Spring 4-12-2016

INTEGRATION OF INFORMATION SYSTEMS INTO SYSTEMS SCIENCE (9)

Janos Korn
Middlesex University, janos999@btinternet.com

INTEGRATION OF INFORMATION SYSTEMS INTO SYSTEMS SCIENCE

janos korn
janos999@btinternet.com

Abstract

Current state of the 'systemic or structural view' of parts of the world is considered and concluded that it is largely speculative, fragmented, with no accepted principles regarded as fundamental which could be exposed at least to thought experiments by means of appropriate models. The practice of information systems (IS) is part of this fragmentation which is aided by its current description. The notion of representation or modelling of parts of the world is described as related, 'subject – predicate forms' which when transmitted become communication. Information is defined as 'message encoded in a medium' and operationally in the context of linguistic modelling as the 'subordinate clause of sentences with information bearing verbs'. This definition enables the flow of information and IS to be modelled following the methods of systems science as outlined. The quantity of selective and semantic information is worked out leading to precision and to ranges of information to be presented to a living operator for selection and action, or not.

Keywords: information, IS, systems science, linguistic modelling

1.0 Introduction

Although the structure of concrete, abstract, symbolic and imaginary things is just as observable as their qualitative and quantitative properties, the development by and large of the 'systemic or structural view' of parts of the world as opposed to 'conventional science of physics' has not gone along the path of **empirical research** : There has not been a systematic inquiry into searching for general principles and methods for their testing against experience [Magee, 1985]. It has taken the path of :

1. Using the term 'system' as a means to refer to a :
Static phenomenon when it appears **complex** and consisting of a number of **related** parts, or Dynamic phenomenon consisting of a number of **interacting** parts engaged in some kind of activity.

2. Generating a vast variety of largely **speculative** views without much thought to their expansion to investigate their relationship to experience. This trend started with the founders of the 'systemic view' [Bertalanffy, 1950] and has continued up to the present day supplemented by a variety of modelling techniques such as 'viable systems model' with no underlying symbolism and diverging into philosophical issues [Jackson, 200]. The trend rejected conventional science in its **entirety** which, with hindsight, was a mistake. In particular, these views have no 'reasoning structures' and 'framework for problem solving'. However, historically they have allowed flourishing diverse thoughts and debates.

3. Developing control theory in the technical field following theories of signal transmission before the 2nd WW to aid construction of control systems for control of antiaircraft guns and similar applications which, due to its multidisciplinary nature, has resulted in difficulties in construction of teaching schemes [Nyquist, 1924, Hazen, 1934, Korn, 1994, Nise, 2008].

The **results of this vast intellectual development** may be summarised as follows :

Indiscriminate and speculative use of the term ‘system’ has caused confusion and fragmentation into information systems, service systems, living systems and so on.
Teaching ‘systems’ is difficult, not much to learn, and currently restricted to university level.
The influence of the ‘structural or systemic view’ on society has been negligible.
Few attempts have been made at integration of the ‘systemic view’ with disciplines like biology, chemistry, nuclear physics, social science etc.
The ‘structural or systems view’ has no firm foundation in the accepted branches of knowledge and it is out of context with human intellectual endeavour. A diagrammatic representation of the latter situation is attempted in Fig.1.

Fragmentation of the ‘structural or systemic view’ has resulted in seeing IS as a separate discipline. Perhaps separation has been aided by the following **description of IS** :

‘An IS is any organised ‘system’ for the collection, organisation, storage and communication of information. More specifically, it is the study of complementary networks of hardware and software that people and organisations use to collect, filter, process, create and distribute data. It is said that IS have roots in computer science, engineering, mathematics, management science and cybernetics’.

This description appears to have led to consequences as summarised below [Anon. 2016, Flynn, 1998] :

1. The understanding of IS as described appears to have resulted in their role as tools supplemented by extensive use of computers in the activities of people in manufacturing, commercial, service, entertainment and other organisations. This understanding has discouraged modelling IS closer to the physics of their operation. Plants also engage in ‘internal’ activities involving the flow of information when, for example, a plant turns its leaves into sunlight as a result of receiving ‘information’ about incoming light. Animals as well as people perform a vast variety of ‘internal’ and ‘external’ activities in accordance with **purpose** which involves flow of information [Nise, 2008, Korn, 2016]. For example, in the course of ‘hunting a prey’ there is an extensive cooperation requiring flows of information. The operation of the autonomous nervous system and cooperation between organs using ‘hormones’ as ‘signals’ are based on information circulating between brain and the appropriate organs in animals and man or seeking a new source of water is induced by information received from the surrounding. A plant dies due to lack of water, an animal attempts to search for it but man can actively engage in such a search using appropriate tools. Nowadays people are involved in a vast range of communication made possible mainly by the use of the immensely expressive power of the symbolism of natural language supplemented by the use of computers and modern technology.

2. Although the examples in point 1. involve the operation of ‘purposive systems’ [Nise, 2008, Korn, 2012, 2016], the description of information above seems to ignore this kind of operation which involves ‘information’ carried by feedback paths and decision making.

3. The description fails to recognise the similarity of functions of ‘flow of energy’ and ‘flow of information’. The role of the first is to change the **physical** state of a living and

any other material object whereas the second is to change the **mental** state of living things and of artefacts using ‘amplifiers’.

We conclude that the activities involving ‘information systems’ take place on a much wider scale in the living sphere of plants, animals and humans at the individual or social level than implied by the description. Thus, it is desirable for the basic notions and modelling of IS to be considered within a theory with a wider scope which is ‘**systems science**’.

A suggestion for a scheme for ‘systems science’ based on the methodology of conventional science of physics but with structural or systemic content is available as developed through a **paradigm** change indicated in Fig.1. [Kuhn,1996, Korn, 2009, 2013, 2015, 2016]. This ‘science’ through its generality is applicable to the ‘systemic view’ of natural, technical and living including human, activities and aids ‘problem solving’ and **design**. Its symbolism is processed natural language which, through adverbial qualifiers of certain dynamic verbs, carries **information**.

Thus, the basic notions and modelling of IS need to be integrated into ‘systems science’ because :
1. IS are involved in **problem solving** which is intensely ‘informatic’ and as prevalent in the living sphere as the action of gravity in the material sphere [Korn, 2016].
2. A theoretical development such as IS standing on its own should be included in that with increased breadth and depth. For example, mechanics, electricity etc can be included in ‘engineering systems’ [Korn, 2012] or attempts have been made to include field theory of gravitation within a ‘unified field theory’. Integration increases **intellectual order**.

Accordingly, the objective of this paper is to introduce ‘system science’ and to show how activities described by IS can be modelled and integrated into it.

2.0 Concept Of Representation

Attempts at understanding the workings of parts of the world including own bodies and mind have been going on by human beings for millennia. The key to this kind of intellectual activity is the ability to **represent** a part of the world by means of a symbolism which happens to be of interest. The following statement applies to the question of representation :

Remark 1. ‘Theoretically we can make an **infinite** number of statements embedded in declarative sentences about any part of the world or empirical object all of which are hypothetical. Thus, complete knowledge is impossible to attain. However, in practice we are satisfied with one or a few statements selected by **interest** or a ‘point of view’ of an observer or analyst. Consistent statements can be organised into a structure like paintings, sentences, mathematical expressions, which constitutes a static or dynamic **representation** of a scenario called **model** of a part of the world’[Korn, 2016].

We make the following points regarding ‘representation’ :

1. Any part of the world whether it is perceived and interpreted as ‘concrete’, ‘abstract’, ‘symbolic’ or ‘imaginary’ can be represented or modelled. When performing the act of ‘representation’ an observer or analyst has one or more means selected or invented or imagined as means of representation or model or 'representer' together with a chosen 'part of the world' which is designated as to be 'represented'. 'Representers' range from drawings on the walls of caves to artistic works, natural language, mathematics, road signs, mobile telephones and so on.

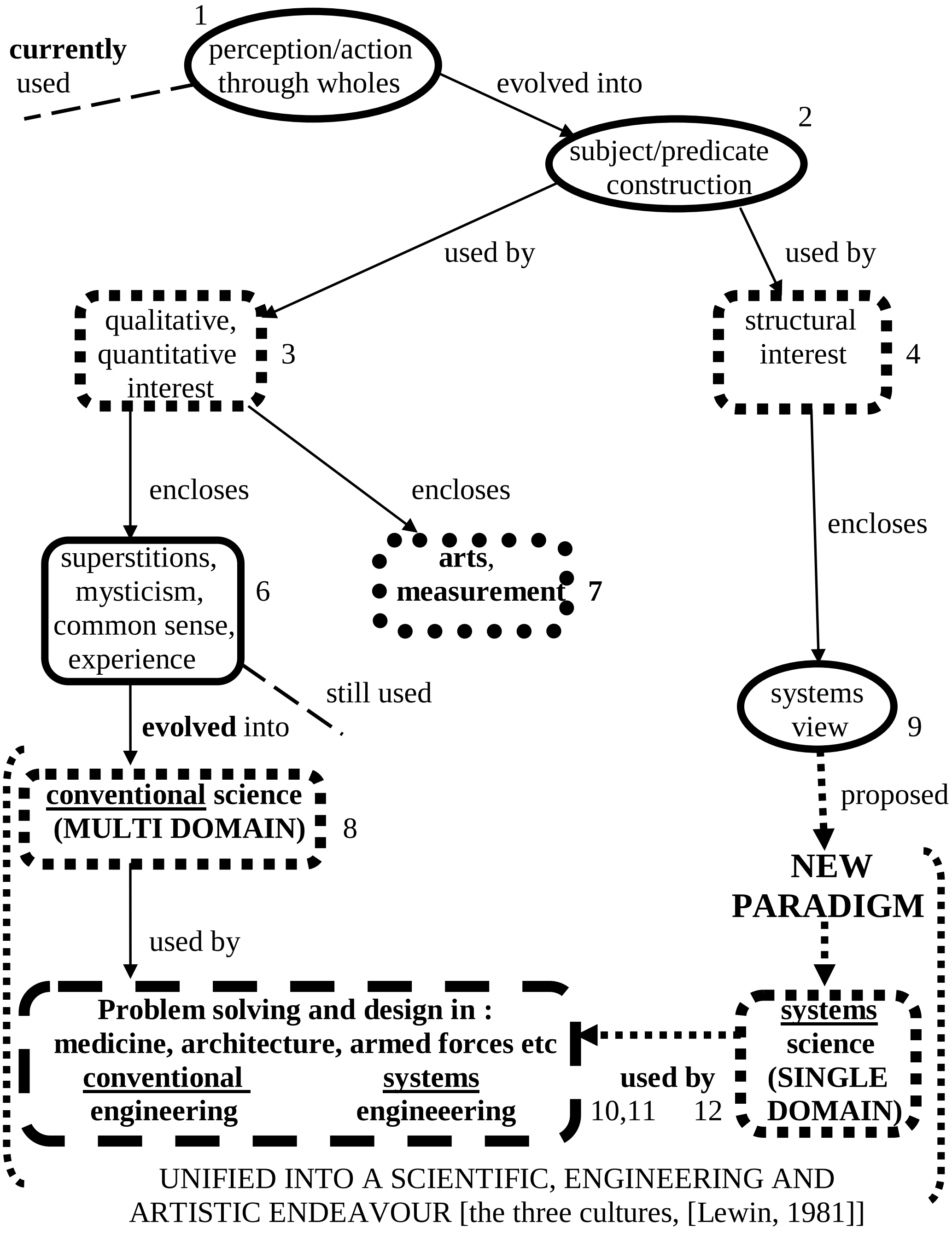

Figure1. Diagram of constituents of human intellectual endeavour

There is an immense variety and diversity of parts of the world in static or dynamic state to be represented if required which existed in the past, exists at present and can be envisaged in the future. It is impossible for each one to be individually 'represented' because each one would need to have its own model. Therefore,

number of representers [models] < number of parts of the world to be represented 1.

2. Any part of the world which is subject of an inquiry or to be 'represented' is recognised and identified in terms of :
A. A topic or **subject** of inquiry, and
B. Opinions, views or beliefs as **predicate** expressed by the observer with interest in the topic.

This is the 'subject – predicate' construction [Burton, 1984] shown in contour 2 in Fig.1. The topic thus created is called the 'theoretical object' against the 'empirical object' which plays the part of 'wholes' in contour 1 in Fig.1. The discovery of the 'subject – predicate' construction has given rise practically to the whole of human intellectual development.

3. Eq.1. stipulates the construction of **categories** or classes or domains into which an array of 'topics' can be fitted and a designation is assigned to. The 'subject – predicate' construction is realised by 'declarative sentences' which are easiest to recognise in **natural language**. The acquired designation plays the part of 'subject' in a declarative sentence.

In practice a **domain** is constructed using 'predicates' or 'properties' or 'characteristics' or 'features' which are the immediately observable means for transcribing a part of the world or a 'topic' to fit into a 'domain' or a 'category'. Once a part of the world has been allocated into a domain and is accepted and subsequently learnt, recognition usually is not difficult. Domain construction is common practice in botany, for example, but it is present in conventional science of physics when we designate an object in terms of its volume, density, elasticity, speed, force called 'invariants' as 'mechanical' [Korn, 2016].

The idea of 'subject – predicate' construction has been invented by man when he wanted to proceed from acting instinctively as implied by contour 1 in Fig.1. to acting according to considerations or just achieving the mental state of considerations or cognition. The notion of **properties** as used extensively in physics as part of predicates which are employed for 'qualifying' a topic is part of this invention.

Statements embodied in declarative sentences are made in the course of observation of aspects of a selected part of the world by assigning properties to its subject as required by **Remark 1.** creating 'theoretical objects' which can be fitted into a domain.

Accordingly, we create a **model** of a part of the world by recognising it as a 'topic' using our domain knowledge followed by selection of predicates governed by interest expressed as views, opinions or beliefs which together we fit into one or more statements of the 'subject – predicate' form. This is the task of an observer or analyst or thinker who may be a person engaged in every day conversation, a student solving an engineering problem or scientist creating a new theory who can offer the resulting model for interpretation to others. Thus, we have a 'thinker – interpreter' scheme.

In general, construction of a model involves :

A. Identification of a set of basic constructs, properties or 'invariants' which form the **vocabulary** of the domain and, using this vocabulary
B. Construction of **relationships** of concepts from the vocabulary expressed as statements which form the model [Korn, 2013, 2016].

When the model is so constructed as to be capable of being exposed to test of experience and is based on general, declared principles of more or less generality, we have ‘science’. This idea is demonstrated by both branches of the diagram in Fig.1. in which we note the features of the two kinds of models : Those of ‘conventional science of physics’ and those of ‘systems science’ disregarding the other intellectual efforts at the moment [Korn, 2016].

‘Conventional science’ is by and large unable to cope and it is not intended to cope with phenomena involving more than a single object. Perhaps this is best seen by the difference in ‘models’ generated by ‘conventional and systems sciences’ :

The **structure of models** in ‘conventional science’ reflects the structure of **relations** of selected properties of a **single** object [usually quantifiable and expressed as a mathematical model],

The **structure of models** in ‘systems science’ tends to reflect the structure of **multiple** theoretical objects in static [signified by relations] or dynamic state [signified by interactions] [Korn, 2009, 2013]. At the most basic level of ‘functional elements’ like an ‘elastic spring’ [Korn, 2012] this boils down to the **structure** of properties such as Hook’s law, for example.

In a **mathematical** model expressing relations among properties the identity of object to which the properties are related is lost. In a **structural** model the theoretical objects or agents are part of the model thus their identity is preserved.

For example, in case of a ‘rectangular, flat table top’ --- The ‘relation of its properties’ [length, ‘a’ and width, ‘b’] is organised into ‘area = a x b’ which is a mathematical model. The ‘structure of properties’ is organised into ‘’a’ is perpendicular to ‘b’’ which is a ‘linguistic model’ or ‘ordered pair’ [Korn, 2016] and reflects the ‘structure of properties’.

3.0 Concept Of Information

When a **representation** or a ‘model’ is transmitted we have **communication** and the model becomes known as **information**. It is the ‘sender’ who initiates transmission to the ‘receiver’ with the objective of sending a ‘message’ which embodies the ‘representation’ and is to be interpreted. Alternatively, part of a ‘sender’ and ‘receiver’ can be played by a single object when it perceives and interprets the ‘message’ which he/she sees, hears etc when confronted by a phenomenon.

This notion is depicted in the diagram in Fig.2. [Korn, 2009]. The diagram includes the ‘representation’ aspect of message creation and the part which the brain/mind assembly appears to play in this. The diagram concludes with the definition of **information** as

information = message in **medium** (means with **meaning**) 2.

which says that ‘Information is described as a ‘message encoded in a medium’ which together is called ‘means with meaning’ and assumes that :

1. The syntax of the message is correct i.e. the medium is correctly put together, in a grammatical sense in case of natural language, and

2. Message can be understood [expressed in English, for example], and
3. Message has semantic content i.e. it is meaningful or it refers to a part of the world : concrete, abstract, symbolic or imaginary. **Meaning** is imparted to the message by the sender and is **interpreted** by the receiver, and
4. Message is encoded correctly in a medium, and
5. The medium which creates the physical effect, can be perceived by an appropriate sense organ.

This description agrees with that given in [Floridi, 2000] but demands more from a 'means with meaning' to qualify for being 'information'. Also, the origin of information in its 'representation' is also considered. The description of information in [Floridi, 2000] uses the term 'data' where we use that of 'message/medium'. Data is described here as, usually, the numerical part of information carried by a property. For example, a message may be formulated as in Fig.2. contours 3 and 4 'the car in the race yesterday achieved a speed of 240 km/h [property + data]' which when encoded as indicated in contour 5 becomes 'information' when transmitted.

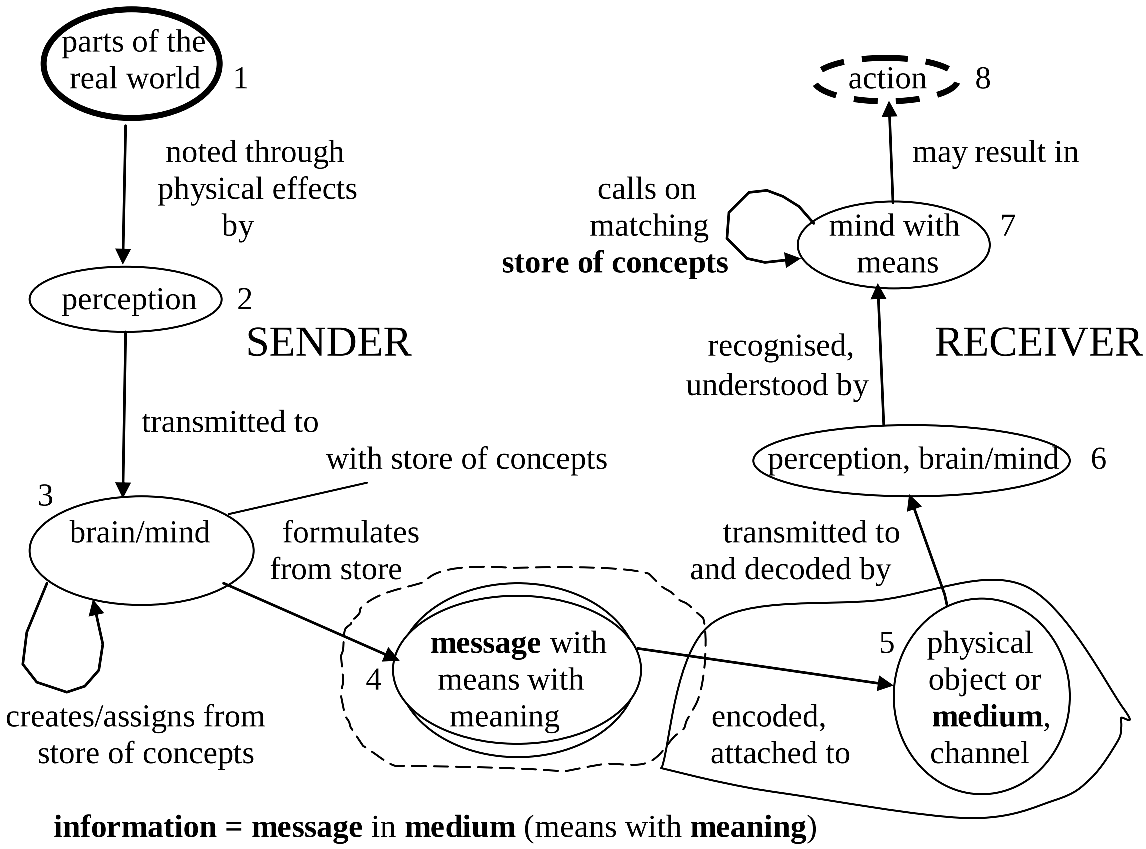

Figure 2. Sender – receiver scheme

The diagram in Fig.2. can be 'read' approximately following the rules of **linguistic modelling** [Korn, 2016]. We have : 'An aspect of a chosen part of the world is noted through its physical effect by perception and the impression is transmitted to the brain/mind assembly which using a store of concepts assigns the processed effect to a concept as appropriate. Thus, this assembly can formulate means with meaning by combining concepts into models carried by means with meaning. Externally they are encoded into physical objects or medium, or channel and then sent. They are transmitted to perception of a receiver and decoded by similarly equipped brain/mind and then recognised and understood by calling on matching store of concepts. A message with means with meaning may result in action'.

We discuss the notion of information from the point of view of its acting as 'informatic product' for the change of **mental states** of chosen, changing objects [Korn, 2016]. There are mental states : rational, aspirational and emotional like 'sadness', 'cleverness' which are caused by informatic products. In general, in the context of information, we are concerned with two kinds of change of mental states :

1. From **uncertainty** (when we are aware of a possibility of choice or selection of objects : It is there but we do not know which ?) towards more **certainty** as in 'The passenger notices (information bearing verb) that 'the train has 5 carriages with 20 rows of seats each with 6 seats (subordinate clause carrying information)''. The passenger may be prompted by this information to find a particular seat which leads to acquiring certainty.

2. From **ignorance** (when we are not or only partially aware of an aspect of a part of the world : It is not there so information is needed to make it there ?) towards **awareness** like in 'The guard warned (information bearing verb) the waiting passengers (with ignorance) that 'the train overdue by 20 min, is now approaching (subordinate clause carrying information)''. We assume that the purpose of the 'guard' in creating and transmitting this information is to input awareness to passengers to get them ready for boarding the train when it arrives in the station.

Accordingly, we have two types of information which are used to alleviate :
1. Uncertainty called **'selective information'** (selection of a particular item from a group of items or ensemble like choosing a letter from a number of letters or a seat on a train or an arrangement of on/off switches).
2. Ignorance called **'semantic information'** (generation of messages like issuing notices, instructions or commands, giving advice…, transmitting feelings like hate, love etc).

In the context of dynamic linguistic modelling **information** is defined as the 'subordinate clause' in sentences with information bearing dynamic or stative verbs [Korn, 2009, 2013]. The **unit** of information is a meaningful sentence with a single verb in the subordinate clause which can be made more explicit by considering its 'context – free' version. For example, from sentence above we have 'train is approaching'.

A context – free sentence represents maximum ignorance or uncertainty since it allows its constituents to wander around their spaces of meaning. We cannot locate a constituent in a particular point in this space. For example, we can say 'tree grows' which is meaningful unlike 'curo broks' but can never be shown to be false, we can always find a 'tree' that 'grows' somewhere, sometime on this planet at the present time [Magee, 1985]. Qualifiers or properties are needed to make a 'context – free' sentence specific.

The definition of information applies to both types of information since their structure is the same as demonstrated by the examples just given and as such can be covered by the same definition. Classical communication theory is concerned with 'amount of information' which is measured as the 'logarithm to base 2 of the number of alternative patterns, forms or messages' selected from an 'ensemble' [Shannon, Weaver, 1964].

4.0 Variety Of Means With Meaning

People have a propensity to and a knack for communication, animals do it of necessity. There is an immense variety of 'means with meaning' available for communication developed by human beings over the history of their existence. For example, the colour of a flag, green, [the means] may mean an envisaged 'representation' carried as instruction [meaning] 'to release the ropes'.

Examples of 'means with meaning' which have been evolved by human beings over the past millennia and can be carried in the mind as images implied in Fig.2., are summarised below :

Ancient/current methods (1. Artificially created images = Heated bones, flight of birds, superstitions, astrology, palmistry, tarot cards....)

Images (2. Artistic images = Pictures, sculptures, dances…, 3. Communicative images = Diagrams, gestures, variety of signs, icons, indexes like readings on a dial of an instrument…, 4. Natural images = Earth tremors, clouds, lightning…)

Symbols (5. Natural language (letters, words, sentences), 6. Music (musical notation, tunes, rhythm), 7. Mathematics (numbers, letters, relations)).

An attempt to relate the variety of 'means with meaning' as indicated by numerals to human intellectual endeavour as shown in Fig.1. can be made by using the contours in this figure as follows :

Numerals 1, 4 -- Superstitions (contour 6),
Numeral 2, 3, 5, 6 -- Fine and performing arts (contour 7),
Numerals 7, 5, 3 -- Conventional science (contour 8), Systems view (contour 9), Conventional and Systems engineering (contours 10, 11), Systems science (contour 12).

Further to the examples of 'means with meaning' we comment as follows :

1. We have suggested that a 'representation' becomes information when it is communicated. 'Means with meaning' under numerals 1, 2, 3, 4, 6 describe when expressed in natural language, 'representations X' but can be interpreted as 'representation Y'. For example, from Superstitions (contour 6) 'Particular shapes acquired by bones when heated' can be interpreted as 'The battle to be fought the next day will result in victory'.

A great achievement of conventional science has been the removal of the **intermediary** by creating 'representations X' using 'means with meaning' under numerals 5, 7 to describe when interpreted in natural language the same 'representations X'. A particular topic is created or observed then predicated, for example, 'a spring made of steel [topic] and it is elastic [predicate]' which is 'representation X'. When perceived, it qualifies for being 'information' and its interpretation is still arbitrary since we are dealing with human beings with imagination but it is much more likely that it refers to the same representation i.e. an 'elastic spring'. In addition, this true interpretation represented by the topic and its predicate may be subjected to investigation leading to establishment of relations between the predicates with the result, in this case, of Hook's law or 'the shortening of spring is proportional to the magnitude of the applied force' within limits [Korn, 2012].

In general, there is always the danger of **arbitrary** interpretation or misinterpretation of statements as part of information. Linguistic modelling can cope with this [Korn, 2016].

2. Information or meaning encoded in a medium is received and interpreted by a 'receiver'. We have seen that there is a large variety of 'means with meaning'. Interpretation involves understanding the 'message' and converting it into a 'representation' or the other way round as we have seen when we discussed 'representations'. This 'representation' is usually **natural language** which is regarded as the 'primary means' for constructing models in the mind. It is the most widely used means, practically everybody can use it as a means of communication.

Unless the meaning of a message has been acquired by customs, habits, tradition or regarded as a 'portent' or interpreted by 'feel' and 'imagination' as to a large extent done by art critiques, for example, there must be a **correspondence** between 'elements of 'message encoded in a medium i.e. information'' and natural language. Otherwise the message cannot be 'read' and it is open to wide, or no, interpretation. In the examples in point 1. this issue did not arise because the message is already encoded in natural language. Different interpretation is random.

Accordingly, there are two sources of different interpretations :
A. That due to deliberate assignment of misleading meaning to the message, and
B. That due to incomplete, inaccurate or arbitrary notation encoded in the medium carrying the message.

The correspondence consists of :

A. Each element of information is to **designate** each element of natural language and vice versa, and
B. There are **rules** according to which the elements are connected.

Thus, correspondence has 'systemic or structural' characteristic. However, the well accepted 'road signs', for example, disobey this feature since they are established by convention and interpreted as 'wholes' as implied by contour 1 in Fig.1.

The notion of correspondence is especially appropriate in case of **diagrams** carrying 'means with meaning' or information which are often used in the practice of the 'systemic view' such as influence diagrams or viable systems models. A diagram is a pictorial representation of a static or dynamic scenario and is used because it is a convenient, concise and effective way of conveying information and it gives an impression of a scenario in one go unlike natural language which does the same sequentially. A scenario should be recoverable from the diagram by correspondence which translate the meaning of symbols used in constructing a diagram into symbols of natural language or mathematics or vice versa. This means that a diagram should be **readable**.

For example, we look at the well known concept of 'transfer function' [TF] used in engineering control theory [Nise, 2008, Korn, 2012]. In a diagram as shown in Fig.3. directed lines designate 'input' and 'output' and 'TF' enclosed in a contour implies the rule of their connection according to : 'Output [equals TF times] input' in which TF is a well defined mathematical expression like a constant or a 'transform' leading to a differential equation. We have converted a diagram into natural language, it is readable. Similar considerations apply to ‘networks’ like an electrical network [Korn, 2012].

We offer another diagram to illustrate conversion which is used in the ‘systemic view’ as depicted in Fig.4.

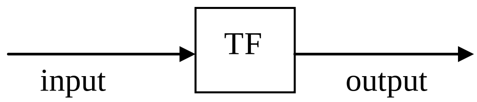

Figure 3. Diagram of transfer function

In Fig.4. there are four expressions written inside contours which are, thus, designated. The double directed line is not designated and specification of connections between elements [contours and double directed line] appears to be open to interpretation, it is not specified by the creator of the diagram. The diagram if used as a ‘message’ cannot be converted into ‘representation’ or model in natural language.

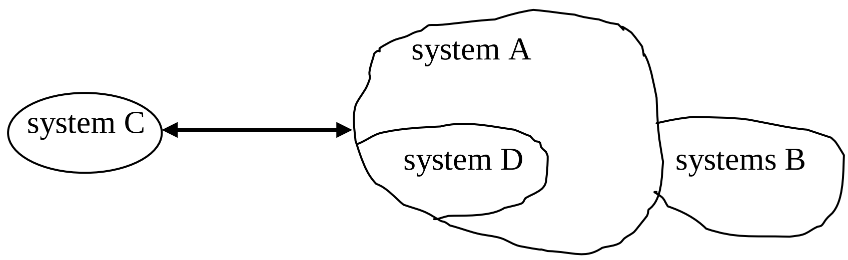

Figure 4. A systems diagram

3. We have described the concept of information and implied its transmission by introducing terms like ‘message’, ‘sender’ and ‘receiver’. The intention in this paper is to introduce how transmission of information can be **modelled** by ‘linguistic modelling’.

5.0 An Outline Of Systems Science

With reference to Fig.1. development of ‘systems science’ as understood here arises from a **paradigm** change [Kuhn, 1996] from the largely speculative and fragmented ‘systemic or structural view’ in contour 9 in Fig.1. to provide an alternative, supplementary approach to the analysis and design of instances in the systems phenomenon in contour 12 [Korn, 2009, 2013, 2016]. The approach is based on adopting the methodology of the highly successful conventional science in acquiring knowledge, inventing new devices and materials, aiding engineering and forming part of teaching schemes but with a **systemic** content. This means that the approach consists of two parts :

A. A set of principles regarded as basic and pervasive throughout the systems phenomenon which views parts of the world primarily in terms of their **structure**, and
B. A method of modelling which is capable of assessing the truth value of these principles by representing their particular instances and exposing them to at least thought experiments.

5.1 Principles of systems

This is a summarised as principles including the basis of **linguistic modelling** developed from **stories** or narratives in natural language, the primary means for modelling scenarios [Korn, 2009, 2013, 2016].

1. Principle of identity
The 1st principle asserts that any theoretical object can be identified by its **structure** including living, chemical, nuclear, galactic modulated by qualitative/quantitative properties of its selected aspects. This leads to the belief that the 'structural or systemic view' of parts of the world as indicated in Fig.1. is **pervasive, indivisible** and **empirical** and has a single **domain** as opposed to 'conventional science' which is domain dependent. Quantitative/qualitative properties are incidental or **situation** dependent.

2. Principle of analysis
The 2nd principle provides the means of analysis or converting selected parts of the world into 'static' or 'dynamic' models expressed by the symbolism of **linguistic modelling** based on elements of 'natural language' shown in Fig.5. or network analysis of engineering systems [Korn, 2012, 2016].

Development of the symbolism begins with constructing a **story** or narrative describing a scenario in natural language leading into **homogeneous language** of 'one – and two – place sentences called **elementary constituents**, of which the immense variety of complex scenarios can be constructed. 'Bricks' in building construction play a similar part.

On this basis : Qualified theoretical objects are connected into --- Static structures of 'linguistic networks' of **ordered pairs**, or Dynamic structures of 'semantic diagrams of **predicate logic** statements as shown in Figs.7.,8.

The elements of symbolism or 'invariants' or 'vocabulary' which **regularly** recur are :
I. Classes of theoretical objects or elementary properties like 'length'
II. Relations producing static states recognised by stative verbs
III. Interactions producing dynamic states recognised by dynamic verbs designating physical or skilled power (carrying **energy** + information) or influence (carrying **information**, use, money or meaning)
IV. Qualifiers (adjectival properties, adverbs) for specifying individuals from a class.
These points all together constitutes the elements of **linguistic modelling.**

3. Principle of change of state
The 3rd principle introduces the structure of change, both in accordance with **purpose** and by **chance** in the natural, technical and living [individual and social] spheres.

4. Principle of hierarchy
The 4th principle outlines how hierarchy can be understood and modelled showing how **complexity** is related to new, **emergent** properties of **aggregates.** The part of **information** flow plays in 'organisational hierarchy' is considered.

Elements	**Function in a sentence**	**Function in linguistic modelling**
Nouns	Subject, Direct and indirect objects	Topic or chosen object **initiating** or **affected** objects
Verbs	Stative verb – being Dynamic verb – action, event	**Relations** **Interactions**
Adjectives	Qualifiers of nouns	**Properties**
Adverbs	Qualifiers of verbs	**Adverbials** of manner, place etc
Conjunctions	Joining words, clauses to create arguments, symbolic logic	Relations, connectives AND, OR

Figure 5. Isomorphism between natural language and invariants of systems science

5. Principle of synthesis or design as part of problem solving
The 5th principle suggests the idea of **universality of problem solving** activity in the living sphere. 'Systems science' acts as knowledge base in design aiding development of 'models of **prototypes**' of 'products and systems'. The basic structure of 'problem solving' activity is shown in Fig.6. which valid even for 'wicked problems' [Rittel, Webber, 1973].

6. Principle of ideas
The 6th principle asserts the role of **ideas** in generating policies, desires, inventions, intentions which may serve as **objectives** in the operation of 'purposive systems'. This principle has been included to act as the '5th cause of Aristotle' [Korn, 2016] which with the other four comprise the basis of the **three cultures** [Lewin, 1981].

5.2 Logic of systems science

According to the 1st principle, the 'structural or systemic view' is **universal** which implies
1. That it has a **single** domain of the inanimate natural, living and artificial spheres and it is indivisible and empirical,
2. Which is followed by a **single** scheme for describing activities

(management)/PRODUCERS – PRODUCT – USER/Consumer 3.

acting as the subject of **analysis** as in Figs.7.,8. or the object of **design** [model of prototype] with 'Management' in brackets becomes null in case of inanimate, non purposive structures or systems,
3. And eq.3. is modelled by the **single** method of **linguistic modelling** of combination of elementary constituents so as to result, or not, in **matching** the **product** to **User/consumer** in accordance with 'requisite variety' or controllability [Nise, 2008, Korn, 2016].

These points suggest the notion of General Systems Theory [Bertalanffy, 1950].

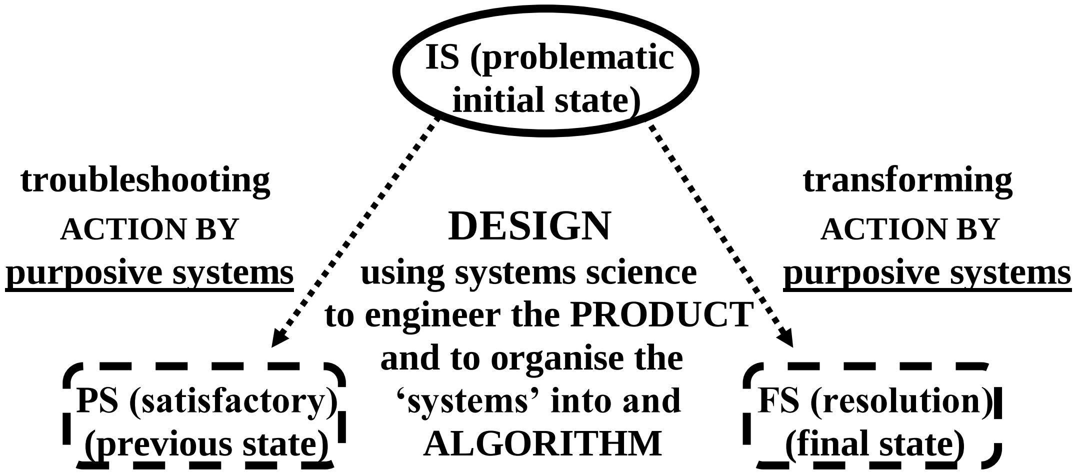

Figure 6. Structure of problem solving

6.0 Examples

The first, simple example using 'linguistic modelling' as referred to in the '2nd principle' demonstrates how conventional and systems sciences are integrated in a single framework of **systems theory** pointing towards a **unification of science**. Conventional science is interested in properties and their relations of single objects and enters systems science at the object level.

This example is followed by a more complicated example to show how **information systems** can be modelled as part of systems theory following the pattern set by the first example. As asserted under 'Logic of systems science' there is a single means of modelling resulting in a **syntax** of a scenario which can be filled with more than one **semantic** content. An IS as a semantic content is recognised by :

1. Information is carried as adverbial qualifier by dynamic verbs as mentioned in
'2. Principle of analysis' [Korn, 2009, 2016], and
2. Objects or agents in a scenario seen as IS must be capable of sending/receiving and interpreting information. Animate objects or inanimate objects like an 'amplifier' qualify.

1st example : The **story** or narrative of scenario is 'A railway engine when operating in a shunting yard, pushes as directed a single carriage with mass of 10000 kg subject to friction between the wheels and rails with coefficient 2500 Ns/m. We need to find out the force required to achieve a steady state speed of the carriage of 1.2 m/s'.

The procedure for solving this mechanical engineering problem which comes under Methodology of design I. [Korn, 2016] is as follows :

The semantic diagram without linguistic analysis is given in Fig.7. with eq.3.

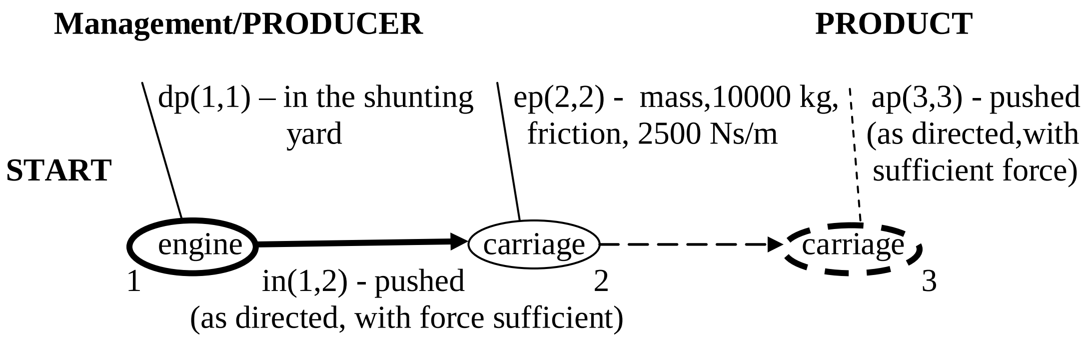

Figure 7. Semantic diagram of engine/carriage scenario

The 'ordered pair' ($n_{3,4}$) from Fig.7. is written as [Korn, 2016] :

At ap(3,3)
$n_{3,4}$ = [mass = 10000 kg, friction = 2500 Ns/m] carriage (pushed [as directed] with) force [sufficient]

from which the 'input/output' relation can be written as [Korn, 2016]
output = **state** [mass = 10000 kg, friction = 2500 Ns/m] times **input** [carriage (pushed [as directed] with)] sufficient force

which is derived from the ordered pair with the state of the object [carriage] in the first square bracket (ep(2,2)) related to the input through the operator 'times' in the second square brackets (ap(3,3)).

Thus, the output or relation between state and input according to conventional science is given by the differential equation

(10000 dv/dt + 2500 v = force), where v – speed of carriage and from which in steady state we have : the required force = 1.2 x 2500 = 3000 N.

2nd example : The following **story** describes a scenario 'John was fed up with his job so he wrote a letter to his boss saying that he, a high wages man, resigns unwillingly from the company with good working conditions. He sent the letter to the boss'. The procedure set by 'linguistic modelling' is followed :

1. Homogeneous language of context free sentences ---
John wrote a letter
John sent the letter

which are obtained from 'linguistic analysis' of the story.

2. Adjectival qualifiers with grading ---
dp(1,1) – fedup (very, just) [so he has in mind to write a letter to boss]
dp(6,6) – interested in john (yes, no)
ep(1,1) – able to evaluate (yes, no)
ep(2,2) – addressed to boss

ep(6,6) – with varied mentality

3. Semantic diagram ---
Shown in Fig.8.

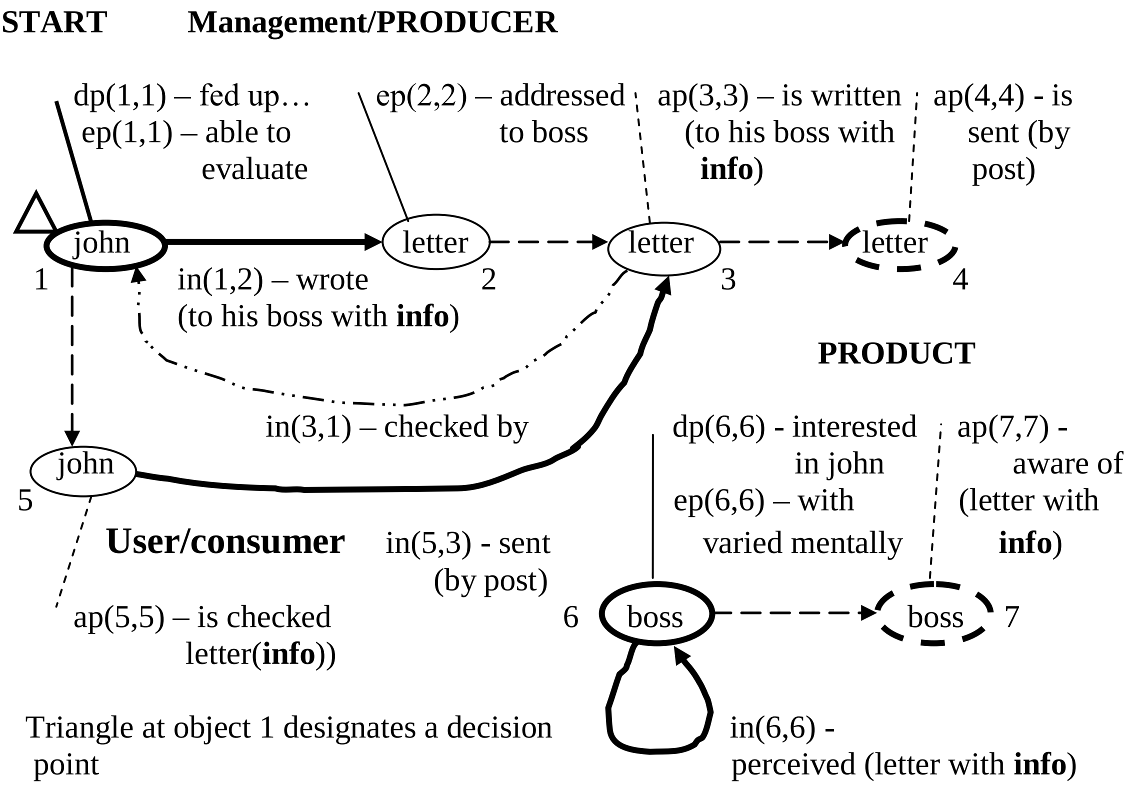

Figure 8. Semantic diagram of john scenario

4. Interactions with adverbial qualifiers ---
in(1,2) – wrote (to his boss with **info**)
in(3,1) – checked by feedback link
in(5,3) – sent (by post)
in(6,6) – perceived (letter with **info**)

where in(3,1) and in(6,6) are introduced from demands of the semantic diagram.

Quantity of information [included here as information is carried as adverbial qualifier of interactions] ---
This is considered under heading 'Interactions with….' because information is carried as adverbial qualifier. Fig.9. represents the information as the subordinate clause in the first sentence of the story and carried by the 'letter' [Korn, 2009]. The qualifiers of the constituents in the sentence are expanded to provide variation to 'semantic' information.

Probability in each column in Fig.9. or probability that a sentence element is to be found in level 1 AND level 2 AND ….

p = .5 p = .5 p = .5

Probability of any unbiased sentence is the product of these probabilities since qualifiers in the 1st AND 2nd AND 3rd etc columns must occur together. The quantity of information in the set of sentences, if each is equally likely, is given by :

$$I = \Sigma(\log_2(1/p_i)) = 1 + 1 + 1 = 3 \text{ bits} \qquad 4.$$

john	resigns	from company	(context - free sentence)
↓	↓	↓	
1	2	3	
high wages low wages p = .5	unwillingly willingly p = .5	good working conditions poor working conditions p = .5	LEVEL 1
	in 1 week in 2 weeks p = .5		LEVEL 2

Figure 9. Diagram of information in 'john/company' example

Alternatively, we introduce a notation to designate the three sets of qualifiers as shown in LEVEL 1 in Fig.9. as follows

X = {A(hw), B(lw)}, Y = {C(uw), D(wi)}, Z = {E(gwc), F(pwc)} from which we generate the ensemble by expanding the sets using Cartesian product [Korn, 2009] with 2 x 2 x 2 = 8 items to obtain

ACE, ACF, ADE, ADF BCE, BCF, BDE, BDF 5.

For example, the first term in eq.5. says : 'john who is a high wages man, is unwilling to resign from the company with good working conditions'. Eq.5. is the **ensemble** in which the quantity of information equals $\log_2 8$ = 3 bits from eq.4. since any one of the terms can occur with equal probability, p = 0.125.

In Fig.9. we have w(1week), x(2 weeks) so we expand Y = {C(uw1 uw2), D(wi1, wi2)} which when inserted into eq.5. gives 2 x 4 x 2 = 16 items in the ensemble and from eq.4. we have I = $\log_2 16$ = 4 bits.

We note the increase of the **quantity** of information due to the vertical expansion of the second column in Fig.9. which is in direction of increasing precision or **informatic content.**

Consequently eq.5. is modified into

AC1E, AC2E, AC1F, AC2F, AD1E, AD2E, AD1F, AD2F 6.

BC1E, BC2E, BC1F, BC2F, BD1E, BD2E, BD1F, BD2F

from which the first term can be read :

AC1E = ‘john who is a high wages man unwillingly resigns in 1 week from the company with good working conditions’,

and the last term means : 7.

BD2F = ‘john who is on low wages willingly resigns in 2 weeks from the company with poor working conditions’.

5. Logic sequences/topology of scenario ---
From the semantic diagram in Fig.8., Causal chains = **1.** 4, 3, 2, 1 **2.** 5, 1 **3.** 7, 6

For causal chain 1.

dp(1,1) → in(1,2(info))
in(1,2(info)) ∧ ep(2,2) → **ap(3,3(written with info)) [in 20 min]**

which says in words without ‘certainty factors’ for variation of qualifiers [Durkin, 1994, Korn, 2009] :

‘If john was fed up with his job then he wrote a letter with **info** to his boss’
‘If he wrote a letter with **info** to his boss and the letter was addressed to the boss then the letter with **info** was written to the boss.’

At ap(3,3)
$n_{3,10}$ = [addressed to boss] letter (is written [with **info** to his]) boss

from which :
output = **state** [addressed to boss] times **input** [letter (is written [with **info** to his]) boss]

which says that ‘letter is addressed to boss’ and [letter is written to boss] which are consistent but indicates no **output.** So to progress along the causal chain, an interaction, in(5,3), to prompt further propagation of state, has to be generated by a not yet known ‘acquired property’, ‘ap(5,5)’.

ap(5,5(checked with info)) → in(5,3(info)) ap(5,5) is not yet known
in(5,3) ∧ ap(3,3) → **ap(4,4(with info in post)) [in 35 min]**

This operation is common when activity such as change of state from object 3 to 4 is subject to another activity such as change of state from object 1 to 5. The operation is repeated for further such activities when object 4 undergoes further changes of state [Korn, 2009].

For causal chain 2.

ap(3,3(with infor)) → in(3,1) information feedback path
in(3,1) ∧ ep(1,1) ∧ cp(1,1) → **ap(5,5(checked with info)) [in 10 min]** ap(5,5) is known

where state of object 3 prompts object 1 through in(3,1) to check its state as information feedback since the ‘encoded letter is observable’ leading to decision by ‘john’ signalled by ‘triangle’ : ‘to send the letter by post’, (in(5,3)) [Korn, 2016]. The decision is subject to there being a difference between ‘john’s state of mind [objective of the purposive system] and actual state of ‘letter’ carried by feedback path’ as follows

cp(1,1) = cp(dp(1,1) – in(3,1))

At ap(5,5(checked with info))
$n_{5,11}$ = [able to evaluate] john (has checked) letter [written to his boss with **info**]

from which :
output = **state** [able to evaluate] times **input**[john (has checked) letter [written to his boss with **info**]]

which says that ‘john is able to evaluate’ and ‘john has letter written to his boss with **info**’ and **presumably** he finds ‘the letter’ satisfactory so there is interaction ‘in(5,3)’ which then prompts change of state of ‘letter’ at 3 to ‘letter’ at 4 to complete causal chain 1.

For causal chain 3.

dp(6,6) → in(6,6(letter with info))
in(6,6(letter with info)) ∧ ep(6,6) → **ap(7,7(letter with info)) [in 20 min]**

At ap(7,7(letter with info))
$n_{7,12}$ = [with varied mentality] boss (aware of) letter [with **info**]

from which

output = **state** [boss with varied mentality] times **input** [boss (aware of) letter [with **info**]] 8.

saying that ‘boss with varied mentality’ and ‘he/she is aware of the letter with **info**’ so for an **output** to exist or for the ‘boss’ to respond the relation between ‘state’ and ‘input’ needs to be examined in the light of varying information as shown in eq.7.

The expression for the **output** at ap(7,7) in eq.8. allows to estimate or to explore the behaviour or response of an animal or human, in this case the ‘boss’ with varying character or different humans of given characters the response to varying **input**. Variation of ‘**info**’ is given by eq.6. and its two extreme cases are expanded in eq.7.

This question has been considered in [Korn, 2009]. Here we expand eq.8. into the scheme :

Object : boss
State [Potential feature = with varied mentality] : gentle, understanding
Input [Circumstances] : is confronted by a number of ‘letters’ with different content of which he/she may have to select one
Output [Predicted feature] : considers sympathetically [rather than being angry] the varying cases as described by the ‘letters (info)’.

Using eq.7. particular cases of eq.8. or the scheme :

Object : boss
State : gentle, understanding
Input : letter with info ‘AC1E = John who is a high wages man unwillingly resigns in 1 week from the company with good working conditions’
Output : boss understands John’s predicaments and probably accepts resignation.

Or with Input = BD2F, ‘boss definitely accepts John’s resignation’

6. Logic sequences with graded adjectives/data for ‘cf’
In this section the effect of uncertainty and grading of qualifiers on the propagation of state is introduced [Durkin, 1994, Korn, 2009].

For causal chain 1.

dp(john, 1,1, (fed (very, 90/.9, just, 80/.5)))(.9, .5) →
(1)in(wrote, john,1, let(info), 2, (boss (with**info**)))(.9, .5)

in(wrote, john,1, let(info), 2, (boss (with**info**)))(.9, .5) ∧
ep(let(**info**), 2, 2, (ad (boss, 100/1))) →
(1)**ap(let(info),3,3,** (written (toboss)))(.9, .5) **[in 20 min]**

where propagation of certainty factors is worked out from relation in [Korn, 2009].

Since ‘ap(3,3)’ is now known, we go to **Causal chain 2.** to obtain ‘ap(5,5)’ to prompt ‘in(5,3)’ which causes change from ‘ap(3,3)’ to ‘ap(4,4)’ to complete **Causal chain 1.**

ap(let(**info**),3,3, (written (toboss)))(.9, .5) →
(1)in(checked,let(**info**),3,john,1, (let(**info**)(byjohn))) (.9,.5)

in(checked,let(**info**),3,john,1,(let(**info**)(byjohn))) (.9,.5) ∧
ep(john,1,1, (eva(able,yes,80/.7, no,80/.2)))(.7,.2,..7,.2) ∧
cp(john,1,1, (diff(dp(1,1) – in(3,1),100/1))) ∧ cp(john,1,1, (cf(cf >.5),100/1))) →
(1)**ap(john,5,5,** (checked(let(**info**))))(.7,.7) **[in 10 min]**

where the 1st ‘cd’ works out the difference and the 2nd prevents further propagation of states with ‘cf’ less than 0.5.

Causal chain 2. is now complete so we return to **Causal chain 1.** to complete it

ap(john,5,5, (checked(letter(**info**))))(.7,.7) →
(1)in(sent, john,5,let(**info**),3, (toboss(by post)))(.7,.7)

in(sent, john,5,letter(**info**),3, (toboss(by post)))(.7,.7) ∧
ap(let(**info**),3,3, (written (toboss)))(.9, .5) →
(1)**ap(letter(info),4,4,** (sent(bypost)))(.7,.5,.7,.5) **[in 35 min]**

which completes the predicate logic sequences along **Causal chain 1.** with uncertainty varying from ‘may be’ to ‘probably’.

For causal chain 3.

dp(boss,6,6, (john(int,yes,100/.8,no,20/.4)))(.8,.4) →
(1)in(perceived,boss,6, boss,6, (let(**info**)(well)))(.8,.4)

in(perceived,boss,6, boss,6, (**let(info**)(well)))(.8,.4) ∧
ep(boss,6,6, (ment(varied,100/1)))(.8,.4) →
(1)**ap(boss,7,7,** (aware(let(**info**))))(.8,.4,.4,.4) **[in 20 min]**

which completes the predicate logic sequences from Fig.8. The 'cf' values in 'ap' mean that the 'boss' becomes aware of the 'letter(**info**)' depending on his/her interest being 'almost certain' or just 'may be'.

6.1 Discussion of the example

Fig.8. shows the propagation of state carrying information encoded in a medium 'letter', it may be called an 'information system'. The propagation leads to 'product' which should be such as to match the requirements or needs of the User/consumer.

Aspects of conventional science enter at the 'product' stage. Thus, in general we have systems science which includes conventional science at the level of 'qualifiers' of objects as the state of objects propagates.

This example demonstrates how selective and semantic information suggesting a unified approach to information theory, are used as integral part of dynamic linguistic modelling [Korn, 2009]. We note that the vertical expansion in Fig.9. towards more precision increases the quantity of information because as precision of information increases the probability of an object finding itself in a precisely defined state decreases. This results in decrease of probability in eq.3. leading to increased quantity of information or 'informatic content' of a message. The higher the quantity of information the easier is to execute a given message. When there is no variation of qualifiers, the quantity of information is zero because the **logarithm of 1** is zero or the probability is one i.e. certainty.

The method of handling information leads to a wide choice of information available to a living thing for further action. This is not the case when dealing with inanimate objects as shown in Fig.7. which will 'obey' a 'law of nature'.

We have shown two methods for working out quantity of information, eqs.4.,5., giving the same results but without their generalisation [Korn, 2010]. The method outlined here yields both, quantity and meaning of information towards increasing i**nformatic content** as shown in Fig.9. going in downward direction.

We note that the 'boss' can be exposed to a large variation of information. His/her response can be assessed when we know his/her relevant character traits or properties as demonstrated above. This leads to an information design type of problem similar to the scenario depicted in Fig.8. in which the characteristics of the changing object are known or can be assessed and we construct the information so as to try to achieve a particular response. In other words information flow can be varied in accordance with **requirements** for changing mental states. For example, when someone is applying for a job, the letter of application needs to be composed so as to achieve a favourite outcome. The same approach is applicable to problems with 'energy flow' for changing physical states as we see in the problem in Fig.8. [Korn, 2009, 2012].

The involvement of **personality traits** or characteristics in estimating the likely response of living in particular human beings to information or impression input extends the scope for research in the field of 'information systems' to psychology. It is a question of **matching** a 'product' to a 'User/consumer' as suggested by eq.3. which is 'john' indicated in Fig.8.

7.0 Conclusions

The 'description of IS' given in the INTRODUCTION assuming it is still currently acceptable, together with the extensive use of computers and high technology has aided the restricted application of IS. IS has been in use since living things in particular humanity came into existence, as part of purposive operation in aid of survival, fulfilment of ambitions and furthering innovations for convenience, entertainment, knowledge and so on. In general, IS serve for attempting to accomplish **mental** change of state as opposed to energetic systems intended for changing **physical** change of state united in the framework of purposive systems [Korn, 2010]. Extension of application IS and locating it in the field of human intellectual endeavour requires a new theoretical framework termed here 'systems science'. This paper has outlined a method for how perhaps this can be done when IS are integrated into this framework.

The topic presented here needs debate regarding its acceptability and, if successful, investment in software development for the computation of dynamics and application to practical problems. The topic may also stimulate further research.

References

Anon., (2016) *Information systems*, Wikipedia, Google.
Bertalanffy von, L. (1950) *An outline of general systems theory*, The British J for the Philosophy of Science, 1(2).
Burton, S. H. (1984) *Mastering English grammar*, Macmillan, London.
Durkin, J. (1994) *Expert systems*, Macmillan, NY.
Floridi, L. (2010) *Information, A very short introduction*, Oxford UP, Oxford.
Flynn, D. J. (1998) *Information systems requirements*, McGraw Hill, London.
Jackson, M. C. (2000) *Systems approaches to management*, Kluwer Academic, NY.
Hazen, H. L. (1934) *Theory of servomechanisms*, J of the Franklin Inst, v218, n3.
Korn, J. (1994) *Fundamental problems in engineering degree courses*, European J of Engineering Education, v19, n2.
Korn, J. (2009) *Science and design of systems*, Troubador Publishing, Leicester.
Korn, J. (2010) *Concept and design of information and IS*, UKAIS Conf., 24/25 March, Oxford.
Korn, J. (2012) *Network modelling of engineering systems*, Troubador Publishing, Leicester.
Korn, J. (2013) *Linguistic modelling of scenarios*, Troubador Publishing, Leicester.
Korn, J. (2015) *Paradigm change from the systemic view to systems science*, Int J of Systems and Society, v2, n1.
Korn, J. (2016) *Purpose of change is problem solving*, Troubador Publishing, Leicester.

Kuhn, Th. (1996) *The structure of scientific revolutions*, U of Chicago P, USA.
Lewin, D. (1981) *Engineering philosophy-The third culture*, Proc of the J of the Royal Soc of Arts, September.
Magee, B. (1985) *Popper*, Fontana Press, London.
Nise, N. S. (2008) *Control systems engineering*, Wiley, Chichester.
Nyquist, H. (1924*) Certain factors affecting telegraph speed*, Bell System Technical J.
Rittel, H. W., Webber, M. M. (1973*) Dilemmas in a general theory of planning*, Policy Sciences, 4., 155 – 169.