What do We Need to Add to a Social Network to Get a Society?

Ref 042

Answer: Something Like What You Have to Add to a Spatial Network to Get a City

Bill Hillier
UCL, Bartlett School of Graduate Studies, London, United Kingdom
b.hillier@ucl.ac.uk

Keywords
spatial configuration; spatial analysis; architectural theory; spatial networks; social networks

Abstract
Recent years have seen great advances in social network analysis. Yet, with a few exceptions, the field of network analysis remains remote from social theory. As a result, much social network research, while technically accomplished and theoretically suggestive, is essentially descriptive. How then can social networks be linked to social theory ? Here we pose the question in its simplest form: what must we add to a social network to get a society ? We begin by showing that one reason for the disconnection between network theory and society theory is that because it exists in space-time, the concept of social network raises the issue of space in a way that is problematical for social theory. Here we turn the problem on its head and make the problem of space in social network theory explicit by proposing a surprising analogy with the question: what do you have to add to an urban space network to get a city. We show first that by treating a city as a naïve spatial network in the first instance and allowing it to acquire two formal properties we call reflexivity and nonlocality, both mediated through a mechanism we call description retrieval, we can build a picture of the dynamics processes by which collections of the buildings become living cities. We then show that by describing societies initially as social networks in space-time and adding similar properties, we can construct a plausible ontology of a simple human society.

The problem: societies as space-time networks

For much of the twentieth century, the concept of network was among the most fertile sources of empirical insights into the working of societies (for overviews see Albrecht, Fitzpatrick & Scrimshaw 2000, Poole & Kochen 1978; also Fischer 1976, Granovetter 1982). The concept had the dual advantage of being both readily quantifiable and permitting the direct investigation of the society as it appears in space-time. More than any other, the concept of network offered to put sociology on the kind of foundation we associate with orthodox science by linking mathematical expression to empirical testing. At the start of the twenty first century it is the concept of social network, and its comparability of networks occurring in the natural world, that has brought sociology into the common realm of scientific discourse. (for example Amaral et al 2004. Watts 2003)

But so far the notion of network has made little impact on social theory. For example, both Giddens' The Constitution of Society (Giddens 1984) and Luhmann's Social Systems (Luhmann 1984), arguably the two most influential social theory texts of the late twentieth century, make liberal use of the concept of 'system' to express the interconnectedness of things, but do not admit the concept of network as a significant element of theory. No less strikingly, Alan Wilson in his remarkable synthesis of a century and a half of mathematical geography, Complex Spatial Systems (Wilson 2000), makes virtually no use of the formal concept of network, even in the section of the book which looks forward to future developments.

Why should this be? Why should social theory be so reluctant to embrace at a theoretical level a concept which has proved so potent methodologically? Why should the gap seem if anything to be widening as network theory advances? The suspicion must be that paradigm issues are involved. Here it is suggested that they are, and that they are related to the problem of space. Networks are space-time entities. It is this that makes them so promising methodologically. As space-time entities, it is natural to follow the usual practice of seeing them, as other space-time phenomena, as the space-time outputs of whatever underlying processes are creating and sustaining the society. The implication is that the social network is a dependent variable of the 'real' social processes, just as in spatial studies the space-time pattern is usually seen as the spatial output of economic processes.

The trouble is, the more it is possible to assign quantifiable structure to a network, the less likely it seems that it is simply a dependent variable and the more likely it is that the network is in some sense implicated in system dynamics through its structural properties. But to admit this in the case of social networks would means to admit a structured space-time entity into social dynamics, and so potentially into social causation. This is where the paradigm problem may lie: in the linking of network agency to space-time agency. Admitting the concept of network in this sense would undermine any paradigm which, implicitly or explicitly, required the exclusion of space time entities from social agency, and this means most twentieth century paradigms within which social theories have been set. In the nineteenth century, of course, writers like Herbert Spencer tries to realize the concept of society as an organism, (Spencer 1876) and so as a space time entity, but it was perhaps the naïve physicalism of this attempt that was one factor in giving subsequent authors confidence that any kind of space time description as a plausible foundation for social theory was to be rejected.

There is in this then a solid reason for social scientists to prefer the notion of 'system' to express the interconnectedness of things. A 'system' is a set of elements and relations, and so agency can rest at the level of elements rather than relations. The 'system' concept is thoroughly compatible with a 'dependent variable only' view of interconnectedness. 'Network' is an altogether more abstracted notion, and describes pure relations while backgrounding the properties of elements. The notion of network in this sense implies structural agency. This is difficult enough for social theory within present paradigms. To link it to the issue of spatial agency is enough to lead to its 'structural exclusion from thought'.

Comparing social and spatial networks

It is here that we can propose a useful parallelism between social and spatial studies, between, that is, the paradigm issues raised by Giddens and Luhmann formulations and those raised by Wilson's. Both cities (and the wider regional systems of which they are part) and societies manifest themselves to us as a primitive space-time networks, primitive in the sense that they offer unmediated and direct experience in manifestly network form. In cities, it is the network of streets and spaces formed by buildings that link the city into a single system. In societies it is the network of interactions that link individuals into a community or society. But, as with social networks, the primitive spatial network has usually been rendered invisible in geographical theories of space. As with the social theorists, Wilson prefers the concept of system, and agency in his system lies in the impact of economic forces on the 'discrete zone' elements that he divides the city into, and the dynamic interactions between them, and little follows from the structural properties of the network that connects them other than through some notion of distance. As with social theories, the space-time system that we are primitively aware of as the city, is assumed to be the space-time output of the 'real' economic processes, spatialised by distance costs, that drive the city.

This paradigm of the city has however been challenged in recent years by the space syntax approach, which begins by modeling the naïve network of space and discovering in its structures an alternative key to the dynamics of the space time city we experience. The paradigmatic novelty of this approach is that it brings to the fore and seems to find a resolution to the paradoxical problem that we identified as lying at the heart of social theory. It shows that the space time network which dominates our direct experience of the city is, not only a dependent variable of social and economic processes, but also an independent variable in the processes by which collections of building evolve into living cities. At the same time it internalizes space into the definition of what a city is. It does so through a precise set of concepts which seem on the face it to offer promise for translation into the study of social networks.

These are the theme of this paper. We first outline the network based processes through which space syntax sees the city as evolving, and show they depend on both spatial laws and human agency working together to create emergent patterns. We then show that to evolve a city from a spatial network, two concepts must be added which we term reflexivity and nonlocality, both mediated through a universal process mediating the relation between mind and world which we call description retrieval. We then apply these concepts to space-time social networks, and suggest how from this a plausible ontology for a simple society can be constructed, one which reflects pervasive properties of all human societies and at the same time internalizes space into the definition of what a society is. We begin by looking at the 'city as space-time object', that is, as the patterns of buildings, spaces and land uses that we would expect to find represented on a map.

Urban processes: network emergence and network agency

There are two processes which form the space-time city. We can call them network emergence and network agency. Both happen through the mediation of spatial laws. The first process is the aggregation of buildings to form emergent patterns of space. This is constrained by simple mathematical laws which relate the placing and shaping of objects in space to the emergence of configurational properties in the ambient space. For example, an object placed in the centre of a bounded space will, ceteris paribus, increase mean trip length and decrease intervisibility from all points to all others in the ambient space, and so will an elongated object compared to a square object of equal area. As objects become dense in space, as in cities, the only way to avoid a high trip length labyrinth is to extend at least some spaces linearly, if necessary at the cost of making others shorter. What we find is that all cities, however grid like their structure, grow in such a way as to construct a network made up at every scale of a small number of longer lines, often connected by 'nearly straight' angles, against a background of a much larger number of shorter lines, for the most part connected at near right angles. The former roughly corresponding to the network of major public spaces where public and economic activity takes place, and the second to the background of predominantly residential space. This is the process of network emergence. (Hillier 2002)

The second process takes place against this background and is set in motion by the impact of the emergent network of space on movement within the network. It is this that shapes the emergent patterns of and uses and densities which give the space-time city its functional character. The process is as follows. As in any non-uniform network, spatial elements — in this case street segments between junctions — will vary on standard graph measures of closeness and betweenness. These correspond to the two components of human movement: the selection of destinations, and the selection of the series of spaces to pass through to get there. Human trips are on average distributed so that there are more short trips than long, so the closeness of a node to all others within a defined radius indicates its potential as a destination from all other nodes up to that radius. Betweenness then measures the propensity for each node to lie on shortest or simplest (depending how you measure distance) routes between each pair of nodes in the system. So each measure reflects one component of human movement. This means that we should mathematically expect the structure of the network to have independent effects on the pattern of real movement flows, and research since 1987 has amply shown that this is the case, most strongly so by recent research which shows that people calculate distance using a geometrical and topological model of the street network rather than direct computations of metric distance (Hillier & Iida 2005).

Once we understand the effect of the emergent street network on movement, then the logic of land use patterns becomes clear. Movement seeking land uses such as retail migrate to locations which the network has made movement rich, while others such as residence often prefer movement poor locations. Attractor land uses in movement rich locations than attract more movement, and this attract other, and more diverse land uses, so setting up multiplier effect by which mixed use patches emerges in the network roughly in proportions to their positioning in the grid. In this way, cities acquire their more or less universal form of a network of linked centres and sub-centres at all scales set into a background of residential space. In effect, the space of cities is generated by a dual process: a public space process which is driven largely by micro-economic factors which are invariant and tend to give cities a similar global structure; and a background residential space process, driven by cultural factors and thus tend to make cities locally different (Hillier 1996, Hillier 2006).

One implication of this is that space can be, and is, used in two modes. By creating different movement potentials, and so different densities of movement, space can, on the one hand, be used to reflect and embody a cultural pattern, as in the residential areas (and even more strikingly in domestic interiors), where space as laid out to give reality to a culturally given pattern of activity, and so reinforce and reproduce it. We can call this the conservative use of space, since space is being use to reflect and so reproduce a given social pattern by controlling and structuring co-presence. On the other, space can be used to create potential social patterns by morphogenesis, as in the public space process, since by shaping movement, space also creates a denser pattern of natural co-presence in space. We can call this the generative use of space, since we are using space to create the potentials for new co-presence and potentially for social relations. This distinction will be important below when we talk about social networks (ibid).

The human subject and the city

From the point of view of the problems we described earlier of linking the concept of social network to theory, this account of the emergence of the space-time city is of some interest. First, it shows that the spatial network is both a dependent variable of the first, space-creating process, and an independent variable in the second 'city-creating' process. Second, it shows that both processes happen within the constructive constraints imposed by spatial laws. Third, it incorporates both spatial agency and network agency in a way which does not seem to raise the ghost of spatial determinism. This has been possible because the spatial network has been put at the heart of the system, and its description as a separate entity, independent of factors with which it interacts, was the first step in research. Without this prior description, it would not have been possible to bring to light either the process of network emergence or that of network agency. In fact, of course, in practices the two processes run concurrently, and at every stage both processes are going on and being modified. But at every stage both processes centre around what we might call the embedded spatial network.

So how can a process which involves both space and laws not be accused of spatial determinism ? Two key factors have not so far been brought to the fore. First, all the spatio-temporal events we have described in the two phases of the process are actions taken by — at least partly knowledgeable — human individuals or human agencies. Since these events are the means by which the spatial laws are expressed in space, it follows that the human actions that create the city have in some sense reflected these laws. Human action, it seems, must be the medium through which spatial laws shape the emergent city. This is a less surprising idea than it might appear at first sight. When someone throws a ball of paper so that its parabola leads it to land in a waste paper basket, that person has intuited — perhaps even felt — the laws of mathematical physics without of course doing the calculations. Cognitive science would describe such familiar phenomena as 'intuitive physics'. Similar evidence can be accrued that people intuit the spatial laws we have described in a similar way, so that spatial behaviour embodies and reflects these laws in the same way as it must embody and reflect physical laws (Hillier 2006).

Second, the embedded spatial network has a peculiar property: although the form of the system has evolved through the first process is bottom-up, its functioning through the second process is top-down, in the sense that the movement flows which drive the evolution of the system reflect the position of each space in the large scale configuration, not the local properties of the space. In this sense, the properties of spaces which are critical to its functioning are non-local and reflect remote, as well as local, connections. This poses a challenging, and highly interesting, question. In order to produce the patterns of flows we find, people must be using some kind of non-local internal representation of the space network with both geometrical and topological properties (Hillier & Iida op.cit.). In fact, both the network emergence process and the network agency process depend on a human ability to cognise the system in order to act on it. In taking decisions about new street alignments to ensure well formed growth, or working out how to go from a to b in such a way that the functional dynamics of the city are maintained, both require some kind of non-local picture of the spatial configuration as it exists at that point. Since cities, like any complex space, are such that they can only be experienced a bit at a time, we can see that this will depends on a prior ability to turn discrete experiences of the bits of the city into a overall picture of some kind - to turn knowledge of routes for example, into a knowledge of maps, or survey knowledge as cognitive science puts it. This is essentially a process of synchronisation. The experience of the bits is dispersed in time as well as space, and by building routes into maps, or parts into wholes, we are converting experiences dispersed in time into synchronic pictures with some kind of 'all at once' geometric order.

Description retrieval

It is worth looking at this process of synchronisation more closely since the next stage of our argument in a sense depends on it. It is part of a process we call description retrieval, by which human beings retrieve abstract information from concrete events (Hillier & Hanson 1984). Suppose one person builds a house and another person builds a house next to it, we can see that this is the case in a concrete sense, but we can also see that one house is in a next to relation to the other (Figure 1). This relation is symmetrical, in that if a is b's neighbour then b is a's neighbour, unlike, for example, above or below, or behind and in front which are asymmetrical. By retrieving the abstraction next to from the event we could then treat it as a rule and follow it, or not as the case may be. So rules do not have to reside in heads, but can be derived from spatio-temporal events. But that is not all that happens. If the process continues, a new form emerges. If we do not retrieve a rule and follow it, a random pattern emerges of which we cannot retrieve a description, but if we do, a linear form emerges. If we vary the rule, other forms emerge. We are then able to retrieve a description of these by synchronising the discrete events into an overall shape (Figure 2).

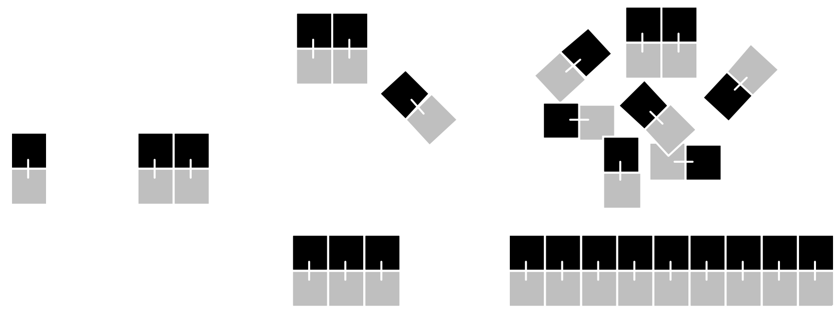

Figure 1
The generation of simple forms from simple rules

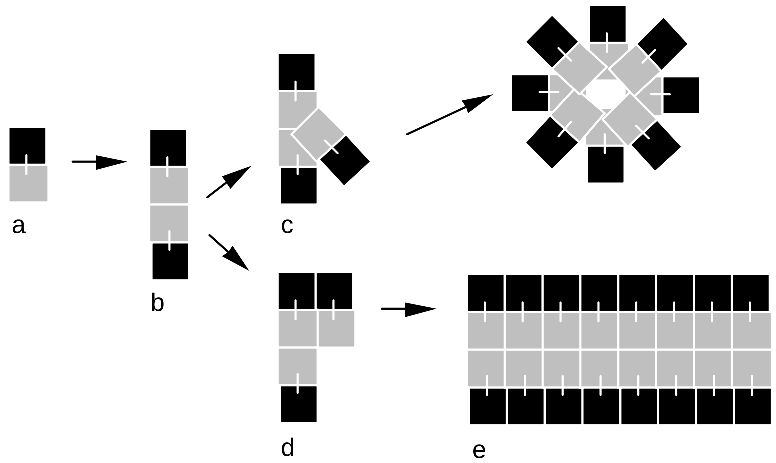

Figure 2
Other simply generated forms

Is this overall synchronisation distinct from the repetition of the local rule ? We can demonstrate that it is. In Figure 3, the left figure is no less recursive than the right figure but we only retrieve is as a repeated local pattern, not as a whole. The one to the right we are more or less able to syncrhonise as a whole because lines have appeared as a whole, the one on the right clearly so. This process of synchronisation is the upper level of the description retrieval process, and refers to emergent products of local activity. We retrieve a template rather than simply a rule. There are good grounds for thinking that templates are distorted by cognitive input — we make space more orderly than it is — and this becomes more so as the realities it deals with become more complex. We simplify in order to understand.

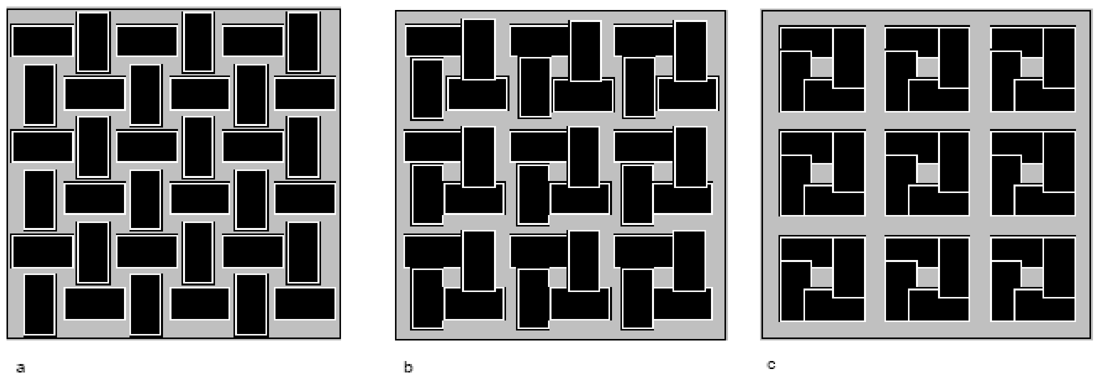

Figure 3
By increasing the linear organization from left to right we move from retrieving a local to a global description

Now these two levels of description retrieval (the retrieval of abstract information from concrete events), the level of the rule and the level of the emergent template, are I believe fundamental to all the complex system that human beings make and inhabit: not only cities, but cultures, economic systems and even whole societies. It is exactly analogous to Levi-Strauss's machines for the suppression of time (to use Leach's felicitous translation — Leach 1970). Kinship in human societies, for example, arises from events similarly dispersed in time and space. But a kinship system, or a set of kinship rules, synchronises these dispersed events into a logical template. This mechanism for turning time into the non-time of logical order was the heart of the Levi-Straussian project. It can operate either by knowing rules, in which case the emergent pattern is poorly understood, but present, or by knowing the logical system, in which we can use it locally as a problem solving device.

The presence of the description retrieval cycle in a process such as settlement growth imparts to it two critical properties we can call reflexivity and nonlocality. Reflexivity means the ubiquitous intervention of human minds first between the forces that bring the city into existence and the form it takes, and as we have seen reflexivity reflects spatial laws which are known intuitively to people. Reflexivity between mind and created world, is then not simply a mechanism, but a pervasive explanation of form. Nonlocality means emergent spatial or functional patterns in systems which depend on remote rather than proximate elements. The simple fact that human movement depends on nonlocal factors is the clearest and simplest instance of this, but once the concept is admitted it can be seen to be quite pervasive both in the network emergence and network agency phases of the process.

So we arrive at a model of the city in which socio-economic processes, human cognition and spatial laws all played an interconnected role, one which, I suggest, requires us to see the city as a semi-autonomous system — that is a system which is in part determined by external forces, and in part structured by into own internal laws, through which these extraneous forces are turned into new and distinctively urban features of the city. We showed this by internalising space into the model of the city, and showing that space was the source of its essential forms and dynamics. We also showed that what we might call the DNA of the city is in its physical and spatial patterns, and we interact with it through the two level description retrieval and embodiment mechanism. The patterns of the city embody social information — using the term in its broadest sense — and this is what we aim to retrieve through syntactic analysis. As was suggested in The Social Logic of Space, a city is like a machine whose programme is in its output. This is why we must see our urban surroundings as both a spatio-temporal and informational or conceptual reality.

Cities and societies

Now this is something like what Giddens said about society in 1984 (the same year as The Social Logic of Space was published). Societies, he said, were virtual structures realised and reproduced through situated practices acted out in space-time. The informational content of society exists in and in reproduced through spatio temporal activity. His model was language, mine biology (though turned on its head, in that the dna is exosomatic), but the conceptual model was similar. But Giddens said little after this. Having shown in principle that space and time can be internalised into social theory, he does not then try to show how and why it happens. In fact, at the end of the 1984 book he turns away from space in the real sense of what we find in buildings and cities and replaces it with the — to my mind — much weaker concept of the spatiality of social and economic processes, just as the old urban modellers did.

But the need to internalise space into social theory is an urgent issue, to my mind the outstanding problem of social theory because without it we cannot say what kind of a thing a society is (Hillier 1996). The twentieth century accumulated an array of potent findings pointing to a powerful and systematic relationship between society and space, but these have never been formalised into a theoretical model. For example, Durkheim's assignation of the sources of the shift from mechanical to organic solidarity to what he called 'moral density' (Durkheim 1915), Service's conclusion that in Australia greater dispersal was associated with more sodality like behaviour and vice versa (Service 1962), Turner's cultural comparison of the Talense and the Ndembu and their different settlement forms (Turner 1xxx), to name only a few. In the late twentieth century a substantial array of work linking real spatial and social processes from authors like Bintliff's work on settlement scales and social morphology (Bintliff 1999), Kristiansen and Rowlands on settlement patterns and social structures (Kristiansen and Rowlands 1998), Perring on social and spatial changes in Roman towns (and others in the remarkable Rich and Wallace-Hadrill 1991), Maisels on spatial and social change in the four main early urban sites (Maisels 1999) and many others. While most disciplines have talked endlessly about space but baulked at the real space of buildings and cities, archaeology has engaged with this in a thoroughgoing way — but never really called it space. If ever there was a body of work looking for a spatial theory this is surely it.

My aim here is to suggest that an ontology by which space can be internalized into society, and the space-time network made central, by making what might seem at first a preposterous comparison between society and the city. It is less preposterous perhaps if we call it a comparison between spatial and social space-time networks. They do after all have a lot in common prima facie: both can be represented as graphs and shown to share surprising large scale mathematical regularities, for example in that each has the property of being both sparse — nearly all elements are not connected to each other — and shallow — graph distances between elements are surprisingly small considering the number of elements. both kinds of system are dual in the sense that they combine the spatio-temporal and the informational, so you never get one without the other; both have the DNA 'out there' in the sense that the material realization contains the genetic information; and both seem to relate to human cognition through some kind of description retrieval process. What is proposed below adds little to knowledge. It merely suggests an ontological framework for a society as a spatio-temporal and conceptual system, through which the twentieth century findings and theories and space and society can make sense together.

First steps towards an ontology: the issue of evolution

The most basic question for an ontology of society is: why do human beings form societies in the first place? The answer must involve evolution, since if societies were did not offer evolutionary advantage, then it is unlikely they would exist. This poses an apparent problem, because the common view of evolution is that it is driven by competitive struggle of all against all. This seems to many to pose a problem for understanding societies because although societies may involve competition, in some more than others, societies are essentially co-operative phenomena, and this is certainly true of the simplest societies of which we have a record. Language provides interesting clues. 'Social' behaviour means cooperative behaviour towards fellow members, and although most people would accept that there are social benefits in economic competition, we would not normally describe competitive behaviour as 'social' behaviour — even though in a broader sense it clearly is.

But, on closer examination, the evolution problem for society turns out to be illusory. It dissolves when we focus on the actual mechanism of evolution rather than its metaphorical embedding. The mechanism of evolution is focused on only one thing: success in producing offspring. The more certain groups rather than others have more offspring, they more their genetic characteristics will dominate the future gene pool, and so be more like them than others. As soon as this is clarified, the supposed contradiction between evolution and society disappears. Societies will be favoured by evolution if they increase the capability of social members to have offspring, and of course this is exactly what societies do. This is what societies are and what they are for. Societies favour the production of surviving children, because whatever else they are, they are set of interdependencies amongst individuals which spread risk amongst those individuals, so that if something goes wrong with one person's circumstances, then others can help, and vice versa. So other things being equal social members are statistically more likely to have the dependable and secure circumstances in which they can produce more progeny than those who are not social members. At root, we might say, societies are insurance policies: they take risk from the level of the individual to that of the society, so over evolutionary time, human beings who are members of societies are more likely to influence the gene pool than those who are not.

So in evolutionary terms, a society is at least some network of relations which is projected through time to makes the interdependencies possible. This suggests that the fact of relatedness may be more critical than the form of relatedness. Any system of relatedness which allows risk to be spread would work to give the evolutionary advantage that must be the reason for society's existence. The fact of being some system of relations is then the foundational notion for society, before we consider either the specific form those relations take or the causes which brought them into existence. The function of a society, we might say, is to exist, and through its existence to provide the security through interdependence that on the evolutionary time space leads to significant advantage. We might even take this one stage further and suggest that the larger the society, and the more individuals involved in the system of relations, then the more successful the society could be held to be in evolutionary terms. So other things being equal, evolution is likely to select for those forms of society which grow large at the expense of those that remain small. If this is so, we do not need to account for social growth, since evolution would already select in favour of societies which are able to grow.

But scale is also evolutionary issue in a more basic sense. If the existence of a 'society' means, as seems likely, that members inter-marry with each other more than with non-members, then the society must be large enough to provide an adequate genetic diversity. Mathematical models suggest that this cannot fall below about 500 members. This has a critical implication for an ontology. Since in the simplest situations most environmental circumstances requires people to live in cohabiting groups of a size well below the intermarrying threshold, it follows that for a reproducible society to be created, it must succeed in creating durable relations across spatial groups, and so non-local relations. So society, if it is to exist, must respond to two kinds of pressure to create a non-local grouping which is much very much larger than the co-residence group. This is of course what societies are in the first instance: they are arrangement of exchange and interdependence between co-habiting groups. This is the first step in our ontology. 'Society' must be sought initially in the nonlocal relations among dispersed co-habiting groups, not within the local cohabiting group — though we would expect signs of the nonlocal society also to appear there.

Societies as space-time networks

Within this framework, a society is first and foremost a network existing in a spatial region within which there are a number of local cohabiting groups. This network will be sustained by social practices, but these social practices are the means by which the network is realized and reproduced, not the society itself. It is not the social practices that gives evolutionary advantage, but the network they create and sustain. So if anything it is the network which comes closer to being at the heart of what a society is. In what follows, we will see social practices as means of creating, controlling and mutating theses networks and their structures, especially under conditions of growth.

As with the city, then, we can and should put the graph of the social network at the heart of our model, and propose that for an evolutionary advantageous society to exist in the form of a network of local and nonlocal groupings there must be two things:

- mechanisms for overcoming space to create the non-local grouping — we could call them mechanisms for overcoming dispersal, or even for overcoming space
- mechanisms for controlling local space, that is securing the local grouping against dispersal, for example by having ways to settle disputes short of fission

The two interact in that fission of the local group can be a means to create the non-local grouping, and the non-local grouping will often means a means to create and re-create the local group. But in general we can say that to come into existence, society has to solve two spatial problems: roughly those posed by dispersal and those posed by proximity.

Spatial and conceptual groupings

How the are non-local relations created? In some simple societies this is a matter of exchanging people with high frequency, so that the very fluidity of the spatial group is a means by which a larger scale social network is continuously recreated (Lee and Devore 1968, Sahlins 1974). Moving to another group is also a standard way of solving disputes within the local group. Almost universally, however, we find that societies define, over and above local, or spatial, groups, groups which are defined non-spatially in that membership is defined by a label, and so can be thought of as conceptual groupings. Households, villages and universities are spatial groupings. Families, clans and academic disciplines are conceptual groupings, and so independent of space. The former exist within a spatially defined domain, while the latter exist regardless of how they are distributed in space. Conceptual groupings have distinct forms and patterns of social behaviour associated with them, as do spatial groupings. For example, ceremonial and ritual activity may be, and often is, organised through the conceptual grouping.

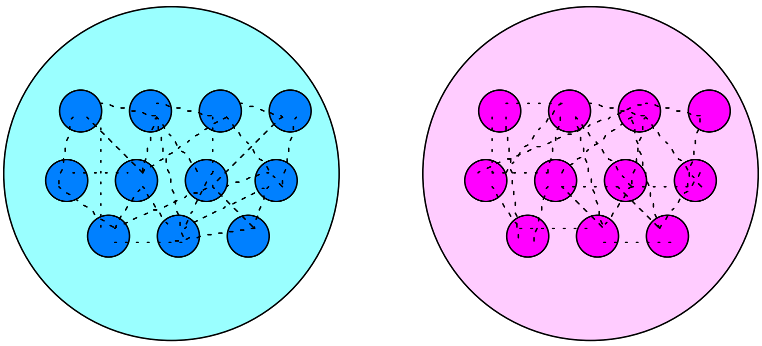

Figure 4a

In the first case, being a member of the blue or pink clan corresponds *to spatial group membership, so everyday and ceremonial activities associated with the clan reinforce the same group. Local identities become stronger, and non-local weaker. The spatial group will need stronger boundary control, and stronger internal rules, to keep it blue or pink. In practice, we tend to find groups of this kind are territorial and internally hierarchical.*

Where then do social labels come from? In general we can say: by description retrieval from the spatio-temporal graph, and so by reflexivity. At the simplest level social labels like sister or father are the roots of j-graphs (that is, graphs justified from a node considered as root) of sets of relations, and each node in the graph acquires a label which implies all the others. Social behaviours appropriate to the label then inherit the formal properties of their position in the graph, so in metaphorical extensions 'sisterly' behaviour reflects the symmetry of the sister relation, and so equality, while fatherly behaviour reflects the asymmetry of the parental relation, and so inequality. A clan system, in contrast, is a template retrieved from the space time graph by synchronising events dispersed in space and time - birth, reproduction and death - into a time-free logical picture. Clans can also inherit the formal properties of their space time origins. A conical clan, for example, is a clan formed from descent from a single ancestor, and so founded on an asymmetric principle which we would expect to find reflected in hierarchical clan behaviour reflecting the asymmetries. In this sense, the way in which we simplify and so bring order into complex social networks seems to resemble the way we do it to cognise spatial networks: we turn relations into abstractions and order them into formal geometrical and logical schemes, which are, as a consequence, are likely to be neater and clearer than their space-time origins.

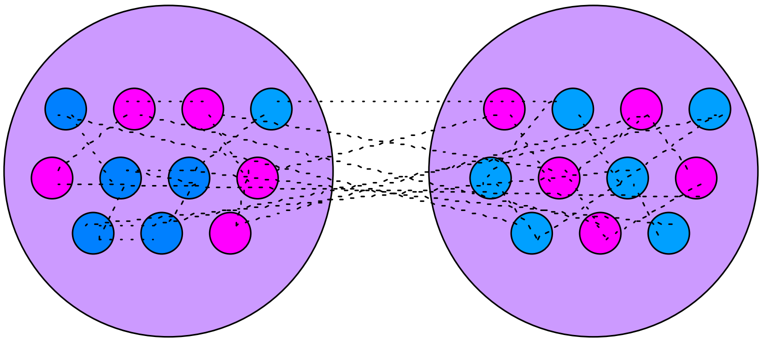

Figure 4b
In the second case, being in the blue or pink clan does not correspond to spatial group membership, so everyday activity merges blues and pinks, and ceremonial activities reinforce non-local *blue or pink connections, and so increases the density of the non-local network at the expense of the local. Local boundaries are weaker as there is no need to control for colour. In this model the non-local network is stronger, and local identities weaker. Freeing the local group from ceremonial identity allows local political interaction to become stronger. In practice, we tend to find such societies less hierarchical, less territorial and more political.*

System of labels in general, are then reflexive constructions from the space-time graph, with abstract properties as well as space time realisations. As soon as they exist, they create potential for some socio-spatial dynamics. Consider two cases in which we have two spatial, or cohabiting, groups and two conceptual labels, say the pink and the blue. In one the membership of the spatial group and tconceptual groups correspond, in another they do not. So if, in the 'correspondence' case, being a member of the blue or pink clan corresponds to spatial group membership, so that all members of the group are the same colour, then everyday activities and ceremonial activities associated with the conceptual group reinforce the same group of people. Local identities will become stronger, and non-local weaker. The spatial group will tend to need boundary control, and stronger internal rules, to preserve its single colour. In practice, we tend to find groups of this kind are territorial and internally hierarchical. In the non-correspondence case, being blue or pink does not correspond to spatial group membership, so everyday activity merges blues and pinks, while ceremonial activities re-inforce non-local blue or pink connections, and so increases the density of the non-local network at the expense of the local. Local boundaries are weaker as there is no need to control for colour. In this model the non-local network is stronger, and local identities weaker. But freeing the local group from ceremonial identity allows local political interaction to become stronger. In practice, we tend to find such societies less hierarchical, less territorial and more political.

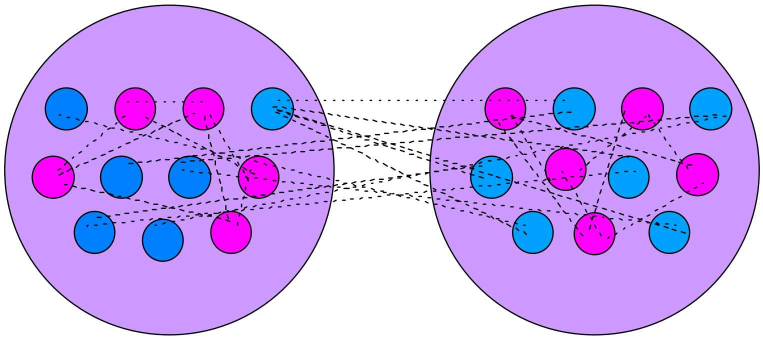

Figure 4c

Now consider a third case in the blue and pink model. We can call it the differential solidarities *case: blues only have relations with blues in the other spatial group, and pinks only have relations with pinks in the* same *spatial group. This means that the two groups not only have relations which are spatially different - pinks only have local relations and blues only have non-local relations - but relations which are of a different* kind*. Blues are likely to use more long models to form relations at a greater distance while pinks are likely to use shorter models to form relations which are primarily local. These are the kinds of spatial and cultural differences that are characteristics of class systems, where differences in cultural behaviour are associated with differences in the spatial ranges of networks. Differential solidarities of this kind will arise to the extent that particular groups have special access to the means of social reproduction, that is the to means of reproducing inter spatial group relations. It is exactly this situation that Yoffee suggests arose in the Ubaid period in Mesopotamia that preceded the formation of cities.*

A third possible relation between structure and dynamics Figure 4c, we can call differential solidarities model. In this case, blues only have relations with blues in the other spatial group, and pinks only have relations with pinks in the same spatial group. This means that the two groups not only have relations which are spatially different - pinks only have local relations and blues only have non-local relations - but relations which are of a different kind. Blues are likely to use more long models to form relations at a greater distance while pinks are likely to use shorter models to form relations which are primarily local These are the kinds of spatial and cultural differences that are characteristics of class systems, where differences in cultural behaviour are associated with differences in the spatial ranges of networks. Differential solidarities of this kind will arise to the extent that particular groups have special access to the means of social reproduction, that is to the means of reproducing inter spatial group relations. As we will see, it is this kind of situation that has been suggested to have arisen in the Ubaid period in Mesopotamia that preceded the formation of cities.

Graph generating and graph-directed behaviour: short and long models

The distinction between spatial and conceptual groupings also relates to another invariant across societies. All societies deploy resources and activity at two levels: the level of everyday production of the material conditions of life, and so the biological survival of individuals; and at a level devoted to seemingly biologically unnecessary activities which serve to reproduce social relations. One expression of this is the difference between everyday events, with their short term recursion periods, and special, more ceremonial events, like births, marriages, deaths, seasonal festivities and so on, which have longer term recursion periods. We can call the upper level the reflexive level, since the object of its behaviours is to reproduce existing patterns in the space-time graph. Its behaviours can be seen as graph-directed, while behaviours at the lower level generate graph relations as a by-product. Where we find templates operating at this upper level we call them institutions or institutional structures.

We find different kinds of behaviour associated with the two levels. All human encounters are made up of two elements; the space time elements of co-presence and interaction; and the abstract elements such as labels, classification and rules which shape the form the interaction takes. The spatio-temporal aspects are the hardware of social transactions, the labels and rules the software. The software however has some very interesting dynamic properties of its own. In all societies human encounters vary on the dimension formal-informal. For example, where encounters are asymmetric we find more formal content - use of titles and forms of address, more formal language, special behaviours, and so on. We can conceptualise this as the ratio of rules to events: the higher the ratio the more formal, the less the more informal, and index it as the length of the string of symbols we must write to describe the rules that control events. The longer the sequence of symbols required — the longer the model — the more the spatio-temporal event is formal, and the shorter the required string, that is the shorter the model the more that is allowed to vary randomly and the less formal it is, while retaining some degree of conceptual intervention.

The limiting case of a long model event is the ritual: everything must happen in a certain sequence, be carried out be certain people, follow an exact format, and so on, so that it would take many symbols to write the formula down. But everyday life also varies across cultures and with phases of culture in the length of model. So while all human encounter is rule governed in some sense, the degree to which it is rule-governed is a variable, and this variable can be in principle quantified (though in reality only with great difficulty). The length of the model indexes the degree of conceptual intervention in a space time event. Now the longer the model is the more the events are reproductive of patterns that already exist, because more of what happens is governed by the rule; while the shorter the model, the more the events lead to morphogenesis in the system of relations, because less of what goes on in the space-time encounter field is rule governed and more is randomised. A ritual is a reinforced description of relations that already exist in society and this is why it has a long model. This mirrors the distinction between the conservative and generative mode of creating space, in a more precise form. There are more rules in conservative space.

Long and short models have their own socio-spatial and temporal dynamics. In everyday life, activity patterns will tend to have a shorter recursion period, involve a great deal of everyday activity, and bring together a local group and use a short model, that is a low ratio of rules to events; while ceremonial activities will tend to have a longer recursion period, take the form of special events rather than everyday activity, and involve a wider group of people and use a longer model, that is a higher ratio of rules to events. So time is involved as well as space, time being a kind of distance. We can generally we can say that the shortness of the model is inverse to spatial and social distance. This is why it is in the nature of things that the ceremonial fund is essentially the non-local fund, and why we tend to find the 'social' more in the relations between spatial groups than within them. It is the primary means by which society creates a non-local network and it is the primary means by which space and time are internalised into society.

An ontological model for society as a space-time network

We can now outline an ontological model for society based on these ideas. Figure 5 The foundation is the space-time graph and the model is about what we have to add to it to arrive at a society. The horizontal axis distinguishes the spatial from the conceptual, and the vertical the nonreflexive from the reflexive. Bottom left we have everyday life in which elementary 'descriptions' in the graph, which may or may not be 'description-retrieved', are generated by co-presence. Bottom right is the conceptual content of these co-presences. Top right we have the realm of ceremony and ritual through which template level conceptual content are realised in space-time through enactment. Top left we have the negotiation and control of template level descriptions, or the realm of politics.

Simplifying, we can see that the left side unreflexive level of activity can be seen as graph generative activity in that it continually poses new co-presences as candidates for description retrieval as enduring relations in the graph, while the right side can be thought of as the conditions of reproduction for those relations. The upper reflexive level can be conceptualised as graph-directed activity, aimed at the structure of the network itself, either by reinforcing its patterns by embodying them in enriched description realisations we call rituals, or by seeking to solve problems that arise as society grows and changes, the realm of politics and law.

	spatial space time events - low conceptual intervention	transpatial special events - higher conceptual intervention	
	the production and reproduction of descriptions at the generative level of the microsociality i.e. everyday life and interaction	the production and reproduction of descriptions at the emergent level of complex descritions or institutional structure	
reflexive graph directed level	the *negotiation* and control of complex descriptions: settlement of disputes, meetings and in general the realm of politics and law, up to warfare.	the *projection* of complex descriptions by enactment in space-time: ritual, ceremony and in general the realm of the ceremonial fund	the institutional level of the macro-society beyond the level of experience
unreflexive graph generating and reproducing level	the *generation* of potential descriptions through space-time relations generated by proximity and interaction	the *reproduction* of description i.e. the rules governing everyday interactions	the level of the everyday micro-sociality at the level of experience
	short models morphogenetic	long models conservative	

Figure 5

An ontological model for a society as a space-time network. Note that the word 'transpatial' is used to express the independence of conceptual descriptions from space, so they work naturally across space.

Society is how we overcome space

Society is then an evolutionary advantageous form that is achieved by overcoming space by using reflexive mechanisms to create non-local relations. Ecological factors like environment, technology and density, and so the conditions for the production of biological survival, set the problem which is solved by how space is overcome. So in conditions in which people can only survive sparsely, society will have to overcome dispersion, while under conditions of density the problems will one of proximity. Exactly what mechanisms evolve in a particular society could involve chance, in that any set of social practices which realised advantageous non-local groupings in a stable way could and perhaps would become normative in that society simply because they created the conditions of evolutionary advantage. This 'normative hypothesis' would even make sense of random variation in social forms, as well as permitting dramatic change to take place.

But under conditions of growth, different mechanisms would be activated. If there are a number of spatial groups in a landscape and population increases, then either the number or the size of groups must increase, or both. Figure 6 If the number increases, the problem remains that of dispersion and, since under dispersed conditions non-local integration tends to happen through the conceptual groupings and associated ritual, rather than politics, this should leads to ritual intensification as the mean of holding the society together. If the size of groups increases then the problem shifts from overcoming dispersion to overcoming the problems of proximity. The left side reflexive level of the model — politics, dispute settlement and so on — is prioritised over the right, ceremonial side. This is why with urbanisation a large proportion of the complexity of 'tribal' societies eventually disappears, including elaborate kinship systems and associated forms of ritual.

Our model then suggests that one of the great discontinuities in human social history from tribal to urban reflexive structures actually arises from what societies are and how they can be created under different spatial conditions. So by seeing societies by analogy with space as spatio-temporal graphs with reflexivity and nonlocality, we can internalise space into our model of society and capture some significant interactions between the social and spatial dimensions.

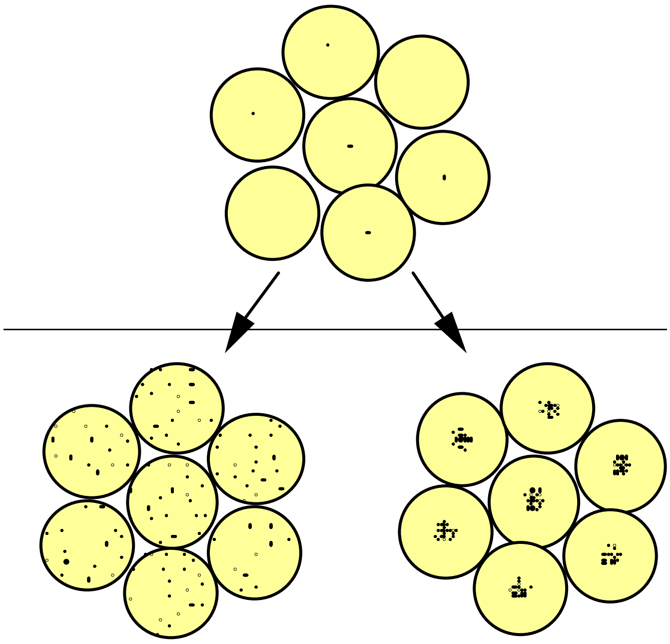

Figure 6
The two pathways of growth for human societies. If there are a number of spatial groups in a landscape (top level) and population increases, then either the number *or the* size *of groups must increase, or both. If the number increases, the problem remains that of dispersion and, since under dispersed conditions non-local integration tends to happen through the conceptual groupings and associated ritual, rather than politics, this should leads to ritual intensification as the mean of holding the society together. If the size of groups increases then the problem shifts from overcoming dispersion to overcoming the problems of proximity. The left side reflexive level of the model – politics, dispute settlement and so on - is prioritised over the right, ceremonial side.*

One final observation. Our analysis of cities suggested that we needed to see the spatial network as a semi-autonomous system meaning that although clearly shaped and driven by exogenous economic and social forces, we do not understand exactly how this is so unless we also understand that it also evolves under the scope of internal spatial laws. In fact it is through the intermediary of these laws that economic and social processes are able to express themselves in space. The same is surely true of societies. What we name as 'society' seems to be a semi-autonomous system in something like the same sense.

References

Albrecht G, Fitzpatrick R & Scrimshaw S. 2000. *Handbook of Social Studies in Health and Medicine.* London: Sage.

Amaral L et al. 2004. Virtual round table on ten leading questions for network research. *European Physical Journal*. J.B.38, 143-145

Bintliff J. 1999. Settlement and territory. In *Companion Encylopedia of Archaeology*. Routledge.

Durkheim E. 1915. *The Division of Labour in Society.*

Dyson-Hudson R and E Smith. 1978. Human territoriality: an ecological reassessment*. American Anthropologist* 80, 21-41

Fischer C, R Jackson, A Stueve, K Gerson, L Jones with M Baldassare. 1976. *Networks and Places: Social Relations in an Urban Setting*

Giddens A. 1984. *The Constitution of Society.* Polity Press.

Granovetter M .1982. The strength of weak ties. In *Social Structure and Network Analysis,* ed. P Marsden & N Lin . Beverly Hills: Sage Publications.

Hillier B & Hanson J. 1984. *The Social Logic of Space.* Cambridge University Press.

Hillier B, A Penn, J Hanson, T Grajewski and J Xu. 1993. Natural movement: or configuration and attraction in urban pedestrian movement*. Environment & Planning B: Planning & Design* 19, 29-66

Hillier. 1996. *Space Is the Machine.* Cambridge University Press.
Hillier B. 2001. A theory of the city as object. *Urban Design International* 7, 153-179.
Hillier B and S Iida. 2005. Network and psychological effects in urban movement. In *Spatial Information Theory*, *Lecture Notes in Computer Science 3603*, ed. Cohn A & Mark D, 473-490. Springer Verlag.
Hillier B. 2006. The art of place and the science of space. *World Architecture, Special Issue on space syntax research* (in Chinese and English)
Hillier B. 2006. Studying cities to learn about minds. Keynote paper to *Workshop on Space Syntax at Spatial Cognition 07 conference*, Bremen (to appear in proceedings and special issue of Environment & Planning B)
Kristiansen K. 1998. Chiefdoms, states and systems of social evolution. In *Social Transformations in Archaeology,* ed. K Kistiansen & M Rowlands, Routledge.
Lee, R B and I Devore (ed.) 1968. *Man the Hunter*. Chicago: Aldine.
Leach E. 1970. *Levi-Strauss* Fontana Modern Masters
Luhmann N. 1984. *Soziale Systeme.* Suhrkamp Verlag, Frankfort; English translation by J Bernarz Jnr & D Baecker. Stanford University Press.
Maisels C.K. 1999. *Early Civilisations of the Old World.* Routledge.
Perring D. 1991. *Spatial organisation and social change.* In *City and Country in the Ancient World*, ed. J Rich and A Wallace-Hadrill. Routledge.
de Poole I S and M Kochen. 1978. Contracts and influence. *Social Networks* 1, 5-51.
Rich J and A Wallace-Hadrill. 1991. *City and Country in the Ancient World.* Routledge.
Sahlins, M. 1974. *Stone-Age Economics*. London : Tavistock
Service E. 1962. *Primitive Social Organisation.* Random House.
Spenser H. 1876. *Principles of Sociology.* Williams & Norgate.
Turner V. 1957. *Schism and continuity in an African Society.* Manchester University Press.
Watts, D. 2003. *Small Worlds: The Dynamics of Networks between Order and Randomness.* Princeton: Princeton University Press
Wilson A. 2000. *Complex spatial systems.* Prentice Hall.