

## A Literature Review and Classification of Selected Software Engineering Researches

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### ABSTRACT

In this paper, a literature review and classification scheme for selected software engineering researches is presented. The study shows that an increasing volume of software engineering researches have been conducted in diverse range of areas. The articles are classified and results of these are presented based on classification scheme that consist of five main categories: software development process, software management, software engineering techniques, software re-engineering, and software applications. Analyses of the selected researches are carried out and gaps in the research are identified. A comprehensive list of references is presented. This review is intended to provide impetus in research and help simulate further interest.

**Keywords:** *Software engineering, Software Re-engineering, Review, Software development process, Software engineering techniques.*

### 1. INTRODUCTION

More than 250 papers, which were published between the time period 2008-2012 in conferences and international journals like Springer, IEEE, IJSEA, IJCSI, IJCSE, IJCA, IJEST, famoosR, COMATS, and Elsevier were collected, analyzed and classified into a number of categories and subcategories. The study led to the identification of gap in software engineering researches and enabled the authors to recommend the area where there is a lot of scope for future research.

#### What is software engineering?

Software engineering can be defined as the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software, and the study of these approaches; that is, the application of engineering to software.[1] It is the application of engineering to software because it integrates significant mathematics, computer science and practices whose origins are in engineering.[2] It is also defined as a systematic approach to the analysis, design, assessment, implementation, testing, maintenance and reengineering of software, that is, the application of engineering to software.[3] The term software engineering first appeared in the 1968 NATO Software Engineering Conference, and was meant to provoke thought regarding the perceived "software crisis" at the time.[4][5]

### 2. IDENTIFIED SOFTWARE ENGINEERING RESEARCH AND EXTENT OF RESEARCH CARRIED OUT

The classification framework shown in figure (1) is based on the literature review and the nature of software engineering researches, which meant to give an understanding of how the subject has evolved and progressing. Since software engineering is an important area it is very essential to be clear of it's definition. There are several researchers working in this area and trying to define and specify the universally accepted list of software engineering principles and concepts and trying to apply all these principles and concepts on a real project but until now they could not do that completely and perfectly. The software engineering researches can be classified into five categories, which are; (I) software development process which account to 35 % (90 papers), (II) software management which counts to 30 % (75 papers), (III) software re-engineering which shares (36 papers) of the distribution 14 %, (IV) software engineering techniques the contribution in which is 13 % (34 papers) and (V) software applications which accounts to 8 % (19 papers). The proportion of research carried out in each category is shown in figure (2).

These main categories are further divided into a number of sub categories as in figure (1). The percentage distribution of research in the main categories is shown in figure (2) and according to the year of publishing these

Papers can be grouped as shown in figure (3). The papers are further grouped based on the journal in which they are published as shown in figure (4), and the number of

papers published in each journal as shown in table (3). All the categories and their sub-categories will be discussed in detail in the later sections with graphs and tables.

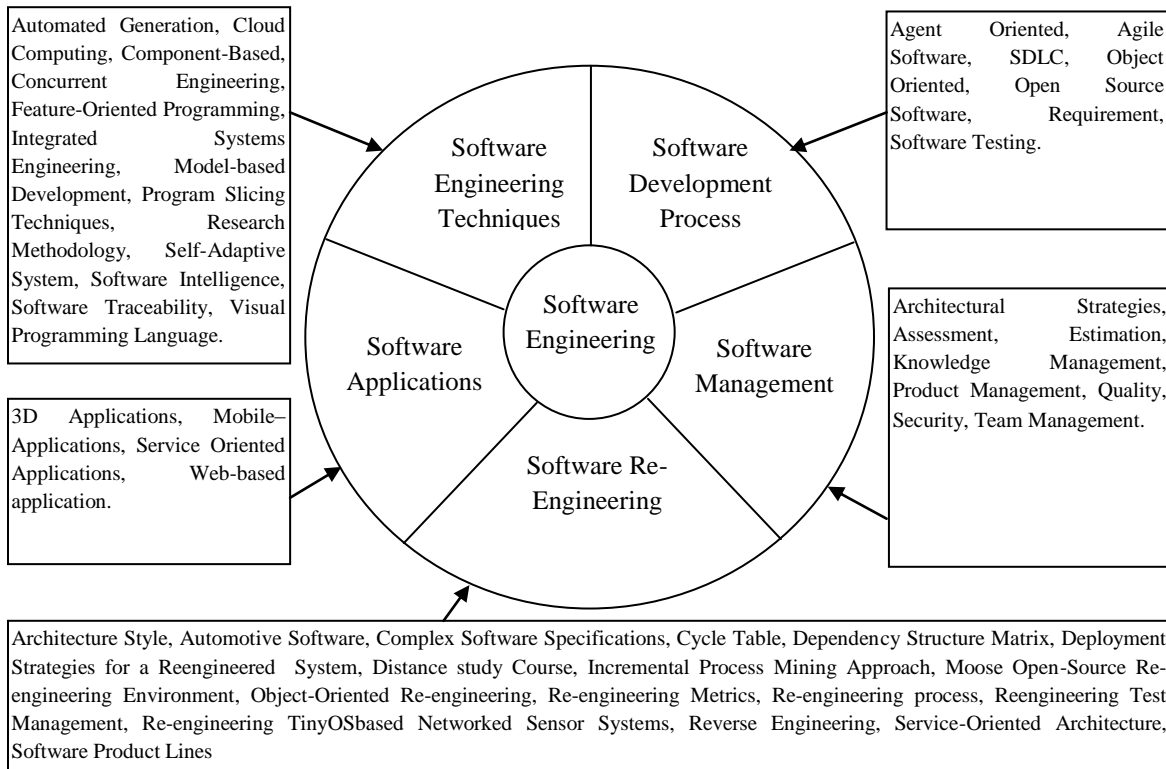


Figure (1): the literature reviews papers classification

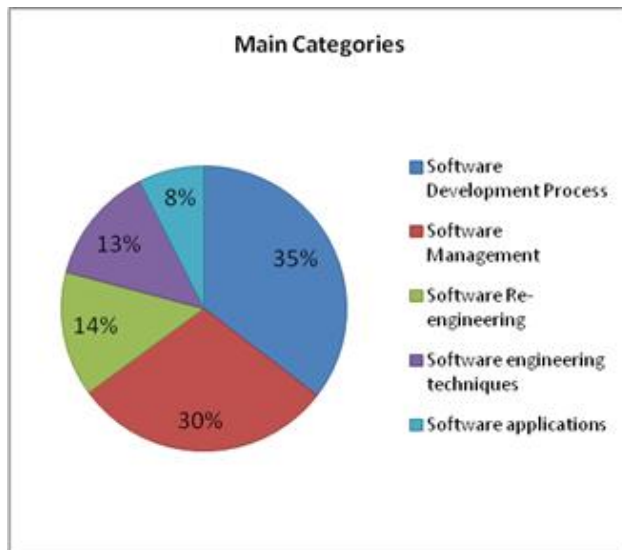


Figure (2): Percentage distribution of research in main categories

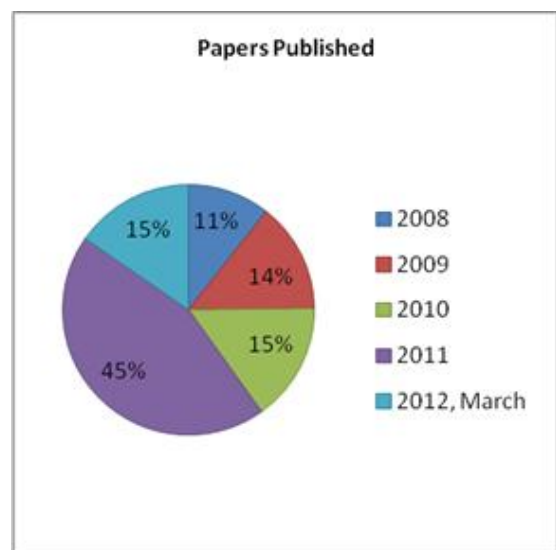


Figure (3): The papers published in a year

Table (1): Number of published papers in each category

Main Categories	No. of papers
Software Development Process	90
Software Management	75
Software Re-engineering	36
Software engineering techniques	34

Software applications	19
Total	254

Table (2): Number of published papers in each year

Year	No. of published papers
2008	27

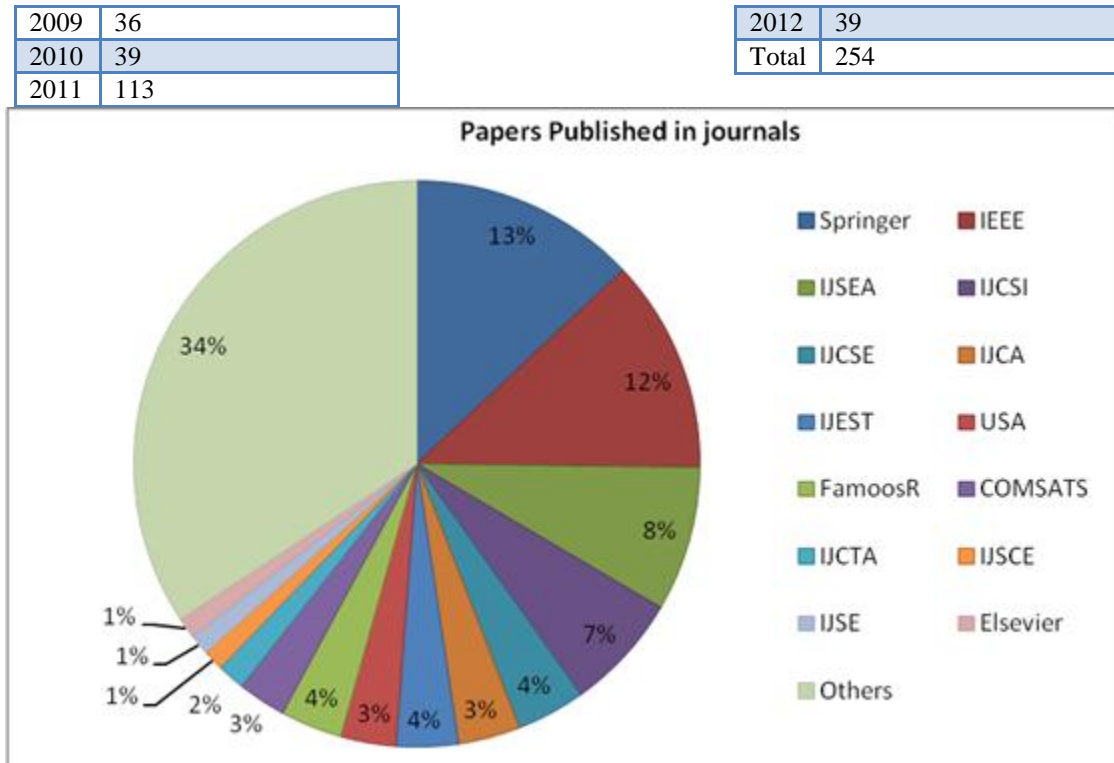


Figure (4): Papers published in various journals

Table (3): Number of papers published in various Journals

Journals / Institute	No. of published papers	Journals / Institute	No. of published papers
Springer	33	FamoosR	9
IEEE	31	COMSATS	7
IJSEA	21	IJCTA	4
IJCSI	17	IJSCE	3
IJCSE	10	IJSE	3
IJCA	9	Elsevier	3
IJEST	9	Others	87
USA	8	Total	254

Extent of research in subcategories of each category is described in detail as follows:

### 2.1 Software Development Process

A software development process, also known as a software development life cycle (SDLC), is a structure imposed on the development of a software product. Similar terms include software life cycle and software process. It is often considered a subset of systems development life cycle. There are several models for such processes, each describing approaches to a variety of tasks or activities that take place during the process. Some people consider a life-cycle model a more general term

and a software development process a more specific term. For example, there are many specific software development processes that 'fit' the spiral life-cycle model. ISO/IEC 12207 is an international standard for software life-cycle processes. It aims to be the standard that defines all the tasks required for developing and maintaining software [7].

There are many activities involved in software development called as “Software development activities”, these activities is planning (requirements analysis), design, Implementation, testing and documenting, Deployment and maintenance.

In this research area there are 90 papers, which are analyzed and classified into number of sub-categories, which are described briefly as follows:

- a. SDLC: It is a software development life cycle and there many models like Waterfall model, V model, spiral model, incremental model, and evolutionary model [7]. In this subcategory there are 32 papers and their percentage is 34%.
- b. Requirement engineering: Requirement is a singular documented physical and functional need that a particular product or service must be or perform. It is most commonly used in a formal sense in systems engineering, software engineering, or enterprise engineering. It is a statement that identifies a necessary attribute, capability, characteristic, or quality of a system for it to have value and utility to a user [7]. In this subcategory there are 15 papers and their percentage is 16%.
- c. Software testing: Software testing can be stated as the process of validating and verifying that a software program/application/product: meets the requirements that guided its design and development; works as expected; and can be implemented with the same characteristics [8]. In this subcategory there are 15 papers and their percentage is 16%.
- d. Agile Software development process: Agile software development is a group of software development methods based on iterative and incremental development, where requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development and delivery, a time-boxed iterative approach, and encourages rapid and flexible response to change. It is a conceptual framework that promotes foreseen interactions throughout the development cycle [9]. In this subcategory there are 12 papers and their percentage is 13%.
- e. Open Source Software development process: Open-source software (OSS) is computer software that is available in source code form: the source code and certain other rights normally reserved for copyright holders are provided under an open-source license that permits users to study, change, improve and at times also to distribute the software. Open source software is very often developed in a public, collaborative manner. Open-source software is the most prominent example of open-source development and often compared to (technically defined) user-generated content or (legally defined) open content

movements [10]. In this subcategory there are 7 papers and their percentage is 8%.

- f. Object oriented software development process: It is a programming paradigm using "objects" – data structures consisting of data fields and methods together with their interactions – to design applications and computer programs. Programming techniques may include features such as data abstraction, encapsulation, messaging, modularity, polymorphism, and inheritance. Many modern programming languages now support OOP, at least as an option [11]. In this subcategory there are 6 papers and their percentage is 6%.
- g. Agent oriented software development process: It is a programming paradigm where the construction of the software is centered around the concept of software agents. It has externally-specified agents (with interfaces and messaging capabilities) at its core. They can be thought of as abstractions of objects. Exchanged messages are interpreted by receiving "agents", in a way specific to its class of agents [12]. In this subcategory there are 3 papers and their percentage is 3%.

All these sub-categories are shown in figure (5) and the numbers of papers in each sub-category is shown in table (4). The number of published paper in this category with respect to the year of publishing is shown in figure (6).

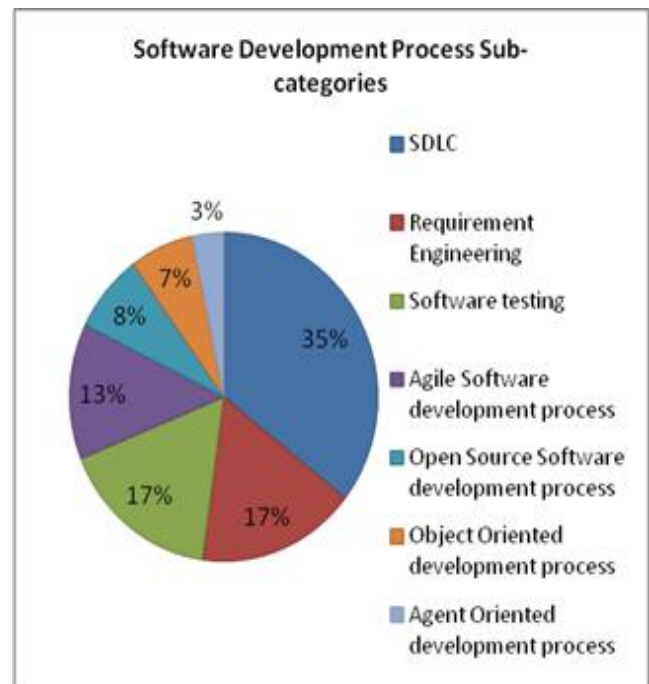
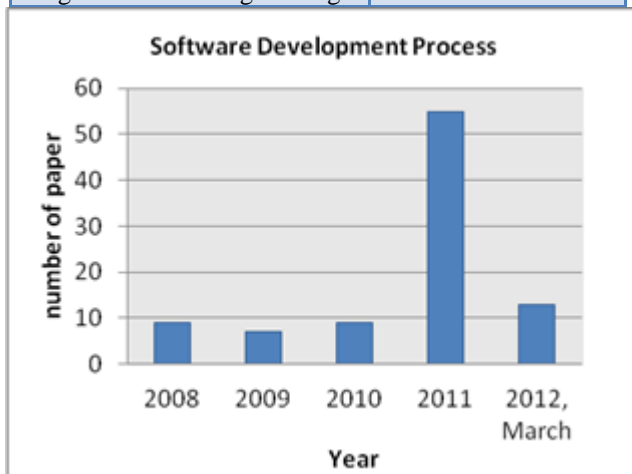


Figure (5): Software Development Process sub-categories

**Table (4): Number of papers in each sub-category of Software Development Process**

Software Development Process Sub-categories	No. of paper in each sub-category
SDLC	32
Requirement Engineering	15
Software testing	15
Agile Software Engineering	12
Open Source Software Engineering	7
Object Oriented Engineering	6
Agent Oriented Engineering	3



**Figure (6): Number of papers published in the software development process based on the year of publishing.**

## 2.2 Software Management

Software project management begins with a set of activities that are collectively called project planning. Before the project can begin, the manager and the software team must estimate the work to be done, the resources that will be required, and the time that will elapse from start to finish. Whenever estimates are made, we look into the future and accept some degree of uncertainty as a matter of course [13].

In this research area there are 75 papers, where are classified into number of sub-categories, brief description of each one is given below:

h. Assessment: Several methods have been created to define an assessment process for software. Some focus on some aspects like the maturity, the durability and the strategy of the organization around the project itself. Other methodologies add functional aspects to the assessment process [13]. In this

subcategory there are 18 papers and their percentage is 24%.

i. Quality: In the context of software engineering, software quality refers to two related but distinct notions that exist wherever quality is defined in a business context: Software functional quality reflects how well it complies with or conforms to a given design, based on functional requirements or specifications. That attribute can also be described as the fitness for purpose of a piece of software or how it compares to competitors in the marketplace as a worthwhile product; Software structural quality refers to how it meets non-functional requirements that support the delivery of the functional requirements, such as robustness or maintainability, the degree to which the software was produced correctly [13]. In this subcategory there are 16 papers and their percentage is 21%.

j. Architectural Strategies: As organizations enhance their architecture competency, architects will come to play a more and more active role in the strategy setting process, in addition to the crucial the role they already play in business strategy implementation. However, strategy is not part of the curriculum of the average computer science program, nor is it a competency that organizations necessarily foster in the technical community. In this primer, our goal is to provide you with a strategy for the intelligent introduction to state-of-the-art business strategy thinking and models. Our aim is to help you develop the language, sensibilities, and tools that will enable you to quickly position yourself to make a useful contribution to the strategy process. There more attention to this competency because it is emerging as a critical avenue for competitive distinction. The trend has been for technology to become more essential to basic business capabilities as well as to creating differentiating value propositions that distinguish the business in the marketplace. At the same time, technology is complex and fast moving enough that it requires its own kind of attention, and it falls to the architects to bring this insight to the strategy table. With this foundation in the formulation of the business strategy, architects can also be a more effective bridge between business strategy and the technical strategy that implements it [14]. In this subcategory there are 12 papers and their percentage is 16%.

k. Estimation: Software Estimation is responsive to the widespread problems the software industry has experienced in creating meaningful cost and schedule estimates. Software estimation is not as hard or mysterious as many people think, but the knowledge

of how to create effective estimates has not been well publicized. Software Estimation provides a comprehensive set of tips and heuristics that software developers, technical leads, and project managers can apply to create more accurate estimates. It presents fundamental estimation techniques and addresses specific estimation challenges. It explains how to avoid common pitfalls. Software Estimation doesn't avoid hairy mathematical approaches, but the non-mathematical reader will find plenty of useful guidelines without getting bogged down in complex formulas [15]. In this subcategory there are 11 papers and their percentage is 15%.

l. Team Management: it is refers to techniques, processes and tools for organizing and coordinating a group of individuals working towards a common goal. The 'Team Development Model', identified by Bruce Tuckman, offers a foundational definition of the stages teams go through during their lifecycle. While the activities of team management are not new, many of the tools used by team managers are. The more Organizational Development-oriented practitioners often use interview-based analysis and provide reportage and insights that team leaders and their management may use to adapt team practices for higher performance. Teams can also be developed through team building activities - which can also be used simply to build relationships where team members lack cohesion due to organizational structure or physical distance. Project managers may approach team management with a focus on structure, communications and standardized practices [13]. In this subcategory there are 9 papers and their percentage is 12%.

m. Security: Security is the degree of protection against danger, damage, loss, and crime. Security as a form of protection is structures and processes that provide or improve security as a condition. Security has to be compared to related concepts: safety, continuity, reliability. The key difference between security and reliability is that security must take into account the actions of people attempting to cause destruction [16]. In this subcategory there are 7 papers and their percentage is 9%.

n. Knowledge management: comprises a range of strategies and practices used in an organization to identify, create, represent, distribute, and enable adoption of insights and experiences. Such insights and experiences comprise knowledge, either embodied in individuals or embedded in organizations as processes or practices. Knowledge management efforts typically focus on organizational objectives such as improved performance,

competitive advantage, innovation, the sharing of lessons learned, integration and continuous improvement of the organization. KM efforts overlap with organizational learning, and may be distinguished from that by a greater focus on the management of knowledge as a strategic asset and a focus on encouraging the sharing of knowledge [17]. In this subcategory there are 1 papers and their percentage is 1%.

o. Product Management: it is an organizational lifecycle function within a company dealing with the planning or marketing of a product or products at all stages of the product lifecycle. Product management (inbound focused) and product marketing (outbound focused) are different yet complementary efforts with the objective of maximizing sales revenues, market share, and profit margins. The role of product management spans many activities from strategic to tactical and varies based on the organizational structure of the company [18]. In this subcategory there are 1 papers and their percentage is 1%.

p. All these sub-categories are shown in figure (7) and the numbers of papers published in each sub-category is shown in table (5). The number of papers published in this category with respect to the year of publishing is shown in figure (8).

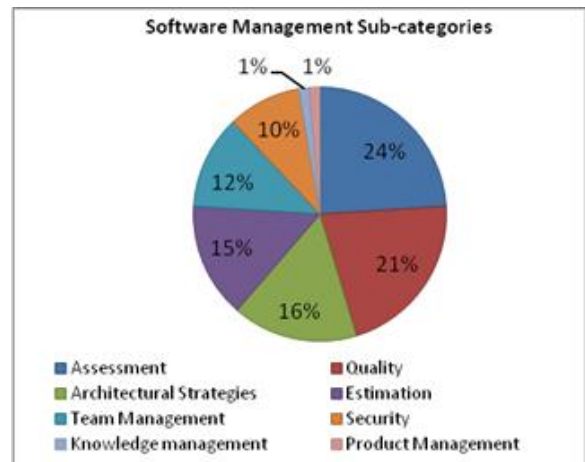


Figure (7): software management sub-categories

Table (5): Number of papers in each sub-category of software management

Software Management Sub-categories	No. of paper in each sub-category
Assessment	18
Quality	16
Architectural Strategies	12
Estimation	11

Team Management	9
Security	7
Knowledge management	1
Product Management	1

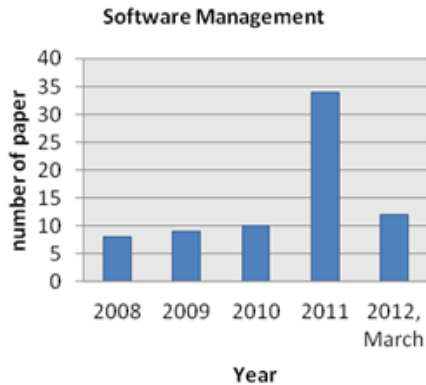


Figure (8): Number of papers published in the software management based on the year of publishing

### 2.3 Software Re-engineering

The reengineering of software was described by Chikofsky and Cross in their 1990 paper [19], as "The examination and alteration of a system to reconstitute it in a new form". Less formally, reengineering is the modification of a software system that takes place after it has been reverse engineered, generally to add new functionality, or to correct errors. This entire process is often erroneously referred to as reverse engineering; however, it is more accurate to say that reverse engineering is the initial examination of the system, and reengineering is the subsequent modification. Re-engineering is mostly used in the context where a legacy system is involved [20]. Software systems are evolving on high rate because there more research to make the better so therefore software system in most cases, legacy software needs to operate on a new computing platform. 'Re-engineering' is a set of activities that are carried out to re-structure a legacy system to a new system with better functionalities and conform to the hardware and software quality constraint.

In this research area there are many papers 36 papers, these papers are classified into number of sub-categories, these categories as following with brief description for each one of them:

a. Reverse Engineering: it is the process of discovering the technological principles of a device, object, or system through analysis of its structure, function, and operation. It often involves taking something (e.g., a mechanical device, electronic component, software program, or biological, chemical, or organic matter) apart and analyzing its workings in detail to be used

in maintenance, or to try to make a new device or program that does the same thing without using or simply duplicating (without understanding) the original [21]. In this sub-category there are 12 papers and their percentage is 33%.

- b. Object-Oriented Re-engineering: Object oriented development has proved its worth in today's system because its design and development is better, reliable and easier to access than the traditional methodologies. Due to updated requirements and lack of documentation in old systems has provided a motivation to revamp the systems. Rebuilding or redesigning the same system is highly expensive. To overcome this problem reverse engineering of the system is used as most suitable alternative [22]. In this subcategory there are 3 papers and their percentage is 8%.
- c. Service-Oriented Architecture: In software engineering, a Service-Oriented Architecture (SOA) is a set of principles and methodologies for designing and developing software in the form of interoperable services. These services are well-defined business functionalities that are built as software components (discrete pieces of code and/or data structures) that can be reused for different purposes. SOA design principles are used during the phases of systems development and integration [23]. In this subcategory there are 3 papers and their percentage is 8%.
- d. Automotive Software: it is different from the kind of software that is usually addressed by current reengineering research. These papers give an overview of the particular conditions and challenges that in the automotive domain [24]. In this subcategory there are 2 papers and their percentage is 6%.
- e. Cycle Table: Identifying and understanding cycles in large applications is a challenging task. In these papers CycleTable which displays both direct and indirect references was presented. It shows how minimal cycles are intertwined through shared edges and allows the reengineer to devise simple strategies to remove them [25]. In this subcategory there are 2 papers and their percentage is 6%.
- f. Re-engineering Metrics: A metric is nothing more than a standard measure to assess your performance in a particular area. Metrics are at the heart of a good, customer-focused process management system and any program directed at continuous improvement. The focus on customers and performance standards show up in the form of metrics that assess your ability to meet your customers' needs and business

objectives [26]. In this subcategory there are 2 papers and their percentage is 6%.

- g. Re-engineering process: it is all the activities from the legacy software analyzing to the generation of new software. In this subcategory there are 2 papers and their percentage is 6%.
- h. There are another research in the software re-engineering field, about one paper in each sub-categories, these sub-categories are: Complex Software Specifications, Dependency Structure Matrix, Deployment Strategies for a Reengineered

System, Distance study Course, Incremental Process Mining Approach, Moose Open-Source Re-engineering Environment, Reengineering Test Management, Re-engineering TinyOSbased Networked Sensor Systems, Software Product Lines, Architecture Style.

All these sub-categories are shown in figure (9) and the numbers of papers in each sub-category is shown in table (6). The number of papers published in this category with respect to the year of publishing is shown in figure (10).

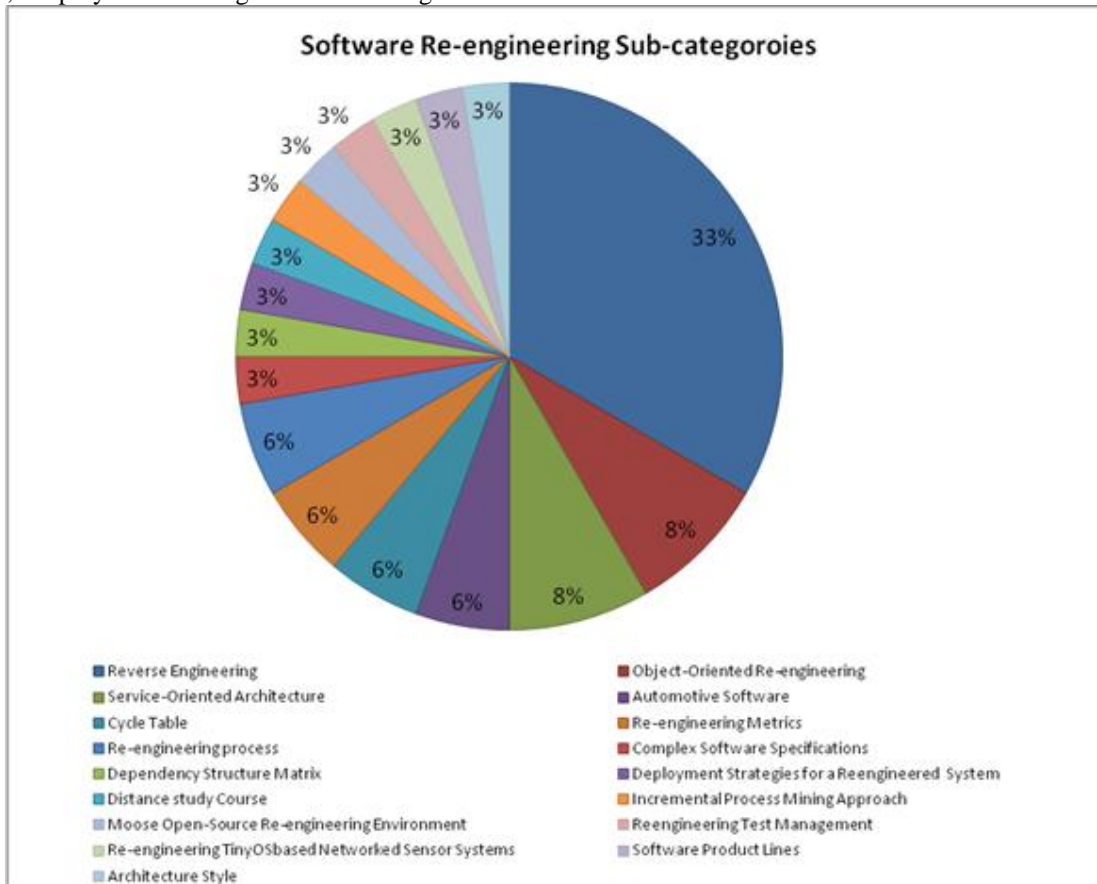


Figure (9): Software Re-engineering sub-categorieois

Table (6): Number of papers in each sub-category of Software Re-engineering

Software Re-engineering Sub-categorieois	No. of paper in each sub-category
Reverse Engineering	12
Object-Oriented Re-engineering	3
Service-Oriented Architecture	3
Automotive Software	2
Cycle Table	2
Re-engineering Metrics	2
Re-engineering process	2



Complex Software Specifications	1
Dependency Structure Matrix	1
Deployment Strategies for a Reengineered System	1
Distance study Course	1
Incremental Process Mining Approach	1
Moose Open-Source Re-engineering Environment	1
Reengineering Test Management	1
Re-engineering TinyOSbased Networked Sensor Systems	1
Software Product Lines	1
Architecture Style	1

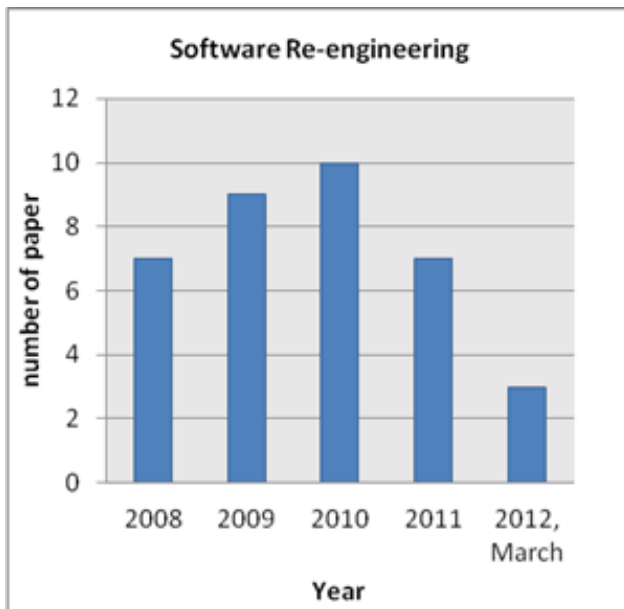


Figure (10): Papers published in the software Re-engineering.

### 2.4 Software Engineering Techniques

Today, software is becoming ever more complex, developed with a very short time to market, and required to cope with changing requirements. This scenario calls for increased levels of flexibility and agility, both in the technologies used and the processes followed for engineering software. So many techniques were provided that can meet these challenges and these techniques are known as Software engineering techniques.

In this research area there are 33 papers, which are classified into number of sub-categories as following with brief description for each:

a. Component-Based: Component-based software engineering (CBSE) (also known as component-

based development (CBD)) is a branch of software engineering that emphasizes the separation of concerns in respect of the wide-ranging functionality available throughout a given software system. It is a reuse-based approach to defining, implementing and composing loosely coupled independent components into systems. This practice aims to bring about an equally wide-ranging degree of benefits in both the short-term and the long-term for the software itself and for organizations that sponsor such software [27]. In this sub-category there are 10 papers and their percentage is 29%.

- b. Automated Generation: is a style of computer programming that uses automated source code creation through generic frames, classes, prototypes, templates, aspects, and code generators to improve programmer productivity. It is often related to code-reuse topics such as component-based software engineering and product family engineering [28]. In this sub-category there are 7 papers and their percentage is 20%.
- c. Concurrent Engineering: is a work methodology based on the parallelization of tasks (i.e. performing tasks concurrently). It refers to an approach used in product development in which functions of design engineering, manufacturing engineering and other functions are integrated to reduce the elapsed time required to bring a new product to the market [29]. In this sub-category there are 3 papers and their percentage is 9%.
- d. Research Methodology: is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically. There are various steps that are generally adopted by a researcher in studying the research problem along with the logic behind them. It is necessary for the researcher to know not only the research methods/techniques but also the methodology. Researchers not only need to know how to develop certain indices or tests, how to

calculate the mean. The mode, the median or the standard deviation or chi-square, how to apply particular research techniques, but they also need to know which of these methods or techniques are relevant and which are not, and what would they mean and indicate and why. Researchers also need to understand the assumptions underlying various techniques and they need to know the criteria by which they can decide that certain techniques and procedures will be applicable to certain problems and others will not. All this means that it is necessary for the researcher to design his methodology for his problem as the same may differ from problem to problem [30]. In this sub-category there are 3 papers and their percentage is 9%.

- e. Cloud Computing: it is a metaphor used by Technology or IT Services companies for the delivery of computing requirements as a service to a heterogeneous community of end-recipients. The term cloud theoretically signifies abstraction of technology, resources and its location that are very vital in building integrated computing infrastructure (including networks, systems and applications). All Cloud computing models rely heavily on sharing of resources to achieve coherence and economies of

scale similar to a utility (like the electricity grid) over a network (typically the Internet) [31]. In this sub-category there are 2 papers and their percentage is 6%.

- f. Self-Adaptive System: the self-adaptability of systems has been studied in a wide range of disciplines, from biology to robotics, only recently has the software engineering community recognized its key role in enabling the development of future software systems that are able to self-adapt to changes that may occur in the system, its requirements, or the environment in which it is deployed [32].
- g. There are another research in the field of software engineering techniques, about one paper in each sub-categories, these sub-categories are: Feature-Oriented Programming, Integrated Systems Engineering, Model-Based Development, Program Slicing Techniques, Software Intelligence, Software Traceability, and Visual Programming Language

All these sub-categories are shown in figure (11) and the number of papers in each sub-category is shown in table (7). The number of papers published in this category with respect to the year of publishing is shown in figure (12).

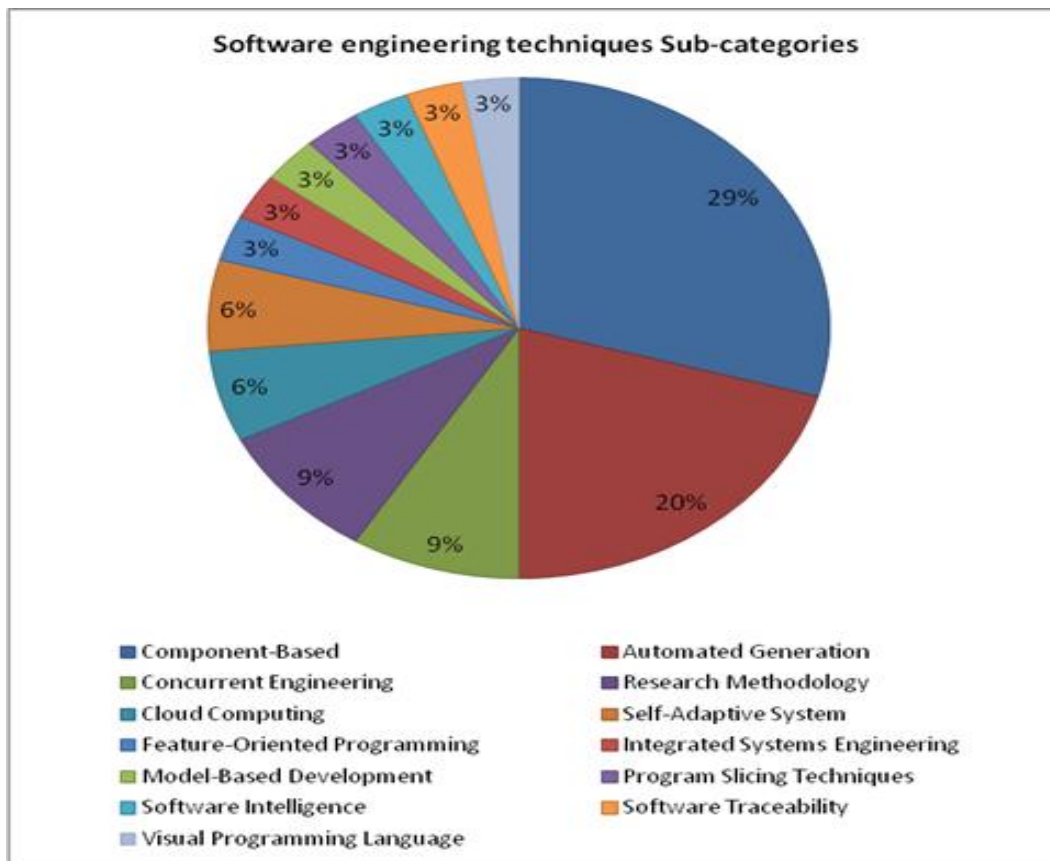
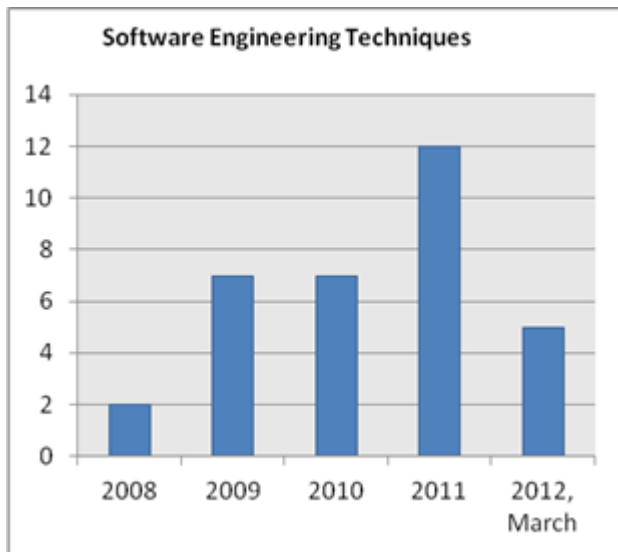


Figure (11): Software engineering techniques sub-categories

**Table (7): Number of papers published in each sub-category of Software engineering techniques**

Software engineering techniques Sub-categories	No. of paper in each sub-category
Component-Based	10
Automated Generation	7
Concurrent Engineering	3
Research Methodology	3
Cloud Computing	2
Self-Adaptive System	2
Feature-Oriented Programming	1
Integrated Systems Engineering	1
Model-Based Development	1
Program Slicing Techniques	1
Software Intelligence	1
Software Traceability	1
Visual Programming Language	1



**Figure (12): Papers published in the software engineering techniques.**

## 2.5 Software Applications

Also known as an application or an "app", is computer software designed to help the user to perform specific tasks. Examples include enterprise software, accounting software, office suites, and graphics software and media players. Many application programs deal principally with documents. Apps may be bundled with the computer and its system software, or may be published separately. Some users are satisfied with the bundled apps and need never

install one. Application software is contrasted with system software and middleware, which manage and integrate a computer's capabilities, but typically do not directly apply in the performance of tasks that benefit the user. The system software serves the application, which in turn serves the user [33].

In this research area there are many papers 19 papers, these papers are classified into number of sub-categories, these categories as following with brief description for each one of them:

- a. **Web-based application:** A web application is an application that is accessed over a network such as the Internet or an intranet. The term may also mean a computer software application that is coded in a browser-supported language (such as JavaScript, combined with a browser-rendered markup language like HTML) and reliant on a common web browser to render the application executable. Web applications are popular due to the ubiquity of web browsers, and the convenience of using a web browser as a client, sometimes called a thin client. The ability to update and maintain web applications without distributing and installing software on potentially thousands of client computers is a key reason for their popularity, as is the inherent support for cross-platform compatibility. Common web applications include webmail, online retail sales, online auctions, wikis and many other functions [34]. In this sub-category their are 12 papers and there percentage is 63%.
- b. **Mobile – Applications:** It is application software that developed for small low-power handheld devices such as personal digital assistants, enterprise digital assistants or mobile phones. These applications are either pre-installed on phones during manufacture, downloaded by customers from various mobile software distribution platforms, or web applications delivered over HTTP which use server-side or client-side processing (e.g. JavaScript) to provide an "application-like" experience within a Web browser [35]. In this sub-category there are 3 papers and their percentage is 16%.
- c. **Service Oriented Applications:** A service-oriented architecture is essentially a collection of services. These services communicate with each other. The communication can involve either simple data passing or it could involve two or more services coordinating some activity. Some means of connecting services to each other is needed. Service-oriented architectures are not a new thing. The first service-oriented architecture for many people in the

past was with the use DCOM or Object Request Brokers (ORBs) based on the CORBA specification [36]. In this sub-category there are 3 papers and their percentage is 16%.

- d. 3D Applications: it is refers to programs used to create 3D computer-generated imagery, there are many software like 3D Studio MAX, 3D modeling application, Animation Master, and etc. [37]. In this sub-category there are 1 papers and their percentage is 5%.

These sub-categories are shown in figure (13) and the numbers of papers in each sub-category is shown in table (8). The number of papers published in this category with respect to the year of publishing is shown in figure (14).

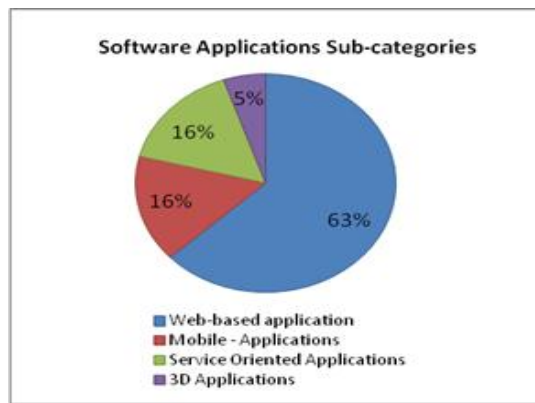


Figure (13): Software engineering techniques sub-categories

Table (8): Numbers of papers published in each sub-category of Software application

Software applications Sub-categories	No. of paper in each sub-category
Web-based application	12
Mobile - Applications	3
Service Oriented Applications	3
3D Applications	1

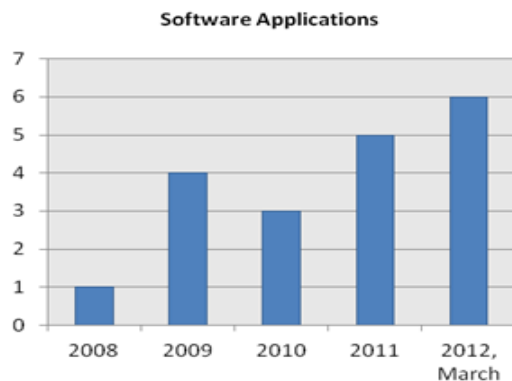


Figure (14): Papers published in the software applications category.

### 3. THE GAP IN SOFTWARE ENGINEERING

On classification of the researches published in the last five years and analysis of data, it gives a concrete idea that research conducted in software re-engineering, software engineering techniques and software applications is meager while a higher percent of research is carried out in rest of the two areas as shown in figure (2) and table (1). The comparison among the number of papers published in all five categories with respect to the year of publishing is shown in figure (15). From the figure, it is understood that very less research is conducted in the area of software re-engineering in the current year (2012, March), therefore, research gap exists in the area of software re-engineering which means more research is possible in the same.

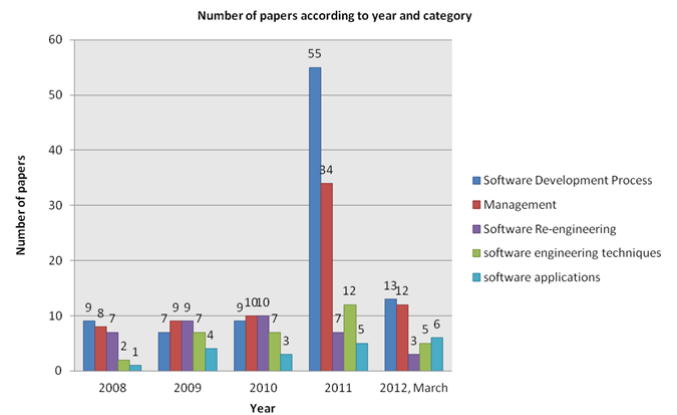


Figure (15): Papers published in each category from the year (2008 - 2012, March).

### 4. CONCLUSION

On reviewing more than 250 papers related to software engineering published in various reputed journals, the authors have realized that software engineering is a very important research area and it can be classified into various sub-areas like software development process, software management, software re-engineering, software engineering techniques and software applications. Research was carried out to a lesser in all five categories in the year 2008, 2009 and 2010, where as there is substantial rise in research conducted in the year 2011 especially in the first two categories, which is again followed by a sudden drop in the year 2012 until March. Further, the study also provides an insight on the insufficient research carried out in software re-engineering and hence the authors recommend greater scope in this particular area and that extensive research may be conducted to improve and enhance the software re-engineering processes.

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