CHAPTER 7

CONCLUSIONS AND FUTURE WORK

7.1 BACKGROUND

Generally, reliability can be evaluated once the software product is finished or nearly finished. Therefore estimating reliability early in the development life cycle can help designers to incorporate required enhancement and corrections, by the coding phase begins. Such estimation would also minimize or at least reduce future efforts and rework to be done on the software product. Requirements and Design stages of development life cycle play a very influential role in the development of reliable software. Therefore predicting reliability of developing software at the end of its design stage would help in predicting the reliability of the finally delivered software.

To accomplish this task, researcher has performed a comprehensive literature review, and proposed a fuzzy based framework for predicting the reliability, as a solution to the identified shortcomings during the review. Further, in order to implement the framework, this research has developed an Early Stage Reliability Prediction Model (ESRPM) which predicts reliability before the coding phase. Subsequently, the developed model has been validated as well as compared

quantitatively with other existing reliability models. The results are quiet encouraging and support and reclaim that the developed model has improved the reliability modeling quite efficiently.

7.2   MAJOR FINDINGS

This section of the chapter highlights the major finding of the study. In the first chapter some research questions have been framed. Now those questions are reiterated with corresponding solutions obtained during the course of study.

Q1.   **Is there any reliability prediction model available for object-oriented software at the design stage?**

Ans.   **Yes**, a wide variety of reliability prediction models have been proposed in the literature within last two decades. Chapter 2 comprehensively answers this question, by presenting the various efforts along with their critical findings.

Q2.   **Is there any fuzzy based reliability prediction model available that predicts the reliability of the developing software upto its design stage, using the requirements and Object-Oriented design measures (before the coding starts)?**

Ans.   **No** Such Model exists so for. Although a significant number reliability models have been proposed by various researchers, but either they are predicting reliability in later stages like testing, or predicting the reliability using only requirements or design stages only. That is not considering the combination of

requirements and design stage. That's why the effort done in this research has not been attempted by any researcher before.

Q3. **Is it feasible to develop an early stage reliability model as specified in above Q2 ?**

Ans. **Yes**, It is feasible. And this research has not only developed (ESRPM), but also validated and compared, in chapter 4, 5 and 6 respectively.

Q4. **Are there any product based measures at the requirements stage those may impact on the reliability of the developing software?**

Ans. **Yes**, there exists product based measures at the requirements stage those may impact on the reliability of the developing software. The chapter 4 of this research has not only identified such early product based measures, but also justified their association with the software reliability.

Q5. **Is it justified to engage the fuzzy technique in order to develop a reliability model as specified in Q2 ?**

Ans. **Yes**, it is not only justified but also advantageous to utilize the strengths of fuzzy logic in order to encounter the subjectivity of early stage reliability relevant metrics. Chapters 1 and 3 have explained its conceptuality, while the chapter 4 and 5 has proved its practicality by developing a reliability model (ESRPM) using Fuzzy Inference System.

Q6. **Are there quantifiable features that can be extracted from information available in early stages that can be used to predict software reliability?**

Ans. **Yes**, there are many features that can be extracted from early stage of software development. Chapter 4 answered it in detail.

Q7. **Is there any framework or roadmap exists that may guide the researchers or industry professionals in developing a model as specified in Q2 ?**

Ans. **No**, such framework exists, but this research has not only developed, but also implemented a prescriptive Fuzzy Logic based software reliability quantification framework ([FL]SRQF) in chapter 3 and 4 respectively.

7.3   CONTRIBUTIONS OF THE STUDY

The study has focused on requirements and design stages to predict reliability before the coding stage. Although the significance of the study has already been mentioned under the section 1.9 of Chapter 1, but at this stage of the documentation it seems quiet reasonable to once again reiterate them:

a)   One of the major significant contribution of this research is the Fuzzy Logic based Software Reliability Quantification Framework ([FL]SRQF). The framework is quite prescriptive in nature, and will definitely facilitate industry professionals and researchers to predict software reliability in the early stage of development, and subsequently decrease the probability of software's unreliability.

b) Consideration of the requirements phase along with the design provides this research an edge over other studies those are based on only design phase, because ignoring or overlooking requirements deficiencies and only concentrating on making the design constructs superior will not seems good enough.

c) The suitability of various requirement and design measures as a contributor for the software reliability has been identified.

d) The reliability model developed as per the guidelines of the proposed framework may help software professionals to take appropriate corrective measures right from its requirements phase, to deliver software with an improved reliability level, close to the user's expectation.

e) Based on the analysis of quantified values, the research assists developers by providing them an opportunity, to once again improve requirements and design related internal characteristics ahead of writing the final code.

f) The proposed model may help designers as well as developers to predict the reliability of the developing software upto its design stage, early in the development life cycle.

g) Based on the predicted reliability of developing software upto its design stage, the developers may predict the reliability of the final software to be delivered in future.

h) In order to overcome the limitations of subjective values of requirements metrics, the research has utilized the strength of fuzzy inference process in its quantification phase.

i) The 'Assessment and Amendment' phase of the framework further strengthens it practicality as well as viability by keeping the doors of improvement open for any of the earlier phases.

j) In most of the cases, developed models only provide quantitative values but neither provides suggestions on how to make improvement, nor the precautions on how to avoid abnormalities. Therefore, to fill this gap research has provided the suggestive measures and recommendations based on the results and contextual interpretations.

k) Apart from the above, reassessment of previously developed or underdevelopment reliability prediction models could be done as per the guidance proposed as well as recommended in this study.

l)   Beside this, as far as further research is concern, the model may open fresh avenues for the researchers, doing research on reliability estimation as well as reliability prediction.

7.4   FUTURE EXTENSION

As this research assumes that the SRSs are written in plain English text. Therefore one possible future direction may be developing some automated approach that could be helpful in identifying the inconsistencies, ambiguities and incompleteness in the SRS.

The research has considered only four object-oriented design constructs to quantify the reliability at the design stage. (i.e. Encapsulation, Coupling, Inheritance and Cohesion). Therefore it further opens more avenues to consider some other design constructs of object-oriented design or non object-oriented design, to move ahead in the direction of reliability prediction.

The reliability prediction model developed in present study focuses on object-oriented paradigm, but in future more generalized reliability prediction model can be developed. The future research may also focus on measuring other quality factors like those proposed in the ISO 9126. In future studies more models can be developed those may focus on other UML diagrams like use case diagrams, state transition diagrams etc.

Besides these, there are also several directions that reliability prediction can take in future includes (i) the use of automated reliability prediction models as acceptance criteria for software quality control and third party software procurement; (ii) the analysis of how software reliability affects other software quality factors such as maintainability, re-usability and portability.

7.5 CONCLUSION

This chapter provides a summary of the entire research study. The chapter starts with the background as well as need of this research and briefly describes the development and validation process of the reliability prediction framework and the reliability model (ESRPM). Subsequently, it presents the major finding in the form of answers to research problems identified in Chapter 1. And finally the chapter ends with highlighting the study's contributions and future scope of further research.