A System Model for Managing Requirement Traceability Matrices via Statistical Artifact Change Analysis
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Introduction and Motivation
The system Requirement Traceability Matrix (RTM) is primarily used for ensuring that all requirements are facilitated by the system artifact deliverables and the management of change to deliverables with respect to impact on other systems. In the system engineering and system of systems (SoS) engineering landscapes, the RTM is a tool that is useful at time of creation, but requires constant maintenance in a frequent environment. The motivation behind having the original level of accuracy. However, in highly complex and rapidly changing systems, this becomes an unattainable proposition. The motivation of our research is the development of a system model which will statistically determine the dependability of the RTM based on the type of changes that have taken place since the most recent generation of the RTM, thereby providing a level of dependability to change management groups working with systems and SoS developers.

As systems grow in size and complexity, the underlying burden of maintaining the RTM grows as well. Time, the registration of the RTM for a dynamic system may become too cumbersome a task to perform regularly. It is the goal of our research to present a model which will allow us to better understand the impact of a type of change and existent RTM in a system being actively modified.

Summary
We create a taxonomy of change based on the observed change patterns presented in three separate Open Source Projects currently in development. The three projects we are currently working with are: 1) Gantt 2) JHotDraw 3) ReaCOS

For each of the changes observed, several pieces of meta data are collected for examination. The requirement(s) affected, the order of change in relation to other changes, as well as the underlying classification of the change according to the previously identified taxonomy of change will be utilized in the generation of our statistical model of change impact to the RTM.

Once all changes between specific versions of code for specific requirements have been identified as they relate to a set of requirements which are being traced, we will be able to generate the RTM for all identified static points of code. For our testing purposes with the Gantt project, this will result in these RTMs being utilized at versions 2.8.9, 2.9.0, and 2.10.0. The changes between each version will allow us to examine the individual traces between artifacts for changes and begin the task of building a statistical model which will allow the prediction of the impact of different changes over time to the RTM.

Requirement Traceability Matrix – Gantt Open Source Software Project
Our initial dataset for evaluation is taken from the Gantt Open Source Software Project (Gantt) and WeekendCalendarImpl.java. The initial trace data has been collected by our developer, Dr. Alexander Egyed at the Institute for Systems Engineering and Automation at Johannes Kepler University. Additional traces of requirements to code for subsequent Gantt versions are being created using similar methods to the original collections performed by Dr. Egyed and other researchers initially involved in the creation of the original version for this dataset.

In the Requirements Traceability Matrix for Gantt, the requirement being traced is identified as a column header. The individual changes that are affected by the change are identified by an ‘x’ in the cell. Each of the cells in the matrix is identified by a ‘+’ if the cell was added or a ‘-’ if the cell was not. This is the format of the current Requirements Trace Matrices for the Gantt Project.

The above data identifies a set of two sample changes as seen between versions 2.8.9 and 2.9.0. While a change itself is unique and seen exactly once, the type of change being seen is not unique. Three types of changes: “New Method”, a subsequent “Calling Dependency Change” are identified and associated to the meta data of the identified change for further evaluation.

The identification of the specific taxonomy of change has been performed previously to this experiment with the assistance of a significant number of graduate students reading through code changes. The suggested taxonomy of change for the Software Engineering Domain of RTM impact analysis has been limited to:

1) Method name change
2) Method parameter change
3) If Statement Changes
4) Variable Changes
5) Constraint Changes (public, private, protected)
6) Calling Dependency Changes
7) New / Deleted Method

As changes are identified between versions of the Gantt system, individual changes must be examined in greater detail in order to properly collect the meta-data needed for further analysis.

Evaluation of individual changes will need to be done in greater detail in order to truly understand the impact of the change to the requirement(s) in question.

As the requirement(s) being affected are identified, we can begin to understand the effect of overlap and any other possibly affected requirements in the product being evaluated. The likelihood of impact is a purely subjective analysis being performed by individuals who are experiencing in creating requirements traces. The impacted requirement(s) can be derived from the trace data captured at each of the stable versions.

Impact to Systems Engineering
Over time, we anticipate seeing several specific impacts to Systems Engineering and, subsequently, Systems of Systems Engineering as well as Software Engineering. After examining the types and availability of trace data, based on our proof-of-concept study we envision that this research will positively impact the domain of systems engineering at many levels. As the taxonomy of changes can be modified for the scope under examination, it is essentially a scalable solution that will be applicable and useful for requirement traceability management from the scope of individual system to the SoS.

Specific impacts include:
1) Comprehensive understanding of the types of changes which impact a system more
2) The taxonomy of change will identify the types of impact on the system
3) Analysis of change impact will be tied to changes
4) Models of change impact on system can be used to manage change during development and evolution.

The Value of the Requirement Traceability Matrix
Kamenev et al identify the underlying necessity of the Requirement Traceability Matrix and the underlying effect on project management, process visibility, verification and validation, as well as project maintainability. Over time, the Requirements Traceability Matrix provides significant insight to the internal workings of the relationships between requirements and deliverable artifacts.

As systems grow in size and complexity, the ability of project managers to maintain insight into the internal workings of the project relationships is diminished. Eventually, the effort required to maintain such relationships is too great for the relationships to be effectively maintained. However, as the complexity of the effort increases, the need for the additional insight into the relationships between requirements and deliverables as well as the overall view between them becomes more important, as the overlap can grow in scope.

REFERENCES