Chapter 3
Digital Swarms:
Social Interaction and Emergent Phenomena in Personal Communications Networks

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ABSTRACT

By converting a fixed network into a mobile system, personal communications technology radically transformed the way we interact with each other and with the environment. Recently, new generation mobile phones (known as smartphones) increased the capacity of the network nodes and added new properties to mobility, converting a once ordered system into a complex and perhaps adaptive network. In this paper, we argue that contemporary mobile phone networks are large-scale complex adaptive systems—with niches, hierarchy, recirculation of information, coevolutionary interactions, and sophisticated collective behavior—that display remarkable similarities with eusocial insects (ants, bees, wasps and termites). Under this framework, we will discuss the impact of personal communications networks in the urban life, without losing sight of the effects—either positive or negative—of the system's emergent patterns on the network itself and on the individual nodes (personal devices and users).

INTRODUCTION

In nowadays, mobile phones are promoting social and behavioral changes of which the full extent people may not yet be aware. The first major change came with the gradual conversion of a fixed into a space-varying (or mobile) network, beginning in the 1980s, when the first commercial mobile phones were launched. In the early 1990s, digital cell phones were introduced and by the end of the century the new technology was widespread in developed countries, swiftly replacing the long-standing fixed network.

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In nowadays, mobile phones have a global penetration rate of approximately 100%, with almost as many mobile phone subscriptions as people in the world (GSMA, 2015).

The transition from a fixed to a mobile network was certainly revolutionary in the sense that it transformed daily routines and habits, shifting the communication nodes from residences and workplaces to individuals and making it possible for a person to be contacted practically everywhere and at any time. Nonetheless, the first mobile systems were somewhat limited at node level. The novelty of the technology was exclusively mobility (and, with the second generation, digital signalling, but the analogical to digital transition did not have an immediate or perceptible impact on users and networks). The nodes were telephones, literally, according to the classic definition: a device that converts sounds into signals that are suitable for electronic transmission, permitting long-distance communication between two or more users. Early mobile personal communication networks (PCNs) were definitely not complex adaptive systems: they lacked many properties frequently associated with complexity, like memory and forgetfulness, signals and cues, positive and negative feedback cycles.

Complex adaptive systems are sets of agents that interact with each other in unpredictable and decentralized ways, while adapting (or learning), individually or collectively, to changes in the environment. From these interactions, patterns emerge which feeds back on the system and informs the behaviour of the agents, as well as the behaviour of the system itself. Since all systems exist within their environment, when the environment changes, the systems adapt. Meanwhile, when they adapt, they change the environment. The process of continuous adaptation to (and with) the environment is one of the fundamental properties of complex adaptive systems and is called coevolution. Furthermore, communication between agents is not always direct: very often, the agents use the environment as a mediator, leaving signs and cues on it than can be detected and interpreted by other agents, stimulating additional actions. This form of indirect coordination between agents is called stigmergy, a term introduced by Pierre-Paul Grassé (Grassé, 1959). Overall, the environment is a fundamental part of complex adaptive systems.

Ecosystems, markets, languages and immune systems are examples of complex adaptive systems in nature and society. In ecosystems, for instance, the agents are organisms interacting via resource exchanges, while the environment is their bounded natural habitat (including species that share the same habitat), where they move and interact. Eusocial insect colonies – like ants, bees, wasps and termites – are a special case of natural species that form a complex adaptive system with their habitat. They are one of the most ecologically successful groups, constituting up to 80% of the total insect biomass on Earth (Hölldobler & Wilson, 1990), and their particular genetic and reproductive properties are the basis of a high level social organization, which includes cooperation, group integration, division of labor, and overlap of generations. These sophisticated features emerge from simpler individual behaviors. Furthermore, they emerge without centralized control or global knowledge on the state of the system. In other words, the complexity of the whole arises from the self-organization of the simple parts.

In order to acquire such level of coordination, eusocial insect colonies require some form of information-sharing between nestmates. Amongst the communication strategies of eusocial insects are stigmergic interactions — in fact, Grassé coined the term to describe the indirect exchange of information in termites. Some species of ants, for instance, communicate with pheromone, a chemical substance that they secrete into the environment. Pheromone, in its turn, attracts other ants, thus promoting swarming behavior and driving the insects towards regions of the habitat with higher gradients of the substance. It is due to pheromone secretion and detection that ants are able to find the shortest paths between foraging sites and the nest.

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