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The Vital Network: An Algorithmic Milieu of Communication and Control

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Abstract
The biological turn in computing has influenced the development of algorithmic control and what I call the vital network: a dynamic, relational, and generative assemblage that is self-organizing in response to the heterogeneity of contemporary network processes, connections, and communication. I discuss this biological turn in computation and control for communication alongside historically significant developments in cybernetics that set out the foundation for the development of self-regulating computer systems. Control is shifting away from models that historically relied on the human-animal model of cognition to govern communication and control, as in early cybernetics and computer science, to a decentred, nonhuman model of control by algorithm for communication and networks. To illustrate the rise of contemporary algorithmic control, I outline a particular example, that of the biologically-inspired routing algorithm known as a 'quorum sensing' algorithm. The increasing expansion of algorithms as a sense-making apparatus is important in the context of social media, but also in the subsystems that coordinate networked flows of information. In that domain, algorithms are not inferring categories of identity, sociality, and practice associated with Internet consumers, rather, these algorithms are designed to act on information flows as they are transmitted along the network. The development of autonomous control realized through the power of the algorithm to monitor, sort, organize, determine, and transmit communication is the form of control emerging as a postscript to Gilles Deleuze's 'postscript on societies of control.'

Keywords
vital network, communication, algorithm, control, Deleuze

Introduction

When Gilles Deleuze contributed his views on the "societies of control" in the 1990s, they were brief reflections on what was coming as technologies of communication and control overwhelmed the disciplinary society; there were, Deleuze said, "new forces knocking on the door".[1] Deleuze gestured toward the general problem of expansive, continuous, digital control, and clearly understood that the "computer that tracks each person's position" signaled a new form of control (and power), which could only be understood through the "study of the mechanisms of control, grasped at their inception."[2] Deleuze understood that control was moving on from brute mechanics and hardware, to software processes imbued with a nonhuman, machinic intellection—control by code, and specifically, by algorithm. Control today is obscure and continuous; its routine is to have no routine. There is no monolithic control; there are only distributed controls tuned to the information and communication flows of the digital network.

What does it mean to examine control at its inception? It might mean interrogating the moment or incept where control starts, at a beginning of some kind, an instance when human subjects make contact with a regulatory apparatus, but it could also point to how we conceive of control itself when so much of our lives are organized through and by communication and networks. How is control *designed* to operate in our communication system? In this article I address the latter question by stepping back from recent scholarly discussion about the power and control of algorithms to shape our media experience and social communication,[3] to interrogate how control itself is being shaped by explicit models of communication drawn from studies of communication in nonhuman organisms. Algorithms are not rare pieces of code within our complex communication ecosystem, they are now prolific and required to monitor, sort,

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[1] Gilles Deleuze, "Postscript on the Societies of Control," *October* 59 (1992): 4; Gilles Deleuze and Antonio Negri, "Control and Becoming: Gilles Deleuze In Conversation with Antonio Negri," translated by M. Joughin. *Futur Anterieur* 1 (1990). http://www.generation-online.org/p/fpdeleuze3.htm

[2] Deleuze, "Postscript," 7.

[3] For discussions on social algorithms, algorithmic culture, and control see Ted Striphas, "Algorithmic Culture," *European Journal of Cultural Studies* 18 (2015): 395-412; John Cheney-Lippold, "A New Algorithmic Identity: Soft Biopolitics and the Modulation of Control," *Theory Culture & Society* 28 (2011): 164-181; Tania Bucher, "Want To Be On the Top? Algorithmic Power and the Threat of Invisibility on Facebook," *New Media and Society* 14 (2012): 1164–1180; Tarleton Gillespie, "The Relevance of Algorithms," In *Media Technologies: Essays on Communication, Materiality, and Society*, ed. Tarleton Gillespie, Pablo Boczkowski, and Kirsten Foot (MIT Press, 2013), 167-194; Daniel Neyland, "On Organizing Algorithms," *Theory Culture & Society* 32 (2014): 1-14.

classify, and filter data across a vast and dense networked world. In what follows, I argue that how we think about control, and how it is designed to function, is shifting from control models that historically relied on the human-animal model of cognition to govern communication and control, first modeled in cybernetics and early computer science, to a decentred, nonhuman model of intellection and algorithmic control over digital systems and networks. It is not as though the human-animal mode of cognition as a model of control does not persist, but it means that the expansion of algorithms as a sense-making apparatus is important not only in the context of social media, such as for Facebook or Google, but also in the subsystems that coordinate the flows of information. In that domain, algorithms are not inferring categories of identity, sociality, and practice associated with internet consumers, rather, these algorithms are designed to act on information flows as they are transmitted along the network.

In this article I will first discuss the biological turn in computing and what it means for the development of algorithmic control and what I call the *vital network*: a dynamic, relational, and generative assemblage that is self-organizing in response to the heterogeneity of contemporary network processes, connections, and communication. I discuss this biological turn in computation and control for communication alongside historically significant developments in cybernetics that set out the foundation for the development of self-regulating computer systems. To illustrate the rise of algorithmic control and the role of biologically-inspired algorithms, I outline a particular form of nonhuman communication and self-organization known as 'quorum sensing.' Taken together, the development of autonomous control realized through the power of the algorithm to sort, organize, determine, and transmit communication is the form of control emerging as a postscript to Deleuze's "societies of control."

A Vital Network

Networks and digital systems are all around us: we connect to them throughout our day, sometimes very consciously, such as when we call another person on our cell phone, or simply in the act of swiping an access card to gain entry to a building. We use applications programmed to run on networks, from those that enable interactive social communications, to those that provide transactions in finance, education, employment, and consumer activities. Communication and information technology and networks feel present through those activities, yet are unseen; we sense them through our media devices such as the cell phone that mediate our network experience alongside software applications such as Facebook or Google, which enable us to interact and to communicate. The network we think we know and experience has become an "Internet of things".[4] Scott Lash argues that this 'Internet of things' is reflective of an era of information intensity defined by information flows carrying all kinds of information such as capital, people, products, genetic codes, and media content circulating in networks governed by a computational logic or sensibility that has become the organizing principle through which more and more of life is converted to information.[5] The computational logic within information flows extends network capacities, but through an increasingly complex form of control, making it difficult to gain insight into the functionality of these opaque control features organizing network processes. For social science, a heterogeneous network that seems to *do* things, that has capacities to *act*, and out of which different material consequences unfold confronts us with a challenge: how might we *see* and understand this new, complex network and its consequences for our social world? How can we uncover its capacities for control, for action and organization, given its propensity for self-regulation obscured beneath the applications we use?

For the most part, when we think about communication technology, we think from our human perspective and about human-centred machines. Computers and communication systems organized through hierarchical control governed by a human logic and enabling human engagement, interaction, and intervention; this was the dominant logic organizing the development of machines, from computers to networks, until very recently. While this organizing logic certainly persists, there is extensive research exploring new models of communication and control that influence the development of self-regulating digital systems and networks and the design of biologically-inspired algorithms (BIAs).[6] In what follows, I examine some of those influences and link the obscurity of control to a shift in the form of control being developed for our increasingly complex digital systems and networked communications—a shift from those human-centred systems to one in which the idea of control is drawn from nonhuman biological systems.

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[4] Kevin Ashton, "That 'Internet of Things' Thing," *RFID Journal* (July, 2009), http://www.rfidjournal.com/articles/view?4986.

[5] Scott Lash, *Critique of Information* (London: Sage, 2002); an earlier and related argument was put forth by Manuel Castells, *The Rise of the Network Society* (Cambridge, MA: Blackwell Publishers, 1996).

[6] C. Zheng and D. C. Sicker, "A Survey on Biologically Inspired Algorithms for Computer Networking," *IEEE Communications Surveys & Tutorials* 15 (2013):1160-1191; S. Binitha and S. Siva Sathya, "A Survey of Bio inspired Optimization Algorithms," *International Journal of Soft Computing and Engineering* 2 (2) (2012), 137-151.

Networks, such as the internet, are comprised of dense information flows with expansive, multi-directional reach that continuously change—and this changeability is what keeps the network active, relative, and vital. I call the form of network exhibiting those dynamic features the *vital network*. This form of network is not simply the outcome of connectivity and communication between diverse affiliative objects and actors such as cell phones and humans that together convey a sense or feeling of 'aliveness'; it is the outcome of deliberate programming goals for algorithms designed for communication systems and inspired by nonhuman, self-organizing biological life. There is a vital quality to the features and capacities of self-organizing systems out of which behaviours emerge as a matter of interaction between machines, programs, processes, and people. Lash, in his critique of information, argues that "[c]ommunication imparts to information a dynamic, a force: a source of energy." [7] This suggests communication is itself a vitalizing force, and increasingly the vital communication properties of nonhuman life provide inspiration and a model of self-organization to underwrite the design of code and processes in new forms of control algorithms, embedding a particular control logic that is more swarm than carefully structured population, and more meshwork than network. [8]

The contemporary interest in vitalism is linked to conceptual shifts in philosophy and social theory that explore the interconnection and inseparability of the human and nonhuman as a means to scale the wall between discursive and material theories of reality and to think beyond linguistic and social construction.[9] This view toward *new materialism* is giving us an opportunity to rethink "the whole edifice of modern ontology regarding notions of change, causality, agency, time, and space," and to locate new "capacities for agency" that are not exclusively human:

For materiality is always something more than 'mere' matter: an

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7 Lash, *Critique,* 204.

8 There is much critical discussion of control, networks, politics, and culture in the work of Tiziana Terranova, *Network Culture: Politics for the Information Age* (London and New York: Pluto Press, 2004); Alexander Galloway, *Protocol: How Control Exists after Decentralization* (Cambridge, MA: MIT Press, 2004); and, Alexander Galloway and Eugene Thacker, *The Exploit: A Theory of Networks.* (Minneapolis, MN: University of Minnesota Press, 2007).

9 Jeremy Packer and Stephen Crofts Wiley, "Introduction: The Materiality of Communication" in *Communication Matters: Materialist Approaches to Media, Mobility and Networks,* eds. J. Packer and S. Crofts Wiley (London and New York: Routledge, 2012); see Susan Hekman's important work on this shift or turn in *The Material of Knowledge: Feminist Disclosures* (Bloomington: Indiana University Press, 2010).

> excess, force, vitality, relationality, or difference that renders matter active, self-creative, productive, unpredictable. In sum, new materialists are rediscovering a materiality that materializes, evincing immanent modes of self-transformation that compel us to think of causation in far more complex terms.[10]

The processes of self-organization in what I call the vital network are not direct, solitary causal forces that always create a dramatic or forceful reorganization of the network, but part of an apparatus of control expressed more subtly. This vitality does not turn on one single communicative transaction, but on the millions of transactions occurring in a continuous flow within and across our contemporary networks. These transactions produce a differentiated communicative milieu as an assemblage that is ever-changing, not because some *one* or some *thing* decides it will be different, but because the flows of information, of communication, taken together produce material changes in the network in a self-organizing manner.

John Johnston, in his comprehensive genealogy of artificial life, argues the life that manifests in contemporary complex systems and networks is a mélange of machines (computers), programs, and processes that produce a vital, self-organizing system that he calls "machinic life."[11] The system may be a software program, or an algorithm that has a particular function such as searching for information, or it may be a physical robot that performs a simple task, and Johnston suggests any system that can operate without centralized control and self-organize, mirroring the purposeful action of organic life, is a "liminal machine" hovering on the boundary between the living and non-living producing machinic life.[12] This idea turns on the now classic notion of synthetic vitality captured by Christopher Langton's conception of artificial life in which "to animate machines … is not to 'bring' life to *a* machine; rather it is to organize a population of machines in such a way that their interactive dynamics is 'alive.'"[13] Any machinic vitality in this context emerges out of the interaction of many entities without central coordination.

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[10] Diana Coole and Samantha Frost, "Introducing the New Materialisms," in *New Materialisms: Ontology, Agency, and Politics*, eds. Diana Coole and Samantha Frost (Durham, NC: Duke University Press, 2010), 9.

[11] John Johnston, *The Allure of Machinic Life: Cybernetics, Artificial Life, and the New AI*, (Cambridge, MA and London, UK: The MIT Press, 2008), ix.

[12] Johnston, *Machinic Life*, 1-2; This owes a great deal to Donna Haraway's foundational work in her essay, "The Cyborg Manifesto," in *The Haraway Reader* (New York and London: Routledge, 2004).

[13] Christopher Langton, "Artificial Life," in *Artificial Life: SFI Studies in the Sciences of Complexity*. ed. C. Langton (Boston: Addison-Wesley Publishing Company, 1988), 5.

The very concept of a digital network—of what a network is—has thus shifted in recent years; away from the notion of a specific grid of connections such as the internet, or a phone network, to the network as a "hypernetwork, a meshwork potentially connecting every point to every other point."[14] What we experience through our connected devices and online practices as a contiguous and seamless internet, is a more complex thing; it is a heterogeneous milieu of objects and processes constituting many networks and sub-networks in a communicative assemblage. The hypernetwork extends Manuel Castells' view of the late twentieth and early twenty-first century period as a "network society" in which the "power of flows takes precedence over the flows of power."[15] The computational logic behind information flows works through an increasingly complex form of control that is opaque and complex, enabled, more often than not, by algorithms. The flows Castells refers to are the streams of data, of information, that circulate on global informatic networks gathered from millions of collection points, human and nonhuman, object and enterprise. The 'hypernetwork' intensifies the local to global connections furnished by telecommunication (and internet) service providers, enabling its commercial and consumer subscribers to connect to the network through a variety of digital devices—from cell phones to computers to a vehicle's onboard computer. The result is a meshwork of people and communicative practices, of data, devices, networks, and software requiring seamless control to coordinate the information flows and network processes. Contemporary information flows require robust processes of control to ensure their continuous circulation on global networks and Terranova argues that a biological turn in computing is a response to the growing multitude of people, processes, information, and parts of networks that must be able to exercise control from within and between the flows and their waypoints on the network.

Algorithmic Control Inspired by Life

The concept for machines that are self-regulating, or autonomous, has been a central preoccupation within computer science and engineering throughout the last 80 or more years, and it is connected to the idea that systems of organization in nature can provide inspiration for human social, political, and technological organization.[16] The current interest in self-regulation maintains at least one

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[14] Terranova, *Network Culture*, 41.
[15] Castells, *Network Society*, 469.
[16] Jussi Parikka, *Insect Media: An Archaeology of Animals and Technology* (Minneapolis and London: University of Minnesota Press, 2010), ix, xiii-xv; and see for related Diane M. Rodgers, *Debugging the Link Between Social Theory and Social Insects* (Baton Rouge, LA: Louisiana State University Press, 2008).

original assumption of mid-twentieth century investigation into what Norbert Wiener viewed as the scientific study of, as his book was titled, *Cybernetics, Or Control and Communication in the Animal and the Machine*, in that "some aspect of a living organism's behaviour can be accounted for [and] modeled by a machine."[17] For cyberneticians, vitality is reproduced in and through information processing; it literally becomes the replication of code to mimic self-regulation in nature that instantiates the philosophically vexing idea that life is information and information is life.[18] The centralized control systems required for those earlier cybernetic machines were inflexible structures—they required considerable physical electric circuitry and careful programming to enable self-regulation. Controls for analog systems and networks were mechanical, structural, and institutional, organized hierarchically to interface with and between humans and machines. Its goals were human-centric and humans were positioned to intervene in an exercise of control over machines that functioned to extend human capability and productivity.[19] I argue that at this moment, control is shifting away from that model of control toward one which is more likely to be digital and nonhierarchical and about *processes* distributed across networks of heterogeneous entities and the human does not necessarily reside in the centre of this new apparatus of control.

The first era or wave of cybernetics, noted above, launched what would become a long project in the artificial sciences exploring human-like intelligence, and set out foundational mathematical logic and algorithmic expressions crucial for modern computing, communication systems, and computer networking. But Wiener and his contemporaries went farther than this initiation into communication as a science and engineering discipline—their work heralded a new era of research, which would trouble the organism-machine divide suggesting that "the newer study of automata, whether in the metal or in the flesh, is a branch of communication engineering" that encompasses "computing machines and the [animal] nervous system."[20] Wiener imagined machinic systems that were dynamic, autonomous and self-regulating and his work was a part of the intensive development of communication and information theory that emerged out of the research of Warren Weaver, John Von Neumann, Warren McCulloch, Claude Shannon, R.V. Hartley, Alan Turing, and others, from the 1930s through

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[17] Norbert Wiener, Cybernetics: Or, Control and Communication in the Animal and the Machine (New York: MIT Press, 1961); Johnston, Machinic Life, 31.

[18] Stefan Helmreich, *Silicon Second Nature: Culturing Artificial Life in a Digital World* (Berkeley and London: University of California Press, 2000); Striphas, "Algorithmic Culture."

[19] Lash, *Critique*.

[20] Wiener, *Cybernetics*, 42.

to the 1950s and beyond, contributing to the foundation of computational systems arising in the twentieth century.[21]

Sherry Turkle has recently pointed to the importance of "evocative objects" that serve as "provocations to thought" and problem solving across disciplines in science and technology.[22] For many researchers in Wiener's era, the human-animal brain served as the object around which to think about autonomous systems and cognition. Social insects have also served many scientists and social scientists as evocative objects. Ants, as biological inspiration, are pivotal in the solution to human logistical and computational problems through the ant colony optimization algorithm; and social insects have expanded our understanding of self-organization in large populations that exhibit collective swarm intelligence.[23,24] In recent work, Jussi Parikka examines social insects as a way to approach media theory, noting that these nonhumans reveal "a whole new world of sensations, perceptions, movements, stratagems, and patterns of organization," which lead to a "non-discursive media construction" reflecting the coupling of insect behaviour, such as swarming, with media technologies.[25] Parikka explores how social insects became entwined within technological discourses, standing as inspiration for, among other things, software agents and web spiders, which are search-capable programs (algorithms) that run on the internet. Parikka has also explored computer viruses and aspects of viral and digital contagion within digital culture more broadly to open up our horizons in thinking about networks.[26]

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[21] Katherine N. Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago, IL: University of Chicago Press, 1999); see also Helmreich, *Silicon Second Nature*; Johnston, *Machinic Life*.

[22] Sherry Turkle, *Evocative Objects: Things We Think With* (Cambridge, MA and London, UK: The MIT Press, 2007), 5.

[23] Marco Dorigo and Thomas Stützle, *Ant Colony Optimization* (Cambridge, MA: MIT Press, 2004); See also Bert Hölldobler and E. O. Wilson, *The Ants* (Cambridge, MA: Harvard University Press, 1990); Deborah Gordon, *Ants at Work: How an Insect Society is Organized* (New York: W.W. Norton, 2000); Deborah Gordon, "Control Without Hierarchy," *Nature* 4468 (2007): 143; and Charlotte Sleigh, *Six Legs Better: A Cultural History of Myrmecology* (Baltimore: Johns Hopkins University Press, 2007).

[24] Scott Camazine, et al., define swarming as a self-organizing collective behaviour based in the local interactions of the many to induce a particular behaviour or action in the population as a whole, in *Self-organization in Biological Systems* (New Jersey: Princeton University Press, 2001).

[25] Jussi Parikka, *Insect Media*, ix, xiii-xv.

[26] Jussi Parikka, *Digital Contagions: A Media Archaeology of Computer Viruses* (New York: Peter Lang, 2007); Jussi Parikka and Tony D Sampson, *The Spam Book: On Viruses, Porn, and Other Anomalies from the Dark Side of Digital Culture*. (Cresskill: Hampton Press, 2009).

The foregoing examples are intriguing in that they propose a model of control that is decidedly nonhuman and decentralized and vital and dynamic. However, following the example of social insects and viral contagion, as metaphors for social, political, and technological organization, microbes, such as bacteria, have proven similarly inspirational to scientists examining nonhuman self-organization and communication in life systems. These organisms show us how large populations self-organize without a centralized form of control or central cognition apparatus.[27] For example, there has been considerable research in microbiology on bacterial communication and in particular around the process known as *quorum sensing.*[28] Quorum sensing occurs at high cell population densities and is a mode of cell-to-cell communication that offers a sort of census-taking from which the bacterial colony can determine aggregate cell numbers and, after a "voting exercise," coordinate activities to permit the bacteria to synchronize global behaviours.[29] Quorum sensing has emerged as one model for computer scientists designing different types of networks in which individual units must operate as a "symmetric, cooperative and self-organising" global entity.[30] Algorithms modeled on bacterial communication systems are thus considered survivability-related routing algorithms by technologists because they demonstrate adaptation to changing conditions across a network much like their biological antecedents.[31] These algorithms provide a dynamic response that is not programmed to react in one particular way to a network or system failure, but to respond in a multiplicity of ways triggered by a set of conditions and the

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[27] Research on microbial self-organization follows the ground-breaking work of Evelyn Fox Keller and Lee Segal on slime mold aggregation ("Initiation of Slime Mold Aggregation Viewed as an Instability," *Journal of Theoretical Biology* 26 (1970): 399-415).

[28] Bonnie Bassler, "Small Talk: Cell-to-Cell Communication in Bacteria," *Cell* 109 (2002): 421-424; Stephen Diggle, et al. "Communication in Bacteria," in *Sociobiology of Communication*, ed. Patrizia d'Ettore and David Hughes (New York: Oxford University Press, 2008), 11-31; Anthony Brabazon, Michael O'Neill, and Seán McGarraghy, *Natural Computing Algorithms* (Berlin and Heidelberg: Springer-Verlag, 2015).

[29] Ian Joint, J. Allan Downie, and Paul Williams, "Bacterial Conversations: Talking, Listening and Eavesdropping," *Philosophical Transactions of the Royal Society B: Biological Sciences* 362 (2007): 1115.

[30] L. Sacks et al., "The Development of a Robust, Autonomous Sensor Network Platform for Environmental Monitoring," (Paper presented at the Proceedings of XII Conference on Sensors and Their Applications, Limerick, Ireland 2003), 1.

[31] Sacks et al., "Sensor Network"; Balasubramaniam, Sasitharan, et al., "Policy-constrained Bio-inspired Processes for Autonomic Route Management," *Computer Networks: The International Journal of Computer and Telecommunications Networking* 53 (2009).

behaviour of nearby network nodes and servers to monitor and maintain quality of service (QoS). Biologically inspired algorithms are *isomorphic* to the organism, but never re/produce identical behaviour because the control algorithms are coded to mimic only the rules for interacting with the digital environment and information flows (rules extending from the model), and respond dynamically and uniquely to the problems within the digital environment.

One specific example of a biologically inspired algorithm is proposed for a multimedia routing algorithm.[32] In this example, the algorithm is designed to check for spare capacity on the network automatically when a computer server (or network node) elsewhere on the network fails. The algorithm is coded to treat multimedia data preferentially as it reroutes data away from the broken network node or server. The goal here is to keep the multi-media data flowing dynamically because often internet service providers (ISPs) set higher carriage fees for customers accessing this content, so the algorithm is coded to drop voice and other data that does not provide the same revenue to the ISP. At some pre-set data capacity, the network will resume transmitting other data flows. When data is re-routed, the failed network server will self-repair and signal its local networked neighbours when it is ready to receive and transmit data.[33] This is a fascinating example of where algorithms of control run as data coordination and prioritization processes that filter flows of data, rather than as processes for social sorting, linking, search, and so on, at the level of software applications for human users such as Google and Facebook.

The multimedia routing algorithm is but one example of a network control process, yet it includes functionality not only to redirect data flows away from problem points on the network, but to differentiate the streams of data and selectively process one form over another (e.g. media over voice). This type of control algorithm is designed to be submerged beneath the application and content layers of the internet and to operate autonomously without direct human intervention. These algorithms are nontransparent and obscure, and their distributed mode of control means the algorithm may execute its decision-making routine quite differently between one event and the next. Algorithms blur the distinction between the straightforward routing or carriage of information and content on networks at the level of infrastructure. In the multimedia routing algorithm example, algorithmic processes are coded to be able to interact with the existing transmission protocols for networks while at the same time exercising a decision-making routine linked to the form of communication (voice, data, or multimedia) and available network capacity or bandwidth. While there are business reasons for these distinctions, it does suggest that the hoped for

[32] Balasubramaniam et al., “Policy-constrained Bio-inspired,” 1666.
[33] Balasubramaniam et al., “Policy-constrained Bio-inspired.”

neutrality or indifference of the control code to content on the internet can be compromised at a deep level. Research in this area rarely makes it into policy debates about network neutrality and quality of service in spite of the fact that bio-inspired strategies such as quorum sensing continue to influence research into control algorithms for large, complex networks and systems of all kinds.[34]

Control within the vital network is designed to be autonomous and self-regulating ostensibly to enhance the human client experience on networks and enable seamless integration between heterogeneous machines and networks. This objective, however, ensures contemporary digital systems and networks achieve the goal of hidden complexity by submerging the complex machine code of control deep in the system to minimize human contact with it.[35] Autonomy and obscurity are programmed together so that digital control processes function "without the direct intervention of humans or others, and have some kind of control over their [own] actions and internal state".[36] What emerges is a vital network with capacities and tendencies that are not simply mimicking a biological organism, but by simulating its behaviour a wholly new assemblage emerges with features of control and self-organization that are isomorphic to the organism, such as signaling near network nodes or neighbours, counting or calculating available nodes or servers in the network, and altering network behaviour based on the active nodes on the network. The critical issue is in the distancing effect this complexity produces. Having sight into this algorithmic milieu is crucial in terms of the social and political implications of transparency and information flows because if we neither see nor understand control within the vital network, it complicates any effort to maintain transparency about what constitutes our networks, how they work, and what the content of information flows do in life. Laura DeNardis argues that "arrangements of technical architecture are inherently

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[34] Further examples can be found in Brabazon et al., *Natural Computing Algorithms;* G.H. Ekbatanifard et al., "Queen-MAC: A Quorum-based Energy-efficient Medium Access Control Protocol for Wireless Sensor Networks," *Computer Networks* 56 (2012): 2221–2236; Sasitharan Balasubramaniam et al., "Biological Principles for Future Internet Architecture Design," *IEEE Communications Magazine* (July 2011); and in R. Vogt, J. Aycock, and M. Jacobson, "Quorum Sensing and Self-Stopping Worms." WORM'07, November 2007, Alexandria, VA.

[35] Marcus Huebscher and Julie McCann, "A Survey of Autonomic Computing—Degrees, Models, and Applications," *ACM Computing Surveys* 40 (2008); cf. Michael Woolridge and Nicholas Jennings, "Intelligent Agents: Theory and Practice," *Knowledge Engineering Review* 10 (1995): 115–152; In much of the research into autonomic computing and artificial intelligence, algorithms are consistently anthropomorphized and ascribed tendencies and capacities of the human: they *learn*, *adapt*, *decide*, *filter*, *affect*, *link*, *preempt*, *predict*, and they *control*.

[36] Huebscher and McCann, "Intelligent Agents," 5.

arrangements of power" and embed particular social, political, and economic interests at the level of network infrastructure, which can be directed to control not just information flows as a matter of coordination, but govern content and communicative expression as well.[37]

Control After Deleuze

Deleuze reminds us that contemporary control is ceaseless, continual, unbounded, and modulating according to the heterogeneous exigencies of networks.[38] Control for communication is often an event outside of or beyond human-computer client applications: the matrix of control and communication, while initially programmed by humans, increasingly takes a form that actualizes fundamental principles of biological life to be self-organizing, whereby purposeful action on the network emerges in response to all the traffic in communication. Algorithms reshape control as a series of "generative rules" that are "compressed and hidden," acting in response to the dynamic information flows.[39] The communication processes and information flows are always in flux, always responding to how human clients of networks and other connected machines and systems interact with the network—control *emerges* within that dynamic environment. Control is directing but not directed, and it is unpredictable and often full of unintended consequences.[40] This is why we can no longer describe control as control *over* communication, or as hierarchical control poised above; rather, algorithmic control is increasingly designed as code running within and through the network.

Control does not have to be centrally situated on a designated server at one data centre; it can be distributed across the network as a modulating force emergent within the transactions and communication processes of a heterogeneous assemblage. Control processes monitor information flows, detect network capacity, and modify transmission routes based on a quorum of communicating objects and processes. It is, as Deleuze and Guattari describe it, an abstract machine that does not have "invariable or obligatory rules, but

[37] Laura DeNardis, "Hidden Levers of Internet Control: An Infrastructure-based Theory of Internet Governance," *Information, Communication & Society* 15 (2012): 734. And see for related discussion, Frank Pasquale, *The Black Box Society: The Secret Algorithms that Control Money and Information* (Cambridge, MA and London, UK: Harvard University Press, 2015); Internet routing protocols and related technical standards are fairly well documented, and see Galloway, *Protocol*, on this point.
[38] Deleuze and Negri, "Control and Becoming"; See for related, Deleuze, "Postscript."
[39] Scott Lash, "Power after Hegemony: Cultural Studies in Mutation?" *Theory, Culture & Society* 24 (2007): 71.
[40] Lash, "Power after Hegemony."

optional rules that ceaselessly vary with the variation itself."[41] A new algorithmic control produced through the actions and doings of the network is an "abstract machine of soft control—a diagram of power that takes as its operational field the productive capacities of the hyperconnected many."[42] Control has expanded its reach while at the same time softened its routine through self-governing processes of control that congeal in this new abstract machine. The abstract machine targets assemblages comprised of machines, processes, networks, institutions, information, and individuals. In the vital network, the algorithm, such as the quorum-sensing algorithm in the example above, deterritorializes; it draws the assemblage (the network) along a vector, creating a new arrangement of forces. This new arrangement solidifies into a temporary arrangement until the next modulation or adjustment by the algorithms of control gives it a tweak in a new direction.

This, it seems to me, is well beyond what Deleuze conceived in his reflection on "societies of control." In that work, Deleuze did what many social analysts do: he thought about the surface arrangements of contemporary software applications and the direct forms of control human clients encounter through processes such as account logins and password access to protected content, networks, and systems. For Deleuze the emphasis in control societies remained on the access/no access control binary, the password-enabled, cybernetic logic defining who or what is in or out, there or not there, seen or not seen on the network's surface (the application and content layer of the internet). Yet, in spite of the suggestion of specific control in his designation for a new form of society, Deleuze barely hints at what that control is, or what is required of/from control in contemporary digital systems and networks. Deleuze alludes to codes of information and control as "numerical language," presumably computational logics such as algorithms, but he never details the codes (software) that provide the control features and capabilities, the "programming and activation," of contemporary networks and digital systems.[43]

Writing in the 1990s, Deleuze offered tantalizing hints about the role of control in late twentieth century life. In his 1990 interview with Antonio Negri, Deleuze refers to "control or communication societies" as those that "no longer

[41] Gilles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, translated by Brian Massumi (Minneapolis, MN: University of Minnesota Press, 1987), 100.
[42] Terranova, *Network Culture,* 100; and see Cheney-Lippold, "New Algorithmic Identity."
[43] William Bogard, "Deleuze and Machines: A Politics of Technology?" in *Deleuze and New Technology*, ed. Mark Poster and David Savat, (Edinburgh: Edinburgh University Press, 2009), 19.

operate by confining people but through continuous control and instant communication" dominated by cybernetic machines and computers that enable continuous monitoring.[44] In 1992, in the English translation of an original article that appeared in 1990 in *L'autre jounal*, Deleuze explained the control society more lucidly; control is numerical, modulating, transmutable and continuous, yet this "postscript on societies of control" did not bring the concept of either control or communication into dialogue with other aspects of his philosophical program in any detail.[45] In the case of control, Deleuze understood it as code that would "mark access to information, or reject it," but he was silent on the matter of communication itself in this context.[46] At other points in his philosophy, communication is clearly important yet not clearly defined. It conveys temporalization and movement; it feels vital and lively. Communication is sometimes *relay* or *circulation* occurring between or among processes, events, and becomings; or a *resonance* between orders, for example between a population and an individual; at other times it is an alliance, or fully a mode of communication suggestive of some form of exchange within a decentred network assemblage.[47] Communication, as a concept, is adrift in Deleuze's cosmology, yet entangled with processes of becoming—the processes of change, of difference, as a force or vector, that directs or shapes the becoming of the real. The more transversal the communication's movement or relays, or the more it cuts across networks, environments, individuals, or institutions, the more acute its effects.

While Deleuze's use of communication is never precise or definitive, it is nevertheless suggestive of flows, of circuits, and of a movement of forces that carry or convey potentials, possibilities, and creative affects. Lash has suggested that "communication and perhaps no longer the 'social act' [has] become the contemporary unit of analysis," meaning "in the information order, the social relation is displaced by the communication."[48] Specifically, Lash understands communication as an organizing feature of contemporary life for what he calls a "communications order," which privileges information flows and networks over the social and symbolic order.[49] The communications order includes the technical processes that enable transmission of information between points or nodes on a network that consists today of many interconnecting circuits and paths, coordinating communication between and among humans and machines.

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[44] Deleuze and Negri, "Control and Becoming," 4.
[45] Deleuze, "Postscript."
[46] Deleuze, "Postscript," 5.
[47] Gilles Deleuze, *The Fold: Leibniz and the Baroque* (New York and London: Continuum, 2006), 111, 154; Deleuze and Guattari, *Thousand Plateaus,* 108.
[48] Lash, *Critique*, 206.
[49] Lash, *Critique*, xii.

From Deleuze's perspective, control operates on the boundary between the human and machine. I would agree, but go even further to suggest this boundary is operational at a deep level that is, as I discuss above, more obscure and nontransparent. This boundary disturbance between human and machine is part of the blurring between biological life and machinic life consonant with cybernetics' original goal to create self-regulating machines in the image of human-animal cognition and control following the life as information and information as life equation.[50] The complication is in the new model of biologically-inspired algorithmic control, which is increasingly the foundation for a decentered and self-regulating control. Algorithmic control processes do things; they can act, they induce state changes in systems, and intervene in informational flows and other network processes. They evince "agential intra-actions," as Karen Barad claims, and "specific causal material enactments that may or may not involve humans'' and so it is that machinic processes that exercise control within networks can be agential.[51]

An Algorithmic Milieu: Opening to the Unexpected

Algorithmic control suggests a very different paradigm of control, which shifts how networks are and will be organized. Whereas the control society contends with fast, powerful computer processors and passwords, the vital network contends with increasing complexity and an assemblage of selves, human and nonhuman, through so-called *smart*, self-capable algorithms. Thus, where the control society contemplates the recurrent and endless modulation of codes allowing or denying access to information and virtual or cyberspaces, a vital network attends to networks of relation and a multiplicity of being across a panoply of autonomous systems.

The logic of a vital network, therefore, extends Deleuze's apparatus of open and continuous control through the enabling of algorithmic control. Agential forces are immanent in the vital network—continuously *at work* in the code. This nonhuman control enables digital systems and networks to act autonomously, to do things following coded processes that are capable of emergent behaviour with unanticipated consequences. It is, as Wendy Chun observes, a fundamentally ambiguous programming: "our computers execute in unforeseen ways, [and] the future opens to the unexpected."[52] Paradoxically, while algorithmic control

[50] Johnston, *Machinic Life*, 106; An idea clearly troubled in Donna Haraway's 'cyborg manifesto' and later work and see, *The Haraway Reader*.

[51] Karen Barad, "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter," *Signs: Journal of Women in Culture and Society* 28 (2003): 817.

[52] Wendy H.K. Chun, *Programmed Visions: Software and Memory* (Cambridge, MA and London, UK: The MIT Press, 2011), 9.

processes organize our communicative lives, shape network traffic, monitor us, learn about us, identify and locate us, we remain fundamentally ignorant of algorithmic capacities, tendencies, and power. Capacities make network assemblages (as wholes) exhibit aspects of their identity that were previously hidden.[53] For instance, when control algorithms respond to changing network conditions and act autonomously to alter the information flows. Human clients on the network cannot see the submerged, agential, autonomous capacity for control, but we feel its effect. Our internet is slow, our email is bounced back to us, our cell phone connects automatically, or our car 'knows' where it is before we do. We are organized by the logic of those devices and processes, coordinating, in turn, our human actions and choices. Our dependence on technical networks and devices for critical social, political, economic, and technological transactions is re-organizing around a profoundly nonhuman model that pivots on this organismal (biologically-inspired) vital communication. These tendencies and capacities depart radically from centralized control and forms of machine intelligence and decision-making that followed the human-animal logic.

This departure, from a rational, hierarchical logic familiar within traditional models of control, suggests that the vital network is a radical shift in the conception of network and control, rather than a new form of social organization to replace or overwrite the societies of control. The vital network is not descriptive of an era, a period, or a cultural moment. Whereas centralized network configurations have a stable orientation well understood by humans, that is, networks as structures with points and lines linked together set out in a predetermined arrangement, the vital network is dynamic and distributed, following biological forms, vital communication processes, and self-organization. The resulting meshwork is an ever-changing hyper-connected swarm, a process and event-driven topology of connections oriented to dynamically occurring self-organization that does not easily translate to the human-computer organizational model. The form of control is no longer about structure, but about *process* and the mode of control is *algorithmic*. This shift in the form and mode of control is an expression of "power through the algorithm" and power "in the algorithm."[54] This produces an organizational logic that is diffuse and self-regulating, emerging dynamically along communication circuits that manifest tendencies for emergence while exercising capacities for algorithmic control that are immanent within a vital, dynamic, ceaselessly changing, network assemblage.

Algorithms of control and dynamic self-organization enable our networked participatory culture and interactivity on the internet and across our

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[53] Manuel De Landa, *Philosophy and Simulation: The Emergence of Synthetic Reason* (London and New York: Continuum, 2011).

[54] Lash, "Power after Hegemony," 71.

communication systems, enhancing mobility, connectivity, and reliability. Social media, online banking, travel bookings, and streaming media would not function without them. Biologically inspired algorithms make Google search perform as it does, park our cars, improve automotive safety, enhance flight controls, and coordinate logistical systems for shipping companies. So-called *smart* algorithms sift through big data repositories, making sense of everything from weather patterns and climate change to celebrity news and traffic patterns. We can appreciate the opportunities and affordances that come with the advanced logics of algorithmic control, but we can also locate problems, risks, anxieties, and ethical concerns that require critical scrutiny. Deleuze, in conversation with Negri, suggested, "Our ability to resist control, or our submission to it, has to be assessed at the level of our every move."[55] I agree; and as researchers, we must be able to track control itself and to do that we need to understand it and find ways to make processes of control visible.

The radical re-ordering of communication and networks through algorithmic control often works uninterrupted and unseen within the network, and introduces a new class of problems affecting accountability, responsibility, liability, network neutrality, privacy, profiling, surveillance, and more. Control operating as autonomous processes modeled after self-regulating biological life systems is decidedly nonhuman; these systems are not mimicking the human, not enacting human-like decision-making, yet have material consequences for humans. This algorithmic logic is sorting, classifying and ranking the social field, whether through marketing segmentation based on collected personal data or wireless or online monitoring conducted by a security establishment.[56] It instantiates "algorithmic normativity," normalizing the rational calculus of analytical machines that survey more of life's activity, transactions, and communication, so that control by algorithm becomes an ordinary consequence or feature of network life;[57] a commonplace machinic sense-making that humans accept as part of their experience on the network. As these processes gain in

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[55] Deleuze and Negri, "Control and Becoming," 5.

[56] Bucher, "Want To Be On the Top?, 1166; David Lyon, *The Electronic Eye: The Rise of Surveillance Society*, (Minneapolis: University of Minnesota Press, 1994); David Lyon, "Everyday Surveillance: Personal Data and Social Classifications," *Information, Communication & Society* 5 (2002): 242–257.

[57] Annette Rouvroy, "Epilogue: Technological Mediation, and Human Agency as Recalcitrance," in *Law, Human Agency and Autonomic Computing: The Philosophy of Law Meets the Philosophy of Technology*, eds. Mireille Hildebrandt and Annette Rouvroy, (New York: Routledge, 2011), 221; Pasquale details the problematic aspects of incomprehensible algorithms at work in business and the 'black-boxing' of algorithms used in finance, search, and ultimately, in reputational contexts, in *The Black Box Society*.

complexity and obscurity, individual and collective surveillance expands; resulting in greatly diminished personal privacy, autonomy, choice, personal information security, and more.

The foregoing analysis exposed a widening gap between our experience as human clients of the network and the codes of control that direct and govern our communications. There has always been a gap between what the non-technical layperson knows about an advanced technology and the complex apparatus within the black box, and a relief people feel that it *just works* without needing to know how. For most of us, this defines our relationship to our laptops and cell phones—we do not know in detail how they work, but we are very pleased that they do. In the case of the vital network as a domain of communication, we can appreciate its liveliness, temporality, and convenience. However, the distancing effect, the gap between us as clients of a system and the features of control that organize it, has been amplified by algorithmic processes of control that remain muted and obscure, while at the same time resilient and continuous. The distancing effect pushes the human user away from the subterranean complexity of communication and control at the same time as a "deepened intimacy, a more intricate mesh" between humans and technology becomes more durable at the point of direct human-computer interaction.[58] This is a result of the distribution of control within the subnets and sub-layers of the internet: it suggests an exclusionary domain of control exercised through layers, levels, and classes of access and visibility whereby individuals make conscious contact with this structure only fleetingly at the surface of the internet, through applications that provide an interface for social communication and transactional services. We can never be certain of the network's efficacy, its actual power, its tendencies and capacities, but rather than a neutral infrastructure that merely coordinates and transmits communication, algorithmic control is *decisive* and *agential* from the surface of the net all the way down to the pipework.

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[58] Bruno Latour, *Pandora's Hope: Essays on the Reality of Science* (Cambridge, MA and London, UK: Harvard University Press, 1999), 196.

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