White Paper

The Operational Controls and Processes Tipping Point

Is Machine Learning the Answer?

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Contents

Abstract

The need to assess process controls, and in particular risk controls, with some frequency is a challenge for many organizations, due to a shortage of time and budget. Even when these aren't an issue there is often a lack of staff with experience with the newest approaches/methodologies. Fortunately, many of the latest technologies and approaches available can simplify processes, lessen the number of controls, and at the same time create controls that are better adapted to the environment. These advances offer a number of efficiencies, including the ability to reallocate staff previously tasked with manual control functions.

The Current Environment

Almost everything we do in life involves a process, some formally documented and others implied. Although the word "process" itself conjures images involving manual or mechanical underpinnings, in today's environment the subject of the "process" is very often data. Data is the lifeblood of many different types of processes and is the focus of this paper, supporting both business groups and businesses exclusively. Fortunately, there has been a wealth of research conducted on processes that have been derived from engineering and mathematics that we can glean quite a bit from, to better facilitate the processing of data. However, recognition of the need, and the adoption seem to have been bifurcated.

> *There are three basic classes of software—systems software, support software, and applications software. Systems software controls the minute-to-minute operations of the computer by allocating resources and scheduling tasks. Support software is typically used for such functions as controlling a communications network, monitoring transaction processing, managing the data base environment, or furnishing tools intended to improve the productivity of programmers and, in some cases, end-users.*

While the above appears to be fully explanatory the surprising thing is that this is taken from a report to the United States Congress by the Office of Technology Assessment in 1984.[1]

The need for Operational Processes (OP) and Controls (risk and general operations) exist in all types of applications: industrial, financial, governmental, and others. The OP and associated controls that facilitate dynamic environments provide assurance checks that facilitate the operations of organizations. Controls have been used for centuries to enable all types of activities with goals ranging from efficiency to quality to regulatory. Over time these controls are often matured in coordination with the process but are always overt and established with a particular goal in mind. In current times the OP that incorporate controls run the gamut and may include manufacturing, business processes, or manual functions carried out by individuals or groups. Depending on the process the number of controls to complete an end to end process can range from one controller to thousands, and in some applications are highly (or exclusively) manual. Given the velocity and magnitude involved in many of today's data intensive processes, the risks associated with manual controls are exponentially increasing. In some industries, finance in particular, these risks have not gone unnoticed by regulators. In fact, the regulators have been forthcoming in their desire for consistency, less complexity, and automation.

As process and/or business grows, or become more complex, controls within the OP become more important and tend to increase exponentially to facilitate the environment. This growth of controls often occurs over time and thus utilizes the same means, primarily manual or rudimentary mechanical, to execute and monitor the controls as dictated by the legacy environment. Until recently there were few alternatives to the manual and/or mechanical solutions to this problem, however, the increase in computational power and methods (e.g. machine learning) provides new and significantly improved answers.

The application of machine learning to the control function may seem cutting edge or even a bit experimental, but in actuality this relationship is very symbiotic. Many would argue that machine learning grew directly out of control theory literature. The feedback loops of classic control theory are the drivers of much of what we think of as machine learning,[2] specifically, what is known as a "reward function" that simply indicates to the algorithm the "states of the world" that are preferred and those that are to be avoided. This paper will go into additional detail concerning various control methodology, and knowledge of this relationship will provide a good basis for what follows.

While OP's are understood by most, the details with which they are executed are often known only by the "owners" of a particular process. Controls tend to be less well understood and as such more background detail is necessary. As a point of reference when controls are discussed it is primarily in two general forms to achieve different goals: 1) to ensure that a certain rule (or set points) is met and to provide a decision point when a deviation to the rule occurs, and 2) to ensure the input required is received to facilitate the process. The rules can be simply binary or can employ some type of "tolerance band" that incorporates known or calculated deviations from an articulated point.

Controls

Controls can be employed as part of a process design but are more often used as a response to a breakdown of a particular process, due in large part to changes in the environment or data. Because change is constant in dynamic environments, this "response" method of control design is ubiquitous. This type of growth often results in more controls than are actually necessary, additional complexity in the process, and often logic breakdowns. Prior to investigating new methodologies to automate process and controls, regular and holistic reviews must be conducted to assess the environment and the OP and associated controls. These assessments require individuals that are familiar with whole processes and the desired outcomes of the processes to ensure what's being controlled for is well articulated and serves the correct function.

CONTROLS PROVIDE ASSURANCE THAT A PROCESS IS OPERATING AS EXPECTED OR TRIGGER AN ALERT THAT THE PROCESS OUTPUT IS *NOT* AS EXPECTED.

Controls provide assurance that a process is operating as expected and provide feedback to this effect or to trigger an alert that the process output is not as expected. As mentioned, controls serve several different functions although the heuristic is that of a risk detection and quantification seems apt in all cases. It's important to have the right context with which to understand the application and use of controls, leveraging what has been studied and modeled; this can be achieved by reviewing work completed primarily in mathematics and engineering to understand uses within systems. Controls may be thought of with two distinct outcomes, referred to as open and closed-loop controls. These open-loop controllers and closed-loop controllers are associated with research that has been done in the area respectively as the products of Control Theory and Classic Control Theory.

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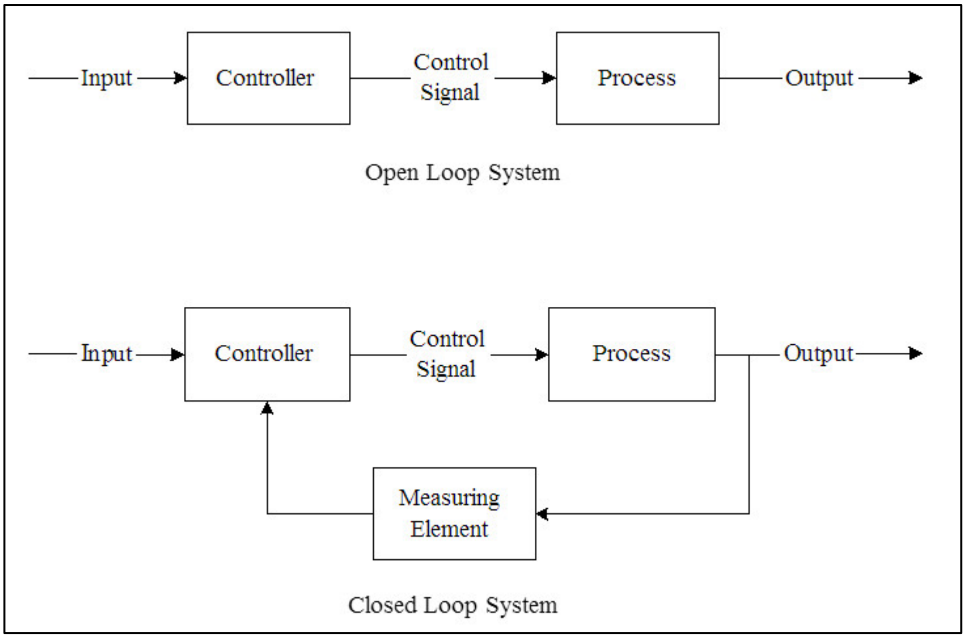
[1] Effects of Information Technology on Financial Services Systems (Washington, D. C.: U.S. Congress, Office of Technology Assessment, OTA-CIT-202, September 1984).

[2] Rumelhart, D., Hinton, G., and Williams, R., (1986) "Learning representations by back-propagating errors", *Nature* vol 323 pages 533-536



While an open-loop system is solely reliant on the input, with no feedback from the output, a closed-loop system is reliant on the output to perform its function. The objective of a closed-loop system is to provide feedback that can be used to bring a system (process) back in line with the desired path. This can be facilitated through automated or manual means. To accomplish this the first step requires that a benchmark or set point (SP) be established, which may be fixed or variable. The output or process variable (PV) is then monitored for any deviation of the actual output to the established benchmark, referred to as the error signal (SP-PV). The resulting product is then used as feedback. Any deviation beyond the established tolerance is utilized as feedback and may be used to adjust the input(s) so that the output can be brought back in line to achieve the desired benchmark or change the process in some other way. The feedback of closed-loop controllers is usually used to modify the input so that the desired output variable(s) is achieved. However, the PV can also be used to modify the process such that it is stopped if the error signal exceeds the desired SP.

As might be imagined up to this point controllers were primarily relegated to a fixed or heavily rules-based SP, but this no longer needs to be the case. Techniques are now available that can change the SP via computational methods, e.g. machine learning. This often allows for fewer controllers, less complex processes, and of course reduced manual intervention. These machine learning techniques are algorithms that "learn" via a system of "rewards." One of the better descriptions is provided by Andrew Ng,[3] who writes that "a well-chosen reward function gives appropriate "hints" to the learning algorithm. But, the selection of these hints-called shaping rewards-often entails significant trial and error, and poorly chosen shaping rewards often change the problem in unanticipated ways that cause poor solutions to be learned."

Data Process and Control Assessments

Unlike many types of business assessments that assume no or slow rates of change, e.g. financials, logistics, supply chains, etc., data processing is characterized in terms of magnitude and velocity. The nature of data is unique and there is a need for an understanding of the underlying components and the desired goals to

[3] "Shaping and Policy search in Reinforcement learning", 2003, University of California, Berkeley

conduct successful regular assessments. This level of assessment familiarity allows for process design to be questioned and control functions to be comprehensively understood. This notion of comprehensive or holistic process design assessment should be at the forefront of consideration, utilizing the true first step in the data acquisition as $T_{0.}$ Using this T_0 approach to assessments alleviates the issue of up and downstream impacts not being fully understood and considered. This method also allows for efficiencies and simplifications to be considered beyond single steps in the process, which were often constrained by legacy systems and/or thought that is no longer valid.

The initial step in the process and controls review is understanding the desired output and documenting how that is being achieved in the current environment. This documentation should account for all control points, closed loop feedback, and inputs that are employed to achieve the output. These individual processes should include tertiary system dependencies, to ensure a complete view is being reviewed from T_0 through completion of the process. This understanding will alleviate the need to constantly amend the current process documentation, as well as to provide a base to assess improvements.

Incorporating Technology Considerations

Technology, and specifically computational advancements, offers options that were previously not readily available in the design of process controls. Prior to the design phase these considerations should be understood, and when appropriate should be investigated as a means of significantly augmenting legacy control methods. It is important that "appropriateness" be part of the decision, too often the latest methods are introduced when a simple linear option will provide the same benefits in a more straightforward manner.

While design features will be primary driver of simplification, there are aspects of the control functions that can serve a similar function by combining or eliminating controls through the use of newer computational logic. Primary to these are the use of algorithms and/or machine learning that can facilitate SP that reflect a dynamic environment. Which is the ability to change SP based on environmental factors to reduce false errors and insure the SP better reflect the desired control function.

Operational Process and Controls Improvement Design

Having the information and understanding resulting from the process and controls assessment will provide the necessary context for improvements that may be made, but should never dictate the direction of the redesign. In other words, there should be no constraints limiting the new design. Following the redesign there may be constraints of various types (e.g. time, resources, etc.) but these should not limit the initial plan. The reason for this is to allow for complete processes to be reimagined utilizing the latest methodologies and technologies, which often addresses factors like time and resources through improved efficiencies that would otherwise not come to light. Similar to the assessment itself, a process redesign necessitates the use of individuals that have a working knowledge of the process and the goals as well as individuals armed with the appropriate skills and pertinent methodologies.

Utilizing the right skills and methods a redesign can be undertaken with goals well-articulated, for example:

- Less complexity (i.e. fewer control point, less "handoff dependencies, etc.)
- Minimal manual intervention (process and controls)
- Increased automation

AUTOMATING MANUAL INTERVENTION OF PROCESSES AND CONTROLS SHOULD BE CONSIDERED IN A PROCESS REDESIGN, DUE TO THEIR IMPLICIT RISKS.

- Controls rationalization and logic
- Input and output rationalization

Of these, manual processes tend to be most troublesome due to the implicit risks that they hold in any type of organization. Eliminating and/or automating manual controls provides many of the other benefits noted. For this reason, manual intervention is of particular interest when reengineering processes.

When assessing manual processes for elimination or automation it is imperative to have a good communication channel with the individual(s) currently performing the manual function. This ensures that the institutional knowledge is well documented and the functional process is well understood. Control points, in particular in the processing of data, occur in various levels of complexity which we refer to as standard and non-standard scenarios, standard being less complex and non-standard being more so.
The ability to interface with those performing manual controls and foster a continuous dialogue throughout the development of non-standard scenarios is significant, as non-standard execution is extremely easy to do in a manual process but when automation requires additional logic so that the process can accommodate those scenarios or fail gracefully. It is also at this stage when decisions will have to be made concerning performance and output expectations, and level setting to understand the full impact that will be realized. For example, flexibility might be reduced in favor of better auditability and tracking changes. These overt decisions occur during every redesign and need to take into account both the current environment and the probable future atmosphere.

Testing and Implementation

The testing of solutions using production data in a test environment is crucial to the success and continuity of the process. As referenced earlier the lack of proper testing may lead to the "learning" of unanticipated poor solutions. Both the function of the control and the logic associated with the particular control must be tested to insure the upstream and downstream data are behaving as expected. Detailed testing protocols are developed and utilized throughout the process to ensure the results are as expected under a variety of conditions. These protocols cover specific controls and processes, as well as the macro environment in which the controls and processes reside. The need for such macro testing is necessitated whenever legacy systems or databases are part of the process being reengineered to detect any anomaly that results from code that is not documented or communicated to those designing the process. The proverbial "ghost in the machine" is a mainstay in many organizations that are products of business combinations and/or dated systems (internal and/or external).

The thorough testing procedures provide one level of feedback for designers and operators; however, the "business as usual environment" is the one in which the redesign must work day in and day out. One of the many advantages of the current technology is the ability to incorporate performance indicators into the operating process and controls. This allows for constant "testing" in the production environment, ensuring that the process is indeed consistent and repeatable.

Realized Results

The techniques and approach put forward provide good perspective on the assessment and augmentation of processes and controls, but how can these changes be quantified? Fortunately, experience with this type of work has provided some very specific results that illustrate the short-term and longer-term value realized. One example in particular realized the following results illustrated in the chart below.

	Legacy Environment	Automated Environment
Reporting Output	No Daily Available Manual controls for risk reporting	Daily in-cycle reporting Controls are automated w/ min manual interaction
Process Speed	Credit run 40+ hours Manually input variables-prone to mistakes	Credit run 4 hours Cycle time reduced from 3 days to 1 for variable creation
Controls & audit	Multiple audit issues and Regulatory MRAs	Audit issues resolved and MRA closed
Model Execution	Spreadsheet driven	90 models automated resulting in 1,000 manual spreadsheets eliminated

While this is a single instance it provides some significant insight into the magnitude of change expected of a thorough assessment and redesign of processes and risk controls. Besides the efficiencies realized in terms of time and resources, the significant change in the risk profile must be noted. As the client results clearly illustrate the financial regulators goals in this particular case are met with less complexity, more consistency, and of course increased automation.

While different environments will yield various results, it's important to have the context of results illustrated through the methodologies set forth here, to better judge the outcome of a process and controls assessment. The ability to leverage expertise can address the questions of staff experienced in the newest approaches and methodologies with which to address simplifying processes, reducing the number of controls, and designing controls that facilitate the current environment.

More Information

FRG would welcome the opportunity to speak with you concerning the findings of this paper, as well as how the approaches developed may fit into specific environments. For more information contact the FRG Research Institute at Research@frgrisk.com or 919.439.3819.

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