



Tobias Harks, Sebastian Vehlken (eds.)

Nighborhood Technologies

Media and Mathematics of Dynamic Networks

diaphanes

NEIGHBORHOOD TECHNOLOGIES

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MEDIA AND MATHEMATICS OF DYNAMIC NETWORKS

EDITED BY
TOBIAS HARKS AND SEBASTIAN VEHLKEN

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SEBASTIAN VEHLKEN, TOBIAS HARKS

NEIGHBORHOOD TECHNOLOGIES

AN INTRODUCTION

Caught in the middle of a sea of hazy light and a sea of hazy noise, Kate Schechter stood and doubted. All the way out of London to Heathrow she had suffered from doubt. She was not a superstitious person, or even a religious person. She was simply someone who was not at all sure she should be flying to Norway. But she was finding it increasingly easy to believe that God, if there was a God, and if it was remotely possible that any godlike being who could order the disposition of particles at the creation of the Universe would also be interested in directing traffic on the M4, did not want her to fly to Norway either. All the trouble with the tickets, finding a next-door neighbour to look after the cat, then finding the cat so it could be looked after by the next-door neighbour, the sudden leak in the roof, the missing wallet, the weather, the unexpected death of the next-door neighbour, the pregnancy of the cat – it all had the semblance of an orchestrated campaign of obstruction which had begun to assume godlike proportions.

Douglas Adams, *The Long, Dark Tea-Time of the Soul*, p. 2.

1.

When the protagonists of Douglas Adams' novels set off for new adventures, they more often than not are immediately confronted with utterly complex situations. And sometimes – regardless of them being religious or not – they indeed have to assume godlike campaigns behind these events. Even if Kate Schechter's abovementioned attempt to deploy her next-door neighbor as a watchdog for her cat obviously resulted in aggravating complications, contemporary *Neighborhood Technologies* are applied to account for, to control, and to operationalize complex real-life phenomena or social systems in a variety of fields – reaching as far as to the introduction of novel laws of physics in computer simulations (see the articles of Dirk Helbing and Sándor Fekete). These *Neighborhood Technologies* have less to do with social or cultural techniques of building local communities – like greeting the new couple that moved in next door with bread and salt or asking the neighbors to look after one's precious cat or *figus benjamina* while abroad, let alone the unfathomable field of dealing with neighborhood conflicts. Neither do they

primarily allude to architectural or urbanistic concepts of arranging buildings into functioning cityscapes or to describing neighborhoods as a societal unit of community-building. Conversely, the idea for this publication is based on the observation of its editors – one with a background of applied mathematics and computer science, the other in media history and cultural theory – that neighborhoods not only play a substantial role in our respective fields of study. We are also convinced that the transdisciplinary coalescence of a mathematical-computational and a media-historical and -theoretical approach on *Neighborhood Technologies* yields substantial benefits for understanding current attempts to operationalize, describe, experiment with, and theorize complex real-life phenomena.

Whether our contemporary society and culture may be characterized by a mere preoccupation with concepts of space or a predominant fixation on the dynamics of time – with the speculative power of world-wide financial markets and their respective financial tools (e.g., micro-trading) and the increasing penetration of scientific research by computational tools like computer simulations and their implications for a futur-ologic governmental style (e.g., in fields like climate research or *pre-emption*) as only two protruding pillars: The time-critical dynamics of our networked societies are eminently dependent on spacial orderings – be it, just to stick to the above examples, the actual proximity of micro-trading servers to the stock exchange or be it the layout of supercomputing hardware like the placement of chips, cooling systems, and wiring infrastructure. And nevertheless, they can only be studied and understood in a four-dimensional perspective which includes their unpredictable system behavior over time. Oftentimes, these time-critical dynamics can best be analyzed, described, and designed by a topology which is based on local interactions in neighborhoods of similar elements.

On first sight, this observation may sound neither very new nor notably creative: Haven't self-organizing, bottom-up systems of simple elements and their nonlinear interactions been a matter of research in various disciplines at least since the boom of complexity science in the 1980s? And doesn't the mathematical interest in *small-world networks* date back at least to the mid-1990s? Granted, but we believe that an examination of *Neighborhood Technologies* still yields interesting results if it does not stop at analyzing and describing dynamic networks as small worlds or – rather mathematically abstract – self-organizing systems, but takes into focus the application of such a neighborly understanding of network dynamics to real world dynamics. Thus, we are interested in delving into the implementation of (mathematical) neighborhood concepts in operative media technologies and to summon contributions which exemplify the ineluctable transdisciplinary approach that is inherent in such concepts and applica-

tions alike. The publication ventures to conduct this examination not only structurally – that is, with contributions from a variety of fields – but also historically, that is, from a selection of applications which not only demonstrate the immediacy, but also the genealogy of *Neighborhood Technologies*.

One early and guiding example of such an entwined mathematical and media-technological understanding of neighborhoods dates back to the year 1971 when the economist, expert on nuclear strategy and later Nobel laureate Thomas C. Schelling published his research on housing segregation in major US-American cities. With his influential paper on *Dynamic Models of Segregation*, Schelling accomplished more than just contributing to a novel type of social mathematics. His interest in the mechanisms of social segregation and its respective models amalgamated the analysis of actual neighborhood dynamics with a *neighborly* research method: Starting from some basic local – a.k.a. neighborly – micro-relations of a defined number of agents whose actions were executed in accordance with a restricted rule set, Schelling dynamically generated macroscopic segregation patterns. The most striking observation of his dynamic models consisted of the fact that these macroscopic patterns generated novel insights which were not deducible from the microscopic properties. For instance, segregation phenomena in urban environments did not necessarily correlate with political attitudes, but were often simply the effect of individuals choosing to live next to similar neighbors. Henceforward, neighborhoods constituted a new research paradigm in which the complex macro-behaviors of a system and the non-linear dynamics of social collectives were *generatively* and *procedurally* put forth by rigidly defined microscopic neighborhood relations. These were, in Schelling's case, first executed on paper, then on checkerboards, and later by computer simulations on cellular automata. The compelling effect was three-fold: Neighborhoods at the same time became an *object*, a *conceptual principle*, and a *media technology* for understanding the dynamics of complex real-world phenomena – here, of housing segregation. This provided the basis for the contemporary operability of *Neighborhood Technologies*. Today, a large number of media-technological applications take advantage of the intermediate level of locally defined, self-coordinating neighborhoods as a *mesoscopic range* to better understand and control the relationship between the interactions of individual agents and the overall global dynamics of complex phenomena. And their fields of application stretch – among others – from Game Theory to Economics, to Sociology and Biology, to Epidemics and Logistics, and to Robotics or Neurology.

2.

The ambiguity of neighborhoods as a contemporary scientific object and operational application plays an important role in mathematical optimization and algorithmic game theory. In optimization one employs the notion of neighborhoods to define local search methods to efficiently compute good solutions for computationally hard optimization problems. In game theory, neighborhood relations are relevant for both the methodology employed (unilateral deviations of players define a neighborhood and thus natural myopic improvement dynamics can be interpreted as executing a local search algorithm) as well as the actual model under investigation (game theoretical analysis of social networks). These disciplines for their part search for actual objects and systems where neighborhood relations play an important role in order to subject them to mathematical analysis. Their major focus lies on predicting, evaluating and qualitatively assessing the state of an uncontrolled system that is determined by distributed actions of (rationally behaved) individuals based on their available information.

The following research questions reflect the major streams of research in this field: Do the actions of individuals guide the system eventually to a stable state (Equilibrium Existence)? How long does it take to reach a stable state by myopic actions of individuals (Convergence of Learning Processes)? What is the complexity of computing or predicting future states of the system? What is the quality of the system at any point in time with respect to a predefined social objective? To which extent can a designer implement rules of interactions so as to drive the system into a desirable state? How vulnerable or manipulable is a system if a group of individuals (for instance, a flash mob, a Facebook campaign by political parties, spam-mail-clients or viruses) coordinate their actions? Or, how well can simulations help predict the system state over time?

Likewise, for some years a growing interest in neighborhood-induced effects can be discovered in certain strands of media theory and history. Be it – to mention only two examples – the ongoing discourse on *swarm intelligence* and the role of distributed (online) communication networks for socio-political action, be it a media-historical approach to *local-based media* (e.g., GPS navigation) and their influence on a transformation of concepts of space and time. Neighborhoods come to be part of not only a topographical and topological, but also a conceptual transformation. As techno-social groupings based on autonomous local interactions, such dynamized neighborhoods become an influential driving force of (global) mass movements. And at the same time, neighborhoods themselves transform into eminently media-technological arrangements, into a particular time-based form of organizing dynamic networks, remodeled

according to mathematical conceptions of neighborhoods. In this sense, neighborhoods convert from mere geo-spatial and architectural to media-technological phenomena which manifest as the central hub for theorizing and conceptualizing dynamic networks and their socio-political effects.

As a consequence, typical research questions in the cultural and media studies consider the democratic potential and altered hierarchy levels inherent in techno-social networks, and thus the future modes of socio-political participation. They ask about the relation of “pattern and purpose” in collective human behavior, and how the topologies of locally-organized neighborhood technologies differ from precedent forms of network structures. They inquire into the constitution of neighborhoods between human agents and a variety of non-human tools, applications, and things in shared media-technological environments, and they engage with the epistemological status of emergent phenomena and complexity levels which derive from the micro-behaviors in neighborhoods. And not least, they inquire how, in contemporary agent-based computer simulations, neighborly principles develop into a media technology that provides novel potentials to address a wide variety of real-life phenomena from a bottom-up perspective.

The understanding of neighborhoods in a mathematical and a media-technological sense thus are intrinsically entwined. The theoretical considerations of neighborhood effects and various mathematical and game-theoretical models are the basis for media-technological applications which re-structure the explanatory modes of cultural and societal developments and the production modes of actual architectural or digital neighborhoods. These, on the other hand, produce novel demands and challenges for re-structuring and modifying the mathematical tools.

Furthermore, the editors have long believed – even before we started working together on *Neighborhood Technologies* – that a fruitful exchange of ideas between an open-minded, culturally and politically interested mathematician and a media and cultural theorist with a strong affection for media technologies is not only a possible, but a mandatory venture. As soon as one finds a mutual attractor which can serve as an operative bridging of Charles P. Snow’s (in)famous gap between the humanities and the natural sciences into two separate academic cultures, the creative potential that Snow mentions in his text – and against all his emphasis on the separating factors – effectively can be gained. A collaboration under such a mutual gravitational concept then oftentimes generates far more intriguing questions and insights as the respective knee jerks of specialized disciplinary discourses. *Neighborhood Technologies* serves as such an attractor, and it thus can also be read as a concept that initiates novel academic neighborhoods.

3.

It is precisely the aforementioned three-dimensional layering of neighborhoods as object, conceptual principle, and media technology that serves as a heuristic guideline for this edition. Section I: *Neighborhood Epistemologies*, seeks as a first step to particularize the term *Neighborhood Technologies*. Mathematician Tobias Harks (Maastricht) and Computer Scientist Martin Hoefer (Aachen) provide an overview of current concepts, notions and definitions of neighborhoods in mathematics and computer science. Media theorist and historian Sebastian Vehlken (Lüneburg) examines the entwined media history of technical applications that implemented neighborhood concepts in order to generate models and explanatory modes for complex real-life phenomena. Furthermore, he depicts several examples of actual *Neighborhood Technologies* applications. In addition – as a case study on ad-hoc-networked traffic simulation – computer scientist Sándor Fekete (Braunschweig) explores how dynamic neighborhoods of computational agents contribute to a novel epistemology of computer simulation and how these provide an instructive media-technological environment for experimentation with the laws of physics.

The following sections, as a second step – and against the background of these systematic epistemological and historical foundations – expand the transdisciplinary discourse with regard to three fundamental dimensions of *Neighborhood Technologies*. In Section II: *Neighborhood Architectures*, Media and Cultural theorist Christina Vagt (Berlin) looks into the media history of architectural neighborhood planning models – with the works of Buckminster Fuller as its epicenter. In this course, Vagt’s paper also reconstructs the becoming of neighborhoods as malleable, flexible and combinable units that hitherto were employed even to generate simulated world models. Complementary, architect Henriette Bier (Delft) inquires into contemporary digitally-driven architecture. With this she refers to architectural shapes that are not only designed and produced by digital means but are, actually, incorporating digital sensing-actuating mechanisms. These enable buildings to interact with their environment and users in real-time.

In Section III: *Neighborhood Societies*, mathematical sociologist and physicist Dirk Helbing (Zürich) presents a thorough re-conception of economic modeling. Helbing argues that networked decision-making and bottom-up self-regulation will be of growing importance in the face of the increasing complexity of socio-economic systems. In this light, he develops the concept of a *homo socialis* as a counter-model to the conventional *homo oeconomicus*. In an actual computer experiment, systems scientist Manfred Füllsack (Graz) investigates the emergence and probability of cooperation in repeated common-good-games under the influence of different network topologies. His multi-

agent model interprets agents as regularly and precariously employed workers, and the results of his simulations indicate that the conditions supporting the *emergence* of cooperation might be less than optimal for the *maintenance* of cooperation and vice versa. Media historian Sebastian Giessmann (Siegen) traces the remarkable transformation of proximity and distance that took place in the history of credit cards and their mediated neighborhoods. He explores how this highly mobile medium of economic cooperation always depended on enabling infrastructural architectures, which have been – and still are – tied to local territories and sites of exchange.

Section IV: *Neighborhood Interactions*, discusses various forms of building dynamic neighborly relations in socio-technical and performative systems. Whilst media archaeologist Shintaro Miyazaki (Basel) examines the dimension of neighborhood sounding as a mode of organizing information transmission in early distributed communication networks, two articles explore the modes of interaction in swarm-like collectives: Sociologist Carolin Wiedemann (Hamburg) – with a case study on *Anonymous* and the 4chan board – discusses the affective infrastructures of online swarms and asks about the effects of digital collectivity on concepts like emancipation and solidarity. Finally, theater and dance scholar Gabriele Brandstetter (Berlin) – by considering examples from contemporary dance and performance – in her essay contemplates the applied kinaesthetic processes and impulses of control that serve as decisive principles for generating proximity or distance in collective bodies and that guarantee of cohesion in collective movements.

Thus, instead of trying to consistently represent the variety and large spectrum of distributed approaches to dynamic networks – a project which would have been doomed to failure from the beginning – with *Neighborhood Technologies* we installed a core attractor as shown by the contributors to this publication in different ways. Rather than bringing out a more-of-the-same book, we attempted to establish some new names and some extraordinary reading encounters for our respective scientific communities. The volume particularly seeks to provide a partly unfamiliar and novel playground that is meant to encourage further discussions and transdisciplinary thinking. With *Neighborhood Technologies* we want to offer and experiment with an updated *passe-partout* of concrete concepts and case studies of neighborhoods and their transformation from a mere local coexistence to an initiative force for multiple, complex and dynamic relations, actions and behaviors.

