Systematic Literature Reviews in Global Software Development: A Tertiary Study

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Abstract—**Context: There has been an increase in research into global software development (GSD) and in the number of systematic literature reviews (SLRs) addressing this topic.**
Objective: The aim of this research is to catalogue GSD SLRs in order to identify the topics covered, the active researchers, the publication vehicles, and to assess the quality of the SLRs identified.
Method: We performed a broad automated search to find SLRs dealing with GSD. We differentiate between SLR studies and papers reporting those studies. Data relating to each of the following was extracted and synthesized from each study: authors and their affiliation at the time of publication, the journal or conference in which the paper was published, the quality of each study and the main GSD study topic.
Results: Twenty-four GSD SLR studies and 37 papers reporting those studies were identified. Major GSD topics covered include: (1) organizational environment, (2) project execution, and (3) project planning and control. The main research groups are based in Brazil (17), Ireland (8), and Sweden (7).
Conclusions: GSD SLR studies are most frequently reported in the International Conference on Global Software Engineering and IEEE Software; the two most popular topics for research are risk factors due to the organizational environment and the development process. The most active researchers are based in Brazil. The quality of the SLR studies has not changed over time.

Keywords-global software development; systematic review; tertiary review; distributed development; mapping study;

1. INTRODUCTION

The software development paradigm is changing with the increasing use of GSD (also termed distributed software development, or distributed software engineering). GSD is used to describe one or more of the following situations: organizations that have shifted all or part of their software development offshore to lower cost destinations, or to destinations where the required skills are more readily available, or organizations that have distributed their software development activities across multiple sites which are in different countries, e.g., IBM, Bosch, and Siemens [3]. Software may be developed globally by an organization to use itself, or to sell, or to incorporate into a device that the company sells (in-sourcing), e.g., Siemens. A client company may outsource software development to a vendor who then develops the required software for the client (outsourcing). The vendor may be located in the same country or in a different country (GSD). GSD projects are often large-scale, and global development leads to significantly increased complexity; GSD complexity leads to increased risk. Offshore projects tend to be unsuccessful, because "physical, time, cultural, organizational, and stakeholder distances negatively influence communication and knowledge exchange between onshore and offshore project team members" [10]. When a software project is developed in multiple countries, the vendor project manager must address additional execution risks, including those related to project distribution, time zone differences, communication, coordination and control issues, project contextual issues, and infrastructure [4, 11, 12]. Suggestions have been made that a 50% failure rate is not uncommon [18]. Research into GSD is escalating and a conference (ICGSE), dedicated to GSD issues, commenced in 2006.

Research into GSD is expanding and systematic literature reviews (SLRs) are increasingly used to organize the literature. The SLR is a way of synthesising existing research by following a rigorous, pre-defined procedure aimed at reducing bias. Guidelines for applying SLRs within software engineering have been developed [17] and a number of SLRs on software engineering and related topics have been published. A systematic mapping study, or mapping study, is a form of SLR that aims to address a broader set of research questions in order to provide a 'map' of a particular topic area by investigating, for example, the number of papers published on the topic per year and where the papers are most frequently published [17]. Studies which synthesize data and information from a number of SLRs in a particular area are called tertiary studies. Tertiary mapping studies are used to provide information about how many SLRs are available in a particular area, where they are published, what topics they address and their overall quality; recent tertiary SLRs in software engineering include [5, 7, 8, 15, 16].

The research described here is a tertiary study investigating SLRs in global software development; it is a mapping study intended to provide an overview of research in GSD. It is the first step in an EU funded research project to provide evidence-based risk advice to GSD project managers. A tertiary SLR provides us with a general understanding of GSD research before we begin the next phase of the research. While there are some

tertiary software engineering SLRs [e.g., 5, 7 15, 16], there are none specifically in GSD.

We define our research questions as:

RQ1 What SLR studies have been published in the area of GSD?

RQ2 Where were they published?

RQ3 What GSD research topics are addressed?

RQ4 What are the limitations of the SLRs in the research area?

RQ5 Which researchers are most active in GSD SLRs and where are they located?

RQ6 What is the quality of the studies and is quality changing over time?

Note in this study we use the term "SLRs" to include both conventional SLRs and mapping studies. In the next section we describe our research methodology; in Section III we present our results. Section IV discusses the limitations of our research while Section V presents our conclusions.

II. RESEARCH METHODOLOGY

A SLR of any kind is a method of "identifying, evaluating and interpreting all available research relevant to a particular research question or topic area or phenomenon of interest" [17]. The aim is to synthesize existing evidence in a fair, rigorous, and open manner. After specifying research questions a review protocol is developed; this includes definitions of: (1) the search process, including search strings and other search criteria, (2) inclusion and exclusion criteria, (3) the selection process, (4) quality assessment, (5) the data extraction process, and (6) data synthesis.

1. Search Process

A broad search process, combining automated and manual searches to increase coverage, was conducted to identify peer-reviewed articles published (or available on-line) up to October 2011. The search process used seven search engines and indexing systems, i.e., ACM Digital library, IEEE Explore, Scopus, Science Direct, Web of Knowledge, SpringerLink and Google Scholar. Manual searches of the Proceedings of the IEEE ICGSE, and Proceedings of the Conference on Evaluation and Assessment in Software Engineering (EASE) were conducted; in addition bibliographies of all selected papers were scanned for additional papers (snowballing).

Search terms used were ((global OR distributed OR outsourc* OR offshor*) AND (software engineering OR software development OR software production) AND (review of studies OR structured review OR systematic review OR literature review OR systematic literature review OR literature analysis OR in-depth survey OR literature survey OR meta-analysis OR analysis of research OR empirical body of knowledge OR overview of existing research OR body of published knowledge)). Adjustments as necessary were made to fit the syntax of the search engines used.

Coverage of the search terms was checked against papers describing GSD included in [7].

2. Inclusion/Exclusion criteria

Articles were included if they:

- Reported SLRs or meta-analyses in GSD and were written in English
- Were published in, or submitted to, a conference or journal or were technical reports or book chapters

Articles related to the following were excluded:

- Masters and PhD studies not published in refereed conferences or Journals
- Informal literature surveys (no defined search questions, no search process, no defined data extraction or data analysis process)
- Papers discussing the process of performing SLRs, or meta-analyses
- SLRs relating to topics such as evaluating installed systems and applications, open source software development, IT services, software applications and IT operations, and teaching and education.

3. Paper Selection

Papers resulting from the automated and manual searches were evaluated by one researcher who, after considering the title and if required, the abstract of the papers, rejected all papers that were obviously not relevant. This resulted in 115 potentially relevant papers. The same researcher read the abstract and conclusion of the selected papers and, based on the inclusion and exclusion criteria, selected 69 papers that appeared to be relevant. Each of these papers was then read by another member of the team and only those papers that both researchers considered relevant were included. This resulted in 35 papers considered appropriate for inclusion. We reference papers included in our study and listed in Table 1 with an S and a study number, e.g., [S12]. If there is more than one paper reporting the same study we follow this with a letter referring to the particular paper, e.g., [S12b]. Snowballing resulted in identification of two additional papers not retrieved earlier, making 37 papers in all. These two papers were not refereed, though we considered them relevant to our research. One was a technical report [S23], and the other was a paper that had been submitted to a journal but had not yet been accepted [S5a].

4. Quality assessment

To answer RQ6 each SLR was evaluated for quality using the York University DARE Criteria (DARE) [6]. The criteria are based on five questions and were scored as follows:

- *Inclusion/exclusion criteria*

Y (yes), the inclusion criteria are explicitly defined in the study, score 1; P (partly) the inclusion criteria are implicit, score 0.5; N (no), the inclusion criteria are not defined and cannot be readily inferred, score 0.

- *Adequacy of search*

Y, the authors have either searched 4 or more digital libraries and included additional search strategies or identified and referenced all journals addressing the topic of interest, score 1; P, the authors have searched 3 or 4 digital libraries with no extra search strategies or they searched a defined but restricted set of journals and conference proceedings, score, 0.5; N, the authors have searched up to 2 digital libraries or an extremely restricted set of journals, Score 0.

- *Synthesis method*

Y, an explicit synthesis method is named and a reference to the method is supplied, score 1; P. A research method is named but no reference to the method is supplied, score 0.5 N. No synthesis method is named; score 0.

- *Quality criteria*

Y, the authors have explicitly defined quality criteria and extracted them from each primary study, score 1; P, the research question involves quality issues that are addressed by the study, score 0.5; N, no explicit quality assessment of individual primary studies has been attempted or authors have defined quality criteria but not used criteria, score 0.

- *Information provided about primary studies*

Y, Information is presented about each primary study; score 1; P, only summary information is presented about papers, score 0.5; N, the results of the individual studies are not specified, score 0.

These are the same criteria used in [15], except that we have included an additional criterion (3) synthesis method, as the DARE criteria were updated in 2008 to include synthesis methods [6]. Although we collected data on the synthesis method used and discuss synthesis briefly in our results, we have omitted synthesis from our quality scores in Table 1 as we did not wish to penalize papers that were written before DARE added this criterion. As noted earlier we reviewed the papers we selected against those that had been found in previous tertiary studies that included GSD SLRs [7, 15, 16]. We found all the GSD papers in [7, 15] but no additional papers for the particular time periods. We did however find several papers that were not included in [16], (e.g. [S1a, S1b, S9, S24]). This is not surprising as [16] used a very different manual search strategy that looked at specific journals and conferences from 2004-2007.

5. Data extraction

The title of the papers, authors' names, their affiliations, and publication venues were extracted by the first author (RQ1, RQ2, RQ5). A data extraction form was provided to each of the researchers. The first author extracted data for all of the papers and data was also extracted from each paper by one of the other researchers and the results were compared; the following details were extracted:

- Type of study: meta analysis, SLR, or mapping study (RQ1)
- Main GSD topic (RQ3)
- Research questions explored (RQ3)
- The number of primary studies included in the SLR (RQ1)
- Whether the SLR was unique; i.e., had the same group of authors reported the study in more than one paper (RQ1).

Any disagreements were resolved by discussion or by a third researcher independently extracting the data. We were particularly interested to identify SLR studies that were reported in more than one of the selected papers. As part of the data extraction the first author reviewed all papers in order to identify multiple papers, with similar authors reporting aspects of the same study; another researcher independently reviewed all papers written by similar groups of researchers.

6. Data synthesis

Most of the data was aggregated using simple counts and percentages. In all, our 37 papers reported on 24 unique SLR studies. We considered it important not to reject papers by the same authors reporting on the same study as we are aware that conference paper space limitations do not always allow researchers to report all their results in a single paper. When we discuss a SLR study reported in more than one paper, we extracted data from the paper that provided the most details of the study (often a journal paper). To answer RQ4 we used thematic analysis [20] and mapped the main topic of each study against both SWEBOK [13] and PMBOK [14]. The first researcher then mapped the topics against Abdullah and Verner's outsourcing risk framework [1] and the ISO 12207 framework [19] used by [S11]. This framework comprises three main lifecycle process areas (primary, organizational and supporting); each process area has several sub-processes that comprise a number of tasks.

III RESULTS

This section reports the results in relation to each of the research questions.

RQ1 What SLR studies have been published in the area of GSD? In Table 1 we organize our results by SLR study, and list each of the papers describing the study.

Table 1: GSD SLR Studies and papers reporting those studies

Study	No of Studies	Quality	Paper	Reference
S1	unknown	1.5	**a**	**Ågerfalk P. J., B., Holmström H., Lings B., Lundell B., Conchúir E.Ó.,** (2005) "A Framework for Considering Opportunities and Threats in Distributed Software Development" Proceedings of the International Workshop on Distributed Software Development, Austrian Computer Society, p.p 47-61.
			b	**Lings B., Lundell B., Agerfalk P., and Fitzgerald B.,** (2006) "Ten strategies for successful distributed development", *The Transfer and Diffusion of Information Technology for Organizational Resilience,* Springer*, pp. 119-137.*
S2	25	1.5		**Ali, N., Beecham, S., Mistrík, I.,** (2010) "Architectural knowledge management in global software development: A review" *Proceedings of the 5th International Conference on Global Software Engineering, ICGSE*, pp. 347-352.
S3	315	1.5		**Alsudairi M, Dwivedi Y. K.,** (2010) "A multi-disciplinary profile of IS/IT outsourcing research*" Journal of Enterprise Information Management,* Vol. 23 Iss: 2, pp.215 - 258.
S4	25	2.5		**Costa C., Cunha C., Rocha R., Franca A., da Silva F., Prikladnicki R**., (2011) "Models and tools for Managing Distributed Software Development: A systematic literature review" *Proceedings of EASE.*
S5	70	3	a	**da Silva F. Q. B., Prikladnicki R., França A. C. C., Monteiro C. V. F., Costa C., Rocha R**., (2011) "Research and Practice of Distributed Software Development Project Management: A Systematic Mapping Study" submitted to *Information and Software Technology*
			b	**da Silva F.Q.B., Prikladnicki R., França A., Monteiro, Costa C., Rocha R.,**(2011) "An evidence-based model of distributed software development project management: results from a systematic mapping study", *Journal of Software Maintenance and Evolution: Research and Practice* (on line).
			c	**da Silva F.Q.B., Costa C., França A.C.C., Prikladnicki R.,** (2010) "Challenges and solutions in Distributed Software Development Project Management: A systematic literature review*" Proceedings of the 5th International Conference on Global Software Engineering, (ICGSE)*, pp. 87-96.
S6	12	1.5		**Ebling, T., Audy, J.L.N., Prikladnicki, R.,** (2009) "A systematic literature review of requirements engineering in distributed software development environments" *ICEIS 2009,Proceedings of the 11th International Conference on Enterprise Information Systems,* , ISAS, pp. 363-366.
S7	24	3		**Fauzi S. S. M., Bannerman P. L., and Staples M.,** (2010) "Software Configuration Management in Global Software Development; A Systematic map" *APSEC '10 Proceedings of 2010 APSEC*, pp.404-413
S8	20	3		**Hossain E., Ali Babar M., Paik H.-Y.,** (2009) "Using scrum in global software development: A systematic literature review" *Proceedings - 2009 4th IEEE International Conference on Global Software Engineering, ICGSE*, pp. 175-184.
S9	31	2.5		**Huang H.,** (2007) " Cultural Issues in Globally Distributed Information Systems Development; A Survey and Analysis" *AMCIS Proceedings, paper 254.*
S10	77	2	a	**Jalali, S., Wohlin, C.** (2011) "Global software engineering and agile practices: a systematic review" *Journal of Software Maintenance and Evolution: Research and Practice* (on line).
			b	**Jalali, S., Wohlin, C.,** (2010) "Agile practices in global software engineering - A systematic map" *Proceedings of the 5th International Conference on Global Software Engineering, ICGSE 2010*, pp. 45-54.
S11	60	2.5	a	**Jiménez M., Piattini M., and Vizcaino A.,** (2010) "A Systematic Review of Distributed Software Development: Problems and Solutions" chapter *in Handbook of Research on Software Engineering, IGI Global and Productivity Technologies: Implications of Globalization*, pp 209-225
	69		b	**Jimenez M., Piattini M., (**2009) "Problems and solutions in Distributed Software Development: A Systematic Review" *Second International Conference on Software engineering approaches for offshore and outsourcing development*, LNIBIP Vol. 16, pp107-125.
	78		c	**Jiménez M., Piattini M., and Vizcaino** A., (2009) "Challenges and improvements in distributed software development: A systematic review" *Advances in Software Engineering.*
S12	98	2.5	a	**Khan, S.U., Niazi, M., Ahmad, R.,** (2011) "Barriers in the selection of offshore software development outsourcing vendors: An exploratory study using a systematic literature review" *Information and Software Technology*, 53 (7), pp. 693-706.
			b	**Khan, S.U., Niazi, M., Ahmad, R**., (2009) "Critical barriers for offshore software development outsourcing vendors: A systematic literature review" *Proceedings - Asia-Pacific Software Engineering Conference, APSEC*, pp. 79-86.

S13	122	2.5	a b	**Khan, S.U., Niazi, M., Ahmad, R.,** (2011) "Factors influencing clients in the selection of offshore software outsourcing vendors: An exploratory study using a systematic literature review" *Journal of Systems and Software*, 84 (4), pp. 686-699. **Khan, S.U., Niazi, M., Ahmad, R**., (2009) " Critical success factors for offshore software development outsourcing vendors: a systematic literature review" *Proceedings - 2009 4th IEEE International Conference on Global Software Engineering, ICGSE,* pp. 207-216.
S14	unknown	0.5		**Kroll, J., Luis J., Audy N., and Prikladnick R.,** (2010), Mapping the evolution of research on global software engineering: A Systematic Literature Review, *ICEIS (3) 2011:* 260-265
S15	36	2		**López, A., Nicolás, J., Toval, A.,** (2009) "Risks and safeguards for the requirements engineering process in global software development" *Proceedings - 2009 4th IEEE International Conference on Global Software Engineering, ICGSE*, pp. 394-399.
S16	26	2		**Noll J., Beecham S., Richardson I.,** (2010) "Global software development and collaboration: barriers and solutions" August, *ACM Inroads* , Volume 1 Issue 3
S17	86	1.5		**Nurdiani I., Jabangwe R., Smite D., Damian D.,** (2011) "Risk Identification and Risk Mitigation Instruments for Global Software Engineering: A systematic review and survey results" *PARIS workshop ICGSE.*
S18			a	**Persson J S., Mathiassen L.,** (2011) "A process for managing risks in Distributed teams" *IEEE Software* 27, 1. Jan-Feb., pp 20-29.
	72	3	b	**Persson J.S., Mathiassen L., Boeg J., Madsen T. S., Steinson F.,** (2009) "Managing Risks in Distributed Software Projects An Integrative framework", *IEEE TEM* Vol 56 Iss 3 August, pp 508-532.
S19	30	3	a	**Prikladnicki R., Audy, J.L.N**., (2010) "Process Models in the practice of distributed software development: A systematic review of the literature", *Information and Software Technology* Vol 52 No 8, August, pp779-791.
			b	**Prikladnicki, R., Audy, J.L.N., Shull, F**., (2010) "Patterns in effective distributed software development" *IEEE Software*, 27 (2), pp. 12-15.
			c	**Prikladnicki R., Damien D., and Audy J. L. N.,** (2008) "Patterns of evolution in the practice of distributed software development: quantitative results from a systematic review" *Evaluation and Assessment in Software Engineering (EASE)*, Bari, Italy, pp. 1–10.
S20	9	3		**Rocha R. G. C., Costa, Rodrigues C., de Azevedo R., Junior I., Meira S., Prickladnicki R.,** (2011) "Collaboration models in distributed software development a systematic review" *CLEI Electronic Journal* Vol 14 No 2, August, paper 1.
S21	59	2.5	a	**Šmite, D., Wohlin, C., Gorschek, T., Feldt, R.** (2010) "Empirical evidence in global software engineering: A systematic review" *Empirical Software Engineering*, 15 (1), pp. 91-118.
			b	**Šmite, D., Wohlin, C. ,** (2011) A whisper of evidence in global software engineering *IEEE Software*, 28 (4), pp. 15-18
			c	**Šmite D., Wohlin C., Gorschek T., Feldt R.,** (2008) "Reporting Empirical Research in Global Software Engineering: a classification scheme" *International Conference on Software Engineering (ICGSE)*
S22	42	2		**Steinmacher I., Chaves A.P., Gerosa, M.A.,** (2010) "Awareness support in global software development: A systematic review based on the 3C collaboration model" *16th International Workshop on Groupware (CRIWG*), Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), LNCS, pp. 185-201.
S23	83	2.5		**Treude C ., Storey M-A ., Weber J.,** (2009) " Empirical studies on collaboration in software development A systematic Literature Review" Review *Literature And Arts Of The Americas and Technical Report DCS-331-IR*, Department of Computer Science, University of Victoria, December.
S24	57	1.5		**Yalaho A.**, (2006) "A Conceptual Model of ICT-Supported Unified Process of International Outsourcing of Software Production," , *10th IEEE International Enterprise Distributed Object Computing Conference Workshops (EDOCW'06)*, pp.47

We found 24 studies reported in 37 papers. Fifteen studies (63%) are reported by a single paper; five studies (21%) by two papers; and four studies (17%) by three papers. Primary studies included in our SLRs studies ranged from 9 [S20] to 315 [S3] although two studies [S1, S14] did not make clear how many primary studies were included in their review. When we consider the year in which the (most complete) paper reporting the study was published, we obtain the results shown in Table 2; the first GSD SLR was published in 2005; research continued at a fairly low level until there was a marked increase in 2009, 2010 and 2011.

RQ2 Where have GSD SLRs been published? Tables 3 and 4, provide details of the publication venues for the papers describing our GSD SLR studies. Twenty papers (54%) are conference proceedings, 15 papers (41%) are journal papers (or have been submitted), while one paper appears as a book chapter, and one is a technical report. The IEEE ICGSE is the most popular conference for this research with seven papers published between 2008 and 2010. The Proceedings of ICEIS, EASE and APSEC each published two papers. Though the most popular journal for this type of paper is IEEE Software, the papers published there provide summaries of the studies aimed at practitioners rather than providing comprehensive details of the SLR. The Journal of Software Maintenance Evolution and Practice has published several special issues with extended versions of the best papers from ICGSE. It is not surprising that Information and Software Technology

provides a venue for SLR studies as it has a special section devoted to the topic. The rest of the journals are fairly scattered, though Empirical Software Engineering is represented and will be publishing a special issue that will include extended versions of the best papers from ICGSE 2012.

Table 2: Number of Studies by Year

Year	Number of studies
2005	1
2006	1
2007	1
2008	0
2009	5
2010	8
2011(until Oct)	8

Table 3: Journal/Book/Report Publication Venues for Secondary GSD SLRs

Publisher	Journal/Book/Report	Number
IEEE	Software 2010, 2011	3
	Transactions on Engineering Management 2009	1
Kluwer	Empirical Software Engineering 2010	1
Elsevier	Information and Software Technology 2010, 2011	2
	Journal of Systems and Software 2011	1
ACM	Inroads 2010	1
Wiley	Journal of Software Maintenance and Evolution: Research and Practice, 2011	2
CLEI	Electronic Journal 2011	1
Emerald	Journal of Enterprise Information Management 2010	1
Hindawi	Advances in Software Engineering 2009	1
IGI Global	Handbook of Research on Software Engineering IGI Global and Productivity Technologies: Implications of Globalization 2010	1
University of Victoria, Canada	Technical report 2009	1

RQ3 What GSD Research Topics have been addressed? The research topics addressed by our studies are shown in Table 5. When we mapped the main topic of each study against SWEBOK [13] and PMBOK [14] we discovered that the study topics were difficult to fit into either framework. Kroll et al., [S13] also mapped their studies against PMBOK and SWEBOK and noted that these frameworks do not have knowledge areas appropriate for classifying some studies. Our studies fitted better into Abdullah and Verner's outsourcing risk framework [1] even though their framework was designed for outsourced software development, not specifically GSD. We identified Vendor Selection as a topic that should be incorporated into the Abdullah and Verner outsourcing framework; we believe that with further development [1] may be useful as a risk framework for GSD projects. We mapped our study topics against the ISO 12207 framework [19] used by [S11]. This framework comprises three main lifecycle process areas (primary, organizational and supporting); each process includes several sub-processes comprising a number of tasks (see Table 5).

Table 4: Conference Venues for Secondary GSD SLRs

Publisher	Conference	Number
IEEE	Int. Conf. on Global Software Engineering (ICGSE) 2008, 2009, 2010	7
	Int. Conf. on Global Software Engineering (ICGSE) PARIS Workshop 2011	1
	International Enterprise Distributed Object Conference Workshops (EDOCW) 2006	1
Springer	Conference on Software Engineering Approaches for Offshore and Outsourcing Development (SEAFOOD) LNBIP, 2009	1
	Product-Focused Software Process Improvement (PROFES) LNCS 2010	1
	International Workshop on Groupware (CRIWG) LNCS 2010	1
	IFIP The Transfer and Diffusion of Information Technology for Organizational Resilience 2006	1
Austrian Computer Society	International Workshop on Distributed Software Development 2005	1
BCS/IET	Empirical Assessment in Software Engineering (EASE) 2008, 2011	2
INSTICC	AIS International Conference on Enterprise Information Systems (ICEIS) 2009, 2010	2
AIS	Americas Conference on Information Systems (AMCIS) 2007	1
	Asia -Pacific Software Engineering Conference (APSEC) 2009, 2010	2

When we consider our SLRs topics "risk factors due to the organizational environment" is one of the most popular topics for research; we found nine studies that focussed on communication, collaboration, control and culture. The focus here is mainly 1) on the vendor environment(s), rather than interaction with the client; and 2) on the vendor team and interactions within the team and team sites (if there is more than one site), rather than vendor politics or high level executive project support by vendor management. Equally popular as a research topic for GSD SLR research is the "development process" (or project execution) where we found nine studies. Again the focus is on the vendor with eight studies concerned with infrastructure and tools; there is a single study on architectural knowledge management [S2] and one on configuration management [S7]. Project planning and control is the third most researched topic with four studies addressing this topic; one study considers tool support for DSD management [S4], the other three consider risk

management [S5, S11, S18]. Once again we are not told which project manager is the focus of the research but the way the papers are written implicitly suggests the vendor project manager, even though there are many risks that the client project manager needs to monitor. Four SLRs [S12, S13, S20, S24] explicitly mention the client. However, the main focus of [S12, S13] is on what vendor organizations should do "in order to be competitive in the outsourcing business" [S13a].

Q4 What are the limitations of the SLRs in the research area? With the main focus on the vendor environment and the development process we are lacking research on users, the client organization (except for some research on vendor selection [S12, S13], distribution rationale [S1] and development of an outsourcing lifecycle framework that includes the client [S24]), project complexity and the effects of several vendors, the type of contract, and cross border financial and legal implications. There are some limitations in the papers we reviewed. We rejected a number of papers from the IS literature because their authors did not differentiate between offshore operations and GSD even though they frequently referenced GSD papers in their bibliographies. We read these papers very carefully, sometimes several times, and would have included them if they had provided specific details about GSD in their results. We do not believe that the risks involved with IT operations and IT development are the same and most of the IS papers did not differentiate. This view is supported by [2]. In several of the studies there appears to be some confusion about who is the owner of the issue discussed, i.e., the term "practitioner" was frequently used though the identity of the practitioner was vague; it was not clear if the authors were discussing issues related to the client, the vendor (including developers), or all those involved in the project. Are the communication issues all with the vendor or is there some consideration regarding communication with the client.

Table 5: GSD SLR Research Topics

Risk	Main study topic	Mapping to Outsourced risk framework	ISO 12207 Mapping; Lifecycle process; sub process	Constituent task
Research		N/A	N/A	
	General, what research has been done and who is doing that research [S3]			
	Mapping the research and identifying gaps in the research [S14]			
	Empirical studies in GSD [S21]			
Architecture		Project execution		
	Knowledge management; identify set of GSD entities and their relationships [S2]		Primary; development	System architectural design
Development process		Project execution		
	Scrum, risk factors and strategies [S8]		Primary; development	software construction
	Agile practices research and context for use of practices [S10]		Primary; development	software construction
	Problems and solutions, challenges and solutions, procedures, models, and strategies employed in development process for managing risks in distributed teams [S11]		Primary; development	software construction
	Managing risks in distributed software project teams (specifically – identifying risks, techniques to solve them, and guidelines for applying the techniques) [S18]		Primary; development	software construction
	What DSD process models (also capability maturity, and stage models) or descriptions of the need for such models have been published [S19]		Organizational; improvement	process improvement
	What are the models of development for the DSD [S20]		Primary; development	software construction
	Phases of outsourcing lifecycle; how to execute and manage these phases [S24]		Primary; development	software construction
Project Management -		Project planning and control	Organizational; management	review and evaluation
	Identify effective models and tools for supporting DSD management [S4]			
	Challenges, practices, tools models [S5]			
	Problems and solutions, challenges and solutions, procedures, models, and strategies employed in development process for managing risks in distributed teams [S11]			
	Risk and risk mitigation instruments [S18]			

Requirements engineering What are the main risks to RE in DSD? What methods, models, techniques, approaches and tools support RE in DSD? [S6] Which new risks and challenges are identified for RE on GSD environments? Which solutions have been proposed [S15]	Project scope and requirements	Primary; development; elicitation and analysis
Configuration Management Configuration management empirical methods, research contribution, issues, solutions major problem areas [S7]	Project execution	Supporting; configuration management
Outsourcing vendor selection Barriers and Influencing factors [S12, S13]		Primary; acquisition process; selection of supplier
Culture Research into issues [S9]	Organizational environment	Organizational; training
Collaboration, communication, control and distance Opportunities and threats regarding communication, coordination, control, and geographic distance [S1] Barriers and Influencing factors [S11] Control, coordination, cultural distance, geographic distance and temporal distance [S16] Barriers that prevent software development teams from collaborating in a global environment; solutions to addressing the barriers to collaboration [S17] Collaboration in software development [S20] Managing risks in distributed software project teams (specifically – identifying risks, techniques to solve them, and guidelines for applying the techniques) [S21] What are the awareness studies carried out to Improve the GSD scenario? Which of the 3Cs are the studies supporting [S22] Insights from empirical studies on collaboration in software development? [S23]	Organizational environment	Organizational; organizational management infrastructure

With GSD the term project manager can be confusing as normally, both client and vendor companies will provide a project manager to oversee the development of a project. The term "vendor project manager", describes the project manager in charge of actual software development. The "client project manager" who is employed by the client company, is expected to liaise with the vendor project manager as well as monitor the software development for the client company. Vendor project managers involved with GSD may need to control multiple groups of developers with different cultural backgrounds, and coordinate multiple sites each with its own time zone (e.g., [3, 11]). The client project manager will mainly deal with the vendor project manager. While a number of issues around the software development will be of direct interest only to the vendor project manager other areas, such as project scope and requirements, and project planning and control, will be of interest to both project managers. However, they will have different perspectives.

RQ5 Which researchers are most active in GSD SLRs and where are they located? Tables 6 and 7 provide a list of researchers most active in GSD SLRs. It is interesting to note that a large proportion of researchers are based in Brazil (17) and that these researchers are also the most active in GSD SLRs. Ireland with nine researchers and Sweden with eight researchers provide the next largest groups of researchers. Given the importance of GSD to the US, a client country, and the software engineering research that occurs there, it is surprising that only three SLR researchers are based in the US, although many of the primary studies do involve US researchers. Table 7 shows that almost all the researchers are based in Universities; very few authors are from industry. Of those researchers that are based in industry, three are from Denmark [S18] which is mainly a client country, so that it is not surprising that they are associated with a study focussing on managing risks in GSD projects.

RQ6 What is the quality of GSD SLRs and is it changing over time? Table 1 which includes details of our quality evaluation of the major paper reporting each of the studies shows that there is no evidence that quality is improving over time.

Table 6: Most Active GSD SLR Researchers

Name	Affiliation	Number of studies
Prickladnicki	Brazil	5
Audy	Brazil	3
Costa	Brazil	3
Rocha	Brazil	3

Table 7: Affiliation of Active Researchers

Country*	Institution*	Researcher^
Australia (4)	University of NSW, 2	Hossain Paik
	NICTA, 2	Bannerman Staples
Brazil (17)	Faculdade Integrado de Campo Mourao	Chaves
	Federal University of Pernambuco (UFPE), 10	Costa (3) Cunha da Silva (2) de Azevedo Franca (2) Junior Meira Monteiro Rocha (3) Rodrigues
	Federal University of Technology Parana	Steinmacher
	Pontifica University Catholica do Rio Grande do Sul (PUCRS), 4	Audy (3) Ebling Kroll Prikladnicki (5)
	University of Sao Paulo	Gerosa
Canada (5)	University of Victoria, 5	Damian Nurdiani Story Truede Weber
Denmark (4)	Aalborg University	Persson
	Systematic Software Engineering Aarhus	Madsen
	Trifors A/S Aarhus, 2	Boeg Steinson
Finland	Jyvaskyla University	Yalaho
Germany	Software Systems Scientist, Heidelberg	Mistrik
Ireland (9)	University of Limerick, 9	Agerfalk Ali Ali-Babar Beecham (2) Conchuir Fitzgerald Holmstrom Noll Richardson
Latvia	University of Latvia	Smite
Malaysia	Universiti Teknologi Mara	Fauzi
Pakistan	National University of Science & Technology, Rawalpindi	Ahmed (2)
Saudi Arabia	King Saud University	Alsudairi
Spain (6)	University of Castilla-La Mancha, 2	Piattini Vizcaino
	Technology Innovation Centre, Albacete; Alhambra-Eidos	Jimenz
	University of Mercia, 3	Lopez Nicolas Toval
Sweden (8)	Blekinge Institute of Technology, 6	Feldt Gorschek Jalali Jabangwe Smite (2) Wohlin(2)
	Skovde University, 2	Lings Lundell
United Kingdom (3)	Keele University, 2	Khan (2) Niazi (2)
	Swansea University	Dwivedi
United States (3)	Fraunhofer Center for Experimental Software Engineering, Maryland	Shull
	Georgia State University	Mathiassen
	Pennsylvania State University	Huang

Note: * One researcher unless otherwise stated, ^ one study unless otherwise stated

The mean for journal papers is 2.5 (sd 0.734) and for conference papers is 1.92 (sd 0.527); there is a significant difference between the quality of the journal papers and the conference papers ($p < 0.05$).

Although we collected data on the data synthesis methods we did not include this in our quality score for two reasons: 1) many of the studies were done before this criterion was added to the DARE criteria and 2) we did not consider that it was important for a mapping study. Of the papers that do discuss the synthesis method used, very few provide any references to the method.

IV. STUDY LIMITATIONS

We may have missed some studies and hence underestimated the extent of SLRs in GSD. However, as noted earlier, we checked our papers against those found in earlier work. No authors identified any papers describing SLRs in GSD that we did not find. Some of the quality data may be erroneous as the quality criteria can be rather subjective. However, two data extractors derived this data independently. For the initial paper inclusion/exclusion we settled differences by discussion, but for the quality scores, if the researchers did not agree, we used a third extractor and in all situations found that we able to use a majority value. For one paper we reviewed [S8], our two researchers gave a

quality score of 3 while [7] and [9] gave this paper a quality score of 4. However, we decided to stay with our evaluation. Several other quality scores in [9] differ from our scores [e.g., S18, S21, S24] although for some studies we actually evaluated a later more extensive paper than that described the other study e.g. [S12, S19].

V. CONCLUSIONS

We found 24 SLR studies reported in 37 papers. The earliest GSD SLR we identified was a conference paper published in 2005. SLRs in GSD began to be a focus for research in 2009 when five papers were published; the research has increased markedly since then. The studies are most frequently reported in the ICGSE; other conferences have only provided minor outlets. Major journals reporting SLRs in GSD are IEEE Software, Information and Software Technology and Journal of Software Maintenance, Evolution and Practice. When we map the GSD SLR study topics the most popular areas for research are risk factors relating to the organizational environment and the development process (project execution). Researchers in most studies do not differentiate between client and vendor perspectives in their research. We are lacking research on the users, the client organization, project complexity including the effects of several vendors, the type of contract, and cross border financial and legal implications. The most active researchers are based in Brazil. The quality of the SLR studies has not changed over time.

Further work includes using the results of this tertiary study, particularly the gaps identified in research, as a basis for conducting a complete SLR of primary studies published in GSD, specifically studies investigating client-oriented risk. We are also interested in investigating the evidence related to the GSD business model and risk in GSD projects.

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