5.2 Predictive Analytics

Product analytics (discussed in section 2.6) are the means available to estimate quality factors so as to build a product that will exhibit those factors in operational use. Quality factors are prescriptively specified to guide the resolution of engineering decisions and tradeoffs. However, the relationship among factors and between a factor and specific decisions and tradeoffs are often not well understood. The purpose of a focus on predictive analytics is to advance product analytics capabilities with a better foundation for understanding and resolving decisions and tradeoffs based on foresight into how problem-solution alternatives affect relevant quality factors.

As an aspect of product development, each quality factor is defined according to how it is measured, the tolerance/range it must satisfy to be acceptable for a given problem-solution, and its significance for a particular endeavor. The ability to satisfy criteria for a given quality factor may be dependent on other quality factors (e.g., performance may limit functionality, usability may limit performance, security measures may inhibit both usability and performance).

An understanding of how decisions and tradeoffs should be resolved for best quality factor results is most amenable to a product family in the context of a DsE program. Product similarity is expressed in terms of observable behavior—both capabilities and quality factors. Specifically, the effort to determine and improve product quality can be leveraged with regard to the degree to which an identified set of products have similar quality concerns. For example, if a set of products are described similarly, having the same resolution of decisions that influence given quality factors, those products tend to satisfy similar quality criteria.

[Statistical quality assurance is a means for controlling quality (see for example Deming or CMMI capability level 4) that relies on a standardized (managed and repeatable) manufacturing process that is suited to building intended products. As such, from a software perspective, it is only soundly applicable in the context of a DsE program, focused on a product family. DsE establishes standardized practices across encompassed projects, defines controls for process capability and performance variations that are due to product differences, leverages assurance efforts across projects, and relies on process conformance and streamlining to reduce instances of special causes of variation.]

When the relationship between engineering tradeoffs and quality factors are more systematically understood over multiple product families, there may be insights that are applicable in the development of other product families or at least of particular classes of singular products or categories of functionality.

The pursuit of predictive analytics capabilities may proceed from any of several perspectives:

- The advancement of product quality capabilities (as discussed in section 3.6)
- More effective analytic methods based on retrospective evaluations of predicted (to-build prescriptive) quality versus operationally observed (as-built descriptive) quality
- Focusing quality factor criteria on those portions of a product that most directly affect each factor, having prioritized a product's most critical quality factors
- Comparative evaluations of problem-solution alternatives considering associated product behavioral quality tradeoffs
- Static and dynamic models of behavior expressed as properties of an ecosystem, with and without an injected product, to distinguish how a product's behavior affects those properties
- Predictive root cause analyses to identify what changes in a product would invalidate existing quality inferences based on historic data (analogous to prognostics versus diagnostics for hardware)

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- Formal verification of the degree to which alternative computational platforms will support a product's specified behavioral quality criteria

- Achieving needed capabilities given operational platform limitations—analyses of massive data with local processing limitations, responsiveness of remote processing, data storage accessibility / transport, source and result data quality criteria, or achievable timeliness of results
- Quality sensitivity of processing options—redundancy, replication for reduced access latency, security, update delays, history retention at needed scale / granularity, timely data accuracy and precision

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Extending Analytics to Intensional Sets

Another category of enhanced predictive analytics is the leveraging of variabilities that define a subfamily of similar products—those instances of a family that share certain decision resolutions that entail similar quality criteria tradeoffs—providing a basis for using quality priorities in resolving decisions. An understanding of how decision resolutions influence quality factors can enhance the ability to building a product that will exhibit intended quality criteria.

A product family, including any subfamily, can be defined as an intensional set—a set of similar products, all adhering to a characteristic abstraction. Similarly, any set of similar product model elements can be characterized in the same way, in particular, a component as the abstraction and characterization of a set on similar modules.

Each instance of such a set has associated properties that characterize its qualities. The purpose of predictive analytics is to expose the degree to which the properties of an instance meet quality criteria of interest. In considering a set of instances, multiple instances will share quality analyses to the same degree that they are otherwise similar.

It may be feasible to leverage instance similarity in establishing corresponding similarity of quality factors. A, generalizing analytic techniques can be generalized to a intensional set so as to derive the quality of its individual instances, thereby leveraging the total effort and reducing the instance-level effort required to apply those analytic techniques.

As a first level development of this quality approach:

1. Identify an intensional set of products—a product family—that have similar quality criteria.
2. Identify the decisions that are sufficient to partition the instances of this set into quality subsets—each subset having similar quality characteristics.
3. Identify critical quality factors for which analytic techniques are effective in characterizing the relevant quality of products that are instances of that set.
4. Applying the relevant analytic technique, specify the quality characterization of instances of a given quality subset.
5. Determine which decision resolutions have led to the quality characterizations of different instances to differ.
6. Generalize the quality characterization, using relevant decisions, to produce a generalized characterization that can be instantiated as an adjunct to each instantiated product.
7. Evaluate each derived product using its associated quality characterization to show that the product satisfies its expected quality.

An instance-level analytic method can be generalized to express variability in quality metrics (e.g., model adaptability based on predicate logic in which commonality is represented by universal quantifiers/predicate constants and variability is represented by existential quantifiers/predicate variables). Each quantitative variable is correlated to one or more deferred decisions associated with the product family such that the associated predicate describes a generalized predicate that characterizes a quality that holds for all derivable instances of the intensional set defined by the family. (The potential application of this approach is proposed in section 3.4.3.)