From Digital Computers to Quantum Genomic Computers Based on Biological Paradigms and Progress Particle Physics

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***Abstract*-The finite state machine is the base of modern computers. Turing has revealed the potential of "instruction based" systems, respectively, put the basis of the programmability of such systems. The last period of time revealed the important barriers involved by the heat inherent "generation" inside computers, as a direct result of the clock frequency increasing. Thus, the "thermal wall" represents nowadays the major obstacle in front of the computation domain development. Looking at biological systems, it becomes obvious that the allowing or gating process that happens at synapses level will inspire the development of a more sophisticated processing of information, based on spatial-temporal integration and correlation. Nowadays, the evolution related to the "condensed matter" is specially developed around carbon allotropic phases, were the most important is the grapheme. This generates the premises for changing the very well known paradigms related the conduction of charge carriers The paper signalize and propose potential new solutions for the next generations of computers. This is related to the application of the nano-scale phenomena revealed in the last few years, as a prolific mechanism used to generate and process (transport, modulate, re-direct, collect, sense, gate and base on Moiré interference, split and/or filter) the charge carriers in structured condensed matter. In this mode, by structural design and organization of nano-structured elements, could be created nano-storage areas and new way to interconnect these zones in new hardware implementation of computational structures based on deflexed charge carriers' flows. A parallel image about main instruments used to data processing in classical and new proposed computers is revealed by the paper. Despite the difficulties in implementation due to the current state of technology, the paper suggests an exchange of views related to signal processing in a very large energetic scale. The last evolutions in the colored algebraic come in accordance with the main ideas proposed by the paper, offering a potential formalism related to the design of this new proposed processing system.**

I. INTRODUCTION

The present paper intents to suggest the necessity to exchange through paradigms related to the processing systems in context of more clear relevance of limits appeared in evolutions of controlling and computing systems. Is obvious that such approach can't cover at the moment all components of computers, and thus, this paper cover only partially this topic. This approach is also in accordance with the main achievements obtained in the domain of condensed matter especially, but also as result of the prolific efforts made in fundamental physics. Another essential aspect revealed by this paper consists in the necessity to reveal the crucial role played by study, analysis and understanding of very sophisticated structure, organization and control of biological systems constituting a huge portfolio of living optimal examples, representing also validated solutions for the complex systems.

The present paper treats on the following issues:

i). an overview of principal phenomena that stay at the base of the suggested proposal;
ii). the advances in research on sub-particles domain and their very close interaction and status dynamics with an emphasis put on consequences of structural design reflected as potentiality for functionality implementation;
iii). the progress done in revealing the finest and deepest paradigms and physiological processes that govern the biological systems, representing the base of sustaining of the life;
iv). the development by analogy with classical computation systems especially with the programmable automata of the two implementation ways that in concurrence and correlation generate the complex functionality for processing system;
v). the formal comparative analogy that revealed the similarity, specific features and performances between the classical and proposed implementation solutions;
vi). the benefits that can be preview by the new solution;
vii). and the open research and technologic issues that still remain to be developed in the future. The conclusions chapter made a review of principal ideas reveled by the paper and also suggests a way that should be followed in order to arrive at a theoretical development of a generic model and simulation based on colored algebraic.

II. RESEARCH QUESTION

The structural design of nano-materials organized together with biological elements becomes a naval means to be able to "induce" potential functionalities for the next generation of processing systems. Another question is how the main constitutive elements forming the processing systems may have to be identified into the new context, characterized, aggregated and exploited in an optimal way in order to buster the overall performance of processing systems. How the structural design generates the functional potentiality, how widely opens this new concept the doors for unification of actually view about information and energy processing systems are also questions that require a completely new vision and approach.

The aim of the paper is to line out a potential architecture for the next information and energetic processing system generations. This is conceived based on the conduction, deflection, filtering and association phenomena in the joint operation of biological structures and nano-structures trigged by particles interactions.

III. SURVEY

This paragraph treats the historical evolution of architecture using computing, build biological structures, when they hand on logical functions. Also, we suggest that only a holistic approach, which takes into account apparently disjunctive phenomena traditionally studied in specific science domains, can bring the right solutions for the future processing systems. The narrow and deeply penetration of actual science evolution is focused on domain specific knowing, this should be balanced in the same time by development of interdisciplinary and "transversal" vision on research. The horizontal mandatory fusion of apparently disparately facts constitutes the main source of innovation and progress.

From historical point of view the last past 80 years were mainly influenced by the computers development based on fundamental research done by Turing [1]. The phenomena that stay at the base of these machines are the binary logic and several very simple structures, that combined assure two main functions:

- storage of the information in a binary form (1 digit), and
- implementation of elementary logical and arithmetical operation.

The finite state machine is the base of modern computers [2]. Turing has revealed the potential of "instruction based" systems, respectively, put the basis of the programmability of such systems. So, from practical point of view, the electronic computers were born as implementation of ideas issued in 1938 [1]. The physical implementation was done as a result of long technological development efforts, initially using electronic tubes and afterward silicon and other adjacent alloys of elements from the Mendeleev periodic table. All of these were the result of the progresses done in semiconductor domain. The fundamental process in digital computers is the electric commutation phenomenon in semiconductor materials. This phenomenon produces a significant amount of heat especially during transient regimes. The last few years revealed the important technological barriers involved by the heat inherent "generation" inside computers, as a direct result of the clock frequency increasing and also increasing of functional density in silicon. Thus, the "thermal wall" represents nowadays the major obstacle of the computation domain development [3], [4]. Even the hardware programmed computing systems suffer from the same fundamental disadvantages related to the electric commutation.

Looking at biological systems, it becomes obvious that the allowing or gating process that happens at synapses level can also handle sophisticated processing of information, based on spatial-temporal integration and correlation. The threshold potential function assures the filtering of "noises" that could appear on the propagation path of the nervous signal. A single remark is important here, that the biological systems already realized the fundamental and encapsulated link between status of neuron and time. The complex topology of nervous systems, illustrated by the huge variety of ganglions inserted on signal pathways, represents complex organic multiplexors and de-multiplexors. In neural pathways, the biochemical and electrical signals' walk and the sensitivity thresholds play the essential role in preserving the stability, reliability and "filtering" capacity of the neural processing [5].

This phenomenon is relevant, for example, in case of the visual analyzer where the "lateral inhibition" phenomena is also present, consisting in a very complex cortical "reflection" process between different cortical zones [7] and the afferent visual ways, illustrating the necessity of processing in a reverberant way of spatial distributed bulk signals.

As an example of a very complex control phenomenon, that also presents a different action mechanism named "allostasis", has been revealed by Sterling E. and Eyer J.[6]. This process "achieves the stability through physiological or behavioral change". In these cases, the parameters vary and the variation anticipates the demands. The design of living beings is conceived to be efficient, and to predict future needs. This means in fact that the specific, dynamic-modified and self-updated knowledge database collections, which are managed by biological system, play a fundamental role in obtaining a remarkable reliability, stability and variety in systems' adaptation and response. The prediction processes require that each sensor will suffer an adaptation at the optimal input range. A similar reaction will be identifiable also for the actuators, which will adapt their output domains to the demanded signal variation. In the case of blood pressure regulation, this illustrates only one of the nature's predictive optimal designs for reliability, complexity, stability and adequate adaptability of the system at the huge and complex challenges, by adapting life to different internal and external excitations. The pattern collections try to anticipate the

demands that where “apriori” discovered, classified and stored as potential “most probable” stages. Multiple, mutually, reinforcing signals acting on multiple, mutually reinforced effectors, override the various feedbacks that oppose to change (“Trend dependence”). A high redundancy on each level of the control system is present. This is reflected by “distributed” & “specific” attribute of sensors and actuators spread on body. It is also remarkable the hybrid material, the functional means for action and the complex topology that such system presents [8].

Nowadays, the evolution related to fundamental particles physics, and especially those developed around carbon allotropic phases, has led to proofing the relevance in graphene and carbon nanotubes for diverse generation of logical functions [12][14]. This generates the premises for changing the very well known paradigms related to the conduction of charge carriers [15][17][18]. As an example, the thermal conductivity in graphene reach the ***k*** value of 5,000W/mK, the Young module 1TPa [13], and also have very high electro conductivity allowing the easy implementation of digital and memory functions [22]. As another example, recent studies revealed that the deflection of charge carriers appears as result of the existence of different kind of lattice places on their pathways [20]. Such lattices can be implemented in silicon, but also inside biological structures using effects as Moiré patterning. Another recently discovered phenomenon, the Quantum Hall Effect (QHE) [16][19], plays a similar role by deflecting the charge carriers from their straight way. Two 2D-layers of the phase space slightly form a network that acts as Moiré filter and deflect the charge carriers flow.

IV. PHENOMENA EXPLOITED BY THE PROPOSED ARCHITECTURE

The actual studies reveal effects such as ballistic conduction, the confinement of the charge carriers: electrons and positrons accordance with fermions composition rules. The reciprocally annulations of opposite charge carrier particle coupling and generation of neutral excitons [21] are only several absolutely very interesting phenomena that must be taken into account for the development of new generation of processing systems, generically named "computers" .

The phenomena that are induced by structural defect inside the allotropic structures 1D, 2D and multi-D, and/or the group effects. These are the result of building up, at nano-scale of the successive 2D, different layers and in this way can be designed new variants and also very complex processing structures. The 2D layers are based on graphene, or lead, or boron-nitride or other nano-structured materials that were inserted inside regular structures [23]. The succession of these layers will permit to deflect, even controlled by sensing local loops, the charge carriers' spots. The phenomena, such as anomalous phase Berry effect (PBE), minimal conductivity, high field degeneracy splitting, suppression of weak localization, long phase coherence length, quantum confinement have been proved by recent researches [23]. All these aspects allows us to affirm that the developing of the new computers generation, in the near or middle future, based on condensed matter phenomena, will become reality and will proof both a high computation capacity and very high energy efficiency.

Using the dissymmetry created into the structured matter, these, it was demonstrated that could be band gap zones where the charge could be stored. The granularity of such structure is able to reach the minimum value to store, like a single electron. Thus, such structures can play the role of very dense memory sub-systems. More important could be the capacitance offered by porous islands that can be inter-connected by using graphene (2D) or carbon-nano-tubes (CNT). So, the charge collector zones would implement the spatial-temporal integration function. If the same porous island (accumulation zone) will be targeted by opposite charge carriers (electron-hole), their coupling will generate excitons that cancel the charge [21]. Regarding the already studied mono-atomic FET transistors, these could play two roles, inside the parallel signalization subsystem, to control the evacuation of the charge accumulated on porous island collectors and to offer the necessary potential switching capacity to control the "input charge flows" (referred to the charge accumulators). Also these CNT play the role of binding together specialized nano-structured entities (we name these quantum genomic entities QGE). By building-up "pathways" between these islands - using 1D and 2D structures - the ballistic conduction will offer the advantage of an extraordinary efficiency in transport of charge carriers. In this way, the heat developed as result of charge moving will be minimized and, in such a case, the signal power will be significantly increased.

V. ARCHITECTURE

The architecture of proposed processing system combines, based on sub-particles confinement and recombination laws and also having as example the architecture of nervous system, two different type of processing ways:

i). Asynchronous processing, that could be also named "flow processing", based mainly on "walking" processes, deflection of charge carriers and accumulation of charge on dedicated areas placed on matter structures of systems (see Fig 1);

ii). Synchronous controlling system, or signalizing sub-system, that assures the implementation of "programmability" view in classical computing systems, especially in states based automata (see Fig 2).

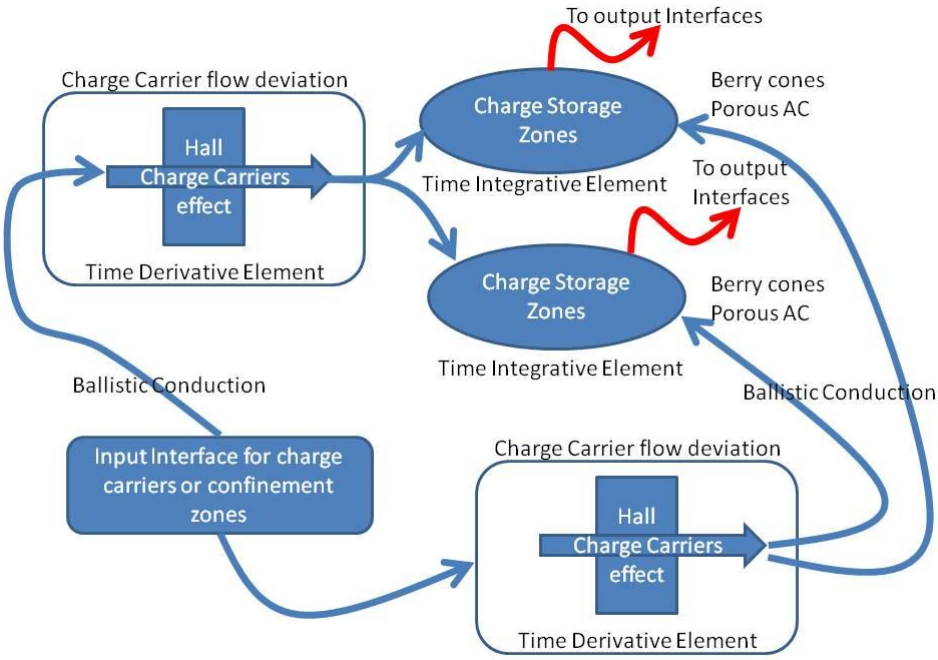

Fig 1 Path oriented walking architecture: Input interfaces or confinement zones; walking paths based on ballistic conduction on 2D graphene; sensing and eventually threshold elements; charge carriers collector zones with or without sensing and eventually threshold elements. All these elements can be placed on a single or adjacent multiple graphene or other condensed matter layers

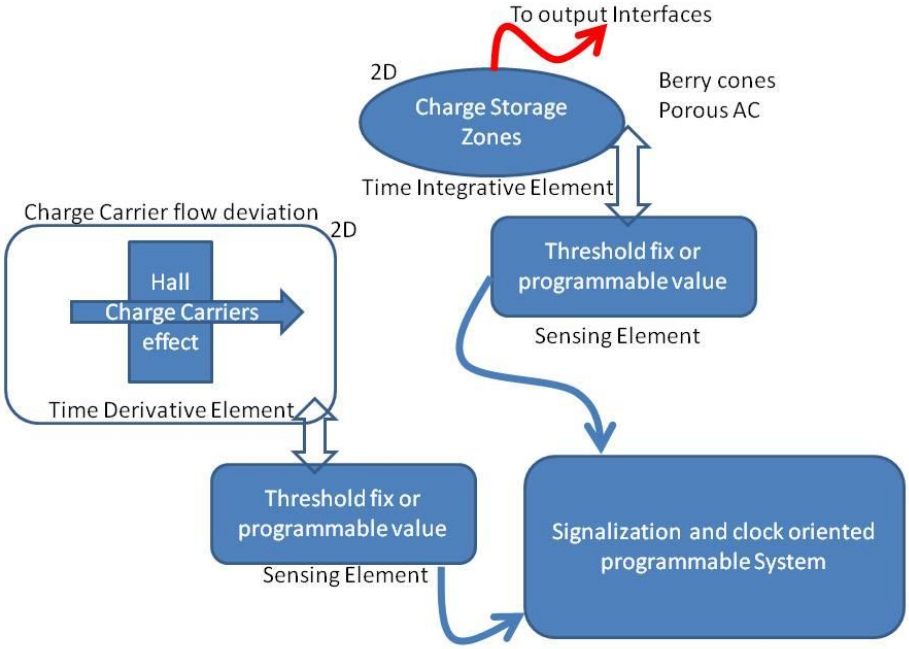

Fig 2 Combined processing system based on walking path, transition time based elements and signalization system that can receive and process the system' internal sensing collected signals, the clock circuits and external programmable control signals, forming together the synchronous extraction of charge/ processed signals

The first sub-system assures a very high speed due to the propagation speed of charge carriers inside condensed matter structures. Also, on these structures, deflection elements without or with possibility to be controlled by signalization system are

implemented. The "without controlled deflection" system is build-up in such way to assure fixed threshold functions by combining sensing with nano-actuators, such as deflection lattices.

Conceiving the system in this way, many possibilities for customizing the structures are possible. From one side, the configuration of structural elements placed on the same mono-atomic layer, consisting in the confinement and collector areas for charge carriers (inputs and outputs for the system), ways defined for propagation, deflection elements that form the processing ways based on different lengths forming in fact the asynchronous part of the system.

In respect with the constraints related to the very close manifestation of interaction matter-anti-matter on mono-atomic structured matter, a limited number of such layers can be "assembled" together and form that we named the quantum genomic entities (QGE).

These QGEs are structural and functional aggregated by both flow sub-systems and signalization sub-system too. The "flow based" sub-system will assure the "transgression" of signals between QGEs using mass less energy carriers or using energized sub-particles able, based on their energy, to pass the physical distance between adjacent QGE. In this way is possible to build-up a large variety of combined functionalities. The second way to assure the "transgression" process between QGE entities is to build up "wires" between the charge collector areas and the next inputs of correspondent QGE, and to use atomic switching devices, mainly based on 1D structured matter that can be controlled by the signalization sub-system.

It is obvious that these two subsystems can relax the dependability and reduce the global frequency accepted for conceived system, which became a "quantum genomic computer" QGC.

VI. REALIZATION OF THE ARCHITECTURAL COMPONENTS

The key elements used at realization of the proposed architectural elements are based on phenomena and structures that were already study such as: structural defect phenomena inside allotropic 1D, 2D and multi-D condensed matter; sub-lattices that can be also inserted and combined with based lattices; putting together different regular structures in adjacent layers that manifest close interactions. These interactions are from electric and/or magnetic nature and determine the shape of atomic potential like Berry cones (effect is known as phase Berry effect [22]). The surface conduction revealed by many laboratory experiences were disclosed as minimal conductivity for charge carriers, high field degeneracy, splitting of carrier beams, suppression of weal localization, long phase coherence length, quantum confinement, etc. The buildup dissymmetry created on mono-atomic layers creates band gap zones where the charge carriers can be collected. If the principles illustrated before are scaled with one or two dimensional order, to combine graphene with porous zones, as consequence will result a significant energetic scalability of the proposed systems. This scalability can start for collecting only a single electron in atomic LDOS band gaps, till large amount of charge, as in the case of porous areas like the ones in supercapacitor systems. Of course, in this last case, a special role is played by the existence of the second order conduction processes, due to ionic conduction and interfaces between stationary (carbon templates and their interfaces with electrolytes) and mobile phase.

A problem, which is almost solved using described elements, consists in remarkable increasing of density of structural and functional elements, and this will create the potential of scalability from the energetic point of view.

Another essential problem is related to the sensing processes that assure, in fact, the "functionality" provided by the computer' next generations. The above mentioned processes are the basis of the potential capability to build-up close loop sensors. These are able to discriminate between the integral values measured at the charge collectors level, the values of instantaneous signals transferred through 1D and 2D pathways using QHE, and the capacitance to build-up combination of sensing and acting systems, formed for example by functional coupling between sensing elements and sub-lattice able to be lightly moved, under control of small electric potential or magnetic fields.

Geim and Novoselov already have demonstrated the "strange" quantum phenomena that are manifested in the very close neighborhood (maximum 10 successive 2D layers)[14]. Thus, the new implementations should take into account this constraint and the granularity of processing entities, the Quantum Genomic Entities (QGE).

In order to better clarify the deep analogy that exists between classical computer programmability features, reflected by the Instruction Set Architecture (ISA) and the proposed processing system, a Quantum Genomic Computer (QGC) is lined out below by means of an intuitive table, containing concordances between the two implementations.

The programmed computers present three main types of instructions: executable, decision and repetitive. More of that, the structured programming technologies have developed the object oriented programming that offers a more generic way to implement algorithms, and also to increase the programming productivity. The main revealed forms are: routines, functions, objects. An important issue on these technologies is how the next computers generation can implement similar techniques?

Fig 3 shows a potential configuration of a layer and Fig 4 represents a quantum genomic "computer" (QGC). As result of this organization type, could be adopted for the computers next generations a modular design flow, leading to significant simplifications of the design process. Moreover, by a simple consideration of the scale, the energetic values that correspond to the signal processing could be significantly increased.

For the formalization and modeling of the new systems, the recent developed support, consisting in the use of generalized (colored) algebras combined with the geometry and graphs theory, could be used in order to model the complex and customized both computing and energetic structures [9], [10], [11].

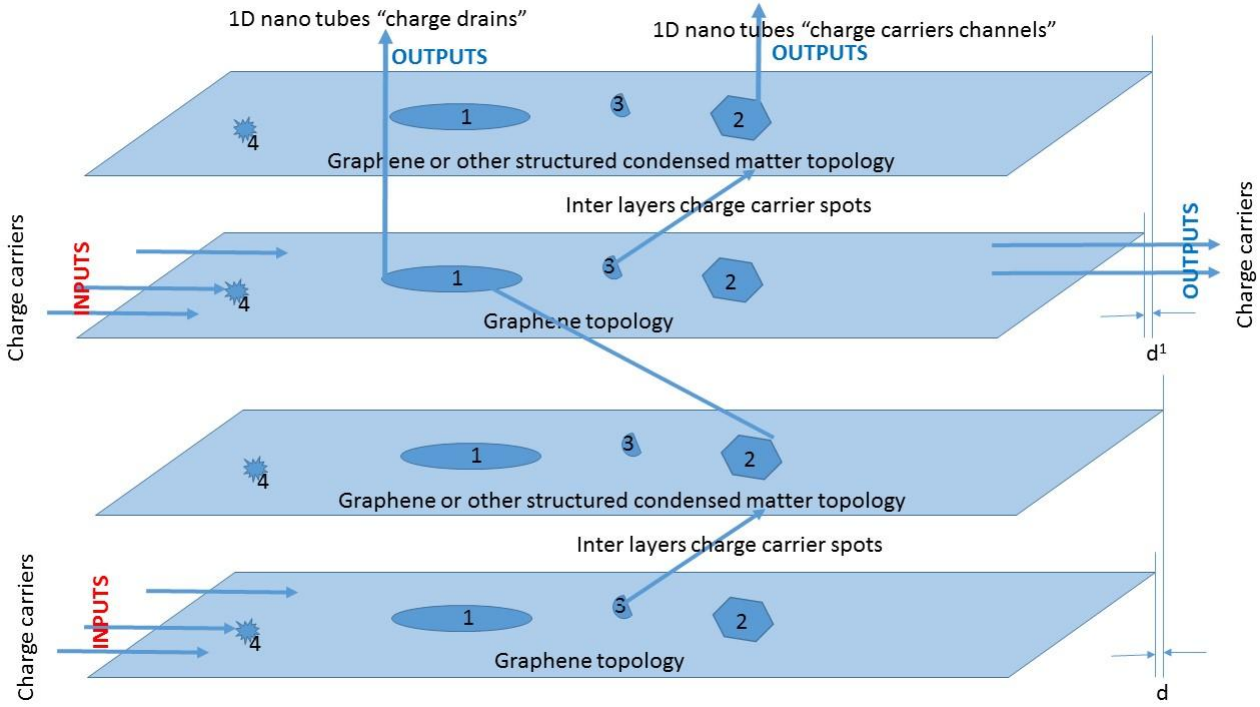

Fig 3 A Quantum Genomic Entity developed on several layers. Each layer can be represented as a "informational compact": 1 represents charge collector islands; 2 are sub-lattice able to deflect the charge carriers flows, 3 and 4 are induced structural defects or QHE based elements, and d, d^1 are the Moiré interference steps between different layers.

A potential response is given in Table 1.

Table 1 A comparison table between classical computers instructions and proposed flow computers based on condensed matter phenomena That is not the way to present; must write in second columns Equivalent architectural building blocks

Classical Computers based on Turing machine -	Computers based on "Quantum Genomic Entities"
Executable instructions	Informational compact implemented by charge collector islands, propagation "pathways" where conduction is assured in a ballistic mode, deflection elements (lattice, Berry cones, Moiré based sub-lattice implementing spatial interferential computing), semantically association between propagation channels issue from structural design and topology implemented at the level of "informational compact". Multiplication of such structures in close interaction layers that, grouped, become QGE.
A QGE could implement one or several classical "instructions" and by interconnecting many QGE instruction streams could be implemented, which form in fact a computing functionality implementing program Out of place; fits into Section on implementation	
Decision instructions	Usage of different techniques for sensing **integral signals** like charge collected on porous island or using QHE, Berry cones, Moiré sub-lattice etc. can be developed. These thresholds can be with: • "fixed" values, as result of structural design applied, respectively in strictly dependence with the dimensions of atoms involved or with the Moiré sub-lattice constant, or type of 2D adjacent layers, or with

	• "variable" values. This case is implemented when by designing the connectivity inside the atomic structure some sensing elements are connected with the sub-lattice or different kind of FET transistors that support to be controlled by voltage, magnetic field, etc. The QHE phenomena will permit to sense the **differential signals** (see QHE is dependent of speed of charge carriers). Thus, using these phenomena we can sense the combined signal that is charge carriers flow dependent. By designing close loop pathways inside the 2D layer, represented as "informational compact", a time dependent threshold can be implemented. This can gather the charge carriers' flows on the propagation channels. Thus, by structural design can be created the temporal windows, very important elements in decision process. Using Moiré sub-lattice different kind of spatial and temporal filters can be also implemented. We can conclude that the essential phenomena that stay at the base of processing functions are related to the "traveling" processes that happen on 1D, 2D and multi D layers.
Repetitive instructions	Applying the homonymic and toponymic structures translated in repetitive "walking pathways" the repetitive instructions could be implemented. The sensing elements will assure the "entrance" of carrier flows inside the "reverberant area (see in **Eroare! Fără sursă de referință.**) and also will permit the exit from such area, as result of conditionality fulfill. As shown in Fig 3 such structures are developed, in general, as systems having similar topologies and toponymy. In this way, such structure will function like "mirrors" for the traveling charge carriers and, based on thresholds inserted on pathways, these carriers will be - at a time moment or carrier flow level - ejected from the reverberant system.
The QGE and their aggregation will simulate classical computers programs	Development of structures based on QGE and QGC can generate complex structures and also functionalities by the simple interconnection of elementary QGE, in series, in parallel or multiplexed topologies. By the semantic allocation attributes, the new computers type will be able to act in a very similar way as the cortex reflection zones and many of reveled afferent paradigms could be applied.

The most interesting aspect is related to the "reverberant" loops that can be use as simple clock generators, or as complex processing systems able to spatial-temporal filtering of the charge carriers beams. These kinds of sub-systems will function in a similar way with the "reflection" cortical area, responsible for the very complex phenomenon related to thinking, feeling, rewarding/pain system and fusion of different highly level information that happen at cortex level.
A special accent should be highlighted in relation with the highly redundancy occurred in such systems and highly complexity of multiplexing/de-multiplexing processes. All those are as result of the highly selective Moiré phenomenon, and allow, in the same time, a variation the reaction responsible for creative processes in the human cortex.

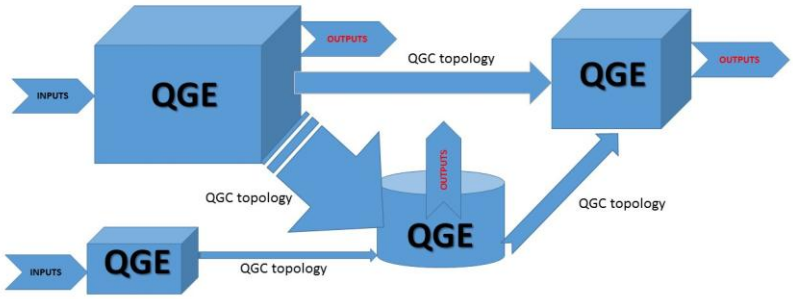

Fig 4. Illustration of the aggregation of QGE in QGC. The main structures that assure this integration are the 1D CNT.

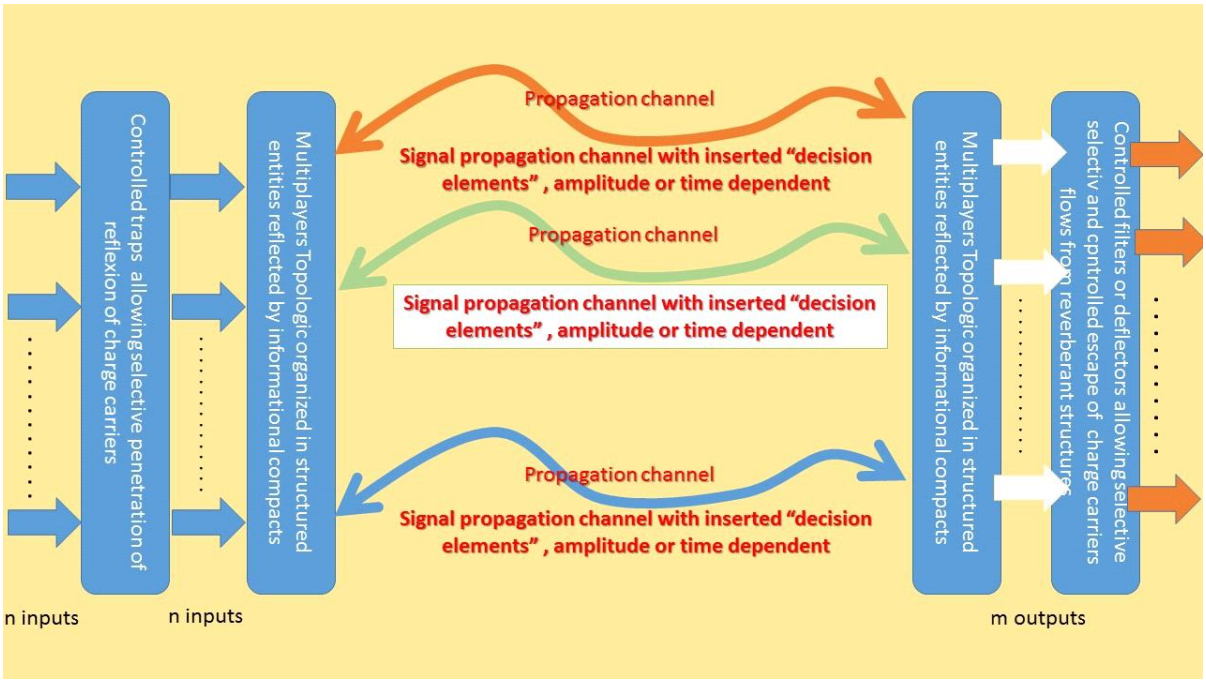

Fig 5 Schematic representation of reverberant structures. The propagation channels could also represents selective" outputs for charge carriers, not represented into the picture

VII. OPEN RESEARCH ISSUES

The paper tries to offer a potential and prospective view of evolution of processing systems unifying the two normally views as disjoint notions: information and energy. Thinking at the time horizon for implementation of these vision, this can be considered as feasible on medium and long term time, but the current studies reveals that this process of discovery is day after day accelerated, creating a moderate optimism related to the achievement of first implementations.

The remaining issues are only lined out and are many. This paper can signalize only several of these issues among them the most important are:

- Necessity to improve the nanotechnology related building up of 1D and 2D structures and especially the process of their separation from already obtained bulk structure;
- The assembly technologies that will assure the combination, at atomic level, between more than two, till minimum ten mono-atomic layers;
- Discovery of new combination of 2D structured matter formed by different kind of atoms, that will can reveal new type of interactions and will generate specific potential shapes, able to assure the more specificity in collecting of charge carriers;

- A very important problem that required a deeply analysis is related to the "life time" of sub-particles and elucidation of a model based on confinement and junction of such particles, that in fact becomes observable for a certain period of time;
- The reciprocally annulations of charge carriers, resulting in excitons or Majorana sub-particles, are phenomenon that require important analysis and studies, especially in order to find out the energetic model that is based on complex equilibrium momentum & energy for the rest mass and mass less particles;
- The mathematical formalization of design methodology for building up the processing elements at the 2D, 1D and multi-D level, their topology and toponymy by structuring, organization, dimensioning, placing, networking and shell functionality development for signalization sub-system too. This last functionality will need an adequate and adapted methodology for design and simulation;
- Not the last open issue refers to the development of studies related to the human very complex thinking, reasoning, feeling and superior, group, species oriented reactivity that is coordinated at cortex level. The reflective processes will be a prolific way for inspiration for building-up new and very complex functionality, more reliable, robust, stable and efficient from information and also energy processing points of view.

In order to conclude, it can be stated that the open issues illustrate the very long range of opened topic made as result of analyzing the actual evolution of experimental and theoretical scientific works.

VIII. CONCLUSIONS

The proposed idea is available at this moment, for the limits of actual research done in the field of computers and also energetic systems. We can summarize several features that such future system can bring: spatial distribution of charge collectors could be the target for many charge carriers flows, simulating in this way the neural inferences manifested in our nervous system. By allocating significance for every propagation channel (carriers flows pathways), the specificity of computation system become an essential feature making it adaptable at the huge variety of the real world. The energetic level of signals that can be processed by this system is much higher than the classical silicon structures. This is the consequence of the very low pathways electric resistance and, also, of the very high thermal conductivity of 1D and 2D layers. Moreover, by building up a cellular based architecture, with parallel-linked processing elements, otherwise can be considered as a topologic aggregation problem. This model is very similar with the case of living systems that are composed by aggregated cellular structures. Specificity, complexity, computation speed and energetic signals level become all more various and more simpler to be conceived.

Unfortunately, as result of this large variety of QGE and their possibilities of assembling, the design complexity increases in comparison with the classical computation systems. In comparison with the classical computers, the new proposed solution is far more energy efficient; eliminating the actual limits and constrains related to power consumption, the speed is drastically increased allowing, for example "by the fly" recognition of patterns and a lot of complex shapes.

The modeling of the new proposed computation systems can take the benefit of usage of the mathematical formalism developed by generalized algebras, geometry and graphs theories.

It is plausible that the modeling of such a system will bring new features, in parallel with the development of "condensed mater" knowledge, improving the possibilities mentioned in the present paper.

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