i) a historical timeline of events and main milestones achieved by the community; (ii) an overview of the research developed by the community, in terms of key challenges, open issues and related work; and (iii) an analysis on the impact of the AOSD-BR community outcomes in terms of well-known indicators, such as number of papers and number of citations.

Results: Our analysis showed that the AOSD-BR community has impacted both the international AOSD Research community and the Software Engineering Research community in Brazil.

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1. Introduction

The emergence of a new research area is often closely associated with problems and challenges faced by a relatively stable community of practitioners and practices. Researchers depart from well-established concepts and techniques to explore unknown

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territories and to discover new avenues that may lead to promising solutions to existing problems. This is certainly a valid common ground for research on Aspect-Oriented Software Development (AOSD) (Filman et al., 2005).

AOSD is a new development paradigm that aims to promote advanced separation of concerns and modularity throughout the software development lifecycle. AOSD has emerged on the shoulders of successive generations of software development paradigms, each of them adhering to fundamental principles such as separation of concerns (Dijkstra, 1976) and modularity (Parnas, 1972), and supported by programming languages, development methods, practices, tools, body of knowledge, and community. In scenarios of increasing complexity and unavoidable need for change, the general goal of these paradigms has been to support the development of software solutions to real-world problems, in a way that promotes internal quality attributes such as understandability, ease of change and reuse of software artifacts.

The *object-oriented* (OO) paradigm has played the role of the dominant development technology for the last two or three decades, with broadly recognized benefits. While the OO paradigm overcomes the limitations of previous paradigms to modularize concerns with respect to their support for encapsulation, information hiding (Parnas, 1972), and polymorphism (Cardelli and Wegner, 1985), it faces its own limitations for modularizing concerns that address global constraints and systemic properties, such as synchronization, persistence, error handling, logging mechanisms, among many others. In fact, these limitations and difficulties to modularize certain dimensions of concerns may not be specific to OO, but rather be part of a general problem that has been coined “The Tyranny of Dominant Decomposition” (Tarr et al., 1999).

Concerns that are difficult to modularize have been called *crosscutting concerns* (CCCs) since they naturally cut across the boundaries of modular units that implement other concerns. Without proper means for separation and modularization, crosscutting concerns tend to be scattered over a number of modular units and tangled up with other concerns, throughout software development activities and across different artifacts. The natural consequences are lower cohesion and stronger coupling between modular units, and reduced degrees of comprehensibility, evolvability, and reusability of software artifacts.

In the last 15 years, research on AOSD has boosted around the world, with initial focus on programming languages and tools (Tarr et al., 1999; Aksit et al., 1994; Bergmans and Aksit, 2001; Harrison and Ossher, 1993; Lieberherr, 1996; Lieberherr et al., 2001; Kiczales et al., 1997, 2001; Ossher and Tarr, 2001; Lopes, 2005). In the last decade, the focus has shifted towards different software development activities (Filman et al., 2005). Recently, research on AOSD has broadened its goals to address software modularity in general, yet with a distinctive emphasis on modular structures that cut across traditional abstraction boundaries (AOSD, 2011).

The AOSD-BR research community (AOSD-BR stands for AOSD in Brazil) emerged in the last decade, and has contributed to several Software Engineering (SE) research areas, including requirements engineering, analysis and design, languages, implementation methods and techniques, modeling, testing, tools, and assessment. In the last few years, this community has been involved in collaborative research networks, inside and outside Brazil, has published a number of papers in several top SE conferences,¹ and has educated a new generation of researchers.

¹ By top SE conferences, we mean conferences broadly recognized as major SE venues. The conferences we considered are listed in Section 4.2.1.

Our previous work (Chavez et al., 2011)² provided a preliminary characterization of the research developed by the AOSD-BR community in the last decade and presented initial evidence about the impact of the AOSD-BR research outcomes. However, there was no comprehensive analysis of such outcomes against those of related counterparts, for instance, the international AOSD research community and the Brazilian SE research community. Moreover, the characterization of the overall contributions of the AOSD-BR research, with respect to existing research challenges, open issues and related work, could be enhanced.

In this paper, our main goal is to characterize the AOSD-BR community with respect to the research developed in the last decade, confronting it with the AOSD international community and the Brazilian Software Engineering community. This work extends the scope, refines and organizes our previous characterization (Chavez et al., 2011), providing improved analysis of the research outcomes and lessons learned from the AOSD-BR research community.

Three research questions were defined to drive our characterization of the AOSD-BR research community achievements and detailed comparisons:

- (i) What is the impact of the research developed by the AOSD-BR community compared to that of the international AOSD research community?
- (ii) What is the impact of the research developed by the AOSD-BR community compared to that of the Brazilian SE community in the international context?
- (iii) What is the impact of the research developed by the AOSD-BR community compared to that of the Brazilian SE community in the national context?

The expected contributions of this work are threefold. Firstly, the documented knowledge about the creation of the AOSD-BR research community and initiatives that promoted its evolution can be generalized to serve as a roadmap for researchers willing to foster new research areas and communities around the world. Second, the enhanced, general characterization of the state-of-the-art in some areas of AOSD can be useful for young researchers that are starting their research on AOSD, by unveiling, for instance, topics that have not been properly exploited yet. It can attract new researchers and fundings for the area as well. Finally, those interested in academic collaboration with Brazilian researchers can benefit from our characterization of the state-of-the-art of AOSD-BR research, to identify research groups, their main publications, and opportunities for collaboration.

This paper is structured as follows. Section 2 presents, in more detail, the AOSD-BR research community timeline, highlighting important events and initiatives, such as the inception and organization of the 1st Brazilian Workshop on AOSD (WASP), held in 2004, and the organization of the 10th International Conference on AOSD in Brazil, held in 2011, among others.

Section 3 presents an overview of the research work developed by AOSD-BR community in several prominent SE areas. For each research area, we highlight some key challenges, describe briefly how they have been addressed by the AOSD-BR community and related research conducted by the international community, and finally, point out some open issues.

Section 4 presents a discussion on the growth, impact, and quality of the AOSD-BR research outcomes in terms of several indicators, such as the number of publications in journals and conferences over the last decade, the number of papers published in top international

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