



# A categorization scheme for software engineering conference papers and its application

Antonia Bertolino<sup>a</sup>, Antonello Calabrò<sup>a</sup>, Francesca Lonetti<sup>a,\*</sup>, Eda Marchetti<sup>a</sup>, Breno Miranda<sup>a,b</sup>

<sup>a</sup> ISTI - CNR, Via Moruzzi 1, Pisa 56124, Italy

<sup>b</sup> Federal University of Pernambuco, Recife-PE 50740-540, Brazil

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## ABSTRACT

**Background:** In Software Engineering (SE), conference publications have high importance both in effective communication and in academic careers. Researchers actively discuss how a paper should be organized to be accepted in mainstream conferences.

**Aiming:** This work tackles the problem of generalizing and characterizing the type of papers accepted at SE conferences.

**Method:** The paper offers a new perspective in the analysis of SE literature: a categorization scheme for SE papers is obtained by merging, extending and revising related proposals from a few existing studies. The categorization scheme is used to classify the papers accepted at three top-tier SE conferences during five years (2012–2016).

**Results:** While a broader experience is certainly needed for validation and fine-tuning, preliminary outcomes can be observed relative to what problems and topics are addressed, what types of contributions are presented and how they are validated.

**Conclusions:** The results provide insights to paper writers, paper reviewers and conference organizers in focusing their future efforts, without any intent to provide judgments or authoritative guidelines.

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## 1. Introduction

Writing good papers is an indispensable part of a researcher's activity. It is thanks to the publication of research results that collective knowledge grows and science advances. Writing good scientific papers is difficult, though. Within many research fields, this is acknowledged and expert guidance is provided on how to structure a paper content and how to articulate its parts, e.g. (Nwogu, 1997; Ruiying and Allison, 2004).

Differently from other disciplines, papers in peer-reviewed conference proceedings constitute an important portion of the SE literature. Very different types of papers are presented at SE conferences: some propose new approaches or theories, other describe empirical studies; some papers focus on industrial experiences, other propose new conceptual frameworks for investigating SE problems; and so on.

However, to date there is not a shared good practice of reporting the various types of SE research, and different writing and reviewing patterns emerge within different conferences. A common taxonomy and more precise guidelines on how to write the different types of articles (Stol and Fitzgerald, 2015; Montesi and Lago, 2008) should be established within the broad SE community. Such taxonomy and guidelines could help conference organizers in more explicitly describing the type of submissions they expect and in clearly reflecting the conference scope in the call for papers. It could also help in defining common criteria for evaluating the different types of submissions, thus making the review process less dependent from the personal expertise and understanding of the reviewers in the SE field. As an example, Wieringa et al. (2005) provide a paper classification scheme and evaluation criteria for papers belonging to Requirements Engineering discipline.

In 2003 (Shaw, 2003), Shaw noted that researchers in SE had not yet developed well-understood guidelines for paper writing. Her seminal work provides a *minitutorial* with insightful advice on how results in SE research should be reported. Moreover, based on the papers submitted and accepted to one edition of the International Conference on Software Engineering (ICSE), she identi-

\* Corresponding author.

E-mail addresses: [antonia.bertolino@isti.cnr.it](mailto:antonia.bertolino@isti.cnr.it) (A. Bertolino), [antonello.calabro@isti.cnr.it](mailto:antonello.calabro@isti.cnr.it) (A. Calabrò), [francesca.lonetti@isti.cnr.it](mailto:francesca.lonetti@isti.cnr.it) (F. Lonetti), [eda.marchetti@isti.cnr.it](mailto:eda.marchetti@isti.cnr.it) (E. Marchetti), [bafm@cin.ufpe.br](mailto:bafm@cin.ufpe.br) (B. Miranda).

fied the elements that should form a good SE research paper and the SE research strategies that emerged from the combination of those elements. Shaw's paper is widely referenced and some other authors have analogously conducted literature analyses to identify SE research strategies and paper types (Stol and Fitzgerald, 2015; Montesi and Lago, 2008; Glass et al., 2002; Zelkowitz and Wallace, 1997).

However, to the best of our knowledge there have been no follow up from Shaw's paper<sup>1</sup>, neither in terms of reviewing and possibly revising her proposed classification of paper elements, nor in terms of matching the presented guidelines against other sets of SE papers.

The study of research methods and practices is the scope of *meta-research*, or "research on research". Meta-research has now established itself as a scientific discipline that attracts growing interest also thanks to the opportunities of analyses offered by the on-line availability of publications, reports and data. Ioannidis et al. (2015) categorize the meta-research discipline into five main thematic areas, namely: Methods, Reporting, Reproducibility, Evaluation, and Incentives, corresponding to "how to do, report, verify, correct, and reward science" Ioannidis et al. (2015).

This paper contributes to meta-research in SE, focusing on how research in the software engineering (SE) field is or should be reported in the context of scientific conferences. The work includes two parts: first we propose a *paper categorization scheme* aiming at identifying a "paper model" that is comprehensive of the article genres published in the SE field, by extending and revising the types of papers and definitions identified in relevant previous studies of SE literature, specifically Shaw (2003); Montesi and Lago (2008); Glass et al. (2002); Zelkowitz and Wallace (1997). This categorization scheme includes four main dimensions that are: *problem*, *contribution*, *validation* and *topic* and provides a classification for each of them. Examples of papers types according to the proposed classifications are also presented.

Then, we use the proposed categorization scheme to classify papers from three SE conferences, namely: i) ICSE that was the subject of Shaw's study (Shaw, 2003); ii) the International Conference on Automated Software Engineering (ASE); and iii) the Symposium on the Foundations of Software Engineering (FSE). Note that every other year FSE is run jointly with the European Software Engineering Conference (ESEC); in the paper for simplicity we refer to the latter as FSE, intending both FSE and ESEC-FSE depending on the year. Specifically, we study the papers published at ASE, FSE and ICSE in five editions (2012–2016), discuss their classification according to the proposed scheme and comment on possible emerging patterns. We mention that an outline of the scheme is already presented in Bertolino et al. (2017). This short work, however, only considered ICSE papers.

We believe that examining what types of papers are accepted at the three above conferences against the resulting categorization scheme is informative because they represent three top-tier publication venues in the field that are recognized by the SE community as very exigent in terms of what is required in a research paper. Our study can thus contribute to better understand how research in SE is reported and to possibly identifying gap in research communication.

The main contributions can be summarized as:

- a categorization scheme for SE conference papers that evolves and merges those presented in Shaw (2003); Glass et al. (2002); Montesi and Lago (2008); Zelkowitz and Wallace (1997);

- the classification of the ASE, FSE and ICSE papers published in five editions according to the proposed scheme;
- a discussion of patterns and trends emerging from the study, and also conclusions on future work needed to improve and refine the scheme.

The paper is structured as follows: in the next section we overview related work. In Section 3 we put this work in context by introducing the notion of paper type or *genre*; then, in Section 4 we describe the categorization scheme. In Section 5, we present the application of the proposed categorization scheme to the papers of ASE, FSE and ICSE. Results are reported in Section 6 and interesting findings are further discussed in Section 7 that also concludes the paper.

## 2. Related work

Our work performs a secondary study of SE research, to identify paper types and patterns. Most closely related work include:

*Secondary studies addressing similar goals.* In searching recent related work, we made a quasi-systematic search by snowballing forward and backward from Shaw's minitutorial, but did not find many relevant papers. More interestingly, Glass and coauthors in (Glass et al., 2002) report findings from the study of a sample of articles published from 1995 to 1999 in six journals. Similarly to us, they used a top-down approach for categorization, among other things, of topics, research approach and research method. However, their scheme is more general and addresses three computing disciplines: SE, Information Systems and Computer Science. The goals and approach of the study are similar to ours, however the examined corpus and the categorization scheme are different.

More recently, Montesi and Lago (2008) also propose a classification of SE paper types. Differently from us, they derive a paper type classification mainly based on the call for papers of major SE conferences, the relevant papers, the SE journals included in the Journal Citation Reports and the instructions to authors of other relevant journals not included in the list of the Journal Citation Reports.

In (Stol and Fitzgerald, 2015) Stol and Fitzgerald observe that the field of SE lacks a holistic view of a more complete spectrum of research methods, beyond those for empirical research that have drawn increasing attention. They thus introduce a framework for positioning SE research strategies (adapting the "circumplex" model originally proposed for analysis of behavioral systems Runkel and McGrath (1972)), however they do not consider paper types, but research strategies.

Finally, Wieringa et al. (2005) propose a paper classification that differently from our proposal specifically targets Requirement Engineering papers. Moreover, their goal is to define a set of evaluation criteria for different paper classes.

*Secondary studies addressing different goals.* Several studies restrict the analysis of research strategies to more specific types of papers. For example, Sjöberg et al. (2005) survey SE papers in nine journals and three conferences (including ICSE) but with the aim of characterizing only controlled experiments. Zelkowitz and Wallace (1997) make a classification of SE papers of a journal, a magazine and ICSE proceedings limited to three different years. Differently from our proposal, they classify papers only according to the type of SE experimentation.

In (Zannier et al., 2006), Zannier and coauthors performed an empirical study to assess whether quantity and quality of empirical evaluations conducted within ICSE papers had improved along the years. They compared a stratified random sample (of 5%) of papers in the periods (1975–1990) and (1991–2005): they found that

<sup>1</sup> For completeness we mention that after this paper's submission we have assisted at a presentation given at ICSE 2017 from a work in preparation by Theisen and coauthors Theisen et al. (2017) that replicates that study on ICSE 2016.

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