2.6 Product Analytics

The product analytics model specifies analyses performed to predict the degree to which a product will satisfy behavioral quality criteria as specified in the product requirements model. Analyses can be used to understand how changes in the problem or solution would affect various quality factors. Secondarily, it specifies the quality factor tradeoffs associated with considered alternative resolutions of problem-solution uncertainties.

Analytics efforts are coordinated with and informed by expert reviews of product model element instances and empirical evaluations (component and product verification). Analytic methods are chosen based on how quality factors relate to the product; methods may be quantitative or qualitative, objective or subjective, and theoretically or empirically based. Each analytic method determines the information needed and the accuracy of its associated predictions.

This model, as the medium for projecting a product's approximate behavioral quality, accommodates various options for analyses that support identifying and evaluating alternatives for improving product quality:

- Mechanisms for obtaining subjective observer (developer or user) measures of quality factors to evaluate satisfaction of product quality criteria
- Instrumentation that supports deriving empirical measures needed at the various levels of product evaluation
- Formal analytic models that have been developed for predicting various quality factors (e.g., aspects of performance or dependability)
- Mechanisms for collecting, analyzing, and visualizing data obtained by examination of the product model or product operation
- Mechanisms for diagnosing the root causes of identified product defects to determine needed developer actions to correct incidental occurrences or to avoid or mitigate future systemic recurrences of similar defects

- Mechanisms for comparative evaluations of effects on quality factors based on applying an analytic method to alternative product model versions representing different resolutions of problem-solution uncertainties

The expected behavior of a product is not only a question of exhibited functionality but also that all relevant operational qualities are properly satisfied. This entails making tradeoffs among qualities, for example, achieving safety and security to an acceptable degree may take priority over some aspects of functionality or usability. There currently exist only limited means to predict, and in some cases even objectively measure, the qualities that software will exhibit in operation. However, both what is possible now and what greater capabilities will emerge over time are worth exploiting to avoid having to make changes after deployment to fix quality deficiencies that could have been discovered during development. The goal of the analytics model is to establish a common basis for defining the quality of software as it is being built, influencing how it is built, and setting customer expectations concerning what is known and what will remain uncertain concerning quality factors of the product in use.

The properties that a product is expected to exhibit and the relative importance of each are specified in the product requirements model. How these are to be met and the effects of both enabling and inhibiting dependencies among these properties are specified in the product design model. The purpose of the analytics model is to evaluate the degree to which the product both as being built and then as built can be expected to satisfy the prescribed quality criteria, both in theory and relative to the actual operational environment as specified in the product environment model.

The product analytics model supports reviews associated with the content of other product model facet elements and empirical evaluations associated with the components, product verification, and product delivery models. Product analytics content is referenced to substantiate results of other competence-based and empirical methods of evaluation.

Reviews are a reasonably effective and less costly means of evaluating product quality. Proven analytic methods that exist for certain quality factors are also relatively inexpensive in effort required but can incur licensing fees (which may be leveraged

across a program or enterprise). Empirical verification (i.e., testing) is necessary for discovering many types of dynamic flaws in a product but is a relatively expensive and somewhat anecdotal method of evaluating quality factors. The most practical and effective approach to achieving product quality entails the judicious use of all types of methods.

{what quality tradeoffs must be made? what are the effects/side-effects of these? what emergent behaviors are likely and what changes would affect those?}

- *quantitative & qualitative models of system/product behavior; are there objective qualitative measures or are these all subjective?*
- *sensitivity-based projections of behavioral qualities; which are more or less significant for a product?*
- *rqmts/design/build alternatives and tradeoff analyses*
- *compare multiple alternative product builds for best-fit to quality expectations*

Product Quality Metrics

The product requirements model specifies and prioritizes product quality objectives. Product analytics provides analyses of the product in terms of its satisfying these objectives. This entails determining the acceptable limits that each quality factor needs to meet relative to its importance for overall product quality. Alternative resolutions of the overall quality space are analyzed in terms of how various qualities interact and the cost to realize each combination of quality factor measures.

Each of the specified quality factors are defined here more precisely in terms of the range of values associated with each and how they are to be measured (quantitatively and/or qualitatively) and how these qualities interact, in particular how changes in one factor affect the others. Each individually identified quality factor represents a facet of the quality space, corresponding to some distinguished property of the envisioned

product. Within the overall quality space, each facet can be defined and measured independently but changes in the value of any facet can cause the values of other facets to change as well. Understanding the relationships among quality factors is a key aspect of product analytics, providing the basis for adjusting the quality of the product as a whole.

Product analytics specifies the degree to which each quality factor identified in product requirements is to be addressed by the product. Failure to satisfy even less significant factors may result in a product that fails to meet customer expectations. Similarly, a failure to include such factors in product requirements should be identified as a discrepancy to be resolved.

As an example of how qualities can interact, a product might be specified as needing high usability, moderate performance, and moderately high security. In this example, security demands may somewhat reduce usability; similarly, security and usability expectations may together modestly reduce performance. If usability and security goals are projected to be satisfied in the resulting product but performance is projected to be unacceptable, either some aspect of the usability or security goal that impact performance might be possible to relax or alternatives for reducing functionality or improving how performance is achieved would need to be explored.

Product Introspection and Instrumentation

Analyses of software product quality factors requires a means to gather data corresponding to the behavior of the product in operation. Some data about a product is associated with the externally observable behavior of the product and can be collected by software operating external to the operational product itself.

Other data can be collected only by modifying the product itself to include instrumentation that provides observability (monitoring and control) of its internal behavior. Such instrumentation of a product may be specified as a required part of the operational behavior of the product but is often only included as part of a distinct developmentally useful version of the software. The detriment of development-time instrumentation (and to a more limited degree, external monitoring) is that it can reduce

the degree to which some (e.g., performance) qualities will be accurately represented in operation of the product.

Formal Models

Formal mathematical models of certain behavioral properties, primarily in particular areas of performance and dependability, have been developed and improved since the 1970's. For a product that conforms to the assumptions on which a particular model is based, developers can obtain a better understanding of how to design and implement a product so as to satisfy the quality factors corresponding to its property focus. Such understanding should then be confirmed through developmental testing and tuning of the product to ensure a proper fit to the model's predictions.

Defects and Root Cause Analyses

{observability: trace/diagnose/understand source/cause of defects} {hard: product is doing what it should; harder: product is capable of doing only what it should/is expected, particularly for reused components}

Alternative Products Evaluation

{multiple product versions: best-fit to needs and eng tradeoffs for quality factors}