A REVIEW OF SECURITY INTEGRATION TECHNIQUE IN AGILE SOFTWARE DEVELOPMENT

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ABSTRACT

Agile software development has gained a lot of popularity in the software industry due to its iterative and incremental approach as well as user involvement. Agile has also been criticized due to lack of its ability to deliver secure software. In this paper, extensive literature has been performed, in order to highlight the existing security issues in agile software development. Majority of challenges reported in literature, occurred due to lack of involvement of security expert. Improving security of a software system without damaging the real essence of Agile can achieved with the continuous involvement of security engineer throughout development lifecycle with its defined role and responsibilities.

KEYWORDS

Agile development, Agile Security Development

1. INTRODUCTION

Agile practices have a significant impact in developing software in recent few years [1]. A fair amount of affirmative response has been noted from organizations [2] that use agile practices. These practices are quite popular for producing evolving software's [3]. Agile practices are related to improved product quality, customer satisfaction, and developer productivity than traditional waterfall practices [4]. Over the period of time one of significant concern is software security. Up to certain level security is successfully integrated in traditional development by developers [5], but there is some serious criticism of agile development methodology to produce less secure software's [6], [7].

Acceptance of changing requirements, favoring regular deliveries, and exclusion of security engineering activities make secure software development challenging using agile methodology [8].This leads agile practices reiteration in respect of making secure software, which negatively affects project timeline, considerable increase in costs, and decreased customer belief and satisfaction, which in the end diminishes the notion of these practices as agile [9]. These

characteristics serve as the foundation of serious criticism on agile methods to produce unsecure software's.

In this study the analysis of related work is mostly revealed about the issues of integration of security in agile. This paper presents the systematic review of techniques, methods for security integration in agile. Existing techniques and methods have been scrutinized that have not impressively produced any significance review or survey based on this particular topic. For supposed investigations, Systematic literature review SLR technique has been used. Keeping in view of these investigations, a thorough exploration has been executed. The organization of the paper is: Sec. 2 includes the literature review, Sec. 3 includes the materials and methods, Sec. 4 includes the results and inferences, Sec. 5 includes the discussion and Sec. 6 includes conclusions.

2. RELATED WORK

The aim of this section is to elaborate the literature done on incorporating security in agile. Various methods are considered with different approaches to conduct surveys on incorporating security in agile.

Review on extreme programming was conducted by Ghani and Yasin [1]. They study literature related to the extreme programming with the perspective of security and they had observed that extreme programming partly supports integrating of security in it. Few of researchers worked on these topics, still comprehensive information regarding their outcome and usage was not published yet. They had concluded that the existing extreme programming practices are not adequate in term of security, hence new XP practices based upon security require to be proposed. Sani [9] conducted a literature survey on DSDM in term of security incorporated in it. From literature they had spotted that currently DSDM lack behind in providing support for secure development of software's. They find that only a single paper discuss about security integration in DSDM and no work done yet by the researchers for secure software development via DSDM. And their intention is to enhance current DSDM model so that it can support secure development. Ghani [10] performed a survey on it model that had been proposed by them for secure software development using DSDM in order to validate their model. After collecting, analyzing, comparing the results they had concluded that their model is very much beneficial in developing secure software using their enhanced DSDM model.

Adila[11] presented an extensive survey on feature driven development aim of literature survey is to study feature driven development with the intensions to produce a secure software. They find that there is no reputable research in respect of feature driven development and its integration with security and finally they had summarized that there is a need of revised feature driven model that can facilitate the secure development of software without compromising agile manifesto. Oustlati [12] conducted a systematic review of agile development methodology and elaborates the challenges its face while developing secure software. They found 20 challenges in 10 studies and categorize them and founded that 14 out 20 challenges are valid in respect of agile methodology and 6 are invalid in case of agile principles. They concluded that secure software development using agile quite challenges, there is a lot of space for researchers to work in this area.

Othmane [13] performed systematic review, and this review is just a mere extension of [12] above mentioned review. Parameters and results of both reviews are almost same but the difference exists between [12] and [13] is of the number of papers selected for both reviews, in [13] number of papers are double as comparable to paper selected by [12].

From above literature, it is extracted that the majority of studies focus on a particular agile practice such as XP, DSDM, FDD in their reviews[1, 10, 9, 11]. And their focus is to identify that how much work is regarding security integration in agile or in particular agile practices and secondly scope of some studies [12, 13] are limited to fewer number of research papers. Although reviews performed in [41, 44] are very systematic but not much systematic in term of agile practices. The Intention of this study is to perform a comprehensive literature which is not limited to any specific agile practice and this study will take into account of all agile practices rather than to some specific practice of agile. Considering all agile practices in regards of secure software development in a systematic manner make our study unique from above mentioned studies.

3. METHODOLOGY

In this literature study, research methodology followed is Systematic Literature Review. A SLR is a mechanism of identifying, understanding and estimating complete existing research interrelated to a specific research query, topic area or matter of consideration. SLR involves following steps such as *planning stage, conducting stage and reporting stage* [14] complete procedure shown in (Fig.1). A unique research study facilitating a systematic review and known as primary research studies whereas a systematic review is a kind of secondary study.

The *necessity for the systematic study (Step 1)*, the communal causes are:

- To precise the relevant research work evidences significant in term of incorporating security in agile.

- In order to mined out gaps in current research and to enhanced proposed parts for further investigation.

- Systematic reviews may be exercised to study the degree to which experimental evidence promotes/negate suppositions, or even to promote the development of novel theories. A search experiment was conducted recording the subsequent searched strings in ACM digital library, Springer and IEEE Xplore. The literature obtained from the string searching may possibly be helpful in discovering a trend for the software development and verification &validation of the preferred search items and the desirable protocols.
  (("Incorporating Security" OR "Integrated Software Security" OR "Secure Software Development" OR "Software Security") AND ("Agile Practices" OR "Dynamic Systems Development Method" OR "Extreme Programming" OR "Feature Driven Development") AND ("Challenges" OR "Issues")).

- The *research questions (Step 2)* in section (3.1) indicate what should be extracted from the selected studies.
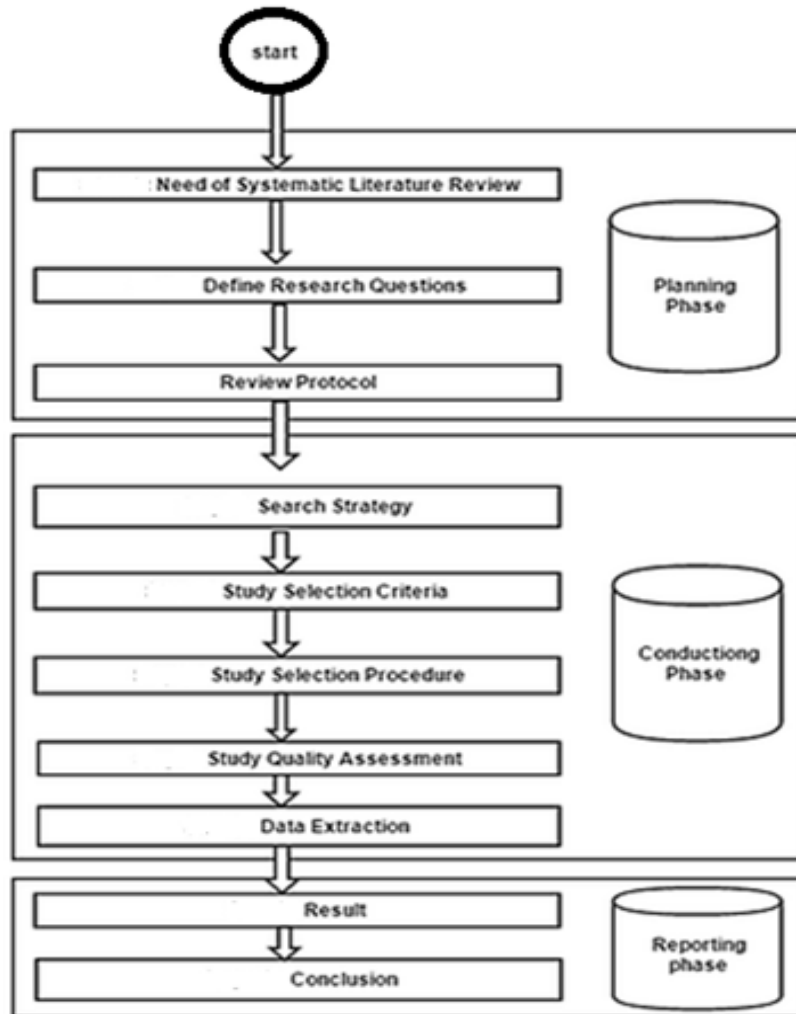

Figure 1: SLR Process

3.1 . Research Questions

(Staples, M. and Niazi, M.2007) [15]: encouraged the searching criteria that are being considered in order to assure the research papers quality and to exclude non-relevant work. The R. questions discussed in the work are as under:

RQ1. What types of approaches are being suggested for the purpose of security incorporation in agile and its practices?

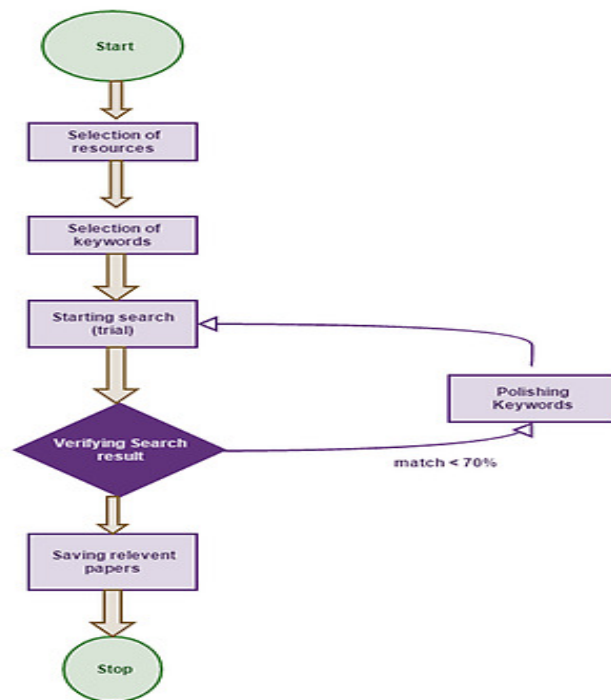RQ2. What is the role of Security expert/ Engineer in these approaches?

RQ3. What kind of challenges emerges while incorporating security in agile and its practices?

The purpose of *(Step 3)* the *protocol review* ensures to overcome likely investigator's bias that will allow duplication in the study (Kitchen ham, 2007) [14]. In *(Step 4,)* the *evaluation of protocol* and the aid of drill in executing studies systematically by scholars. Depends on opinion and collected knowledge during the development, we repeatedly advanced the evaluation structure. The brief of the conclusive protocol is presented in sec. 3.2 to sec. 3.5.

3.2 Search Strategy

We adapted the procedure proposed in (as shown in Fig.2) for the selection of work. From the questions for research, we extracted the key-phrases for the mining. In order to validate the strings quality used for searching, we conducted a sample search on, IEEE Xplore, Science Direct and Google Scholar.

Figure 2: Search Strategy

3.3 Study Selection Criteria

The vital aspects for concluding as primary study is data elaboration, depictingthat the studies to be used that are related to our key-phrases that are similar to those described in the test searchingis calculated shown in (Table.1) and therefore answering the research questions. So, all papers on incorporating security in agile and its practices will be incorporated.We eliminated non-English data that is books, text and presentations. We ignored material that was not included in our searched strings and non-relevant data to security in agile development and studies that do not satisfy agile development practices.
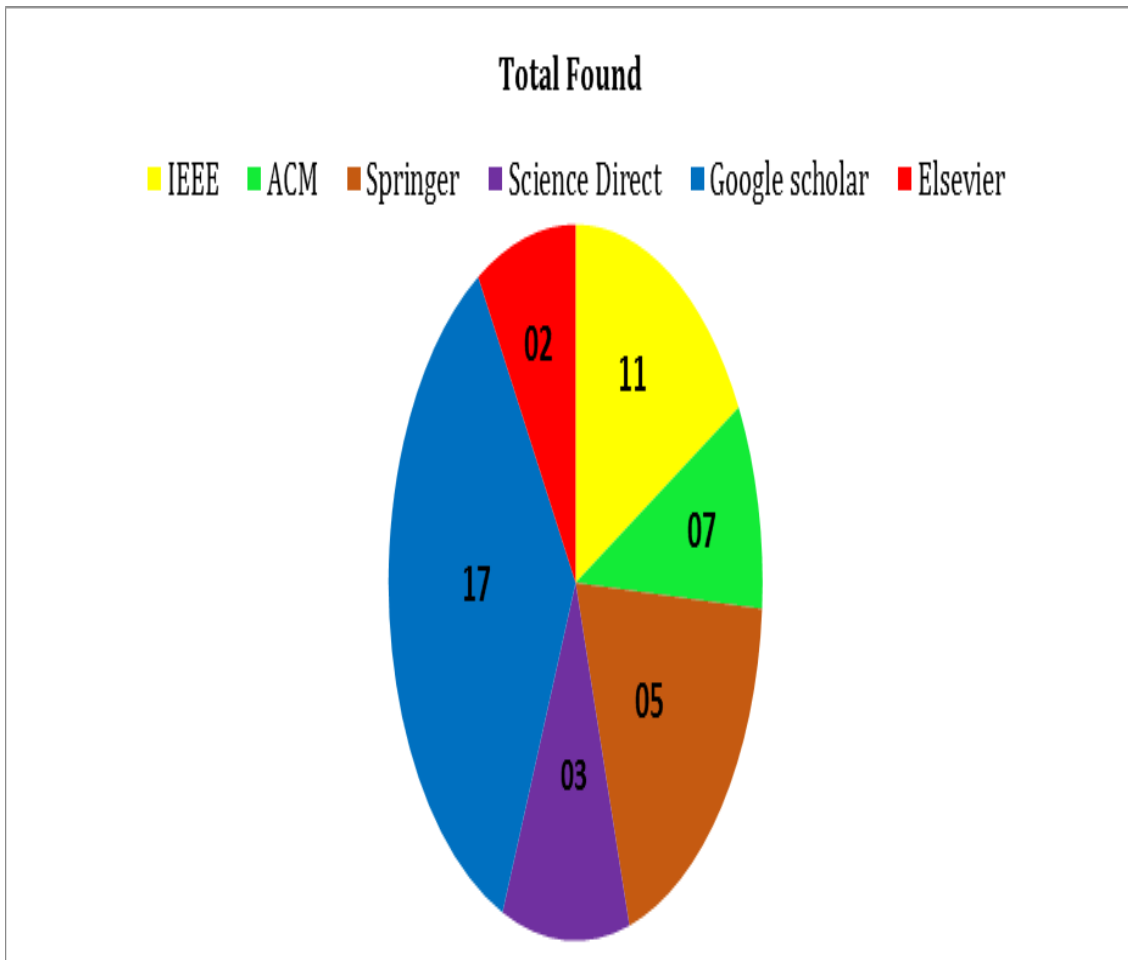
Table 1: Criteria for Selection Study

Selection Of study	papers left
Based on complete text	45
Based on Abstract	69
Based on title	102
Based on searched strings	172

3.4 Study Selection Procedure

The *study selection procedure (Step 5)* was performed for the collection of a related analysis of the selection criteria between the investigators that organized the review. The selection criteria were implemented to the title and the abstract and essentially, for the complete text of the papers of the related area. As an experiment, we solely evaluated 69 randomly selected studies from a search conducted in ACM, Google Scholar, Springer and IEEE Xplore.

We documented the unclear explanation of the questions and selection principles on which the judgment for selection was exclusively grounded upon. We found total 45 papers, applying searching string, that have data interrelated to incorporating security in agile and its practices (as show n in Graph 1). We rejected documents that have emphasis on other domains than our related area of study. We aggregated needed sections from the papers to enhance the inferences towards success in finding incorporating security in agile (as shown in Fig.3). In addition, once more we read from selected papers and guaranteed that the papers selected are absolutely lawful as indication for integrated security in agile practices, (as shown in Table.2) as the outcomes# per basis and increased points of indications gathered (as shown in Graph.2).

Graph 1: Selected Papers

3.5 Study Quality Assessment

In this section *(Step 6)* depicts the quality of our research. We hardly found relevant work for the questions that are entirely in support of our research work. Using data collected, we supported our choices and explorations. From QA-1, it is found that relevant approaches which incorporated security in agile and its practices. With QA2, we examined the challengesemerges while incorporating security in agile. With QA3, we evaluated those approaches were sufficient for integrated security in agile development.
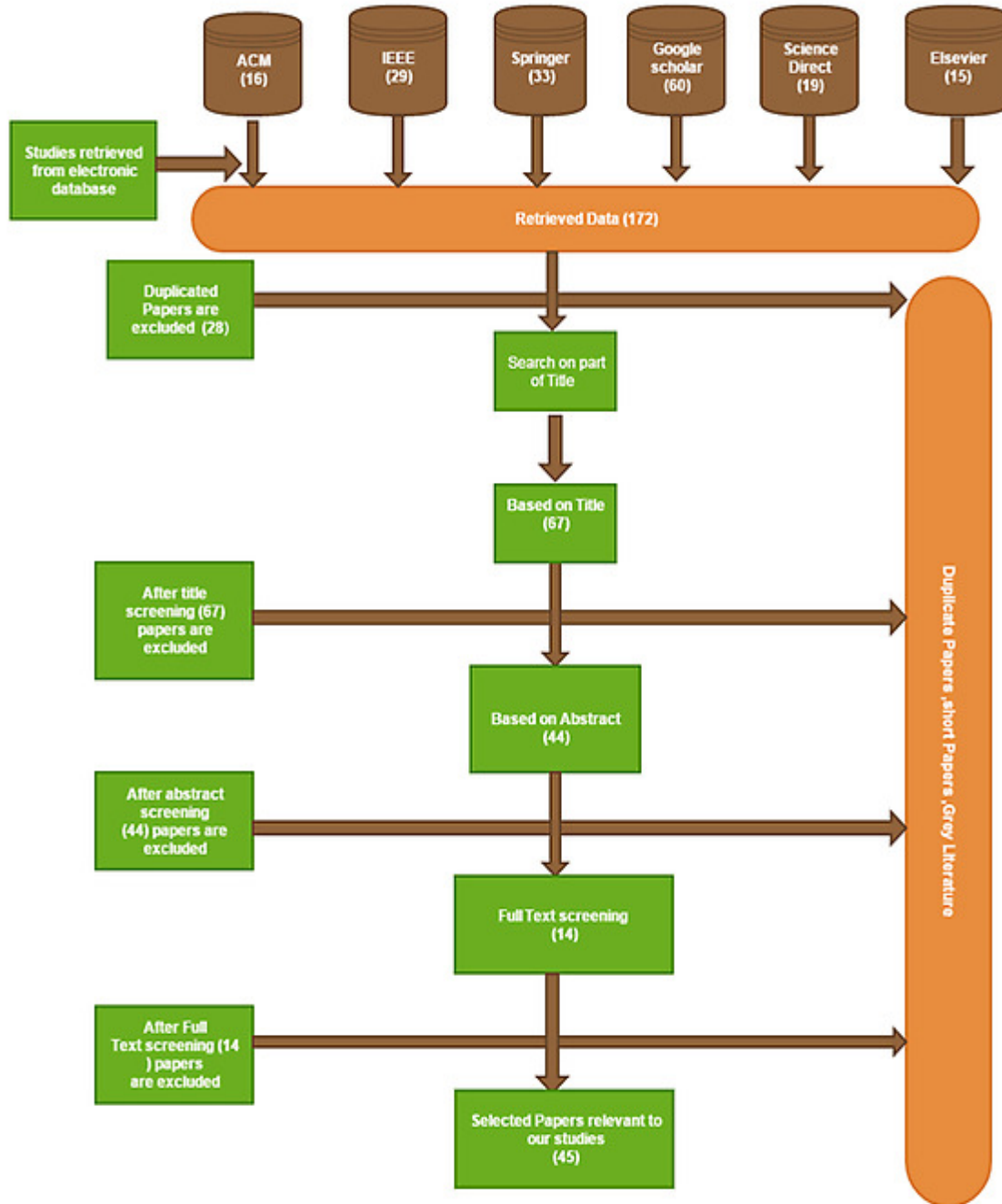
Figure 3: Selection of Primary Studies
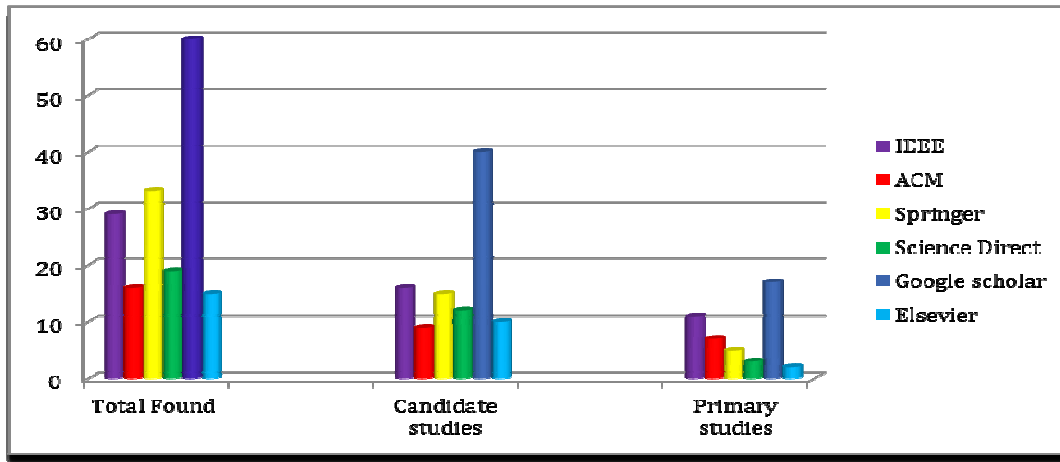
Table 2: Results over sources

	IEEE	Google scholar	Elsevier	ACM	Science Direct	Springer
Primary studies	11	17	2	7	3	5
Total Found	29	60	15	16	19	33
Candidate studies	16	40	10	9	12	15

3.6 Data Extraction

In the similar fashion, we break-down the work. *Data extraction (Step 7)* was achieved in a repetitive manner.We have endorsed the inferences given by [14]; it is predicted which might found challenging constituting a precedence a comprehensive group of charges for the whole belongings. We initiated the mining form with the attributes like research techniques, perspectives that displays the mapping to the particular. Questions addressed by the attribute (as shown in Table.3).

Table 3: Data Extraction

Attributes	Research question
Title/Year/Author	Overview of candidate literature
Context	Overview of candidate literature
Search Strategy	SLR

Graph 2: Number of results per sources

4. RESULT AND ANALYSIS

RQ1. What types of approaches are being suggested for the purpose of security incorporation in agile and its practices?

In order to answer to RQ1 we conduct a detailed analysis to facilitate our finding (see table 4).Twenty six studies are considered for analysis, foundation of considering studies in this particular review study is that only those studies are considered which provide any technique, method, principal framework for integrating security in agile methodology and its practices. The Parameters of this study were hauled out from numerous existing methodologies and studies were evaluated on the basis of succeeding parameters. (1) For which particular agile practice mechanism for security incorporation is provided [10]. (2) Involvement of security engineer/expert in particular technique [16], [17]. (3) Provision of framework or principal for security integration [10], [9]. (4) Research methodology used in the study [18]. (5) Domain consider in a particular paper. [19], [20].It has been observed that out total50% of the studies consider integration of security in agile generally, while 15% in Scrum, 23% in XP, only 12% in FDD and no study mention any mechanism for security integration in DSDM(see graph 3). These agile practices are included in this literature study because they are considered as popular among researchers and practitioners.
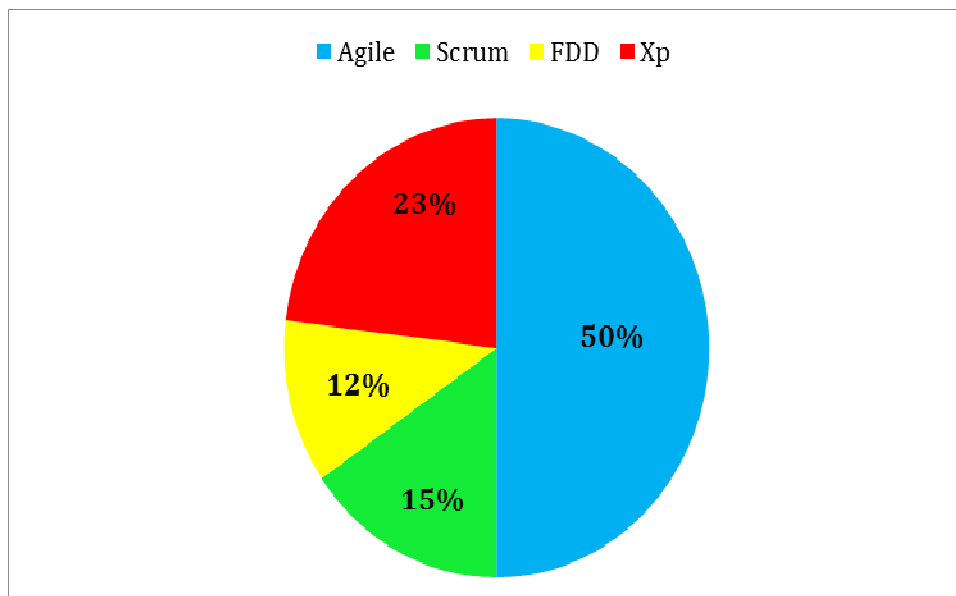
Table 4: Selected Studies Analysis

Title	Year Of Publication	Agile Practice [10]	Involvement of security engineer/expert [16],[17]	Framework/security principal [10],[9]	Methodology [18]	Domain [19],[20]
Agile Development of Secure Web Applications [19]	2006	FDD	No	Principal	Case Study	Web applications

Agile Security using an incremental architecture [21]	2005	Agile	No	Principal	Exploratory	Not mentioned
Agile Development with Security Engineering Activities [22]	2011	Agile	No	Framework	Case Study	Mobile application
Improved Extreme Programming Methodology with Inbuilt Security [23]	2011	XP	No	Framework	Case Study	Web applications
FISA-XP: An Agile-based Integration of Security Activities with Extreme Programming [16]	2014	XP	Yes	Framework	Experiment	Not mentioned
Selection of Security Activities for Integration with Agile Methods after Combining their Agility and Effectiveness [24]	2014	Agile	Yes	Framework	Exploratory	Not mentioned
A Novel Security-Enhanced Agile Software Development Process Applied in an Industrial Setting [25]	2015	Agile	Yes	Framework	Experiment	Mobile application
Extending the Agile Development Approach to Develop Acceptably Secure Software [26]	2014	Agile	No	Principal	Case Study	Web applications
ROLE-BASED EXTREME PROGRAMMING (XP) FOR SECURE SOFTWARE DEVELOPMENT [27]	2013	XP	Yes	Framework	Exploratory	Not mentioned
Developing a Secure website using Feature	2013	FDD	No	Not mentioned	Case Study	Web applications

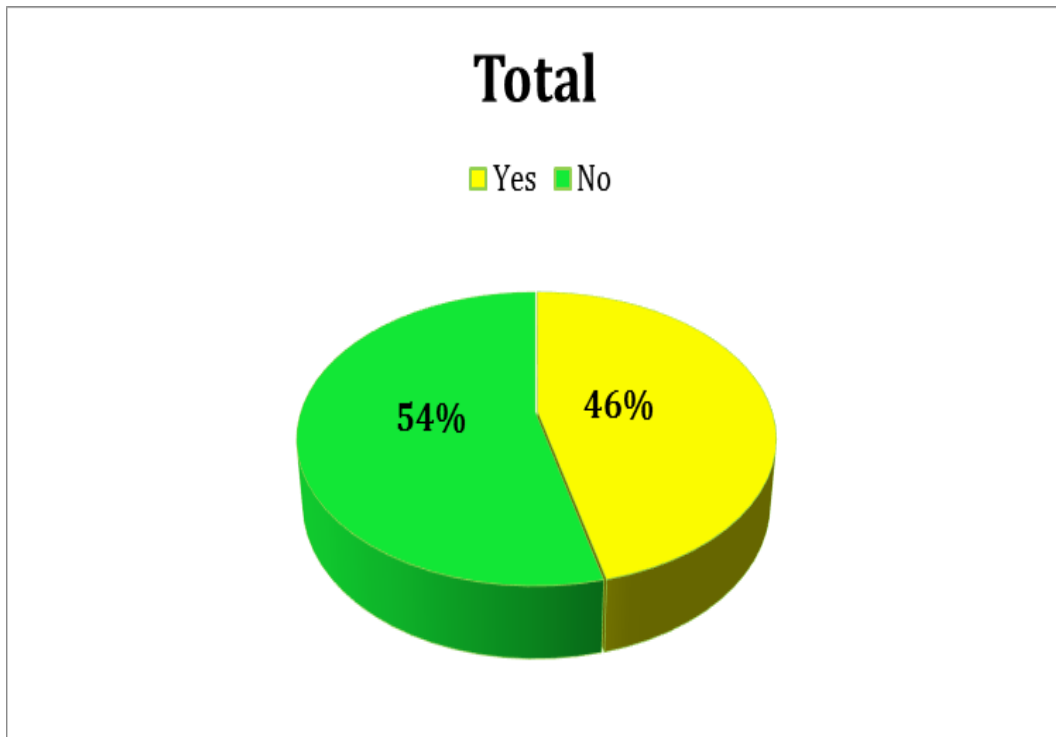|						
Driven Development (FDD) [20]						
Risk-Driven Security Metrics in Agile Software Development – An Industrial Pilot Study [28]	2012	Agile	No	Framework	Experiment	Mobile application
Secure Software Development Model: A Guide for Secure Software Life Cycle [29]	2010	Xp	Yes	Framework	Exploratory	Not mentioned
S-Scrum: a Secure Methodology for Agile Development of Web Services [30]	2013	Scrum	No	Framework	Case Study	Web applications
Towards Agile Security Assurance [31]	2005	Agile	No	Principal	Exploratory	Not mentioned
Extending XP Practices to Support Security Requirements Engineering [32]	2006	XP	Yes	Framework	Experiment	Web applications
Security Planning and Refactoring in Extreme Programming [33]	2006	XP	No	Principal	Case Study	Web applications
Security Backlog in Scrum Security Practices [34]	2011	Scrum	Yes	Framework	Exploratory	Not mentioned
Integrating Security into Agile Development Methods [35]	2005	Agile	No	Principal	Case Study	Web applications
Development of Agile Security Framework Using a Hybrid Technique for Requirements Elicitation [17]	2011	Agile	Yes	Framework	Case Study	Not mentioned
Integration Analysis of Security Activities from the perspective of agility[36]	2012	Agile	Yes	Principal	Exploratory	Not mentioned
Integrating	2008	Agile	Yes	Principal	Exploratory	Not

Software Development Security Activities with Agile Methodologies[37]						mentioned
Using Assurance Cases to Develop Iteratively Security Features Using Scrum[38]	2014	Scrum	No	Framework	Case study	Communication
Secure Feature Driven Development (SFDD) Model for Secure Software Development[39]	2013	FDD	Yes	Framework	Exploratory	Not mentioned
Secure Scrum: Development of Secure Software with Scrum[40]		Scrum	No	Framework	Survey	Not mentioned
The Creation of a Distributed Agile Team [41]	2007	Agile	No	Framework	Exploratory	Web Services
Towards Agile Security in Web Applications [42]	2006	Agile	YES	Principal	Exploratory	Not mentioned

Graph 3: Agile practices that integrate security

RQ2. What is the role of Security expert/Engineer in these approaches?

In order to develop secure software, it is important to have a dedicated person that has a fair amount of knowledge about software security or in other word require security expert[24], [16]. Security experts should be responsible for proper integration of security in particular software system [24], [36]. Traditionally involvement of security expert in agile software development for developing secure software is considered as overhead [27]. But it has been observed that for developing secure software using agile it is important to have a security expert and it will increase the level of agility in development [16], [36]. Most of the time development teams are not aware and familiar of security related construct and issues in the developing secure software and because of lack of expertise in term of security it is difficult for developers to properly integrate security in projects and increase the development time which in turn effect deliverable time of agile increments [36],[29]. Thus, it is important to have the involvement security expert in agile methodology to facilitate secure development. From literature that has been sighted it is extracted that 54% studies had not mentioned the involvement of security expert in their approaches that has been proposed for secure software development using Agile and its practices which is a major drawback of these techniques and rest of 46 % mentioned the involvement of security expert in their approaches (see graph 4)

Graph 4: Numbers of studies involving security expert

46% of studies encourage the participation of security engineer, after analyzing the studies encouraging the participation of security expert it is spotted that [36], [16], [24], [37] calculate the

agility degree of various security activities using different techniques and proposed that the activity with high agility degree needs to be integrated with agile methods so that it will not disturb the agility of methods. If security engineer is involved throughout the development process it is being assigned high value of agility and partial involvement is assigned as low values of agility [16]. Rest of studies practically involved security expert in their proposed techniques. We have analyzed these studies on the basis of two parameters which are derived from the above discussion. (P1) involvement of security expert throughout the development lifecycle or in any particular phase while (P2) clear definition and description of roles and responsibilities of security expert.(See Table 5)

Table 5: Involvement of Security Expert in SDLC phases

Paper	P1	P2
[25]	Throughout development lifecycle	✓
[27]	Not mentioned	✗
[29]	Requirement engineering& design phase	✗
[32]	Requirement engineering phase	✗
[34]	Documentation, analysis & testing phase	✓
[17]	Requirement engineering phase	✗
[39]	Documentation, Development & testing phase	✗

In (table 5) only [25] encourage the throughout involvement of security expert's during the development life cycle with defined roles, but major drawback of this approach is that it involves security expertise more than required like security manager, security architect, security expert. Involving a number of security experts e.g. 3 or more security related personals in agile team don't seem to be effective and may consider as overhead, whereas [34] doesn't involve expert throughout development life cycle and partially define the role and responsibilities of security expert.

RQ3. What kind of challenges emerges while incorporating security in agile and its practices?

Underneath are some of the challenges that are reported in the literature that limit agile methodology and its practices to produce secure software (see Table 6). It is observed that challenge Ch1, Ch5, Ch10, and Ch12 are closely related to the collaboration and awareness among stakeholder in an agile development environment. Challenge Ch2, Ch4, Ch7, Ch11 are often caused due to the iterative and incremental nature of agile development methodology. Challenge Ch3, Ch9 have occurred as a consequence of security assurance of agile increments. Ch6, Ch8, Ch13 are directly related to the development life cycle of agile. In Oder to improve

agile methodology and its practices to provide secure software, it is quite necessary to eliminate these challenges or to trigger down their effect to possible minimal level.

Table 6: Agile security challenges

Code	Challenge	Papers
Ch1	Need of separation of roles between software developer and security expert	[42],[40],[37],[29]
Ch2	Security assurance of increment & activities are difficult if the code is changing continuously.	[31],[26]
Ch3	Detailed documentation is required for security assessment	[31],[42],
Ch4	Security constraints are violated due to refracting	[31],[33]
Ch5	Lack of experience of developers in developing secure software	[29],[20],[24]
Ch6	Neglecting risk assessment	[32],[28],[19]
Ch7	Security requirements are difficult to track if requirements change frequently.	[32]
Ch8	Security measure is not considered in every iteration	[31],[23],[19],[26]
Ch9	Test cases are not adequate to ensure the integration of security related requirement	[31],[24]
Ch10	Lack of security requirements and considerations	[7],[17]
Ch11	Requirements change and design change violate the security requirement of the system.	[32],[17]
Ch12	Unawareness of customer in term of security	[34],[39]
Ch13	Neglecting security requirements in elicitation phase	[32],[19],[17]

5. DISCUSSION

After reviewing and analyzing the literature, it is observed that involvement of security expert throughout the development life cycle is necessary in order to cater security related concern and for proper integration of security in agile increment. In the majority of studies (54%) security expert is unavailable and seems that it is undefined, who will be responsible for maintaining security of agile increments and deliverables. In the absence of security expert it is hard to define that who will be responsible for this critical task, because it is quite unjustified to handover this critical task to individuals having limited knowledge and background of software security. If this important and critical task is assigned to teams or individuals who are not expert in the field of software security it will not only increase the cost in term of time and negatively affects the quality of software in term of security.

Out of the total 45 % of the studies mentioned the involvement of security expert in their techniques, but the major draw of these studies is that they are not facilitating the involvement of security expert throughout development life cycle and secondly there is no clear description of roles and responsibilities of security expert. Ch1, Ch5 and Ch12 (see table) can be catered by involving security expert with defined and separate roles and responsibilities in software development life cycle, Ch13 and Ch10 can be managed by the involvement of security expert in requirements engineering phase by taking into account of security requirements. Involving security expert in the construction phase can affect Ch7, Ch8 and Ch11 positivity by having a critical eye on the construction phase in term of security. Ch2, Ch9 can be handled by involving security expert in testing and transition phase.

From the consequence of the above discussion, it is mined that useful techniques has been proposed in regard of developing secure software using agile. The Major weakness of these techniques due which they are not able to properly integrate security in agile are lack of involvement of a security expert, or if involved, then he was not been involved throughout the development life cycle and his roles and responsibilities are not defined. So it is quite important to have the involvement of security expert with defining roles and responsibilities throughout the agile development life cycle, i.e. in inception, construction and transition phase, in order to take care of security related aspect of software and for fruitful integration of security in every agile iteration and deliverable. It has hauled out from literature that if security is not considered in every phase of the agile development cycle, it makes secure software development challenging and leaves possible glitches in developed software in term of security.

6.CONCLUSION

To gain insight into the current status of security in Agile Development Cycle and its techniques, a systematic literature review (SLR) has been conducted that highlights the current issues of security in Agile practices. Agile has been criticized for lacking security due to its incremental approach. Some complications have been highlighted such as lack of consideration of security throughout the agile development life cycle and absence of the dedicated resource person, having a fair knowledge of software security, with defined responsibilities. From review it has been observed that some researcher has agreed that there should be a defined role to fulfil security aspects in complete lifecycle. In the future, we are planning to develop a framework in order to address the issues mentioned in this paper for security integration in agile properly and correctly with ease and to obtain better results.

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