Social Systems Theory and Practical Problem Solving

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Introduction.

Many Professional Civil Engineers quickly learn that the technical and economic difficulties of implementing a project are often dwarfed by the social difficulties. Successful projects must not only be technically and economically viable, but also socially acceptable. But what is "social acceptability", especially when some favour a project and others actively oppose it?

This article addresses that question. It describes the application of Social Systems Theory to practical present-day problems to determine the social acceptability of potential solutions. Social Systems Theory combines the insights of systems science, with insights from the human sciences of psychology, sociology, political science, and economics, to form a single practical discipline. This discipline can be used to better understand why problems exist, or it can be used to understand what potential solutions are socially acceptable. The application Social Systems Theory to the latter is described below. The methodology is described in very general terms and is widely applicable. However, a real-world problem is also used as an example.

This real-world problem is a nation suffering severe water management difficulties. It is not necessary to name the nation because its problem is shared by many others. Most of its water is abstracted from aquifers whose levels are steadily declining. The agricultural sector has historic rights of abstraction and consumption that are vigorously defended. The country is steadily industrialising, and its population steadily growing, but industry and the public have fewer legal rights than those of the agricultural sector. Unless action is taken to rectify this situation, aquifers will run dry, and society will collapse. In systems science, such problems are known, very appropriately, as "wicked problems".

To correct this situation and allow the continued development of the country, two things are necessary: a solution that is technically and economically feasible, and a solution that is socially acceptable. When the latter is ignored, even the best economic and technical solutions can fail to be implemented, or unanticipated social consequences can arise.

The suggested methodology is set out as a step-by-step process below, using the real-world example where appropriate.

Social Systems Methodology.

Step 1 – Identifying stakeholders.

Society is a complex of interacting organisations, so the first stage is to identify the relevant organisations. They are those affected, either positively or negatively and either directly or indirectly, by the existing problem and any potential solutions. Here, the term "organisation" refers to any group of people who work together with a common purpose. It is used generically and can refer to individuals, clubs, societies, charities, businesses, government departments, sectors or collections of organisations with a common function, government, the army, the police, and so on. In the international context, the term can also refer to entire nations and groups of nations. All such organisations share common features.

All organisations are inter-related and cannot be considered in isolation, so theoretically, all will be affected. For example, the public need drinking water, but agriculture also needs water so that it can supply the public with food. Industry needs water so that it can supply the public with goods and the government with taxes. The government needs taxes so that it can provide the public with education and healthcare. However, for practical reasons, a cut-off point must be defined. It is suggested that this be when the impacts of a project are so minor that they do

not motivate any action by the organisation. Nevertheless, the number of stakeholders involved can be substantial. Neglect just one significantly affected stakeholder and unintended consequences can occur.

Human organisation is recursive. All organisations comprise several "child" organisations and are also members of "parent" ones. An employee is a member of a department; a department is part of a business; a business is part of a sector; a sector is part of a nation; and so on. To ensure that the number of stakeholders is manageable, they should be selected from these levels. For example, if the problem is international, then the appropriate level is the nation. If the problem is national, then the appropriate level is the sector. Water supply is a national matter, and so the appropriate stakeholders are sectors: the public, agriculture, industry, and government. However, when one sector is particularly severely affected by a problem or its potential solutions, then it is appropriate to treat its component organisations as stakeholders.

Step 2 – Identifying stakeholder needs.

All people and organisations have needs. It is the state of these needs, i.e., whether they are satisfied or not, and threatened or not, that motivate us. Human needs were formally identified by the humanist psychologist, Abraham Maslow, (Maslow, 1943) but his original theory has since been improved upon (Alderfer, 1969). Our needs can be collected together into the following categories:

- existence, for example, the need for nutrition, hydration, and reproduction;
- kin group relatedness, for example, being an accepted member of a family and having good relationships with them;
- non-kin group relatedness, for example being an accepted member of an organisation or other group and having good relationships; and finally,
- the need for growth, for example, improving one's understanding of the world, or developing one's skills, abilities, and talents.

In very general terms, we prioritise our needs in that order, with existence taking highest priority, followed by relatedness, particularly kin relatedness, followed by growth.

In each category there are many detailed needs whose nature and relative priority varies according to our culture. However, it is not only individuals who have needs. With minor differences, the needs of organisations are much the same, and are prioritised in the same way. So, the continued existence of an organisation takes highest priority. Relationships with other organisations come next, especially relationships with organisations that could be described as members of the same family. Finally, growth is an important need, but tends to take a more material form than for individuals.

Before any solution is implemented, each stakeholder need will be in a state varying from entrenched satisfaction to a complete absence of it. The overall state of satisfaction of the stakeholder's needs takes account of the state of each need and its relative priority. The same will, of course, be true after the implementation of any proposed solution. It is the net change in this overall level of satisfaction that motivates the organisation to either support or oppose the proposed solution. So, for example, some will regard changes in the supply of water as an opportunity to satisfy their needs, whilst others will regard it as a threat to established satisfaction.

Unfortunately, people are generally unwilling, and sometimes unable to reveal the true motives for their behaviour. This would make them vulnerable to manipulation by others. So, for example, a focus group is unlikely to clarify a stakeholder's needs. It may, therefore, be more practical to deduce their motives from past behaviour.

Step 3 – Identifying stakeholder interactions.

The Chilean economist Manfred Max-Neef explained that we satisfy our needs with "satisfiers" (Max-Neef, 1989). These are physical things in the external world. For example, water satisfies our need for hydration, and education satisfies our need for growth. In the case of an organisation, satisfiers are those things that enable it to exist, carry out its function, have satisfactory relationships with others, and grow. For example, energy and labour are needed by a steelmaking plant. If our needs are not fully satisfied, then this motivates us to seek satisfiers. This concept can be expanded by the introduction of contra-satisfiers. Contra-satisfiers are things in the external world which reduce the level of satisfaction of our needs. Covid19, for example, reduces our level of physical health, and we are therefore motivated to avoid it. All individuals and organisations are motivated to seek satisfiers and to avoid contra-satisfiers.

The status of both satisfiers and contra-satisfiers varies on the following scale:

- absent;
- latent, i.e., promised in the case of satisfiers, or threatened in the case of contra-satisfiers;
- precarious, i.e., existing in the short term but not necessarily in the longer term; and
- entrenched, i.e., firmly established, and difficult or unlikely to change.

The status of an organisation's satisfiers and contra-satisfiers determines the state of its needs.

If an organisations needs are not fully satisfied, this leads to

- a satisfier seeking disposition, or
- a contra-satisfier reducing disposition, or
- a combination of both.

The term "seeking" is generic and means, for example, increasing a satisfier from precarious to entrenched, as well as obtaining an entirely new satisfier. Similarly, "reducing" can mean the total elimination of a contra-satisfier, as well as, for example, reducing it from entrenched to latent. In general, the more satisfied an organisation's needs, the less inclined it will be to seek satisfiers. The more its needs are threatened, the more inclined it will be to reduce contra-satisfiers.

Interactions between two organisations can take one of three forms:

- Co-operation. This usually takes the form of trading satisfiers, for example the payment of taxes in return for education and healthcare, or the simple purchase of goods and services.
- Negative competition. This occurs when two organisations attempt to undermine one another's efforts. This usually comprises an exchange of contra-satisfiers. An extreme example is war.
- Positive competition. This occurs when two organisations compete to carry out their function better than one another. Positive competition involves no direct interaction except the maintenance of good relations and the adoption of one another's successful practices. However, if two positive competitors perceive a common interest, then they will often co-operate in its pursuit. For example, trade organisations can be formed to lobby government in their members' interest.

These interactions are also dispositions. They are partially innate and partially learned. Co-operation and positive competition are more common as these dispositions help to bind us

together into a social species for our mutual benefit. However, negative competition also exists. Its source is often the personal disposition of an organisation's leader, and can be a consequence of severe duress or personality traits.

Step 4 – Intra-organisational modelling.

Every organisation is a system comprising inputs, processes, and outputs. The inputs to an organisation are its own satisfiers and contra-satisfiers. The outputs are satisfiers or contra-satisfiers for others. When outputs are of a type, then this is referred to as the organisation's function. For example, the function of the water sector is to supply water.

In very general terms, an organisation's processes are shown in the following diagram. The meanings of the symbols used are given in the appendix.

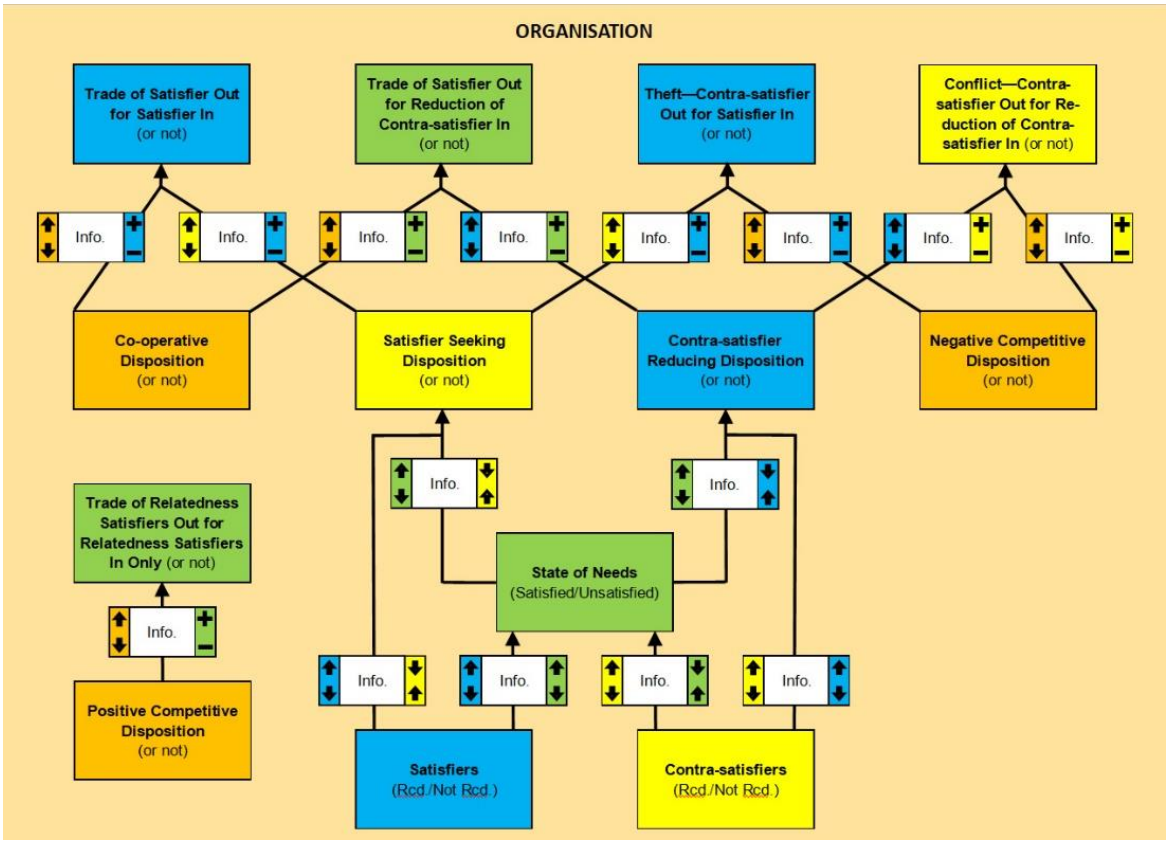

Figure 1. Intra-organisational process diagram.

However, because this general process is the same for all organisations, it is not necessary to repeat it in detail when modelling organisational interactions. Rather it can be simplified as follows.

Figure 2. Simplified intra-organisational process diagram.

Where S means satisfier in, C means contra-satisfier in, SS means satisfier out traded for satisfier in, CS means contra-satisfier out traded for satisfier in, and so on.

Step 5 – Present-day inter-organisational modelling.

All organisational interactions are trades. Each organisation's outputs of satisfiers and contra-satisfiers are traded in return for the input of satisfiers or the reduction of contra-satisfiers. This return can be directly from the organisation to which satisfiers or contra-satisfiers are provided, or indirectly via some other organisation.

At this point it is necessary to mention money. Money is a virtual satisfier. In early human society we relied on geographical territory to satisfy our needs. It provided, for example: drinking water; plants and animals for food; materials for shelter; and so on. Territory was, therefore, a major satisfier. It came to be regarded as property, and was vigorously defended. This is not unique to human beings, of course. This trait also appears in many animals. However, human beings differ from the latter in an important way. Both have a concept of "what is me" and "what is mine". But human beings also have a concept of "what is you", "what is yours", "what is us", "what is ours", "what is them", and "what is theirs". As human society became more complex, as people specialised and traded, and as populations grew, ever fewer of us had access to geographical territory. In modern Western society hardly any of us satisfy our needs in this way. However, money has come to replace geographical territory as a satisfier by virtue of its use in trade. The "what is…" concepts now apply to it as much as to any other property.

As previously mentioned, an organisation can be disposed to trade with another in one of three ways: through co-operation, positive competition, or negative competition. This disposition combines with the disposition to seek satisfiers or reduce contra-satisfiers, to determine the organisation's overall disposition. This overall disposition, in turn, determines the type of trade that the organisation will engage in. These types of trade are as follows:

- **Co-operative satisfier seeking behaviour (SS)**. The outputs are increases in satisfiers for the other organisation, in return for increases in satisfiers for oneself. This is of course normal civilised trading, in which goods and services are provided in return for payment.
- **Negatively competitive satisfier seeking behaviour (CS)**. The outputs are increases in contra-satisfiers for the other organisation to obtain, either directly or indirectly, increased satisfiers for oneself. An example is the theft of another individual or organisation's property.
- **Co-operative contra-satisfier eliminating behaviour (SC)**. The outputs are increases in satisfiers traded with another organisation in return for the reduction of a contra-satisfier to oneself. For example, payment of a fine to avoid a jail sentence or handing over one's wallet when threatened with a knife.
- **Negatively competitive contra-satisfier eliminating behaviour (CC)**. The outputs are increases in contra-satisfiers for another organisation to reduce contra-satisfiers for oneself. The classic example is, of course, war and other forms of conflict, in which each party harms the other with the aim of preventing the other from harming them.

Note that when two organisations are in positive competition with one another, they do not interact except to exchange relatedness satisfiers. Rather, they act independently to trade satisfiers with a third in the hope of obtaining satisfiers in return. The third organisation then compares the competing organisations to identify the most desirable partner, with whom co-operative trading then takes place. Thus, positive competition is usually a precursor to co-operative trading. One example is several contractors tendering for a contract. Another is, unfortunately, the payment of bribes in the hope of winning the contract.

Similarly, two competing organisations can act independently to trade a satisfier with the third, in the hope of reducing a contra-satisfier for themselves. Again, the third organisation compares them to identify the most desirable partner. This situation would arise when a group is being coerced and each tries to better their situation, for example, trusties who assist the guards in a prison camp. Clearly, there are serious ethical questions around this practice.

The aim of social systems modelling is to clarify the relationships between stakeholders, the ways in which they influence one another, and the consequences of any changes. If, for example, a change results in a contra-satisfier for just one stakeholder, then negotiations between stakeholders can completely alter the state of support for a project. The next stage is, therefore, to create a causal model of the way that the stakeholders interact. The diagram below models the example of a nation with water supply difficulties. It also uses the simplified intra-organisational process diagram.

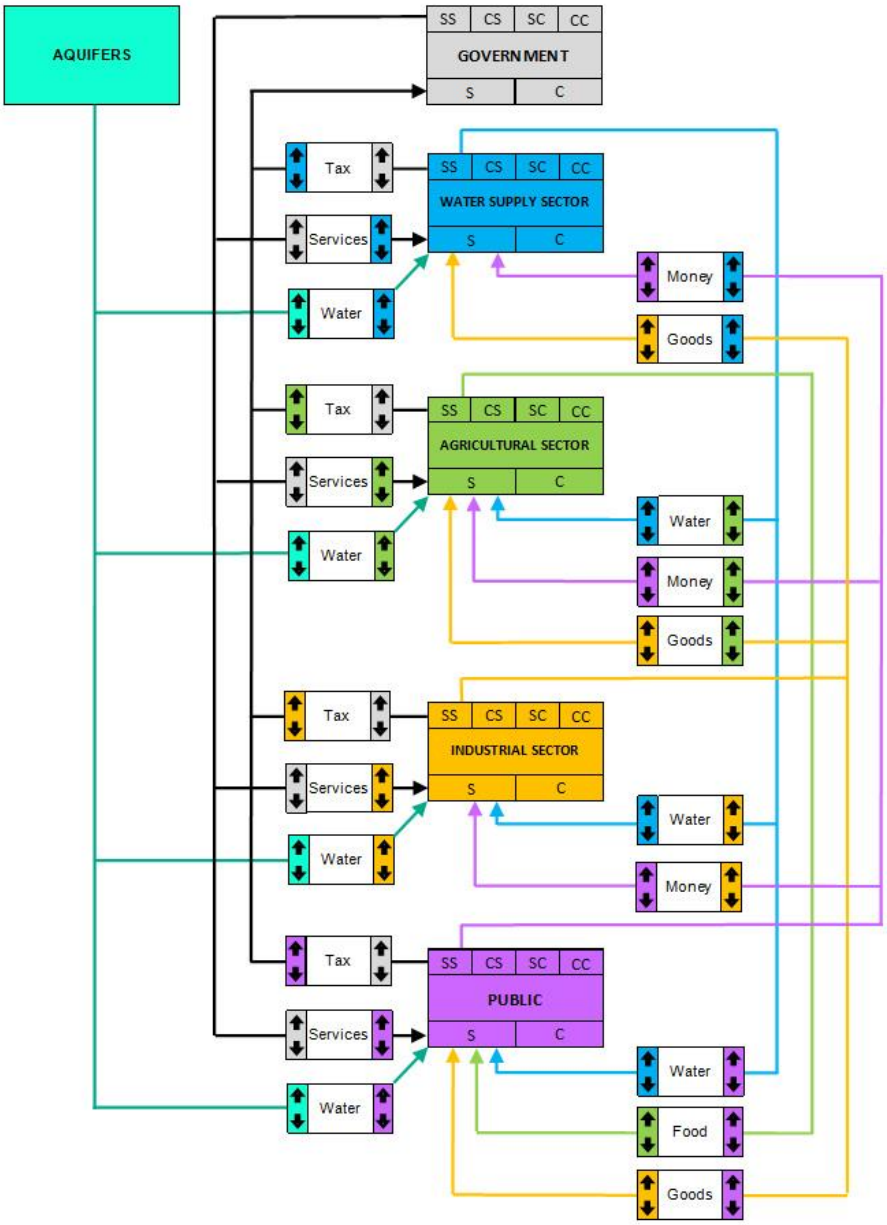

Figure 3. Interactions between five national sectors.

This model is ideal. It shows a stable situation in which all sectors trade co-operatively and the depletion of aquifer levels is not a factor. The advantages of a present-day model are that it identifies the implications of doing nothing and allowing the situation to continue unaltered into the future. For example, if aquifers become depleted then all sectors will experience the decline of an important satisfier, and will be unable to fully carry out their function. Their reaction may be to seek alternative satisfiers or engage in negative competition for the resource.

The present-day model also, identifies the social obstacles to potential mitigations and solutions, gives insight into the actions needed to overcome these obstacles, and the implications of doing so.

A present-day model is helpful in identifying general trends and the critical factors associated with them. For example, if a positive feedback loop with no constraints is encountered, then exponential growth can be expected. A negative feedback loop, on the other hand, would lead to exponential decay. Further work is needed, therefore, on the identification of causal patterns and their implications.

Such models are qualitative rather than quantitative. It may be possible to quantify some of a model's variables. If so, then any relationships between these variables can be expressed mathematically. However, a great deal of research would first be needed.

Because these models are qualitative, it is possible to include logical relationships and probabilistic ones. For example, "if a water shortage is likely, then consumers will fill containers". This reflects human behaviour far more accurately than a quantitative model.

Finally, present day models must be built in an objective manner, avoiding any idealism or political correctness. If, for example, corruption or despotism are significant factors, then no benefit will be gained from a model that neglects them. Inevitably there will be pressures to do so. However, if they exist and are relevant to the problem to be solved, they must be built into the model.

Regarding corruption, Professional Civil Engineers are duty bound not to engage in or encourage it. However, this does not mean denying its existence. We are also duty bound to call it out when we become aware of it, so that solutions can be found.

Regarding despotism, it is an unfortunate fact that some leaders will steer their organisations to act in the leader's personal interest, rather than that of the organisation or society in general. So, for example, what may appear to be a satisfier for the organisation may in fact be opposed.

Step 6 – Historical inter-organisational modelling.

It is what exists at present that is important in seeking solutions. However, there may be some advantage in building a historical model to understand how the present-day situation came about. For example, it may identify motives or social processes that existed in the past and which still exist in the present.

Step 7 - Identifying Technical Options.

In practice, it is a good idea to have a range of options at concept stage, and to put these to the stakeholders. Their reactions will often reveal whether they regard each option as a satisfier or a contra-satisfier and for what needs. This would provide useful information should a review or revision of those options become necessary.

In very general terms, the options for the nation with water management problems are: to increase supply, reduce wastage in transit, reduce consumption, or combinations of the three. These very general solutions should be taken as a starting point, for the assessment of their social impact. More detailed technical and economic solutions can be worked up as the social acceptability of each option becomes clearer.

Step 8 - Assessing the impact of potential solutions.

To assess the impact of the potential solutions on stakeholders, it is first necessary to identify whether the present situation acts as a net satisfier or net contra-satisfier for each. It is then necessary to identify whether each option will act as a net satisfier or net contra-satisfier. In practice, the option may comprise a combination of both. The net benefit or disbenefit for each stakeholder can be determined by adjusting the present-day model to include the option and comparing it with the original. Each stakeholder will carry out a subjective form of benefit/cost analysis before supporting or opposing the option. The modeller must attempt to emulate this. If there is a net benefit to a stakeholder, then they will usually support the option. If there is a net disbenefit, they will usually oppose it.

Unfortunately, organisations can prioritise benefits or disbenefits to themselves, and even to their leaders, over community interests. Thus, the benefit or disbenefit for all stakeholders together must also be considered.

It is worth putting effort into finding a proposal that will provide satisfiers for all. However, if this is impossible, then a proposal that most effectively provides satisfiers, together with some form of mitigation for those who see the proposal as a contra-satisfier, should be sought.

Discussion and Conclusions

In summary, social systems modelling provides a powerful tool for identifying solutions that are technically, economically, and socially feasible. As societies become increasingly complex, our ability to understand and predict the social impact of change decreases. Formal modelling provides a tool that better enables us to understand those impacts. Many Civil Engineers do, of course, already use similar approaches to develop successful schemes. However, these tend to be informal and based on knowledge gained through experience. This article formalizes and generalizes the approach, so that it can be applied to problems of any type, including climate change, and bio-diversity loss. Formalisation also enables the approach to be taught.

Further development of this formal approach is, however, needed. This includes:

- research into more complex causal patterns and their implications;
- research to enable the quantification of models where possible; and
- the development of computer modelling to extend the approach to systems of greater complexity.

References

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Maslow, A. H., (1943). "*A Theory of Human Motivation*". Psychological Review, 50, 370-396. http://www.researchhistory.org/2012/06/16/maslows-hierarchy-of-needs/

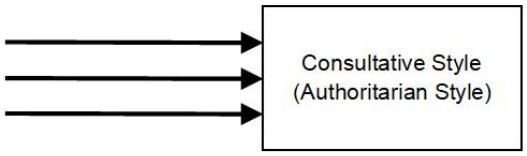
Max-Neef, Manfred A., with Elizalde, Antonio, & Hopenhayn, Martin, (1989). "*Human scale development: conception, application and further reflections*". The Apex Press, New York & London.

APPENDIX A – KEY TO DIAGRAMS

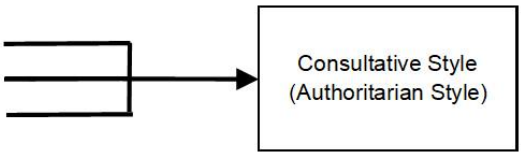
The direction of the arrow is from the cause to the effect.

The box is a cause or an effect. The text represents states. These can be discrete, i.e., either one state or the other or they can be continuum, i.e. on a range between one extreme and the other.

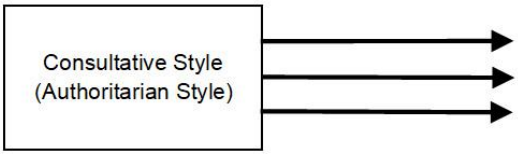
The question mark indicates unspecified causes.



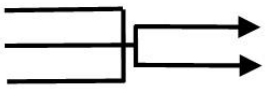
3 causes each of which is sufficient for the effect.



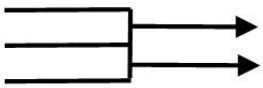
3 causes each of which is necessary but only together sufficient for the effect.



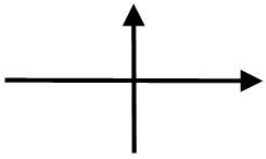
1 cause with 3 effects.



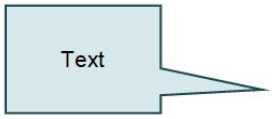
3 causes each of which is necessary but only together sufficient for 2 effects.



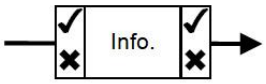
3 causes each of which is sufficient for 2 effects.



Causal arrows which cross one another but are not connected.

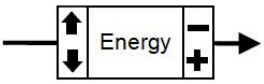


Comment box.

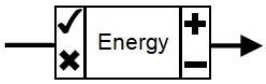


The cause and effect are both discrete states. If the causal state is as checked then the effect is as checked.

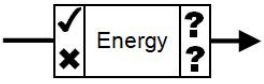
The cause is a continuum state and the effect a discrete one. An increase in the causal state results in an increase in the probability of the effect state marked plus. Normally, this implies that a decrease in the former results in a lower probability of the latter.



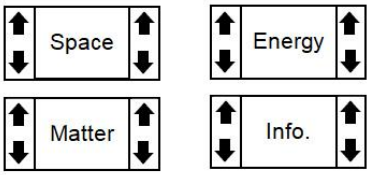
The cause is a continuum state and the effect a discrete one. An increase in the causal state results in an decrease in the probability of the effect state marked minus. Normally, this implies that a decrease in the former results in an increase in the latter.



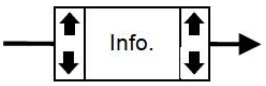
The cause and effect are both discrete states. The state of the cause checked results in an increase in the probability of the state of the effect marked plus.



The effect occurs but its state is unknown for this cause.



The text describes what is transferred from the cause to the effect. When and effect has more than one alternative sufficient cause, each must make the same transfers.



The cause and effect are both continuum states. An increase in the causal state, from that in brackets to that above the brackets, results in an increase in the effect state. Normally this implies that a decrease in the former implies a decrease in the latter.

The cause and effect are both continuum states. A decrease in the causal state results in an increase in the effect state. Normally, this implies that an increase in the former results in a decrease in the latter.