GST 88 — Causal Organisation and Systems

Formal Description

A system can be understood as an organised concentration of causal relationships in which interacting components form a relatively coherent causal organisation. This shifts attention from systems as collections of things towards the causal interactions through which their organisation is maintained and their behaviour produced.

The distinction developed in previous modules between potential and realised causality is important here. A persistent configuration establishes causal possibilities by determining which components can interact and which transfer pathways are available. When processes operate and transfers occur through those pathways, some of those causal possibilities become realised. Configuration and activity are therefore complementary aspects of causal organisation rather than alternatives.

Interactions within a causal organisation need not occur equally. Some components may interact more frequently, strongly or rapidly with one another than they do with other components. This uneven distribution of causal interaction can be described as differential coupling. Where relatively strongly coupled groups of components interact less intensively with their surroundings, comparatively coherent causal organisations can become recognisable.

This provides a causal basis for near-decomposability. A complex causal network may sometimes be analysed as relatively distinct systems or subsystems because interactions within them are stronger or more frequent than interactions between them. Their boundaries are nevertheless relative rather than absolute: causal transfers can continue across them.

Differential coupling alone, however, is not sufficient to establish that any densely connected cluster should be regarded as a system. A stronger basis for system recognition exists where organised causal interactions generate emergent properties, behaviours or outputs attributable to the organisation as a whole rather than to its components considered independently.

Systems can therefore be recognised through the combination of relatively coherent causal organisation and emergence. The resulting boundary identifies an organisation useful for investigation while remaining permeable to causal interaction with its wider environment.

Plain English Explanation

Imagine looking at a very large causal network containing hundreds of interacting processes. If every process interacted equally with every other process, it would be difficult to identify any particular systems within it.

But real causal organisation is often uneven.

Suppose one group of processes interacts frequently and rapidly:

A ↔ B ↔ C ↔ D

while another group also interacts frequently:

E ↔ F ↔ G ↔ H

and only occasional or weaker interactions occur between the two groups.

We might reasonably recognise two relatively distinct causal organisations.

This does not mean that an invisible wall separates them. Matter, energy and information may continue to pass between them. Their boundaries arise because interaction is concentrated more strongly within each organisation than between them.

This is differential coupling.

A familiar example is the human body. Processes within the body interact intensively with one another, yet the body also exchanges matter, energy and information continuously with its environment. Its boundary is therefore not a boundary beyond which causality stops. It marks a relatively coherent concentration of causal organisation.

The same idea can occur within a system. Processes within the heart interact particularly closely with one another while also interacting with the wider organism. We can therefore recognise the heart as a subsystem without pretending that it operates independently of the rest of the body.

This is the basic idea behind near-decomposability. Complex reality can sometimes be decomposed into relatively coherent systems and subsystems because causal interaction is unevenly distributed.

But dense interaction is not quite enough.

Imagine a crowded railway station. Many people may interact with one another, yet this does not necessarily mean that every temporary cluster of interacting people constitutes a meaningful system. We obtain stronger grounds for system recognition when the organisation as a whole exhibits something that its components do not exhibit independently.

A heart, for example, pumps blood through the organised causal interaction of its constituent parts. No isolated component performs the complete pumping behaviour. The behaviour is emergent from their organisation and interaction.

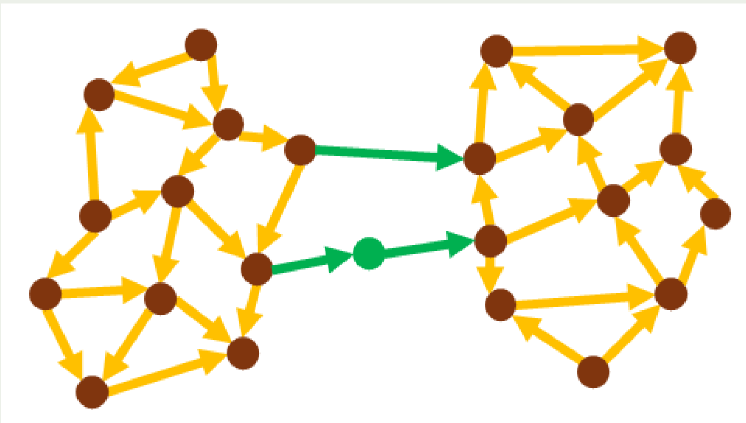
This gives us two complementary questions when identifying a system:

Are causal interactions relatively concentrated within this organisation?

and:

Does the resulting organisation exhibit properties, behaviours or outputs attributable to the whole?

Together, differential coupling and emergence provide a much stronger basis for recognising systems than simply drawing convenient boundaries around collections of components.



Differential Coupling and Relative System Boundaries

Frequent or strong causal interactions within parts of a wider causal network can produce relatively coherent causal organisations, while less frequent or weaker interactions occur between them. Such differential coupling provides a causal basis for recognising relative system boundaries without implying causal isolation.

The figure should be interpreted together with the concept of emergence. Differential coupling helps reveal where a possible boundary lies; emergent properties, behaviours or outputs help establish whether the enclosed causal organisation is meaningfully recognisable as a system.

Examples

An organism provides a particularly clear example. Internal physiological processes are highly interconnected, while exchanges with the external environment occur through more restricted pathways such as respiration, ingestion, excretion, sensory reception and physical action. The organism is therefore relatively bounded while remaining an open causal system.

A business organisation provides a different example. Employees within a particular team may communicate and coordinate more frequently with one another than with people elsewhere in the organisation. The team may consequently be recognisable as a subsystem. Its boundary remains permeable because information, resources and decisions continue to cross it.

A computer contains many similarly nested concentrations of causal interaction. Components within a processor interact particularly intensively, while the processor communicates with memory and other components through more restricted pathways. Different levels of causal organisation can therefore be distinguished without treating any level as causally independent.

The town used in our rolling exercise presents a more difficult case. A river, drainage network, flood-defence system, road network and built environment interact, but the appropriate system boundaries depend partly upon the purpose of investigation. If the purpose is flood management, causal relationships that might normally be allocated to separate engineered, hydrological and social systems may need to be considered together.

This illustrates why system boundaries are both grounded in causal organisation and influenced by investigative purpose.

Provenance and Links

The concept of near-decomposability is particularly associated with Herbert Simon, who observed that complex systems commonly contain subsystems within which interactions are stronger than interactions between subsystems. This makes complex organisations partially decomposable for analytical purposes without requiring their components to be completely independent.

The recognition of systems through patterns of interaction also has strong antecedents in general systems theory. Ludwig von Bertalanffy emphasised open systems whose organisation persists despite continuing exchanges with their environments, helping move systems science away from the idea that system boundaries necessarily imply physical isolation.

The importance of emergence has an even longer intellectual history and became central to many twentieth-century approaches to complex systems. The treatment adopted here emphasises that emergent properties, behaviours and outputs arise through organised causal interaction and are not exhibited by the interacting components considered independently.

The particular combination developed in these course modules is that differential coupling provides a causal basis for recognising relative system boundaries, while emergence provides an additional criterion for recognising a relatively coherent causal organisation as a system. This relationship will be developed much further in subsequent course modules devoted specifically to emergence.

Practical Exercise

Return to the town experiencing local flooding after heavy rainfall. You should now have a causal network containing persistent and transient processes, transfers, conditions and constraints.

Begin by looking at the whole network without imposing any predetermined system boundaries.

Identify groups of processes that appear to interact more frequently or directly with one another than with the rest of the network.

Consider, for example, whether you can recognise a relatively coherent river system, drainage system, built-environment system or flood-defence system. Do not assume that these conventional labels automatically identify the correct causal boundaries. Use the causal interactions in your representation to justify any boundary you draw.

Choose one proposed system and identify several causal interactions occurring within its boundary. Then identify transfers crossing the boundary between that system and its environment. Explain why the existence of these boundary-crossing transfers does not prevent the organisation from being recognised as a system.

Now look within your selected system and ask whether it contains a smaller concentration of causal interactions that could reasonably be regarded as a subsystem. Explain how the same causal organisation can therefore be represented at more than one level of granularity.

Next consider potential and realised causality. Identify some pathways within your selected system that persist as causal possibilities even when no flooding occurs. Then identify which of those possibilities become realised during the particular flood event.

Now apply a stronger test of system recognition. Ask whether your proposed system exhibits any property, behaviour or output arising from the organised interaction of its components rather than from any component acting independently. If you can identify such an emergent phenomenon, explain why it strengthens the case for treating the organisation as a system.

Finally, change the purpose of the investigation. Imagine first that you are responsible for maintaining the drainage network and then that you are responsible for reducing flood damage across the whole town. Compare the system boundaries that are useful for these two purposes. Consider whether broader boundaries reveal important causal interactions that a narrower system representation conceals.

At the end of the exercise, write a short explanation addressing the question:

What makes a system a relatively distinct causal organisation without making it causally independent of its environment?

Retain your resulting system representation for the next module, Causal Leverage. There you will use the causal organisation you have developed to identify places where relatively small causal inputs might enable, inhibit, control or redirect much larger causal consequences.