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Spatial Integration at the Room-Level of 'Sequina' Slum Area in Alexandria, Egypt

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Abstract**—**The social logic of 'Sequina' slum area in Alexandria details the integral measure of space syntax at the room-level of twenty-building samples. The essence of spatial structure integrates the central 'visitor' domain with the 'living' frontage of the 'children' zone against the segregated privacy of the opposite 'parent' depth. Meanwhile, the multifunctioning of shallow rooms optimizes the integral 'visitor' structure through graph and visibility dimensions in contrast to the 'inhabitant' structure of graph-tails out of sight. Common theme of the layout integrity increases in compensation to the decrease of room visibility. Despite the 'pheno-type' of collective integration, the individual layouts observe 'geno-type' structure of spatial diversity per room adjoins. In this regard, the layout integrity alternates the cross-correlation of the 'kitchen & living' rooms with the 'inhabitant & visitor' domains of 'motherhood' dynamic structure. Moreover, the added 'grandparent' restructures the integral measure to become the deepest space, but opens to the 'living' of 'household' integrity. Some isomorphic layouts change the integral structure just through the 'balcony' extension of access, visual or ignored 'ringiness' of space syntax. However, the most integrated or segregated layouts invert the 'geno-type' into a shallow 'inhabitant' centrality versus the remote 'visitor' structure. Overview of the multivariate social logic of spatial integrity could never clarify without the micro-data analysis.

Keywords**—**Alexandria, Sequina slum, spatial integration, space syntax.

I. Introduction

THE universal issue of unhygienic slum areas explores social aspects of redevelopment. In Egypt, the poverty of housing slums sprawls against the building codes with the lack of basic infrastructures [10], [11]. The dense slums of Egypt accommodate the majority of unemployed rural migrants. In this respect, each slum area requires a human study to classify the spatial structure for a programmed rural migration [5], [6]. Among the selected populous slums in Egypt for detailed building survey is 'Sequina' area in Alexandria, which clusters low-skilled laborer migrants from the nearby province of 'Behera' rural governorate. The unrealized building documents or census data on migration had necessitated the prerequisite of household survey on a cluster of building blocks, with the latter stratification of twenty-building samples to conduct the detailed survey of interior rooms, Figs. 1 and 2. The micro-level spatial analysis of 'Sequina' area complements the scope of previous studies on slums of Egypt such as [2], [3], [8], [12].

The social study on building slums addresses the analytical method of interdisciplinary space syntax [4]. The social logic of space converts the building rooms into topological graph representation, which interprets spatial measurements with graph algorithms [9]. Meanwhile, the spatial visibility enriches the space syntax of housing decodes [7]. This specific study focuses on the integral measure of rooms according to the analytical criteria of: 1) real relative asymmetry (RRA) of collective layouts, 2) relative asymmetry (RA) of individual layouts, and 3) spatial visibility in layouts. The correlation of these issues clarifies the social logic of spatial structure at different levels of integral resolutions. The prospected social overview adjusts the long-term comprehensive plan strategy of redeveloping slum areas for a better future of Alexandria [1].

Fig. 1 Location of 'Sequina' slum area

Fig. 2 Location of sample buildings

II. Real Relative Asymmetry of Survey Rooms

The urban sprawl of 'Sequina' area in Alexandria forms linear blocks of different heights along narrow passages, Figs. 3-6. The common layout composes one or two flats per typical floor with a single façade. The survey of interior rooms details the typical floor plans of twenty-sample buildings from various blocks in the area, Fig. 7. The survey assumes the carrier of layout to start from the entrance door at the staircase access, with the bedroom serial numbering in clock-wise direction for comparative structure. The graph of rooms

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represents the access corridors as bold dots, while the balcony space is treated as an individual room, Fig. 8. The resulted graphs observe the shallow bushy-tree structure of spatial organization, with a maximum length of four adjacency steps. The distinctive components of graphs observe the 'visitor' domain of 'reception' room in the form of central branching space, while the 'inhabitant' rooms form a deep graph structure. The justified graphs measure the spatial depth from each room to all others. The collective layouts compare the spatial measurement of real relative asymmetry (RRA) with respect to the graph-size per layout, where the less value indicates more spatial integrity. Meanwhile, the graph-vertex of each room compares the relative asymmetry (RA) with the other rooms of individual layouts, Table I. The social logic clarifies the measurements of spatial integration in correlation to the functional and visibility issues of the room structure at different levels of the discrete spatial resolutions.

The measured RRA of the layout samples ranges from the integrated value of '0.8' to the more segregation of '1.47'. The layouts '16, 19 & 2' represent the range of highest integration with an average of '0.85' RRA value. The most integrative layout-16 shares with the layout-7 isomorphic graph structure, but a different integral measure of functional aspects. The multifunction of the central space maximizes the layout integration in contrast to the other layout of single function. Also the correspondent functions of graph vertices changes between the two cases to suggest a different room structure. The comparable layout-19 shares a similar graph structure, but of fewer adjacencies (graph degree) for the central space. However, the multifunctional room of the 'inhabitant' domain compensates the less integrity of the central space. In this regard, the layouts of higher integration observe the same spatial depth and graph centrality, but differ in the graph order (number of room vertices) and the degree of adjacencies due to the changing function of multipurpose structure. The further comparison with layouts '5, 8 & 17' of less integrity sustains the same graph structure, with the change of layout into visual integration between the 'kitchen' and the central 'visitor' space. Although these cases are similar to the more integral layout-2, the single functioning of rooms in the deep 'inhabitant' domain with the deep 'utilities' cause the less integration.

The second range of layouts '17, 9, 18 & 12' measure '1.04' of RRA in average. The layouts '17 & 12' compare a maximal degree of 'inhabitant' vertices, which reduces the graph-tails. Meanwhile, the branching graph inside the 'inhabitant' domain competes with the 'visitor' of integral centrality. In addition, the two layouts have a common attachment of the 'living & reception' of dual social domains. The layouts '9 & 18' share the same graph and room structure, with added 'balcony' to the first case of unique 'ringiness' space syntax that forms the only cyclic-graph component among all of the survey layouts. The cyclic 'balcony' converts the deep 'inhabitant' structure into a more integral space than the second layout. The following range of layouts '7, 10, 4, 3 & 20' measures '1.09' RRA in average. Their common layout of central tree-graph characterizes the integral measure. The layouts '10 & 4' observe more graph vertices at the deep fourth-level. Nevertheless, the layout of multifunctional vertices at the various graph levels is more integrated than the other of functional merge only at the deep 'inhabitant' domain. The isomorphic graphs of layouts '4 & 1' enforce the same observation with the less layout integrity of single function per room. However, the graphs of layouts '3 & 20' have a fewer number of deep vertices with a higher spatial integrity. Thus, the deepest graph level of more vertices with single functions causes the less integration of layout. Another phenomenon observes the more layout integration of direct access between the 'visitor' and 'inhabitant' domains, while the insertion of access corridor between them causes the decrease of spatial integrity. Meanwhile, the first two layouts of integral range split their utility rooms apart from each other, while the further three layouts set the 'toilet' inside the 'kitchen' depth.

Fig. 3 Passages

Fig. 4 Heights

Fig. 5 Staircases

Fig. 6 Interiors

TABLE I
INTEGRAL MEASURE OF SURVEY ROOMS

Layout	S	R	L	D	K	T	BI	BII	BIII	AI	AII	C	RA	RRA
No.1	0.3929	0.17857	0.25		0.5	0.39286	0.5	0.5		0.25		0.464	0.380952	1.2
No.2	0.4	0.075	0.225	0.075	0.3	0.65	0.225	0.4				0.55	0.322222	0.95
No.3	0.3571	0.10714	0.3571		0.4643	0.46429	0.286	0.3571		0.21		0.536	0.349206	1.1
No.4	0.381	0.12698	0.2063		0.5079	0.50794	0.444	0.2063	0.381	0.25		0.444	0.346032	1.09
No.5	0.381	0.09524	0.381		0.2857	0.57143	0.286	0.381				0.571	0.369048	1.13
No.6	0.4286	0.17857	0.2857		0.4643	0.71429	0.536	0.4643		0.29		0.536	0.43254	1.36
No.7	0.4	0.06667	0.2667		0.4	0.4	0.4					0.6	0.361905	1.06
No.8	0.381	0.09524	0.381		0.2857	0.57143	0.286	0.381				0.571	0.369048	1.13
No.9	0.3571	0.10714	0.2857		0.4643	0.46429	0.286	0.3571		0.21		0.464	0.333333	1.05
No.10	0.45	0.125	0.275		0.125	0.6	0.275	0.6		0.25		0.6	0.366667	1.08
No.11	0.2857	0.42857	0.2222	0.429	0.6032	0.66667	0.603			0.35	0.41	0.667	0.466667	1.47
No.12	0.5833	0.20833	0.2083		0.5	0.5	0.5			0.08			0.369048	1.06
No.13	0.3929	0.14286	0.3214		0.4286	0.67857	0.393	0.3929		0.25		0.571	0.396825	1.25
No.14	0.4667	0.13333	0.4667		0.5333	0.53333	0.467			0.2			0.4	1.18
No.15	0.3889	0.16667	0.3333		0.5556	0.38889	0.389	0.5556	0.389	0.17	0.33		0.366667	1.2
No.16	0.3429	0.34286	0.0286		0.0286	0.34286	0.229	0.3429				0.571	0.278571	0.82
No.17	0.4	0.08571	0.0857		0.2857	0.62857	0.286	0.4				0.629	0.35	1.03
No.18	0.381	0.09524	0.381		0.4762	0.47619	0.381	0.381		0.19			0.345238	1.05
No.19	0.4286	0.03571	0.1786		0.0357	0.5	0.179	0.4286				0.571	0.294643	0.84
No.20	0.3571	0.10714	0.3571		0.4643	0.46429	0.286	0.3571		0.21		0.536	0.349206	1.1

The consecutive range of layouts '5, 8 & 14' increases the average RRA to '1.14' of less spatial integration. The tree-graph of branching utility rooms from the central space observes a higher integration when forming graph-tail instead of binary graph structure. In this respect, the direct access from the central 'reception' to the 'kitchen' causes more layout integrity than the structure of intermediary access corridor between the two rooms. Meanwhile, the layouts of graph structure having the 'kitchen' vertex in between the staring graph components correspond to the maximized spatial integration. Therefore, the structure of the 'kitchen' room has a direct effect on the whole layout integration. The isomorphic graphs of layouts '5 & 8' share a similar RRA measure, while their room structure observes some variance. The layout-5 enlarges the 'living' space next to the 'inhabitant' zone and apart from the utility rooms, while the other layout-8 juxtaposes the largest 'bedroom-I' with the 'living & utility' spaces in separate from the 'bedroom-II' zone. The former layout realizes visual integration between the 'kitchen' and the central 'visitor' space, while the latter forms an open 'inhabitant' space across the 'reception' of longitudinal shape. Thus, the 'inhabitant' spatial structure of 'geno-type' diversity enriches the 'pheno-type' of graph isomorphism. Meanwhile, the layout-13 of transitional corridor to the deep 'utility' rooms dissatisfies the isomorphism with the layouts '5 & 8'. This change of graph isomorphism reverses the 'pheno-type' layout into 'geno-type' graphs of phenomenal two-way spatial variety.

The further layouts '15, 1 & 13' decrease the spatial integration to an average value of '1.2' RRA. The main observation is the graph-tail of three-depth levels or binary-graph structure of deep 'inhabitant' domain. The unique graph of layout-15 combines both of the tail and binary structures in one graph component with double corridor spaces. Also the unique layout-1 composes a doubled binary-graph of the same 'inhabitant' domain. However, both of the layouts superimpose the separate 'toilet' room towards the middle position of the social domains, which forms the only graph-tail between the binaries of layout-1 compared to the maximal staring corridor of layout-15. The usual addition of this 'toilet' to the utility zone would have changed the integral structure of both cases. The layout-13 of less integrity forms the longest graph-tails of doubled structure for the 'utility' and the 'living' rooms of the 'inhabitant' domain. Although the central 'visitor' domain forms an integrated graph of 'bushy-tree' structure, the increased graph-tails of the 'inhabitant' domain causes the decrease of layout integration. The least integrated range of layouts '6 & 11' extends the RRA measure up to '1.4' average value. The layout-6 enforces the least integral measure of longest graph-tail for the 'utility' rooms, in addition to the binary-graph structure of the deep 'inhabitant' domain on the expense of a less 'bushy-tree' centrality. The bottommost integrity of layout-11 observes a unique binary-graph structure at the root-level of the 'staircase', which segregates the 'visitor' from the 'inhabitant' domains in both terms of spatial measurement and layout organization. The comparison of these two disintegrated layouts enforces the 'geno-type' structure of spatial diversity, while sustaining the 'pheno-type' generality of shallow 'visitor' and deep 'inhabitant' domains.

Overview of comparative integration demonstrates a social logic of functional and spatial variables. Whenever the graphs tend to be isomorphic, the room functions change between the 'visitor' and 'inhabitant' domains. Nevertheless, the one-to-one correspondence of room functions changes through the graph isomorphism. The increase of spatial integration correlates with the less visibility between rooms and also the more visibility for the less integrated layouts, thus the integral logic of 'geno-type' social diversity beyond the 'pheno-type' of deep 'inhabitant' and shallow 'visitor' domains.

Fig. 7 Typical floor plans of survey buildings in 2015

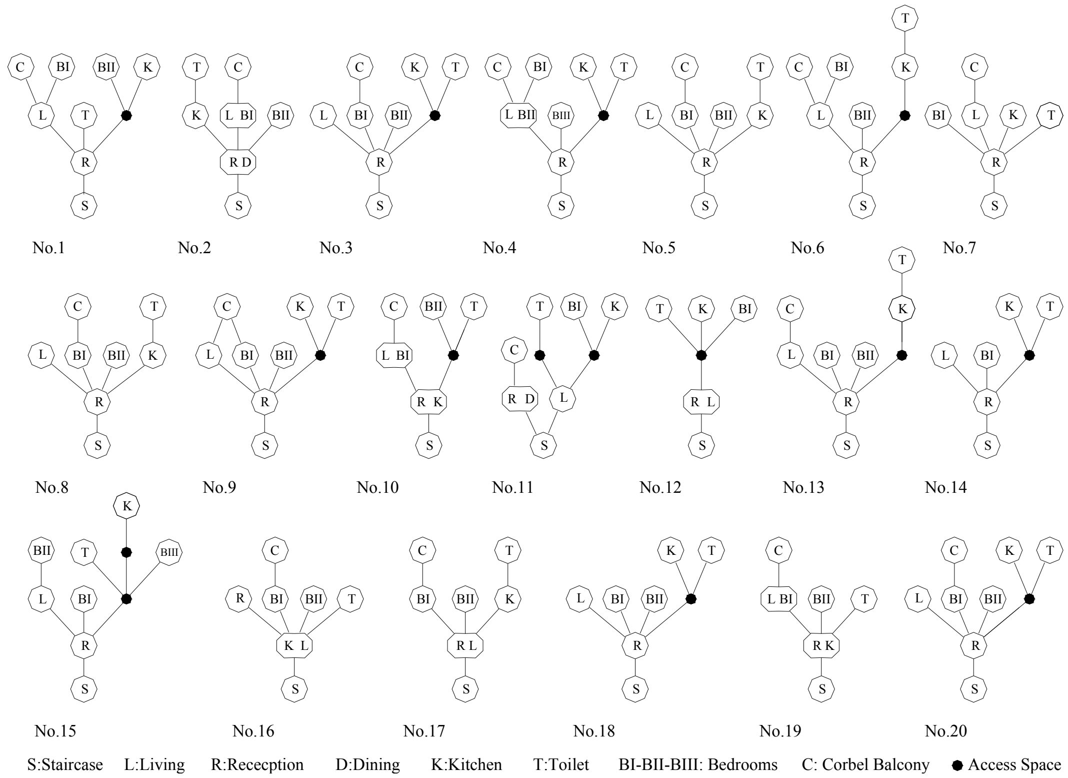

Fig. 8 Room graphs of survey buildings

III. Relative Asymmetry of Survey Rooms

Individual layouts measure the detailed relative asymmetry 'RA' of each room adjacency in turn of justified graphs. In this respect, the integration of each room is compared to all others of the same layout simultaneously. Meanwhile, the individual room integration observes the extended cross-comparison among the survey samples of the discrete spatial system, Table II. The assembly of room components configures the prototype of layout organization in aggregate measures. The calculated RA assumes a half-step between multifunctional rooms of combined vertices. The layout-1 measures an RA of '0.38' average value, which subdivides into a least integrated 'inhabitant' domain of '0.5' RA for 'kitchen, bedrooms & balcony' rooms, compared to a minimum value of '0.17' for the most integrated 'reception' room. The 'living & corridor' rooms blend the two extreme measures through a moderate integral measure of '0.25' RA value. Nevertheless, the two rooms of 'toilet & staircase' of '0.39' RA approach the layout average value. The social logic, thus, structures the shared facilities as the most balanced integrity, with the semi-inhabitant -visitor spaces in transition between the segregated 'inhabitant' privacy and the integrated 'visitor' space. The layout, however, resets the RA measure into two separate 'inhabitant' wings of 'living, bedroom-I & balcony' apart from the 'kitchen, bedroom-II & corridor' and centered by the 'reception, staircase & toilet' rooms. The 'inhabitant' wing of 'children' locates on the façade-side with tolerable spatial transparency, while the other 'parent' wing locates at the deep inner shaft. The shallow 'children' wing is characterized by a visual ring of window and open wall integration of the interior spaces on the 'balcony' threshold, while the deep 'parent' structure forms a buffer of 'corridor' space with 'kitchen' privacy. Logically, the 'parent' structure occupies the deep 'bedroom' of segregated motherhood rooming such as cooking, while the 'children' space exposes to the exterior 'strangers' and the interior 'visitors' through the common rooms of less social restrictions.

The following layout-2 of '0.32' average RA divides into binaries of most integrated 'reception & dining' room of 'visitor' space, less integrated 'bedroom-I & living' room of 'inhabitant' space, moderate integration of 'bedroom-II & staircase' rooms of mixed domains, and least integration of 'toilet & balcony' common rooms. The special 'kitchen' room, however, has the closest RA to layout average. The layout, nevertheless, maintains the 'parent-children' structure of 'children' integration through plan transparency of combined graph vertices on the exposed façade, compared to the 'parent' segregation with the layout opacity of tailing graph structure. Only the 'kitchen' is allowed to integrate with the various domains in visual and functional dimensions. Therefore, the social logic emphasizes the structure of 'motherhood' through the most balanced 'kitchen' integration of layout. The layout-3 of average '0.34' RA value is characterized by a representative room from each of 'visitor, parent and children' domains at different integral levels of the graph structure. The first set of the most integrated rooms includes the 'reception, access corridor to 'kitchen', and bedroom-I', while the second set measures closest RA to the layout average for each of the 'staircase, bedroom-II and living' rooms. Thus, the graph logic matches the integral structure among the various domains. The most segregated 'utility' rooms with the 'balcony' projection represent the deepest layout, with the exception of 'kitchen' having a visual integration with the most integrated central space. Therefore, the social integration forms zones of mixed domains for a universal-like layout within the limited space.

The other layout-4 sets 'bedroom-III & staircase' in nearest '0.38' RA value to the layout average. Thus, the 'parent' and 'carrier' rooms abstract the integral structure of layout. The remaining two 'bedrooms' of 'children' structure maintain the one zone at the façade-side, but substantially differs in their integral structure. One room multifunction with the 'living' space in high RA integrity and also visual merge with the most integrated 'visitor' space. The other one, however, is obstructed by the former with less integrity. In this regard, the 'elder' child is given more privacy of the least integral structure of 'bedroom-I', while the 'youngsters' share the most integrated 'bedroom-II' in hierarchy. Otherwise, 'brothers' may share the integrated room, while 'sisters' are afforded more privacy in segregation (or the inverse) depending on gender and age of children, which may restructure overtime. The 'balcony' shares the same RA of the most segregated 'bedroom-I' with the same access through 'bedroom-II/living' space. The 'window' opening of the most segregated 'bedroom-I' compensates by the visual integration to the 'balcony' room. The deep 'utility' rooms connect to the 'parent' rooming wing. The similar layout-5 adds the 'living' room to the 'parent-bedroom & staircase' of '0.38' RA that is close to the layout average. Also the 'kitchen' ties with the children's 'bedroom-I' with more spatial integrity. The unique layout forms one zone of 'bedrooms' instead of two separate wings. Despite the unity of household members, the spatial distribution maintains the 'children' structure on the façade-side with the 'balcony' access, while the invisible 'living' is compensated by the 'window' overlooking the outside passage. The 'kitchen' forms an open access with the most integrated 'visitor' space, and also controls the most disintegrated 'toilet' room. Although the 'balcony' and 'toilet' rooms measure the same RA as shared facilities, one exposes to 'strangers' and the other hides inside 'kitchen' depth. In this regard, the 'parent' structure performs dual layout strategies of analogical 'master-bedroom' and 'kitchen' of 'motherhood' identity by visual and spatial integrity.

The less integral layout-6 measures an RA of '0.43' average value, where the deep 'parent' integrates more than the shallow 'children' domain. In this inverted structure, the 'living' room integrates with the 'visitor' domain in an open plan structure. The 'children' domain becomes more segregated behind the 'living' to suit any of the social domains according to the instant situation. This adds a time dimension to the 'living' of integrated 'inhabitants' when the 'visitor' is absent or the inverse. Nevertheless, the 'kitchen' has been given more privacy with the segregated 'parent' structure against the freed 'living' structure. Therefore, the inverted integral structure takes place without altering the social domains with temporal change of domain to overcome the limited space available.

The smaller layout-7 has the only layout of the 'kitchen' besides the 'balcony' on the façade-side with the 'visitor' in central integrity. The re-inverted model allows the 'kitchen & living' to have a similar adjacency with the central 'reception' along the façade, but with a different integral structure. The accessible 'balcony' through the 'living' has privileged the layout integrity in comparison to the spatial structure simultaneously. Supposedly the relative degree or the visited household member of the 'visitor' decides where to be received. The near relative is expected in the deep 'reception', while the far relationship more suits the shallow 'living' room. Also the 'visitor' of 'children' is expected in the 'living' with deep privacy of the 'parent' domain, while the 'parent' visitor may invert the process. The different layout-5, nevertheless, has the only choice of a central shallow 'visitor' with the deep 'inhabitant' of 'geno-type' model. Therefore, the social logic demonstrates a different type of spatial integration through the degree of the 'visitor' interaction within the layout.

Although the layout-9 is comparable to the layout-8 structure, the integral measure differs through the 'ringiness' syntax of cyclic space. In this ring, the 'living & balcony' rooms increase the integral measure the common segregation of the 'kitchen, toilet & bedroom' with the highest RA value. In this regard, the integral structure is not defined by the common room adjacency to the central space, but through the 'balcony' buffer. This structure is emphasized through the 'inhabitant' domain without any room adjacency among each other, but combined in one integral measure away from the 'living'. Therefore, the locational and adjacency structure can vary without affecting the social structure of the layout. Meanwhile, the 'living' along with the 'visitor' domains are structured adjacent to all the 'inhabitant' rooms for instant change of domain depending on the presence of a 'visitor'.

The isomorphic graphs of layouts '8 & 5' observe non-isomorphic layouts. Despite the one-to-one correspondence of graph adjacency with identical RA values, the room utilization observes some differences. The deep furnishing area of the reception room in layout-8 causes more integral structure of the 'visitor' space with the deep 'parent' room. The shallow 'children' room, however, forms one cluster with the 'living, kitchen & toilet' at the 'staircase' side. Meanwhile, the 'living' room facilitates the direct access from the 'staircase' of the 'staircase, bedroom-II and living' rooms. Thus, the graph logic matches the integral structure among the various domains. The most segregated 'utility' rooms with the 'balcony' projection represent the deepest layout, with the exception of 'kitchen' having a visual integration with the most integrated central space. Therefore, the social integration forms zones of mixed domains for a universal-like layout within the limited space.

Although the layout-9 is comparable to the layout-8 structure, the integral measure differs through the 'ringiness' syntax of cyclic space. In this ring, the 'living & balcony' rooms increase the integral measure through their direct adjacency with cyclic connection to the 'children' and 'visitor' domains. The circulation of various social domains in one cycle optimizes the alternating interface of any room in either 'visitor' or 'inhabitant' structure. Meanwhile, the 'parent' domain preserves the deep privacy away from the ringy space, with more kitchen integration through the binary utility access. In fact, the spatial ring distracts the 'visitor' domain from integrating with the 'parent' structure, although both have direct adjacency to each other. However, the 'parent' has the privilege of direct adjacency to integrate with the cyclic space as desired, thus a unique social structure of one-sided integration through 'cyclic-acyclic' spatial structure.

The different layout-10 for the first time combines the 'reception & kitchen' in the central space, with the further adjacent combination of the 'living & bedroom-I' at the façade. On the contrary, the segregated 'bedroom-II & toilet' beyond their binary access corridor of the 'parent' structure, together with the opposite 'balcony' of similar depth, maximize the disintegrated structure of the layout. Therefore, the contrast of integral measure among the social domains emphasizes the geno-type spatial structure with clear distinction of layout functioning. Nevertheless, the split of the 'kitchen' from the 'parent' domain restructures the layout into totally integrated 'motherhood' within the segregated 'parent' structure. This logic conveys the social message of primary 'inhabitant' and secondary 'visitor' priority of space, where the motherhood engagement in the central 'kitchen' forces the 'visitor' towards the 'living/bedroom-I' option. Otherwise, the layout turns into absolute integrity of 'visitor' or 'inhabitant' during the absence of either, thus another spatiotemporal dimension of social structure.

The layout-11 exploits the carrier 'staircase' of the most integrating measure as part of the interior structure to access either the 'visitor' or the 'inhabitant' domains in separate. Although the layout represents the most segregated structure among the survey buildings with the highest RA value of '0.47' in average, the 'living' structure compensates the integral centrality of the 'inhabitant' domain. Meanwhile, the 'reception' compensates the 'living' adjacency through the multifunction with the 'dining' space of seldom existence in the survey buildings. Therefore, the social logic defines the formal rituals of receiving a 'visitor' with the highest restrictions on both the ‘visitor’ and 'inhabitant' to meet in the isolated space for 'reception/dining' function, while the informal structure of the 'inhabitant' centralizes the 'living' in free network of 'inhabitant' with the possibility of integrating a 'visitor' if socially close. This unprecedented social model differentiates between the formal and informal 'visitor' integrity in spatial relationship to the ‘inhabitant’ structure.

The exceptional layout-12 undermines the layout centrality, while the access 'corridor' of the 'inhabitant' domain forms the most integrating space. However, the integral 'visitor' domain combines the 'reception' with the 'living' in a single room at the façade. The simplified layout measures a constant RA value of '0.5' for the 'inhabitant' rooms of 'kitchen, toilet & bedroom' in common, with a shared RA integrity of '0.2' value for the 'visitor' space, while the 'corridor' of only '0.1' RA value maximizes the layout integrity within the 'inhabitant' domain. In this regard, the 'inhabitant' is no longer segregating, with the realized spatial integrity through the circulation space rather than the room structure. This is evident when skipping the 'corridor' measure to highlight the segregated 'inhabitant' rooms against the integral 'visitor' space. Thus, the pseudo 'corridor' integrity separates the segregated 'inhabitant' from the integrated 'visitor' domains, while in the meantime integrates the total layout structure to form the essence of social logic.

TABLE II
ADJACENCY OF SURVEY ROOMS

Rm.	S	R	L	D	K	T	BI	BII	BIII	AI	AII	C	Sum	RA	RRA	Rm.	S	R	L	D	K	T	BI	BII	BIII	AI	AII	C	Sum	RA	RRA
S01		1	2		3	2	3	3		2		3	19	0.39	1.24	R01	1		1		2	1	2	3		1		2	13	0.18	0.56
S02		1	2	1	2	3	2	2				3	16	0.40	1.18	R02	1		1	0.5	1	2	1	1				2	9.5	0.08	0.22
S03		1	2		3	3	2	2		2		3	18	0.36	1.13	R03	1		1		2	2	1	1		1		2	11	0.11	0.34
S04		1	2		3	3	3	2	2	2		3	21	0.38	1.20	R04	1		1		2	2	2	1	1	1		2	13	0.13	0.40
S05		1	2		2	3	2	2				3	15	0.38	1.16	R05	1		1		1	2	1	1				2	9	0.10	0.29
S06		1	2		3	4	3	2		2		3	20	0.43	1.35	R06	1		1		2	3	2	1		1		2	13	0.18	0.56
S07		1	2		2	2	2					3	12	0.40	1.18	R07	1		1		1	1	1					2	7	0.07	0.20
S08		1	2		2	3	2	2				3	15	0.38	1.16	R08	1		1		1	2	1	1				2	9	0.10	0.29
S09		1	2		3	3	2	2		2		3	18	0.36	1.13	R09	1		1		2	2	1	1		1		2	11	0.11	0.34
S10		1	2		1	3	2	3		2		3	17	0.45	1.32	R10	1		1		0.5	2	1	2		1		2	10.5	0.13	0.37
S11		1	1	1	3	3	3			2	2	2	18	0.29	0.90	R11	1		2	0.5	4	4	4			3	3	1	22.5	0.43	1.35
S12		1	1		3	3	3			2			13	0.58	1.67	R12	1		0.5		2	2	2			1			8.5	0.21	0.60
S13		1	2		3	4	2	2		2		3	19	0.39	1.24	R13	1		1		2	3	1	1		1		2	12	0.14	0.45
S14		1	2		3	3	2			2			13	0.47	1.37	R14	1		1		2	2	1			1			8	0.13	0.39
S15		1	2		4	3	2	3	3	2	3		23	0.39	1.27	R15	1		1		3	2	1	2	2	1	2		15	0.17	0.54
S16		2	1		1	2	2	2				3	13	0.34	1.01	R16	2		1		1	2	2	2				3	13	0.34	1.01
S17		1	1		2	3	2	2				3	14	0.40	1.18	R17	1		0.5		1	2	1	1				2	8.5	0.09	0.25
S18		1	2		3	3	2	2		2			15	0.38	1.16	R18	1		1		2	2	1	1		1			9	0.10	0.29
S19		1	2		1	2	2	2				3	13	0.43	1.23	R19	1		1		0.5	1	1	1				2	7.5	0.04	0.10
S20		1	2		3	3	2	2		2		3	18	0.36	1.13	R20	1		1		2	2	1	1		1		2	11	0.11	0.34
∑S	0	21	36	2	50	58	45	35	5	26	5	47	330	0.40	1.21	∑R	21	0	20	1	34	41	28	21	3	15	5	32	221	0.15	0.44
L01	2	1			3	2	1	3		2		1	15	0.25	0.79	K01	3	2	3			3	4	2		1		4	22	0.50	1.58
L02	2	1		1	2	3	0.5	2				1	12.5	0.23	0.66	K02	2	1	2	1		1	2	2				3	14	0.30	0.88
L03	2	1			3	3	2	2		2		3	18	0.36	1.13	K03	3	2	3			2	3	3		1		4	21	0.46	1.46
L04	2	1			3	3	1	0.5	2	2		1	15.5	0.21	0.65	K04	3	2	3			2	4	3	3	1		4	25	0.51	1.60
L05	2	1			2	3	2	2				3	15	0.38	1.16	K05	2	1	2			1	2	2				3	13	0.29	0.87
L06	2	1			3	4	1	2		2		1	16	0.29	0.90	K06	3	2	3			1	4	3		1		4	21	0.46	1.46
L07	2	1			2	2	2					1	10	0.27	0.78	K07	2	1	2			2	2					3	12	0.40	1.18
L08	2	1			2	3	2	2				3	15	0.38	1.16	K08	2	1	2			1	2	2				3	13	0.29	0.87
L09	2	1			3	3	2	2		2		1	16	0.29	0.90	K09	3	2	3			2	3	3		1		4	21	0.46	1.46
L10	2	1			1	3	0.5	3		2		1	13.5	0.28	0.81	K10	1	0.5	1			2	1	2		1		2	10.5	0.13	0.37
L11	1	2		2	2	2	2			1	1	3	16	0.22	0.70	K11	3	4	2	4		4	2			1	3	5	28	0.60	1.90
L12	1	0.5			2	2	2			1			8.5	0.21	0.60	K12	3	2	2			2	2			1			12	0.50	1.43
L13	2	1			3	4	2	2		2		1	17	0.32	1.01	K13	3	2	3			1	3	3		1		4	20	0.43	1.35
L14	2	1			3	3	2			2			13	0.47	1.37	K14	3	2	3			2	3			1			14	0.53	1.57
L15	2	1			4	3	2	1	3	2	3		21	0.33	1.09	K15	4	3	4			3	4	5	3	2	1		29	0.56	1.82
L16	1	1			0.5	1	1	1				2	7.5	0.03	0.08	K16	1	1	0.5			1	1	1				2	7.5	0.03	0.08
L17	1	0.5			1	2	1	1				2	8.5	0.09	0.25	K17	2	1	1			1	2	2				3	12	0.29	0.84
L18	2	1			3	3	2	2		2			15	0.38	1.16	K18	3	2	3			2	3	3		1			17	0.48	1.45
L19	2	1			1	2	0.5	2				1	9.5	0.18	0.51	K19	1	0.5	1			1	1	1				2	7.5	0.04	0.10
L20	2	1			3	3	2	2		2		3	18	0.36	1.13	K20	3	2	3			2	3	3		1		4	21	0.46	1.46
∑L	36	20	0	3	46.5	54	30.5	29.5	5	24	4	28	280.5	0.27	0.84	∑K	50	34	46.5	5	0	36	51	40	6	14	4	54	340.5	0.39	1.19
D02	1	0.5	1		1	2	1	1				2	9.5	0.08	0.22	BI01	3	2	1		4	3		4		3		2	22	0.50	1.58
D11	1	0.5	2		4	4	4			3	3	1	22.5	0.43	1.35	BI02	2	1	0.5	1	2	3		2				1	12.5	0.23	0.66
∑D	2	1	3	0	5	6	5	1	0	3	3	3	32	0.25	0.79	BI03	2	1	2		3	3		2		2		1	16	0.29	0.90
T01	2	1	2		3		3	3		2		3	19	0.39	1.24	BI04	3	2	1		4	4		1	3	3		2	23	0.44	1.40
T02	3	2	3	2	1		3	3				4	21	0.65	1.91	BI05	2	1	2		2	3		2				1	13	0.29	0.87
T03	3	2	3		2		3	3		1		4	21	0.46	1.46	BI06	3	2	1		4	5		3		3		2	23	0.54	1.69
T04	3	2	3		2		4	3	3	1		4	25	0.51	1.60	BI07	2	1	2		2	2						3	12	0.40	1.18
T05	3	2	3		1		3	3				4	19	0.57	1.74	BI08	2	1	2		2	3		2				1	13	0.29	0.87
T06	4	3	4		1		5	4		2		5	28	0.71	2.25	BI09	2	1	2		3	3		2		2		1	16	0.29	0.90
T07	2	1	2		2		2					3	12	0.40	1.18	BI10	2	1	0.5		1	3		3		2		1	13.5	0.28	0.81
T08	3	2	3		1		3	3				4	19	0.57	1.74	BI11	3	4	2	4	2	4				1	3	5	28	0.60	1.90

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Rm.	S	R	L	D	K	T	BI	BII	BIII	AI	AII	C	Sum	RA	RRA	Rm.	S	R	L	D	K	T	BI	BII	BIII	AI	AII	C	Sum	RA	RRA
T09	3	2	3		2		3	3		1		4	21	0.46	1.46	BI12	3	2	2		2	2				1			12	0.50	1.43
T10	3	2	3		2		3	2		1		4	20	0.60	1.76	BI13	2	1	2		3	4		2		2		3	19	0.39	1.24
T11	3	4	2	4	4		4			3	1	5	30	0.67	2.10	BI14	2	1	2		3	3				2			13	0.47	1.37
T12	3	2	2		2		2			1			12	0.50	1.43	BI15	2	1	2		4	3		3	3	2	3		23	0.39	1.27
T13	4	3	4		1		4	4		2		5	27	0.68	2.14	BI16	2	2	1		1	2		2				1	11	0.23	0.67
T14	3	2	3		2		3			1			14	0.53	1.57	BI17	2	1	1		2	3		2				1	12	0.29	0.84
T15	3	2	3		3		3	4	2	1	2		23	0.39	1.27	BI18	2	1	2		3	3		2		2			15	0.38	1.16
T16	2	2	1		1		2	2				3	13	0.34	1.01	BI19	2	1	0.5		1	2		2				1	9.5	0.18	0.51
T17	3	2	2		1		3	3				4	18	0.63	1.85	BI20	2	1	2		3	3		2		2		1	16	0.29	0.90
T18	3	2	3		2		3	3		1			17	0.48	1.45	∑BI	45	28	30.5	5	51	61	0	36	6	27	6	27	322.5	0.36	1.11
T19	2	1	2		1		2	3				3	14	0.50	1.43	AI01	2	1	2		1	2	3	1				3	15	0.25	0.79
T20	3	2	3		2		3	3		1		4	21	0.46	1.46	AI03	2	1	2		1	1	2	2				3	14	0.21	0.68
∑T	58	41	54	6	36	0	61	49	5	18	3	63	394	0.53	1.60	AI04	2	1	2		1	1	3	2	2			3	17	0.25	0.80
BII01	3	2	3		2	3	4			1		4	22	0.50	1.58	AI06	2	1	2		1	2	3	2				3	16	0.29	0.90
BII02	2	1	2	1	2	3	2					3	16	0.40	1.18	AI09	2	1	2		1	1	2	2				3	14	0.21	0.68
BII03	2	1	2		3	3	2			2		3	18	0.36	1.13	AI10	2	1	2		1	1	2	1				3	13	0.25	0.74
BII04	2	1	0.5		3	3	1		2	2		1	15.5	0.21	0.65	AI11	2	3	1	3	1	3	1				2	4	20	0.35	1.10
BII05	2	1	2		2	3	2					3	15	0.38	1.16	AI12	2	1	1		1	1	1						7	0.08	0.24
BII06	2	2	2		3	5	3			2		2	21	0.46	1.46	AI13	2	1	2		1	2	2	2				3	15	0.25	0.79
BII08	2	1	2		2	3	2					3	15	0.38	1.16	AI14	2	1	2		1	1	2						9	0.20	0.59
BII09	2	1	2		3	3	2			2		3	18	0.36	1.13	AI15	2	1	2		2	1	2	3	1		1		15	0.17	0.54
BII10	3	2	3		2	2	3			1		4	20	0.60	1.76	AI18	2	1	2		1	1	2	2					11	0.19	0.58
BII13	2	1	2		3	4	2			2		3	19	0.39	1.24	AI20	2	1	2		1	1	2	2				3	14	0.21	0.68
BII15	3	2	1		5	4	3		4	3	4		29	0.56	1.82	∑AI	26	15	24	3	14	18	27	19	3	0	3	28	180	0.22	0.70
BII16	2	2	1		1	2	2					3	13	0.34	1.01	AII11	2	3	1	3	3	1	3			2		4	22	0.41	1.30
BII17	2	1	1		2	3	2					3	14	0.40	1.18	AII15	3	2	3		1	2	3	4	2	1			21	0.33	1.09
BII18	2	1	2		3	3	2			2			15	0.38	1.16	∑AII	5	5	4	3	4	3	6	4	2	3	0	4	43	0.37	1.20
BII19	2	1	2		1	2	2					3	13	0.43	1.23	C06	3	2	1		4	5	2	3		3			23	0.54	1.69
BII20	2	1	2		3	3	2			2		3	18	0.36	1.13	C07	3	2	1		3	3	3						15	0.60	1.76
∑BII	35	21	29.5	1	40	49	36	0	6	19	4	41	281.5	0.41	1.25	C08	3	2	3		3	4	1	3					19	0.57	1.74
BIII04	2	1	2		3	3	3	2		2		3	21	0.38	1.20	C09	3	2	1		4	4	1	3		3			21	0.46	1.46
BIII15	3	2	3		3	2	3	4		1	2		23	0.39	1.27	C10	3	2	1		2	4	1	4		3			20	0.60	1.76
∑BIII	5	3	5	0	6	5	6	6	0	3	2	3	44	0.38	1.24	C11	2	1	3	1	5	5	5			4	4		30	0.67	2.10
C01	3	2	1		4	3	2	3		3			21	0.46	1.46	C13	3	2	1		4	5	3	3		3			24	0.57	1.80
C02	3	2	1	2	3	4	1	3					19	0.55	1.62	C16	3	3	2		2	3	1	3					17	0.57	1.68
C03	3	2	3		4	4	1	3		3			23	0.54	1.69	C17	3	2	2		3	4	1	3					18	0.63	1.85
C04	3	2	1		4	4	2	1	3	3			23	0.44	1.40	C19	3	2	1		2	3	1	3					15	0.57	1.64
C05	3	2	3		3	4	1	3					19	0.57	1.74	C20	3	2	3		4	4	1	3		3			23	0.54	1.69
																∑C	47	32	28	3	54	63	27	41	3	28	4	0	330	0.56	1.69
																∑S-C	330	221	280.5	32	340.5	394	322.5	281.5	44	180	43	330	2799	4.29	13.26

Rm.	S	R	L	D	K	T	BI	BII	BIII	AI	AII	C	Sum	RA	RRA
Ave.	27.5	18.4167	23.375	2.667	28.375	32.8333	26.88	23.458	3.667	15	3.58	27.5	233.3	0.36	1.10

The layout-13 compares the layout structure with the former layout-5 of close similarities. In this latter case, the 'inhabitant' structure divides across the 'visitor' centrality into the 'children & living' against the 'parent & utility' rooms. Although the graph structure is isomorphic, the entrance to the 'kitchen' adds an access space before the deep 'toilet' inside, which shifts the utility rooms one further depth-level of the graph-tail. This causes the higher RA average value of '0.4' compared to '0.37' of the former case. Another observation is the swap of adjacency with the 'balcony' between the 'living & bedroom-I', which enforces the integral structure of the 'living' in compensation to the subdivided domains. Therefore, the former social logic integrates the 'inhabitant' domain in correlation to the single zoning in layout, while changes in the latter to the 'living' integrity for the subdivided zones of less integral layout. The 'visitor' domain further enforces this logic with the increase of integration form '0.14' to '0.09' RA value in correlation to the 'inhabitant' change of structure from integrated zoning to the segregated subdivision. Another similarity compares the layout-14 with the former layout-2 of simple structure and a few graph vertices. The binary corridor of 'utility' rooms improves the integral structure of the single 'bedroom-I' domain, with less integrated 'reception & living' rooms. This changes the former strategy of 'inhabitant' subdivision with maximized integral structure of 'visitor & children' domains. In this regard, the abstracted 'inhabitant' domain by default of the single bedroom reduces the need of layout integration. This is evident by the other layout-11 of the most segregated layout between the 'visitor & inhabitant' domains with single bedroom structure. In addition, the layout-10 of maximized integral structure with subdivided 'inhabitant' domain in spite of the limited space. Meanwhile, the 'balcony' of graph-tail increases the integrity of multifunctional 'living' in contrast to the less integrated layout-14 without this tail.

The integrative 'toilet' room of '0.38' RA value characterizes the layout-15 with elongated corridors inside the 'parent' domain. Nevertheless, the three bedrooms of the layout are structured into three different integral dimensions of graph and adjacency measures. The first and third bedrooms have exactly the same '0.38' RA value compared to the second of '0.55' higher value. However, the first is adjacent to the most integrating central 'reception' apart from the third deep inside the most segregated 'parent' domain. Meanwhile, the segregated second bedroom is adjacent to the 'living' integrity of the layout. This controversial structure of the 'inhabitant' domain inverts the geno-type of space syntax with new integrity of the 'living' room towards the new domain of 'grandparent' segregation. Therefore, the dual social structure of the 'grandparent' is given the full depth, while in the meantime directly links to the 'living' integrity across the 'household & visitor' domains. Also the 'children & parent' domains become of secondary integral rank in comparison to the 'grandparent' with equal RA value, but unequal adjacency of the most exposed 'children' versus the most hidden 'parent' with respect to the 'visitor' domain. This explains the integral 'toilet' to serve the extended domains of various structures, while the 'kitchen' segregates towards the 'motherhood' end. Thus, the unique spatial structure correlates the integral and layout dimensions in three-wings of 'inhabitant' domain.

The extreme layout-16 converts the most segregated layout-11 into the most integrated structure through the shifted outer 'reception' inside the 'inhabitant' domain. In this respect, the 'reception' becomes one of the 'inhabitant' wings, which sets the 'parent & children' domains free to occupy the layout center without graph tails. The inverted geno-type of deep 'visitor' allows its conversion into a true 'inhabitant' wing at the time of unexpected guests. In addition, the permanent surveillance of the shallow 'inhabitant' over the deep 'visitor' controls the social interaction with the easement or enforcement of formal rituals at any level of restrictions. This has been realized through the multifunctional central space of possible representatives across the 'inhabitant' domains, with the adjacency to both accesses of the 'staircase' carrier and the 'reception' room for ritual variations. Meanwhile, the layout of highest spatial integrity compensates the restricted visibility for privacy among the absolute connections of social domains.

Among the narrow layouts, the case of layout-17 represents the most integrated spatial structure of '0.35' average RA value. The increased integrity shifts the multifunctional space from the single room at the façade to the central space. Also the direct visibility with the 'kitchen' optimizes the central integration of the layout. Nevertheless, the spatial merge at the center of 'reception/living' changes the social model with the less possibility of forcing the 'visitor' domain towards the 'children' of only 'bedroom-I' function. Thus, the layout has only one choice of alternating the social structure between the absolute 'inhabitant' or 'visitor' domains. In this regard, either domain causes the other to change according to the degree of intimacy, where the closer social relationship becomes totally 'inhabitant', otherwise turns into an absolute 'visitor' layout. The comparable layout-19 converts the visible 'kitchen' to become of true central merges with the 'reception' space, while the 'living' attaches to the widened single bedroom of the 'children' domain. Therefore, the 'visitor' domain is afforded the possibility of moving to the 'living' part in the 'children' space, which frees the center for the 'inhabitant' structure.

The layout-18 is similar to layouts '9 & 20' with the only difference of 'balcony' structure. In one case the 'balcony' is removed, in another is found adjacent only to the 'bedroom-I' with overlooking 'window' from the 'living' side, while in the third case forms a complete spatial ring with the 'children & visitor' domains. Despite of these variations, the average RA values among the three cases measure a little variance without affecting the layout structure. However, the individual room integration changes from one structure to the other. The layout without 'balcony' measures the most integrated central 'reception' in comparison to the other two layouts. The 'inhabitant' rooms, nevertheless, decrease the spatial integrity in contrast to the layouts of added 'balcony' space. Meanwhile, the layouts with 'balcony' have exactly the same RA value in one-to-one room correspondence, except the cyclic 'living & balcony' of some integral increase. Therefore, the three layouts of almost isomorphic structure observe different social logic just through the ‘balcony' of alternative integration for the 'visitor' or 'inhabitant' domains. Further similarities with layouts '5 & 13' compare the tailing graph of utility rooms, with added 'balcony' of no spatial or visual rings, thus the mostly decreased layout integration.

Overview of the survey layouts aggregates the integral structure of each room with generalized social logic. The segregating 'balcony' improves the RA measure when structured in visual ring with the next door 'window', while the isolated 'toilet' deepens inside the 'kitchen' structure. Further 'bedroom-II' integrates more when directly accessed from the 'visitor' domain of central space, while the 'staircase' shows some integrity for layouts of more rooms or less tailed graphs. Meanwhile, the 'kitchen' sets three levels of most integrated central space, less integrated visual connection with the central space and hidden view of the least integrating structure. Comparable 'bedroom-I' has three levels of most integrated multifunction with the 'living' space, less integration of visual or spatial ringiness with the same 'living' space, or least integration if contained deep inside also the 'living' space. The 'living' space, however, integrates more when located in central space or multifunction in one further step from central space. The access 'corridor' has the most stable integrity that connects the 'visitor' central space with the 'inhabitant' domain. The 'reception' of 'visitor' domain has the most integrative privilege, except in some special cases of inverted 'geno-type' structure of cases '11 & 16' in particular. The common layout of 'Sequina' rooms structures the central space without window openings, but the deeper spaces open to small wells for 'parent' domain and sanitary installations. The ‘children’ domain including the ‘living’ room is afforded the maximum possibility of sunlight and ventilation on the façade side with reduced health hazards. The observed room integrity increases with the decrease of visibility among the social domains. In return, the more transparency of open layouts with interactive room function logically decreases the spatial integration. These observations are further enforced through the aggregated measures of room adjacencies. The 'reception' has the shortest lengths of total '212' adjacencies to all rooms of the survey layouts, which reflects the integral centrality of the 'visitor' domain. The direct adjacencies maximize with the 'access' corridor of the 'parent' structure, but minimize with the 'kitchen & toilet' of the same domain for motherhood comfort. The adjacencies of the same 'Kitchen' together with the 'living' correlate the shortest lengths towards the respective domains of 'parent & children' structure. The quantitative adjacencies, thus, generalize the 'pheno-type' structure of 'Sequina' layout.

IV. Conclusion

The spatial integration of survey rooms in 'Sequina' slum area in Alexandria determines the social structure of 'visitor' and 'inhabitant' domains as follows:

1) The comparison of layouts observes the increase of spatial integrity through the multifunction centrality of the 'visitor' domain, with the 'inhabitant' of minimal graph lengths. Meanwhile, the integrated layouts facilitate the visibility between the rooms of both domains, with spatial rings of combined 'access & window' transparency of the 'balcony' space. The gradual decrease of the layout integration set the deep 'inhabitant' domain into more 'graph-tails' than the branching structure, with the single functioning per room. The least integral structure separates the 'visitor' room from the layout through the 'public' domain of 'staircase' access. The relocation of the same 'visitor' space deep inside the 'inhabitant' domain turns into the extreme contrast of the most integrative layout with inverted 'geno-type' structure.
2) The room integration at the detailed level of individual layouts clarifies further structure of the 'inhabitant' domain in the form of deep 'parent' and shallow 'children' integrity. The 'visitor' centrality integrates with the 'children' domain through the 'living' space towards the 'balcony' threshold, which relaxes the central space with the opposite 'parent' structure to attain the 'motherhood' convenience of 'kitchen' interconnection. Alternatively, the 'living & kitchen' rooms swap the spatial integration with the 'visitor & inhabitant' domains, while preserving the layout structure of deeper 'parent' than the 'inhabitant' adjacency. In this regard, the interactive integration of the 'kitchen & living' rooms bypasses the confrontation of coexisting social domains, while optimizing the temporal reset into the other domain without affecting the layout structure.
3) The individual layouts of 'pheno-type' social structure interchange the rooms of 'geno-type' spatial integrity on a case-by-case manner. In one case, the integral structure changes to the graph property of favorite-matching in binary room-sets, while in another extends to the clustering of one-room from each social domain at the various integral levels of layout. Further social breakdown differentiates the integrity of children by age or gender, with the possible integration towards the parent zone instead of visitors. However, the social structure inverts into deep children and shallow parents, while the change of room adjacencies disaffects the integral grouping of social domains. The unique case of cyclic space circulates across the various social domains. The spatiotemporal structure observes the 'motherhood' priority in the central space, which extends to the maximum spatial restrictions on the isolated visitors. The disintegrated visitor allows the access corridor of the deep inhabitant domain to become the most integrative space of the layout structure. However, the added 'grandparent' forms the most segregated space with direct link to the 'living' room integrity in compensation. Thus, the close isomorphism of classified ‘pheno-type’ graphs and layouts encapsulates 'geno-type' space syntax of integral diversity.

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