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Article

Toward a general theory of cities

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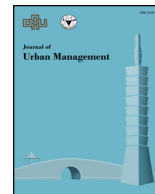
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Editorial

Toward a general theory of cities



We now know that many phenomena, social or natural, are manifestations of complex systems and we are just beginning to construct a general theory to explain such phenomena (e. g. [Simon, 1996](#) and [Holland, 2012](#)). Though there is still a long way before we could find such a theory, we have gained so much understanding of complex systems that we should start thinking about such a theory. In this editorial, we are particularly interested in complex systems that are open, rather than closed. In other words, these systems exchange materials with their environment. Here we propose a conceptual framework toward a general theory of complex systems and attempt to apply such a framework to explain one of the most complex human artifacts, the city.

1. The conceptual framework

Any complex system is composed of a large number of agents, a set of flows of such agents, a hyperspace (HS) in which these flows of agents take place and interact with each other, and a set of regulatory rules (RRs) that govern these interactions. Agents are entities, tangible or intangible, that constitute the physical components of the complex system. There are mainly three types of such agents: energy-demanders (EDs), energy-suppliers (ESs), and mixing pots (MPs). These agents may or may not be adaptive. There are flows of EDs, ESs, and MPs, each with a different speed of which the combination characterizes a different world. When EDs, ESs, and MPs collide in a hyperspace, something happens depending on the regulatory rules. The regulatory rules specify which EDs and ESs are eligible to be available in which MPs. In the MP of a collision, when the total energy across all available ESs exceeds or is equal to that across all available EDs, an action is activated and the energy is transacted. Otherwise, no action is taken and energy remains unchanged. [Fig. 1](#) shows the conceptual relationship between EDs, ESs, and MPs, which forms the building block of the complex system as shown in [Fig. 2](#). Note that the network is composed of a set of effective, interdependent MPs in which EDs and ESs collide, with other agents floating around in the hyperspace.

The hyperspace is an abstract, rather than physical, space in which all agents float around. The simplest hyperspace is a grid as shown in [Fig. 3](#) in which agents can move horizontally or vertically. Note that the agents can float in different speeds that would warp the system ([Olshansky, 2017](#)).

Regulatory rules are organizational principles ([Laughlin, 2005](#)) that specify which EDs or ESs are eligible to collide with other agents in which MPs. These rules can be represented by 0–1 matrices as shown below. Note that a “1” indicates that the ED or ES in the corresponding row is available in the MP in the corresponding column, whereas a “0” indicates the reverse. Note also that energy connotes resources, including but not limited to utilities, monetary values, labor, time, land, facilities, nutrition, etc., depending on the system under consideration.

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2. The city as an example

The city is no doubt a manifestation of complex systems ([Batty, 2013](#)) and it fits well the conceptual framework for a general theory as depicted in [Section 1](#). A large number of objects constitute the city, including, but not limited to, people, buildings, and other artifacts, such as cars, street furniture, public facilities, etc. These entities or agents interact in an unpredictable way which can be characterized by a two dimensional hyperspace. More specifically, there are generally five streams of such agents, that is, decision makers, problems, solutions, choice opportunities, and places. Decision makers are people residing or working in the city. Problems

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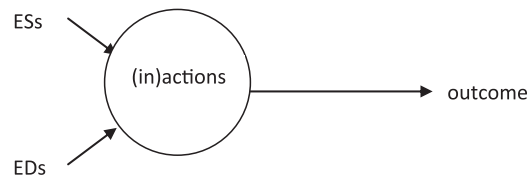


Fig. 1. A Mixing Pot.

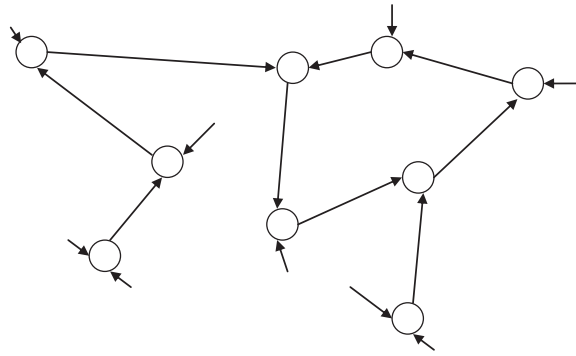


Fig. 2. A network of MPs.

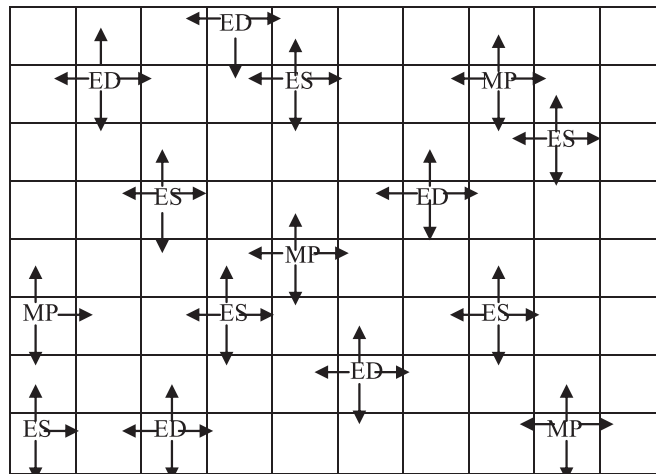


Fig. 3. A two-dimensional hyperspace.

are the discrepancy between what is desired and what is realized. Solutions are artifacts, tangible or intangible, that could solve the problems. Choice opportunities are decision situations where decision makers, problems, and solutions are brought to bear. Places are locations where choice opportunities take place. In the context of the conceptual framework, decision makers, solutions, and places are ESs, whereas problems are EDs and choice opportunities are energy free.

These five streams of agents float in the hyperspace (HS) and once decision makers, problems, and solutions collide in a particular choice opportunity associated with a particular space, something happens. If the energy provided by the decision makers, solutions, and places exceed that required by the problems to be solved, a decision is made and an action is taken to solve these problems which then leave the system. Otherwise, no decision is made and no action is taken. In addition, in order for the decision to be effective, the colliding agents must meet the conditions of regulatory rules (RRs) or structural constraints which are manifestations of institutions in the city, such as regulations and cultural norms. These regulatory rules specify which agents are eligible to attend which choice opportunities. For example, commercial activities must take place in shopping centers and working activities must occur in office buildings. A spatial model of the city has been constructed using the conceptual framework (Lai, 2006) and the results of the computer simulation were partially validated in Taipei city in that a particular set of regulatory rules governing the relationship between problems and choice opportunities were found more effective than those governing the relationship between places and choice opportunities in affecting the outcome of system performance (Lai, Kuo, & Yu, 2018). This model is so powerful and robust that it has also been used to investigate whether the city is a dissipative structure (Lai, Han, & Ko, 2013), to explain the rapid urbanization process in China (Lai, 2017), to explore into the emergence urban institutions (Lai & Han, 2015), to compare

institutional and spatial change in the self-organizing city (Lai, Wang, & Han, 2012), and to prove deductively the effectiveness of plans in complex spatial systems (Lai, 2018).

3. Conclusions

Many social and natural phenomena are manifestations of complex systems. There is an urgent need of a general theory of complex systems that help us understand such phenomena. Here we propose a conceptual framework for such a theory, rather than providing a concrete one as such. The conceptual framework works well in understanding how the city works, one of the most complex human artifacts, so it might be worth pursuing further this framework into a general theory of complex systems.

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