Urban Centrality

A fully configurational model of a self-organizing process

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Abstract

It is proposed a conceptual model for the urban centrality dynamic process, based on fundamentally configurational forces. Starting from "an undifferentiated agglomeration of agents which tend to interact" the model provides the means for functional specialisation of space to emerge. Centralisation process is supposed to be driven by centripetal as well as centrifugal configurational forces, acting on both services and consumers, leading the former to cluster in central positions, but also to decentralise in a polinuclear fashion, and the latter to segregate into homogeneous areas.

The emergence of functional specialisation (and presumable morphological differentiation) as a result of a spatial interaction process, potentialised by configuration, suggests a dynamics in which social and economic forces act only as a stimulus, just as a start to a fundamentally spatial process which, once activated, goes along with proper rules. This is a fundamental characteristic of self-organised systems.

Keywords:
Centripetal and centrifugal configurational processes, morphological differentiation, self-organizing urban systems

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1. Introduction

For most urban studies, either from economic or geographic and urbanistic approaches, the urban centre is not only given, but a very condition for theoretical formulation and elaboration of conceptual models of the city. Few authors (Papageorgiou & Smith, 1983; Fujita & Mori, 1996) have tried to discuss the emergence of urban agglomeration as derived from a process governed by laws of its own. Papageorgiou & Smith suggest that in the basis or urban process there is a fundamental tendency to interact, meaning that the social agents keep interchange relationships and, by doing that, they produce external effects. In this way, every urban agent is exposed to a composite of externalities generated by others. This process is known as spatial interaction, and agglomeration emerges from the continuous agents' attempts to maximise their positive externalities and to minimise the negative ones. The urban process would be, as a consequence, submitted to a constant instability.

Spatial interaction has very well known principles (Wilson, 1987; Williams, 1977), which involve the effect of attraction among concentrations of interdependent activities. Such an attraction has intensity proportional to the size of those concentrated activities, as well as the distance between them. However, spatial interaction provides means to represent the phenomenon starting from a certain point, when differentiation, interdependency and concentration are already in place. Once applied to a homogeneous system, interaction becomes irrelevant. In this way, Papageorgiou & Smith's model can only suggest a possible emergence of agglomeration of non-specialised agents, that is, a non-centralised, "flat" system. Centrality is expected to develop from such a flat system as a result of spatial differentiation, driving it to functional and morphological specialisation.

This paper takes the topic from this point on, trying to represent the process of centrality formation as a result of a self-organised configurational process. By that it is understood the formation of a spatial structure characterised by concentration and functional, as well a morphological specialisation, derived from configuration rules. These are basically the contents of a spatial distribution of interconnected public spaces and built forms.

2. The spatial configuration and its measures of centrality and convergence

In order to get the necessary spatial relationships clear it is assumed, for simplicity, a linear city, partitioned into a number of undifferentiated cells, letting a cell to be any segmentation of space, from a planning zone down to a convex space. Such a city has the same characteristics of a two-dimensional cellular system. This city has, say, 8 cells all of them containing the same number e type of built form units, hence, the same number and type of social agents. The model to be proposed is space based, so that there is no explicit social agents, although they underlie the spatial structure. In this situation, each cell has the probability to interact to every other cell, and this potential can be expressed by the measure of centrality (Krafta, 1994), which assumes as central every space which lies in the shortest path between two others, within a same spatial system. There is a tension between any pair of spaces, that is, a probability of interaction, proportional to the attributes of both and the number of spaces that fall in their shortest path. Tensions can then be assigned to all spaces, which compound the circuit between each pair of spaces. From the viewpoint of each space, centrality is the sum of all bits of tensions assigned to it after all pairs in the system are taken up. From the viewpoint of the system, centrality is the rank created by every space with its own particular centrality measure. The following expressions give the structure for such a calculation:

$$T_{ij} = (a_i \times a_j) \qquad (1)$$

$$c_{i.j} = T_{ij} / n_{ij} \qquad (2)$$

$$C_{1\ldots n} = \Sigma\, c_{ij} \qquad (3)$$

T_{ij} is the tension between an unordered pair of spaces, a is the attribute of each space, $c_{i.j}$ is centrality generated by the pair ij that affects all *n* spaces belonging to the shortest path, *n* is the amount of such spaces and $C_{1\ldots n}$ is the overall centrality, all pairs considered. Table 1 shows the application of the measure to the 8cell linear system, in which the attribute of every cell is assumed to be 1. It can be seen that the most central spaces are cells 4 and 5, as expected.

Services

A service can occur as a function of a demand, which, in spatial terms is described by a sufficient population of potential consumers located in the area around a considered point where the service is supposed to operate. This area results from the longest distance (radius) a potential consumer is willing to move in order to get the service; in a regular cellular space this area is a diamond-shaped set of cells, provided that the adjacency is counted only when cells share an entire face, as the figure 2 shows.

PAIR	PATH	TENSION								SPACES
			1	2	3	4	5	6	7	8
1 – 2	1, 2	1*1/2 = 0.5	0.500	0.500						
1 – 3	1, 2, 3	1*1/3 = 0.33	0.330	0.300	0.300					
1 – 4	1, 2, 3, 4	1*1/4 = 0.25	0.250	0.250	0.250	0.250				
1 – 5	1, 2, 3, 4, 5	1*1/5 = 0.2	0.200	0.200	0.200	0.200	0.200			
1 – 6	1, 2, 3, 4, 5, 6	1*1/6 = 0.17	0.170	0.170	0.170	0.170	0.170	0.170		
1 – 7	1, 2, 3, 4, 5, 6, 7	1*1/7 = 0.14	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
1 – 8	1, 2, 3, 4, 5, 6, 7, 8	1*1/8 = 0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
2 – 3	2, 3	1*1/2 = 0.5		0.500	0.500					
2 – 4	2, 3, 4	1*1/3 = 0.33		0.330	0.330	0.330				
2 – 5	2, 3, 4, 5	1*1/4 = 0.25		0.250	0.250	0.250	0.250			
2 – 6	2, 3, 4, 5, 6	1*1/5 = 0.2		0.200	0.200	0.200	0.200	0.200		
2 – 7	2, 3, 4, 5, 6, 7	1*1/6 = 0.17		0.170	0.170	0.170	0.170	0.170	0.170	
2 – 8	2, 3, 4, 5, 6, 7, 8	1*1/7 = 0.14		0.140	0.140	0.140	0.140	0.140	0.140	0.140
3 – 4	3, 4	1*1/2 = 0.5			0.500	0.500				
3 – 5	3, 4, 5	1*1/3 = 0.33			0.330	0.330	0.330			
3 – 6	3, 4, 5, 6	1*1/4 = 0.25			0.250	0.250	0.250	0.250		
3 – 7	3, 4, 5, 6, 7	1*1/5 = 0.2			0.200	0.200	0.200	0.200	0.200	
3 - 8.	3, 4, 5, 6, 7, 8	1*1/6 = 0.17			0.170	0.170	0.170	0.170	0.170	0.170
4 – 5	4, 5	1*1/2 = 0.5				0.500	0.500			
4 – 6	4, 5, 6	1*1/3 = 0.33				0.330	0.330	0.330		
4 – 7	4, 5, 6, 7	1*1/4 = 0.25				0.250	0.250	0.250	0.250	
4 – 8	4, 5, 6, 7, 8	1*1/5 = 0.2				0.200	0.200	0.200	0.200	0.200
5 – 6	5, 6	1*1/2 = 0.5					0.500	0.500		
5 – 7	5, 6, 7	1*1/3 = 0.33					0.330	0.330	0.330	
5 – 8	5, 6, 7, 8	1*1/4 = 0.25					0.250	0.250	0.250	0.250
6 – 7	6, 7	1*1/2 = 0.5						0.500	0.500	
6 – 8	6, 7, 8	1*1/3 = 0.33						0.330	0.330	0.330
7 – 8	7, 8	1*1/2 = 0.5							0.500	0.500
	CENTRALITY VALUES		**1.715**	**3.305**	**4.255**	**4.705**	**4.705**	**4.255**	**3.305**	**1.715**

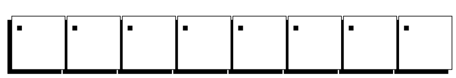


Fig. 1 (left) / Table 1: the measure of centrality of a linear cellular system of 8 cells with equal attributes, valued 1

Taking the linear city, already introduced, and considering 8 as the longest distance and a sufficient population of potential consumers, so that every cell is in principle eligible to place a service, the problem is to determine in which position the service is optimised. Since that one particular cell contains a service, the tensions across the system do not involve the totality of pairs any longer, but just those that begin with that particular cell. By considering an ordered pair of locations in which one cell is a consumer location and the other is a service location, it is possible to establish a new configurational measure, in this case named "convergence" (Krafta, 1996). Table 2 shows the convergence calculation for the 8 cell linear city, assuming one service unit located successively in cell 1 to 8, proceeded according the following equations:

$$T_{ij} = (P_i \text{ x } 1) \qquad (4)$$

$$cv\, ij = T_{ij} / n_{ij} \qquad (5)$$

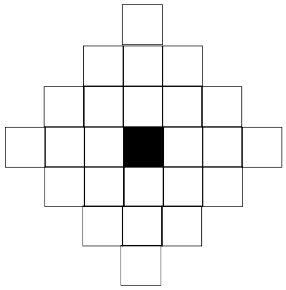


Fig. 2: the area covered by a service, considering 3 as the longest distance, within a two-dimensional cell matrix

$$CV_{i...n} = \Sigma c_{ij} \qquad (6)$$

The meaning of the new terms are: P_i - amount of potential consumers in i, 1 - the unit of service located in j, and cv - convergence in cell i. It can be seen that the maximum potential interaction lays precisely in the most central cells. This does not mean either that the considered service can not exist and prosper in any other cell, or that the locational choice of the service provider will be those most central cells, but simply that the most central cells do have the highest interaction potential, and such an attribute can be taken as the configurational dimension of the service's economic optimisation.

The example also suggests that the "natural" centrality held by the spatial configuration informs the attractor's location, and the attractor's location reinforces the natural centrality. This evidence is in line with Hansen's accessibility theory (Hansen, 1959), as well as, to a certain extent, with Hillier et al theory of natural movement (Hillier et al, 1993). However the argument holds only under two very strong constraints: the first one that takes each urban service as independent from the others, that is, producing no externalities, and second, that the social-spatial system is unchangeable. It seems possible to make advances in the matter by looking at it from a dynamic point of view.

3. Spatial Dynamics 1

The main interest lays in the possibility of emergence of specialisation (functional, morphological) from a growing, homogeneous spatial system. In order to observe that, it is assumed a list of possible services, each of them defined by its particular consumer profile and spatial distribution, as well a spatial system that at time t0 will have just a few cells with an even, homogeneous population, and no services. From this point onwards the population will keep a constant rate of growth and will fatally reach a status that enables some services, the less demanding ones first. In order to detect that, the system must be scanned after each iteration, and each one of the situations found must be compared with the parameters that control the emergence of each service. Such a comparison, called here preference can be measured by using the following equations:

$$\text{Pref } (i)^{s1} = \text{Voc } (i)^{s1} / \text{P } (i)^{s1} \qquad (7)$$

$$\text{Voc } (i)^{s1} = \Sigma (\text{pop } j / n^{ij}) \quad \text{and} \quad \text{P } (i)^{s1} = \Sigma (\text{min\_pop } j / n^{ij})$$

he expressions are read as: *Preference* (Pref) of cell *i* to place a unit of *service 1* is given by the comparison between its *vocation* (Voc) and its minimum *performance* (P). *Vocation* is the *convergence* in *i*, considering the existing potential consumer population within the *service 1 radius*, while minimum *performance* (P) is the *convergence* in *i*, considering *the minimum potential consumer population of service 1*, evenly distributed over the cells within its radius. Values over 1 will represent eligibility for service location, under 1 the opposite.

In the linear city of the examples, if a radius 2 is considered, cells 3, 4, 5 and 6 will have the same Pref indicator value. Assuming that service providers can perceive such privilege, the first service of the system will occupy one of those cells. In this situation the service provider will be deciding under the influence of only one, centripetal, force. The service will occupy a central position, considering the distribution of potential consumers, privileging agglomeration.

PAIR	PATH	TENSION	1	2	3	4	5	6	7	8
			SPACES							
Service placed in cell 1										
1 – 1	1.000	1*1/1 1	1.000							
1 – 2	1, 2	1*1/2 = 0.5	0.500	0.500						
1 – 3	1, 2, 3	1*1/3 = 0.33	0.330	0.330	0.330					
1 – 4	1, 2, 3, 4	1*1/4 = 0.25	0.250	0.250	0.250	0.250				
1 – 5	1, 2, 3, 4, 5	1*1/5 = 0.2	0.200	0.200	0.200	0.200	0.200			
1 – 6	1, 2, 3, 4, 5, 6	1*1/6 = 0.17	0.170	0.170	0.170	0.170	0.170	0.170		
1 – 7	1, 2, 3, 4, 5, 6, 7	1*1/7 = 0.14	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
1 – 8	1, 2, 3, 4, 5, 6, 7, 8	1*1/8 = 0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
		Convergence in cell 1	2.715	1.715	1.215	0.885	0.635	0.450	0.265	0.125
Service placed in cell 2										
Similar measurement procedure										
		Convergence in cell 2	0.500	3.090	1.590	1.090	0.730	0.510	0.310	0.140
Service placed in cell 3										
Similar measurement procedure										
		Convergence in cell 3	0.330	0.830	3.280	1.450	0.950	0.620	0.370	0.170
Service placed in cell 4										
Similar measurement procedure										
		Convergence in cell 4	0.250	0.580	1.080	3.360	1.280	0.780	0.450	0.200
Service placed in cell 5										
Similar measurement procedure										
		Convergence in cell 5	0.200	0.450	0.780	1.280	3.360	1.080	0.580	0.250

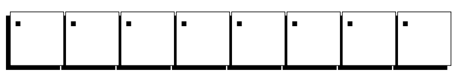
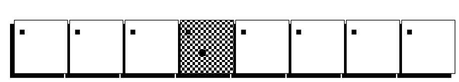


Table 2: The measure of convergence applied to the 8cell linear city, considering one service unit located successively in cell 1, 2, 3, 4 and 5

The emergence of a first service will generate a power field, determined by the potential of interaction between itself and its potential consumers, and measured by the convergence indicator, as suggested. However, despite the fact that every space between a residential and a service location will be assigned a convergence value, these figures represent different things. Due to that convergence is a service provider point of view (Krafta, 1996) the indicator value assigned to the cell where the service is does represent convergence truly; the values assigned to the others can be interpreted as a measure of positional dependence from that cell containing the service. This difference will be important for the argument and will be developed further. For these purposes, the two sub-indicators will be named "condition" - *Cond* and "position" - *Pos*, respectively, as illustrated in table 3.

PAIR	PATH	TENSION	1	2	3	4	5	6	7	8
			SPACES							
Service placed in cell 4										
4 – 1	4, 3, 2, 1	1*1/4 = 0.25	0.25	0.25	0.25	0.25				
4 – 2	4, 3, 2	1*1/3 = 0.33		0.33	0.33	0.33				
4 – 3	4, 3	1*1/2 = 0.5			0.50	0.50				
4 – 4	4	1*1/1 = 1				1.00				
4 – 5	4, 5	1*1/2 = 0.5				0.50	0.50			
4 – 6	4, 5, 6	1*1/3 = 0.33				0.33	0.33	0.33		
4 – 7	4, 5, 6, 7	1*1/4 = 0.25				0.25	0.25	0.25	0.25	
4 – 8	4, 5, 6, 7, 8	1*1/5 = 0.2				0.20	0.20	0.20	0.20	0.20
Convergence in cell 4			0.25	0.58	1.08	3.36	1.28	0.78	0.45	0.20
Condition index						**3.36**				
Position index			**0.25**	**0.58**	**1.08**		**1.28**	**0.78**	**0.45**	**0.20**

Fig 3 (below) / Table 3: Convergence, calculated for a service located in cell 4, and individualisation of condition and position indicators



So far, the initial homogeneous system has evolved to a situation where a first differentiation, at functional level, has emerged, creating a sort of power field that affect all cells. Assuming that the existing population enables another service unit to exist, the problem now is to define the optimum position for it. Two alternatives arise, one being the new service equal to the already existing, and other, different. Consider the latter alternative first, a different consumer profile as well as a specific radius define the new service. The identification of its locational preference must involve, besides the already familiar search for potential consumer concentration, two new issues: the possibility of consumer mutual inclusion and the convenience of being near the existing service. The first issue refers to agglomeration economy, to the possibility of part of its potential consumers being polarised by the existing service (mutual inclusion), in which case the adjacency of the two services being beneficial to both. The second issue refers to minimisation of service costs (Anas et al, 1998). In this case the locational decision will be driven by three concurrent forces, all of them centripetal: proximity to the consumers, proximity to the other service unit and proximity to the other service unit's consumers. It is clearly a case of co-operation, when positive externalities are produced and leads to concentration and functional specialisation. The formalism for this sort of calculation is:

$$\mathrm{Pref}\ (i)^{s2} = [\mathrm{Voc}\ (i)^{s2} + \%\mathrm{Pos}\ (i)^{s1}] \,/\, \mathrm{P}\ (i)^{s2} + \mathrm{Com}\ (i)^{s1<>2} \qquad (9)$$

The new terms are: '%Pos', which means the fraction of potential consumers of *service 1* that also belongs to *service 2*, and 'Com', that expresses the interest of both services to be near to each other. In this case the indicator *Pos* suggests that cell *i* is not the one where the service *1* is placed, because otherwise there would be no *Pos* but *Cond* value. In the case of different kind of services it makes no difference to take one indicator or the other.

The next case is the new service being of the same type of the one previously located. Taken individually, its Pref indicator would be optimum for the same cell as for the service 1, which is actually there. Being there, the old service absorbs the demand, or part of it, producing, in this way, a negative externality to the new one. Table 4 illustrates the situation, suggesting that the best locational choice is the *cell next to the one where the old service is placed.*

Emerging from this still on going spatial dynamic formalisation is a clear pattern of functional specialisation of space, as resulting from the operation of forces that privilege the *co-operation* between services of different natures and *competition* between services of same nature. Agglomeration and multipolarisation seem to be two faces of the same process.

4. Feedback

The system being described has considered, so far, only the feed forward factors, that is, the effects that an already existing service determines on the locational decision of another, however the opposite is also significant. In effect, if in the table 4, the new service unit is placed in cell 3, it surely will affect the performance of the old service unit located in cell 4, as suggested in table 5. It is shown through the normalised convergence values that performance of cell 4 decreases in the presence of a new service in cell 3.

Introduction of feedback forces suggests that spatial dynamics described in item 3 could have alternative, simpler formulation: instead of using one elaborated rule, based on preference, it could have several different, simpler ones, representing service providers different approaches to location. Examples of rules like that are: a) just to find the most crowded cell and place the service there, or next to there; b) to find the most crowded cell within a

PAIR	PATH	TENSION	1	2	3	4	5	6	7	8
Services S1 and S3 placed in cell 4										
Condition index due to S1						3.36				
Vocation for service S3 (radius 2)										
4 – 3	4, 3	1*1/2 = 0.5			0.5	0.5				
4 – 2	4, 3, 2	1*1/3 = 0.33		0.33	0.33	0.33				
4 – 4	4	1*1/1 = 1				1				
4 - 5 five	4, 5	1*1/2 = 0.5				0.5	0.5			
4 - 6 six	4, 5, 6	1*1/3 = 0.33				0.33	0.33	0.33		
		Vocation		0.33	0.83	2.66	0.83	0.33		
Communication between s1 and s3										
4 – 4		41*1/1 = 1				1				

Preference for cell 4: pref (4) s3 = voc (4) s3 – cond (4) s1 + com (4) s1<>s3 = 2.66 – 3.36 + 1 = 0.3

			1	2	3	4	5	6	7	8
Service s3 located in cell 3, service s1 remains in cell 4										
Position index due to s1			0.25	0.58	1.08		1.28	0.78	0.45	0.2
vocation			0.33	0.83	2.66	0.83	0.33			
Communication between s1 and s3										
3 – 4	3, 4	1*1/2 = 0.5			0.5	0.5				

Preference for cell 3: pref (3) s3 = voc (3) s3 + pos (3) s1 + com (3) s1<>s3 = 2.66 + 1.08 + 0.5 = 4.24

			1	2	3	4	5	6	7	8
Service s3 located in cell 2, service s1 remains in cell 4										
Position index due to s1			0.25	0.58	1.08		1.28	0.78	0.45	0.2
vocation			0.5	2.33	0.83	0.33				
Communication between s1 and s3										
2 – 4	2, 3, 4	1*1/3 = 0.33		0.33	0.33	0.33				

Preference for cell 2: pref (2) s3 = voc (2) s3 + pos (2) s1 + com (2) s1<>s3 = 2.33 + 0.58 + 0.33 = 3.24

			1	2	3	4	5	6	7	8
Service s3 located in cell 1, service s1 remains in cell 4										
Position index due to s1			0.25	0.58	1.08		1.28	0.78	0.45	0.2
vocation			1.58	0.58	0.33					
Communication between s1 and s3										
1 – 4	1, 2, 3, 4	1*1/4 = 0.25	0.25	0.25	0.25	0.25				

Preference for cell 1: pref (1) s3 = voc (1) s3 + pos (1) s1 + com (1) s1<>s3 = 1.58 + 0.25 + 0.25 = 2.08

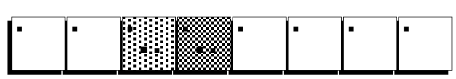
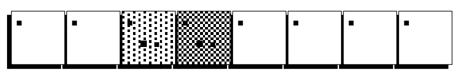


Fig 4 / Table 4: Preference indicator for a new service, of the same type of an old, previously located

previously established neighbourhood, or c) to find the axially most crowded cell in the system. Those, and other possible rules could be used randomly, when the feedback system would check out the most successful ones and increase their probability to be used next iteration. This is a genetic approach to locational decision that can self-adjust the system.

PAIR	PATH	TENSION								SPACES
convergence in cell four										
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
4 – 1	4, 3, 2, 1	1*1/4 = 0.25	0.25	0.25	0.25	0.25				
4 – 2	4, 3, 2	1*1/3 = 0.33		0.33	0.33	0.33				
4 – 3	4, 3	1*1/2 = 0.5			0.5	0.5				
	4	41*1/1 = 1				1				
4 – 5	4, 5	1*1/2 = 0.5				0.5	0.5			
4 – 6	4, 5, 6	1*1/3 = 0.33				0.33	0.33	0.33		
4 – 7	4, 5, 6, 7	1*1/4 = 0.25				0.25	0.25	0.25	0.25	
4 – 8	4, 5, 6, 7, 8	1*1/5 = 0.2				0.2	0.2	0.2	0.2	0.2
Convergence due to s1			0.25	0.58	1.08	3.36	1.28	0.78	0.45	0.2
convergence in cell three										
similar measurement procedure										
Convergence due to s3			0.33	0.83	3.28	1.45	0.95	0.62	0.37	0.17
Overall Convergence			0.58	1.41	4.36	4.81	2.23	1.4	0.82	0.37
Normalised convergence due only to s1			3.13	7.27	**13.53**	**42.11**	16.04	9.79	5.64	2.51
Normalised convergence due only to s3			4.12	10.38	41	18.12	11.87	7.75	4.63	2.125
Normalised overall convergence			3.63	8.82	**27.28**	**30.29**	13.95	8.76	5.13	2.32

Fig 5 / Table 5: convergence values compared, highlighting the interference between services in a same system



5. Spatial Dynamics 2

The dynamics above suggested has been kept restricted to service allocation, in reaction to a given population distribution, to which no particular attention is paid. Stocks, in the same way, have not been considered. Assuming, firstly, that stocks can not be changed (short-term iterations), the following factors can be included:

a) Services follow demand concentrations, so that every new service unit will be preferable located right in the middle of potential consumer spatial concentration, consuming, in this way, cell space.

This means that whenever a new service is located, following the pattern of service concentration, it has the side effect of getting the demand a little farer away, either by preventing new residential location to take place or expelling residents already located in the considered cell. Hence, by seeking a better location, the service ends up by getting the performance a little poorer.

b) Service concentration demands support from other services. These are sort of second-generation services, whose consumers are the primary services, and they also do consume cell space, and increases the distance between services and consumers.

c) It has been assumed that services follow potential demand, although the opposite in not necessarily true.

Consumers are supposed to react differently to spatial distribution of both people and services, so that particular social sectors have particular tolerance / dependence to other social sectors and services. As the system evolves and grows up, new people entering the system faces the locational decision, in the same way as services. A similar process of spatial assessment and decision can be though of, in which indicators of spatial opportunity can replace indicators of convergence. Residential preferences will be then expressed in terms of area homogeneity and density, and for particular social groups will spread population, generating in the process new attraction fields to which services to respond.

Secondly, it is possible to think about the stocks being replaceable. A first attempt to simulate an intraurban process of built form transformation has been already made (Krafta, 1994, 1999), by using configurational models. Such an attempt has concentrated on housing renewal and surely will gain fresh insights from the process described in this paper.

6. Preliminary Simulations

A preliminary set of simulations has been carried out, based upon some simplified assumptions for residential location, although rigorous methodological procedure has been used for service location. As far as residential input, the following issues were observed:

a) three social segments were considered, each one assigned a specific consumption power (A, B, C; 3, 2, 1), as well as a maximum density (9, 14, 20);

b) some simple rules for co-presence of other segments and services were adopted.

For service allocation, the procedures previously described were complemented by simplified rules on proportionality between services and consumers, in such a way that processing results simpler. Twelve iterations were made, six population and six service allocations, alternated. First one allocated initial population randomly, and all following population iterations did allocate the same, constant amount of new residents. The first four service iterations allocated one type 1 service each time. Type 1 service was assumed to be the least demanding, most local one. Type two is a more global sort of service, allocated first time in iteration 8. Population increased from initial 8 residents, 14 consumer units up to final 28 residents, 49 consumer units. Figure 6 shows the simulated configurations. It can be seen that the following patterns have emerged:

a) services of local range agglomerate around places where density of consumer units is higher (population A and B), but split in relation to other service units, generating a multiple local centre configuration (iterations 2 to 7);

b) population segments tend to agglomerate, forming homogeneous areas (due to population allocation direct assumptions);

c) central cells tend to loose population, forming a “volcano” type density profile, growing from the periphery up to the centre borders, with a hollow centre.

d) centre hierarchy shifts from cell 6 in the beginning, to cell 5 short after, back to cell 6 in the final iteration;

e) hierarchy of a new scale starts from the existing local centres, redefining its own hierarchy;

f) performance falls continuously, forcing some services to collapse;

g) “final” configuration shows three centres of higher degree, in cells 5, 6 and 7, being the later two equally in the highest position, diverting, in this way, from the grid centrality (cells 4 and 5).

Performance of services throughout the simulation is shown in table 6.

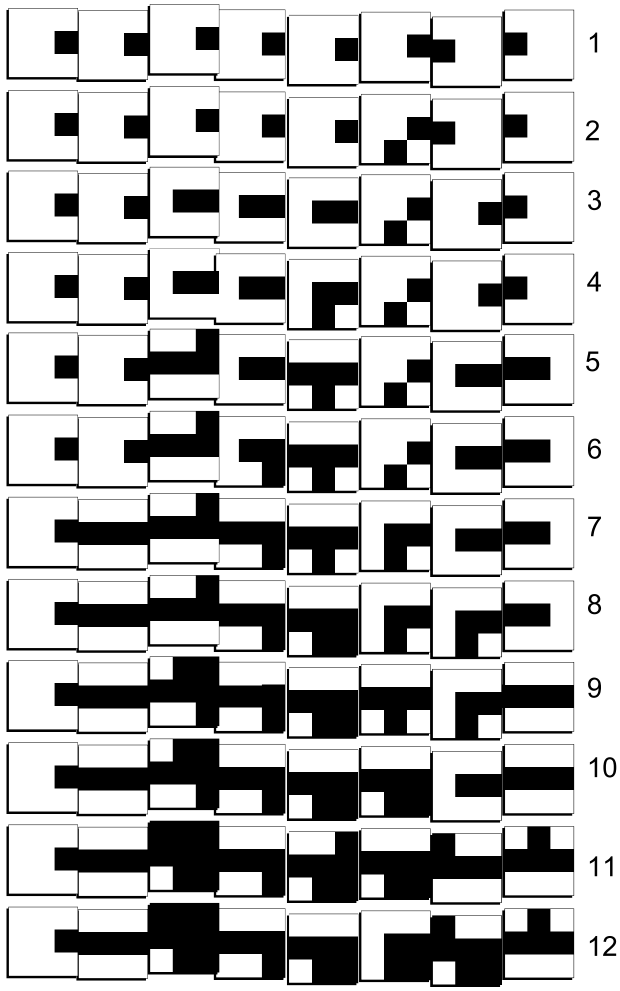


Fig. 6: configurations obtained through 12 iteration simulation. A, B and C are population segments, S^1a and S^2a are services of type 1 and 2.

Table 6: performance indicators for all services, all iterations, related to their particular potential consumers share

it	$S^1 1$	$S^1 2$	$S^1 3$	$S^1 4$	$S^1 5$	$S^1 6$	$S^2 1$	$S^2 2$	$S^2 3$	cons
2	14									14
4	9	12								21
6	7	11	10							28
8	9									
9	10									
12	8									
7	8									
7										
35			35							
10	14	16	x	x	12		21	21		42
12	13	13			10	13	15	17	17	49

7. Methodological Alternatives

The service allocation system can be considered as ideal, in the sense that each time the system is scanned and rigorously evaluated, and the solution is always optimal. This is not, however a realistic approach, yet most agents decide heuristically on basis of limited information. The mechanism could be replaced by a genetic procedure. Such an approach allows for various simplified decision making methods to be equally available to agents, and randomly selected in the early stages of the process. These decision rules could be, for instance, just to find a cell "sufficiently" animated to place the service, or to find a neighbourhood sufficiently dense, or to find lines of animation (axiallity). The performance measure used by the model could, then, weight each rule according to its success, being this ponderatation used to increase or decrease the probability to which each one will be selected in the future. In this way, the model could simulate the agents learning process, alongside with spatial dynamics.

7. Concluding Remarks

The conceptual model described in this paper represents the urban dynamics from a strict configurational viewpoint and suggests the possibility of explaining the urban phenomenon as evolving from fundamentally spatial motivation. Starting from the principle that social agents tend to interact, the model demonstrates the intrinsic potentiality of spatial configuration to inform such an interaction. The process admits, in a first stage, indifferent agglomeration, as suggested by Papageorgiou & Smith, then functional differentiation in straight association with accessibility, as suggested by Hansen and Hillier et al, and finally a dendritic multipolarisation defined in terms of the action of simultaneous centripetal and centrifugal forces. As far as the conceptual development allows to oversee, the forces leading to concentration are clearly stronger than the ones leading to dispersion, however the process evolution suggests that these ones can grow up to a degree as to make decentralisation possible.

The emergence of functional specialisation (and presumable morphological differentiation) as a result of a spatial interaction process, potentialised by configuration, suggests a dynamics in which social and economic forces act only as a stimulus, just as a start to a fundamentally spatial process which, once activated, goes along with proper rules. This is a fundamental characteristic of self-organised systems, in this case, a spatial self-organising system set in motion by social forces, but running along and ruled by strict spatial processes (Portugali, 2000). By providing means to represent it, the paper also provides preliminary support for a possible autonomous theory of urban form.

It is possible to think of a computational model to simulate the described process by using cellular automata techniques. It is well known that such a technique is based on a sequential iterative operation that changes the state of each cell of a system, according to its previous state, as well as the state of its neighbours, through a transition rule. In this way, for each iteration, the algorithm assesses and changes the state of every cell of the system. For this specific case, the procedure is similar, observing, however, the following particularities:

a) It should have alternated allocation iteration for services and population. The only external stimulus is in fact populational growth, which must be informed in every iteration. Services do occur whenever size and spatial distribution of certain consumer types meet the minimal performance standards of each service type.

b) From an initial population randomly distributed over a cellular space, the first service allocation can be simulated. Assuming that there can be various services, each one defined by consumer population size and spatial distribution, the allocation procedure should acknowledge this and perform allocation according a certain hierarchical order, such as the service with longer radius.

c) Minimum performance calculation: proceeded only once, to determine a numerical value from which a service can be considered viable. The calculation is made by considering a cell, where the service is placed, a neighbourhood defined by the service radius and a minimal potential consumer population evenly distributed over the neighbourhood. The measure to be obtained is the convergence.

d) Vocation calculation: performed every iteration, for every cell, according to the principles established in equation 7. The procedure takes a cell, where the first service is assumed to be placed, and calculates the convergence, considering the service's specific radius and the existing population.

e) Preference calculation: performed according to equation 7. It is simply the comparison between the indicators of minimal performance and vocation. Being higher than 1, the respective cell is considered eligible. Assuming that it is possible to have more than one cell equally eligible for a service, the allocation can be decided through a random choice.

f) The same sequence is proceeded for every service.

The next iteration refers to population increases, and goes along according to:

g) Similarly to services, population can be allocated by considering different groups, and assuming residential preference indicators as indicated.

As every cell has a defined capacity, allocation of services and consumers can determine expulsion of other services and consumers previously placed in particular cells. This procedure must assume a hierarchical order so that more competitive services and higher rent consumers have preference. At least two indicators must be produced, one that assesses the aggregated effect of the system on the services, and another over the consumers.

Note

The following persons have contributed to the paper: Alice R. Clok, Ana Paula N. de Faria, Andrea Mussi, Andrea Espνnola, Clαudia Boal Pereira, Cleandro Krause, Eliane Constantinou and Niara Clara Palma, all of them part of the UFRGS's "Urban Configurational Systems Research Group"

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