We're faced with complex business, organisational and personnel issues every day in our roles as business analysts and project team members. Our issues are complex because everything, from people, businesses and environments, is interconnected internally and externally. If we don't adequately consider these dependencies, our solutions are ineffective or they result in unintended consequences that ripple throughout all the processes. Complex problems are systems issues that require systems thinking to solve.

A system is any entity that’s made up of dependent components which exchange information, energy, or matter with each other to produce a result. Systems use inputs, which get transformed into outputs through processes, tools, or techniques to produce outputs, and these outputs are often inputs to other components within the system or to other systems entirely.

And systems don’t just interact with themselves; they’re part of ever larger and more complex systems. Because of these internal and external relationships and influences, a system is complicated; take away any part of a system, its behaviour is altered; rearrange the relationships within a system and it'll function differently; make a change to a component within a system and that change could reverberate with unintended consequences to other systems.
What’s needed for complex problem-solving is a technique that looks holistically at the whole and this is what systems thinking can help us do.

**Systems Thinking and Linear Thinking**

Systems thinking is necessary for all complex problems, such as project management, portfolio management, quality management, business process improvement, and organisational management. The PMBOK, BABOK, Six Sigma, TQM, and Lean all have strong roots in systems thinking because it’s the only way to create solutions for the long-term, stop reoccurring problems and to minimise unintended consequences.

Because systems thinking focuses on the whole, it can:
• Spark innovation by encouraging questions and exposing new possibilities and options not seen when components are looked at individually.
• Help identify and manage risks stemming from relationships and dependencies.
• Improve communication and reduce business silos because of attentiveness to interdependence.
• Raise awareness of larger business objectives.
• Lead to products, services and results that are better designed.
• Allow faster response to rapid changes.
• Improve our leadership skills.

The human mind has difficulty making sense of complex problems, and systems thinking is not what comes naturally for us. We tend to be linear thinkers, looking for simple patterns, sequences, and causes-and-effects. Traditional problem analysis relies on reductionism where a complex entity is broken down into its simplest components and these are studied individually. The challenge with this approach is that when the components are reassembled into a system, the dynamics change. The components will not behave in the same way or have the same characteristics when they interact together and function as a whole. For instance, DNA is made up of only three simple chemical compounds, but when combined into sequences forming the basis for biological life, the dynamics change, the biological system is not just the sum of the characteristics exhibited by the core chemical components of DNA.

But the linear and systems thinking comparison is not itself a linear either, or issue. There is a need for both and they should complement each other. Even systems thinking relies on a cause-and-effect and reductionist approach to problem solving because we can’t solve a system problem without first understanding all its components. But the difference is one of perception. In traditional analysis cause-and-effect is looked upon as linear situation (Event A caused Effect B). In systems thinking, cause-and-effect is looked at from a circular perspective (what is a cause at one point in the system can be an effect at another point). When we practice systems thinking, we keep an open mind and look not only at the processes themselves, but of their inputs, outputs, relationships, dependencies and influences on each other and other systems before making conclusions.

Systems

To be better systems thinkers, we have to understand some basics about systems. We can’t let our view of a system be restricted, so the first thing for us to recognise is that systems can be anything, mechanical, biological, ecological, social, economic, organisational, technological, engineered and even abstract.

Secondly, systems are either open or closed. Closed systems can’t interact with their external environments, so they receive no information, matter, or energy from the outside world. And without any exchange of information, closed systems are not adaptable to changes. It’s easiest for us to envision a closed system as something artificially created, such as a laboratory environment or a quality control testing environment where the process must be tightly regulated. But closed systems can also be unintentional. If there’s no mechanism for an organisation’s sales people to let manufacturing know ahead of time that large orders have been placed then the relationship between sales and manufacturing systems is a closed system.

Open systems receive and exchange varying levels of information, matter, or energy with their environment, and it’s this interaction that makes open system most adaptable to change. But it also makes them more complex to understand. Since open systems have feedback with many other systems, it’s not always evident what other systems and components are involved. It takes a lot of thought, research, and investigation to really understand an open system, and even then there will likely be elements not discovered.
The third thing we should know about systems is that they're made up of five primary elements.

1. **Objects**: These are the parts, components, variables, subsystems, or elements that make up a system. The objects within a system exchange information, energy, or matter with other objects and usually with other systems. Though it's easiest to think of these as something tangible, the objects can be abstract.

2. **Attributes**: These are the properties and qualities of a system, which may be measurements of effects or behaviours at a point in time.

3. **Relationships**: All the objects within a system have relationships with other objects in the system, and in open systems the system itself will have relationships with other systems.
4. **Boundaries**: A system is restricted by a boundary. In an open system this is a permeable boundary since information, energy, or matter is exchanged with and received from outside, but in a closed system its boundary can’t be penetrated.

5. **Environmental Influences**: All systems, even closed systems, exist in larger environments. Open systems exert influences on the external environments and are themselves influenced by their environments.

Systems also have some interesting characteristics and behaviours:

- This was mentioned earlier, but it's a vital point for us to remember. All systems are themselves components of larger systems. More than anything else, it’s this realisation that separates systems thinking from ordinary linear thought.
- All systems have an ideal state of equilibrium based on current conditions, object values, environmental influences and relationships. Systems will attempt to self-correct themselves when they sway from their equilibrium. We shouldn’t assume that systems’ desired states are necessarily the ideal states we desire.
- Systems at or near their ideal states are relatively stable and predictable; conversely, systems that are far from their ideal states can be chaotic and unpredictable.
- There are always time delays in stable systems between the introduction of changes and when the effects are seen.
- Open systems have equifinality, which means that there are multiple ways of achieving the same objectives or results. We’ve seen this mentioned in the PMBOK as alternatives analysis.
- Open systems have multifinality, which means that the same objectives or results can have multiple purposes. For example, in a project undertaken to develop and manufacture a new hammer, the project team views the hammer as its final deliverable (project “system”); the performing organisation looks at the hammer as a revenue producer (business “system”); and the customer buying the hammer looks at it as a tool it’ll use to build houses (construction “system”).
Stories and Diagrams

The behaviour and effects of systems are described textually through stories and visually through diagrams. Through the process of creating stories and diagrams we can better understand the components, relationships, and interactions between systems, find root causes, and describe the systems to others. They can also help us model simple scenarios, but both stories and diagrams are only conceptual generalisations of the systems, so we need to avoid taking them too literally. Stories and diagrams also convey a false sense that the actions occur sequentially when in fact systems are dynamic entities with lots of actions occurring simultaneously. None of this should be surprising to those of us who’ve studied the PMBOK. Its project management processes are presented as discrete, stand-alone elements to help us study them, but we know that the project management processes are happening all at once and recurring over-and-over.

One type of diagramming technique is called causal loop diagrams (CLD). Using circular arrows and labels, causal loop diagrams show causes-and-effects, relationships and time delays for the components of systems.

Let’s look at an example and see how it can be diagrammed.

Example: Arinn likes to say busy, so when she has free time she volunteers for additional projects at work, and because of those additional projects, she’s working a lot of overtime. But Arinn also wants to study the PMBOK and pass the PMP examination. The more time she spends studying the more she desires to pass since she doesn’t want the time she’s invested to be wasted. And the more she worries, the more she’s concerned that she isn’t spending enough time studying, so she wants to devote more time to it.

Variables: These are the specific causes, effects and influences within the system of what is occurring and what is desired. It’s often difficult to uncover all variables, but we need to be thorough to ensure that we’re not overlooking an effect, influence, or behaviour. In our example the primary variables are her main goal of passing the PMP exam, her objective to spend more time studying, her actual study time, her overtime, and her amount of free time available to devote to her study time. We’ll find more variables as we look deeper at causes and effects.

Loops: Loops show the relationships in the system by linking the variables together. The causation or influence link between the variables is either:

- **Same**: An increase in one results in an increase in the other, or a decrease in one results in a decrease in the other. This can be shown with an “S” on the loop or with a plus sign.

- **Opposite**: An increase in one results in a decrease in the other, or a decrease in one results in an increase in the other. This can be shown as an “O” on the loop or with a minus sign.

Let’s start by pairing some of the variables up into their most basic cause-and-effect relationships:

The more time she studies, the less free time she has.
There is a gap between how much time she's currently studying and how much time she thinks she needs to be studying. As she spends more time studying, this gap decreases. A gap in a CLD is a variance between an actual value and a desired value.

While this gap exists, it motivates her to look for more free time that she can use for studying.

Since she likes to stay busy, she volunteers for additional work when she has free time.

As she volunteers for more projects at the office, she has to work overtime.

The more overtime she works then the less free time she has.

Her desire to pass increases the more she studies because she doesn't want the time she's invested to be in vain.

As her desire to pass increases, her worry that she needs to spend more time studying increases.
As her worry increases, she spends more time studying.

The arcs help us to identify the variables, causes, effects, and influences, but they need to be connected into loops in order for us to see the whole picture. It will probably take at least a few attempts to get the causal loop diagram drawn. I suggest starting by looking for the variables that have multiple influences, and these will end up being the intersecting points in the diagram. In this example, we have two main variables (free time and study time) that appear to be a central point with several influences.

Next, from these intersection points, find the commonality centred on the intersecting points, and these will become the loops. These loops are the feedback, or exchange points of information, matter, or energy within the system. So for free time, we have her influences from the office that impact her free time, and we have a second set of influences affecting free time that she's devoting to studying. And we have something else influencing her study time, and it's her desire to pass and her worry that she's not spending enough time studying.

If we now connect these into related loops, we can begin to see some patterns, and follow the complete story. It's important to correlate the CLD to a textual story because this will help us determine whether our diagram is accurate (and it often isn't on the first few attempts). If the textual story doesn't make sense then the diagram can't be correct.

1. When she has free time, she volunteers for more projects, which results in extra hours at the office, reducing her free time.
2. She's devoting some free time to studying, but she doesn't think she's studying enough. This gap motivates her to find more free time to allocate to studying.
3. Because she doesn't want to waste the time she's already spent studying, she wants to make sure she passes the exam. This increases her worry that she's not studying enough, influencing her to study more.
Now that we have loops established, we can see another component to causal loop diagrams. There are only two types of loops. A reinforcing loop promotes an effect and a balancing loop restricts an effect. Reinforcing loops are shown with an R designation and balancing loops by a B. To determine which type of loop is occurring, count the minus signs or O's; if there are no minus effects or an even number of them then it's a reinforcing loop; if there are an odd number of minus signs then it's a balancing loop.

This should make sense to us based on our example: Loops 1 and 2 are limited by a finite set of free time, so these are balancing loops, while loop 3 is a reinforcing loop because the more she wants to pass, the more she worries, and the more time she'll study.

We have one more item to discuss before our diagram is complete. Delays are points in the system where an influence takes some time to play out and are shown by two short parallel lines. Delays in a system mean we need to show patience and make sure we've given sufficient time for the system to read just before making further changes. They are important to note in the diagram and story because we have a tendency to be impatient, overreact, and introduce more changes if we don't immediately see the effects we desired.

In our example, even if Arinn stops volunteering tomorrow, it's very likely that she'll not be able to stop working immediately on the projects that she's already taken, so there will be a delay between the point she stops taking on more projects and her overtime diminishes.

So what benefits do systems thinking and diagrams bring to problem solving? They help us to highlight influences and causes-and-effects we might have missed, and they helps us to identify better options because
we can visually see the relationships between options. In fact, applying systems thinking to our CLD example, we should begin seeing other questions that beg further investigation and diagramming before Arinn decides on a solution:

- What if the extra projects Arinn takes on help her career advancement at work?
- What if the money she's earning from overtime is essential for her to meet her expenses?
- What is driving her desire to pass the PMP exam?
- Is there another source of free time for her, such as commute time, hours she spends sleeping, lunch hours?

As we might have seen in this example, there can be a lot of variables involved in a system. And the interplay between those variables results in a predominant behaviour of the system.

In part two (project-managers-guide-to-systems-thinking-part-2.php) of this article, we'll look at these relationships, called archetypes, because they help us understand a system's behaviour so that we can effectively try to influence that behaviour.

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