Risk and Liabilities of Software Systems

Key Terms Essential to Understanding Risk Management

There are a number of key terms that should be understood to manage risk.

Risk:	The possibility of suffering harm or loss.
Risk management:	The overall decision-making process of identifying threats and vulnerabilities and their potential impacts, determining the costs to mitigate such events, and deciding what actions are cost-effective for controlling these risks.
Risk assessment (risk analysis)	The process of analyzing an environment to identify the threats, vulnerabilities, and mitigating actions to determine (either quantitatively or qualitatively) the impact of an event that would affect a project, program, or business.
Asset	Resource or information an organization needs to conduct its business.
Threat	Any circumstance or event with the potential to cause harm to
Vulnerability	Characteristic of an asset that can be exploited by a threat to cause harm.
Impact	The loss resulting when a threat exploits vulnerability.
Control (also called countermeasure or safeguard)	(also called countermeasure or safeguard) A measure taken to detect, prevent, or mitigate the risk associated with a threat.
Qualitative risk assessment	The process of subjectively determining the impact of an event that affects a project, program, or business. Qualitative risk assessment usually involves the use of expert judgment, experience, or group consensus to complete the assessment. Often used to attach a potential monetary loss to a threat.
Quantitative risk assessment	The process of objectively determining the impact of an event that affects a project, program, or business. Quantitative risk assessment usually involves the use of metrics and models to complete the assessment.
Mitigate	Action taken to reduce the likelihood of a threat occurring.
Single Less Expectancy (SLE)	The monetary loss or impact of each occurrence of a threat.
Exposure Factor	A measure of the magnitude of loss of an asset. Used in the calculation of single loss expectancy.
Annualized Rate of Occurrence (ARO)	On an annualized basis, the frequency with which an event is expected to occur.
Annualized Loss Expectancy (ALE)	How much an event is expected to cost per year.

Examples of Technology Risks

The most common technology risks include:

? Security and privacy
? Information technology operations
? Business systems control and effectiveness

- ? Business continuity management
- ? Information systems testing
- ? Reliability and performance management
- ? Information technology asset management

Introduction to Complex Systems: Basic Definition

A Complex System is any system which involves a number of elements, arranged in structure(s) which can exist on many scales. These go through processes of change that are not describable by a single rule nor are reducible to only one level of explanation, these levels often include features whose emergence cannot be predicted from their current specifications. Complex Systems Theory also includes the study of the interactions of the many parts of the system.

Previously, when studying a subject, researchers tended to use a reductionist approach which attempted to summarize the dynamics, processes, and change that occurred in terms of lowest common denominators and the simplest, yet most widely provable and applicable elegant explanations.

But since the advent of powerful computers which can handle huge amounts of data, researchers can now study the complexity of factors involved in a subject and see what insights that complexity yields without simplification or reduction.

Scientists are finding that complexity itself is often characterized by a number of important characteristics:

- ? Self-Organization
- ? Non-Linearity
- ? Order/Chaos Dynamic
- ? Emergent Properties.

From the learning process of analyzing, simulating, and modelling these characteristics of Complex Systems, a number of unique and thought-provoking computer programming approaches have emerged viz. Artificial Life, Genetic Algorithms, Neural Networks, Cellular Automata, Boolean Networks.

Self-Organization

Scientists are finding that change occurs naturally and automatically in systems in order to increase efficiency and effectiveness, as long as the systems are complex enough as defined above.

This change is accomplished by the elements that make up the system when they respond automatically to feedback from the environment the system inhabits. Environmental feedback can be seen as providing information about the system's efficiency and effectiveness.

Elements that survive negative environmental feedback will automatically re-settle themselves, or re-organize themselves and their interactions in order to better accomplish the system's goals. Success at this then assures their continued existence by also protecting or reinforcing the structures of which the elements are a part.

Such responsiveness occurs even when the elements and system are non-organic, unintelligent, and unconscious as long as the system is complex as described above.

Non-Linearity

When change occurs in Complex Systems it occurs in a non-linear fashion.

Linear change is where there is a sequence of events that affect each other in order as they appear one after the other. In contrast, in non-linear change, one sees elements being changed by previous elements, but then in turn these changed elements affect the elements that are before it in the sequence.

Thus in non-linear analysis, researchers look at how everything in the sequence has the possibility of affecting everything else in the sequence before and after it. Thus often the result ends up being unproportional to the original input.

This type of dynamic in a complex system is much closer to how things actually happen in nature. Almost never in nature does a purely linear sequence of events and change occur.

Order/Chaos Dynamic

It is usually fairly easy to predict what will develop in the next stage of system development when one has extensive knowledge of the previous stage. And this knowledge is usually of a range of possibilities that can develop next.

But as one begins to deal with stages of development farther and farther down the sequence of developmental stages, it becomes more and more difficult to predict what will develop based only on knowledge of that first stage, even when that knowledge is extensive. Thus even though there is logical development from stage to stage, there is an increasing inability to predict what will actually be the next development. This uncertainty of predictability is called "chaos".

Thus, one can then see how a tiny change in a condition can eventually lead to a huge number of different possible results. But yet all these changes are still logical results of that tiny change, it just becomes increasingly difficult to predict exactly which result will actually occur. But since some probability of occurrence for many of them can be known, then statistical analysis is still very important for helping describe the overall situation.

The classic illustration for this is the idea of how the flapping of butterfly wings in one part of the world can contribute to the evolution of a hurricane in another part of the world.

Emergent Properties

The unpredictability that is thus inherent in the natural evolution of complex systems then can yield results that are totally unpredictable based on knowledge of the original conditions. Such unpredictable results are called emergent properties. Emergent properties thus show how complex systems are inherently creative ones.

Emergent properties are still a logical result, just not a predictable one. This can also include higher level phenomenon that cannot be reduced to it's simpler constitutes or it's origins.

Characteristics of a complex software system

A complex system is emergent. In an emergent system, smaller parts comprise a larger system. This larger system has properties the smaller units lack. For example, the brain is made up of individual neurons that, when functioning together, are capable of tasks no single neuron can perform alone. The new properties only emerge when the neurons work together.

- A complex system is unpredictable.
- A complex system contains many iterations and feedback/feedforward loops.
- In a complex system, decision-making is decentralized.

Learning is a typically a "complex" activity. Most learning systems contain a number of separate parts that must work together for learning to occur. For example, a typical learning system consists of students, a teacher, a content focus, and resources. This system operates according to a fixed plan--the students follow the teacher's "rules."

Learning environments

A learning environment can be emergent. Working together, a group of learners can collectively build their knowledge of a topic, for instance, the phases of the moon. To do so, each learner might research a particular lunar phase, then share what he or she has learned with the rest of the group. This way, the group amasses a body of knowledge that no one person could have acquired alone.

A learning environment can be unpredictable. An exploration of the phases of the moon could result in the group considering whether planets also have phases.

A learning environment can contain many iterations and feedback/feedforward loops. People learn by trial and error--in other words, they learn from their mistakes.

Decision-making in a learning environment can be decentralized. Groups can really thrive when students control the learning process, rather than the instructor.

It's quite possible that learning occurs best on the "edge of chaos," where order and chaos meet. To see for yourself, check out these two resources:

What is a non Complex System?

An Example of a Non-Complex System: This approach contrasts with, say, the neo-classical approach to modeling economic systems. Usually, in order to work with expressions and equations that are tractable by mathematical analysis, microeconomic theorists assume that all consumers are identical and never change their preferences or characteristics. (so much for education or advertising!) Consumers either do not communicate at all or they interact in some simplistic random fashion, and the underlying system is always in equilibrium. Rarely do macroeconomic models build naturally on the underlying microeconomic models, as the complex systems approach strives to do.

The Implication of Unrestrained Complexity

“The more complex the system, the more open it is to total breakdown”. Rarely would a builder think about adding a new sub-basement to an existing 100-story building; to do so would he very costly and would undoubtedly invite failure. Amazingly, users of software systems rarely think twice about asking for equivalent changes. Besides, they argue, it is only a simple matter of programming.

Our failure to master the complexity of software results in projects that are late, over budget, and deficient in their stated requirements. We often call this condition the software crisis, but frankly, a malady that has carried on this long must he called normal. Sadly, this crisis translates into the squandering of human resources - a most precious commodity - as well as a considerable loss of opportunities. There are simply not enough good developers around to create all the new software that users need. Furthermore, a significant number of the developmental personnel in any given organization must often be dedicated to the maintenance or preservation of geriatric software.- Given the indirect as well as the direct contribution of software to the economic base of most industrialized countries, and considering the ways in which software can amplify the powers of the individual, it is unacceptable to allow this situation to continue. How can we change this dismal picture? Since the underlying problem springs from the inherent complexity of software, our suggestion is to first study how complex systems in other disciplines are organized. Indeed, if we open our eyes to the world about us, we will observe successful systems of significant complexity. Some of these systems are the works of humanity, such as the Space Shuttle, the England/France tunnel, and large business organizations such as Microsoft or General Electric. Many even more complex systems appear in nature, such as the human circulatory system or the structure of a plant.