Faculty and Researchers	Faculty and Researchers' Publications

1993-11-06

Achieving Success in Measurement and Reliability Modeling

Keller, Ted; Munson, John C.; Schneidewind, Norman; Stark, George

http://hdl.handle.net/10945/45148

Panel Session at the International Symposium on Software Reliability Engineering 1993

Saturday: 6 November 1993, 0830-1000 and 1030-1200

Achieving Success in Measurement and Reliability Modeling

Ted Keller, IBM Federal Sector Services Corporation
John C. Munson, University of West Florida and Naval Postgraduate School
Norman Schneidewind, Naval Postgraduate School (coordinator)
George Stark, MITRE Corporation (moderator)

Background

The NASA Space Shuttle on-board software is one of the nation's most safety-critical software systems. The process which produces this software has been rated at maturity level five. Among the quality assurance methods that are used to ensure the software is free of safety-critical faults is the use of reliability modelling and prediction. In addition, IBM-Houston and NASA have recently embarked on a comprehensive metrics collection and analysis program aimed at providing early indicators of software reliability, improving the accuracy of reliability models by including metrics as components of reliability models, and building a metrics and software failure data base. In addition to supporting the mission of the Space Shuttle, this effort will contribute to the national software reliability data base being developed at the Rome Laboratory Data Analysis Center for Software, as part of the American Institute of Aeronautics and Astronautics (AIAA) Recommended Practice for Software Reliability. Furthermore, the combination of data base, IBM's experience with reliability modelling of the Space Shuttle on-board software, and on-going research in quality metrics, will lead to new insights in the relationship between quality metrics and software reliability. The outputs of this project will significantly increase research opportunities in software metrics.

Content of Panel

This panel will present the current results of IBM FSSC's continuing investigation of enhanced reliability models and metrics data collection and analysis research now in progress to support the Space Shuttle and AIAA databases. Of particular interest to the workshop participants will be the development of a software measurement system for both static and dynamic aspects of program complexity to assess the reliability of the Space Shuttle on-board flight software and results from incorporating metrics in reliability models. The results of the current research program will be summarized by area of expertise by each of the panel members.

Position Statements

Ted Keller, IBM Federal Sector Services Corporation

Mr. Keller will report on the IBM effort to create the Space Shuttle Software data base: contents, applications to the Space Shuttle, data collection and validation procedures, problems in defining and associating data elements required by both practitioners and researchers, and the procedures for providing data to and retrieving data from the AIAA data base.

John C. Munson, University of West Florida

The results of the application of software measurement tools for the software for the on-board fight software for the Space Shuttle will be discussed. This software system is a very large and extensive system for which a large amount of software development information has been collected. The focus of this presentation will be on the development of a complexity domain model for the HAL/S programming language in which all of the Space Shuttle software is written. This research has shown that some aspects of software complexity in other programming language environments are strongly related to software problems introduced in software development and also in the change process. The goal of the current research effort is to measure the relationships between identified software attributes and software fault and failure data.

A major research objective has been to identify those software complexity attributes that are most closely related to or highly correlated with software faults and, ultimately, with software failures in test. Of particular concern are the number of major actions found during program inspection, discrepancy reports and the number of change requests. It is important to understand the relationship between software code measures and software reliability measures in that the complexity measures can be obtained as soon as a program is coded. Given the strong relationship between the selected set of software complexity measures and change request and discrepancy reports, it will be possible, in the future, to anticipate which specific regions within the on-board flight software systems that are most likely to contain software faults that may lead to software failures.

The software complexity data will be used in conjunction with the operational profiles generated by the on-board flight software, in test mode, to examine the dynamic complexity of the various functional test of the software.

Norman Schneidewind, Naval Postgraduate School

Professor Schneidewind will describe the advantages of optimally selecting a subset of failure data for driving a software reliability model and its application to improving time-to-failure and failure occurrence predictions for the Space Shuttle. He will also discuss initial results obtained from incorporating metrics into a reliability model. He will indicate whether doing this seems to improve reliability predictions for software in general and for the Space Shuttle in particular.

With respect to the use of metrics in reliability prediction he will distinguish between *implicit* and *explicit* prediction. Implicit prediction is used during design, when metrics data are available but fault and failure data are not available, to predict the reliability of a given module when it is tested or becomes operational; the model is based on a previous validation of metrics against fault or failure data for other modules. The advantage of implicit prediction is that the metrics can serve as early indicators of potential reliability problems. Software management can remedy these problems by taking corrective action during design when the cost of correction is less expensive than during test or operation. The disadvantage is that accurate predictions of actual reliability quantities (e.g., probability of no failure, time to failure, failure rate) may be difficult to achieve because: 1) The characteristics of the software during test and operation may be significantly different from the characteristics during design, meaning that implicit prediction may be attempting to predict reliability for a module that has changed considerably since the time of prediction. (This problem can be alleviated by updating

predictions as the software evolves.) 2) There is no fault or failure data available to drive the model.

Explicit prediction is used during test and operation to make predictions of future reliability quantities of the given module based on using failure or fault histories of the *given* module to estimate model parameters. The advantage of explicit prediction is accuracy of prediction because the model is driven by recent fault or failure data that has been collected in the *actual* prediction phase. The disadvantages are that 1) predictions cannot be made until late in development when fault correction is costly and 2) the models seldom contain (until now) metrics to reflect characteristics of the software.

George Stark, MITRE Corporation

The US Space Shuttle is a truly remarkable vehicle that is totally "fly-by- wire." The Primary Avionics Software System (PASS) is the highly reliable code at the heart of the manned space program. Furthermore, the PASS project has won many awards and accolades - from the NASA Quality Partnership award to being labeled as a SEI Maturity Level 5 project. This kind of commitment to the software development process and the product by both NASA and IBM has lead to a large number of lessons learned. Fortunately, neither of these organizations rests on their past laurels and this panel is sure to provide us with discussions of techniques currently being explored to improve the PASS process and end product quality. With audience participation, this panel will address existing and potential problems related to software measurement, resolve some misunderstandings and conflicts, and hopefully reach a fundamental basis for the advancement of the field. Some topics to be addressed will include:

How can knowing the dynamic complexity

profile be incorporated into software reliability models?

How has the software process and product data collection evolved and changed over the past 15 years? What major lessons should be carried forth on future systems? What commonly held ideas should be discarded?

How do faults relate to failure rate?

Is there an optimum "age" for failure data supplied to software reliability models?

Can any of these techniques be applied to a process that is not as mature as that of the PASS? What are the ramifications?

Panel Format

o Introduction: Norman Schneidewind-- Coordinator (purpose of panel, motivation for panel, introduction of moderator), 5 minutes

o George Stark--Moderator (introduction of panelists, format of panel, key issues) 10 minutes

o Space Shuttle and AIAA Data Base: Ted Keller, 25 minutes

o Space Shuttle Software Metrics Research: John C. Munson, 25 minutes

o New Results in Reliability Prediction with Application to the Space Shuttle: Norman Schneidewind, 25 minutes

o Break, 30 minutes

o Questions to the panel by the Moderator, 25 minutes

o Audience Question and Answer: 65 minutes

Biographies of Panel Participants

Ted Keller

Ted Keller is a Senior Technical Staff Member with the IBM Federal Sector Services Corporation and reports to the Program Manager of IBM's Space Shuttle On-Board Software Project. He also manages the Project Coordination organization responsible for overall integration of schedules and commitments, software configuration control, control boards, software quality and reliability metrics, and Certification of Flight Readiness for the Space Shuttle Primary Avionics Software. Mr. Keller holds a Bachelor's degree in Aerospace Engineering from the University of Tennessee. He joined IBM in 1976 and served as Requirements Analyst for the development of the Shuttle Entry and Landing software until 1980 when he became the lead engineer for the IBM Shuttle Flight Support Team. Prior to assuming his present position, from 1982 through 1987, he served as Lead Systems Engineer and as Chairman of the two senior IBM control boards for Shuttle software. In 1988 Mr. Keller was awarded the NASA Public Service Medal for his contributions to the Space Shuttle Return to Flight activities. Before his association with IBM, he worked for TRW Systems Group from 1971 until 1976, on the Apollo, Skylab, and Apollo-Soyuz Programs. Mr. Keller is Co-Vice Chairman of the AIAA Space Based Observations Systems Committee on Standards Software Reliability Working Group and is a member of the IEEE Computer Society.

John C. Munson

Dr. John C. Munson is Director of Research for Technical Software Services of Pensacola, Florida. He is also a member of the faculty of the Department of Computer Science at The University of West Florida, Pensacola, Florida. He has been actively engaged in research and publication in the areas of software reliability engineering, software complexity metrics, software quality, and software maintenance. He is currently funded by IBM FSC Houston, NASA, and NSF to do research on software reliability modeling for the Space Shuttle on-board flight software system. He is a member of the Association for Computing Machinery, the IEEE, the IEEE Computer Society and the IEEE Reliability Society. He has served as the Program Co-Chairman of the IEEE International Symposium on Software Reliability Engineering, 1991 and 1992. For the years 1990 and 1991 he served as the Program Co-chairman for the IEEE Conference on Software Maintenance and as General Chair for this conference in 1992. He is a member of the Steering Committees of the IEEE Conference on Software Maintenance and the IEEE International Metrics Symposium. He is a member of the Executive Committee of the IEEE Computer Society Technical Committee on Software Engineering. He is currently serving as Vice Chair for Planning and Assessment of the IEEE Computer Society Conference and Tutorials Board. He is a member of the Editorial Board of the Software Quality Journal.

Norman Schneidewind

Dr. Norman F. Schneidewind is professor of information sciences at the Naval Postgraduate School where he teaches and performs research in software engineering and computer networks. He is also the director of labs in his department. He was awarded a certificate for outstanding research achievements in 1992 by the Naval Postgraduate School. He is the developer of the Schneidewind software reliability model which is used by IBM-Houston to assist in the prediction of software reliability of the NASA Space Shuttle. This model is one of the models recommended

by the American Institute of Aeronautics and Astronautics and the American National Standards Institute Recommended Practice for Software Reliability. Dr. Schneidewind is a Fellow of the IEEE, elected for "contributions to software measurement models in reliability and metrics, and for leadership in advancing the field of software maintenance". He is a member of the Department of Defense Software Engineering Institute Measurement Steering Committee and a member of the Defense Systems Information Agency Executive Panel on Software Metrics. He was also Chairman of the Working Group that produced the IEEE Standard for a Software Quality Metrics Methodology, which was published in March 1993; he was awarded the IEEE Computer Society Outstanding Contribution Certificate for his contribution. Prior to his current position, Dr. Schneidewind had twenty years experience in system and software development management in the private sector.

George Stark

George Stark is currently a lead scientist with the MITRE corporation in Houston, Texas. He received his Bachelor's degree in statistics from Colorado State University in 1983 and his Master's degree in Mathematics from the University of Houston in 1988. George has been involved with software reliability measurement for ten years and is currently the co-vice chairman of the American Institute of Aeronautics and Astronautics (AIAA) "blue-ribbon" panel on software reliability engineering. He has published more than 20 articles on software measurement and has been the manager of software testing and reliability for a local loop fiber optic telephone system. He has received NASA's Quality Partnership award and the MITRE General Manager's Award for the definition and implementation of a software quality metric set for NASA's Mission Operations Directorate at the Johnson Space Center.