Socio-spatial Networs

Social segregation as a real-time phenomenon

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Abstract
The present work proposes a configurational understanding of both social system and urban activity system as a co-related social construct: socio-spatial networks is the interlacing of agents' actions in time in contexts of social activity. That is, convergences of social action-interaction to urban activity-places, which would create conditions for the development of social relations as well as provide organisational frames to a social system. The spatial activity system would - while structuring the positioning of social activities - also structure the social system as a system of social actions, what is fundamental for its reproduction. In other words, a new activity-place[i] or attractor would converge co-presence and interaction of agents, changing groups, the configuration of social relations and the future of the social system itself.
The concept permits us to understand social segregation not as social distance motivated by the production of socially homogenous areas but as barely overlapped dynamic networks of agents in action upon space. It could demonstrate possibilities of interaction and explain how socially different individuals may have or not contact within daily life. Modelling and measurement techniques are outlined to handle the problem in a broader, dynamic perspective: segregation as a real-time phenomenon, manifested rather over the body than on spatial areas.

Brief criticism of usual approaches on social segregation

The conceptual basis for understanding social segregation as a real-time phenomenon, manifested rather over the social agent than spatial areas would lie on the possibility of surpassing usual theoretical considerations and methodological treatment: social segregation is the spatial concentration of certain groups or classes in specific socially homogenous areas. However, a city is not a static scenario where people are restrained to such areas but a highly dynamic phenomenon where people move all the time, possibly crossing over such areas to use same spaces. In this sense, usual approaches seem to describe social segregation insufficiently: they do not describe possible levels of contact between socially different individuals. They lack an analytic description of social dynamics involved in activities and movement - conditions for social interaction. Zoning techniques defined in such approaches and clustering measures are relevant indeed (as Lee and Culhane, 1998), including possibilities of growth and change of segregated areas (as in cellular automata techniques), since they represent social differences spatially manifested. However, they seem insufficient as measures of consequences of social inequalities and spatial segregation for the social dynamics and scenario of interaction within an urban social system.

In this sense, the present work an attempt to focus certain instances of social organisation and its materialisation to handle dynamics of reproduction of social segregation. It is part of a concern with an apparent absence in social theory of more analytic accounts on 'real-time' social dynamics or the instance of reproduction of social systems upon their material conditions, social action and interaction. To do so, it will draw substantially from the configurational understanding of spatial structure and its relations to co-presence (as in Hillier and Hanson, 1984, Hillier, 1996), drawing also from urban modelling theories to extent it to the urban activity system (as in Krafta, 1996; 1997) to relate it to social systems structure and dynamics.

Representing an urban social scenario

To understand the activity and movement dynamics and their role in the process of reproduction of our society, the city can be seen as a phenomenon which, upon a physical basis for movement of people, goods, information and energy, individuals come and go, run activities and use places for interaction, consumption, work, etc. The city is a way of running such multiplicity of actions and processes. In a systemic way, every individual action is inserted in the social process of production, linked to all others involving any productive area, interfering as an indirect subproduct in other individual processes and actions. However, such web of social actions can be understood in a description which preserves the complex logic of the collections of elements and their processual relations.

A social scenario can be simplified as a collection of social activities developed in places within the city, which demand movement of agents. Activities and movement consist of a substantial part of the dynamics of an urban system and of social life - if we consider such places are used for developing social contacts and relations amongst individuals as well as organisation of institutional frames, involving different levels and forms of social interaction. They would be basically:

1. places for consumption of goods and services and for activity of leisure (examples are shops and restaurants);

2. places for work and study (offices, shops, schools, etc.);

3. places for distribution of movement (as bus and underground stations, airports, etc.)

It will be fundamental for us to define the spatial structure of the system of activity-places - for such configuration will be crucial for structuring and relatively fixing the action of the individuals of a social system. Drawing from urban modelling and spatial interaction theory, the city as a structure of viability of social activity and movement can be represented as a system of places of origin (residences) and destination (activity-places or attractors of social action and movement). That is, a collection of built forms is initially divided in two subcollections.

Simplifying considerations of knowledge of urban space, cognition and choice criteria, movement within a city is related to configurational properties of urban space regarding possibilities of shortest path between certain places as well as different forms of movement. In rather an utilitarian view of social systems, there would be a sense of functionality in the dynamics of activity and movement which the agent is involved. In principle we could consider movement following certain patterns: from residence to work, consumption or distribution places (as bus and underground stations) and second, movement as combination of such possibilities. It is possible to define and recognise one or more shortest paths for any pair of these discrete spaces (one as residence and the other as attractor). They consist

of "conductors" of a tension between origin and destination of agents in movement. Considering all possible pairs within an urban spatial system, public spaces would contain less or more dense streams or lines of tension - depending on their positions within the system. Here, the property of centrality of spaces is relevant. Centrality as a morphologic property consists of the capacity of a public space (streets) to be part of the shortest paths for all pairs of built forms, that is the level of tension or interaction between built forms (Krafta, 1997). In other words: the more a built form is part of collections of shortest paths the more central it is for the whole urban system. It is intended to describe the urban activity system as a system of attraction between places of origin and destination upon active morphologic properties of the built environment - namely configurational properties.

Such understanding of an urban system would permit us to assume the configurational tension of built forms (centrality) as an analogy or proxy to real social movement. Relations between places of activity imply 'potential flows' of people, goods and information. This is the first step in our relation between the spatial system of activities and the social system itself - the constitution of networks of agents in action in urban space.

Relating spatial and social systems: the concept of socio-spatial networks

Let us propose the concept of socio-spatial networks as the interlacing of actions of individuals in time as social interaction in spaces of activity (Netto 1999; Netto and Krafta 1999). Interaction here implies co-presence and meaningful communication. Networks of agents would converge to and be constituted in activity-places, which would effectuate social contact and create conditions for developing social relations involving both the individual level and organisational, institutional frames. Social networks would therefore be constituted in time as socio-spatial networks upon collective action-interaction and the spatial structure of the activity system. In other words, social networks manifest themselves temporally and spatially as geographic networks of appropriation of space, that is the use of space when one is performing his/her routines[ii].

A step further, in a purely spatial sense the action of social networks would contain fundamentally constrains and enablements on movement and realisation of activities generated by the urban structure itself. Such constrains and enablements are related to location patterns according to centrality and integration properties. Consequently, they influence possibilities of spatial access to social situations and therefore influence the possibility of interaction between individuals.

Conclusively, the simultaneous action of social networks as geographic networks of movement, activity and interaction would compose the urban social system. That is, a complex urban social scenario can be decomposed in different social networks according to criteria of social routinisation and differentiation. In this sense, a new activity-place converges the action, co-presence and interaction of agents, approximating people and changing the scenario of social relations and the future of a social system. It implies the fact that social networks may be changed as a new activity is located within the urban space.

The notion of socio-spatial networks is intended as a configurational understanding of the social system and the urban system of activity as a co-related social construct. However, such understanding of the dynamic 'material structure' of an urban social system as socio-spatial networks may help us to understand the dynamic instance of particular social phe-

nomena - as the configuration of segregated networks of interaction within certain social categories, which may not (and in general seem no to) be exclusively contained in specific spatial areas.

From the dynamic structure of social systems to dynamic segregation: the overlapping of socio-spatial networks

Nevertheless, the materialisation of social networks would also depend substantially, amongst unpredictable aspects (as temporal synchrony of action and encounter, and individual choice for a particular activity-place to perform), on the influence of social similarities of life style, position in the social division of labour, income and therefore personal action, forms of movement and access to social situations. 'Real-time' social segregation would happen following principles of possibility of encounter and interaction of individuals - sharing routines in activity-places and streets according to social differentiation criteria.

Spatial networks of movement of specific social groups can be constructed through modelling their activity-places and movement networks and overlapped in order to demonstrate the urban scenario of potential interaction within and between these groups. Representing routes of movement and activity-places permits to visualise the use of space by the social groups under study.

Figure1. Scheme of representation of social networks active within spatial networks: dots are activity and interaction places; lines are public spaces of potential encounter in pedestrian and vehicular movement. In [BLACK], working class; [GREY], middle and upper classes - hypothetical example for a Brazilian case.

The overlapping of different social networks in the same spaces (streets and activity-places) means co-presence of socially different agents. That is, relevant spaces for social contact (as in streets) and for interaction (developed more substantially within buildings, in circumstances of activity, therefore more relevant for possible integration of different social groups). Spaces used predominantly by a single group or class can be understood as segregated, where no contact to the socially different is constructed in space. Such composition can be considered a 'map' of dynamic social segregation in which movement in space and time and social activity are represented as lines and dots.

In a dynamic perspective, the change in the urban activity system may change the panorama of social segregation/integration - when it changes the spatial structure of a social network, possibly generating changes in its social configuration and its overlapping to other socio-spatial networks. It can be verified comparing two 'different states' of such system, before and after the inclusion of the new activity-place within the city. The procedure for constructing the spatial manifestation of social groups is described as it follows.

Modelling dynamics of social activity and movement

As we saw the present model consists of an approximation to the panorama of movement between places of origin, destination and distribution in a city. Nevertheless, in order to increase the precision of such analogy, the representation of social flows (as pedestrian and vehicular movement) should include other components than topologic location: some activity-places might be more attractive than others. It regards the nature of activity and capacity of attraction. The initial centrality tension between every pair of built forms is reinforced with the influence of attraction, defined as the quantity of people to use na attractor as a parameter for movement. Attraction is then used as a measure for the quantity of people to use the attractor and consequently, simulate movement levels.

A second component regards arrangements of temporary relations between built forms when an agent is performing his/her activities - for instance, coming from his/her residence to a shopping centre. By doing so, a model would be able to represent precisely routines of the individuals of a social system - and simulate actual possibilities of interaction. Of course collecting and handling data here are major problems. Therefore, "selective interaction" as temporary pairs activity-places-residences will not be considered in the present model, demanding different modelling techniques and broader structure and amount of data.

Another aspect to be explored is that an urban activity system could be described without the consideration of all activity-places as small shops of local use. Social movement over the urban macrostructure are substantially conditioned by macroattractors as structural attractors of movement - for example, universities, supermarkets, hospitals, underground stations, shopping centres, etc. In other words, certain activity-places would structure social routines of large parts of a population describing routines of movement and activity with reasonable representativity. Macroattractors demand flows of people of different social categories to perform activities according to social position regarding work or consumption and social differentiation criteria. In this sense, attractors can be classified according to target-public. It seems relevant if we consider that a model of movement could be able to grasp and demonstrate differences in movement and possibility of interaction between different classes or groups. Modelling such phenomenon, every macroattractor is considered with a certain 'value' according to its capacity to generate movement. Such value is simply the data of average number to use the activity-place a day. It does not demand extensive data since there would be a relatively small number of structural attractors compared to the total number of activity-places.

If we consider specificities related to residences (that is specific social groups associated) and to attractors (types of social groups attracted), lines of tension as a proxy for movement can be handled as different lines of, say, different colours (as in fig. 1). Lines of socio-spatial networks also may refer to specific moments of the daily urban routine, being useful in the analysis of the temporal dimension of the phenomenon. These considerations are necessary if we are to recognise differences in social movement since purely syntactic treatment does not differentiate them.

Modelling the socio-spatial networks

Different levels of social segregation in space can be modelled using values of attractivity and centrality of activity-places in each axial line. Such levels can be from zero (presence of a single group or class in an axial space) to the equilibrium of co-presence, where more than one group effectively use that space. The same scale is applied to activity-places. Therefore a very

socially segregated city would present low numbers of streets and/or activity-places used by superimposed networks. Cities with high levels of contact between differentiated groups tend to present dynamic socio-spatial networks 'fitted' to the actual urban structure.

In this sense, built forms and axial lines are considered as a whole although preserved as entities. It is due to their different role and nature for social purposes of movement (streets), occupation and situation of social action and interaction (activity-places).

Algorithmic procedure

It will be described now schematically principles of configurational handling of the social system of agents, action and potential interaction (convergence of action-interaction as activity-places) and the urban system of activity. It is referred to urban configuration, location of activity and social differentiation criteria (in the present example, class differentiation) and different forms of intra-urban movement (pedestrian, private and public vehicular movement). These elements will generate a 'map' of dynamic socio-spatial networks of different groups or classes in action in a same urban system.

1. Data: list of location of residence for axial line;

1.1. group or class attributes: in the present case, according to Brazilian patterns of appropriation: red (middle and upper classes) and blue (working classes).

2. Data: list of location of macroattractors classified according to group or class, categorised as:

2.1. consumption/leisure; work/studying; distribution/transport;

2.2. attractivity level (average of daily number of people to use the attractor).

3. Data: axial grid of public spaces.

4. Data: axial grid of public transport networks.

5. Generation of tension of attraction for built forms according to use of activity-place by specific social groups;

5.1. define routes of possible paths between macroattractors and residences according to use of activity-place by specific social groups and form of transport;

5.2. distribution of attraction level in axial lines between activity-places;

5.3. accumulate attraction level in the axial lines (centrality values);

5.4. verify pairs left undone; if there are undone pairs, repeat previous procedure.

6. Count accumulated value of attraction/appropriation in every axial line as a function of proximity between attractor and residences and the number of times which every line is part of the route.

7. Verify axial lines (public spaces) regarding use of one or more social groups or classes.

8. accumulate value of level of presence of group or class in the axial line regarding.

9. Measurement of overlapping of classes in every axial line and attractor within the city; calculate total values of social segregation parameters.

10. Outputs: parameters and values of partial (in every axial line and attractors) and total (all axial lines and all attractors) social segregation upon level of overlapping of social networks in the urban space.

11. Plot axial map of socio-spatial networks in the urban grid.

Measuring the level of real-time social segregation

Measuring the level of evidence of social segregation as a real-time phenomenon would involve two processes. First, calculate levels of centrality for urban spaces according to social groups as a function of specific residential locations, activity-places and networks of public space and movement (pedestrian, private and public vehicular movement). Second, relate the incidence of different social groups to the system of urban spaces: from extremely socially segregated (just one social network using certain spaces) to extremely socially integrated (co-presence of social groups or classes analysed). In the first case, we can demonstrate the level of segregation in every axial space which are handled according to the level of group/class co-presence. The present consideration takes into account the level of segregation in every street and the number of streets used in a segregated way.

In order to clarify concepts and measurement procedures, we propose an example based on a 'linear city' divided in 8 public spaces as cells, as in the scheme:

Each public space or cell contains:

1 10 people from social group C

2 10 people from social group C

3 10 people from social group B

4 attractor capacity "100", referred to C (10%), B(30%) e A(60%)

5 10 people from social group B e 5 people from social group A

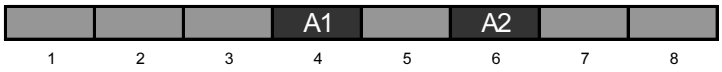

Table 1: A schematic linear city

6 attractor capacity "50", referred to C(50%), B (40%) e A(10%)

7 10 people from social group B

8 10 people from social group C

Every pair of spaces linking a residence to an activity-place contains a tension which can be calculated as it follows:

Measurement works upon three basic assumptions as variables: convergence that is the result of measuring the tension within the urban system; position that is potential for co-presence; and condition that refers to potential interaction. Colours in tab.2 represent three social groups. The whole scenario changes during the day. It implies that collecting data and measuring different moments in the day and in the week could provide us the character of every space as a function of social characteristics of the predominant agent to use the space and the form of interaction and co-presence.

Conclusions: the proposed concepts for understanding social systems and social segregation

• The concept of socio-spatial networks tries to handle the dynamic structure of social systems, including their material conditions: a system of social convergences of actions and interactions structured in a spatial system of activity-places in time. It relates the social system constituents: the agents, their potential personal activities and movement and social differentiation as conditions for social relations, arranged as the urban spatial and functional structure - features of social organisation and social life.

•Conceptually, it considers the role of the structure of space related to the activity system (as the notion of centrality) in structuring and reproducing a social system.

PAIR	PATH	TENSION	SPACES							
			1	2	3	4	5	6	7	8
4 - 1	4 3 2 1	10 * (100*10%)/4 = 25	25	25	25	25				
4 - 2	4 3 2	10 * (100*10%)/3 = 33.3		33.3	33.3	33.3				
4 - 3	4 3	10 * (100*30%)/2 = 150			150	150				
4 - 4	4	100 * 0=0								
4 - 5	4 5	10*(100*30%)+				150	150			
		"5*(100*60%)/2 = 300				"150	"150			
4 - 6	4 5 6	100*0=0								
4 - 7	4 5 6 7	10*(100*30%)/4 = 75				75	75	75	75	
4 - 8	4 5 6 7 8	10*(100*10%)/5 = 20				20	20	20	20	20
		Convergence in cell 4	25	58.3	208.3	603.3	395	95	95	20
		Condition index				603,5				
		Position index	25	58,3	208,3		395	95	95	20
6 - 1	6 5 4 3 2 1	10*(50*50%)/ 6 = 41.7	41.7	41.7	41.7	41.7	41.7	41.7		
6 - 2	6 5 4 3 2	10*(50*50%)/ 5 = 50		50	50	50	50	50		
6 - 3	6 5 4 3	10*(50*40%)/4 = 50			50	50	50	50		
6 - 4	6 5 4	50*0 = 0								
6 - 5	6 5	10*(50*40%)+ 5*(50*10%)/2 = 100 + 12,5					100 12.5	100		
6 - 6	6	50 * 0 = 0								
6 - 7	6 7	10*(50*40%)/2 = 100						100	100	
6 - 8	6 7 8	10*(50*50%)/3 = 83.3						83.3	83.3	83.3
		Convergence in cell 6	41.7	91.7	141.7	141.7	254.2	437.5	183.3	83.3
		Condition index						437.7		
		Position index	41.7	91.7	141.7	141.7	254.2		183.3	83.3
		Overall indicators of potential interaction				78,3 x 375 x 150		175 x 250 x 12.5		
		Overall indicators of co-presence	66.7	125	150 x 200	170 x 425 x 150	101.7 x 300 x 162.5	185 x 325 x 12.5	103.3 x 175	103.3

Table 2: Measuring levels of segregation in the cells as streets

• According to the concept, socio-spatial networks may be changed as soon as a new activity-place is constructed or modified within a town - what may change the panorama of social segregation/integration changing the scenario of social relations and the future of a social system.

• Spatialising social networks permits to identify social segregation as an endogenous element of social life and the reproduction of a social system - a consequence of different dynamics of action and movement within the general dynamic of a social system. By doing so we can amplify the understanding and handling of social segregation: from the usual spatial aspect of segregated zones to the configurational level of the activity and movement system, co-presence and potential social interaction of agents, sociologically broader than the traditional view.

Positive aspects of the model

• The model can be used as a representation of the activity of social groups and classes on space - recognised as configurations of agents and spaces or socio-spatial networks.

• It permits to represent non-material aspects of social systems and of social segregation contained in movement and social activity, graphically visualised. It considers the phenomenon would happen virtually in every space, understanding segregation in social activity and in movement as components of the phenomenon: social networks in action upon the urban structure, possibly ignoring restrictions of segregated zones - not grasped in usual approaches.

• It contains the role of spatial configuration as an active feature when treating group and class dynamics in the urban space, conditioning movement and the activity scenario.

• It is a parameter for the intensity of use of streets for different social groups.

• Social segregation is measurable considering the level of overlapping of social networks on space.

• It permits to evaluate impacts of new activity-places or changes in the urban grid on the social panorama of a city - and consequently, on the panorama of social segregation and integration. Therefore, it is potentially useful for understanding cities and their population and in urban policies of social integration.

Negative aspects of the model

• The model is a schematic representation of a socio-spatial system. It is an account of overlapping dynamic networks -not the effective treatment of the conditions of social networks formation. The concepts treat it in a broader way - although not discussed in this paper.

• The model shows rather a potential scenario for interaction than actual possibilities of change within such system. Change in the scenario of social interactions (the change of the configuration of the social system itself) depends on what happens in actual interaction, within human activities, within buildings. Interaction may change social segregation - what is handled just schematically in present modelling techniques.The representation of dynamics of change due to endogenous dynamics of interaction is therefore severely restricted in the present model.

• It does not describe individual routines but a potential scenario of action and spatial appropriation for groups and classes. It is due to the fact that it does not handle agents schedules as movement between defined places in the urban system.

• It is a schematic parameter for real levels of movement - what would demand enormous quantity of data. However, the model handles attraction (number of people to use a macroattractor) proportionally. It means strong similarities to the real ranking of used streets.

• The complete collection of activity-places used by social groups or classes is not considered but the most used spaces (macroattractors) - what generates a similar scenario of movement in the global scale (large movements in the urban structure). Local movements due to ity-places) are not considered in the present study. In cases of social segregation upon class, such problem can be minimised due to strong pedestrian use of working class and the higher emphasis on broader, vehicular movement for middle and upper classes (for a Brazilian case, see Holanda, 1999). Nevertheless, the consideration of all attractors is possible and would amplify the precision of the model, although demanding extensive amounts of data.

• Despite grasping conceptually temporal dynamics for convergence of action-interaction in space, the present modelling technique consists of a 'static picture' of such scenario. Impacts of changes in a socio-spatial system can be shown comparing its states before and after a specific change. Temporal processes of flows of movement and activity as well as changes in the urban structure and the activity system can be modelled using other techniques and data - to be developed as this research follows.

Endnotes

i It happens upon spatial properties, location decisions and relations to complementary activities within urban economic processes. However, both the transformation of a social activity system and the dynamics of a changing scenario of segregated networks will not be described in this paper.

ii The concept of socio-spatial network is therefore fundamentally different from the static view of 'social network analysis' research field which treats small groups of agents and their links (see for example Wasserman and Galaskievicz, 1994). Here time is included as an endogenous variable in the approximation or distance of individuals by force of personal action and social differentia-

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