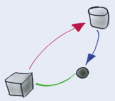
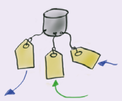
STRUCTURE

How it hangs together

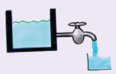
A **system** is a **set** of **connected elements** that **operate coherently** toward a **purpose**.



This network is often visualized as a graph with the **elements** as nodes, their relations as lines to show a connection or arrows to show a direction of influence.
In a systems view, understanding the relations between the elements is essential.

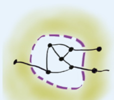


The elements can be different, and can have different **properties** or parts; the relations in the system are often defined between the parts of elements.
Properties are often described by **variables**.

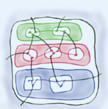


One much-used type of variable is a **stock**, an amount which varies between empty and full, and its change, called **flow**.

The network is **coherent**, meaning that the elements fit together and **influence** eachother.
The **boundary** of the system separates elements that are considered to be part of the system from whatever is outside.



In a **closed** system, all connections are between the elements inside the boundary. In an **open** system, there are influences from (and to) the outside.



Subsystems are parts of a system which have their own boundary. This boundary can be given by nature, chosen for description, or created for control.
Subsystems may occur side to side, or be organized in **levels**, where relations between subsystems within a level work differently than from those between levels.

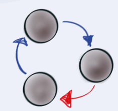
The **purpose** is readily recognized in human-made systems, but also natural systems can be seen as working toward a goal.

Taking a systems view often means taking more **context** into account, to look outside the initial boundary of your focus, or to include other attributes of the elements you were considering at first.

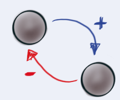
DYNAMICS

How it moves along

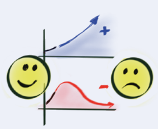
A system **evolves over time** through **feedback loops** which modify the inputs. As a result, patterns of behavior emerge.



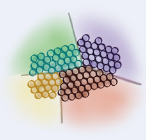
Feedback loops take place when a element's output hase influence on its input. Feedback can magnify, distort, or negate inputs that are fed into the system.
Feedback on an element's output can be **direct** (from the receiving element), **indirect** (through a third element), or even **immediate** (feedback from the element itself).



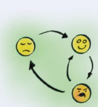
A feedback loop as a whole can be positive or negative. **Positive feedback** loops amplify their signal. **Negative feedback** loops counteract their signal. Feedback can be strong or weak, quick or slow. Timing and delays play an important role.

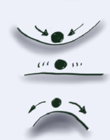


Positive feedback loops are called **virtuous** if it is a desireable strengthening, or **vicious** if it is an undesireable explosion. Negative feedback loops can similarly be called **stabilizing** (good) or **stagnating** (bad).



The dynamic relations, especially feedback loops, can exhibit **patterns**. Such patterns can show as **emerging properties, behavior, and structure** (e.g. new boundaries, levels appear).
When **self-organisation** occurs, a system maintains a structure despite varying external influences.
A system's dynamic can be in different **states**: patterns of how the system behaves and reacts, with particular repertoires of behavior patterns.
Descriptive terms may only be meaningful for certain states, and undefined for others.





A change from one state to another is called a **transition**, and is often accompanied by a reorganization, rearrangement, and adjustments.
When a disturbance occurs, a system may return to its previous state (**stable**), break down to another state (**fragile**), or adjust its structure slightly but remain largely the same (**resilient**).

Some important state dynamics are **hysteresis** (sensitivity to history) and **resonance** (a strong buildup from continuous weak inputs).

CHANGE

How you may (not) be able to direct it

Designers and Engineers want to improve or control how something goes. But the system can have a will of its own.

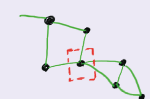
Feedback in systems makes predicting how they react to changes or inputs more difficult (or sometimes easier). The system may resist, absorb, '**kick back**', or explode in reaction to certain inputs.

Chains of cause and effect relations can become complex, because effects become causes and multiple chains of influence occur in parallel, and may interact.

Problems are called **wicked** to indicate that they cannot be simply 'solved' or even completely defined. Instead, improvements are made gradually, iteratively, developed along the way, and requiring action from multiple stakeholders.

In **nonlinear** (feedback) systems, costs of a small change may require effort that is **disproportional**. The extra inch may be more costly than the previous mile (or the other way around).

Emergent structure can appear along the lines of existing natural or artificial structure. Or shift or break those lines.



Intervening in systems is most effective at a **leverage point**, where key relations come together. Discovering such points is a strategic element in systemic design.

Interacting with system depends on its **complexity**, whether it's **simple**, **complicated**, **complex** or **chaotic**. Especially if there is **tight coupling** (fast, strong feedback), you may need tactics for chaotic systems.

Three columns of Terms and Jargon

The narrative often goes from left to right: first describe the structure, then see how the relations evolve, finally push it somewhere. But we also need the right-to-left logic: an intervention can bring a system into a new state we had not seen before, and feedback loops can create boundaries in structure which were not there, and were not expected or intended when the elements were assembled.