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Beyond LLMs: A Discussion on Non-Linear, Syntax-Free Semantic Modeling with AIR Models

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Abstract: This paper proposes that it is possible to model semantics in a syntax-free manner, and therefore, independent of language or mathematics. The purpose of syntax, semantics and intelligence is presented. The discussion on syntax proposes that syntax requires several new properties, unambiguity, sender's effort and recipient's effort. Thus, the Syntax Rule and the Minimization Rule. Semantic Obfuscation is proposed as an approach to hiding the meaning of a message in addition to cryptology. A non-linear syntax-free semantic model is proposed as a method to modeling semantics. Finally, some basics for implementing semantic modeling in hardware is proposed. However, a lot more research is required.

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I. INTRODUCTION

In 1955, McCarthy *et al* [1], proposed a definition for intelligence "…making a machine behave in ways that would be called intelligent if a human were so behaving." Looking back 71 years later, this was a good working definition for intelligence at that time. However, 71 years later, given the enormous amount of research into AI [2-18] and brain research [19-29] it is clear, that there is now a need for a more succinct definition for intelligence.

Solomon [30] proposed a new definition of intelligence based on decision theory, "The ability to make sustainable decisions within a valid context, and pertinent goal in both familiar and unfamiliar environments." Sustainable is defined as the ability to survive or even thrive in the present context. That is, the purpose of intelligence is survive and even thrive in a changing context at a rate of change that is quicker than that of the context change. This intelligence is supported by mental, physical, and emotional cognitions. That is in humans, the brain's mental activity consists of mental, physical, and emotional cognitions and intelligence uses these cognition inputs to determine a relevant and timely decisions.

Let's step back a little bit. Solomon [30 & 31] proposed (1.) that there are three type of decision models, Solomon, (2.) that knowledge can be constructed from knowledge elements, and (3.) Semantic Information as opposed to Shannon's Information. Thus,

➢ *Models:*

Solomon proposed [31] that the three types of decision models,

- Best outcome (given external states are not controllable)
- Best path (given states are known and selectable)
- Decision assist (given that an optimal solution is difficult to solve due to the problem being time variant, lacks sufficient information, etc.)
- That cognition is decision assists.

➢ *New Field:*

Knowledge Constructs [30 & 31] is a new field that evolved from a 1985 question, "How do you legally and ethically infer a company's private information?" Private information is the information a small group of people have that the rest of the population does not. It is not encrypted data. The only way to do this legally and ethically is to construct a knowledge structure that reveals all the pertinent information. Solomon [31] proposed the Asymmetric Information Resolution (AIR) models as a means to inferring private information. Fig. 1, depicts an AIR model Map consisting of 5 Frameworks. See later Section.

➢ *Semantic Vs Shannon:*

Semantic Information [30] is a function of the meaning of the message transmitted as opposed to Shannon's Information that is about information capacity. See Fig 2. Per Semantic Information, a name is a handle for a meaning which ranges from a simple to a complex collection of ideas.

➢ *Knowledge Growth:*

History shows that knowledge K_n at step or time n, increases to K_{n+1} at the next step $n+1$ with each transformation of current knowledge Δ_k which can be interpreted as a perturbation $\delta K_{n,n+1}$ between each step, using *mathematical formalism* as,

$$K_{n+1} = K_n + \Delta_k K_n = K_n + \delta K_{n,n+1} \text{ Knowledge Growth (1)}$$

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Or as $n \to \infty$, $K_n \to \infty$, that is, total knowledge is infinite, thus a need to handle knowledge efficiently. This begs the question, can knowledge be represented analytically, as in (1)? Note, in this paper *mathematical formalism* is a means to critique the thinking process and expose implicit axioms, that may or may not deliver a solution.

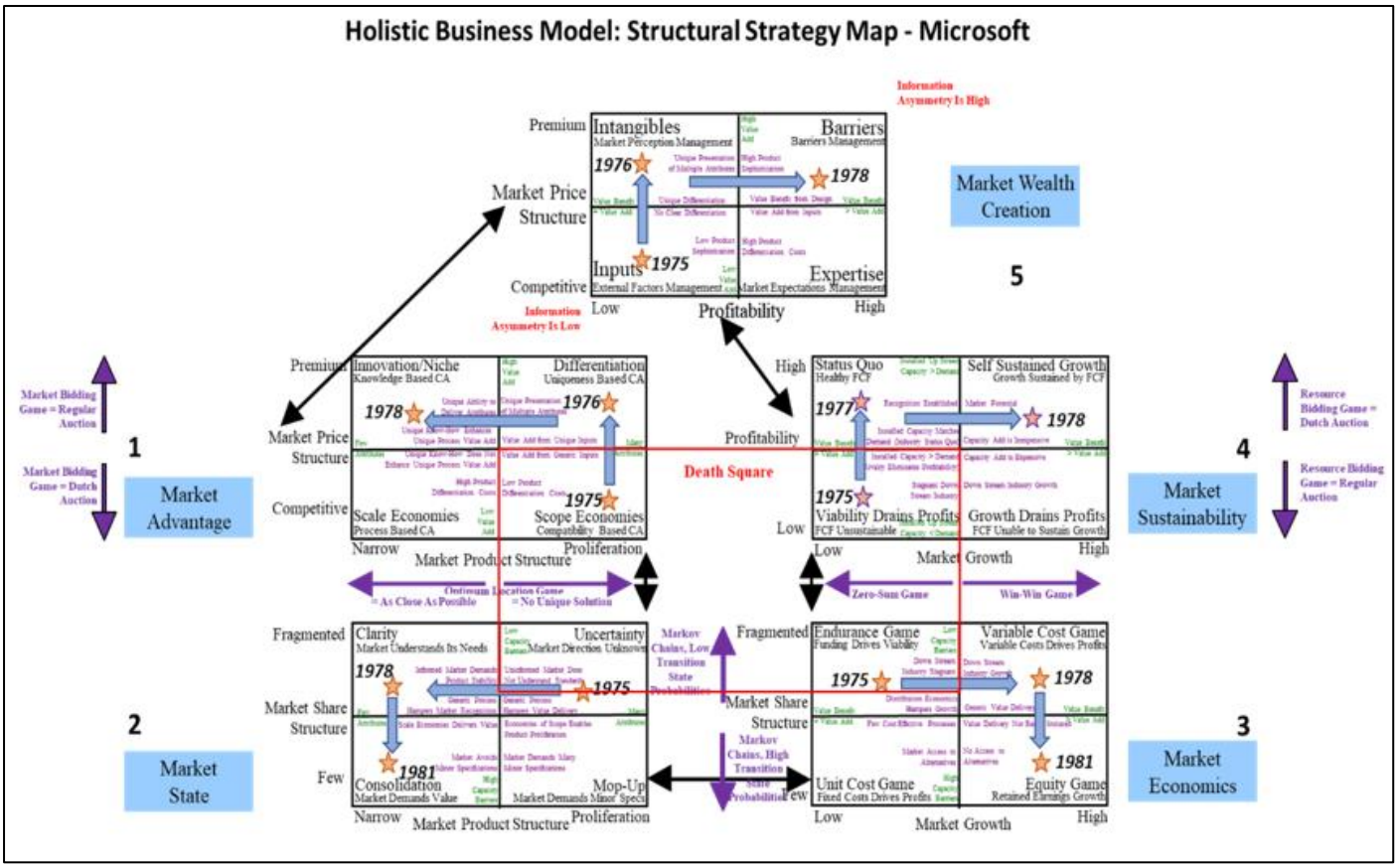


Fig 1 Asymmetric Information Resolution (AIR) model of Microsoft's strategy (Map 1 of 3)

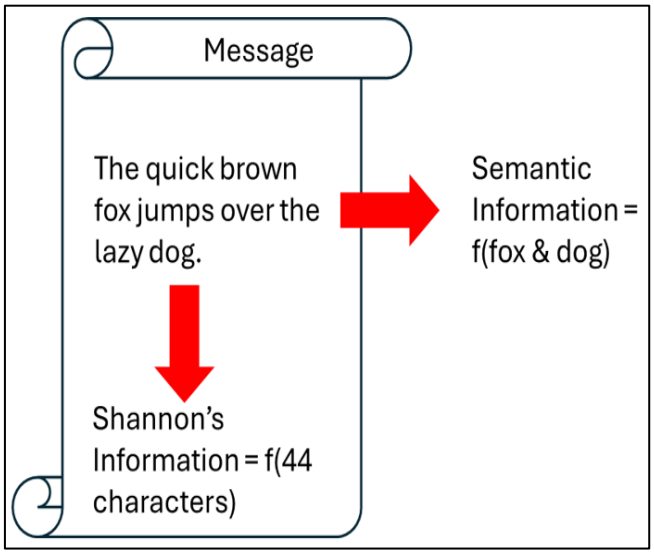


Fig 2 Semantic Information Versus Shannon's Information

II. A SHORT EXPLANATION OF AIR MODELS

With hindsight, there is a field of study, Knowledge Constructs, that investigates how knowledge is constructed from its elemental parts (knowledge elements). Knowledge elements are assembled into a structure based on the relationship between these elements, and not by how these elements are used in a sentence.

An AIR model [30, 31] consists of one or more Maps. Fig. 1, depicts a Map consisting of 5 Frameworks. Each Framework is constructed from x- (or horizontal, H) and y- (or vertical V) factors. Note, Boston Consulting Group (Alan Zakon *et al*) in 1970, proposed the Growth Share Matrix (GSM) approach [32], but it stayed the same this past half a century. AIR Model Frameworks [30, 31] use this matrix structure to reveal many possible decisions as opposed to a single best by GSM. The final, user's decision is not just based on the current Framework, but when interlinked, by common Factors, these other Frameworks must be taken into consideration.

The Framework adds knowledge elements of Exit Barriers, Factors, Co-Factors, Transitions between States, State Descriptions, Framework Names, and linkages to define how knowledge can be constructed, thus revealing private information. See Fig. 3 for a definition of the components of a Framework which depicts the Transition decisions cycling clockwise and anti-clockwise. Fig. 1 depicts, using Microsoft as an example, how Frameworks are linked by the common Factors between any two neighboring Frameworks.

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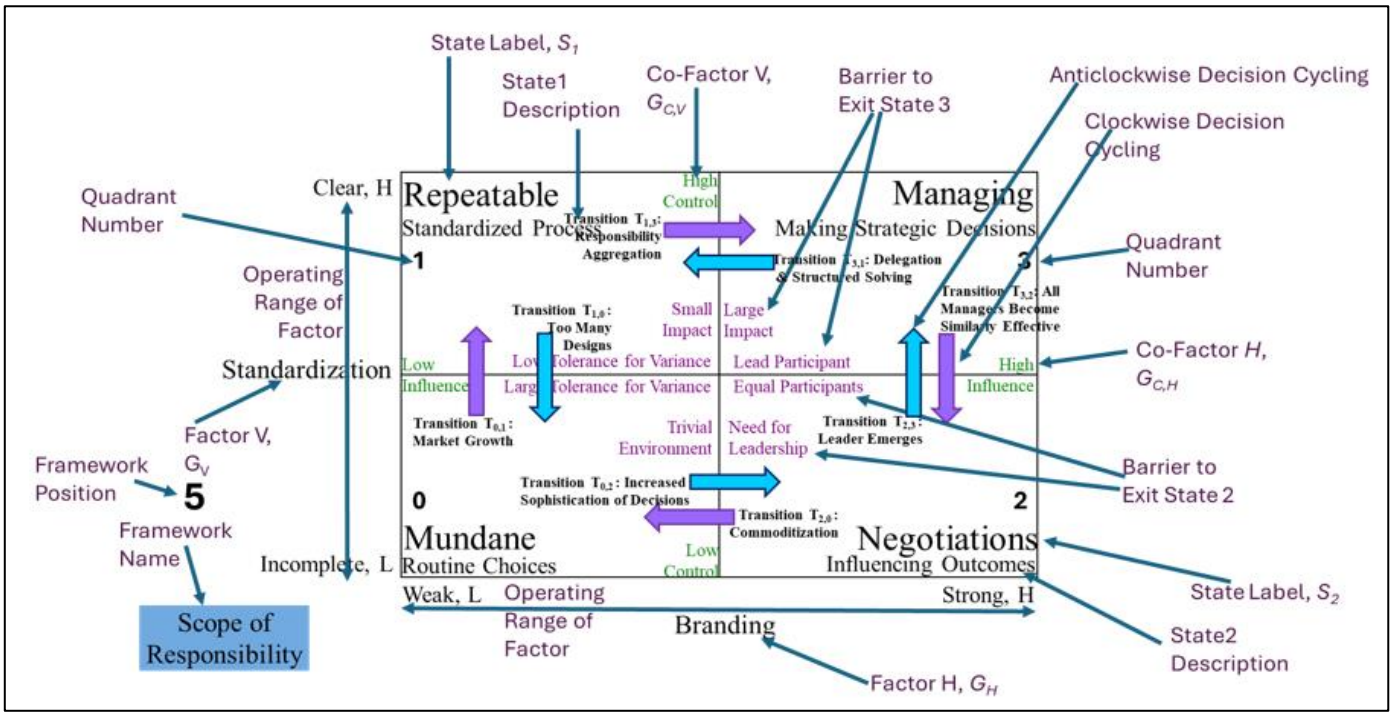


Fig 3 The Description of the Components of a Framework

➢ *The Purpose of Syntax:*

Intelligence requires a means to communicate, thus the need for syntax-based communication protocol, i.e. language in humans. Two definitions for syntax are,

- "Syntax is the study of the structure of sentences, the principles, both universal and language specific, that govern how words are assembled to yield grammatical sentences". [33]

- "Syntax is the branch of linguistics that studies the structure and rules governing the arrangement of words and phrases in sentences. It examines how different elements of language combine to form coherent and grammatically correct expressions, focusing on the relationships between words and their functions within sentences." Academia [34]

One can restructure these definitions of syntax to provide a goal-oriented definition as opposed to language syntax modeling (for example Adger [35]). Language syntax has several objectives given a set of grammatically correct construction rules for sending and receiving information and knowledge,

✓ To provide a clear and unambiguous transmission of semantics, ideas, decisions, and intentions.
✓ To obfuscate the transmission of semantics, ideas, intentions, and private information when intentions are not aligned.
✓ To convey emotions.

This paper is concerned with the first objective of clear and unambiguous transmission of semantics, ideas, and decisions, i.e. the transmission of information and knowledge.

Consider two examples with minimal syntax but focused on the relationships between words,

- "I go. You stay. I eat. Watch fire"
- "I go. I eat. You stay. Watch fire"

In the first example, it is not clear who watches the fire, and only one intention is clear, I go eat. In the second example two intentions for I (go eat) and You (stay and watch fire) are expressed clearly.

Therefore, the requirements for language syntax are,

- Unambiguity: To unambiguously communicate intended semantics. That is, given an interpretation and/or translation Δ_k, the error $\delta_{s,r}$ in determining the correct understanding or semantics is minimized.
- Sender Effort: To minimize the effort E_s, brain activity, required by the sender, with intention I_s, to construct a syntax-based semantics, $M_{s,j}$.
- Recipient Effort: To minimize the effort E_r, brain activity, required by recipient, with intention I_r, to deconstruct a syntax-based semantics, $M_{r,j}$, such that Unambiguity, is achieved.

Thus, the purpose of syntax using mathematical *formalism* can be stated as,

- Syntax Rule: To minimize the semantic error $\delta_{s,r}$ between sent semantics and the received semantics, given a possible syntax interpretation and/or translation Δ_k,

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$$(M_{r,j}|I_r) = \Delta_k(M_{s,j})|I_s + \delta_{s,r} \quad \text{Syntax Rule} \quad (2)$$

Such that $\delta_{s,r}$ is minimized.

- Minimization Rules: Since Nature is always energy minimizing, the effort required by both sender and receiver is minimized.

The sender's effort is expended to transform Semantic Information into Shannon's Information such that,

$$\frac{d^2E_S}{dM_{S,j}^2} > 0 \quad \text{Sender Effort Minimization Rule} \quad (3)$$

The recipient's effort is expended to transform Shannon's Information into Semantic Information such that,

$$\frac{d^2E_r}{dM_{r,j}^2} > 0 \quad \text{Recipient Effort Minimization Rule} \quad (4)$$

Of course, at this juncture, there isn't a formal analytical definition for E_s, E_r, $M_{s,j}$, $M_{r,j}$, I_s, or I_r, to enable an analytical solution for (3) & (4).

Note that, mathematics is a syntax-based system, and therefore, implementing a language-based syntax system as a mathematical syntax-based system may not provide additional useful insights. Also, noting that the semantics of language is context sensitive. In mathematics, context sensitivity is implemented as explicit and implicit axioms.

➢ *About Semantics:*

Having considered syntax, let define semantics. Four definitions or descriptions of semantics are,

- "Semantics research is about how the meaning of a sentence is determined from its parts and the way the parts are put together." [36]
- "Semantics is the study of meaning in language, encompassing the interpretation of words, phrases, and sentences. It examines how meaning is constructed, understood, and communicated, focusing on the relationships between signifiers, such as words and symbols, and what they signify in various contexts." Academia [37]
- Wikipedia [40] provides a detailed and excellent summary of the field of semantics, the study of linguistic meaning i.e. the linear arrangement of words, accomplished by analyzing it parts.
- Meriam-Webster's definition of linguistic semantics [41] is, "the study of meanings" and meaning [42] is "the thing one intends to convey especially by language".

Using structure of language research [40], one could view AIR models as some form of lexical, cognitive, frame and conceptual semantics, by constructing non-linear constrained, conditional, transition states based on the relationship between knowledge elements (words & short phrases).

The study of linguistic semantics is a very wide field. Much of the research is focused on developing models of sentence structure to determine the meaning of a sentence, for example Panther & Thornburg [38]. However, the author does not believe that understanding the structure of a sentence is the same as understanding its meaning. This is evident when one considers that, in the world today, there are 7,170 living languages [39] with their respective linguistic syntaxes, all pointing to the same knowledge. Thus, the case for semantics modeling that is syntax-free.

Borrowing from Merriam-Webster, from a decision-making perspective, an open-ended if not recursive definition of meaning is "the idea to be conveyed using supportive ideas". Thus, an AIR model Framework is an idea, that is supported by other ideas such as factors, co-factors, states, barriers, and transitions. That is, meaning or semantic S_i is a constellation or set of ideas $\{I_j\}$ that have specific set of relationships $\{R_k\}$ to each idea, within this constellation.

$$S_i = \{I_j\}|\{R_k\} \quad \text{Framework Set} \quad (5)$$

It may be possible to define a Framework as a matrix $[I_j][R_k]$ but much research is needed as there are conditional-constrained transition state requirements between Frameworks.

III. SYNTAX RULE CLARIFICATIONS

Solomon [31, 43] proposed Asymmetric Information Resolution (AIR) models as a means to modeling knowledge that is based on the relationships between knowledge elements but neither as a tree-like graph nor as syntax-based structures. An AIR model is composed of one or more Maps, with each Map consisting of 2 or more Frameworks. See Fig. 1, depicting a Map consisting of 5 Frameworks.

A Map i, M_i, can be represented as a set of j Frameworks, F_j,

$$M_i = \{F_j\} \quad (6)$$

Each Framework F_j, can be represented by a set of properties, factors G, co-factors G_c, states S, barriers B, transitions T, and stars a (i.e. positional data points), see Fig. 1,

$$F_j = \{G, G_c, S, B, T, a\} \quad (7)$$

The necessary conditions [31] for constructing a Map, are,

➢ *Randomness:*

The x- and y- axes, Factors, are related to the context but not correlated as correlated Factors produces no new information. This is, in agreement with Shannon's Information in that, the more randomness there is, the more information there is.

➢ *Interlinked:*

Frameworks do not have to be interlinked, but when they are, each neighboring Framework share a common

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factor. Thus, for Framework n, F_n, the common Factor, G_c, is given by,

$$G_{c,s} = (F_n \cap F_{n+1}) \neq \{\} \text{ for all } n \quad \text{Subsequent Interlinked Rule} \quad (8)$$

$$G_{c,p} = (F_n \cap F_{n-1}) \neq \{\} \text{ for all } n \quad \text{Preceding Interlinked Rule} \quad (9)$$

$$G_{c,s} = G_{c,p} \text{ for each } n \quad \text{Interlinked Common Factor Rule} \quad (10)$$

That is, when interlinked, the intersection of two neighboring Frameworks must not result in an empty set when the Frameworks are treated as a set of properties, such that this intersection results in one common Factor G_c.

Returning to the Syntax Rule (2), above,

$$\delta_{s,r} = 0 \quad (11)$$

When the sender's and recipient's Message semantics as Maps are identical, the intersection of sets $M_{s,j}$ and $M_{r,j}$ is the set $M_{s,j}$,

$$M_{r,j} = M_{s,j} \quad i.e. \quad \{M_{r,j}\} \cap \{M_{s,j}\} = \{M_{s,j}\} \quad (12)$$

(12) is stated as an intersection as either the interpretation and/or translation Δ_k, or the recipient's intention I_r, may alter the received message semantics $M_{r,j}$ by adding or subtracting Frameworks. That is, both intentions need to be similarly aligned for the message semantics to be understood correctly.

When there are small differences between sender's and recipient's Message semantics as Maps, for example some/few of the properties of a Framework are different,

$$M_{r,j} \cong M_{s,j} \quad i.e. for\ example \quad \{M_{r,j}\} \cap \{M_{s,j}\} = \{G_p, G_s\} \neq \{\} \quad (13)$$

When there are large differences between sender's and recipient's Message semantics as Maps, for example at least one Framework is different,

$$M_{r,j} \neq M_{s,j} \quad i.e. for\ example \quad \{M_{r,j}\} \cap \{M_{s,j}\} = \{F_{p,n}, F_{s,n}\} \neq \{\} \quad (14)$$

The upshot of this discussion is that one can now introduce a new field, semantic obfuscation. In cryptology, one endeavors to encrypt and decrypt Shannon's Information. In semantic obfuscation, one endeavors to encrypt (i.e. obfuscate) and decrypt Semantic Information using hidden knowledge and intentions, see equation (2), thus breaking the cypher does not enable a third party to determine the correct Semantic Information. See Fig. 4. For example, "He gave birth to 10 puppies" is syntactically correct but semantically not. With hidden knowledge it would be interpreted as "She educated 10 children". One approach to semantic obfuscation is to transform a correct AIR model to false AIR model that appears to be correct.

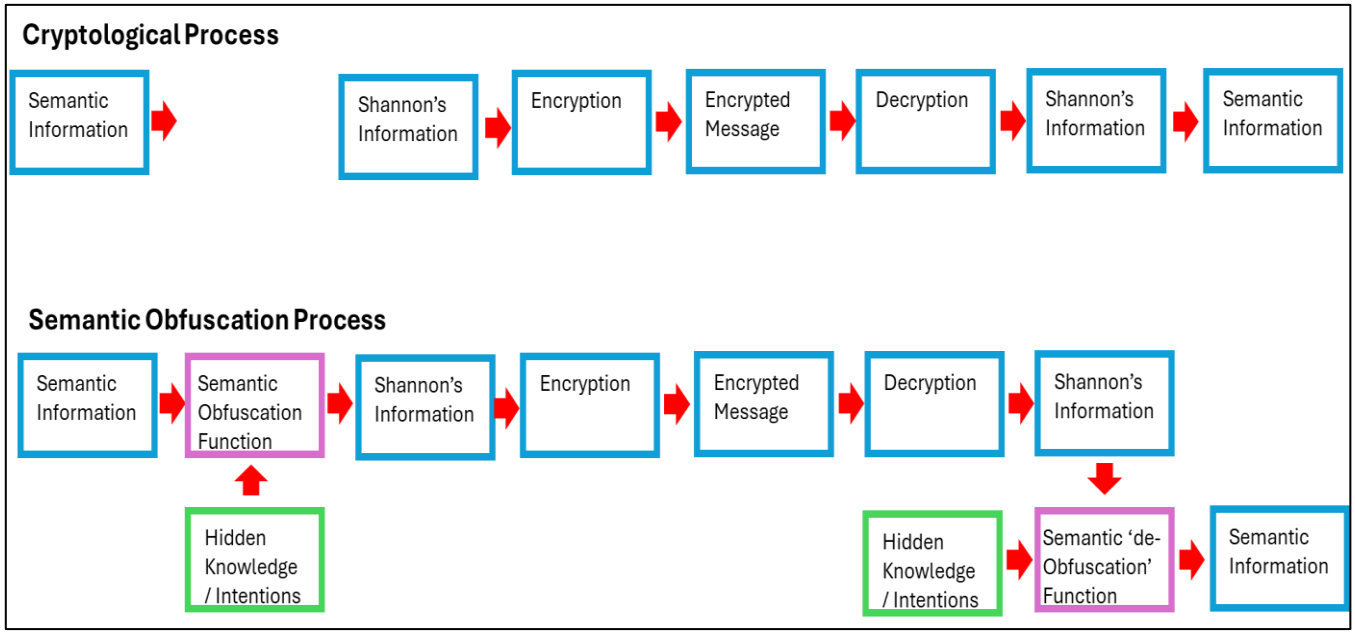


Fig 4 Cryptology Process versus Semantic Obfuscation Process

➢ *A Short Summary on Decision Making and Intelligence:*

Solomon [30 & 31] proposed that there are three types of decision problems, (i) Best state, (ii) Best path, and (iii) Decision assists. Decision assists models are used to simplify and elucidate a complex problem so that a best state or a best path can be determined. AIR models combine best state and best path into a single structure of a linked constrained conditional transition states. Fig. 1 depicts 5 Frameworks consisting of 4 States each, and the preferred best solution is the desired State within each Framework, and the path required to get there. The transition between states is constrained and conditional on the states of the preceding and subsequent Frameworks. If necessary, to achieve a better State at a given Framework, the preceding and subsequent State positions (i) may need to be changed or (ii) may prevent the transition to a subsequent State.

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Solomon [30] proposed Mental Activity can be deconstructed into Physical Cognition, Emotional Cognition, Mental Cognition, and Intelligence. See Fig. 5. Cognition is decision assists. For example, Physical Cognition is hampered in the physically handicapped, Emotional Cognition is dysfunctional in toxic people, and Mental Cognition is disadvantaged in illiterate people. This lends itself to a narrowed, manageable definition of Intelligence as the application of these three types of Cognitions to deliver sustainable decision-making while the decision context is valid, given a specific goal i.e. intention. That is, the Physical, Emotional and Mental Cognitions, as decision assists, supports the development of the context to solve a problem. Intelligence is applied to construct this context and determine a best state and path while the context is valid.

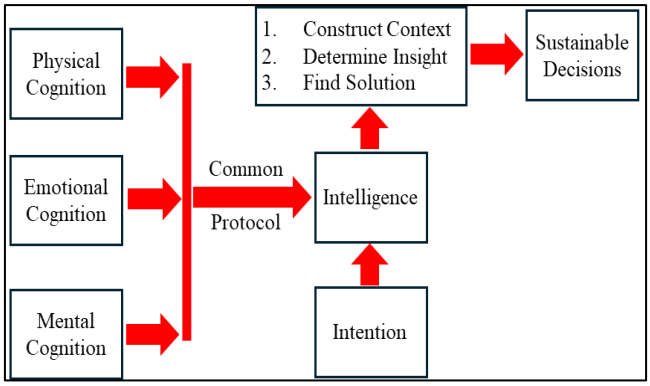


Fig 5 Proposed Interaction between Cognition and Intelligence to Determine Sustainable Solutions

IV. NON-LINEAR SEMANTIC MODELING

AIR models, unlike sentences, are non-linear semantic models. Thus, this paper proposes that semantic modeling should exhibit 8 properties,

➢ *Semantic Risk:*

To reduce ambiguity in the meaning when precision is intended and to increase ambiguity when obfuscation is intended. This is the equivalent of the Syntax Rule, however, the Syntax Rule is about the arrange of words, while Semantic Risk is about the correct selection of knowledge elements. This is expressed clearly by the earlier "I go. You stay. I eat. Watch fire" & "I go. I eat. You stay. Watch fire" example even though it is also and example of the arrangement of words.

➢ *Dynamic Collation:*

Combining knowledge constructs (Frameworks) into a more complete, larger knowledge constructs (Maps). For example, 4 standalone Frameworks form the Operations Map. See Fig. 6. Context determines what is included and excluded. One can substitute any Framework for a different one as long as these fit the Context being considered.

➢ *Interlinking:*

Combining knowledge constructs into a more complete, larger knowledge constructs through common Factors i.e. interlinked. For example, Fig. 7, depicts 5 Frameworks joined by common Factors to form the Structural Strategy Map. One cannot easily substitute any Framework for a different one because they are interlinked by Common Factors. Not all Maps have interlinking Frameworks, as show in Fig. 6.

➢ *Interactions:*

How each Framework interacts with neighboring Frameworks determines what is included and excluded. There is a consistent Context within a Map, and between Maps. The three types of interactions are, (i) No interactions, between Frameworks, Fig. 6. (ii) Linked interactions, Fig. 7. and (iii) Indirect interaction, see Fig. 8 'Revenue Transaction Map' where the interaction is shown on a different Framework, 'Industry Rivalry'.

➢ *Transactions:*

Transactions are how one engages with the AIR model. The moving of Stars or data points to select States to identify the State selected. See Fig. 7. This is constrained by States in neighboring Frameworks, and conditional by what is allowed by the neighboring Frameworks. Conversely, the selected State may force changes in the neighboring Frameworks.

➢ *Context Updating:*

Fig. 9. depicts an AIR model whose context has been updated by adding more Maps.

➢ *Networks:*

Per the earlier discussion 'About Semantics', a State can be resolved into a 'lower level' Framework i.e. interpolation, or a 'higher level' Map, i.e. extrapolation, which can form other types of Maps. See Fig. 10. Interpolation occurs where the name or label (i.e. meaning) of a State in one Framework is the name or label (i.e. meaning) of another Framework. Extrapolation occurs when the name or label (i.e. meaning) of a State is name or label (i.e. meaning) of another Map. That is a semantic network that allows for an 'explosion' of semantic-based networked connections.

➢ *Emergence:*

A Map consists of a set of Frameworks. Each Framework consists of 2 Factors that are not correlated. This lack of correlation between the Factors, induces the emergence of new concepts or ideas between these 2 Factors, known as States. Note that though the Factors are uncorrelated they must be relevant to the Context of the problem being described otherwise it is nonsense. The Factors of the Framework induces the emergence of States, Barriers and Transitions.

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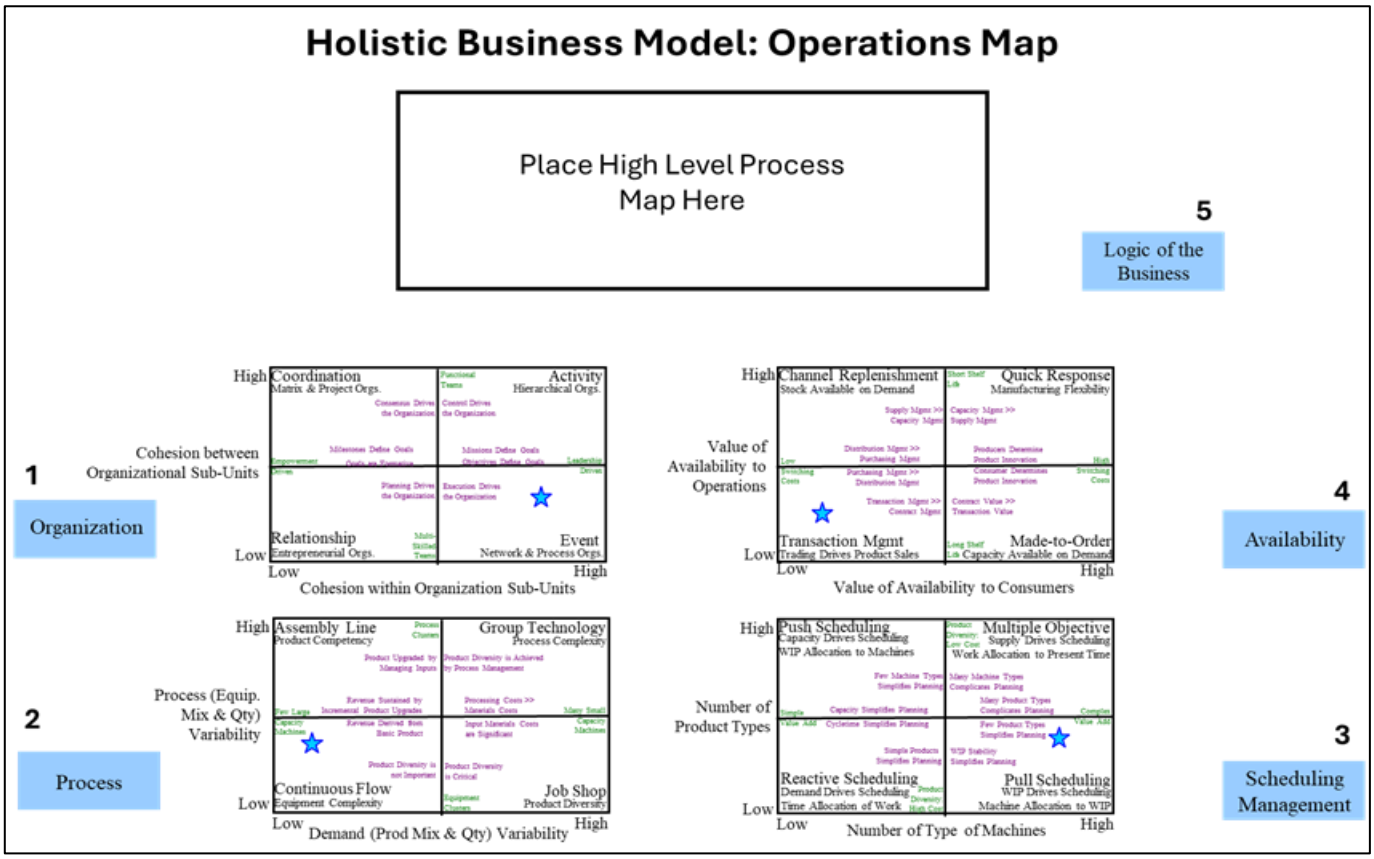


Fig 6 Operations Map Depicting 4 Frameworks that are not Linked to each other.

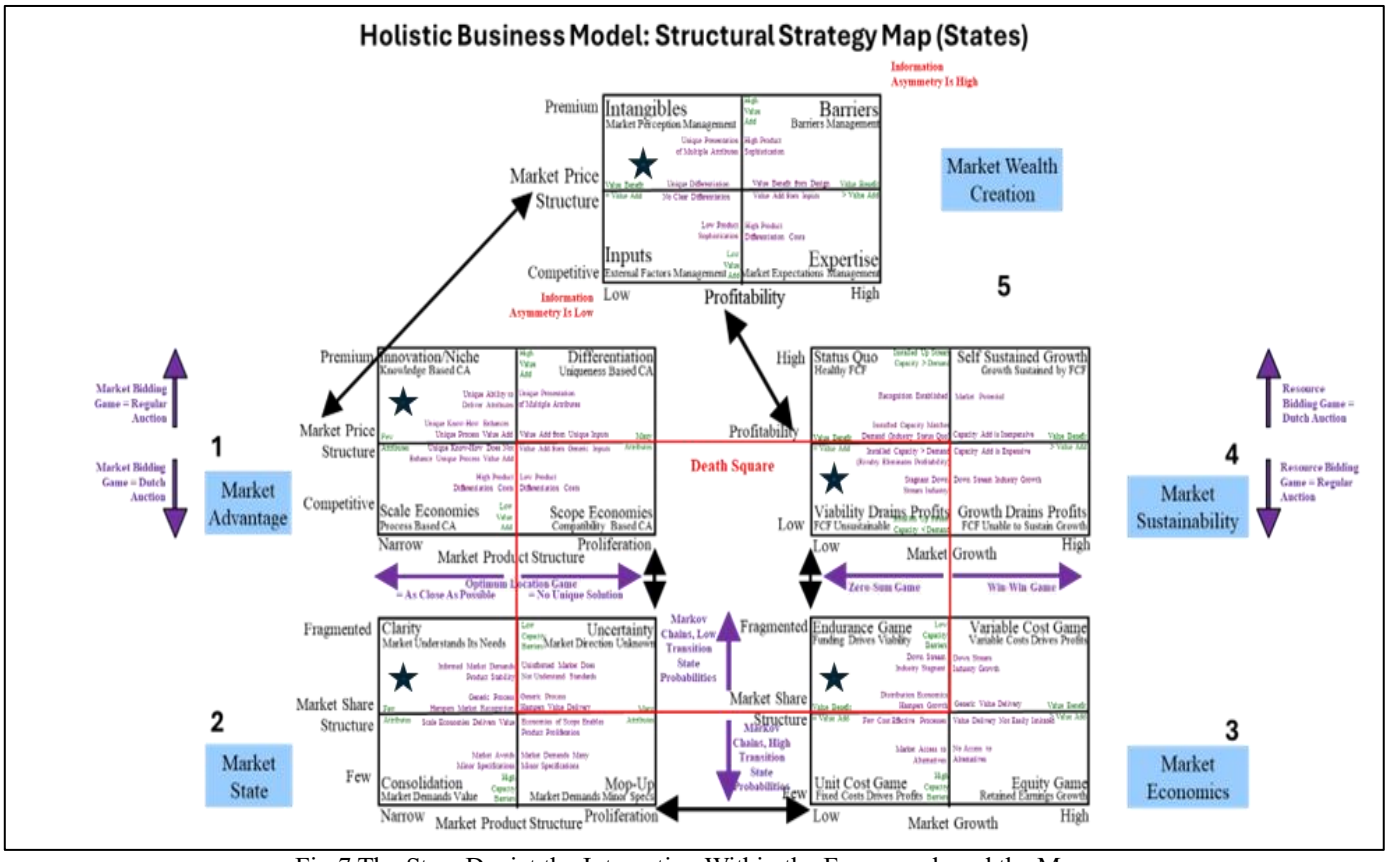


Fig 7 The Stars Depict the Interaction Within the Framework and the Map.

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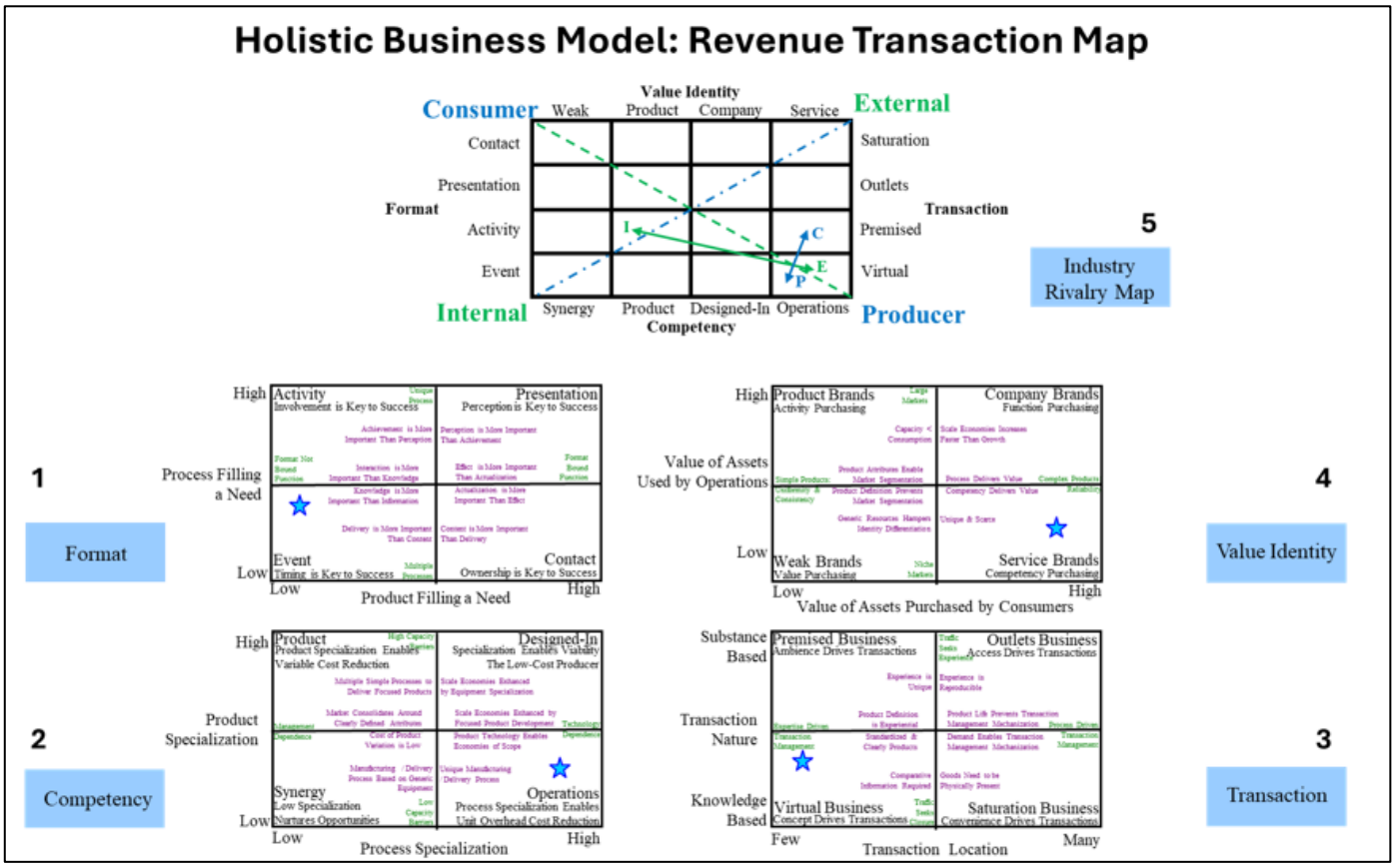


Fig 8 Indirect Interaction shown on top Framework 'Industry Rivalry'.

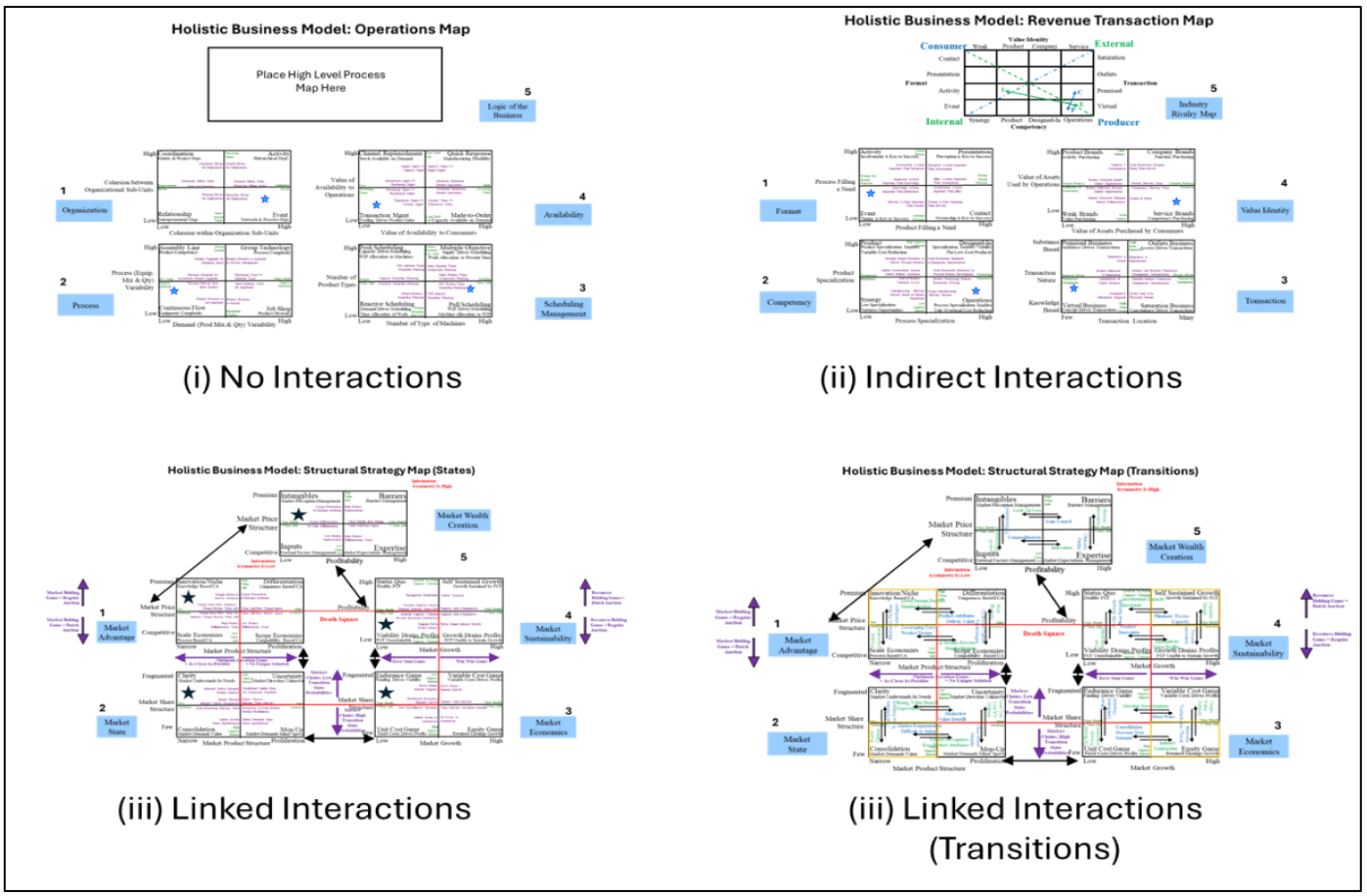


Fig 9 AIR model Context was Updated by Combining Several Maps.

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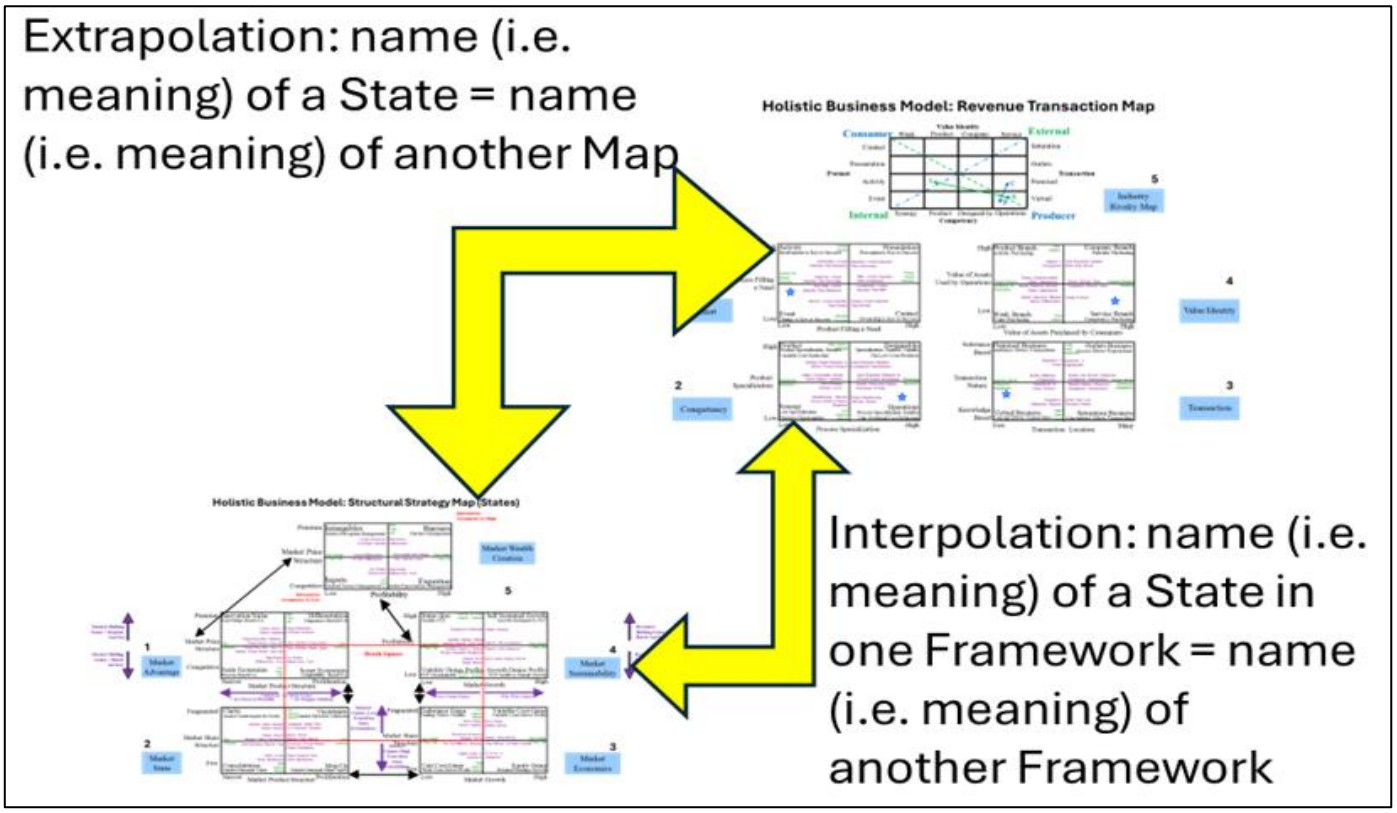


Fig 10 Interpolation Versus Extrapolation

V. CONCEPTUAL BASICS FOR A NEW TYPE OF NEURAL NETWORK

The motivation for this analysis is that the human brain operates at 20 W only, Balasubramanian [47]. Therefore, is it possible to design machine intelligence systems that operate at similar wattages?

Given multiple dendritic inputs, neurons exhibit computational functions [44 - 46] to determine when to transmit signals across the neuron's axon. This section introduces some basic concepts as the basis for a new type of neural network, the Framework Neural Network, but a full analysis is better left to a future paper.

The outputs are States. Inputs are Factors and Co-Factors. Barriers are equivalent to neuron inhibition and Transitions are equivalent to neuron excitation [49]. Like neurons, Barriers have a threshold that when exceeded results in a Transition with an output of the new State, and when it does not the State remains the same. See Fig. 11.

Comparing the neuron version of the AIR model (Fig. 11) suggests that axon knobs are too simple as they enable [49] only a single neurotransmitter most of the time. To process information, this suggest that neurons work in groups, as vindicated by specialized functional brain regions. However, since up to a thousand synaptic connections, can occur at a neuron's input with only one axon output, this suggests that the neuron is much more sophisticated than is believed, i.e. the neuron's cell body possibly acts like a CPU.

Introducing the subscript nomenclature *i,j* or *from, to*, respectively, for States *i* and *j*. Let's assume that the States are numbered 0 to 3, with 0 at bottom-left, 1 at top-left, 2 at bottom-right and 3 at top-right. See Fig. 3. That is, *i* and *j* range between 0 to 3. This facilitates a binary horizontal-vertical coding for State numbers. Thus,

- Barrier $B_{i,j}$ is the barrier at State *i* preventing the Transition to State *j*.
- Transition $T_{i,j}$ is the Transition from State *i* to State *j*.

The expressions for new outputs (equivalent to the Trigger Zone in Fig. 11), O_N are,

$$O_N = T_{i,j}(S_i) | (T_{i,j} > B_{i,j}) = S_j \quad \text{Transition Effected} \quad (15)$$

$$O_N = T_{i,j}(S_i) | (T_{i,j} < B_{i,j}) = S_i \text{ No Transition Effected} \quad (16)$$

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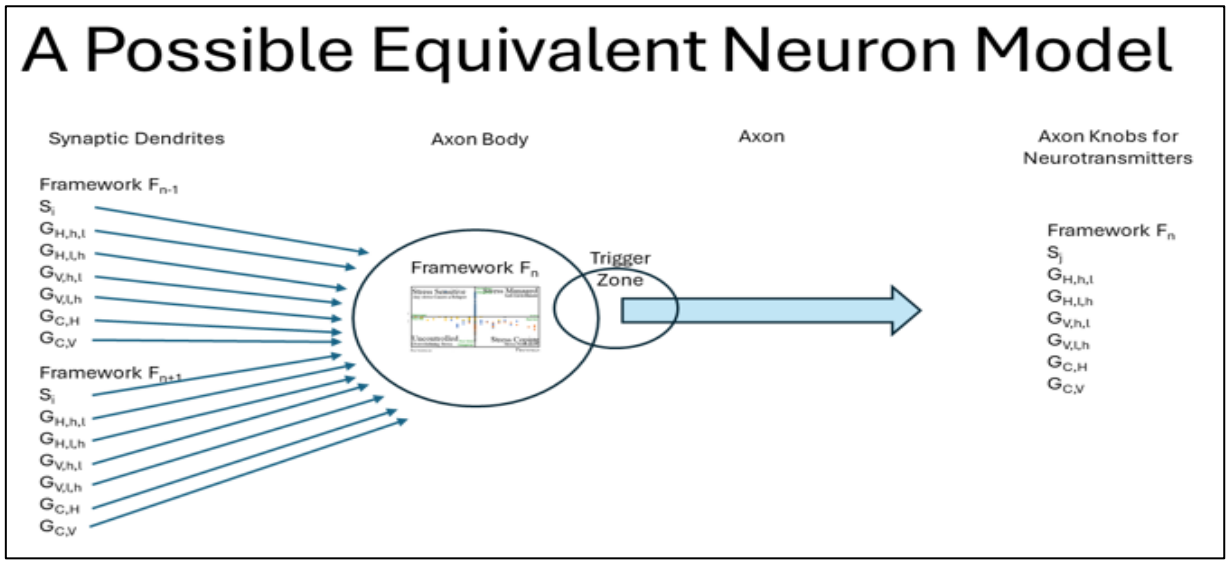


Fig 11 AIR Model as an Equivalent Neuron Model

Introducing vertical, *V*, and horizontal, *H*, for Factors *G* and Co-Factors G_C, (see Fig. 3) such that,

- Factors, G_V and G_H are the vertical and horizontal factors, respectively.
- Co-Factors, $G_{C,V}$ and $G_{C,H}$ are the vertical and horizontal co-factors, respectively.
- The factors can be denoted by a high, *h* (i.e. binary 1) and a low, *l* (i.e. binary 0),
- Thus, a change in the factors can be represented as,

$$G_{H,l,h} = S_{i,j} \qquad \text{Low to High Transition} \qquad (17)$$

Where *i=0* & *j=2* when G_V is low, and *i=1* & *j=3* when G_V is high.

$$G_{H,h,l} = S_{i,j} \qquad \text{High to Low Transition} \qquad (18)$$

Where *i=1* & *j=0* when G_V is low, and *i=3* & *j=2* when G_V is high.

$$G_{V,l,h} = S_{i,j} \qquad \text{Low to High Transition} \qquad (19)$$

Where *i=0* & *j=2* when G_H is low, and *i=1* & *j=3* when G_H is high.

$$G_{V,h,l} = S_{i,j} \qquad \text{High to Low Transition} \qquad (20)$$

Where *i=2* & *j=0* when G_H is low, and *i=3* & *j=1* when G_H is high.

As a short form, change in Factors (17) to (20) can be written as,

$$\delta S \cong \delta G \qquad \text{Short Form, } \delta S \text{ corresponds to } \delta G \qquad (21)$$

To touch on this subject, from a neuronal perspective, Factors and Co-Factors are inputs that may or may not change the States. A necessary input includes whether neighboring Frameworks' Factors G_V and G_H are linked. Thus, there are 14 inputs. See Fig. 11. These inputs are working in logical 'or' pairs, (G_V v $G_{C,V}$) and (G_H v $G_{C,H}$). However, it gets more complex with the necessary checking of the preceding and subsequent Frameworks, and beyond the scope of this paper. Thus, necessarily, there is a bit-adder to convert the logical 'or' operations into State numbers and a specialized microcode 4-bit processor would handle all the Framework-Common Factors computation required. All together a low wattage computation.

VI. CONCLUSION

This paper clarifies that linear and non-linear semantic modeling are different constructs and proposes a method, AIR models, for non-linear modeling of semantics without the use of language or mathematical syntaxes. The purposes of syntax, semantics are proposed and discussed. Some basics for a potential hardware implementation are proposed. However, AIR models are probably one of many possible Knowledge Construct models, but further research is required.

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