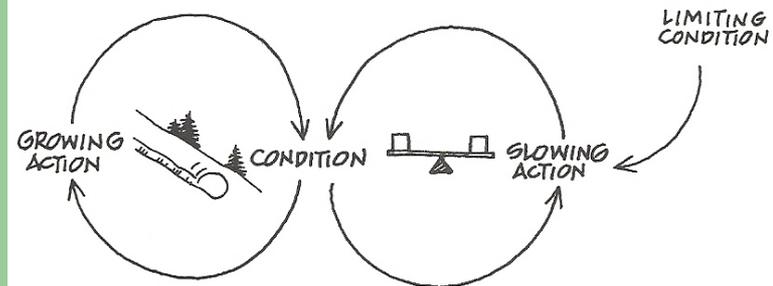


# Systems Thinking

## Whole solutions for whole problems

Dr. Colin J. Neill

Associate Professor of Software Engineering  
Assistant Division Head, Engineering



# Systems Thinking

"Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static 'snapshots'...Today systems thinking is needed more than ever because we are becoming overwhelmed by complexity."

Peter Senge, The Fifth Discipline

# Emergent Properties

- Nature does not show us isolated building blocks, but rather a complex web of relationships between the parts of a unified whole.
- The importance of each component of a system is tied to its relationship to the whole and the essential properties of a system are properties of the whole.
- By looking at just one component in isolation we would not have realistic picture of its importance
- We term this systemic properties, emergent properties.
  - The vehicular potential of a bike only applies to its whole, not its parts.

# Systemic not systematic

- The power of systems thinking comes from a focus on systemic structures
  - which is where the greatest leverage for problem solving and positive change lies.
- A systems approach can help shed light on current problems
  - especially those that seem to continually repeat - by viewing them from a different perspective.
- Systems thinking offers a range of tools for gaining deeper insight into problems
  - from simple causal-loop diagrams and systems archetypes to more complex computer simulation models.

# The World through a filter

- We interpret newly encountered things, situations and events in terms of our previous knowledge
  - When the Spanish conquistadores arrived in Mexico the indigenous people, unfamiliar with horse riding saw the riders dismount and thought a new creature had arrived on their shores that could separate itself in two at will.

# It's all perception

- What golf is to you?
  - A game, frustrating, a good walk ruined, a drain on natural resources and the ruin of natural habitats, exercise, stress relief, stress inducing, marriage savior, marriage destroyer.
- What your car is to you?
  - Environmental disaster, killing machine, a money pit, transportation, fun, thrilling, a taxi, pride and joy.
- What jail means to you?
  - Punishment, rehabilitation, protection of society, training camp for criminals, worse than death, taxpayer's burden, a necessity, inhumane, a deterrent, a gym.

# Fresh perspectives

## A guerilla band

- outlaws
- an army
- freedom fighters
- terrorists

... etc.

## Newspaper publishing

- informing
- misinforming
- entertaining
- providing an advertising medium
- providing packaging material
- enabling a society to talk to itself

... etc.

## A professional football league

- providing entertainment
- providing opportunities for displays of tribal loyalty
- providing vicarious conflict
- enabling football skills to be refined
- enabling police to test crowd control skills
- providing data for the betting industry

... etc.



# Hard and soft systems

- Hard systems:
  - Well-defined with clear objective and hence, a clear “means-end” solution.
  - E.g. A payroll system - many elements, but well-defined relationships, and therefore solvable.
- Soft systems:
  - Poorly defined, unclear objectives so has no “class” of solution.
  - Often referred to as “wicked” problems
  - Actually most systems!

# Soft Systems

- Soft systems exhibit emergent (unexpected, counterintuitive) behavior because of complex feedback loops among system components.
- And we find that:
  - Organizational goals are a matter of controversy
    - We assume that all members of an organization accept goals set by top management, but this is usually not the case.
  - Standard methods usually begin with a problem statement.
    - But, fixing the problem too early means we are unlikely to see different, possibly more basic, problems.
  - The method itself restricts what can be found out;
    - if we expect an organization to be describable by the interaction among a number of clearly bounded subsystems then that will happen – we will see in the organization a reflection of our methods

# The Fifth Discipline

- Systems thinking is necessary in business as well as engineering.
  - Every problem we face is multi-faceted, inter-related, non-intuitive and time-delayed so that cause and effect are unclear.
- Peter Senge called it the Fifth Discipline

# Some laws of the 5<sup>th</sup> Discipline

- Today's problems come from yesterday's solutions.
- The harder you push, the harder the system pushes back.
- Behavior grows better before it grows worse.
- The easy way out usually leads back in.
- The cure can be worse than the disease.
- Faster is slower.
- Cause and effect are not closely related in time and space.

# Today's problems come from yesterday's solutions

- Often we are puzzled by the causes of our problems; when we merely need to look at our own solutions to other problems in the past.
  - A well-established firm may find that this quarter's sales are off sharply. Why? Because the highly successful rebate program last quarter led many customers to buy then rather than now".
- Furthermore, solutions that merely shift the problem to another sector will often go undetected because the people who “solved” the problem aren’t the ones who inherit the new problem.

# The harder you push, the harder the system pushes back

- This refers to the idea of compensating feedback.
- It turns out that even our best efforts to redesign or improve a process often call forth responses (from the system) that offset the benefits of the intervention.
  - Invariably, it seems that the more time and effort that is spent, the more time and effort that is required.
- “When our initial efforts fail to produce lasting improvements, we “push harder” . . . all the while blinding ourselves to how we are contributing to the obstacles ourselves.”

# Behavior grows better before it grows worse

- Low-leverage interventions often work in the short-term before their real effects are felt and the problem gets worse.
- This is akin to treating symptoms rather than the disease. We get relief from those painful symptoms while the disease grows and spreads.

# The easy way out usually leads back in

- “We all find comfort applying familiar solutions to problems, sticking to what we know best.”
- Those who push harder and harder with familiar solutions while failing to change the fundamental problem are demonstrating nonsystemic thinking. Senge characterizes this as the “what we need here is a bigger hammer” syndrome.
- We should seek to do the right thing, not the easy thing.

# The cure can be worse than the disease

- “Sometimes the easy or familiar solution is not only ineffective; sometimes it is addictive and dangerous.”
- The most insidious consequence of nonsystemic solutions is the ever increasing need to apply more and more of the solution.

# Faster is slower

- “For most US business people the best rate of growth is fast, faster, fastest. Yet, virtually all natural systems have intrinsically optimal rates of growth. The optimal rate is far less than the fastest possible growth.”
- When growth becomes excessive the system will seek to compensate by slowing down . . . and that could put the organization at risk.

# Cause and effect are not closely related in time and space

- “The root of the difficulties is not recalcitrant problems or evil adversaries, but ourselves. It’s the mismatch between the true nature of the reality in complex systems and our thinking about that reality.”
- The first step in correcting that mismatch is to let go of the notion that cause and effect are related closely in time and space.

# But why?

- Structure influences behavior
- Structure in human systems is subtle
- Leverage often comes from new ways of thinking

# Structure influences behavior

- “Different people in the same structure tend to produce the same results. When there are problems it is easy to find someone or something to blame. But, more often than we realize, systems cause their own crises, not external factors or individuals’ mistakes.”

# Structure in human systems is subtle

- "We usually don't see the structures at play much at all. We just find ourselves feeling compelled to act in certain ways."
  - cause and effect not closely related in time and space
  - small changes producing big results
  - from the systems perspective, the human actor is part of a feedback process. We are continually both influenced by and influencing our reality

# Leverage often comes from new ways of thinking

- Reject linear cause-and-effect thinking
- Reject who-is-to-blame thinking
- Note hidden balancing processes
- Note hidden processes that reinforce themselves

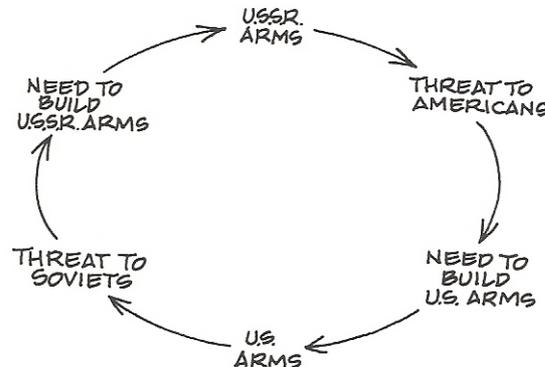
# Causal loop diagrams

- Rather than thinking in terms of linear causal relationships, think of circular causal relationships.

From...

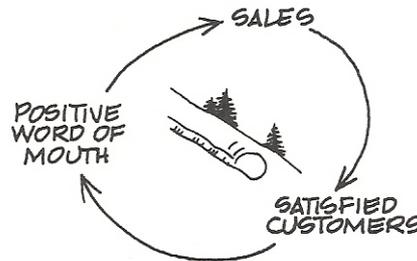


To...

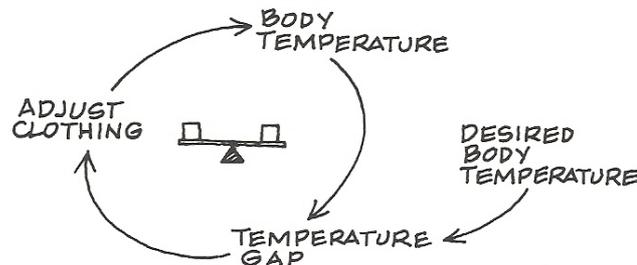


# Reinforcing and balancing feedback

- Reinforcing feedback processes are engines of growth. Reinforcing patterns can also accelerate decline – a pattern of decline where small drops amplify themselves into larger and larger drops.

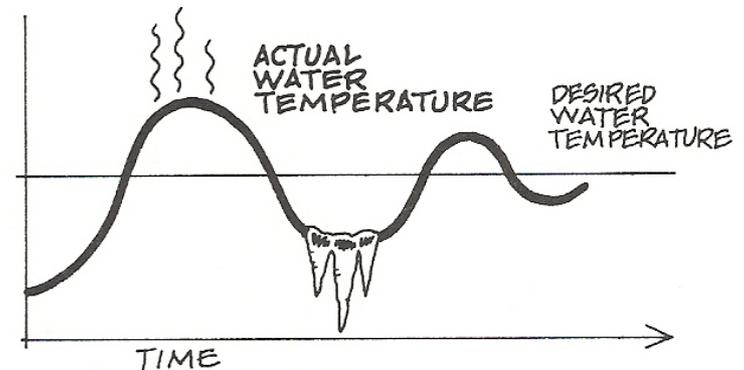
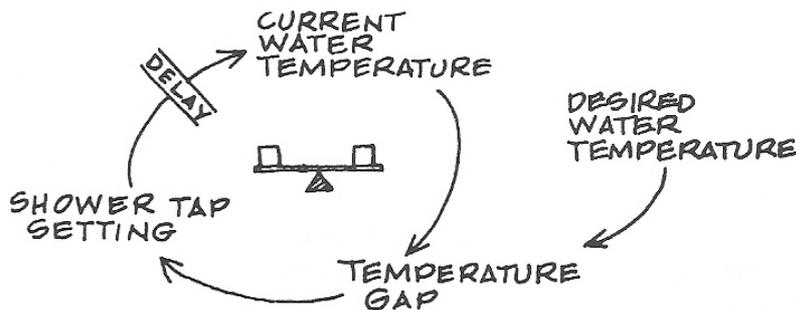


- Balancing feedback operates whenever there is goal-oriented behavior – a target, either explicit or implicit.



# Delays – between cause and effect

- We can show delays in the feedback, and these lead to instability and oscillation

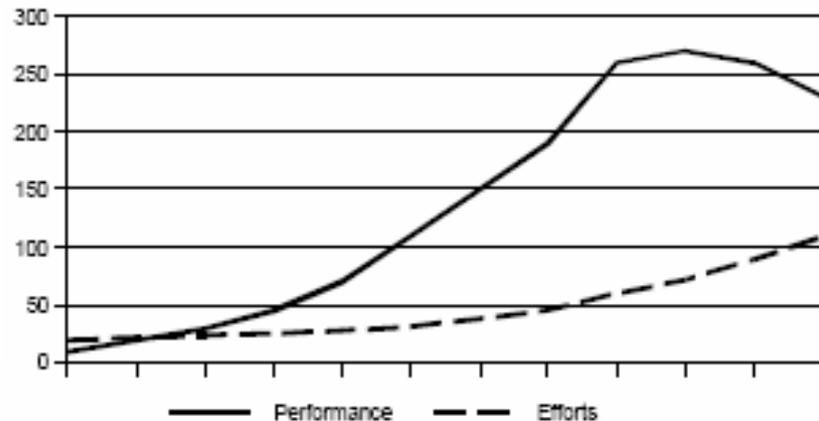
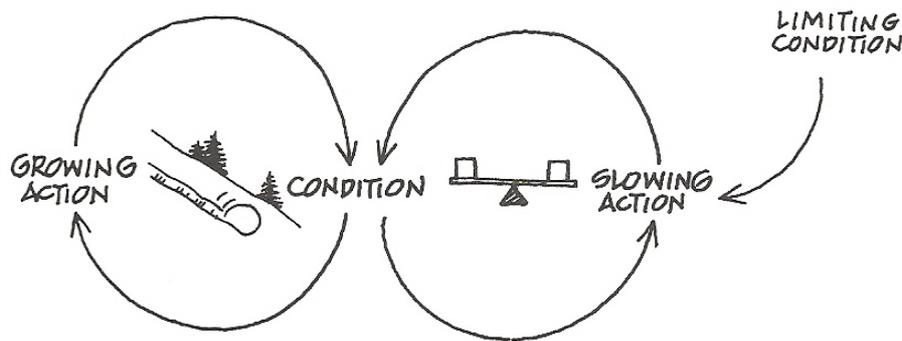


# Systems Archetypes

- Patterns, expressed as feedback loops, that describe common organizational behavior.
  - Limits to Growth
  - Shifting the Burden
  - Eroding Goals
  - Escalation
  - Success to the Successful
  - Tragedy of the Commons
  - Fixes that Fail
  - Growth and Underinvestment
  - Accidental Adversaries
  - Attractiveness Principle

# Limits to growth

- Something always pushes back. There is no such thing as unrestricted positive reinforcing behavior. There are always limits that eventually make themselves known and felt.



# References

- P. Checkland. Systems thinking, systems practice. John Wiley. 1999.
- P. Checkland, & J. Scholes. Soft systems methodology in action. John Wiley. 1999.
- P. Senge. The Fifth Discipline: The art & practice of the learning organization. Doubleday. 1990.
- G.H. Watson. Business systems engineering: Managing breakthrough changes for productivity and profit. John Wiley, 1994.