PARADIGM CHANGE FROM THE SYSTEMIC VIEW TO SYSTEMS SCIENCE :

THROUGH LINGUISTIC MODELLING

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FORMULATION OF THE 'PROBLEM'

THE SYSTEMS PHENOMENON
Everyday usage : referring to anything that looks 'complex'...... 'systemic view',

Usage in science, arts : History of use, solar system, systems of rigid bodies, systems of differential equations, a word [a system of letters], mathematical model [a system of symbols], painting [a systems of colours, shapes], system of thought and so on,
24 definition of the term 'system' [Klir, 1969]

Technical use : control of position, speed, processes, manufacture

DEALING WITH THE PHENOMENON
2nd WW [servomechanisms] and after....

Control systems : linear control theory, control engineering....
General Systems Theory, Operational research, Cybernetics [Ashby...], System dynamics [Forrester...], Systems thinking, Systems science, Complex systems....
Systems engineering, information systems, management systems, systems theory...

Brief historical development of the 'systemic or structural view' due to von Bertalanffy, Boulding, Beer, Checkland….. shows the strands of the vast range of topics :

1. Descriptive SPECULATIVE approaches
2. Methods of modelling [viable systems model, agent based..], systems tools [influence diagrams]…..
3, Design flavour [Banathy….., soft systems methodology….]
4. Philosophical trends [Jackson, 2000]
5. Control theory has not fitted into teaching schemes [Finniston, 1980…]

CONCLUSIONS

1. Any structure appears to have an emergent OUTCOME : energy flow, information flow [impression of meaning [beauty, words…], use (their subjective interpretations)] leading to change of state [FUNCTIONALITY of PRODUCT !!!!],
2. Either STATIC or DYNAMIC structures : Generality of the structural view ????
3. Remark 1. Following Newton's 1st law : No change of state expressed as a property can take place by itself. ACTION for execution of a CAUSE is required for the accomplishment of a CHANGE arising either by 'chance' or in accordance with a 'purpose' and is subject to WILL in case of living beings ???
4. Static structures exist as a result of CHANGE OF STATE by action or activities, Dynamic structures or agents in activity bring about the CHANGE OF STATE

PROBLEMATIC ISSUES

1. Speculative views, although 'systems' is an empirical phenomenon negligible attention to tests by experience has been paid but useful for generating ideas
2. Fragmentation
3. Lack of fundamentals
4. Lack of 'discipline' character
5. Out of context with other views of parts of the world
6. Vague, impossible <u>to read</u> diagrams, multitude of models without theoretical basis, computer simulations ???????
7. Lack of integration of control theory into framework of the 'systemic view'
8. Lack of integration of the 'systemic view' into branches of existing knowledge
9. Lack of basis in branches of existing knowledge
10. Possible difficulties in teaching [due to speculative nature, lack of symbolism...], no teaching at school level
11. Chemistry and nuclear physics should be a part of 'systems science'

1. Current SYSTEMIC VIEW has these problematic issues, and
2. For all its generality has not been able to exert influence in <u>society</u> and <u>education</u>.

Perhaps a <u>PARADIGM CHANGE</u> will alleviate 1. and facilitate 2. ??? However, the intention is <u>to supplement</u> current views and <u>to debate</u> the ANOMALY between the universality of the systemic view and the multitude of views ????

           OBJECTIVE : TO INTRODUCE PARADIGM CHANGE !!!!!
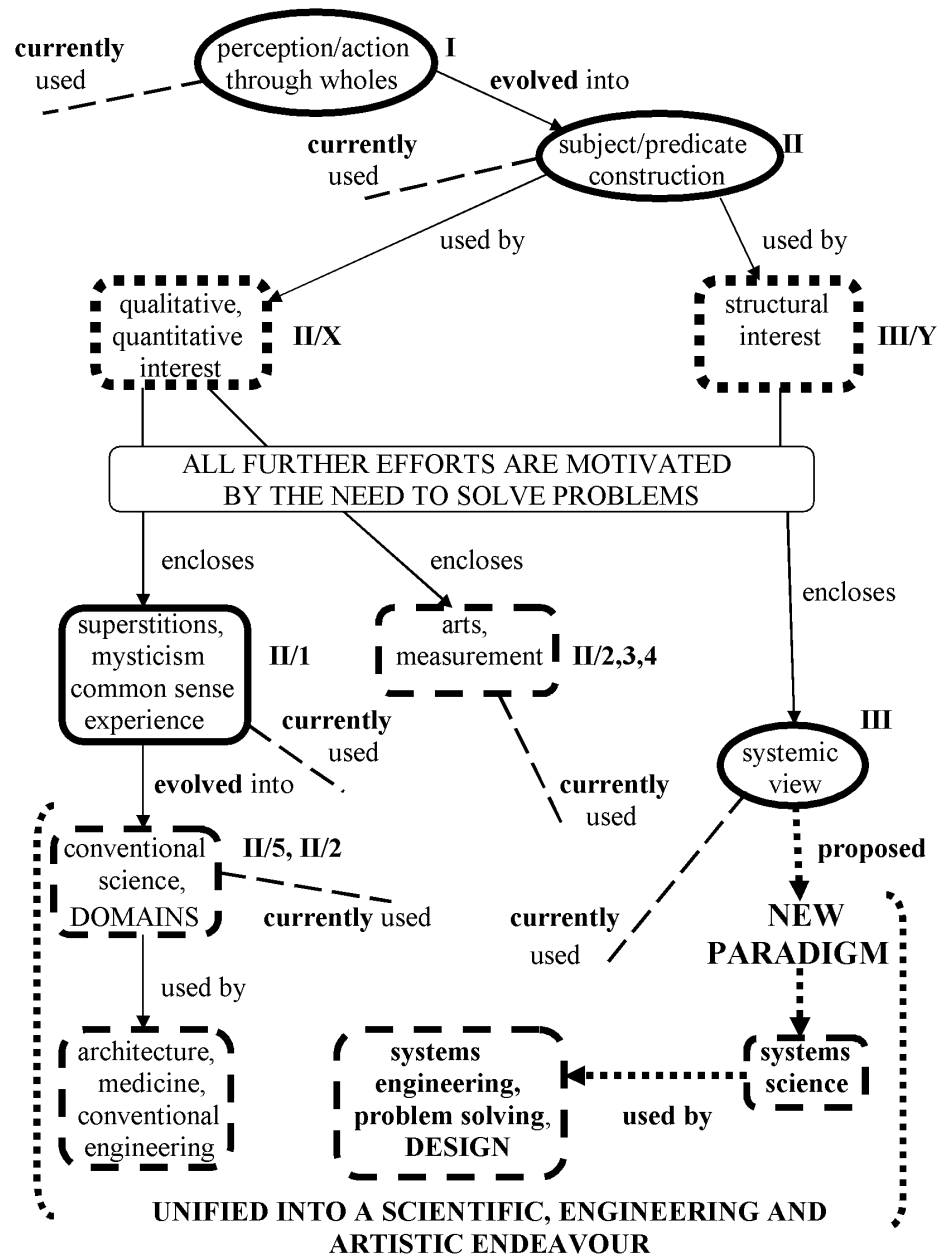
THE 'SYSTEMIC VIEW' IN CONTEXT

currently used

perception/action through wholes I

evolved into

currently used

subject/predicate construction II

used by

used by

qualitative, quantitative interest **II/X**

structural interest **III/Y**

ALL FURTHER EFFORTS ARE MOTIVATED BY THE NEED TO SOLVE PROBLEMS

encloses

encloses

encloses

superstitions, mysticism common sense experience **II/1**

arts, measurement **II/2,3,4**

systemic view **III**

currently used

currently used

evolved into

proposed

conventional science, DOMAINS **II/5, II/2**

currently used

currently used

NEW PARADIGM

used by

architecture, medicine, conventional engineering

systems engineering, problem solving, DESIGN

systems science

used by

UNIFIED INTO A SCIENTIFIC, ENGINEERING AND ARTISTIC ENDEAVOUR

Fig.1. Diagram of constituents of human intellectual endeavour

POBLEM SOLVING

IS (problematic) (initial state)

troubleshooting
ACTION BY
purposive systems

DESIGN
(systems science)

transforming
ACTION BY
purposive systems

PS (satisfactory) (previous state)
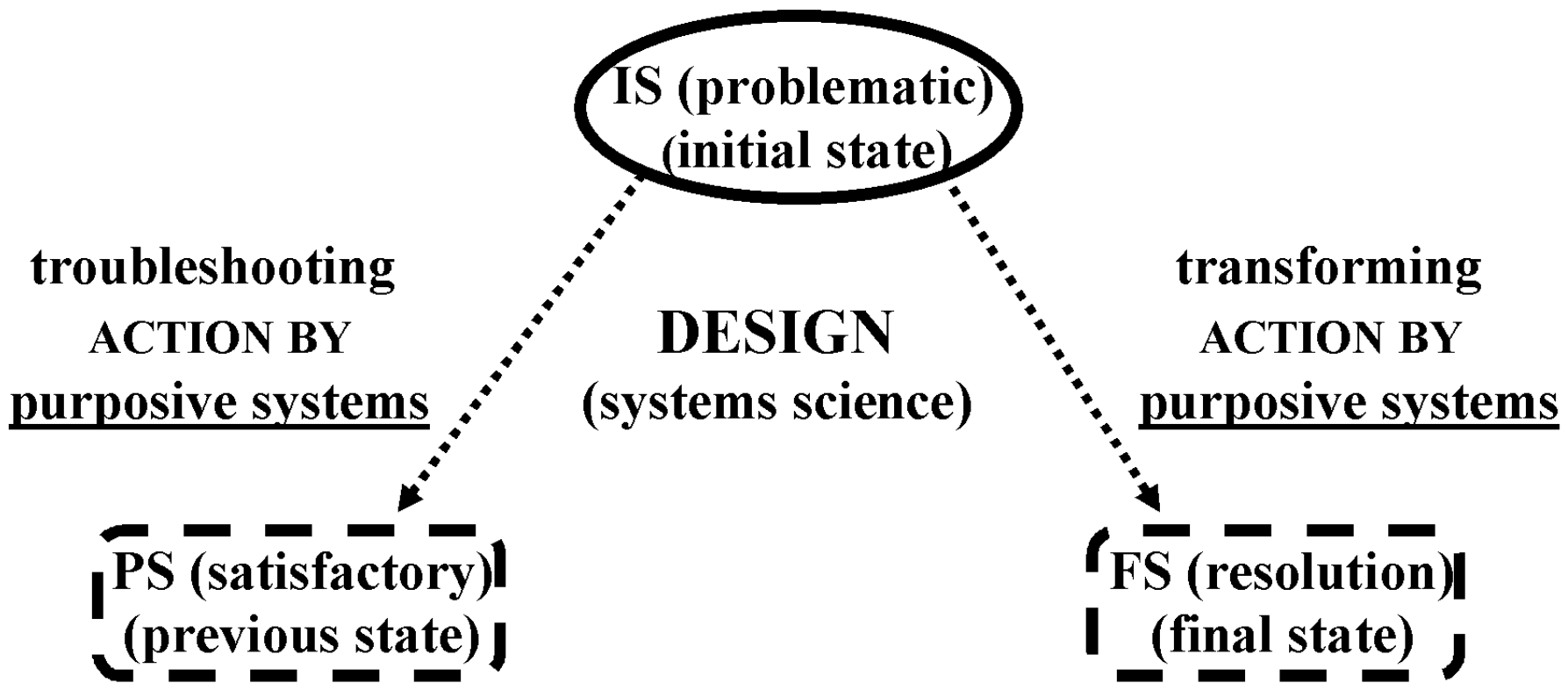
FS (resolution) (final state)

Fig.2. Structure of problem solving

Remark 2. The world may be seen as a conglomeration of **related** OR **interacting** things and ideas in static or dynamic state respectively **any chosen part** of which may be regarded by a living in particular human being as a candidate for change. Thus, an **object** to be **changed** (concrete (chair) or abstract (transparency (of the window))) can be selected with features any of which is perceived to fail to fit an **expectation** and as such is regarded to be in a **problematic initial state**.

1. Problem solving in the living sphere is as common as gravity is in the material sphere !!!!!!
2. Possibility of <u>unlimited change</u> is the basis of innovation….

Remark 3. Based on the formal structure of Fig.2. **any change may be seen as a process of problem solving although an IS may not be perceived as problematic through any of its physical, mental or emotive properties.**

Contribution of constituents of human intellectual endeavour to society through their characteristic features

Superstitions, mysticism, common sense knowledge, experience ---- [source of prediction of events of human interest (outcome of a battle)]

Fine arts, paintings, literally works ---- [pleasure, emotions…..]

Performing arts, music and dance ---- [pleasure, emotions…..]

Architecture, medicine, conventional engineering ---- [dwellings, offices, bridges, healing, artefacts ……]

Conventional science ---- [immense success in influence on life of people, animals, plants and on the environment and education, reliable knowledge of <u>WHAT</u>, explanatory, predictive statements, discoveries/invention of theories, devices ….]

Systemic view ---- [speculative views, generation of ideas, little if any reference to systematic exposure to experience, models difficult to use …..]

<u>Systems science</u> ---- [follow methodology of conventional science !!! hoped for reliable knowledge of <u>HOW</u>, continuity of the scientific enterprise, predictive statements, part of <u>PROBLEM SOLVING/DESIGN</u> (prototype model) ……. . achieved by

<u>PARADIGM CHANGE</u>]

Following its success, we adopt methodology of conventional science to generate systems science leading into <u>unity of the scientific endeavour</u> !!!!!

BASIC PROPOSITIONS OF 'SYSTEMS SCIENCE'

Construction of a view of parts of the world that may be described as 'scientific' needs one or more **'law-like statements'** of varying generality followed by a **'symbolism'** with 'invariants' organised into **hypothetical or conditional expressions** inclusive of models which enable these statements to be exposed to experience for the assessment of their **truth value**.

Examples : Archimedes [buoyancy, pressure, flow rate, crown of king Hieron], Newton [1st law, 2nd law, force, velicity], 1st and 2nd laws of thermodynamics [entropy flow, temperature]

For the 'structural view, we have :

A. A belief about the nature of parts of the world : 'The 'systemic view' of parts of the world is **pervasive, indivisible** and **empirical',**

B. Change of existence of parts of the world : 'Any part of the world can be seen to change as a result of activity by 'sets of objects in informatic and/or energetic interactions operating in an algorithm [the **producers**] intended to create or to destroy a physical, intellectual or emotive **product** the function of which is to induce changes in individuals (natural, artificial, living, social) [the **consumers**] for their benefit or otherwise'. Fig.3. is a diagrammatic representation of this statement.

C. View of existence of parts of the world : 'There is an agreed number and kind of parts or theoretical **objects** each with its own **qualifiers** AND these parts are connected into =
X. A static **structure** [recognised by qualified relations as stative **verbs**] to represent a part of the world or a state, OR
Y. A dynamic **structure** [recognised by qualified interactions as dynamic **verbs**] to represent activity.

The **symbolism** is based on 'processed natural language' derived from a 'story of a scenario' which is the most general means of representation and communication or a model. Meaning preserving linguistic **transformations** convert a story into **'basic constituents'** of one - and two – place sentences of which complex static or dynamic structures can be constructed in terms of **'ordered pairs'** or **'predicate logic statements'**. **Reductionism** is restored to the 'systemic view'.

9

Diagram of proposition B. :

initial state

final state

initial state

final state

product – – – – → product

used, consumed by

changing object (CO)

changing object

delivers

PRODUCER
PRODUCT
FEEDBACK LOOP

CONSUMER
OUTER FEEDBACK LOOP

feeds back current state of product (ps)

tool, appliance, aid

interaction of skilled power

feeds back current state of changing object (cs)

feeds back current state of tool (ts)

INNER FEEDBACK LOOP OF ALGORITHM

IO with AMPLIFIER

START

h((rt) – (ts))

instructs

agent 2

instructs

agent 1 B

instructs

agent 1 A

rp = f((rs) – (cs))

objective (rs)

rt = g((rp) – (ts))

reference of state of tool (rt)

rp – reference of product state
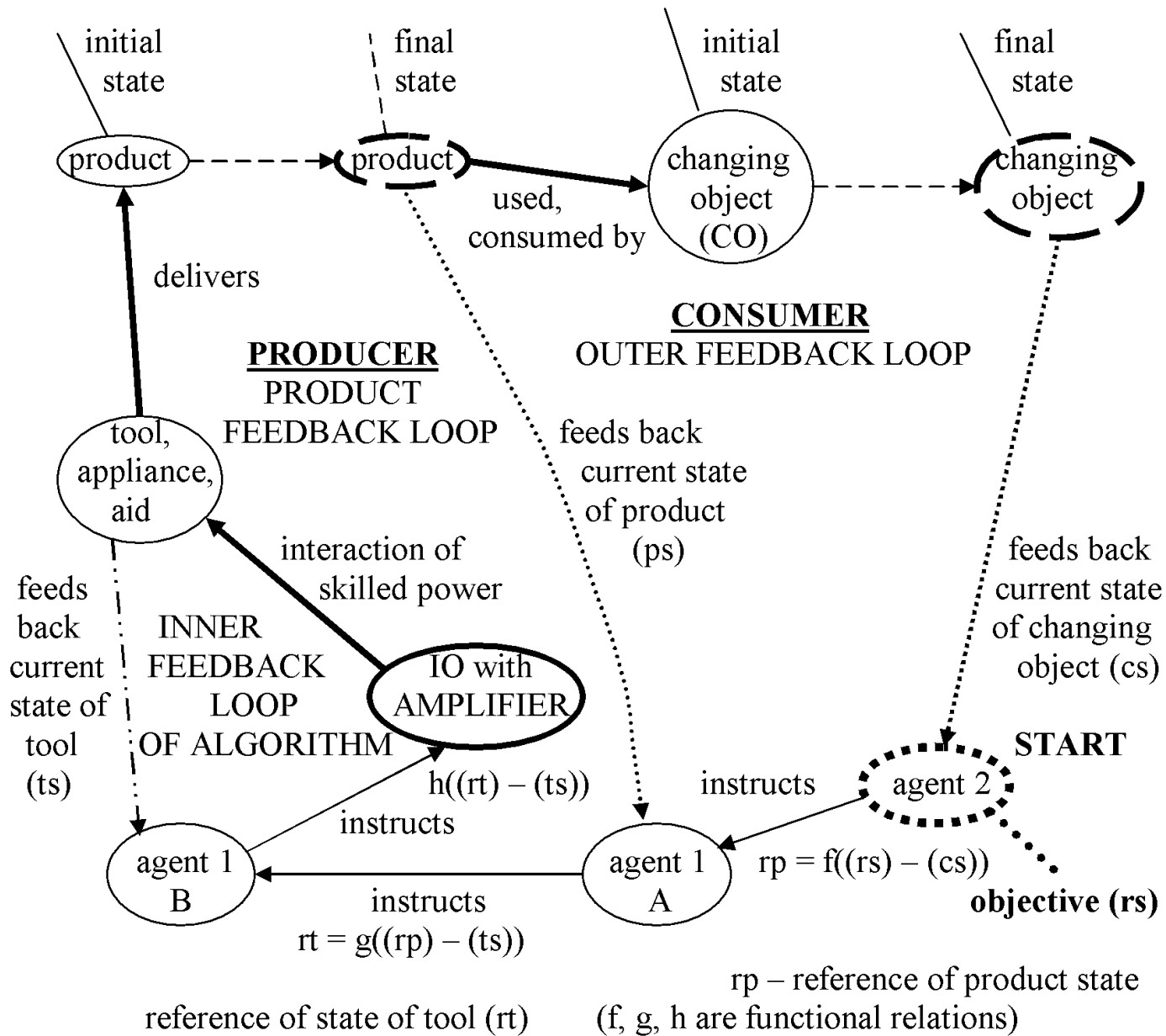(f, g, h are functional relations)

Fig.3. Diagram of production and consumption

From proposition C. :

Four invariants used for organised description of a scenario ---- I. Theoretical objects [functional elements][concrete, abstract, imaginary, symbolic], II. Relations, III. Interactions, IV. Qualifiers.

I. Class of objects or 'related pertinent properties'
II. Static state (produced by **relations** (stative verbs, spatial, kinship etc))
III. Dynamic state (created by **interactions** (physical power (carrying energy) or influence (carrying information or impression of meaning or use)),
IV. Qualifiers (adjectives [properties], adverbs) for selecting **individuals** from a class,

which all together form an entity or **whole** so as to be capable of producing, or not as the case may be, an 'outcome' [emergent **NOVELTY**] or change of **physical, mental or emotional** STATE affected by **topology, properties/qualifiers of objects [simulation].**

SYMBOLS ---

Natural language as **primary model** of **declarative sentences** or **stories/narratives**

Constituents	Function in a sentence as	Relationship to a part of the world
Nouns	Subject, Direct and indirect objects	Topic or chosen initiating or affected objects
Verbs	Stative verb – being Dynamic verb – action	Relations Interactions, impression
Adjectives	Qualifiers of nouns	Properties
Adverbs	Qualifiers of verbs	Adverbials of manner, time etc of action
Conjunctions	Joining words, clauses to create arguments, symbolic logic	Relations, complex scenarios

Fig.4. Isomorphism between natural language and invariants of systems science
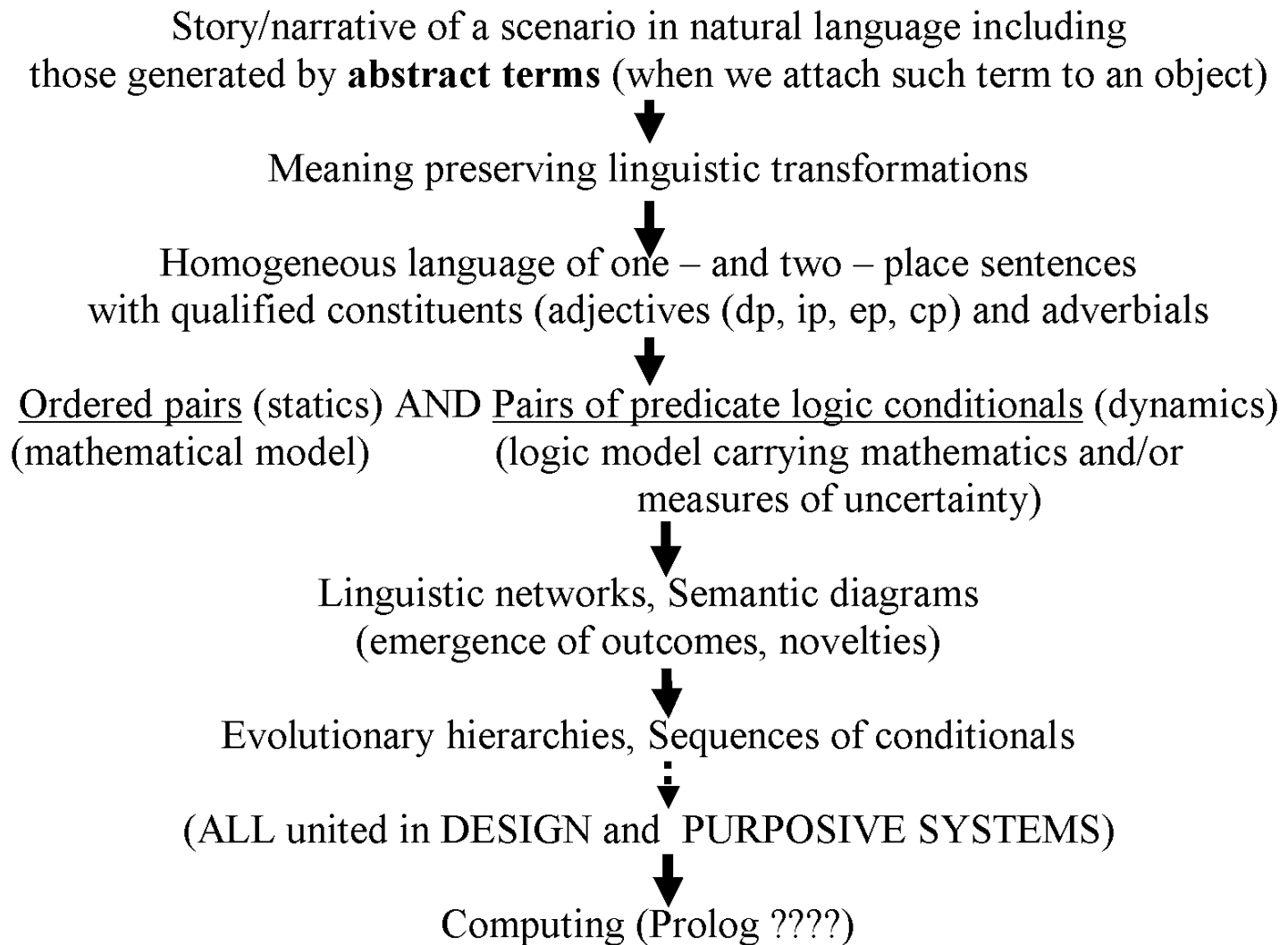
Story/narrative of a scenario in natural language including
those generated by **abstract terms** (when we attach such term to an object)

⬇

Meaning preserving linguistic transformations

⬇

Homogeneous language of one – and two – place sentences
with qualified constituents (adjectives (dp, ip, ep, cp) and adverbials

⬇

Ordered pairs (statics) AND Pairs of predicate logic conditionals (dynamics)
(mathematical model)   (logic model carrying mathematics and/or
                                        measures of uncertainty)

⬇

Linguistic networks, Semantic diagrams
(emergence of outcomes, novelties)

⬇

Evolutionary hierarchies, Sequences of conditionals
⋮
⬇

(ALL united in DESIGN and PURPOSIVE SYSTEMS)

⬇

Computing (Prolog ????)

Fig.5. Structure of linguistic modelling

1. **Ordered pairs** to carry objects and relations and their qualifiers (static state),
2. **Predicate logic conditionals** to carry objects and interactions and their qualifiers
leading to change of state (dynamic state)

ELEMENTARY CONSTITUENTS

Static linguistic modelling

ordered pairs $=$ (n_i rel$_i$, n_k)   2.2.

ordered
pair

a ——R——> b

a R b

reduced
ordered
pair

a R

a R a
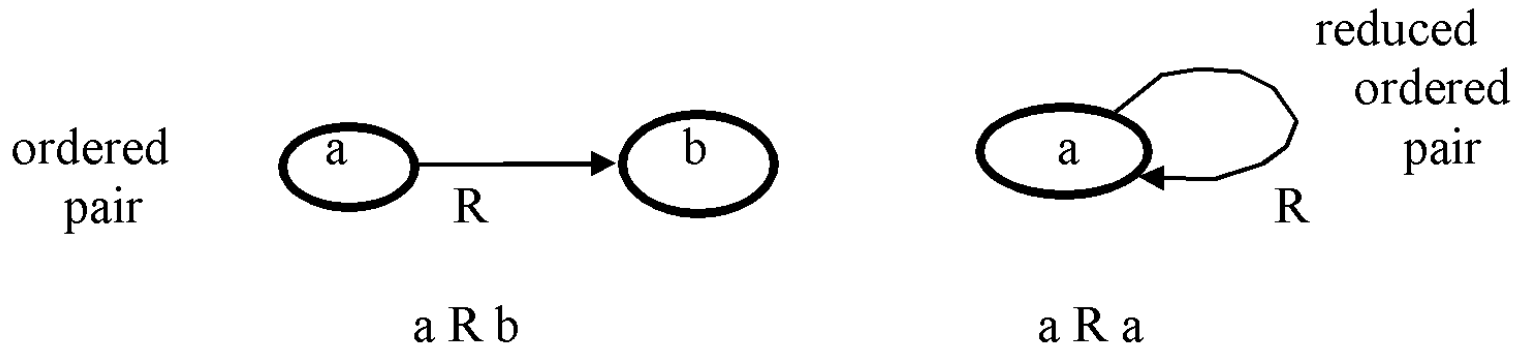
Vessel (contains) water [systems science]   Vessel (is deep) [conventional science]

Fig.6. Elementary graph or network representation of ordered pairs

Story : 'Top of the table is supported by legs which stand on the carpet' which is expressed as :

i = 1 = 'top (is supported by)', i = 2 = 'legs (stand on)' and i = 3 = 'carpet (is)'

$$
\begin{pmatrix}
\begin{array}{ccc}
n_{11} & n_{12} & n_{13} \\
0 & \underline{\text{top is supported by legs}} & \text{top is supported by carp} \\
n_{21} & n_{22} & n_{23} \\
\text{legs stand on top} & 0 & \underline{\text{legs stand on carp}} \\
n_{31} & n_{32} & n_{33} \\
\text{carp is top} & \text{carp is legs} & \underline{\text{carp is carp}}
\end{array}
\end{pmatrix}
\qquad 2.3.
$$

$$
\text{number of structural trees} = n^{(n-2)} \qquad 2.6.
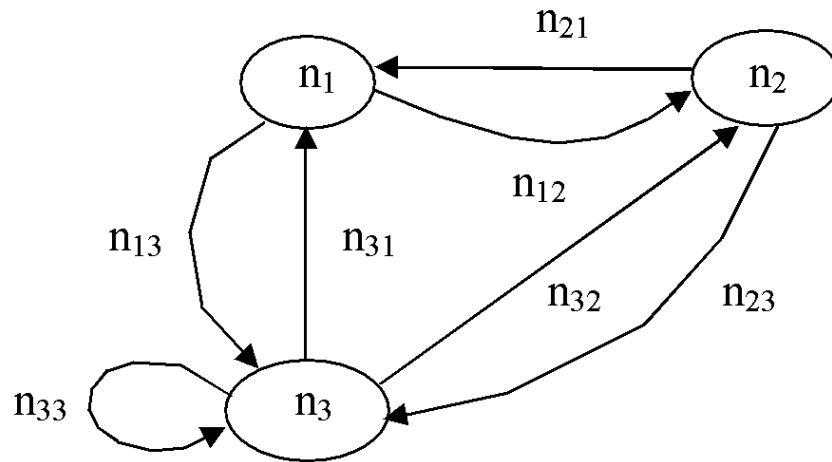$$

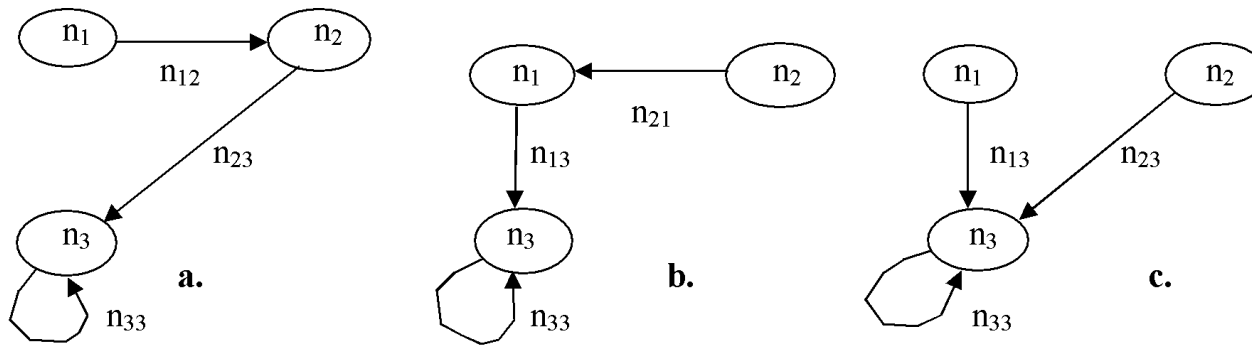
Fig.7. Directed graph representation of eq.2.3.

Fig.8. Trees from directed graph in Fig.7.

From Fig.8.a. we can write **:**

n_{12} = 'top is supported by legs'
n_{23} = 'legs stand on carpet'
n_{33} = 'is carpet'

Also, from b.

n_{21} = 'legs stand on top'
n_{13} = 'top is supported by carpet'
n_{33} = 'is carpet'

Also, from c.

n_{23} = 'legs stand on carpet''
n_{13} = 'top is supported by carpet'
n_{33} = 'is carpet'

$$n = 1 \; 2 \; 3 \; 4 \;\; 5 \ldots\ldots\ldots$$
$$\text{number of trees from eq.2.6.} = 0 \; 1 \; 3 \; 16 \; 125 \ldots\ldots..$$

Further developments

Hierarchy ⟶ to achieve complex **products** driven by **SURVIVAL, CONVENIENCE…**
leading to exploitation of the natural **ENVIRONMENT** and increased **WASTE**.

Dynamic linguistic modelling

Story : 'A number of trained and willing girls who needed money, looked for well paid and interesting jobs'

$$dp(1,1) \wedge ip(1,1) \rightarrow in(1,1) \quad \text{and} \quad in(1,1) \wedge ep(1,1) \rightarrow ap(2,2) \qquad 2.10.$$

To expand with uncertainty inserted for a **one – place** sentence shown in Fig.9. as a **semantic diagram** :

dp(ngirls,1,1,(needmon(badly,100/1.0))) (1.0) $\wedge$
ip(ngirls,1,1,(traid(vhigh,80/0.4, high,70/0.9, low,50/0.3), wilg(st,90/0.8, wk,40/0.5)))
(0.61, 0.43, 0.84, 0.75, 0.62, 0.39) $\rightarrow$

(cf of rule = 1, .8, .6, .4)in(lookedfor,ngirls,1,ngirls,1,
            (wellpaid(verywell,well),interesting(very,just))) 2.11.

dp(1,1) – needed money ap(2,2) – is engaged (in
ip(1,1) – trained, willing looking for well paid,
ep(1,1) - 0 interesting jobs)

OUTCOME !!
(if any ?)

initiating number time$_{12}$ number
and of of
affected girls girls
object 1 2

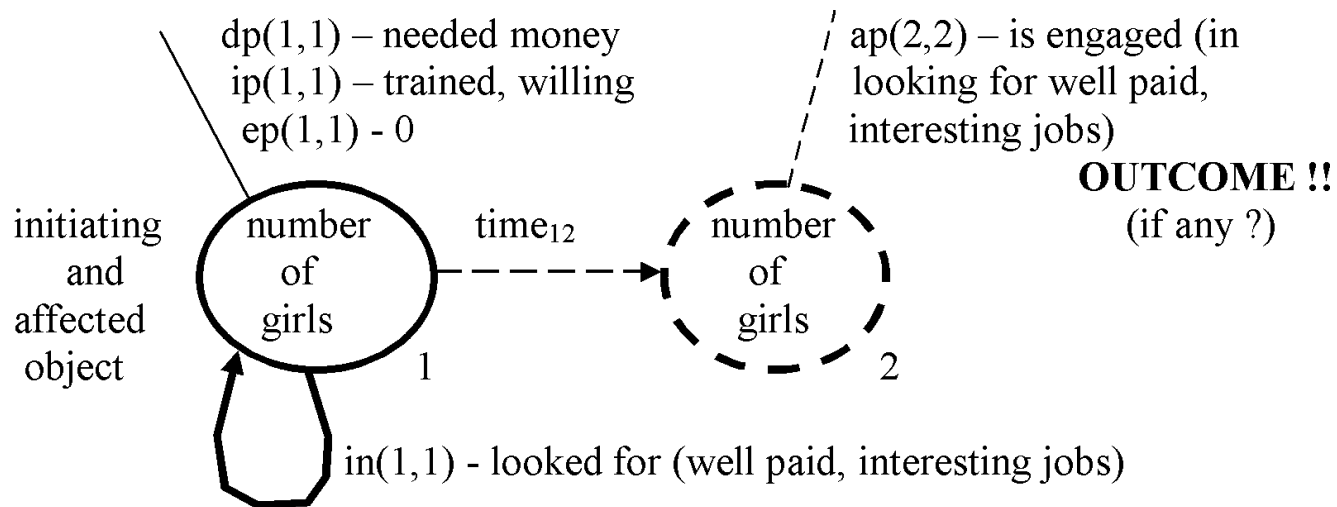in(1,1) - looked for (well paid, interesting jobs)

Fig.9. Semantic diagram of a one –place sentence

in(lokedfor,ngirls,1,ngirls,1,(wellpaid(verywell,well),interesting(very,just))) with 24 terms of cf values, 6 for each : ((verywell, very), (verywell, just), (well, very), (well, just)) $\rightarrow$

(1) ap(ngirls,2,2,(engagedinlookingfor (wellpaid, interestingjobs)))(with 24 terms of cf values, 6 for each : ((verywell, very), (verywell, just), (well, very), (well, just))   2.12.

A particular instance of eqs.2.11. and 2.12. chosen for demonstration is

dp(1,1) (1.0) $\wedge$ ip(1,1) (0.61) $\rightarrow$ (0.8) in(1,1) (0.8 x min(1.0, 0.61) = 0.49) for :
                                        (verywell, just)

in(1,1) (0.49) for : (verywell,just) $\rightarrow$ (1.0) ap(2,2) (1.0 x 0.49) = 0.49 for : (verywell, just)

Descriptively using the equivalence between 'uncertainty numbers' and 'words' [Durkin, 1994] :

'If there is a number of girls with (probably) <u>very high training</u> and <u>strong willingness</u> who <u>badly needed money</u> then (may be) they looked for <u>very well paid</u> and <u>just interesting job</u>'.

'If (may be) they looked for <u>very well paid</u> and <u>just interesting job</u> then they (may be) became engaged in looking for <u>very well paid</u> and <u>just interesting job</u>'

which display the objects, properties and their precise role in the scenario.

The semantic diagram representation of a **two – place** sentence is given in Fig.10. using the <u>**story :**</u> 'Postman with good eyesight, sense of duty and care for the job, sorts addressed letters according to code'.
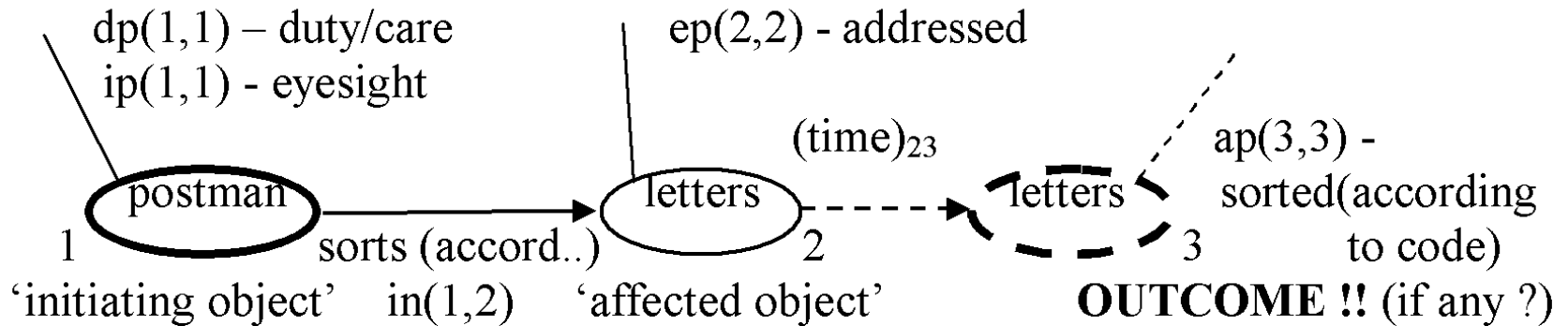
$dp(1,1)$ – duty/care
$ip(1,1)$ - eyesight

$ep(2,2)$ - addressed

$(time)_{23}$

$ap(3,3)$ - sorted(according to code)

postman

letters

letters

1

sorts (accord..)

2

3

'initiating object' $in(1,2)$ 'affected object'

OUTCOME !! (if any ?)

Fig.10. Semantic diagram of a two – place sentence

EXAMPLES OF APPLICATIONS OF 'SYSTEMS SCIENCE'

Scenarios of related objects

Concrete –
'There is an apple which appears to consists of core, edible meat, pips and stem covered by smooth skin. They are spatially related.'

Parts of the sentence can be seen to form a pattern :
Parts = pips, core, meat, (smooth) skin, stem,
Apple as a structure = pips (sit inside) core,
                  core (is inside) meat [edible],
                  (smooth) skin (covers) meat [edible],
                  stem (is attached to) core,
                  [edible] meat (surrounds) core,
Outcome (if any) = emergence of a (bounded whole of an edible object and its 4845
          variations of five related objects [Korn, 2009]).

Symbolic –

We consider a word such as 'mile',

Parts : letters = m, i, l, e,

Mile as a structure = m (is before) i,
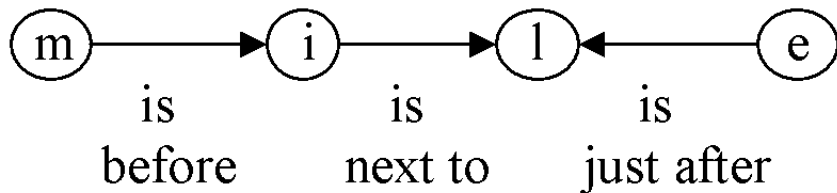
i (is next to) l,

e (is just after) l,

all of which is shown as a 'linguistic network' in Fig.11. [Korn, 2009].

Outcome = emergence of a (word with **meaning**).

The effect of topology on change of meaning.

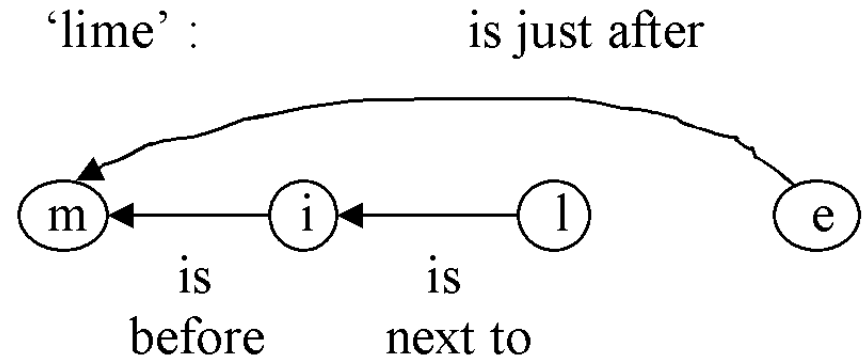'mile' :   'lime' :   is just after

Fig.11. Effect of topology on meaning

Abstract ---

'The audience is dissatisfied with the theatre for a number of reasons in other words there is dissatisfaction (with theatre).'
Parts : stage, audience, actors, scene,
Dissatisfaction with theatre as a structure = stage (partly covers up) scene,
audience (shouts at) actors,
actors (face away from) audience,
which occur simultaneously connected by an **AND** function for an outcome to exist.

Outcome (if any) = emergence of a (feeling).

A scenario of interacting objects

The narrative or <u>story</u> of the scenario : 'There is a farm with land for grazing but in the winter for the cows to be able to give milk, they must eat hay which is delivered to them by the farmer who uses a tractor, from the store to the shed twice a day. The cows are milked every morning by means of machines. Having accomplished these jobs, the farmer is content'.

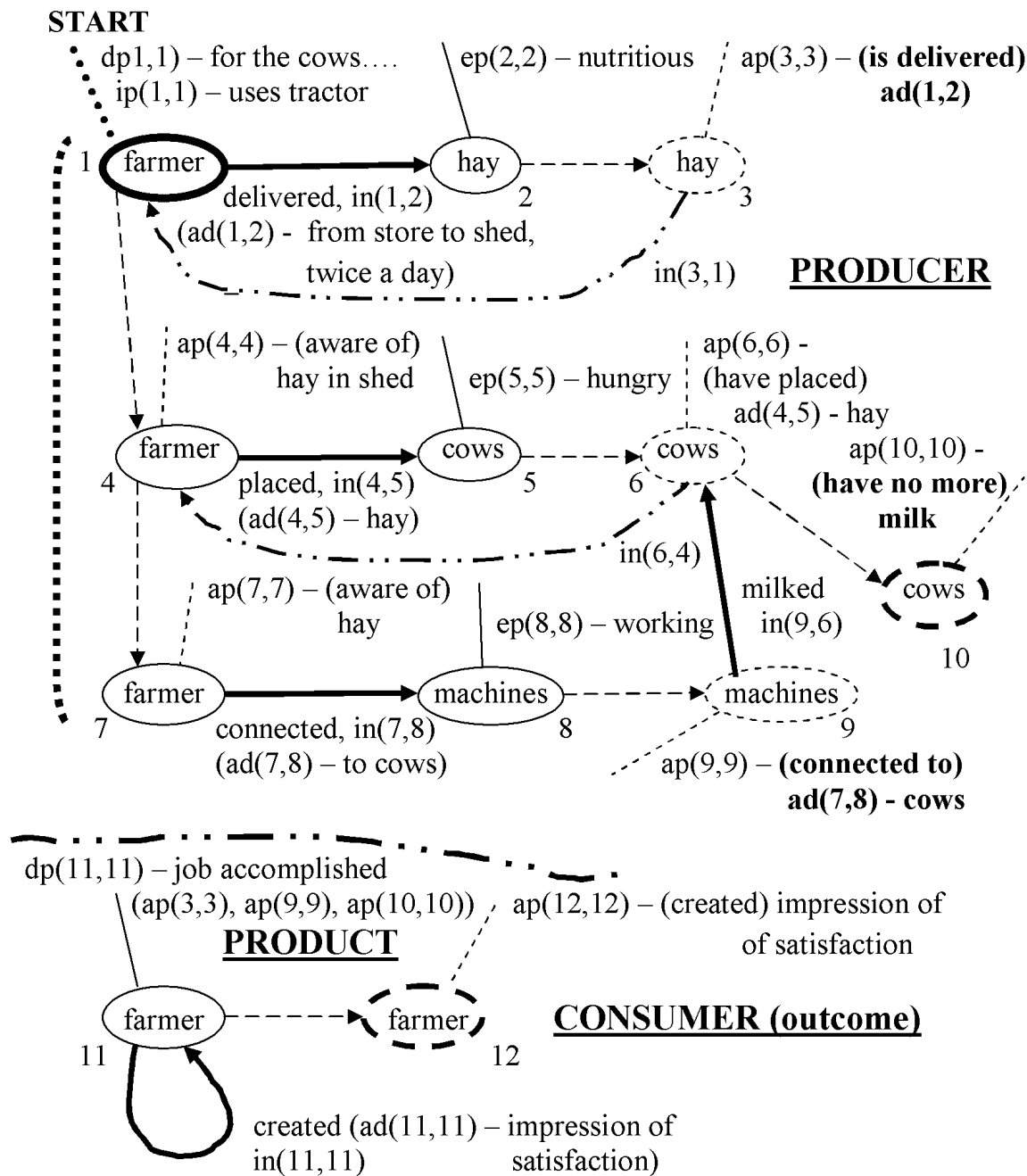**Representation as a semantic diagram is given in Fig.12.**

START

dp1,1) – for the cows….   ep(2,2) – nutritious   ap(3,3) – **(is delivered)**
ip(1,1) – uses tractor   **ad(1,2)**

1 farmer ──────► hay ─ ─ ─► hay   **PRODUCER**
        delivered, in(1,2)   2   3
   (ad(1,2) - from store to shed,
            twice a day)   in(3,1)

ap(4,4) – (aware of)   ap(6,6) -
     hay in shed   ep(5,5) – hungry   (have placed)
                                           ad(4,5) - hay
farmer ──────► cows ─ ─ ─► cows   ap(10,10) -
4   placed, in(4,5)   5   6   **(have no more)**
   (ad(4,5) – hay)   **milk**
                                    in(6,4)
ap(7,7) – (aware of)   milked   cows
     hay   ep(8,8) – working   in(9,6)
                                                        10
farmer ──────► machines ─ ─ ─► machines
7   connected, in(7,8)   8   9
   (ad(7,8) – to cows)   ap(9,9) – **(connected to)**
                                   ad(7,8) - cows

dp(11,11) – job accomplished
   (ap(3,3), ap(9,9), ap(10,10))   ap(12,12) – (created) impression of
           PRODUCT   of satisfaction

farmer ─ ─ ─► farmer   **CONSUMER (outcome)**
11   12

      created (ad(11,11) – impression of
      in(11,11)   satisfaction)

Fig.12. Semantic diagram of the farmer, hay, milk scenario

Logic sequences/topology of scenario

Causal chains : 1. 3,2,1   2. 10,6,5,4   3. 9,8,7   4. 12,11

For 1.
dp(1,1) ^ ip(1,1) → in(1,2)
in(1,2) ^ ep(2,2) → ap(3,3)   no more change of state, therefore, object 3 'hay', is an
                                                        output
 For 2.
ap(3,3) → in(3,1)   feedback link 'prompts' change of state ap(4,4),
in(3,1) → ap(4,4)   **decision junction**
ap(4,4) → in(4,5)
in(4,5) ^ ep(5,5) → ap(6,6)
in(9,6) ^ ap(6,6) → ap(10,10)   link in(9,6) is assumed to exist, no more change of state,
                                                        therefore, object10 'cows', is an **output**

For 3.
ap(6,6) → in(6,4)   feedback link 'prompts' change of state ap(7,7),
in(6,4) → ap(7,7)   **decision junction**
ap(7,7) → in(7,8)
in(7,8) ^ ep(8,8) → ap(9,9)   no more change of state, therefore, object 9 'machines', is
ap(9,9) → in(9,6)   an **output**, link in(9,6) can be generated as ap(9,9) exists

The term 'output' refers to 'output of the product' which together change the state of the 'farmer', the changing object as shown in Fig.12.

For 4.
dp(11,11) → in(11,11)
in(11,11) → ap(12,12)

Development of product

ap(3,3) ---   [nutritious] hay (is delivered, twice a day, from store to) shed (n_{34})
ap(9,9) ---   [working] machines (are connected to) cows (n_{51})
ap(10,10) --- [hungry] cows (have no more) milk (n_{12})

hay (is eaten by) cows (n_{31})
milk (is also stored in) shed (n_{24})
machines (increase production of) milk (n_{52})

We can calculate the number of groups of ordered pairs in a digraph which for 'n = 5',
(20 x 19 x 18 x 17)/(1 x 2 x 3 x 4) = 4845. These are the candidates for 'trees' or 'bounded
objects' of which one just mentioned functions as the **product** in this problem.
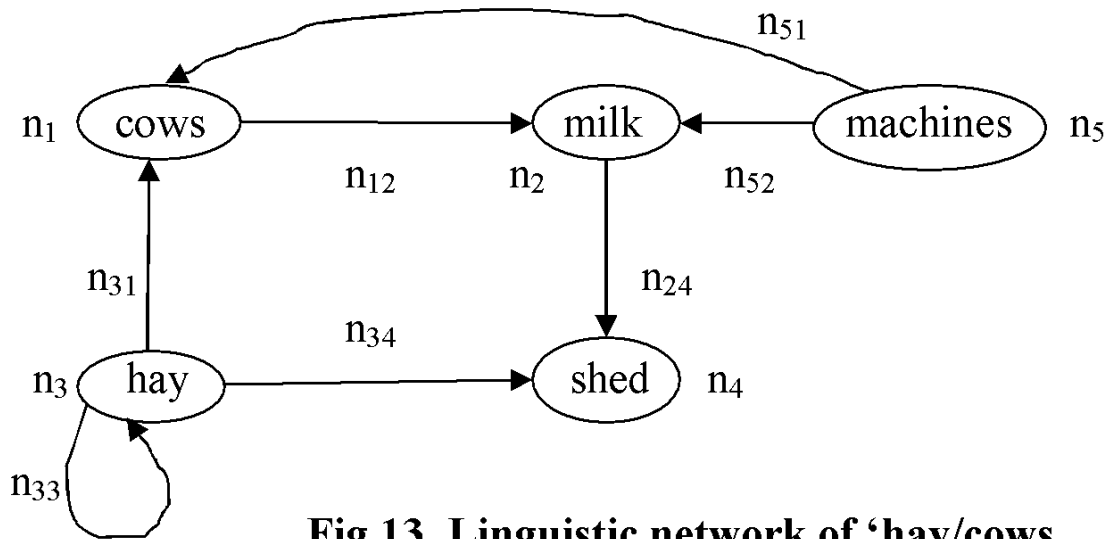
Fig.13. Linguistic network of 'hay/cows

measure of complexity = number of ordered pairs

Here we are concerned with **business science** (finance, accounting, law, marketing and so on) with a story as a continuation of the narrative of the scenario :

'The herd of cattle consists of 56 cows each eating 15 kg of hay a day during winter time assuming there is no grass and gives 18 litres of milk a day. The price of hay is £250 a tonne. The question for the farmer is --- If the winter lasts 90 days what is the minimum selling price of milk to break even ???'

Mathematical model : Total cost of hay is 56 x 0.015 x 250 x 90 = £18900 from which the minimum selling price of milk 18900 = 56 x 18 x 90 x price which is about £0.2 per litre.

CONCLUDING REMARKS

We have suggested a number of problematic issues in the current 'systemic view' which may be resolved by the development of a 'systems science' through a PARADIGM CHANGE.
Three 'law – like statements' have been suggested followed by the symbolism of 'linguistic modelling' which, through the use of 'natural language' processed from a 'story of a scenario' through 'meaning preserving transformations', matches the generality of the 'systemic or structural view' of parts of the world.
This approach claims :
1. To establish a fundamental view of the empirical systems phenomenon. However, it is subject to passing debate, software and other developments and more substantial applications,
2. To be computable, teachable, also linguistics supplements mathematics as symbolism, based on existing branches of knowledge etc,
3. To be a part of problem solving/design [product and system prototype model],
4. To turn a 'story/narrative' into a computable reasoning scheme,
5. To be able to explore large numbers of variations of the same 'story' to plan ahead.

Static linguistic modelling is based on the mathematics of 'ordered pairs'. It makes explicit the structure of artefacts or 'products' [natural, technical, living or social (concrete, symbolic or abstract)].

This structure of related and qualified objects can :
1. Vary thereby generating a large number of possible alternatives which can be exposed to the test of 'feasibility' for filtering, and
2. Aggregate into 'hierarchical structures' with other structures driven by increasing the chance of survival of individuals, convenience, higher performance and so on. Thus, the appearance of more and more complex structures seems inevitable through natural selection and by the limitless inventive activity of the mind, especially human.
The number of ordered pairs in a structure is a 'measure of complexity'.

Dynamic linguistic modelling is based on aggregation of pairs of 'predicate logic statements' to represent a 'story of a scenario' which makes the structure of such a 'story' explicit and enables events to propagate in time [subject to integration procedure].
This structure of interacting and qualified objects :
1. Makes the conditions of occurrence of a final outcome carried by a chosen object as a result of a change of state, explicit assuming the features of the conditions remain constant for the duration of the analysis [simulation],
2. Expresses these conditions as objects, interactions and qualifiers any or all of which can vary,
3. Identifies initiating or affected objects in a sentence,
4. Can carry mathematics to aid decisions, grading of qualifiers and uncertainty associated with operation of living and other objects.

INTERPRETATION of reductionism, repeatability, refutation !!!!