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Probability of events: a theoretical application of the VRPD function to organizational processes

In a previous Continuity Central article, Alejandro Aristizábal Correa looked at ways to calculate the probability of events and introduced the Variable-Rate Probability Distribution (VRPD) theorem. In this article he shows how the VRPD concept can be used in practice by business continuity managers.

"Although human ingenuity can create various inventions that, with the help of various machines serving the same purpose, will never produce any invention more beautiful, simpler, or more appropriate than those made by Nature; because in his inventions nothing is lacking, nor is anything superfluous, and Nature does not need a counterweight when it creates appropriate members for movement in the bodies of animals..."

Leonardo D' Vinci

Complexity, when it is fragmented, requires that our brains reconstruct the scattered pieces over and over. Such systemic thinking pushes us to find a way to make the pieces fit together. Although this is not a consequence of a natural process, it is a good lesson from nature itself to seek consistency and interdependency.

When it comes to a business impact analysis (BIA), the impacts may be analyzed from different perspectives. Imagine that we are in the middle of a dense forest surrounded by small, mid-size, and high hills. Depending on our physical altitude with respect to the hills' heights we will have different versions of the landscape. In business, the vision of the organizational leaders is taken as the objective perspective; after all, it is their role to define corporate vision.

One of the challenges of a business continuity consultant when starting a risk analysis is to capture the organizational risk perspective, e.g., the way the leaders perceive the threats and goals, and specifically, which of them is at the top of the list and which are considered as part of the rest of the pie. This is such a complex matter that it seems like we ought to have a psychologist next to us during the BIA and risk analysis interviews. And although our comprehension of the leaders' risk perspective is limited, the product/service[1] priorities approved by the executive committee is an important, yet incomplete, impression of the corporate vision, as we will see.

Now, between organizational processes and service priorities there is a subtle but very strong link that connects the risk analysis with the business impact: the interdependency mapping, which depends on the organizational structure, the processes structure, and the organization's risk perspective (appetite?).

But how does the interdependency map connect with the leaders' perspective?

Every BC specialist has his or her own heuristic to build up interdependency mapping; however, while the service priorities are the technical fingerprint of the organizational vision, this relationship is not always evident. In fact, the interdependency map seems to be an exclusive deliverable of the continuity strategies, with little or no relation to the risk analysis or the BIA. The answer to the above question may be efficiently derived from a solid theory plus the probabilistic understanding of every service workflow component and the application of the VRPD theorem, as we will see.

First, let us look at probabilities - as this leads to the answer for our question. Although the risk perception depends on the leaders' understanding of the whole business and industry, the probability of events is not always a mathematics-based calculation that provides management with an unbiased perspective to assess corporate threats.

Additionally, the probability of events, among other factors, may be largely influenced by the top management perspective, reducing its inherent mathematical objectivity, leading to poor decisions. To avoid the risk of a biased probability of service interruption, we must rely on a proven practice, such as Reliability Engineering, which is a useful and well-known discipline that that makes use of a powerful tool (Fault Tree Analysis) that we may apply to the organizational interdependency mapping, facilitating the calculation of the interruption probability of organizational services.

Reliability Engineering is a sub-discipline focused on the availability of systems, i.e., the conditions that make a system work without failures until a certain time in its useful life. A system reliability calculation is based on the interdependency between its subsystems and their probabilities of failure.

[1] Hereafter referred to as "services"

Before applying the Reliability Theory to a hypothetical case let us see some of its key concepts - widely used to calculate a system's reliability. One of these concepts is the Fault Tree Analysis (FTA) that has been largely proved and well documented, developed by H.A. Watson (Bell Labs – U.S. Air Force Ballistic Systems Division) in 1962. The FTA along with the FMEA (Failure Modes and Effects Analysis), developed by NASA, are two *qualitative methods* to evaluate systems failures. Conversely, the U.S. Nuclear Regulatory Commission produced a book that takes the mentioned qualitative techniques and the *Reliability Theory* (a quantitative method), produced after some initiatives, but mainly after the Challenger disaster of 1986. It is considered an engineering classic of applied reliability: NRC Fault Tree Handbook NUREG–0492[2].

Now, to calculate the probability of interruption of a complex system (non-elementary), composed of evolutionary subsystems, i.e., the ones that evolve over time, we may take advantage of the VRPD function applied to the FTA. The following steps show how to calculate the probability of an organizational process, an IT platform, or the combination of several elements of both types that make part of the interdependency map of a given service or product delivery:

1. Build up the interdependency map of a service with all its subprocesses, IT modules involved, and the expertise of the personnel involved in the service workflow[3], assigning different IDs to every element, distinguishing IT from expertise from operational processes.

2. Translate the interdependency map to Boolean gates (typically AND and OR gates) as shown in Diagram 1, where the service X is the system (in FTA) and its components are the integrating subsystems. The output of every gate gives an up or down condition depending on the status of its inputs.

    a. If a subsystem shuts down only if all of its components fail, the joining gate of the components corresponds to an AND. For example, if the activity[4] B (AND output) fails only if B1 and B2 fail, the gate must be an AND.

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[2] Vesely, W. E.; et al. (1981)

[3] The probabilities of interruption from personnel expertise, including external parties and IT components are described in the book "*Probability of Interruption and Business Impact – A mathematical approach to Business Continuity"*

[4] A gate is an aggregation of elements that constitutes a sub-activity (subsystem) of a service. This is a different viewpoint from the traditional organizational process.

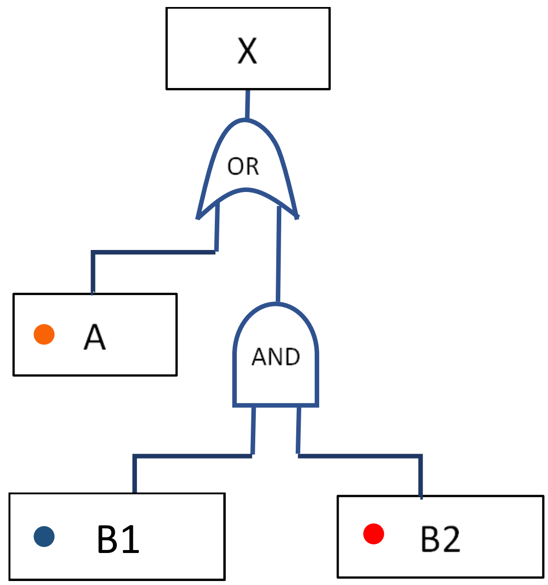


Diagram 1 – Fault Tree Diagram using Boolean Logic

b. If a subsystem fails with the failure of any of the two elements that make up the subsystem, the gate will be an OR. For example, if the service X interrupts with the interruption of B (B1 and B2) or the interruption of A, the joining gate must be an OR.

3. Calculate the probability of interruption of every component of the service using the VRPD function, considering the time since every component went to production and the redesigns they have received.

4. Aggregate the probabilities of all the service components according to their joining gates using the corresponding probabilities laws.

Based on Diagram 1, we may have:

A. The simplest case where all its components have a fixed probability of failure, i.e., they have a constant probability of interruption. In that case the whole system probability of interruption is calculated as follows:

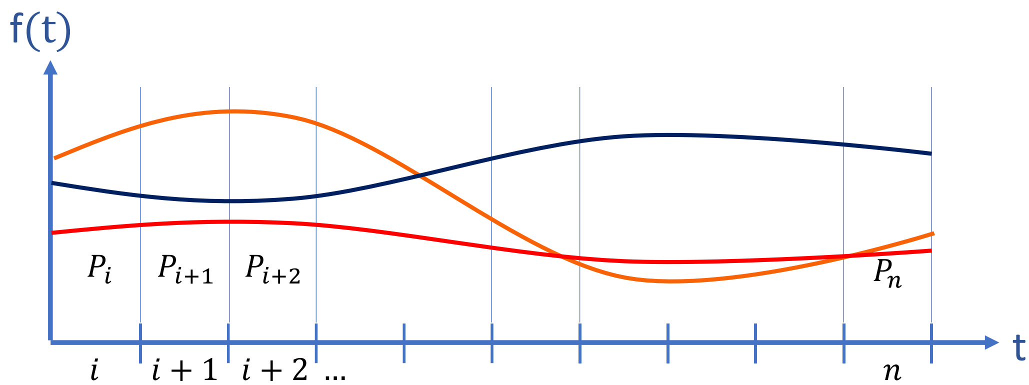
   The interruption of the activities $B1$ and $B2$ might result from independent causes, while the probability of interruption of subsystem B ($P(B=1)$) is the product of the probabilities of B1 and B2:

$$P(B=1) = P(B1) * P(B2)\ (eq1)$$

As the probability of interruption of system X depends on the probabilities of interruption of the subsystems A and B, we have:

$$P(x = 1) = P(A) + P(B) - P(A) * P(B)\ (eq2)$$

B. Nevertheless, we know that organizational processes, IT platforms and personnel expertise are evolutionary processes (see Graphic 1). This means that the probability of interruption of every component changes over time, each one with a different maturity level.



Graphic 1 – Probability of Interruption of Three components of a Service X

Therefore, the probability of interruption of a real system X, with real components (where every component has a variable probability of interruption), may be calculated as follows:

1. Calculating every component's probability of interruption at the desired interval using the VRPD theorem
2. Then applying eq1 to obtain the probability of interruption of the subsystem B; and
3. Finally applying eq2 to obtain the probability of interruption of the whole system X.

The above procedure adds objectivity to the product/service probability of interruption, applying the VRPD function to the Fault Tree version of the service's Interdependency map.

The author

Alejandro Aristizabal was born (1972) in Medellín, Colombia, Graduated as Electronics Engineer and with a MSc in statistics. He has been teacher of Digital Electronics, Electromagnetics Theory and Radio propagation at USB Colombia.

He created an IT, risk management and business continuity consultancy company in 2012 with the purpose of providing new ideas and academic support to the concepts underlying the consultancy practices.

In 2018, when seeking a solution to calculate the probability of interruption of organizational processes, he discovered the probability distribution function for any variable-rate process (Variable-Rate Probability Distribution - VRPD) along with another theorem and mathematical models applied to business continuity.

With more than fifteen years of experience in telecommunications networks and business continuity in more than six industries, Alejandro Aristizabal is the author of 'Probability of Interruption and Business Impact', a book that approaches business continuity from a mathematical perspective, including some fundamentals on Risk Level calculations. The book includes a personal perspective on business continuity, but also the mathematics underlying the Evolutionary Processes' interruption, including some interesting discussions about the effects of an organizational process' interruption as well as the application of the VRPD theorem in reliability theory. The book is available as printed and Kindle versions on Amazon.