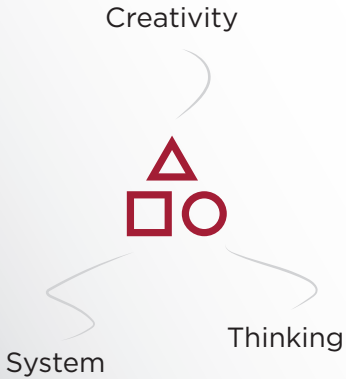
INSPIRATION DESIGN TOOLKIT

t



Design Team

Prof. Edward F. Crawley, Dr. Beatriz Carramolino,
Sheng-Hung Lee, Michael Chien, Daryl Phua

June 2020 at MIT

Purpose

The **Inspiration Design Toolkit (IDT)** is a set of human-centered supporting material to enhance the overall online and offline learning experience to make class participants fully engage with the community and content as well as enjoy the delightful journey with MIT

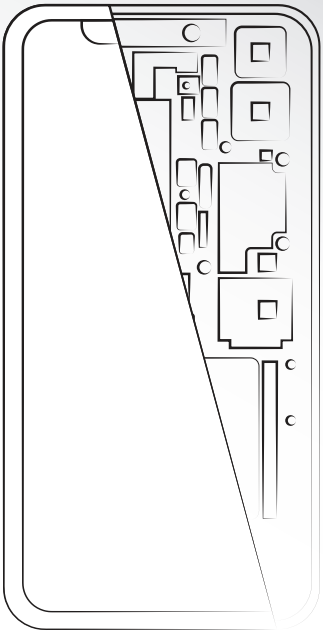
Reflection Icon

Observe — MIND: Use your mind to see and listen.

Feel — HEART: Use your heart to understand.

Act — HAND: Use your hands to make and prototype.

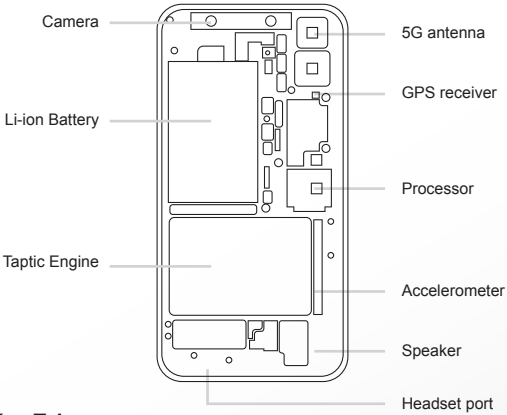
INFO: Connect to MIT xPRO Dashboard.



System thinking is thinking of things as systems. What systems are you thinking about?

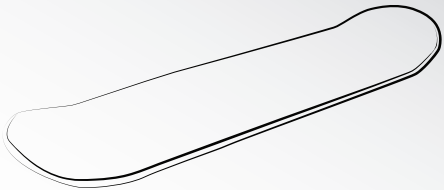
Observe Feel Act

Smartphones are becoming more complex as we ask more from them.

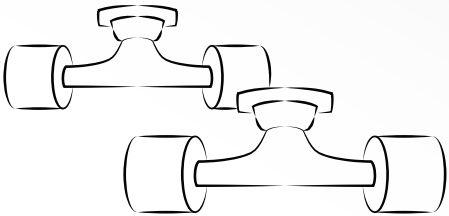


Key Takeaways

- Systems have interrelated entities and deliver new function.
- System thinking is thinking of things as systems.
- Systems are becoming more complex as we ask more from them.
- System thinking helps make complex things appear simple.
- System thinking expands the scope of thinking and avoids stovepipes.



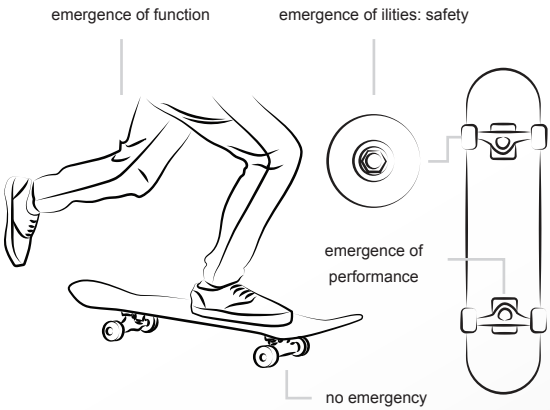
+



= ?

What will emerge as we combine the entities of a system?

Observe Feel Act



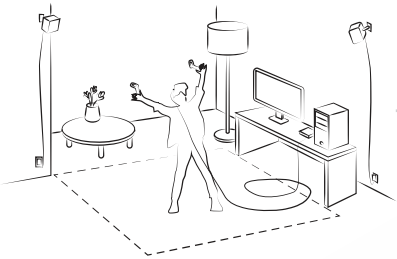
Key Takeaways

- Emergence of function—the system does something that was never done before.
- Emergence of performance—the system does something better than before.
- Emergence is of the ilities or non-functional attributes—for example the system has more reliability.
- Emergence of an emergency that we don't want to happen.

What is the function of the system? What does it do?

Observe Feel Act

VR system for human entertainment

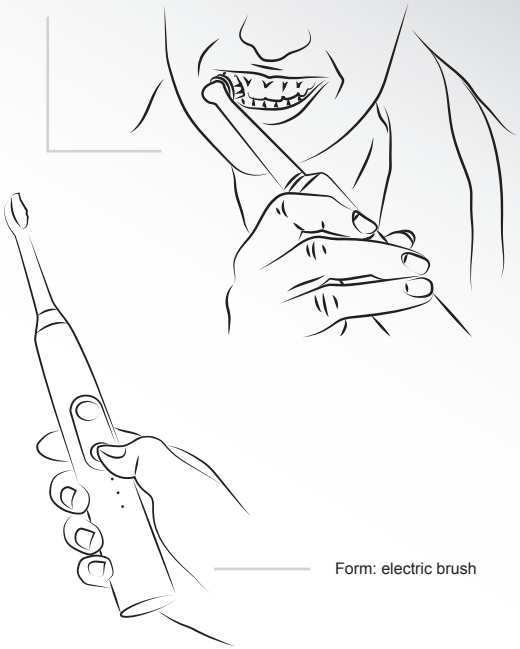


VR system for data manipulation

Key Takeaways

- Function is what a system does.
- It is how systems create benefit.
- It consists of an operand that is changed, and a process that brings about the change.
- Emergence occurs in the functional domain.

Function: clean teeth



Form: electric brush

What is the form of the system—the physical or informational embodiment? What is it?

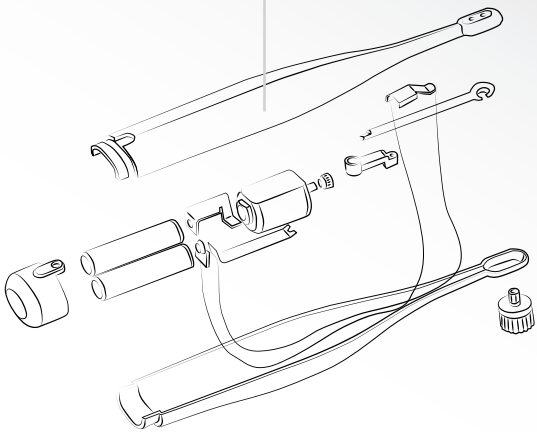
Observe Feel Act

The water jet cleaner can be used to perform the same function—clean teeth—but with a very different form.

Key Takeaways

- Form is the physical or informational embodiment of the system—what it IS.
- Form is the instrument of function—what the system does.
- Value is benefit at cost, benefit derives from function, cost is dependent on form.
- Abstractions help make systems appear simple by hiding un-needed details.

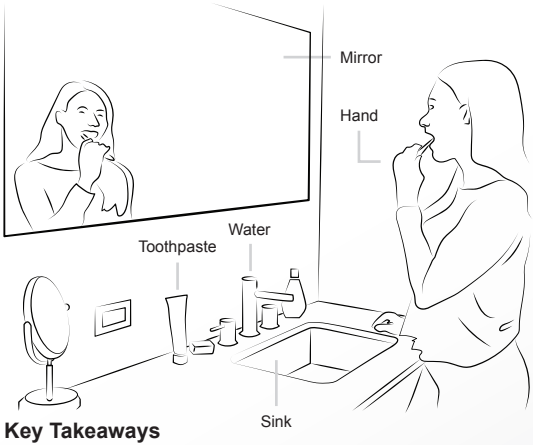
Decompose the electric toothbrush into smaller systems.



What are the entities of a system? Are they entities of form? Are they entities of function?

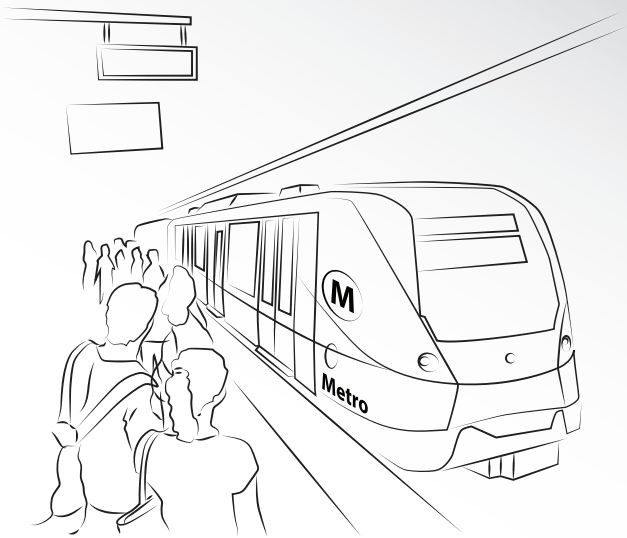
Observe Feel Act

Compose a larger system for cleaning teeth that includes the toothbrush.



Key Takeaways

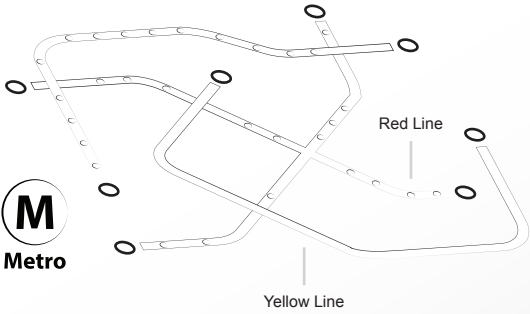
- A system can be decomposed into entities, and entities can be composed into a system.
- This decomposition and composition is one of our most powerful tools in managing complex systems.
- Every system is part of a larger system and can be decomposed into smaller systems.
- Every system and entity can be thought of as an abstraction with form and function.
- Systems and entities can be placed in a hierarchy.



What entities are within the boundaries of this system? Might a different view of the system cause you to pick different boundaries?

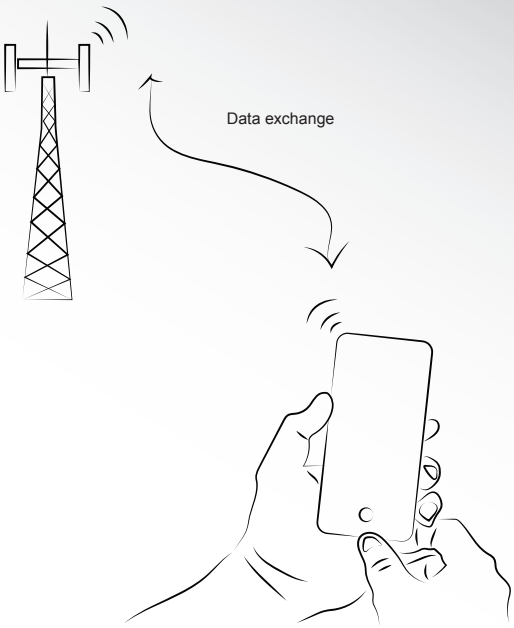
Observe Feel Act

Check out the metro map and think about how to describe its system entities and boundaries?



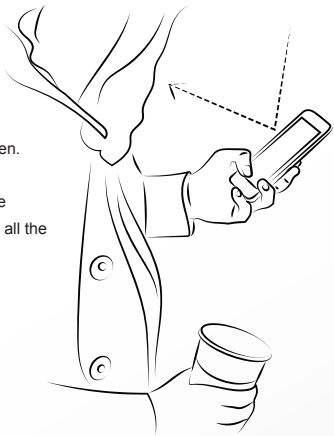
Key Takeaways

- Identify the entities by decomposition or composition
- Try to limit the number of entities to 7 +/- 2
- Use holistic thinking to identify all reasonable entities of a system
- Focus on the minimum set of essential entities
- Draw a boundary that divides the system from its context



What are the interactions of the entities that allow for emergence?

People look at their screen. The light will serve as interaction to transmit the images, text, colors, and all the visuals on the phone.

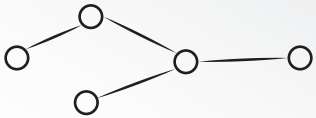


Key Takeaways

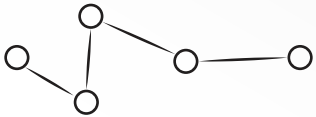
- A group of entities become a system when there are relationships.
- Relationships have form and function—emergence happens as a direct result of functional relationships.
- Functional relationships are interactions—one entity affects another, an operand is passed or an operand is shared.
- Functional relationships can be among the entities within the system, or with entities outside the system in the context.

How does the structure change if we use different connections among the same station locations?

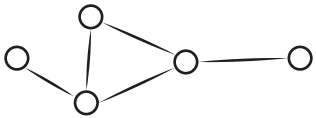
Metro Network 1



Metro Network 2



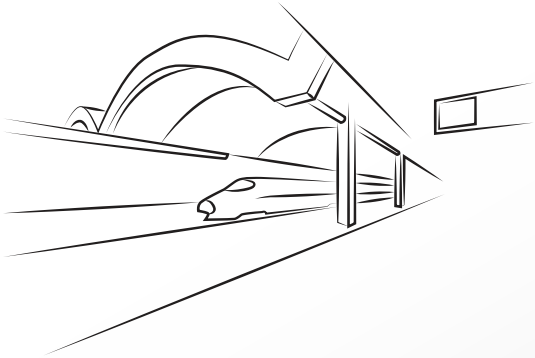
Metro Network 3



What is the structure? Connection? Location? How does it enable interaction?

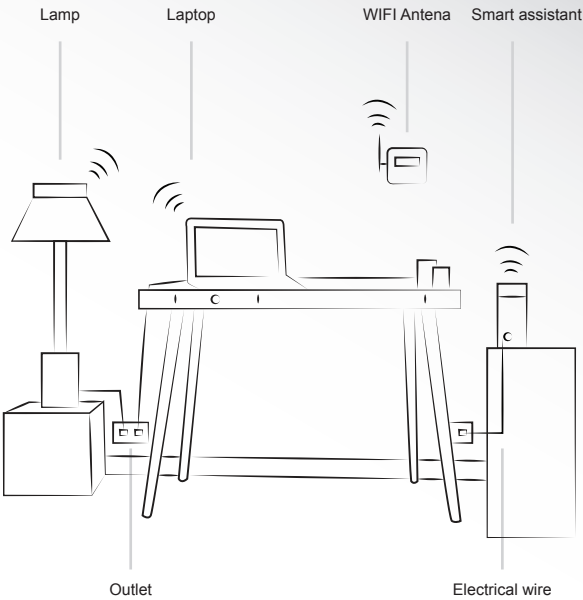
Observe Feel Act

Formal structure (connections between the stations) enables functional interactions (transporting people).



Key Takeaways

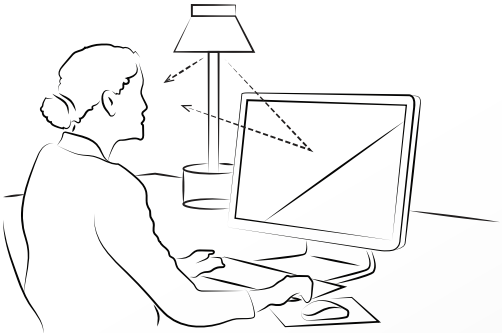
- Where there is a functional relationships (an interaction) there is usually a formal relationship (the structure).
- The functional interaction is usually enabled by a formal relationships.
- Structure can include all kinds of connections, as well as location and sequence.
- When structure and interaction cross a system boundary, careful system thinking is required.



Can you predict the emergence of a system by reasoning from its form and structure to its functions?

Observe Feel Act

People turn on the lamp for reading, but can not see the screen clearly now. The emergence (the light and the reflection) happens.



Key Takeaways

- Emergence occurs when the functions of entities interact through the functional relationships.
- Emergence is enabled by the form of entities (the instrument of the function) and the form of the relationships (the instrument of interaction).
- When emergence actually is tested, the possible results are that the expected emergence occurs, it fails to emerge, or an unexpected emergence occurs.
- When a piece of a system is altered, that change can propagate far throughout the system.

Drawing is like modeling.

The finished house is like a precedent example.

How would you predict emergence? By using human reasoning and precedent? Experimentation? Modeling?

Observe Feel Act

Human reasoning and experience are critical.

Model the house design in software.

Key Takeaways

- It's hard, but essential, as emergence is why we deal with systems.
- Emergence can be understood and predicted by human reasoning, supported by precedent, experimentation and modeling.
- For unprecedented systems, where modeling and experimentation are not easy, only human reasoning is available to predict emergence.
- This is the real goal, and the real art in System Thinking.

Do you think this child can eat the ice cream successfully?

Why does the system fail even though all the entities and all the relationships function well?

Observe Feel Act

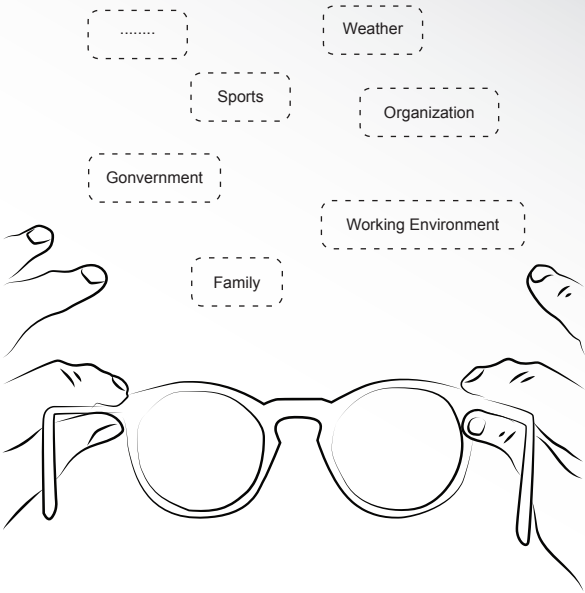
Do all the entities and relations function well?

Why does the ice cream fall to the ground?

Key Takeaways

- For systems to succeed, all the entities and all of the relationships have to be functioning.
- A system can fail if one entity or one relationship—the weak link in the chain—fails to function.
- But a system can also fail as a system even though all the entities and all the relationships function well.

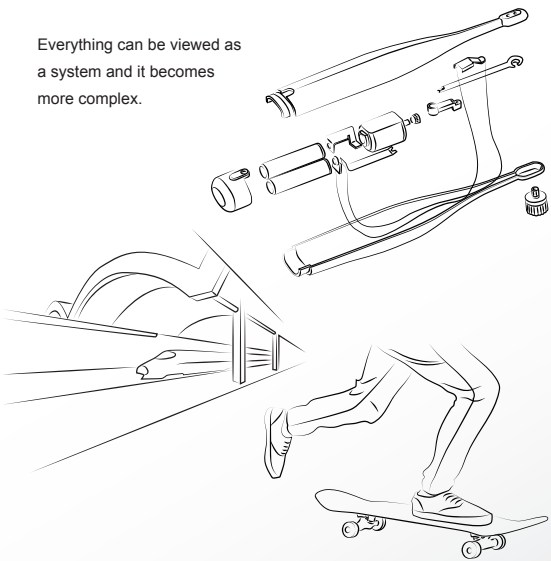
Almost everything can be viewed as a system.



What if we view our world through the lens of a system?

Observe Feel Act

Everything can be viewed as a system and it becomes more complex.



Key Takeaways

- System thinking is thinking of things as systems: entities and relationships, form & function, emergence & value.

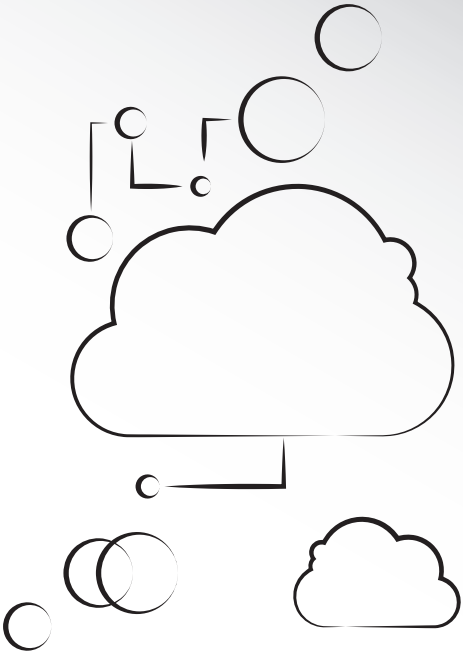
Logistics and Transportation Approach to System Thinking

System Dynamics Method for System Thinking

Notes

- Policy resistance is the phenomenon where when well intentioned people receive sufficient support and implement the policies that they believe are best suited to address the pressing challenges that they face, it doesn't work, or more commonly and more insidiously, it works locally right now, but then the problem comes back often worse later.
- “There is no such thing as a side effect - there are just effects: you make decisions, your decisions have multiple effects. You're not the only player in the system, there are other actors and other agents with their own goals and those goals are typically different from your goals. But we all share the same world. So whenever you take action that pulls the status system closer to your goals. You're almost certainly pulling it farther away from the goals of those other actors. And they're not just gonna sit there and take it, they're gonna respond.” - Professor John Sterman

Your Thoughts



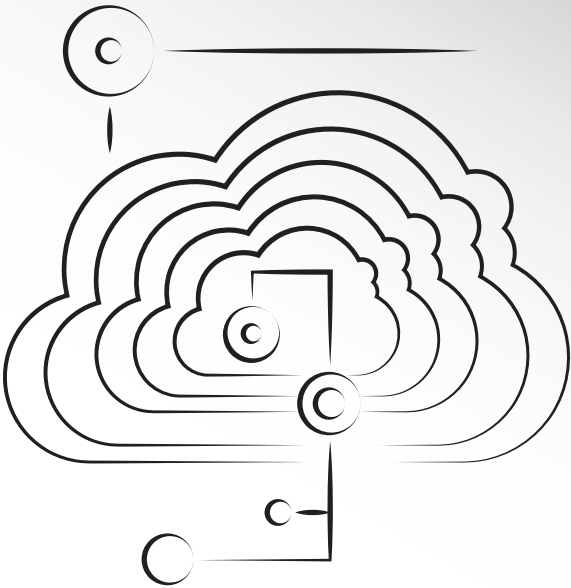
System Dynamics: Tools for learning in a Complex World

System Dynamics on Project Management

Notes

- Common problems of project management: LEW (late, expensive/over budget, wrong/fail to meet customer requirements, low quality), 90% syndrome, corner cutting and quality erosion, normalization of deviance, liar's club, firefighting, blaming people for process and systems problems.

Your Thoughts



System Dynamics Application: Managing Complex Projects

Project Management

Notes

- Liar's club: Concealing known rework requirements from managers and colleagues
- Self-confirming attribution error: workers become reluctant to reveal problems, and managers overestimate the impact of their get-tough policy
- Lessons learned:
  - start with more people than the plan, do not wait to hire at the end, hire upfront and hire more people than you think you're going to need;
  - use overtime sparingly and only at the end of a project;
  - never cut corners; and
  - never cut testing.

Your Thoughts

Logistics and Transportation Approach to System Thinking

Form, Function, and Performance

Notes

- We care about the performance of the systems, that is how well the system conducts its functions.
- The performance of a system depends on its entities, their relationships, our knowledge of the system, and our ability to regulate it.
- The performance of systems can vary because of differences in: the systems' form; the systems' entities; the entities' connectivity; the scale; the control of the entities; the knowledge of the system; or the behavior of the operands
- Three scenarios:
    - When we know almost everything about the system and have the ability to regulate the operands and entity behavior - A very high level of performance can be obtained through optimization.
    - When we know something about the system but have limited ability to regulate the system - Good performance can be obtained through control policies.
    - When we have limited knowledge of the system but not about the operand behavior - Improvement in performance can be obtained through implementing methods to collect information to increase knowledge about the system.

Logistics and Transportation Approach to System Thinking

Counterintuitive Emergent Behaviour

Notes

- The Price of Anarchy is a concept in economics and game theory in which the performance of a system degrades due to its agents (operands) acting in their own self interest and doing what's best for them (selfish behavior).

Your Thoughts

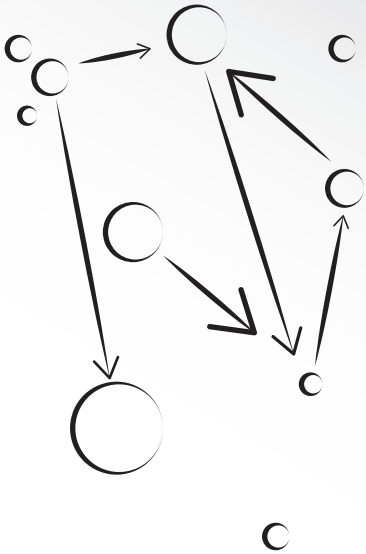
Logistics and Transportation Approach to System Thinking

Queuing Systems and Networks

Notes

- Queuing systems - Little's Law is a powerful concept to help us analyze simple or complex systems.
- Networks - Cascading Failures are an emergent property of network systems.
- The bullwhip effect is a result of trade-off between uncertainty and the efficiency of the system. Improving information sharing and the ability to regulate the system can mitigate the bullwhip effect.

Your Thoughts



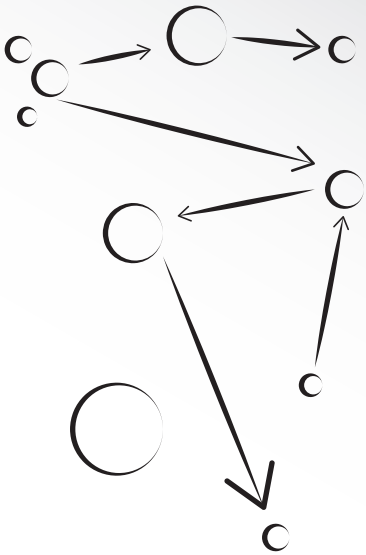
Computational Approach to System Thinking

Modern Logistics and Transportation Systems

Notes

- Modern technologies such as AI and ML enable us to go from data to models to decision and insights
- We should be mindful about trade-offs between efficiency obtained from sharing information and security and privacy concerns

Your Thoughts



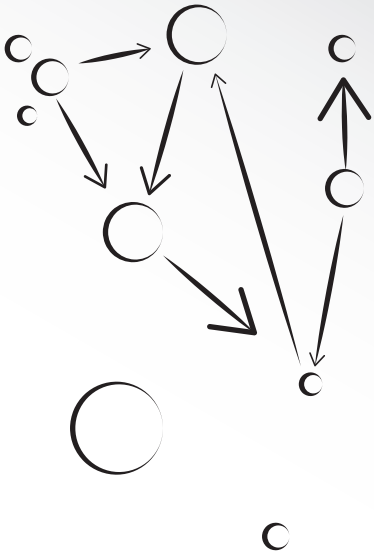
Computational Approach to System Thinking

System Thinking: The Computational Approach

Notes

- A system is an entity with interrelated and interdependent parts. It is defined by its modules, by the boundaries between the modules, and by their interaction
- Computational systems thinking design process: database -> choose modules -> compose modules -> simulate and verify -> fabricate

Your Thoughts



Computational Approach to System Thinking

Case Study: The legged Robot

Notes

- Computational approach to systems thinking is data driven. Data driven approach relies on a database that is seeded with low level designs, and some higher level designs created by experts
- “The gap between symbolic reasoning and concrete, precise specifications is filled through computational approaches.” - Professor Daniela Rus

Your Thoughts

System Dynamics: Tools for learning in a Complex World

Computational Design: Wrap up

Notes

- Computational approach to systems thinking is enabled by 3 important concepts: data driven specification, hierarchical composition, and simulation and verification.

Your Thoughts

Main Inspiration Visual

Provocative Questions

Observe Feel Act

Complementary Visual

Key Takeaways