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H. Inter – and Transdisciplinarity in Science and Technology

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Interface management in relationships between systems

CUNCEV IOAN*

Technical Sciences Academy of Romania

Abstract. Modeling of complex systems is based on established theories and concepts, but also on innovative constructions that harmonize the system with the requirements foreseen for its operating life. The problems of system interaction are concentrated at each coupling interface between them, where the harmonization of inputs and outputs of matter, energy and information, the management of coupling variables, the mutual compatibility of systems, the harmonization of error handling procedures, data processing protocols and reliability are achieved. The refinement of current and future systems, especially in the context of advanced integration of artificial intelligence and the human factor, requires new approaches, theories and tools of mutual interaction, involving even the quantum level of human consciousness and awareness. The inter-, trans- and multi-disciplinary characteristics of system coupling interfaces must be considered, covering a wide range of phenomena, from deterministic to probabilistic, even to quantum subtleties. Therefore, interface management must become a strategic solution in the optimal functioning of networked systems.

Keywords: system coupling, interface management, quantum reality, interdisciplinary.

1. Introduction

The interface is the contact area between components or systems, managing their exchange of materials, energy and information. It ensures the coherence of the interaction between the coupled objects, allows the modularization and evolution of the system over time and reduces the risk of malfunctions. In terms of category theory, the interface between systems A and B can be formalized by the functor F, which is a morphism between these categories, F: A → B, bringing the physical or logical representation of the interface into an abstract structural and functional framework of the transformations and relationships between the systems. The

*Correspondence address: icuncev@yahoo.com

interface is modeled by a pullback (fiber product) between the flows of the two systems towards a common kernel. The functor F is thus a transformation between two categories that preserves their internal structure, that is, the internal logic of the source system into the target system.

2. The dipole, as elementary coupled systems

The dipole is a case of network connection, a pair of two poles being connected as a couple, even permanently, the presence of each pole being mandatory in its existential logic. The dipole can be recognized in a wide range of coupled systems, even in domains where it apparently makes no sense.

Complementarity of the dipole

As an extreme dipole, could be considered the famous quantum phenomenon of instantaneous action at a distance, the entanglement, a coherence where a change in the state of one pole instantly changes the state of the other pole.
There are expressions in everyday speech that show the *affinity* of the poles of a dipole. An artistic example is the text of an well-known song [1], debated in a film [2]:

> What would the sea be without the sun?
> What would the field be without flowers?
> What would today be without tomorrow?
> What would my life be without you?

Structural concepts such as soul mates, my other half, multiple universes, multilayer system, are equivalent and refer to the composition of an object from successive foils (membranes, levels, etc.) to build a new coherent system. The problem extends through models such as "a person can have several soul mates". The meeting of an individual with his halves, consciousnesses spread across the planet, is a quantum state represented by a probability function $|\Psi|^2$. In fact, the dynamics of any system in quantum reality is a superposition of states of its subsystems and so on towards (- ∞), but also towards (+∞). Moreover, at a given time t, this multiple composition is carried out on each sub-sub-... sub-system and system of systems, considering all probable states from the possible variants.
The state of a dipole could also be evaluated by Lupasco's logic theory (the principle of included tertium), as well as a quantum state Ψ as a superposition of the states of the component poles. See also a saying attributed to Einstein in which a pole is defined by the negation of its pair: there is no darkness, but the absence of light. And in the case of a set of objects: if those objects had not been paired, it would not have been possible to unpair them.

The fundamental dipole, good vs bad

As a rule, if there is an entity of type (+E), there is also its opposite (-E), each pole being complementary to the other. That is, there is the dipole (+E, -E), as in the law of action and reaction, the system being in balance through mutual compensation. The interface can also be the place of confrontation/cooperation of the two poles. Even intensity can be present in the dipole, at (++E) corresponding to (--E). If the poles start to be very different, the system becomes unstable (disturbed immunity), resulting in anomalies, diseases, mutations, etc.

The producer vs consumer dipole

The one who produces is fruitful, attracting the hostility of others, like a fruitful tree that is hit with stones or a stick, is shaken to have its fruits taken from it by those who do not bear fruit (Genesis 49.22-25). Thieves steal from the one who is fruitful, not from the one who does not bear anything useful. The situation becomes critical when thieves, the lazy, in general those who do not produce anything, become a critical majority, the system becoming unstable, the shortage of products and services increases, and as a perverse effect, thieves begin to steal from each other. This results in the need to intervene in the interface through a strategy of restoring the balance between production and consumption, optimizing the allocation of development funding vs consumption, the markets balance of supply and demand, etc.

Critical problems arise when one of the poles of the dipole is missing. For example, when the national production of goods and services is destroyed, financial sources disappear, the society turns into a consumer based on debt and thus enters a course towards bankruptcy. With the disappearance of national producers, the domestic dipole is broken, transforming it into a dipole with producers from outside the country and national consumers. The effects for citizens are high prices, inflation, deficits, poverty. Avoiding disaster is possible only by returning to the sustainable "production-consumption" dipoles.

3. The interface in the part vs. whole relationship

A system is made up of subsystems, which in turn are subsystems within another system that encompasses it. Between all these objects there are coupling interfaces through which, their coherence and functionality are achieved. According to the Bellman optimality theorem (principle) [3], a system is optimal if it is made up of optimal subsystems. It could be wrong to decide that a member-state of an union of states should be obliged to pay for the consequences of the degradation of common relations in a certain context, eliminating the right of veto. This would mean that a subsystem should bear the costs to the advantage of the system, i.e. *one for all*. Similarly, a member-state in relation to the EU, a non-polluting industry vs. the rest of the polluting economic systems, tax-paying citizens vs. bad-payers.

4. The interface as emergence from micro- to macro-reality

Networking of systems

The coupling of systems is complex, and its intensity can be: tight coupling in which the systems are dependent on each other; loose coupling in which the systems collaborate with each other, but can also function independently. The state of the system composed of the set of elements in the process of approaching during the coupling of two systems that also contain the consciousness of each person involved, is of a quantum nature, being described by a wave function formed by the superposition of the states of a large number of probable micro-connections at the interface level. This is a quantum interface at the subtle level of micro-reality, which achieves the collective emergence towards the collapsed state of the system from macro-reality. For generalization, it can be considered the network of systems. And in extended generalization, a network with quantum nodes and morphisms could be considered, a quantum network, even having the form of a quantum nature. That is, the quantum cloud.

The transition from quantum to classical reality

Let us consider quantum reality represented by the category Q of quantum systems, and physical reality by the category C of classical systems, as well as the transition functor F:

$$F : Q \rightarrow C$$

which realizes the emergence from quantum micro-reality to macro-reality. The functor can be:

$F = D \otimes M$

D is decoherence, i.e. interaction with the environment;

M is the collapse of the state naturally, by measurement, free will, etc.

The process "quantum state → decoherent state → measurable classical state", is the diagram:

$$Q \rightarrow D(Q) \rightarrow F(Q)$$

In another approach, one reaches macro-reality through collective emergence, starting from an ensemble of inter-related quantum particles $\{Q_i\}$ f_{ij} , as a co-limit of the diagram D of their relationship:

$$C = \mathrm{colim}_D\,(F \circ Q_i)$$

That is, quantum reality is more complex and subtle than physical reality.

Quantum subtlety of inter-systems relations

Two systems that interact over a certain time interval (t_1 - t_2) after separating will continue to interact at a distance when they become non-local again. For example, two individuals who get to know each other over a certain time interval, become close at the level of consciousness, even sentimentally (soul-mates). If they separate, they continue to interact at a distance [4] [5], each having a state described by a different wave function than that before their direct interaction.

In case of two systems X and Y that interacted in the past until the moment t_k and moved away after the moment t_k to stop interacting, the state $|\Psi\rangle \in H_{XY}$ of the composite system X+Y, is:

$$|\Psi\rangle = \sum_i C_i\, |a_i\rangle \otimes |b_i\rangle ,$$

H_{XY} is the product space, A and B are observables for X and Y, and $| a_i \rangle$ and $| b_i \rangle$ are eigenvectors.

If two quantum systems that were separated up to time t_1, as well as after t_2, have the state vector Ψ of the composite system X+Y, described by the Schrödinger equation:

$$i\hbar \frac{\partial}{\partial t} | \Psi \rangle = (\hat{H}_x + \hat{H}_y) | \Psi \rangle$$

and in the time interval (t_1 - t_2) in which the systems interact:

$$i\hbar \frac{\partial}{\partial t} | \Psi \rangle = (\hat{H}_x + \hat{H}_y + \hat{H}_{int}) | \Psi \rangle$$

Although they are separated again, the systems are affected by a residual influence remembered from the time they were coupled, leaving after separation a remnant of the synergy created during the time the two systems were together, which we call *residual synergy*. There will also be a behavioral remnant to similar external stimuli.

Some examples of *synergistic quantum couples* can be significant:

- institutional twinning (EU-RO, etc.) where the quantum nature of human consciousness is manifested, which considers mutually conditioned probabilities, i.e. the quantum state is a superposition of states in each system, in which the conditional probabilities resulting from the relationship of the parties participating in the twinning are also considered;
- long-distance transport + local collection and distribution = combined transport;
- member parties in coalitions (CDR, USL, etc.), are different after their subsequent separation, compared to the state of each one before the alliance;
- the relationship between generations of systems;
- other couples: mentor-mentee relationship; husband - wife, including divorce; ethnic majority-minority; parents-children; diaspora-nation of origin, etc.

Relative position of systems

If two processes lead or must lead to the same effect, then the interface is modelable by an equaliser, or co-equaliser, over two parallel morphisms. In terms of category theory, an *equaliser* is a limit on a pair of morphisms and generalises the idea of a solution to an equation between those morphisms [6].

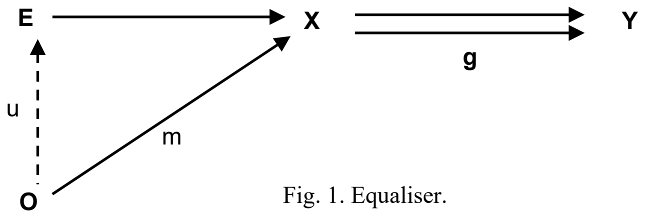

Fig. 1. Equaliser.

The equaliser, fig. 1, consists of an object E and a morphism e: E → X , satisfying f ○ e = g ○ e, and such that, given any object O and a morphism m: O → X, if f ○ m = g ○ m, then there exist an unique morphism u: O → E such that e ○ u = m. The morphism m is said to equalise f and g. A category has equalizers if it has binary products and pullbacks.
The equaliser selects the part of X where the images f and g are equal. That is, given two parallel processes f and g starting from the same source, the equaliser selects the elements for which the two processes lead to the same result. It is the answer to the question "what are the inputs for which f and g behave the same?". For instance, in case of two supply chains with similar reliability. If two processes lead to the same effect, then the interface is modelable by an equaliser between two parallel morphisms.
A *co-equalizer* is the dual of an equalizer that, instead of selecting the values of the variables where two functions coincide, makes them coincide. If in a category we consider two objects X and Y, as well as two parallel morphisms f, g : X → Y, then we define a co-equalizer, fig. 2, as an object Q and a morphism
q : Y → Q, such that q o f = q o g. The pair (Q, q) must be universal, that is, given any other pair (Q', q'), there is a unique morphism u : Q → Q' for which the diagram commutes.
The co-equalizer creates a new reality in which it makes the images of f and g considered equal in Q. That is, it identifies all the differences between f and g and creates a space where those differences disappear.
In the category of sets (Set), for f,g : X → Y, the co-equaliser is the set obtained from Y by identifying all values of f(x) with g(x) for each x ∈ X, and q: Y → Q is the canonical map that reduces Y by this identification.

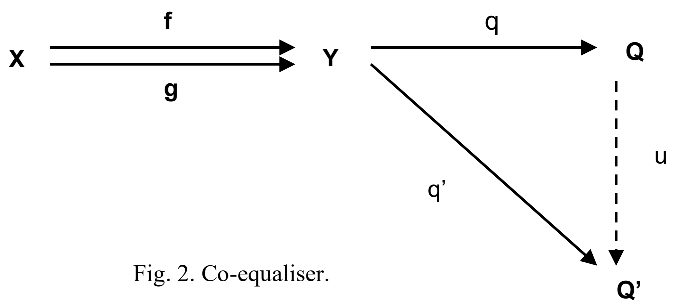

Fig. 2. Co-equaliser.

In a category of sets, the co-equaliser of two functions f, g : X → Y is the set of quotients of R by the equivalence relation generated by the relation f(x) = g(x) for all x ∈ X. An equivalence relation between the elements of the set Y is a relation R ⊂ Y x Y that has the properties of reflexivity, symmetry and transitivity. The set of all equivalence classes is the quotient of Y by R: Y/R. The quotient Y/R is a partition of Y into disjoint subsets two by two.

The final equalizer

No matter how much society and nature differentiate and polarize, death is the final equalizer (omnia mors aequat), moving everything from minimizing entropy to maximizing it.

Harmonizing system generations. Gap management

Let us consider two dynamic systems, X and Y, fig.3. System X is born at t = 0, and Y is born later, at

t = τ. At a time t, X has age f = t, and Y has age g = t-τ. There is a constant age gap, an interface, between the two systems (f - g = τ). We assume that f and g are linear with respect to t. With respect to Y, the age difference ratio is τ / (t - τ) = 1 / ((t/τ) - 1) which, in the limit, for t →∞, becomes:

$$\lim_{t \to \infty} \frac{\tau}{t - \tau} = 0$$

that is, the weight of the age difference decreases with the passage of time, reaching infinity. Basically, the two systems will simultaneously reach "eternity".

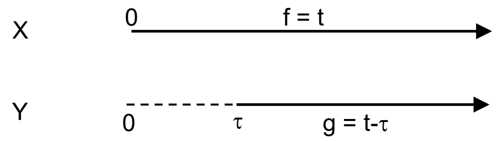

Fig. 3. Relative dynamics of systems

In another approach, relating the younger age to the older one (new to old, young to old age), that is, for

(t - τ) / t = 1- (τ / t), in the limit, the two systems will have the same age in eternity (t →∞):

$$\lim_{t \to \infty} (1 - \frac{\tau}{t}) = 1$$

The functions f and g have different meanings: technical state of the two systems, their technological level, quality of the human resource (including different generations), competence of managers, etc.

The functions f and g can also be multivariable, containing different time-dependent influencing factors, they can also be nonlinear, probabilistic, even containing quantum observables.

In interaction, the state and dynamics of one system is influenced by the other and vice versa. The gap τ(t) shows the time-varying relative position of the two systems. The emergence of the two systems can be deterministic, but the disappearance of each can be probabilistic (*we are born one after the other, but we die at random*).

The generality of the model can be extended to more than two systems, resulting in a system of systems. The applications can continue, with: the dynamics of the relative technological gap between a new member-state and the EU average (gap management); the gradual re-technologizing of a group of companies using the income generated by their members, as an alternative to their total destruction by the "tabula rasa" method applied after 1989; the liquidation of the maritime fleet instead of gradually adding new S_2 type ships, simultaneously with the gradual modernization of the existing S_1 type ones; the mentor-disciple dynamic (the accelerated increase in the disciple's knowledge in the context of the mentor's vitality decreasing over time); in the modeling of a man-woman couple of different ages, the relative age difference decreases until it is canceled out in eternity, as in poetry [7]:

Our limits
Being equal to zero,
We are two thoughts
Which we approach
Towards infinity.

Syncretism of systems

Through syncretism, a new system can be generated by combining elements from other systems using interfaces. A new category of systems can even be created through natural transformation from another category of systems.

Possible applications: technological vs. artistic systems; economic vs. logistic systems; inter-, co- and multi-modal vs. modal systems; EU vs. national systems; inter-, trans- and multi-disciplinary vs. disciplinary systems, etc.

5. Interface management

Let C be a category of systems, having:

- objects: systems S_1, S_2;
- morphisms or functors, $F : S_1 \rightarrow I$, $G : S_2 \rightarrow I$, with respect to an interface category I;
- the common interface, can be:
    - a fiber product (pullback) $P = S_1 \times_I S_2$, if the interface is a coordination of information between two systems that use a common resource;
    - a co-limit (pushout): if the systems must merge through the common interface;
    - an equaliser / co-equaliser: for example, when two processes lead to the same effect, the interface is modelable by an equaliser between two parallel morphisms.
- Internal transformations can be natural morphisms between functors.

Genesis of interface classes

A simplified model of man consists of his body as a biological object in which the soul is based, guided in turn by the spirit from God (John 14.15-16). Man is in fact his soul, his body as the interface with the external environment, and the spirit as presence of divinity. The soul and spirit may be invariant, but the body is degradable, modifiable and transient. In the interface there are the different

connections, even quantum. The interface can be generalized by the Lupasco state (the tertium included), as well as by the quantum state Ψ of consciousness and awareness.
Systems interact through interfaces that are continuously updated, learning from the interaction with the external environment [8]. Man tends, even without chances, to create an entity equivalent to himself that would equal his performances. The *descending causality* needs the coherence of hierarchical chains between different levels of reality vertically, but also on the same level [9]. Such an object equivalent to man will have different types of corresponding elements: hard (body), software and AI (soul), and the human will to substitute the role of the spirit of divine origin. This is the difference between the ephemeral creation that man is capable of, and the divine creation. On the level of reality of AI entities, man can exercise the role of guiding, controlling and orienting their behavior, completing a similar trio, mutatis mutandis, with that of the divine creation on the higher level of reality, but which is located above the natural and scientific environment, fig. 4.

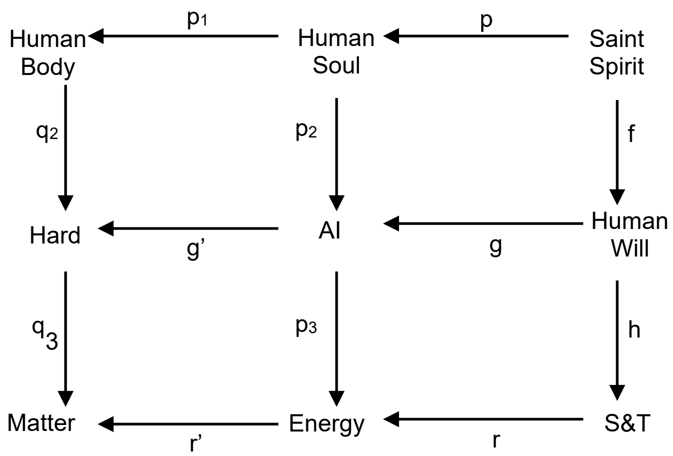

Fig. 4. AI based system control by pasting fibrate products.

The result is a relationship of order between several self-similar levels of reality, a network of creativity on which flows of fiber products (pullbacks) circulate that show a certain universal coherence.

Planning the interfaces in systems networking

A strategic direction for the development and operation of systems is the optimization of their operation in networks. This objective is achieved through planning and optimal operation of the system coupling interfaces in the networks. Networks can be simple chains of systems, planar networks, n-dim networks, intersection of networks. Networks can be permanent, especially those inside an object (system), but also with variable geometry in a structural and/or functional sense, ad hoc, temporary networks, networks for cases of force majeure (military campaigns, large-scale accidents). The interface between systems or networks of systems is the place where acceleration/deceleration of system cooperation are made. In the interface, specific planning concepts and a certain dynamic are applied through which the functioning of the whole, of the system of systems, is personalized. The connections in the interface can be deterministic, but also probabilistic, and quantum. The flexible coupling elements can be intelligent including AI, seeking out each other for coupling. Interface planning can be the main element in the resilience of the system, the shape of the network being driven by the interfaces.

6. Conclusions

This paper attempts to discuss the role of the coupling interface of the structural and functional elements that shape the systems, making them effective, efficient and adaptive to the external environment.
The complexity of the systems that are coupled also means sophisticated interfaces, requiring new theories and models through which to identify nuanced aspects of their functioning, going up to quantum phenomena from the micro-reality of the contacts of the component elements, continuing with their emergence towards physical macro-reality. The importance of this approach will be more evident with the increase in the applications of artificial intelligence integrated with the increasingly highly qualified human factor (quantum minds). In this sense, the inter-, trans- and multi-disciplinary approach of the coupling interfaces of the systems is proposed as a key system with requirements, standards, analysis and decision methods specific to them.

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