LOCALITY AND SYMMETRY IN INTERCONNECTING

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Localitatea este comportamentul (auto-organizare structurala) a unei colectivități in jurul unei origini. Localitatea de grup este comportamentul unei colectivități determinat de anumite proprietăți de grup, de exemplu simetriile unor figuri plane finite. Localitatea de grup este un alt punct de vedere asupra localității. Exprimând interconectarea ca model de colectivitate, demonstrăm că dihotomia localite-globalite acoperă matematic unul dintre înțelesurile structurale ale colectivității: local şi global, adica, un potențial structural al dinamicii colectivității, sau o auto-organizare structurală a unei colectivități.

Locality is the behavior (structural self-organization) of a collectivity around an origin. Group locality is a behavior of a collectivity determined of certain group properties, e.g., symmetries of finite plane figures. Group locality is another point of view on the networks locality. Expressing the interconnection as collectivity model we prove that the dichotomy locality-globality covers mathematically one of the structural meanings of the collectivity: local and global, i.e., a structural potential of a collectivity dynamics, or a structural self-organization of a collectivity.

Keywords: structure, collectivity, interconnection, locality, symmetry, globality

1. Introduction. Structure and Collectivity

A complexity system modelling means the perception of a *self-organization* of the system and the proper modelling. “To perceive a complex”, said Wittgenstein in [1], “means to perceive the relations of its constituent parts in a determined way”. One of nature’s characteristics is the *collectivity*. Professor Moshe Sipper said: “during the past few years a new wind swept, slowly changing our fundamental view of computers. We want them, of course, to be faster, better, more efficient, and proficient at their tasks. More interesting, we are trying to imbue them with abilities hitherto found only in nature, such as evolution, learning, development, growth, and collectivity [2].

We can observe collectivities in the not living world (universe galaxies, solar systems, crystalline units) as in the living world (ant hills, bee swarms, nations). What properties are behind the relations who tie the collectivities? Maybe is the gravity, the symmetry or the survival instinct? In a word, it is the

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structural self-organization. The self-organization can be structural and functional. Our article refers to the structural self-organization applied to the interconnected collectivities. First let us define the collectivity. Therefore we must answer to another question: what is a *set*? A set "can be selected by a membership or by a relation which substantiate the membership or by bringing in the set field elements which fulfil the relation" [3]. Because Bourbaki names "collectivizing relation" the relation defining a set, we name collectivities only the sets selected or built by the help of the *relations*. Therefore, we exclude the sets selected by the membership, the most general. A collectivity means not a set made, for example, of a star, a planet, a crystal, an ant, a bee and a man. The relation that substantiates the membership of a collectivity is connected with its *structure*: a collectivity is made of the least structural entities; e.g., an interconnection means nodes and links, equivalent to the graph definition. In this paper we try to begin to study the collectivities by the help of the concepts of *structure* - *locality* and *architecture* - *globality*. The architecture is a connection concept between the structure and the function. We start by defining the concept of structure [4]: the word is inherited from Latin that contains *structura* - building, and *struere* - to build, with the past participle *structus*. The *connection between parts* - first meaning - is something less necessary, less outlined, more approximately, more vaguely and more generally than the *total interdependence system of each part with all other parts* - second meaning. The *architecture measures by the degree of membership to global properties*. The symmetry is a global property. Helping the interconnection as a collectivity model we try to prove that the dichotomy locality-globality covers mathematically one of the structural meanings of the collectivity: the localization and the globalization, i.e. a *structural potential of a collectivity dynamics*, or a *structural self-organization of a collectivity*.

2. Interconnection as a Collectivity Model

A geometric figure remains itself even represented in other coordinate system, decreased, enlarged, color modified. This invariance of transposing is an *isomorphism*. The linguistic researchers contribute resolutely to the understanding and to the using of the structure concept unifying both meanings: the coherent, coagulated globality and the relations system between local parts or, in few words, the *globality* and the *locality*. This step in the evolution of the structure term opens a path to the identification between structure and essence of an object or a phenomenon. Wittgenstein writes in *Tractatus* "the manner in which the objects depend some on the others in the state of affairs constitutes the structure of the state of affairs".

Therefore, the *structure of a collectivity* can be self-organized *locally* and *globally*, e.g., an interconnecting structure estimates locally by neighbourhoods.

Thus, *locality is the behavior* (structural self-organization) *of a collectivity around an origin*. The origin can be temporal or spatial. The locality definition refers to the first meaning of the structure concept (the connection between parts).

Globality is the behavior (structural self-organization) *of a collectivity around a property*; e.g., the interconnections can be estimated and designed by the help of the *symmetry* properties. The globality definition concerns to the second meaning of the structure concept at which referred Wittgenstein - total interdependence system of each part with all others. On the other hand, the *collectivity architecture*, a connection concept between the structure and the function, gives a global meaning to the collectivity with the aim to better understand the connection between the structure and the function of the collectivity. Thus, we speak of the universe -, system -, house -, town -, computer -, or interconnecting -, communication architecture. *Architecture measures by the degree of membership to global properties*.

The symmetry is a global property. Helping the interconnection as a collectivity model we try to prove that the dichotomy locality-globality covers mathematically one of the structural meanings of the collectivity: the localization and the globalization, i.e. a *structural potential of a collectivity dynamics*, or a *structural self-organization of a collectivity*. The interconnections made of N nodes and L links model very well, in the sense given by Wittgenstein to the perception of structural self-organization, a collectivity. The nodes are the members of the collectivity that are tied by links - *interconnected collectivities*; they do not limit at sets with the same type of nodes - resulting collectivities with non homogenous nodes, and/or at sets with the same type of links - resulting collectivities with non homogenous links. What is certain is that structural entities forming the collectivity are interconnected one way or another. We limit, without losing too much of generality, to the *orthogonal interconnections* or *orthogonal collectivities*. Any number N can be represented as a product of whole numbers, $N=m_r \cdot m_{r-1} \cdot \ldots m_1$, i.e.,to each node of an interconnection we can associate an address X with r digits, $0 \leq X \leq N-1$. We present some orthogonal interconnections as collectivities, i.e. sets selected or built by *relations*.

A *generalized hypercube*, GHC, is an orthogonal collectivity with $N=m_r \cdot m_{r-1} \cdot \ldots m_1$ nodes interconnected in r dimensions. In every dimension i of a collectivity the m_i nodes are interconnected all by all. The relation which establishes the interconnection of N nodes all by all is: the nodes addressed by $X = (x_r\, x_{r-1} \ldots x_{i+1}\, x_i\, x_{i-1} \ldots x_1)$ are connected addressed by $X' = (x_r\, x_{r-1} \ldots x_{i+1}\, x'_i\, x_{i-1} \ldots x_1)$, where $1 \leq i \leq r$, $0 \leq x'_i \leq m_i - 1$ and $x'_i \neq x_i$. The *hypercube*, HC, is a GHC with $N = m^r$. The *binary hypercube*, BHC, is a HC with $N = 2^r$ nodes, and the *completely connected structure*}, CCS, is another HC with $N = m$ nodes.

A *generalized hypertorus*, GHT (Fig. 1), is another orthogonal collectivity with $N=m_r \cdot m_{r-1} \cdot \ldots m_1$ nodes interconnected in r dimensions. In every dimension i,

$1 \leq i \leq r$, the m_i nodes are "collectivized" in a torus. The relation which establishes the r tori of GHT collectivity is: nodes addressed by $X = (x_r\, x_{r-1}..x_{i+1}\, x_i\, x_{i-1}..x_1)$ are connected with the nearest neighbor nodes addressed by $X' = (x_r x_{r-1}..x_{i+1} x'_i x_{i-1}..x_1)$, $1 \leq i \leq r$, $x'_i = |\, x_i \pm 1|$modulo m_i. *Hypertorus*, HT, is a GHT with $N = m^r$ nodes, and *torus*, T, is a HT with $N=m$ nodes. BHC can be and HT with $N=2^r$ nodes.

A *generalized hypergrid*, GHG, is, also, an orthogonal collectivity having $N=m_r \cdot m_{r-1} \cdot \ldots m_1$ nodes interconnected in r dimensions. In every dimension the m_i nodes are being collectivized in a *chain*, or, better said, every node X is connected in a *grid* with the nodes addressed by $X' = (x_r\, x_{r-1} \ldots x_{i+1}\, x'_i\, x_{i-1} \ldots x_1)$, $x'_i = x_i \pm 1|\ x_i \neq 0$ and $x_i \neq m_i - 1$; $x'_i = x_i + 1|\ x_i = 0$; $x'_i = x_i - 1|\ x_i = m_i - 1$, for $1 \leq i \leq r$. The *hypergrid*, HG, is a GHG with $N = m^r$ nodes. The *chain*, C, is a HG with $N=m$. A binary hypercube can be, also, a hypergrid with $N = 2^r$ nodes.

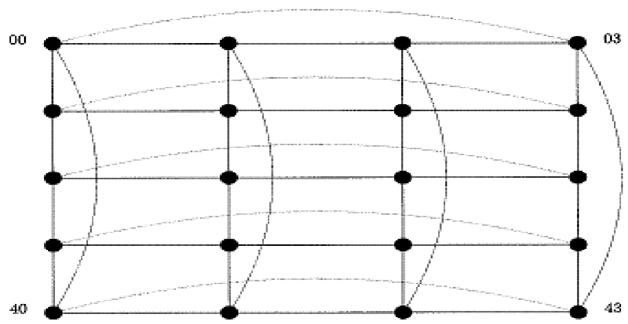

Fig. 1. An interconnected collectivity having a structure of GHT

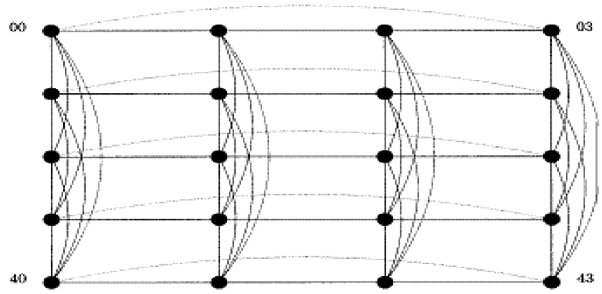

Fig. 2. An interconnected collectivity having a structure of GHS

Figures 1 and 2 represent two examples of simple associations in collectivity modeled by a homogenous interconnection, respectivelyby a non-homogenous interconnection. At homogenous regular interconnections, as the GHC or HT, the origin position - point of view, does not matter. The collectivities that they model are *spherical*. The diameter is the same, doesn't matter the point of view. At irregular networks, as GHG and other non-homogenous interconnections, e.g. GHS, it matters where the position of the origin is, it matters the point of view. The "structural" behavior around the origin at the collectivities modeled by these interconnections is not spherical anymore.

GHC, GHT and GHG are collectivities represented as *homogenous at links interconnections* or *homogenous interconnections* (the collectivities are homogenous at nodes, also; this paper does not refer to the non homogeneity at nodes). Most generally, the *non homogenous collectivities* can be represented as non homogenous (at links) interconnections. Examples of non homogenous collectivities are the collectivities represented by *generalized hyper structures*, GHS, [5]. A GHS (Fig. 2) is an orthogonal collectivity with $N=m_r \cdot m_{r-1} \cdot \ldots m_1$ nodes interconnected in r dimensions and in which every node X is collectivized (connected) in every dimension i, $1 \leq i \leq r$, to the nodes addressed by a *collectivizing (interconnecting) vector* $\left(\bigcup_{j=1}^{k_i} X^{ij}\right) = (x_r\ x_{r-1}\ \ldots\ x_{i+1}\ x'_i\ x_{i-1}\ \ldots\ x_1)$. $\left(\bigcup_{j=1}^{k_i} X^{ij}\right)$ specifies that a node of GHS is connected (non homogenous) by a *vector of elementary collectivizing structures* instead of a *single* structure in the homogeneous collectivities. This is non homogeneity at links of GHS specified by the collectivizing vector having, on the one hand, r elements, and on the other hand, k_i, $1 \leq i \leq r$, elementary collectivizing structures (homogenous) for which are specified the unions $\left(\bigcup_{j=1}^{k_i} X^{ij}\right)$, $j = 1, 2, \ldots, k_i$. So, X^{ij} are homogeneous elementary structures, like tori, grids, and chains, and must not be disjoint for a dimension.

Why does the origin position matter? The structural non-homogeneity of an association in a collectivity from an origin is equivalent to a *functional potential*. E.g., the more numerous and more varied the links in an interconnected collectivity from a point of view - an origin - are, the more sophisticated, more *adaptable* at a demand, or more *self-organized* the functions are The interconnected collectivities, non-/homogenous, can be appreciated, initially, by two general measures: *locality* and *globality* [6].

3. Interconnection Locality

The term *interconnection locality* is used by Hillis when presented the problems of memory allocation at Connection Machine [7]. He generalizes the characteristic of *physical locality* of the memory, hidden to the programmer of conventional von Neumann computers, and the characteristic of *bidimensional physical locality* in the implementation of the integrated circuits technology.

We consider the *interconnection locality* to be classified firstly *structural* (topological), and, secondly, *functional* [5]. Therefore, the locality of the interconnected collectivity will be defined by two localities: a *structural locality* and a *functional locality*. The structural localities can be appreciated, measured, by *neighborhoods*. The neighborhoods can be classified as *surface* (radial) *neighborhoods* and *volume* (spherical) *neighborhoods*. The surface neighborhood of an interconnected collectivity is the number of nodes at a distance d, $SN_d(O) = N_d(O)$, where O is the origin chosen arbitrarily. The volume neighborhood is $VN_d(O)=\sum_{i=1}^{d} N_d(O)$. The structural locality can be evaluated analytically by neighborhoods. Another more synthetical measure of the structural locality is the diameter: at the same number of nodes, the smaller diameter corresponds to the greater structural locality. A problem is: neighborhoods and the diameters depend on the *origin positions*. At homogenous regular interconnected collectivity, as the generalized hypercubes or hypertori, the origin position does not matter. At irregular interconnected collectivity, as the generalized hypergrids and other non-homogenous interconnected collectivity, the origin position matters. The topographic model presented in [5] helped us to study the description and the behavior of the direct interconnected collectivity, homogenous and, especially, non-homogenous. The structural locality is invariable information depending on the interconnected collectivity topology. A functional point of view on interconnection locality can take into consideration the message routing distributions, $\Phi_O(d)$, where O is the origin and d is the distance. As the structural locality, the functional locality measures also by neighborhoods: a *functional surface neighborhood,* $FSN_d(O)=\Phi_O(d)\times N_d(O)$, and a *functional volume neighborhood*, $FVN_d(O)=\sum_{i=1}^{d} \Phi_O(i)\times N_i(O)$. For the functional locality, there is also a synthetic measure, the *functional average distance*. The surface and volume neighborhoods and the diameter or the degree are analytical and synthetic evaluation means of the intercommunication capability of interconnected collectivity, measuring *structural locality* of the interconnected collectivity.

By functional neighborhoods and, indirectly, by functional average distance, it expresses which part of the structural locality is used by communication process implemented on the collectivity. In other words, the functional neighborhoods and functional average distances express the *functional locality* of interconnected collectivity. Obviously, for a given network, $SN_d \geq FSN_d$ and $VN_d \geq FVN_d$. The difference between the two types of neighborhoods represents what we named the *neighborhood reserve*. The neighborhood reserve is of surface, $SNR_d = SN_d - FSN_d$, or of volume, $VNR_d = VN_d - FVN_d$. Using the neighborhood reserve, we introduced a design/evaluation criterion of a topology by enunciating the following conjecture: The intercommunication structural potential of an interconnected collectivity is optimally used in a communication process characterized by a routing distribution Φ if the neighborhood reserve is minimal.

To evaluate the structural locality of an interconnected collectivity, besides the neighborhoods and their reserves, we proposed a simple measure: the *Moore* *reserve* based on the *Moore bound*. The Moore bound is the *maximum number of nodes* which can be present in a graph of given degree *l* and diameter *D*: $N_{Moore}= =1+l(((l-1)^D-1)/(l-2))$. The bound is deduced from a complete *l*-tree with diameter *D* and is an *absolute limit* for a *diametrical volume neighborhood*, $VN_d(O)=\sum_{i=1}^{d} N_d(O)$, in *any graph/ network* of *l* degree, *D* diameter. Except the complete *l*-ary trees, this bound is rarely reached. Therefore, we compute for the direct interconnection a network how far is this bound: the farther away *Moore* bound the structural locality properties are worse. We implement this by the *Moore reserves*. The *surface Moore reserve* is the difference between the number of nodes at distance *d* in a corresponding *Moore* tree - degree in considered network, and the surface neighborhood in considered network: $SMR_d=l(l-1)^{d-1}-N_d$. The *Moore reserve* is the difference between the *Moore* bound at the distance *d* and the volume neighborhood: $MR_d=N_{Moore}(d)-VN_d$.

4. Group Locality

Any interconnected collectivity, in the meaning of communications maintenance or connectivity, is more secure if it is more symmetrical. On the other hand, one of the most important properties of any physical space structure is the *symmetry*. The *transformation* that keeps the structure of the space is named *automorphism*. Giving a space configuration, a structure, a form, an *interconnection*, we can emphasize a set of space automorphisms, which leave unchangeable this interconnection. Thus, the emphasizing automorphisms form a *group/ subgroup*, which describes precisely the symmetry of giving configuration. The amorphous space has a *total symmetry* corresponding to the group of all automorphisms. The symmetry of an interconnection will be described, as we have told, by a subgroup of all automorphisms. The total symmetry of the space defined by *n* points (nodes, permutations) will be described by $S_{n!}$, while a *partial symmetry* is expressed by a subgroup of permutations. Therefore, symmetrical groups $S_{n!}$ model the symmetry of a space defined by *n* nodes and inversely. The total symmetry of a space is represented by a total interconnection, a *completely connected structure* with *n!* nodes. To define the locality by group properties, we give as first referencing examples the physical symmetry characteristics of some plane figures. A plane figure can have as constitutive symmetries only the *identity*, *rotation*, *translation*, *reflection* and *reflection-translation*.

A rectangle has four symmetries: the identity transformation, *I*; the two reflections S_1 and S_2 vs. non-parallel sides perpendicular bisectors, A_{S1} and A_{S2}; the rotation with 180°, *R*. The four automorphisms can be exemplified by a rectangle interconnection, the vertexes of which are noted 1, 2, 3 and 4. With this, we equate the symmetries of the rectangle with following permutations (generators): *I*=(1 2 3 4), S_1=(2 1 4 3), S_2=(4 3 2 1) and *R*=(3 4 1 2). The four

rectangle symmetries form a commutative group to the composition operation but, equating them with permutations, we notice that these symmetries form only a subgroup of the symmetric group of order 4, $S_{4!}$. The rectangle symmetries share the symmetric group $S_{4!}$ in subgroups of four elements. The *Cayley* graph of these subgroups, using as generators the symmetries (without *I*), is a completely connected structure with 4 nodes, Fig. 3. The graph of this figure is *vertex symmetric* as any *Cayley* graph. Let us notice that the subgroup of rectangle symmetries can have other generators than all three symmetries, e.g., only *R* and S_1 ($RS_1=S_1R=S_2$) or only *R* and S_2 ($RS_2=S_2R=S_1$) or only S_1 and S_2 ($S_1S_2=S_2S_1=R$). With these generators, we obtain other Cayley graphs: *minimal* rectangle symmetries *Cayley* graphs, Fig. 4.
These graphs are *Hamiltonian cycles* in the *complete Cayley* graph of the rectangle ymmetries.

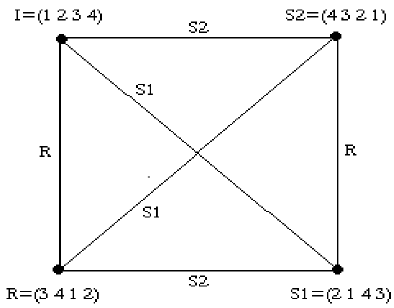

Fig. 3. *Complete Cayley* graph of rectangle

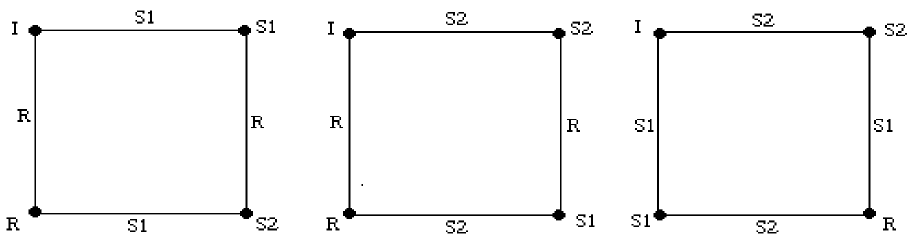

Fig. 4. *Minimal Cayley* graphs of rectangle symmetries

We can examine the symmetry properties of plane figures, which share the symmetric groups $S_{n!}$ in different subgroups. In the Table 1 we give some figures of which *groups (subgroups) of symmetry* G_S share symmetry groups $S_{n!}$, where n is the nodes number of the examined figure. As we see in Table 1, the (sub)groups of symmetry of the plane figures, G_S, *define* a *partial* symmetry, more weak than the *complete* symmetry defined by the corresponding symmetric groups $S_{n!}$. G_S *divides*, *shares* $S_{n!}$ in more subgroups. The groups of symmetry generators action is, generally, more *local*. The interconnections of the elements of a (sub)group defined by the symmetries of a plane figure emphasize, in general, a certain *locality* in comparison to the interaction *globality* which supposes the symmetry of the group $S_{n!}$.

Table 1.

The sharing of the symmetric groups by the symmetries of some plane figures

Structure	*Group of symmetry* G_S	$S_{n!}$ *Sharing*
Segment	{I, S}	$\lvert S_{2!}\rvert=\lvert G_S\rvert$
Isosceles Δ	{I, S}	$\lvert S_{3!}\rvert=3\times\lvert G_S\rvert$
Trigon	{I, R_1, R_2}	$\lvert S_{3!}\rvert=2\times\lvert G_S\rvert$
Equilateral Δ	{I, R_1, R_2, S_1, S_2, S_3}	$\lvert S_{3!}\rvert=\lvert G_S\rvert$
Tetragon	{I, R_1, R_2, R_3}	$\lvert S_{4!}\rvert=6\times\lvert G_S\rvert$
Rectangle	{I, S_1, S_2, R}	$\lvert S_{4!}\rvert=6\times\lvert G_S\rvert$
Square	{I, R_1, R_2, R_3, S, T, U, V}	$\lvert S_{4!}\rvert=3\times\lvert G_S\rvert$
Pentagon	{I, R_1, R_2, R_3, R_4, S_1, S_2, S_3, S_4, S_5}	$\lvert S_{5!}\rvert=12\times\lvert G_S\rvert$

Group locality [5] is an interconnection (behavior, interaction, granularity) of some nodes - sets of elements - determined by certain group properties. This definition differs radically from (interconnection) locality definition used in this paper and in other works, where the locality is understood first as *neighborhood* [8]. While the old definitions of interconnection locality are based on *logical distances* between the nodes of some structure and then on some *structuring rules*, the definition given now to the locality is based on certain *properties* of interconnection (sub)group of nodes, e.g., figure symmetries, which *divide*, *share* the group ($S_{n!}$). A quantitative appreciation, a measure of group locality, which we note L_n, is given by the ratio of the symmetric group order and the group of symmetries order used for dividing in subgroups; the minimum number of interconnection symmetries is 2 - excluding the trivial case of a single symmetry – *I*, consequently, the *maximum group locality* corresponding to (1), will be $|S_{n!}|/2$. The *minimum group locality*, L_n=1, or the *maximum globality* (*maximum granule*), is obtained when $|S_{n!}|=|G_S|$.

$$L_n=|S_{n!}|/|G_S| \qquad (1)$$

Table 1 shows the minimum locality is obtained for an interconnection of two points, L_2=1, and for an interconnection in an equilateral triangle, L_3=1. The maximum group locality, in the same table, is in the case of interconnection through a pentagon, L_5=12. Group localities should be compared at the same number of interconnecting nodes; e.g., the group localities of the tetragon and rectangle are the same for they refer to the same symmetric group, $S_{4!}$, while we can not say anything about group localities of isosceles triangle and square for they refer to the different symmetric groups, $S_{3!}$ and $S_{4!}$. In Table 1 there are geometrical figures with the same number of symmetries, e.g. the rectangle and tetragon, leading to the same group locality.

How we distinguish the interconnections that have the same L_n or *which of the two figures is more symmetric*? At this question, we answer giving another example. The tetragon has other four symmetries: *I* identity and R_1, R_2, R_3 rotations, with 90°, 180° and 270°, in the same sense. To express these symmetries as permutations we number constitutive triangles as in Fig.5: the tetragon has the same *number* of symmetries as the rectangle but other *properties* of symmetry. To represent the group of R_1, R_2, R_3 we have extended the definition of the graph *Cayley* to the *directed Cayley graph*. A directed *Cayley* graph is made only of vertices and arcs. If the *Cayley* graph has edges, it will be named *mixed Cayley graph*. For tetragon, the complete *Cayley* graph is mixed graph, Fig. 6. This graph is undirected only on diagonals and the generators R_1 and R_3 go through the graph vertices in the opposite directions. In the group table of tetragon symmetries we emphasize a single subgroup of order 2, {*I*, R_2}, while among the rectangle symmetries there are 3 such subgroups, {*I*, *R*}, {*I*, S_1}, {*I*, S_2}.

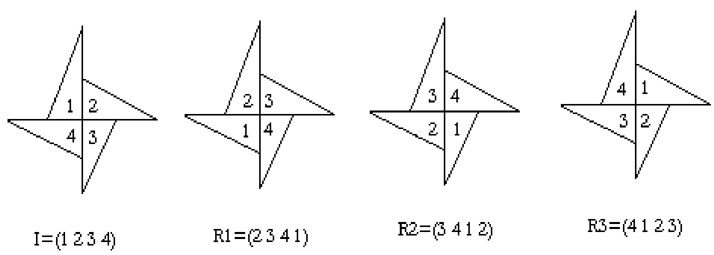

Fig. 5. Symmetries of a tetragon

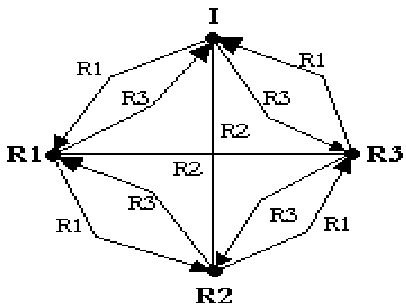

Fig. 6. Complete *Cayley* graph of tetragon symmetries

Now we can answer the question concerning symmetries of the figures that have the same group localities, through a conjecture: a *plane structure is more symmetrical as the complete Cayley graph is more undirected.* So, by using the mixed *Cayley* graphs we introduce the possibility of symmetry measurements (symmetric group locality): *an interconnection structure is more symmetric as mixed Cayley graph is more symmetric, i.e. it has more edges and fewer arcs.* Taking these into account, the symmetry can measure by S_n given by ratio between the number of edges of the mixed *Cayley* graph (NE_{MCG}), representing the interconnecting structure, and the order of symmetrical subgroup G_S: $S_n = NE_{MCG} / |G_S|$. Asymmetry is the inverse of the symmetry. Table 2 shows some symmetries/asymmetries of Table 1 figures, computed with the above formulas. Symmetries S_n and asymmetries AS_n can be compared for the same number of nodes n (interconnection of $S_{n!}$).

Table 2.

Some plane figures symmetries and asymmetries

Structure	*Symmetry* S_n	*Asymmetry* AS_n
Segment	S_2=1/2=0.5	AS_2=2/1=2
Isosceles triangle	S_3=1/2=0.5	AS_3=2/1=2
Tetragon	S_4=2/4=0.5	AS_4=4/2=2
Rectangle	S_4=6/4=1.5	AS_4=4/6=0.66

5. Conclusion

Instead of relying on the logic distances between the nodes, we wanted to design/evaluate a network based on the group properties. The group locality put the *properties*, a constructive, synthetic principle, before the analytic principle of *distances*, especially formulated for the interconnection locality. The logic distances “disappear” into the group locality, displaying the properties. Therefore, the group locality is qualitatively a step forward to the interconnection locality relying on logic distance. The interconnection locality principle helped us to design/evaluate new non-homogenous interconnection networks, as *generalized hyper structures*, and the group locality principle let us imagine new interconnection paradigm based on symmetrical *morphemes* and *ensembles*. The conclusion is: *discovering the rules that govern the future interconnection environment is a major challenge* [9].

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