# SYSTEMIC VIEW OF PARTS OF THE WORLD


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## ABSTRACT


An argument based on the systemic view (views of complexity and hierarchy) to justify the use of minimal elements of processed natural language for the construction of models to apply this view, is given. Abstract elements of language are expressed as static arrays of minimal elements which allow their implementation in design of products. Linguistic modelling, dynamics of sentences, is introduced and used as prototype, the end result of design. Hierarchies are constructed using arrays and their combinations with emergent properties. The notion of unit and measure of complexity is introduced.



Keywords : complexity, hierarchy, language, arrays, purposive activity, design


## INTRODUCTION

Directed observation of parts of the world tells us that any part can be seen to consist of wholes, or objects, or properties (length etc.) *related in a specific manner*. This notion applies to real or imaginary (centaur) *concrete objects* in *static scenarios* like a mountain range, a table or a newspaper or signs and symbols created by animals and humans, a word, a sentence, mathematical equations or works of art. *Dynamic scenarios* can also be viewed as related objects with plant, animal, technical or human activities and their conceivable combinations. We tend to perceive things as 'wholes' which is the most effective and common way of perception and recognition as no time is lost, for example, in the face of danger, in contemplation. The notion of viewing parts of the world as related objects appears to be *pervasive, indivisible and empirical*.

Apart from sporadic references to the term 'system' over the past, human intellectual effort directed at creating *descriptive, explanatory and predictive* symbolic structures in the arts and sciences has disregarded, to a large extent, the topic of related objects. Conventional science focuses on fitting objects into classes or compartments based on selected *properties*. It then makes universal, hypothetical statements intended for description or explanation concerning objects in a class. Its interest lies in gathering empirical knowledge, hence its preoccupation with truth which can be investigated using *quantitative properties* of an object organised into predictive mathematical structures with terms which can be related to experience. Conventional science is uncomfortable with the notion of related objects, it tends to treat them as a whole without topological considerations. LaGrangian mechanics is an example of related objects which science regards as its own (Lanczos, 1970). Others like electric networks, engineering and control systems, production and social systems are outside conventional science.

In general, the ideas of irreversibility, information, purposive activity involving machines and humans, and design are of little interest to conventional science. Perhaps the first organised effort to consider the notion of related objects was the subject matter of control theory (Brown, Campbell, 1948, Korn, 1995) which evolved into control engineering. In the 1950's pioneers of the 'systems view' (Bertalanffy, 1950, Boulding, 1956) drew attention to the generality of the notion of related objects and strong attempts were made to develop a general theory using isomorphism or mathematics (Klir, 1969, Yi Lin, 1999). Perhaps because of the immense *variety and diversity* of particular manifestations of related objects, no general, underlying principles and a suitable symbolism have been found. The subject matter of the systems, or systemic, view became fragmented into energetic and information systems, living systems, ecosystems, management (people and project), social science and others. Perhaps the development of and preoccupation with technology, computers, internet etc have lessened the desire for search for fundamental ideas. The widespread interest in the subject is reflected by the large number of people engaged in universities (not at school level) and at conferences in the production of views, theories expressed in *abstract language* with no systematic attempts to relate terms to observables (Jackson, 2000). Use of 'jargon' and borrowing long established concepts from conventional science and engineering such as entropy, feedback etc., is practiced. A variety of techniques and diagrams reflecting system views, has been produced without in depth theoretical basis in mathematics or language (Holt, 2001).

Current work is aimed at searching for unifying, *basic principles* underpinning the notion of related objects and at the use of *formalised natural language* supplemented by mathematics when needed, as the symbolism which fits the generality of the systemic view. Such symbolism is used for creating *schemes* for *predictive reasoning* used for investigating the existence or otherwise of ***outcomes of scenarios*** and for ***design of products and systems*** (Korn, 2002, 2003, 2004, 2005a,b). This paper describes the *systemic view* of parts of the world, the view of *complexity and hierarchy*, and the formalisation of natural language for showing how *emergent properties* appear to evolve and their application in design of products and systems. Linguistic modelling is outlined and is used to show how to represent prototypes in design. The notions of *unit of complexity* and how to assign a *measure of complexity* to a product, are introduced. The approach is rich in analytical content such as linguistics, issues of grammar, predicate logic, uncertainty theory, mathematics etc. which facilitates construction of teaching schemes and allows concrete problems to work out at varying levels of difficulties.

# EMPIRICAL BACKGROUND

At the most fundamental level human and other animate beings appear to be able to perceive through their sense organs, chosen parts of the world, permanent or changing, not so much in detail as in their *entirety*. In many cases, they are capable of recognising and reacting appropriately, and perhaps *intuitively*, to such impressions : enemy (fight or flight), prey (hunt), snake (jump) and so on. This method of rapid processing of information and subsequent action may have evolved as a result of need for survival : in the face of danger, there is no time for contemplation and analysis.

A part of the world thus perceived is called a 'whole' or 'object' and judgement is formed towards recognition (Buelens, 2006). Sense organs are sensitive to physical effects. Thus, to create an impression for the mind to work on, a whole must be a *physical object*. Based on directed observation such objects may be classified into :

A. <u>*Concrete*</u> - Inanimate natural (rock, water, oxygen..),
artificial (artefacts.., gear box, motors, knife..),
natural changing (hurricane, volcano, earthquake..)),
Animate (tree, zebra, man..),
Technical (control and computer systems..),
Animate activity (cells in organs, forest, herd, human social (family) and production organisations),

B. <u>*Symbolic*</u> - carried by *medium* in which *means with meaning* for handling thoughts are embedded (Korn, 2001). Means with meaning are : 1. Images (pictures, sculptures, diagrams, shapes, signs and any object to which means with meaning can be attributed : centaur, devil, works of art, gestures (with a fist..)), 2. Natural language (letters, words, sentences), 3. Music (symbols to express tunes, rhythm) and 4. Mathematics (symbols like letters, numbers and relations).

Correspondingly, humanity has produced the basic disciplines of : 1. Arts, 2. Literature, 3. Music and 4. Conventional science, plus the cross disciplines of engineering, medicine, law, economics etc.

With reference to the classification, we note :
1. Inanimate, natural objects exist in nature and have come about by *chance*. Artificial and symbolic objects are manufactured *in accordance with purpose* by animals (bird's nest, spider's web…) or humans (knife, petrol from crude oil, a letter…) *for use or consumption* by self or others. Symbolic objects are *perceived* and *used* for *description* of themselves or of concrete objects, for *expression* of feelings, sentiments, emotions and for reasoning by animate beings with suitable central nervous apparatus (Johnson-Laird, 1988).

2. Through their activities natural changing, also animate, technical and animate activity objects can cause or bring about *impressions*, *experience or a change* in *another* object when suitably *qualified*. The first does so by *chance* and the others *in accordance with purpose*. Purposive activity is as common in the animate sphere as gravity is in the natural.

3. Animate, technical and animate activity objects can make use of other such objects for causing a change in self or in others. For example, 'man rides a horse *to move faster* (objective)' or 'the party in opposition organises a demonstration *to make a point to the government* (objective).

A dichotomy of objects has emerged : the *results of change*, a bird's nest, man hit on the jaw (which can exist in static state) and the *causers of change*, the bird, another man (which exist in dynamic state). When a causer operates in accordance with *purpose* to bring about an envisaged *change of state* in a *changing object* which is embodied in an *objective* and uses *interaction* generated by *product*, we have an *organisation*. Change of state is expressed as a quantitative or qualitative *property* as defined in physics (Rogers, Mayhew, 1963), here we use the notion extensively but in much the same sense. An organisation is embedded in its physical, social etc *environments* (Hatch, 1997).

Viewing parts of the world as *related properties or objects* is the view of *complexity*. When an object is seen to consist of others and so on until an *agreed 'limit'* is reached or parts are *aggregated* from objects into more complex parts for the production of a new property, we have a view of *hierarchy*. Tendency to form hierarchies is perhaps motivated by acquiring new properties which enable an object fit into an environment more successfully. These views comprise the *systemic view* of parts of the world.

We suggest the following argument :
1. Any part of the world can be viewed as *related objects or properties*, view of *complexity*.
Point 1. implies that
A. The systemic view is *pervasive, indivisible and empirical*. Pervasive and indivisible means that the view transcends compartmentalisation and other divisions (technical systems, information systems, management systems….) only details vary.
B. Objects, properties enter or entered (design) into relations to produce quantitative or qualitative *outcomes* or new properties (emergent) of a whole.

2. There is an immense *variety and diversity* of particular instances of the view complicated by the *variety of roles* that a part can play as scenarios vary.
Points 1. and 2. imply that
A. *Conventional science* with its objective interest in outcomes expressed as combinations of selected, quantitative properties of a single object as part of a class, method of division, compartmentalisation and use of mathematics is not fruitfully applicable to the systemic view. Although it has its fields of application at the level of properties of objects (Korn, 1995, 2003) and in specific problems like decision making.
B. *General principles and a symbolism* relevant and appropriate to the systemic view need to be found. Natural language as a symbolism matches the generality of the view but it has problems when it comes to its use as a *model* for predictive reasoning to investigate possibilities of outcomes and as aid to design (to increase its expressive power it operates in abstract, collective terms, rich in complex expressions, metaphors, innuendoes….(Korn, 2006)).

Point 2. implies that 'building blocks' need to be found of which ANY part of the view can be constructed. ***Therefore***, *abstract* expressions regarded as wholes which can convey impressions and effects and *stories of scenarios* in natural language need to be converted into homogeneous language by linguistic analysis consisting of *minimal elements* of the former (one and two place simple sentences (ordered pairs)) which can be used for *development of models* (analysis) which in turn are used for the *reconstruction* (synthesis) of expressions and stories with acceptable fidelity.

In practice, reconstruction may take place by *chance or purpose*. In the former case we speak of evolution and in the latter we have design, both can lead to a view of hierarchy.

This argument forms the basis of the approach of the current work aspects of which are outlined in this paper.

## LANGUAGE AS THE MODEL OF COMPLEXITY AND HIERARCHY

Only a whole or an object *in its totality* as defined by its conceptual boundary (discussed later) and organised by an agent, can create an *impression, effect or interaction* fired by the *property of the whole*, its emergent property (Checkland, 1981). We tend to describe and communicate in terms of abstract expressions which stand for wholes (noun phrases) or actions (dynamic verbs) (Burton, 1984). There is no time and ability to create complex arrangements of objects or properties and relations. However, when such expressions need to be executed they must be seen in terms of their *concrete related constituents* (bird's nest = assembly of twigs and feathers organised so as to give soft support) .

Natural language as a symbolism or *primary model* can be developed to cater for this proposition. In addition, it is the symbolism of sufficient generality to fit the systemic view and capable of formalisation for creating predictive, *reasoning schemes*. The schemes include *predicate logic sequences* which can handle *uncertainty* associated with human components and can carry mathematics as needed to establish precise criteria for decision making, for example. However, language as it stands is too complex, rich in metaphors and other picturesque means which have evolved to facilitate effective *communication*. Language needs to be seen as a *model* that reflects the systemic view. Here we are concerned with elucidating the *view of complexity of words and sentences* forming a scenario. We express these as collections of basic constituents (one/two place sentences (ordered pairs)), the minimal elements of language with *full sense* or meaning to relate states of mind to experience (Burton, 1984) which are to be used for reconstructing complex scenarios.

If language has evolved to help people navigate in the world then it must reflect the nature of the world i.e. there is isomorphism between the organisation of language and that of parts of the world as *we perceive it*. If we perceive parts of the world as *related objects* then it follows that language, and any other symbolism, is also organised in this way (mile $\gamma$ lime, same letters but different spatial relations). *Elements of language* are used for its organisation. For the current purpose, these are :

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1. Designation of conditions, qualities and quantities (constant or time varying) organised into conjunctions leading to,
2. States (permanence), events and actions (change), and
3. Their qualified *relations* in static and *interactions* in dynamic scenarios.

1. Naming conditions, qualities and quantities
We call ‘property’ used for referring to conditions, qualities and quantities of objects, the *basic unit of perception* which enables us to examine an object in more detail. We limit our discussion to descriptive properties realised by adjectives, adjective phrases or clauses and participles (Burton, 1984). Properties are divided into

*Concrete* : geometric, material, numerical, energetic and informatic (Korn, 1995, 2001) which are directly observable either through the senses or instruments because they create *physical effects* like reflecting light. Geometric and material properties can be used to create *medium* for carrying *energy* and *information* when these are added as in Figure 1. For example, carbon when used as a fuel carries stored, chemical energy. When it is used for making marks on paper, it may carry information. In the latter case these properties are called ‘informatic’.

*Abstract* : all other properties which are assigned by the mind to observed *conjunctions of concrete properties and objects* in permanence or changing.
a. Complex properties. For example, from the geometric and material properties of skin on the face of a person (a part of the world) we can conclude if he/she is ‘old’ or ‘young’.
b. Mental properties which indicate features, attitudes and abilities. For instance, *features* : ‘happy’, ‘sad’, ‘fearful’, ‘uncertain’, ‘anxious’ ; *attitudes* : ‘ambitious‘, ‘benevolent’ ; *abilities* : ‘clever’, ‘skilful’, any of which can be deduced from concrete properties of face and from those exhibited by observable behaviour. Mental properties constitute *mental states* like ‘sadness’. Awareness of ‘rules’, ‘expectations’, ‘beliefs’, ‘habits’, sentiments, feelings, emotions etc are constituents of mental state.
c. Properties of condition, events, action and behaviour. For example, ‘perfect’ designates a condition when the conjunction of relevant concrete properties are seen as having no defect, ‘honest’ refers to quality of a person who habitually tells the truth, action may be described as ‘merciful’or ‘loyal’ and behaviour as ‘brave’.
d. Particular properties. These are phrases or clauses which act as qualifiers of physical or mental state of objects. For example, ‘Policeman who *was on duty*, noted the complaint’.

We note
a. Abstract properties have been created to avoid repetition of conjunctions of concrete properties i.e. to increase the effectiveness of communication.
b. Any part of the world or an object can be seen as a conjunction of an *infinite number* of properties carried by statements of which one or a few are selected depending on the scenario in which an object finds itself. These properties are called *contingent* and referred to as *adjective phrases*.

2. Naming states and activities (events, actions)
Objects or conjunctions of properties are designated by ‘nouns’ or ‘noun phrases’. We divide objects into :

*Category 1* : Common nouns are seen as labels assigned to carriers of things (objects) which are assumed to have material existence including *medium with energy or information*, concrete objects. They can be modelled as conjunctions of *concrete and abstract* properties selected on the basis of a particular point of view or role in a scenario which are, thus, *contingent*. When one or more contingent properties of an object vary in time we have an *event or action or a state of change*.

*Category 2* : Abstract and collective nouns designate non-material things which exist in the mind and as such are deduced from *states or activities* of category 1. They are used to name states of mind or being, feelings, conditions, concepts, qualities, activities or groups of people or collection of things, all displayed by concrete objects. For example, STATES of concrete objects : clarity (of glass), happiness (of the boy), character (of the man), ACTIVITIES of concrete objects : revolution (by people), arrival (of trains), courage (of soldier), thief (man who steals), crew (personnel in an aircraft cabin).

An abstract or a collective noun *cannot stand on its own* : it is attached to concrete objects to which it acts like a qualifier, an adjective. It can have properties which refer to *extent, intensity*, or *behaviour*, it cannot have concrete properties which refer directly to a part of the world.

*Category 3* : These are proper nouns which refer to objects like individual persons, places etc. A 'person' can play the part of lowest 'limit' in a hierarchy of living/human activity (biology).

3. Naming relations, interactions and their qualifiers

The terms 'relation' and 'interaction' refer to connectedness between two or more objects. *Relation* between objects is time independent, *interaction* involves activity like a process or action. *Relation indicators* are : space (left, above..), time (before..), order (first..), kinship (father, son..) stative verbs (to be, to stay), relational (and, or..) and dynamic verbs (interactions (to dig (with skilled power), to shout (carrying information))) (Korn, 2001). Most relation indicators can be qualified by an adverb of manner (firmly), place (in the corner), time (at 10.00 hours) etc or adjectives. (Burton, 1984).

A stative verb describes a relation between objects (the keeper *held down* the animal *firmly*) or between an object and a property designating state (the bucket *is usually* full).
A dynamic verb describes interaction between objects (the shopper *lifts* the bag *with difficulty*) or can be applied to a single object (the man *shaves each morning*) with adverbial qualifiers. We have a *two – or one – place verb* (Korn, 2003).

Verbs can be *concrete* or *abstract*. A concrete verb describes a state or activity which impinges directly on the senses. For example, we can say that this object (a bucket) has another (water) inside it in which case the state is described by the verb '*to contain*' or 'the dog *barks*'. An abstract verb refers to a group of concrete verbs like '*to move*' which represents a group of verbs 'to run', 'to walk', 'to swagger', 'to amble' or 'to glide'. There are abstract verbs which stand for a series of action or activities like '*to deliver* (the post)'.

## Empirical content of words (static view of complexity of words)

Natural language consists of symbols. Thus, all linguistic terms are theoretical, the results of generalisation following observation. For a theoretical term to have meaning, it should be capable of being 'instantiated' i.e. to be related to a part of the world or to experience and its coverage of particular aspects of experience is its *empirical content*. The method of instantiation is to see this coverage as *properties or objects in relation in the context of a scenario*. We identify objects by name or label, relations by relation indicators including dynamic verbs in *passive voice*. The objective of instantiation is to break down a theoretical term into terms which are, or closer to, concrete terms so that an *agent* by *tracking an algorithm, can combine them into an object leading to an acquired, emergent property*.

We demonstrate the method of instantiation of *category 1.* terms by considering a 'supply of water' in which 'supply' represents a class of objects and 'of water' places 'supply' at a particular point in the class, it acts as an adjective phrase. We can describe 'supply of water' as follows : 'A copper *tap* is screwed into a *container* which is connected to the water *mains*. A *hose* is attached to the tap'. Here we have four objects and three relations (Korn, 2005a) as we discuss later in detail : 'Tap *is screwed into* container', 'Container *is connected to* mains', 'Hose *is attached to* tap'. An agent can construct 'supply of water' by accomplishing the actions indicated by the verb relations in accordance with an algorithm leading to an *emergent property* such as 'An assembly for use as a supply of water'.

Terms in *category 2* have no direct reference to a part of the world through *concrete* properties. 'Scientific, political or bloody revolution', for example, gives an impression about the kind of 'revolution' but still unrelated to experience.

We can describe an 'actor' as having 'popularity' which refers to a quality and is anchored by the term 'actor' to a class (category 1 terms) of persons. We need to express under what circumstances we would describe an 'actor' 'popular'. Let us say : 'He *makes* good films', 'His films *are liked by* the public', 'Charities *benefit by* him', 'He *promotes* his profession'. There are five objects (actor, films, public, charities, profession) and four relations with simultaneous presence as eq.1. which gives 'popular (emergent property) actor'.

Abstract verbs cover a series of *actions or activities* and, in the course of their execution when anchored to a category 1 noun, need to be broken down to show these explicitly. 'To deliver the post to houses with specific addresses' serves as example.

We have shown how category 1 and 2 terms can be described as related objects so as to *formulate products* for the execution of change as part of design scheme (Korn, 2004, 2005a).

Conversion of category 1. and 2. terms into collections of ordered pairs or their instantiation can be *formalised for use in design* since these collections can be executed.

## Evolving structures (view of hierarchy)

The intention is to show how hierarchies evolve using ordered pairs. The sources of ordered pairs are category 1 and 2 terms and 'heaps' selected by chance or purpose (bottom up design), the former can be used as *executable design objectives* (Korn, 2005a,b). Stative (supplemented by relation indicators) and dynamic verbs (in passive voice) create relations between nouns. In general, a series of two place sentences or ordered pairs, can be written as

$$n_i\,(adj_{ix})\ verb_i\,(adv_{iy})\ n_j\,(adj_{jz}) \qquad 1.$$

where adj - adjectival qualifiers of nouns 'n', adv - adverbial qualifiers of verb. These are *contingent properties* selected so as to be relevant to the nouns and relations (aiding or hindering) expressed by the 'verb' and make the sentence *context dependent*. In a one place sentence the subscript $j = 0$. For each noun 'i' we can have a number of adjective qualifiers : for $i = 1$, $x = 1,2,\ldots$, and $i = 2$, $x = 1,2,\ldots$ and so on. The subscript 'j' can be similarly expanded with 'z' number of adjectives. Each noun as the *subject* of sentence has one verb attached to it with a number of adverbial qualifiers $y = 1,2,\ldots Y$.

We assume that we have a number of 'heaps' each with *randomly distributed*, qualified and unrelated objects designated by noun phrases. For demonstration we select three heaps with objects 'n', 'p' and 'q' from which we take 'n' for detailed development. Each object in 'n' can carry one qualified relation indicator which designates the relation that the *object is judged to be capable of entering into*

$$(n_i\,(adj_{ix}))\ (verb_i\,(adv_{iy})) \qquad 2$$

Each object in eq.2. can enter into relations with others which are without relation indicators and are designated by the subscript 'k' in the *same heap* to form *ordered pairs* (Lipschutz, 1982) arranged as an *array* in eq.3.

$$(n_{ik}\,(adj_{ix}))\ (verb_i\,(adv_{iy})) \qquad 3.$$

for $i = 1$ $k = 1$
$i = 2$ $k = 1, 2$
$i = 3$ $k = 1, 2, 3$
$i = 4$ $k = 1, 2, 3, 4$ and so on

where 'i' and 'k' indicate the vertical and horizontal expansions with '$i = k$' leading to a square array which is the expanded form of eq.3., with number of ordered pairs = $n^2$.

We use the 'supply of water' in the previous section as example of how to construct eq.3. We have a set of objects in a heap with contingent properties and data (Korn, 2001) : Water is (clean), Vessel is (3 m high, has diameter 1 m), Tap is (made of copper), Hose is (12 m long, flexible), Water supply is (available).

We have from eq.2. : water (clean) *is inside*
vessel (3 m high, has diameter = 1 m) *contains*

tap (copper) *screwed into*
hose (12 m long, flexible) *attached to*
supply (available) *connected to*

which are used to develop eq.3. with designations abbreviated and i = k = 5

| | | | | | |
|---|---|---|---|---|---|
| (w inside w) $n_{11}$ | (w inside v) $n_{12}$ | (w inside t) $n_{13}$ | (w inside h) $n_{14}$ | (w inside s) $n_{15}$ | |
| (v contains w) $n_{21}$ | (v contains v) $n_{22}$ | (v contains t) $n_{23}$ | (v contains h) $n_{24}$ | (v contains s) $n_{25}$ | |
| (t screwed w) $n_{31}$ | (t screwed v) $n_{32}$ | (t screwed t) $n_{33}$ | (t screwed h) $n_{34}$ | (t screwed s) $n_{35}$ | 4. |
| (h attached w) $n_{41}$ | (h attached v) $n_{42}$ | (h attached t) $n_{43}$ | (h attached h) $n_{44}$ | (h attached s) $n_{45}$ | |
| (s connected w) $n_{51}$ | (s connected v) $n_{52}$ | (s connected t) $n_{53}$ | (s connected h) $n_{54}$ | (s connected s) $n_{55}$ | |

Eqs.3. and 4. are the basis for development of *hierarchical structures*. Arrays such as eq.4. yield a large *number of choices* to some of which new, emergent properties can be assigned as discussed later, an important factor in hierarchy and design. Each term in eq.4. can now be executed by an *organisation* according to an *algorithm* to produce the *totality* of a new object 'supply of water' which can then be used as such. This is shown in 'APPLICATION TO DESIGN…' (Korn, 2005a).

In short, we let i = k = 4 and x = y = 0 i.e. we consider context-free sentences, then eq.3. becomes

$$\begin{matrix} n_{11} & n_{12} & n_{13} & n_{14} \\ n_{21} & n_{22} & n_{23} & n_{24} \\ n_{31} & n_{32} & n_{33} & n_{34} \\ n_{41} & n_{42} & n_{43} & n_{44} \end{matrix} \qquad 5.$$

Each term in eqs.3., 4. and 5. is an ordered pair. For example, the sentence or the story 'Top of the table is supported by legs which stand on the carpet' is expressed as eq.2. to form 3 relations for the 3 objects : i = 1 = 'top is supported', i = 2 = 'legs stand on' and i = 3 = 'carpet is'. From eq.3.

| | | | |
|---|---|---|---|
| 0 $n_{11}$ | (top is supported by legs) $n_{12}$ | (top is supported by carp) $n_{13}$ | |
| (legs stand on top $n_{21}$ | 0 $n_{22}$ | (legs stand on carp) $n_{23}$ | 6. |
| (carp is top) $n_{31}$ | (carp is legs) $n_{32}$ | (carp is carp) $n_{33}$ | |

In eq.6. one *selected term* from first two rows (3 objects, 2 relations) is part of the sentence. In the 1st row 'top is supported by legs', in the 2nd row 'legs stand on carpet' and in the 3rd row 'carpet is carpet' = 0. The three relations together may be described as : 'table supporting arrangement' which, when assembled by an agent, is the *emergent property* of the whole *conceptually bounded* by the concatenation of the three ordered pairs. However, the array offers a *choice of aggregation*. For example, we have in the 1st row 'top is supported by the carpet', in the 2nd row 'legs stand on the top' and in the 3rd row 'carpet is carpet' = 0. This aggregate also makes sense, we can name it 'upside down table' as its *emergent property*.

We can conclude that the arrays in eqs.3., 4., 5. and 6. *offer a choice* of wholes and show how a variety of structures emerge from a collection of separate objects for *existence, possible use or potential accomplishment of change*. An emergent property is produced by a *new structure*. Varying the qualifiers of nouns and verbs enables an existing structure to *adapt* or fail to adapt to objects external to it called *environmental objects*.

We construct a pattern of relations by *selecting one relation from each row of an array* like eq.5. The converse would mean that the same object would be related to more than one other object, an indeterminacy. In other words, we only allow a single instance in the *domain* with *multiple range* which creates a *function* (Lipschutz, 1982). Accordingly,

$$\text{simultaneous presence (sp)} = \prod_{i=1}^{i=I} ((n_{i(\text{with } k = 1,2,3\ldots)}\ (adj_{ix}))\ (verb_i\ (adv_{iy}))) \qquad 7.$$

in which for each 'i' we select a 'k' from each. ∏ is the simultaneous presence operator which defines the *conceptual boundary of the whole* and indicates that a *whole is greater than the 'sum of its parts'*. In other words, a whole is not an algebraic sum but an aggregate of parts with relationships.

Application of eq.7. to the example in eq.6. results

$$\text{simultaneous presence (sp)} = \prod_{i=1}^{i=3} (n_{12} \text{ x } n_{23} \text{ x } n_{33}) \qquad 8.$$

## Representation of arrays by graphs or linguistic networks

The array of ordered pairs in eqs.3. or 5. is a collection of objects and relations which can be represented as a graph (Jun-Ming, 2003, Korn, 1995). The 'nouns' in an array as eq.3. are depicted as 'nodes' which are connected by lines designating the relations. Using eq.5. as a demonstration we construct Figure 1.

Each object can enter into relations with the others in (n – 1) ways and with itself making the total number of relations equal to 'n'. Selection of one term in each row of an array means in graph terms that only *one line* is allowed to leave a node but a node can have any number of lines entering. 'Leaving' and 'entering' are defined by the order of subscripts. The graph shows the *choice* offered by combining objects in a heap in a variety of ways to create a number of sp's. Selection of one term also obviates the possibility of the same two or more objects having the same relationships with different objects at the same time. Eq.6. demonstrates this restriction, 'carp is legs', 'carp is tops'. 'Carp' cannot be both at the same time, it must be either.

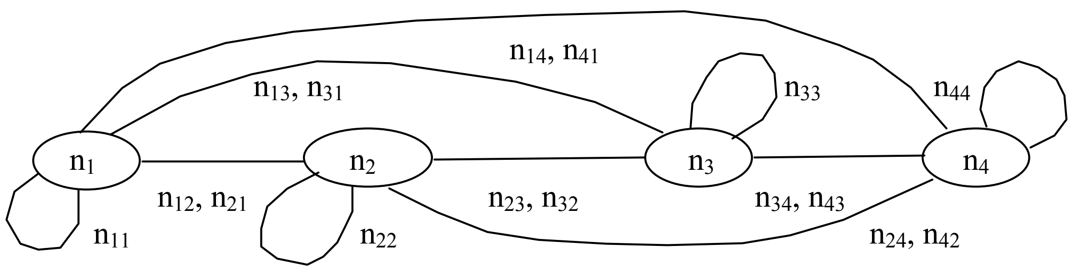


Figure 1. Graph or linguistic network representation of array

The selection of a particular choice is given by the *tree* of a graph (Jun-Ming, 2003, Korn, 1995). Tree is defined as a graph which connects all nodes without forming a loop (not self loops). A tree of the graph in Figure 1. is shown in Figure 2.

When constructing a tree we insert a line or branch which connects *two* nodes. Each additional branch inserted subsequently connects *one* additional node. Thus,

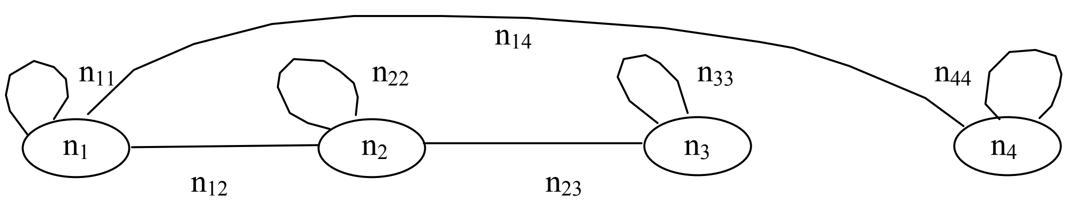


Figure 2. Graph showing a tree

$$\text{number of tree branches} = n - 1 \qquad 9.$$

According to eq.9. the number of relations equals the number of tree branches which defines the conceptual boundary in eq.7. with $I = (n - 1)$.

The number of trees which can be constructed on 'n' nodes in an undirected graph is given by (directed graphs lead to more complicated treatment)

$$\text{number of trees} = n^{(n - 2)} \qquad 10.$$

The tree representing an sp in eq.8., is shown in Figure 3., from eq.10. number of trees = 3.

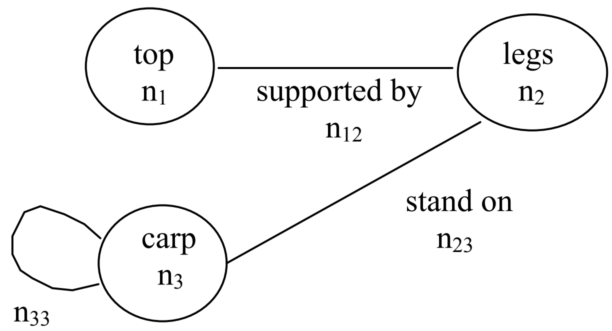


Figure 3. Graph of ‘table supporting arrangement’

In order to further the construction of a hierarchy, we carry out the same procedure with the other heaps, ‘p’ and ‘q’ to produce new sp’s as eq.7. In each case the number of sp’s are determined from graph considerations. These sp’s are *operated on and selected* by agents to produce new objects ‘$N_f$ ‘, ‘$P_g$’ and ‘$Q_h$’ with emergent properties and their combined number (f + g + h) is then treated as described above and so on. The procedure is summarised in the scheme in Figure 4.

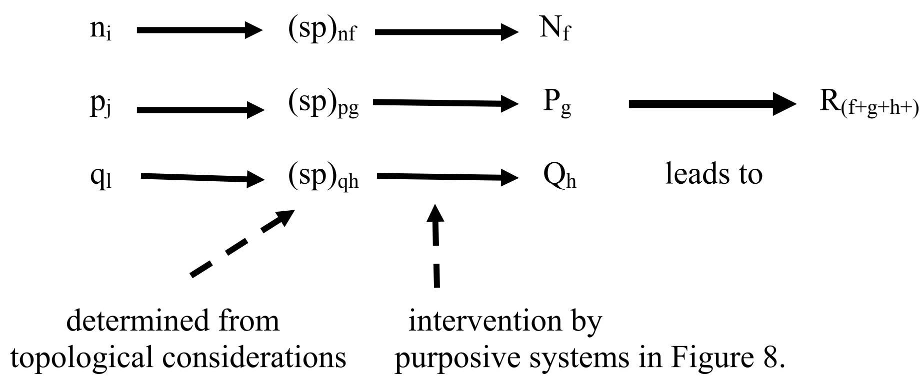


Figure 4. Procedure for generating hierarchy

We have outlined a procedure for the production of hierarchy in which :
1. The properties or objects and their relations at the level of ‘limit’ are *defined and conserved* unless added to or subtracted from objects as the hierarchy progresses. This may overcome the ‘semantic barrier’ of recognition.

2. The objects in an array as eqs.3. and 5. may be endowed with the *abilities of agents*. In such case we have *self-organisation* (Kaufman, 1993).
3. The production of sp’s alternates with operations by purposive agents which are modelled as the scheme in Figure 7. using *linguistic modelling*.

## Introduction to linguistic modelling (dynamic view of complexity of sentences)

Natural language as the primary model contains linguistic complexities, metaphors etc. It needs to be converted by *linguistic analysis* into a *homogeneous language* of one and two place *context dependent* sentences which can then be used for constructing the reasoning schemes of linguistic modelling (Korn, 2003).

Adjective qualifiers can be classified into properties with *specific roles*. The causal relations between a driving property (dp) and an interaction (in) and an interaction and an acquired property (Korn, 2002) lead to expressing a one- or two-place basic constituent as a pair of predicate *logic conditionals*. For instance, the sentence 'As part of his duty with care about the job (dp) and with good eye sight (ip = facilitate/hinder interaction), the postman sorts (in) according to code (adverbial phrase) properly addressed (ep = facilitate/hinder change (ap)) letters' can be formulated into :
'IF (it is part of his duty and with care about the job) AND (he has good eye sight) THEN the postman sorts letters (according to code)'.
'IF the postman sorts letters (according to code) AND the letters are (properly addressed) THEN the letters *become* sorted (ap)'.

The result of the 'postman's' action in the example above is a change of physical property of the 'letters', referred to as *outcome*. Exercising his skilled power, the 'postman' converted letters from unsorted into ‘sorted’, *he has created order out of chaos* or an *emergent property*.

We use the example of the 'postman' to show the inferential structure (Korn, 2002) which demonstrates the *propagation of state in time* towards outcomes the possibility of which is subject to qualifiers assumed to be *relevant* and their associated *uncertainties* (Durkin, 1994).

*Homogeneous language of context-free sentences* (from the story by linguistic analysis)
Postman sorts letters. (Skilled power carrier)

*Semantic diagram*
Shown in Figure 5. where the object labels are enclosed in contours connected by solid, directed lines of interaction pointing towards the affected object. A dotted directed line indicates change in time, not explicitly stated. Lines attached to contours indicate qualifiers.

*Adjectival qualifiers with grading* (from the story)
dp(1,1) – partofhisduty (strong,med,weak), care (high,low)
ip(1,1) – eyesight (excellent,poor)
ep(2,2) – addressed (perfect,mistake)
where the first numeral in the brackets designates the object which is described by the property and the second designates the object at which the property is active.

*Logic sequences/topology of scenario* (from the semantic diagram)
1/1. dp(1,1) $\wedge$ ip(1,1) $\rightarrow$ in(1,2)
1/2. in(1,2) $\wedge$ ep(2,2) $\rightarrow$ ap(3,3)
where the logical AND function is used, however, the properties 'ip' and 'ep' can be regarded as *additional evidence* which alters the calculations of certainty factors (cf) (Durkin, 1994).

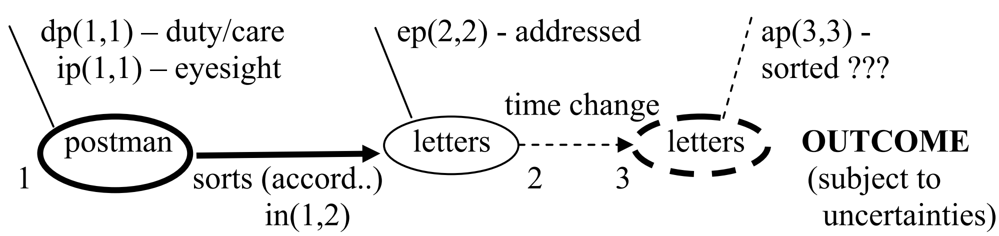


Figure 5. Semantic diagram of a two-place sentence, a basic element

*Interactions with adverbial qualifiers*
in(1,2) – sorts : sorts(according to code)

*Logic sequences with graded adjectives/data for cf*
This part of the method deals with detailed expansion of the logical forms and with computation of uncertainty of outcome (not given here).

A one-place basic constituent is given by the sentence 'Depressed, strong willed man with financial problems, tried to kill himself by jumping off a cliff 2 weeks ago'. This is diagrammed in Figure 6. based on the context-free sentence, 'Man tried' as before

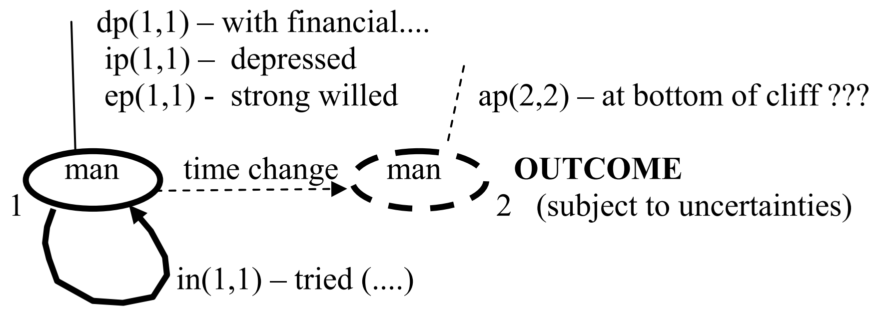


Figure 6. Semantic diagram of one-place sentence, a basic element

*Adjectival qualifiers with grading* (from the story)
dp(1,1) - with financial problems
ip(1,1) - depressed
ep(1,1) - strong willed

*Interaction and acquired property*
in(1,1) - tried (to kill himself (by jumping off a cliff (2 weeks ago)))
ap(2,2) - man at the bottom of cliff

One and two place sentences into which a story representing a scenario is broken down by linguistic analysis, are recombined so as to reconstruct the story as a semantic diagram which can be *read*. However, the story is now in a form which is suitable for further analysis into a predictive, reasoning scheme.

## APPLICATION TO DESIGN AND MODELLING OF ORGANISATIONS

A procedure for design of systems and products is outlined. It leads to the use of linguistic modelling for constructing models of *prototypes* for testing particular designs.

Figure 7. shows a *scheme* of objects and their interactions organised into purposive activity to change a *single property of a changing object* (CO) or user or consumer. The scheme also embodies the elements of design :

1. A *problematic* IS is noted and agreed on by agents having an interest in the problem,
2. A FS of CP or *outcome*, consistent with IS, is envisaged, agreed on and postulated as the solution to the problem and expressed as ‘objective’ (rs),
3. CP joins IS to FS and is induced by an appropriate *interaction*.
4. The interaction is generated by a *generalised product*.
5. *Alternative products* are postulated.
6. A *particular product* is selected using *quiescent properties* (QP) of CP and environmental objects like stake holders. Properties of this product are determined from *requirement analysis*

of CP and environmental objects. Uncertain environment, payoff and bias, prejudice and preferences affect the selection (Thomas, 1972).
7. For change of state of the *known product* the process just outlined is repeated for IO.

Points 1., 2., 5. and 6. are shared with decision making.

## Role of product in changes of properties

A *change of state* of a CO takes place as a result of *interaction* denoted by a dynamic verb. Thus, CO appears to act as a converter in accordance with generalised Newton's 2$^{nd}$ law : *nothing changes by itself* (mass is 'forced' 'to accelerate'). A potential *product* (such as inanimate (lava), animate (trained person), artificial (artefact : knife, component : gear box) or symbolic object (sentence : statement)), has to be brought to a *state* or has to have an *emergent property* imparted by IO to enable it to generate the *appropriate interaction*. A product also has to be delivered to be *available* to CO to exert interaction so that *CO with IS can become CO with FS*.

There is, thus, a *causal connection* between a changing property (CP) and interaction generated by a product which is called the *semantic functional relation* (SFR).

*SFR of causal connection* has the form : 'Statement with *changing property* (CP) and to accomplished this' - *calls for* – 'Statement with *generic product* and the infinitive form of a *dynamic verb* designating *interaction*'.

There is an SFR for *selection of particular products* and for generating *requirements* from *quiescent properties* (Korn, 2004, 2005a).

*Generic products* to effect the immense variety of change of CO are suggested as

1. Energy carried by medium (mechanical, electrical..(Korn, 1995), food.., chemicals..).
2. Information (*with factual and emotive content*) carried by medium (with means with meaning). In the sentence 'The fireman shouted to the other that *the corrosive liquid in the vessel stands at a level of 2 m*', the subordinate clause is *information*. 'Fireman' is the *sender*, 'other' is the *receiver* and the verb 'shouted' designates *influence interaction*. The context-free sentence in the subordinate clause is 'liquid stands'. 'Liquid' is qualified by 'corrosive', an adjective, and the verb is qualified by adverbial phrases 'in the vessel' and 'at a level' where the latter is further *qualified by data '2 m'* (Korn, 2001).
3. Components (artefacts (knife, a meal, fruit juice..), hardware (motors..) operated by *skilled power* which is power (energy) driven by influence (information) via an amplifier which can be technical, biological, social or animate like a horse, etc… i.e. beings unable to set objectives.

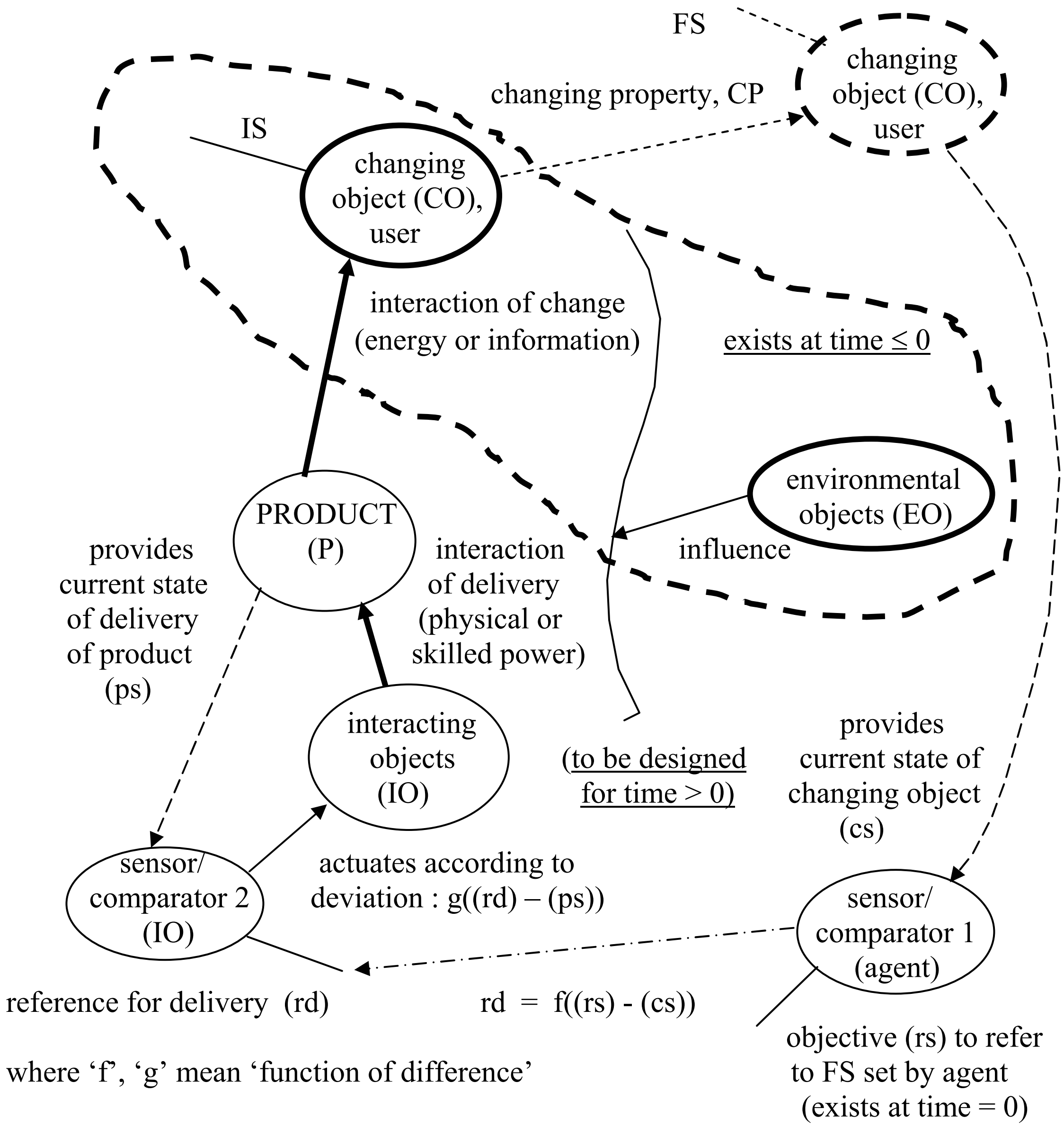


Figure 7. Scheme of purposive activity to change a single property

4. Linguistic terms which, *in totality*, stand for states and their changes or expressing *ideas* which can create impressions or effects to influence animate beings carried by medium with category 1 (a garden, advertisement..) or category 2 terms (access (to a road), selection (of candidates for a job)).
5. Part of a scheme or manipulation to fit into the scheme in Figure 8. and can be used to bring about a benefit or otherwise to an animate object (putting a family in prison (product) by a despot (agent) directing his soldiers (IO) *to influence the father* (CO).

*A product to be effective for creating a change, an impression or an effect in a CO must exist in its totality with parts which are assembled, added or subtracted in accordance with an* *algorithm by IO within the framework of an organisation.* The scheme of the simplest organisation is depicted in Figure 7.

We make the following remarks
1. In general, any purposive scheme (the simplest being a technical speed control system (Korn, 1995) changes *one property* of a changing object at a time since only two properties (the *current state* through feedback and *objective*) can be compared at the same time. Such a scheme is called a *unit of complexity* of which more complex schemes can be constructed. Figure 8. depicts a purposive system where 'cs' of CO is compared with objective 'rs' by an 'agent'. The number of purposive operations by the same or more units of complexity, required to construct the *totality* of a product within a unit of complexity, is called the *measure of complexity* of product. For example, construction of a shoe (product) involves a number of purposive operations until it is complete or its totality is reached (its measure of complexity) so that it can exert influence on the buyer (CO).
2. In Figure 7. the 'agent' knows both : *the 'objective' AND the 'product'* the application of which according to an algorithm by IO brings about the desired 'objective' or FS.
3. We have identified 'alternatives' in decision making (Thomas, 1972) with 'particular products' in the scheme in Figure 7. In view of the causal relation between interaction and changing property (CP) ALL envisaged 'alternatives' must produce the *same interaction*.

## An example

This example is intended to demonstrate the use of arrays, the expansion of category 1. and 2. words, as product in the design of organisations as defined here.

Story of scenario : 'A shop keeper (agent with overall objective) wants his customers (CO) to have an increased level of satisfaction. He can lower prices, provide tables and chairs or can display sandwiches with easier access and selection. He prefers the 3rd alternative'.

CO – customers
IS (problematic) – low level of customer satisfaction
FS – increased level of customer satisfaction
CP – customers become increasingly satisfied

<u>SFR for causal connection</u> : 'Customers become increasingly satisfied' and 'to achieve this' - calls for – 'Linguistic terms to influence customers to become more satisfied'

<u>SFR for selection</u> : 'Linguistic terms to influence customers to become more satisfied' AND 'Shopkeeper prefers sandwiches with more attraction' and 'to realise this' – select – 'More attraction to mean sandwiches with easy *access* and *selection*'

We do not pursue 'requirements' here but instantiate 'access' and 'selection'.
'Access' means that 'sandwiches' are placed on 'shelves' when the latter are ready.
'Selection' means that 'sandwiches' are to be arranged and priced according to their 'content (cheese, ham or tuna)'. 'Priced' means that prices (cheese, £, ham, £, tuna, £) are

attached to sandwiches. 'Ready' means that shelves are clean. Both tasks are carried out by an assistant (agent). If not, there is need for design of 'interacting objects' (IO).

We construct an array (Korn, 2005b). There are 4 nouns or objects : sw (sandwiches), sh (shelves), co (content) and pr (price) (of which sw, co and pr are still abstract) to which we assign relation indicators, stative verbs in this case i.e. introducing ordered pairs starting with : 'sw are placed on (pl), sh are clean (cl), co is used to arrange (us), pr are attached to (at)' from which

| | | | | |
|---|---|---|---|---|
| 0 | sw pl sh | sw pl co | sw pl pr | |
| $n_{11}$ | $n_{12}$ | $n_{13}$ | $n_{14}$ | |
| sh cl sw | sh are cl | sh cl co | sh cl pr | |
| $n_{21}$ | $n_{22}$ | $n_{23}$ | $n_{24}$ | 11. |
| co us sw | co us sh | 0 | co us pr | |
| $n_{31}$ | $n_{32}$ | $n_{33}$ | $n_{34}$ | |
| pr at sw | pr at sh | pr at co | 0 | |
| $n_{41}$ | $n_{42}$ | $n_{43}$ | $n_{44}$ | |

An 'ordered pair' can be represented as a two-terminal network (Korn, 1995). The network representation of an ordered arrangement of pairs as eq.5. is shown in Figure 8.

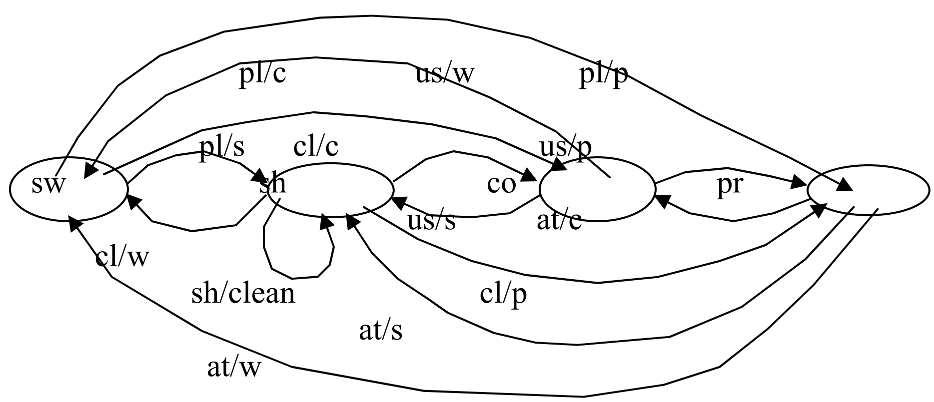


Figure 8. Linguistic network representation of eq.11.

Arrays like eq.5., 11. and the network in Figure 8. give a *large number of choices* the number of which can be calculated, for relating the objects. A particular choice is selected by *design or evolution*. For example, by selecting one term from each row in eq.11. or a *tree* as shown in Figure 9., we can generate the following *assemblies* which make sense :

1. sw are placed on sh, sh are clean, co is used to arrange sw, pr are attached to sw
2. sw are placed on sh, sh are clean, co is used to arrange sw, pr are attached to sh
3. sw are placed on sh, sh are clean, co is used to arrange sw, pr are attached to co

each of which defines the *conceptual boundary* of a choice or assembly.

We formulate objectives using the first assembly which are arranged in a *time sequence* as would be indicated by an appropriate *algorithm* :
Objective 1 of agent (with IO1) is to <u>clean</u> sh

Objective 2 of agent (with IO2) is to place sw on sh
Objective 3 of agent (with IO3) is to arrange sw according to co
Objective 4 of agent (with IO4) is to attach pr to sw.

Detailed design of IO and product as part of the scheme in Figure 7. is described elsewhere (Korn, 2005a). Figure 10. shows the sequence of the algorithm. From Figure 10. the *overall objective* is achieved when all *objectives* have been fulfilled i.e. *totality of product* will have been achieved

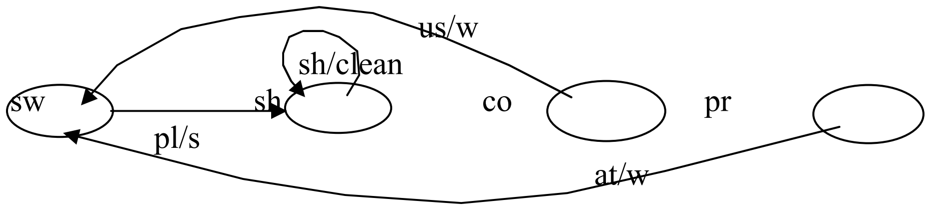


Figure 9. A network of tree from linguistic network

$$\text{overall obj} = \sum(\text{obj (cleaned,1,placed,2,arranged,3,priced,4)}) \quad 12.$$

where $\sum$ stands for 'totality' and with a *measure of complexity of 4* since there are four operations to be accomplished by four purposive schemes as in Figure 7. to achieve the overall objective. In general, measure of complexity is defined as the number of explicitly shown operations needed to achieve a specific emergent property embodied in the overall objective.

In this example the *shopkeeper is the environmental agent* who makes the selection of the assemblies and instructs the 'assistant' who will act accordingly as depicted in the *semantic diagram* in Figure 11. Further to Figure 11. 'customers' will become aware of 'sw' when the conditions as *acquired properties (ap)* standing for *emergent property* are all present = (ap(3,5) = 'sw are on shelves', ap(4,5) = 'sw are arranged' and ap(5,5) = 'sw are priced'). When the method of linguistic modelling is applied to the semantic diagram in Figure 11. we calculate that the certainty of occurrence of 'customers' will become aware of 'sw' varies from ***unknown to may be*** (Durkin, 1984).

Based on the preceding discussion we define an *organisation* as a series of IOs engaged in producing products by tracking an algorithm in accordance with objectives towards accomplishing specified changes in COs, the overall objectives set and monitored by an agent.

## CONCLUSIONS

We tend to perceive objects, concrete and symbolic, in their entirety and can respond or make comments which are based on impressions, beliefs, prejudices, preferences etc. These are usually expressed in abstract linguistic terms. However, more detailed analysis is needed for assessing meaningful *outcomes or testable beliefs and design* of such terms i.e. the creation of specified wholes or products which can accomplish specified changes of properties of CO.

This can be achieved by seeing these entireties as aggregates of related parts, objects or properties. Related objects are expressed as minimal elements of which entireties can be reconstructed with acceptable fidelity (A vivid example is Self-portrait by van Gogh). This reductionist approach is adopted here for putting the systemic view into practice i.e. for creating models that can be related to experience.

The approach is based on adopting natural language as the primary model of complexity and hierarchy. Its minimal elements are one and two place sentences (ordered pair) which still retain the view of complexity. Abstract linguistic terms are broken down into arrays of such sentences to be used in design and for developing evolving structures. Also, narratives of scenarios in natural language, through linguistic analysis, can be turned into a homogeneous language of one and two place sentences which are used for constructing dynamic, reasoning models from the topology of a scenario as given by semantic diagrams.

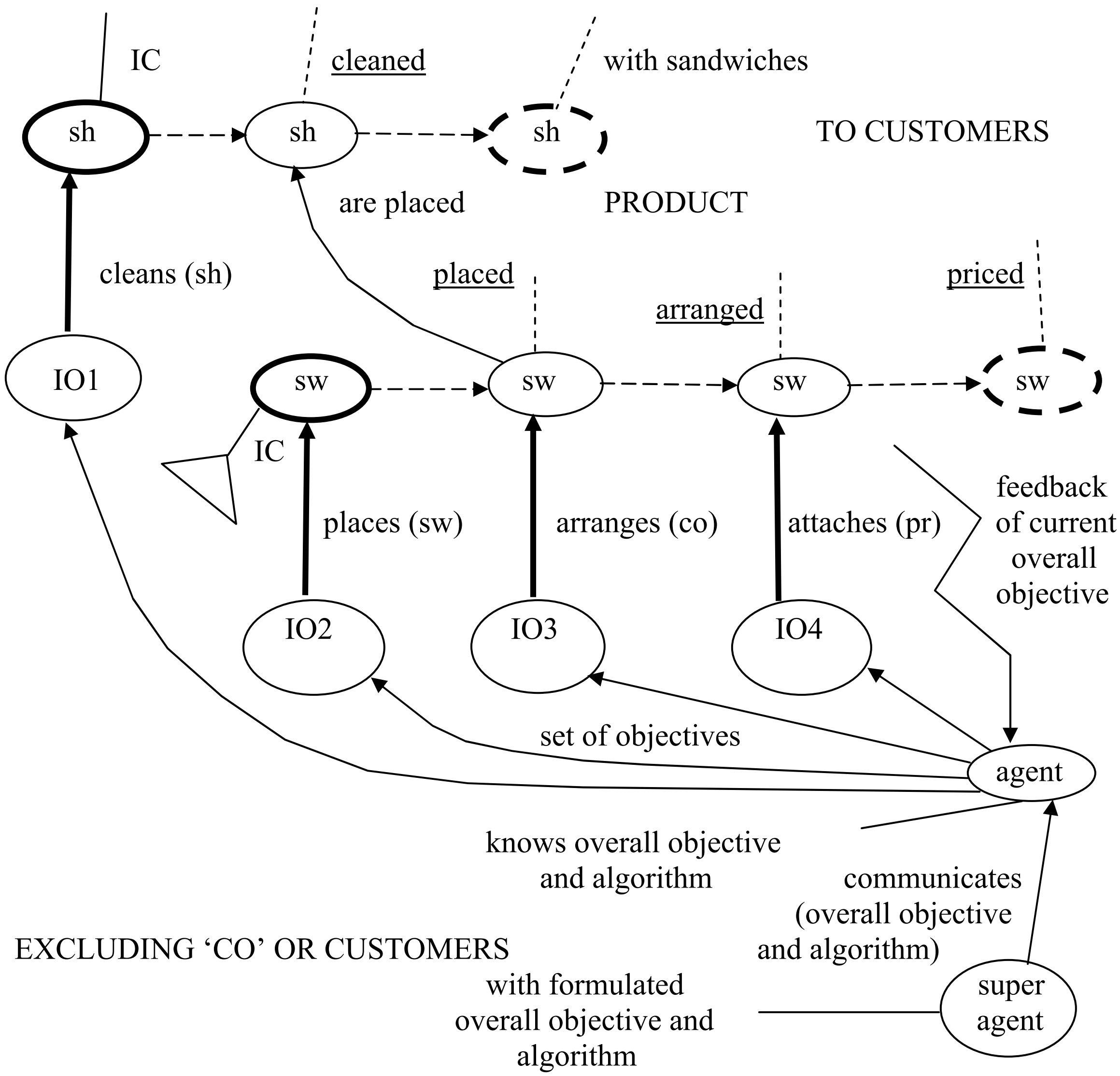


Figure 10. Simplified semantic diagram showing algorithm of 'access and selection'

A procedure for design of systems and products has been outlined. This is based on identifying a problematic initial state (static state : 'garden fence is ugly' or dynamic state : 'a group of people on parole commit burglary') as the starting point which leads to changes of physical or mental states. Integrating decision making into design has been attempted.

The idea of unit and measure of complexity has been introduced for the production of a single property to be used for creating products which, once achieved their totality, are seen to bring about change in a changing object by exerting an interaction. The complexity of product invokes the operation of many kinds of complex operations leading to complex organisations (Mintzberg, 1979). Such an organisation can be seen as a connected network or a field of *purposive units* in which each is managed so as to produce a 'local CO with FS' acting in coordination for bringing about the production of the intended product aimed at a user or consumer. In living/human activities purposive actions appears to be as *pervasive as gravity* is in the natural sphere.

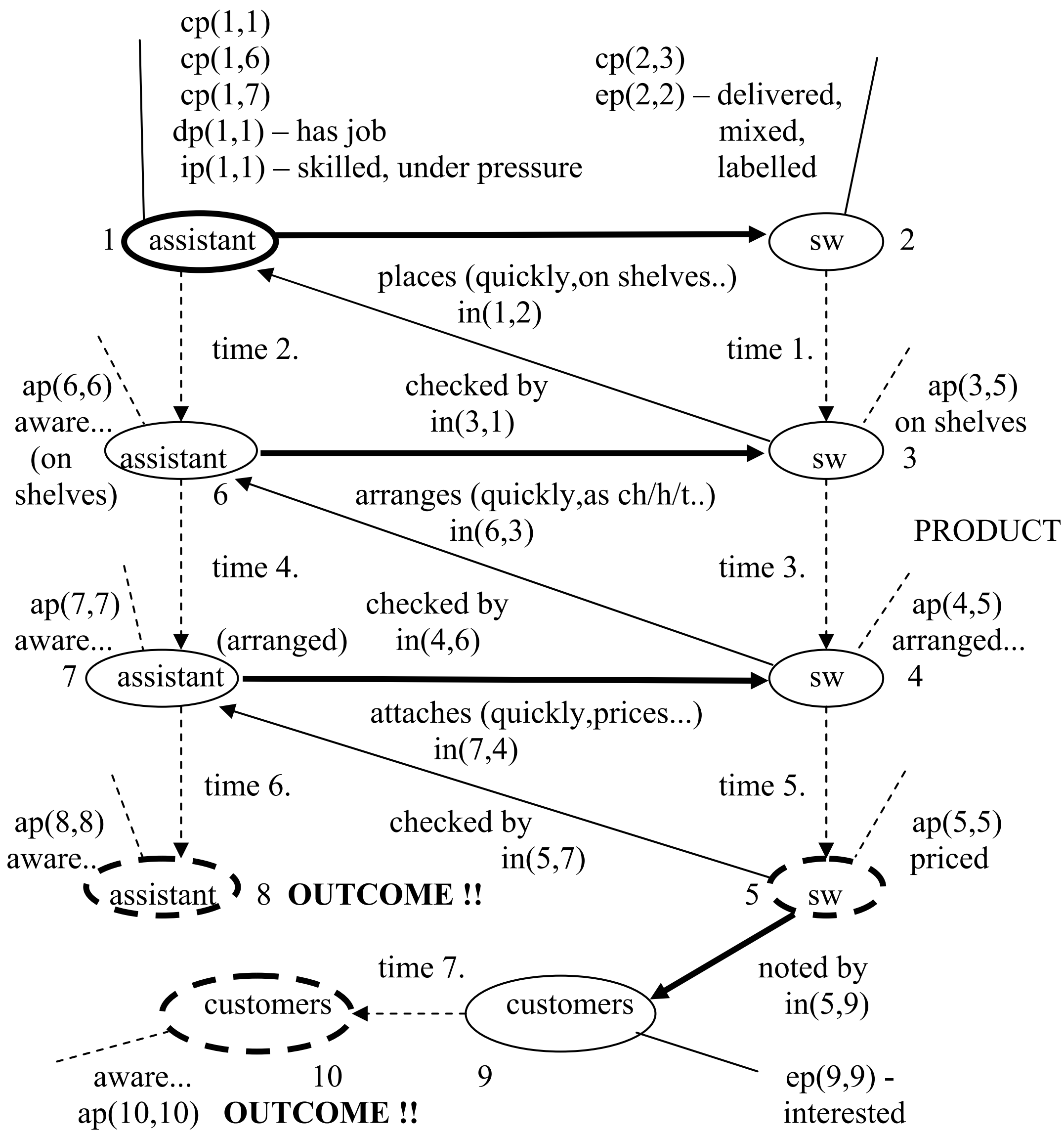


Figure 11. Semantic diagram showing details of 'access and selection'

The scheme in Figure 7. appears to be a general mode of thinking that pervades everyday life, social and technical activity. Its adaptation as a basis of modelling organisations could lead to suggestions for improved management to face contingencies with uncertainties associated with operations of environmental objects.

The concept of *'outcome'* is defined as the impression, effect (due to related properties or objects) or interaction. An outcome can arise by chance or in accordance with purpose.

The approach outlined here can lead to imaginary, virtual organisations which can then be used as prototypes for dynamic simulation as indicated in Figure 11. Sequences of predicate logic statements derived from semantic diagrams of prototypes as suggested in 'Introduction to linguistic modelling' leads to an assessment of the certainty of occurrence of outcomes based on variation of qualifiers of components. This kind of effort would need software development assuming the approach discussed here will have passed the test of debate.

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