

# Software Engineering Research: Understanding SE Paradigms and Methods

R P Shrivastava<sup>1</sup>, Khalida Kamaal<sup>2</sup>

<sup>1</sup>MP State Industrial Development Corp. Ltd., Bhopal (M.P.) India.

<sup>2</sup>AISECT University, Bhopal (M.P.) India.

## ABSTRACT

There is a broad use of the term “paradigm” in Software Engineering. Concepts such as Structured paradigm, Cascade paradigm or Agent-oriented paradigm are very frequent in SE research proposals. The functional and scientific paradigm in SE is about the functional or engineering paradigm rather than scientific paradigm. Four possible perspectives and, in this context, the scientific perspective is intrinsic and hence very difficult to properly identify and describe. A discussion about the scientific paradigm in SE could help us to evaluate and improve the research practice in SE. A Programming Paradigm is simply a fundamental style of computer programming. It is like the blue print of a construction site. A programming paradigm provides some very basic concepts and patterns which various designers of programming languages adopt and implement.

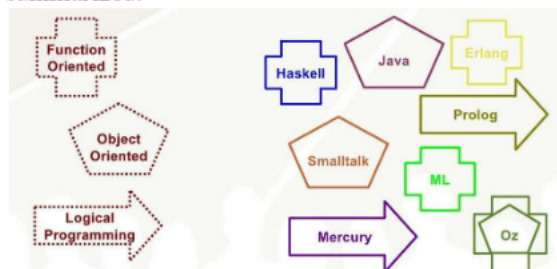
**Keywords:** Software, Engineering, Paradigm, Scientific, Functional, Conceptual Framework, Perspective.

## I INTRODUCTION

Since inception of software engineering research, one can identify many proposals using the term “paradigm”. The meanings of these references are engineering interpretations rather than scientific interpretations. Moreover, there is not an obvious identification of what are the basics and philosophical assumptions in SE research which conform its scientific paradigm. In order to show these concepts, two common interpretations about the general concept of paradigm have been discussed.

The interpretations of the paradigm concept in SE explored. The distinction between software engineering as a profession and software engineering as research discipline has been examined.

Finally, the circle of the previous discussions arguing in favour of the necessary identification and description of the scientific paradigm in software engineering. The main conclusions are summarized.



**Fig.1 - Some languages, are flexible enough to implement many paradigms in almost native fashion.**

## II TWO COMMON INTERPRETATIONS

The word paradigm in some dictionaries, find out a definition built on words: “model”, “example” or “pattern”. For example paradigm is defined as “an example that serves as pattern or model”. It is said that a paradigm is a “a model of something which explains it or shows how it can be produced”.

These common interpretations appear be included in computer topic, e.g. a paradigm is a pattern which constitutes a process or system model. Moreover, it is said that a paradigm is a technique, method or computer tool, which allows give a solutions to a specific problem.

On the other hand, there is a scientific use of the word. For example it is said that paradigm is “a conceptual framework for a scientific discipline; a set of assumptions, methodologies, and objectives that determine a scientific investigation”. Moreover, a “set of fundamental assumptions that influence how people think and how they perceive the world” and also as “a framework of guiding assumptions, theories, and methods that define a particular approach to scientific problems”.

Consequently , a understanding of paradigm and, also, a more specific point of view with the scientific understanding of the word “paradigm “ that the scientific progress is done through paradigmatic shifts. A paradigm as the total pattern of perceiving associated with a particular image of reality that prevails in a branch of science.

- conceptualizing,
- acting,
- validating, and
- valuing

The cycled model of scientific progress with the first pre paradigmatic stage, where a paradigm has not been yet broadly accepted; a normal science period, where the current paradigm is used; and a revolutionary stage, when the paradigm is changed; this process conform a paradigmatic shift.

Although that science does not precisely follows this pattern, the concept of paradigm imposed, has gained acceptance in discussions.

A scientific paradigm is a radical view, because when a paradigm changes the scientist works in a different world afterwards. There is a moment when different competing paradigms confront each other.

### **III SUMMARIZING, TWO INTERPRETATIONS OF THE PARADIGM**

first, a understanding related to a model, pattern or example of something and, on the other hand, the scientific approach, oriented to a set of assumptions related with a conceptual framework supporting these assumptions and influencing how scientists think and how science is carry out.

The first functional paradigm and the second scientific paradigm. Both interpretations are different because a functional paradigm can be seen as an abstraction tool, something that one can change easily.

Follow a model A under some conditions, and under other conditions one could follow a model B. This does not mean that we have changed our basic assumptions or that we have modified our way of thinking.

On the other hand, Do not change easily the basic assumptions, because assumptions are beliefs. Therefore a scientific paradigm is constituted by a set of beliefs which influence the approach to define the research object and the ways to study it.

Finally, other interpretations for the word "paradigm", especially from grammar, although these interpretations are not interesting.

### **IV INTERPRETATIONS OF "PARADIGM" IN SE**

In Software Engineering the word "paradigm" has been used from many years ago: we have used the cascade paradigm, the structured paradigm, the object-oriented paradigm and some others.

From the modeling point of view the "paradigm" refers to a set of related concepts which are used by a person to perceive the real world or a part of it".

The object-orientation as a paradigm means "approach goes beyond the object-based technique...", and that the "... artifacts' of the design process used in conjunction with a modeling based decomposition approach yield a paradigm,...".

The idea of paradigm as a broadly conceptual framework is that software paradigms generally go through three main phases:

- (i) early pioneers identify a way of doing things,
- (ii) individuals and organisations that are early adopters of leading-edge technologies recognise the potential, and
- (iii) basic concepts become more widespread and enter in the mainstream.

The deep analysis includes many relevant points of view from Plato and Aristotle to the contemporaries Foucault and Kuhn. One of the explanations is the metaphor of the darkness glass. The paradigm would be this element that allows us a specific perception of the reality. There are two additional features of paradigms : the existence of the imprecision in the conceptual framework and the idea of a broad application of it.

Moreover the perception that there is some mystic aura around the concept of paradigm. this conception is supported by two elements.

First the darkness glass metaphor, which reflects that an specific paradigm does not allow us to see the reality as is because there is a conceptual framework that acts as a filter and second, it is usual that there is not an agreement about the specific conceptual framework. On the other hand, we could speculate that this last feature allows an extensive use because many interpretations over the same conceptual framework are possible and therefore its use is not limited by the interpretation of this conceptual framework.

A paradigm is constituted by a diffuse conceptual framework can be obtained mixing two results: first, that agent orientation is a software engineering paradigm and second the how the basic social conceptual framework of agent-oriented methodologies have many differences. Thus similar but not identical conceptual frameworks interpreting a specific paradigm (agent orientation).

Coming back to to distinguish between a functional paradigm and a scientific paradigm that, the examples mentioned above refer to how to do software and not how to do science, i.e. the examples show a functional point of view of paradigms.

It is not clear how static is the inherent conceptual framework. i.e., can we easily change our darkness glass? Any answer (positive or negative) guides us to confirm our idea that dividing paradigm between functional and scientific. A positive answer implies that the perception can change easily and therefore we could use different paradigms under different conditions. On the other hand, a negative answer says that the vision is static; the conceptual framework is formed of solid beliefs.

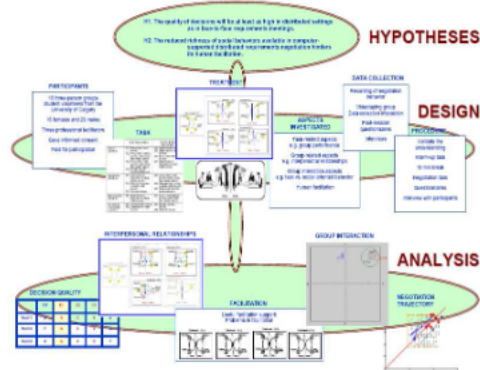


Fig. 2 Literacy view of Design

## V THE TWO FACES OF SE: AS A PROFESSION AND AS RESEARCH DISCIPLINE

SE has two faces, the professional face and the scientific one. The concept of SE that “software engineering is an engineering discipline that is concerned with all aspects of software production” and specifies that the basic activities are: software specification, development, validation and evolution. We think that there is no doubt about software engineering being an engineering discipline, in any case some arguments supporting this - that engineering principles have used successfully in order to build complex computer systems. This position is defended as a result of some answers about what is engineering.

The application of scientific knowledge always appears as one of the engineering principles. In this case, mathematics and computer science seems to be the most relevant sources of scientific knowledge provided to software engineering discipline.

However, software engineering is a research discipline too. To rely this belief, where software engineering is assumed a research discipline. In these cases the question is how to do research. In addition, according to the definition of software engineering, we can say that software engineering, as a research discipline, is concerned about the

production of software and that the software process is the research object. Therefore, in software engineering as research discipline we have a relevant source of knowledge oriented to improve the software engineering practice. Thus, if the goal of a generic research area is to produce knowledge, then the goal of the software engineering scientific discipline is to produce knowledge about improving the software process. When one distinguish software engineering as a research discipline that an additional differentiation from related disciplines is necessary. However this specific differentiation could take us some additional space.

Computer science, software engineering and information systems research constitute different research disciplines with different research objects and different research approaches.

In Information Systems (IS) research the term paradigm in the scientific way is clearly acknowledged. For example, a difference between the concept of scientific paradigm and the implications for IS research. Result shows paradigmatic dichotomies in IS research mentioning Positivism.

Those research disciplines are different from Software Engineering in which the research object is the software process. Here there is a clear concentration about conceptual analysis and proof of concepts as its main research approach.

To sum up in favour of differentiating between software engineering as a profession and software engineering as a research discipline. One should distinguish among computer science, information systems and SE research disciplines. This last distinction allows focusing in software engineering as a different research discipline from computer science and information systems.

## VI THE FOUR PERSPECTIVES

It is obvious, two types of paradigms and two facets of software engineering. These two differentiations are orthogonal views i.e. that in practical aspects the two types paradigms has been used by both, software engineering researches and software engineers. This cross product provides four different perspectives, (EE) engineering paradigms used by software engineers, (ES) engineering paradigms used by software engineering researchers, (SE) scientific paradigms used by software engineers, and (SS) scientific paradigms used by software engineering researchers. Illustrated these four perspectives in the figure 1. On the EE perspective, that software engineering as a profession uses the different paradigms as tools. Maybe a simple add can be done in a structured way, a calculator could be

implemented with a proper class and a data processing service could be implemented using an

They are different choices to tackle a software development process. Hence the structured, object-oriented and agent-oriented paradigms coexist without problems and moreover, this coexisting is positive and synergic. These functional paradigms are really engineering paradigms, i.e., model or patterns that guide us the modeling when we need to develop software.

On the ES perspective, engineering paradigms constitute firstly research products and thus a way to focus the current solution approach to software development. Engineering paradigms are not scientific paradigms, because they do not change

agent. But all these alternatives are not really competing.

our assumptions about software engineering is, they do not change our research object (the software process) and they do not change our way to do research. Moreover, the successful of software engineering as research discipline as precisely providing engineering paradigms with their related components (for instance design tools, programming languages, developing techniques and testing methods).

Therefore, the normal and historical behavior of the software engineering research discipline has been to produce engineering paradigms about how to develop software.

	Engineering Paradigms (e.g. Object-Oriented)	Scientific Paradigms (e.g. Positivism)
Engineering Use (goal: to produce software)	<b>EE</b> Like a Design Metaphor	<b>ES</b> To understand the specific domain and developing assumptions
Scientific Use (goal: to produce knowledge)	<b>SE</b> Like a specific solution approach	<b>SS</b> <u>To produce software engineering knowledge</u>

**Fig. 3 Perspectives about paradigms in software engineering**

On the SE perspective, the use of scientific paradigms and some specific research methodologies into the software process. For example, it is reviewed some scientific paradigms and its application to software development is analyzed.

Where action research and focus groups research methodologies are proposed like requirements elicitation techniques, i.e. scientific paradigms and scientific approaches used into the software process as engineering techniques.

About the SS perspective a debate is necessary. The behavior of the discipline has been static. We have not found a paradigmatic SS discussion in software engineering. In the sense of perhaps we are living a normal science period. But, this period has been critiqued because it has an inherent sense of mediocrity.

This point, should be very debatable, because, there are many proposals about the research methodologies that software engineering could follow. Furthermore, these recommendations oriented to change the research practice and, in this sense, there are initiatives to support a paradigmatic change in software engineering research. However, these proposals are based mainly on importing research methodologies, i.e. using somewhere formulated methodologies in SE.

Thus research methodologies are visualized like technologies. Indeed, we need a broad and critique discussion about what is really the research scientific paradigm in software engineering, the SS perspective. That it is not clear, but, at the same time, its identification and description is the first step to evaluate it, which could allow us seeing our set of inherent assumptions with their weak and strong points. This step is foundational in the generation of a true paradigmatic-shift in software engineering research.

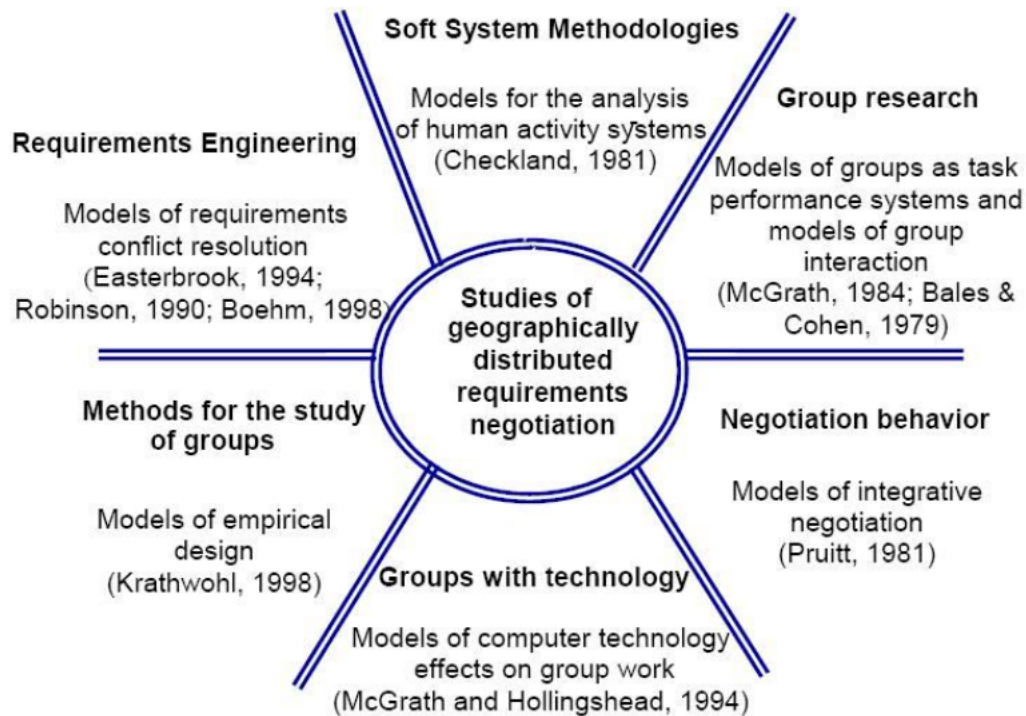


Fig. 4 Research paradigm

## VII CONCLUSION

A review of the concept paradigm has been presented there exist at least two types of paradigms: functional paradigms and scientific paradigms. In a parallel way that software engineering has two faces, the professional and the scientific face. We have demonstrated how the traditional concept of paradigm in software engineering corresponds to the functional type, i.e. that paradigm is broadly conceived as a modeling tool rather than a philosophical point of view. Thus we have identified four perspectives to understand the use of paradigms in software engineering.

The scientific perspective of the current SE scientific paradigm is not evident and a broad discussion could be the first step to acknowledge general assumptions which should be the start point of a real paradigmatic shift in SE, which has been the base of memorable research outcomes.

## REFERENCES

- [1] Cowie, A. P. (ed.): Oxford advanced learner's dictionary of current english. Fourth ed., Oxford university press, Oxford (1989).
- [2] O'Neill, M. (ed.): Concise dictionary & thesaurus. ed., Chambers Harrap Publishers Ltd, Edinburgh (2001).
- [3] Soukhanov, A. H. (ed.): The American heritage dictionary of the English language. Third ed., Houghton Mifflin Company, Boston - New York (1992).
- [4] Sinclair, J.: English dictionary for advanced learners. Chief editor John Sinclair, Third ed., Harper Collins publishers, Glasgow (2001).
- [5] Kuhn, T. S.: The structure of scientific revolutions. Third ed., The University of Chicago Press, (1996).
- [6] Kitchenham, B. A., Pfleeger, S. L., Pickard, L. M., Jones, P. W., Hoaglin, D. C., Emam, K. E., Rosenberg, J.: Preliminary Guidelines for Empirical Research in Software Engineering. IEEE Transactions on Software Engineering Vol. 28. (8) (2002) pp. 721-734.
- [7] R P Shrivastava, Khalida Kamala, et al "A Paradigm Shift in SE Research : Convergence Of Social Media", Proc of 2 Days International Conference on "Emerging Trends in Science and Technology" ,Aug. 22-23, 2014, Sri Satya Sai University of Technology & Medical Sciences. Conference. Download Proceeding ICETST 2014. Copyright © SSSUTMS.
  - i. <http://sssutms.co.in/web/pageDetails.aspx?subcat=94&cat=NOTICE>
  - ii. <https://drive.google.com/file/d/0B784xVGlrtK-cDlMa1hvVVNpckk/edit>