

5.2 Predictive Analytics

Product analytics 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 acceptable tolerance/range in which it must fall 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 limits 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 initially most amenable in the context of a product family. For a product family, product similarity is viewed in terms of observable behavior—both capabilities and quality factors. Specifically, the effort to understand the relevant relationships can be leveraged in regard to the degree to which an identified set of products have similar quality concerns. For example, if two products share a particular decision resolution and the influence of that decision on a particular quality factor, both products are likely to adhere to the same criteria for that factor.

When the relationship between engineering tradeoffs and quality factors are more systematically understood for some number of product families, there may be insights that can be determined that are applicable in the development of either other product families or possibly particular classes of individual products or categories of functionality.

The attainable satisfaction of a factor may be constrained by behavioral limitations of the operational platform on which the product is deployed. In addition, the degree of importance of a quality factor may be localized—differing in different portions of a solution and accommodating different tradeoffs with other factors.

The pursuit of predictive analytics capabilities may start with any of several perspectives:

- A reasonable degree of formal verification of a product's computational platform.
- Improved analytic methods utility based on retrospective evaluations of predicted prospective (to-build prescriptive) quality against observed operational (as-built descriptive) quality
- Quality criteria focused on those portions of a product that most directly affect its most critical quality factors
- Comparative evaluations of alternative solutions to a problem based on how product quality criteria tradeoffs correlate to exhibited behavioral qualities
- Instance-level product analytics methods 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)
- Static and dynamic models of behavior expressed as properties of artificial-natural systems and ecosystem, with and without an injected product, to distinguish how a product's behavior affects those properties
- Predictive root cause analyses—what changes in a product would invalidate existing inferences based on historic data (analogous to prognostics versus diagnostics for hardware)
- Options for adjusting to 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, effective deadlines for results

- Quality sensitivity of processing options—redundancy, replication for reduced access latency, security, update delays, history retention at needed scale/ granularity, time-sensitive data accuracy (e.g., how sensing-capture-retention delay affect acceptable precision)

Extending Analytics to Intensional Sets

{applying analytics to the entirety of a product family/ subfamily or adaptable component}

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 degree they are otherwise similar.

It should be feasible to leverage instance similarity in establishing corresponding quality similarity, generalizing analytic techniques to a set of similar instances so as to derive the quality of individual instances, leveraging the total effort, and reducing the instance-level effort, required to use those analytic techniques.