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## Scalar entanglement in digital media ecologies

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### Introduction

Media ecology presents an emergent, non-representational approach towards the study of media systems. This article seeks to extend the theoretical underpinnings of media ecology by introducing the concept of scale – or more precisely scalar entanglement – as a way by which media ecology can usefully engage with a range of ethical and political issues. By positing content, software, and hardware as three entangled scales akin to the conceptual approach of the three ecologies of mind, society, and environment posited by Gregory Bateson and subsequently adopted and expanded by Felix Guattari, this article argues that a triadic schemata which encourages transversal thinking across and between these relational scales can allow media studies to approach a multiplicity of the ethical and political issues surrounding mediation; this ranges from traditional concerns surrounding representation and privacy to less familiar issues, such as the ecological costs of extracting ores for manufacturing devices or the ecological legacies of the toxic substances associated with media hardware.

This essay begins with an outline of central issues surrounding the emergent discourse of media ecology and its differentiation from the North American tradition with which it shares a name before considering various divergent genealogies of the term ‘scale’ and its deployments within cartography, geology, geography, and ecology, in order to develop how notions surrounding scalar entanglement can be usefully developed within media ecology. This theoretical perspective is subsequently deployed in two brief

case studies: analysing the multiscalar ethical concerns which exist within and are explicitly addressed by the game *Phone Story* and also the open source hardware project *Open Source Ecology*. The article concludes by considering the ways in which the case studies support a thesis of entangled scales as a means of exploring materialist concerns within media, departing from traditional media studies scholarship which has focused upon discursive and representational tropes without resorting to a discourse/materiality dualism which posits content and hardware as separate spheres.

## Divergent traditions of media ecology

The terms ‘media ecology’ and ‘media ecologies’ are primarily used in two divergent ways in differing areas of media scholarship, with one appropriation of the term originating in the works of Marshall McLuhan and Neil Postman and a second employing methods derived from new (or speculative) materialism and non-representational theory exemplified by the work of Matthew Fuller<sup>1</sup> and Jussi Parikka. While the term ‘ecology’ is commonly used as an alternative way of saying ‘environment’ or denoting environmental concern its etymology derives from the Greek term *oikos*, meaning ‘household’. Ecology comprises the study of patterns of interconnection, interaction, and transferences of energy between agents involved in complex networks featuring living and non-living nodes, exploring how different parts of the global household relate to one another. While ‘environment’ evokes a ‘natural’ exterior outside of human systems ‘ecology’ makes no such distinction between human and nonhuman, living and non-living nodes, and consequently has utility in connecting humans both to the nonhuman ecosystems which we are dependent upon and the technological systems which underpin social organisations and mediated communications. As Fuller states, ‘the term “ecology”...is one of the most expressive language currently has to indicate the massive and dynamic interrelation of processes and objects, beings and things, patterns and matter’.<sup>2</sup>

Fuller draws upon theorists such as Guattari, Bateson, Friedrich Kittler, and Gilbert Simondon to approach media-art practices in ways that ‘allow accounts of technicity and media to escape from a merely semiological reading of the world into an expanded involvement with and in it’.<sup>3</sup> This entails that media ecology shifts the study of media from the production of messages and signs towards exploring material assemblages within which semiology is only part of the systemic context. In probing these assemblages Fuller contends that the ‘meanings’ and ‘effects’ of media

go beyond the symbols and signs of content and that broader ecologies of media require analysis if we are to address ethical dilemmas within contemporary techno-cultures. Fuller approaches media technologies as dynamic assemblages rather than stable wholes, using media-art practices to uncover specific potentialities for creative and socially-aware ways of repurposing technological apparatuses.

This diverges sharply from the practices of the Media Ecology Association (MEA) of North America – a group of scholars whose work derives from the writings of McLuhan and Postman. Their version of media ecology is concerned primarily with human engagements with the symbolic or cultural environment of media and the moral ramifications of these interactions. While there is overlap vis-à-vis concerns pertaining to effects of technologies on social structures and individual well-being, the MEA variant of media ecology diverges sharply from its European namesake insofar as it attempts:

[t]o make people more conscious of the fact that human beings live in two different kinds of environments. One is the natural environment and consists of things like air, trees, rivers, and caterpillars. The other is the media environment, which consists of language, numbers, images, holograms, and all of the other symbols, techniques, and machinery that make us what we are.<sup>4</sup>

Whereas ecology is used here to elide binary oppositions between nature and culture the MEA approach reinforces dualistic ontologies through the study of a symbolic or cultural environment which is distinct from its natural counterpart. Consequently, this article explores not only discourse and symbols but also considers the materiality of media networks: the metals, minerals, and power requirements of contemporary media infrastructures which connect media ethics to issues of environmental degradation, loss of biodiversity, and anthropogenic climate change.

A further divergence between the MEA method and that employed here is the former's emphasis upon media ecology as 'a humanistic approach to understanding media, communication, and technology'.<sup>5</sup> Humanism – the dominant philosophical tradition within Western culture – emphasises humanity's separation from nature, casting humans as rational animals that possess free will while differentiating them from the determinate automatons which comprise other living and non-living systems. Ecophilosophy opposes this mode of dualistic thought, instead following Guattari in positing humans as one species entwined with others within autopoietic

ecological assemblages. As Parikka demarcates, seemingly stable bodies are always formed of intensive flows and their molecular connections. Bodies are not merely predefined organs and functions – they form as part of the environment in which they are embedded. Simondon talks about individuation and the (in)formative role of environmental milieus in this metastability of transductive relations; Deleuze and Guattari insist that we must get away from closed models of bodies and organisms and look at how bodies are continuously articulated with their outside.<sup>6</sup>

This shift away from understanding systems based on internal properties involves exploring connective capacities, re-orienting both organic and inorganic bodies as evolutionary beings that develop over differential temporal frameworks as heterogeneous assemblages. Systems (biological, ecological, and media-related) are not individuals or subject/object composites but rather compose dynamic and complex autopoietic assemblages which contain multiple (human and nonhuman) agencies. Consequently, Parikka concludes that:

[t]he best way for media studies to really make sense is to think outside media – of where it expands, takes us, if we persistently follow its lead. So far, for a long time, it took us to think about humans, human relations, intentions, unconscious desires, economics as much as politics and power. Such paths need to take us to the other direction too; to things less intentional, but as important; to nature, bacteria, chemicals, forms of life outside our headspace but inside our gut; to milieus of living in which our conscious agency is only a minor part of what matters.<sup>7</sup>

Media ecology contends that understanding media ethics requires analysis which not only focuses upon the content of mediated communications but also explores values built into the systems of software and hardware upon which communication infrastructures are predicated. That is to say that ecological analysis – which is based on the ontologies of complexity theory<sup>8</sup> and related scientific systems theories which have evolved over the 20<sup>th</sup> century – requires the analysis of dynamic multiscalar systems rather than just a particular scale within these assemblages.

Most existing approaches to media ethics<sup>9</sup> focus upon issues such as pornography, propaganda, privacy, and representations of violence; these are all serious issues, though ones which primarily relate to the final communicational outputs of media content. An ecological approach requires that in addition to considering these ethical issues we also consider the ethics which are embedded within infrastructures which afford the production

of content – the code, algorithms, and programs which exist at the scale of software; and the circuits, capacitors, cabling, and associated components which comprise the scale of hardware. A materialist investigation into these scales requires considering the ecological costs surrounding how materials are sourced, what occurs during the various stages that see ores and earths transformed into smartphones and tablets, and what happens to these items once they are disposed of. Within the architectures of software and hardware upon which mediation is dependent are a multiplicity of affects, ethics, and values which are frequently rendered invisible by discourses of virtuality, informationalisation, and immaterial labour<sup>10</sup> which surround ICTs (information and communications technologies).

A multiscale approach to media ecology insists that ethical issues pertaining to the life-cycle of ICTs are not posited as distinct from either the content of those communications or the materialities associated with the software required to produce and consume digital content. While such striation – which sees the study of ethics and politics within media systems cleft into hardware studies<sup>11</sup> and software studies,<sup>12</sup> alongside traditional media scholarship regarding content and reception – is commonly encountered within existing approaches to media studies and media ecology, the contention here is that for a more realistic assessment of contemporary media assemblages, an approach which works across and between the scales of content, software, and hardware, is required. In order to elaborate upon such a methodological approach I next turn to various interdisciplinary usages of the term 'scale' to elucidate how and why a multiscale approach appears beneficial within the context of media ecologies.

## An interdisciplinary exploration of scale

The concept of scale is applied in varying ways across a broad spectrum of academic disciplines. Perhaps the most commonly encountered application of the term is within cartography, whereby scale refers to the reduction of space by a certain numerical factor, allowing vast areas to be graphically represented upon maps. For example, Ordnance Survey maps within the United Kingdom utilise scales ranging from 1:1000000 to 1:1250.<sup>13</sup> In each case one centimetre on the map represents a specific distance, denoting that within cartography scale indicates a direct and quantifiable relationship which exists between map and territory.

In contrast, within geology and palaeontology, the geologic time scale (GTS) is applied as a way of dividing the earth's history into a number of

chronological periods.<sup>14</sup> The various units within the GTS do not present chronological divisions based upon equal temporal durations but instead denote alterations to geological strata corresponding to significant geological or palaeontological events. For example, the onset of the Cambrian period is defined by the rapid diversification of multicellular life-forms – known as the Cambrian explosion – in which the first members of phyla such as arthropods appeared. Similarly, the boundary between the Permian and Triassic periods is the Permian-Triassic extinction event, the most severe mass extinction event found within the geological record which, like the Cambrian explosion, denotes an abrupt change in the fossil record. What is important to grasp about the GTS then is that scale does not demarcate a linear series of measurements but rather particular relational aspects between neighbouring time-periods.

Scale is a concept which has been heavily discussed within cultural geography – a discipline in which the cartographic connotations of scale as size have existed for a considerable time in tension alongside relational variants closer to the application of scale in the GTS. Indeed, scale is claimed to be a foundational concept within cultural geography alongside space, place, and culture.<sup>15</sup> However, there has been considerable debate over the precise meaning and utility of scale within cultural geography, with positions ranging from Richard Howitt's suggestion that a relational conception of scale (as found in music or the GTS) generates a useful analytic tool for political geographers<sup>16</sup> through Sallie Marston's (et al) contention that scale presents a highly problematic concept which should be eliminated from geographical discourse.<sup>17</sup>

Marston et al apply theoretical insights from Deleuze and Bruno Latour surrounding the notion of a flat ontology to argue that scale presents ontological divisions which, while adding nuance to a global/local distinction through the addition of intermediaries such as the national, are ultimately founded upon verticalism and hierarchy, thus inhibiting network-led approaches to micropolitics. Consequently, they contend that 'scale is a classic case of form determining content, whereby objects, events and processes come pre-sorted, ready to be inserted into the scalar apparatus at hand'.<sup>18</sup> This approach to scale concentrates on scale as size and to a lesser degree scale as level (although Marston et al argue that within geographical discourse there is often conflation between the two), while scale as relation is absent from their critique. Additionally, the focus on an ontological critique of scale presupposes that scale addresses ontological rather than epistemological phenomena, whereas various alternative perspectives within cultural geography emphasise that scale is an epistemological tool rather than a series

of ontological divisions;<sup>19</sup> rather than representing a rigid striation between hierarchically nested layers of reality, 'scale itself is a representational trope, a way of framing political spatiality that in turn has material effects'.<sup>20</sup>

Indeed, the approach to ontology within media ecology is largely drawn from Deleuze, Guattari, and Manuel DeLanda's work surrounding a flat ontology and meshworks of assemblages whereby nothing is understood to exist in isolation from the dynamic flows of matter and energy that comprise the cosmos. There seems no reason why the contention that existence is comprised of a single plane of immanence is incompatible with an epistemology which explores phenomena across a range of entangled relational scales, presenting numerous overlapping apertures with which to comprehend entangled phenomena; as we shall see, Guattari's delineation of the three ecologies exemplifies such an approach.

Another area in which discussions surrounding scale are productive to considering scale within media ecology is the science of ecology, where scale is frequently described as a concept central to contemporaneous approaches to the field.<sup>21</sup> Begon et al explain that ecology is concerned with interconnection at three distinct scales of organisation: the individual organism, the population (consisting of individuals of the same species), and the community (consisting of a greater or lesser number of species populations). At the level of the organism ecology deals with how individuals are affected by (and how they affect) their environment; at the level of the population ecology is concerned with the presence or absence of particular species, their abundance and rarity, and with the trends and fluctuations in their numbers. Community ecology then deals with the composition and organisation of ecological communities. Ecologists also focus on the pathways followed by energy and matter as these move between living and non-living elements of a further category of organisation: the ecosystem, comprising the community together with its physical environment.<sup>22</sup>

Consequently, *Ecology: From Individuals to Ecosystems* is separated into three sections, each addressing a particular scale: from organisms through populations and finally to communities and ecosystems. Scale is not determined by spatio-temporal dimensions, for example the size of a community of intestinal microbiota are far smaller than the individual creature in which they reside; instead, it refers to types of relation between ecological systems. The ecological approach to scale is of particular interest to media ecology as it seeks to extend the methods by which ecologists explore the flows of matter and energy within ecosystems to systems of mediation. Indeed, a central contention of media ecology (and of political ecology in general) is that the often imagined divides between nature and



culture are largely illusory, and so ecology itself ought to include cultural flows alongside ‘natural’ ones;<sup>23</sup> also, understanding both natural and cultural spheres is greatly enhanced by departing from dualistic approaches which separate the world into (amongst other dualisms) nature and culture, science and humanities, discourse and materiality.

Indeed, eco-philosophical approaches have frequently introduced a concept of scale closely related to that found within the scientific discipline of ecology. The pioneering eco-philosopher, cyberneticist, and anthropologist Gregory Bateson introduced the concept of the three ecologies<sup>24</sup> – mind, society, and environment – a triadic schemata of entangled assemblages designed to reconnect ethical and political issues pertaining to mental, social, and environmental issues. Each ecology exists as a complex system consisting of heterogeneous components constantly interacting within and between the three ecologies, both dynamically creating and constituting them with balance between the three portrayed as essential to the continued maintenance and proliferation of human societies. Bateson contrasts this ecological theory of balance and feedback with the anthropocentric, dualistic philosophy predicated upon competitive individualism which underpins Occidental culture, arguing that:

[t]he last hundred years have demonstrated empirically, that if an organism or aggregate of organisms sets to work with a focus on its own survival and thinks that is the way to select its adaptive moves, its ‘progress’ ends up with a destroyed environment. If the organism ends up destroying its environment, it has in fact destroyed itself.<sup>25</sup>

The thesis of the three ecologies connects the micro-level constitution of subjectivity with the macro-level constitution of societies and ecosystems, challenging the dualisms of macro/micro, individual/society, and culture/nature and instead proposing a series of scalar assemblages which reconnect binary pairs. Furthermore, the three ecologies do not imply a hard or ontological division between mind, body, and environment. For example, Bateson outlines a model of distributed cognition whereby the pathways of the mind are always articulated from not only within the body and brain of an individual but exist within the connections between bodies, social groups, technology, and ecosystems.<sup>26</sup> The ecology of mind then does not refer merely to an individual human brain or nervous system but also encompasses flows which pass through synapses, software, semiotics, and silicon – through various elements of the social and environmental ecologies with which it is thoroughly entangled and so cannot be function-

ally cleft. The three ecologies do not imply ontological separation but an epistemological tool presenting overlapping lenses through which to view particular modes of relation within entangled assemblages.

Guattari subsequently engaged with and advanced Bateson's concept of the three ecologies, synthesising this ecological epistemology with post-Marxism and poststructuralism. For Guattari ecosophy rejects the value system employed by capitalism in which GDP per capita and economic growth are viewed as the sole determinant of the worth of societies, following Bateson's rejection of economic determinism. Guattari instead posits subjective well-being and happiness, social justice and minimising inequalities, ecological diversity and resilience as sources of value ranging across the three ecologies.

Where Guattari and Bateson diverge is that Bateson's model of ecology was predicated upon early (1940s-1970s) cybernetic models consisting of multiple negative feedback loops to form homeostatic systems. Guattari's version, by contrast, is largely derived from combining nonlinear dynamics and complexity theory (with a focus on chaotic systems and positive feedback loops) with elements of Humberto Maturana and Francisco Varela's work surrounding autopoiesis<sup>27</sup> – self-organisational systems which operate far from equilibrium. However, Guattari departs from what Maturana and Varela demarcate as the scope of autopoietic systems:

Varela reserves the qualification 'autopoietic' for the biological domain. Social systems, technical machines, crystalline systems and so forth are excluded from the category. That is the sense of his distinction between allopoiesis and autopoiesis. But autopoiesis, which thus encompasses only autonomous, individuated and unitary entities that escape relations of input and output, lacks characteristics essential to living organisms, such as being born, dying and surviving through genetic phyla. It seems to me, however, that autopoiesis deserves to be rethought in relation to entities that are evolutive and collective, and that sustain diverse kinds of relations of alterity, rather than being implacably closed in upon themselves. Thus institutions, like technical machines, which, in appearance, depend on allopoiesis, become ipso facto autopoietic when they are seen in the framework of machinic orderings that they constitute along with human beings.<sup>28</sup>

Additionally, Guattari and Bateson's ecosophical approaches diverge insofar as Guattari's ecosophy is framed within a broadly post-Marxist context, while there is no notable Marxist influence within Bateson's work. They do, however, present multiscale ecophilosophical approaches whereby scale is understood as a relational quality between elements of ecological systems occurring within a single ontological register but requir-

ing differing perspectival approaches to be adequately addressed. As such, both authors agree that it is ‘quite wrong to make a distinction between action on the psyche, the socius and the environment’.<sup>29</sup>

Media ecology stresses entanglement within the context of the networks of energy and matter, software and hardware, humans and technology, which comprise contemporary social structures, contradicting approaches such as that found within software studies whereby software is proclaimed to be central to these structures:<sup>30</sup>

[t]o be entangled is not simply to be intertwined with another, as in the joining of separate entities, but to lack an independent, self-contained existence. Existence is not an individual affair. Individuals do not pre-exist their interactions.<sup>31</sup>

Entanglement presents a novel way of approaching the world in which the atomised individual components which are normatively conceived of as nodes within networks or organisms within environments are considered as meshworks of entangled lines, whose collective bundles of dynamic knots compose the ecology of life.<sup>32</sup> For media ecologies the epistemological consequences of entanglement are that we cannot separate particular aspects of a techno-cultural milieu – either declaring them to be of central importance or studying their capacities in isolation from dynamic entanglements across multiple scales.

Homologous to the three entangled ecologies of mind, society, and environment proposed by Bateson, this article examines three entangled relational scales of content, software, and hardware, which will be applied as a method by which to approach the two case studies which follow. As with Bateson and Guattari’s three ecologies the scales explored within this study are not presented as distinct and separable layers but as entangled ecologies which cannot be functionally isolated from one another. The utility in exploring them as scales lies in grasping the differing types of relation highlighted by adopting alternate apertures. While it would be wholly wrong to ascribe particular qualities in a singular fashion to each scale – such as claiming that meaning derives solely from content and materiality entirely relates to hardware – there are important differences in the way that particular relations manifest within different scales. There are different forms of materialities, agencies, and meanings which exist within images and languages, algorithms and codecs, CPU architectures and fibre-optic cables; grasping how these differences operate across and between entangled relational scales is within the remit of media ecology.

## Phone Story

*Phone Story* is a game for use on touchscreen mobile phones using the Android or iOS platforms, developed by Molleindustria – an Italian collective of artists, programmers, and designers who aim to create video games which foster critical perspectives on globalised capitalism, aiming to ‘free videogames from the “dictatorship of entertainment”, using them instead to describe pressing social needs, and to express our feelings or ideas just as we do in other forms of art’.<sup>33</sup> *Phone Story* takes the player through a series of events examining ecological costs associated with the life-cycle of mobile phones. The initial scenario dealing with ore extraction features the player controlling armed militia at a Coltan mine tasked with coercing prisoner-of-war child labourers to continue working. This references the fact that Coltan (a contraction of the two elements it comprises: columbium and tantalum) has attracted significant controversy regarding the ore’s role in financing ongoing conflicts within the Democratic Republic of Congo, allied with the fact that the majority of global tantalum supplies are used in microelectronics; tantalum is used as a powder within capacitors due to its volumetric efficiency and reliability, the former in particular being pivotal to the miniaturisation of devices such as mobile phones and tablet computers.<sup>34</sup>

In the next scene the player controls a net and is charged with catching workers jumping off the roof of a microelectronics factory. This references events at the Foxconn-owned factory in Shenzhen (China), where in 2010 fourteen young migrant workers committed suicide by jumping off factory roofs, causing an international scandal with attention focused upon conditions at the plant which supplies hardware for brand name corporations including Apple, Dell, Nintendo, Sony, and Hewlett-Packard.<sup>35</sup> The suicide scandal helped make Foxconn, the world’s largest microelectronics manufacturer, a household name; the negative publicity generated by the affair led to Foxconn and Apple (one of Foxconn’s largest clients) ostensibly taking action to improve wages, reduce mandatory overtime,<sup>36</sup> and reduce the severity of the company’s disciplinary regime. However, recent NGO research contends that many Foxconn employees still work up to 100 hours a month of compulsory overtime (the legal limit in China is 36 hours), are not paid for all the overtime worked, and face ‘deplorably harsh working conditions’.<sup>37</sup>

The game’s third level features players throwing phones to consumers while narration discusses the manufacture of consumer desires; the final encounter features the player taking on the role of impoverished e-waste workers, sorting materials into separate piles of circuit boards, copper

wires, glass, and screens, while the narration discusses the fact that the majority of mobile devices end up being exported and dismantled in ways which damage worker health and local environments. While it is illegal in most cases for OECD nations to ship e-waste (electronics-waste) to non-OECD countries<sup>38</sup> due to the toxicity of microelectronics, the majority of North American e-waste and a substantial proportion of European Union e-waste is shipped illegally to countries such as China, India, Nigeria, and Ghana where certain materials are salvaged from scrap microelectronics by workers (many of whom are children) using few if any safety precautions, for financial remuneration in the region of US\$1.50 per day.<sup>39</sup> The social and ecological costs of manually ‘recycling’ e-waste in this way include poisoning from substances such as lead, barium, chromium, and dioxins.<sup>40</sup>

If at any stage the player fails to complete the task at hand they are greeted with a screen where the narrator tells them ‘don’t pretend you are not complicit’ in the harmful actions they are being asked to symbolically enact. The game is only playable on smartphones, constantly reminding users that they are implicated in the events experienced via the game world through their ownership of the phone. This demonstrates a powerful way of implicating the user in current events, exhibiting the type of politicised configurational activity outlined by Stuart Moulthrop<sup>41</sup> in which ludic action presents users with insights into the complex systems which comprise globalised capitalism.

The way in which the game (a form of software) uses a combination of narrative and ludic modes – what we conventionally term content and form – to reconfigure user understanding of the ecological costs of hardware and their subjective relationships with technological devices demonstrates how contemporary media experiences can tie together ethical concerns across the scales of content, software, and hardware, which are as entangled as Bateson and Guattari’s three ecologies of mind, society, and environment. Indeed, what makes *Phone Story* a pertinent example here is the way that it demonstrates entanglement across these scales, making various interconnections visible and tangible to the user who is situated within the assemblage through their complicity in both the game-world and the real-world (ecologically-harmful) activities featured.

Four days after its release Apple banned *Phone Story* from their App Store, contending that the application breached numerous developer guidelines – they claimed that the application contained excessively objectionable content. The fact that this content regards the production of the hardware used to play the game is irrelevant: in the highly-controlled App Store there is no place for satirical critique examining the detrimental impacts

of technology or questioning current levels of consumption. Additional alleged breaches of developer guidelines regard donations to charities, with the Apple guidelines forbidding the collections of charitable donations via any means other than the Safari Web browser or SMS and forbidding apps which allow donations to charitable organisations. *Phone Story* does not allow users to make donations; however, Molleindustria pledged to donate all funds received from the \$1 cost of the application (minus the App Store/Android market fee of 30%) to charities working to raise awareness of the issues explored in the application, with the initial recipient being SACOM, an NGO whose campaigning focuses upon labour rights abuses within the microelectronics industry.

The result of Apple's decision to ban *Phone Story* from the App Store created a news story which was covered by mainstream media,<sup>42</sup> online technology publications such as *Wired* magazine,<sup>43</sup> as well as numerous blogs; Apple's decision to censor the application resulted in the generation of a significant volume of attention and coverage for *Phone Story* and its themes surrounding the ecological costs of IT, alongside the authoritarian manner in which Apple polices content within its App Store. Apple's censorship ironically resulted in achieving the aims of *Phone Story*, as the news regarding Apple's decision to exclude the application focused more attention and awareness towards these issues than had the game simply been left as one of the 500,000+ apps within the store.

*Phone Story* presents a case study exhibiting how issues pertaining to content, software, and hardware do not exist as separate spheres or distinct strata but instead form an entangled media ecosystem. This also demonstrates how engaging with the ethics and politics of architectures of software and hardware can build systemic and configurative awareness, locating user actions and agencies within the complex globalised flows of contemporary systems of production and consumption. Ecological costs and ethical issues surrounding software and hardware are often best illustrated by forms of mediated content which raise awareness, garner attention, and mobilise action via the creation of systemic awareness of these issues.

While *Phone Story* provides a useful example which delineates scalar interconnection and configurative awareness within a particular media system, creating a performative engagement whereby the power structures surrounding modes of production reveal themselves via the user's explorative and configurative engagement with content, its impacts largely end at raising awareness. Although \$0.70 raised by each sale of the app is donated to SACOM this revenue would not itself achieve meaningful alterations to the system of production presented in the game. The issue may then be

that although users are enraged by their complicity within the systems depicted by the game, there is no obvious outlet for practical political action designed to affect this situation. The user may still be caught within the trap of representation.

## Open Source Ecology

A second example which addresses this issue is the Open Source Ecology (OSE) project. Founded by Marcin Jakubowski in 2003, OSE aims to create the Global Village Construction Set (GVCS): 'a modular, DIY, low-cost, high-performance platform that allows for the easy fabrication of the 50 different Industrial Machines that it takes to build a small, sustainable civilization with modern comforts'.<sup>44</sup> The GVCS is composed of Open Source Hardware (OSH) designs for machines varying from tractors and compressed earth block (brick) presses to 3D printers. The machines are designed to be modular, cheap to construct, easy to maintain and repair, and built to last rather than to become rapidly obsolete. These are seen as hallmarks of OSH.

OSH is related to Open Source Software (OSS), but as the taxonomical distinction suggests relates to hardware rather than software. The designs of OSH are openly released over networked ICTs allowing communities to collaboratively create, customise, and alter devices; this signifies a divergence from OSS in that the final product cannot itself be freely distributed via peer-to-peer telecommunications networks, as hardware remains a rival rather than non-rival good.<sup>45</sup> OSH has been heralded as part of a peer-to-peer mode of production which presents an emergent alternative to currently hegemonic market-led production. This arguably produces benefits insofar as it is both economically hyperproductive, with numerous OSS projects outcompeting lavishly funded proprietary alternatives,<sup>46</sup> and also because peer-to-peer production allegedly provides a series of beneficial social externalities;<sup>47</sup> this results in a social dynamic which values commonwealth over commodities<sup>48</sup> and consequently is engaged with long-term issues surrounding ecological costs (across Bateson's three ecologies) and sustainability rather than short-term profitability or what Franco Berardi has termed 'economic fanaticism',<sup>49</sup> whereby wealth is equated purely within monetary terms. Consequently, there appears at the very least to be productive homologies between the benefits of OSH and the ecosophical approach advocated by Guattari.

By 2011 OSE created functional prototypes of eight machines including a tractor, hydraulic power unit, and CNC torch table. The OSE team lives and



works at the Factor-e-Farm located near Kansas City and are supported by a distributed network of volunteers, some of whom attend dedicated project visits, assisting with prototyping and manufacturing while supporting infrastructure and agriculture (the farm is a working sustainable farm using the GVCS machines). The GVCS prototypes already demonstrate economic and ecological savings over commonly deployed industrial alternatives. Whereas a commercially-available tractor and compressed earth brick press retail at around US\$40,000 each, the materials for the OSE versions cost around US\$4000 apiece.<sup>50</sup> For each machine OSE releases design rationale, 3D CAD files, 2D fabrication drawings, exploded part diagrams, circuit diagrams, control codes for automated devices, scaling calculations, the physics of the device, and cost and performance comparisons to contemporary industry standard machines so that other parties can copy, share, alter, and improve their designs. The documentation is all published online, allowing a distributed audience to access and interface with their work and to become participants in the process of creating and refining the GVCS.

This demonstrates another way in which software and hardware form an entangled meshwork for OSH projects: without the connectivity afforded by the Internet this type of distributed peer-to-peer collaboration would be impossible, relegating the scope of the project from collaboratively designing the GVCS with a distributed community and sharing their work with a global audience to a group of individuals working within a network of personally-known collaborators whose results would only be accessible to this limited network. The fact that the design information, which is crucial to the dissemination of the project, exists as varying forms of content ranging from video documentation to 3D CAD files also demonstrates how sharing content over the networks of hardware and software which compose the Internet is key to the viability of the project. Hardware, software, and content do not exist as separate spheres but rather function within a triadic relationship; without any one of these scales the entire project would effectively fail to function.

Furthermore, the way in which the project has been funded and advertised again highlights entanglement between content, software, and hardware. OSE is sustained through crowdfunding carried out through their own website and via a campaign on Kickstarter in 2011 which collected over US\$63,000 from 1,300 contributors. By using various forms of media content housed on software platforms – which are in turn predicated upon hardware including personal computers, servers, modems, wireless networks, Internet exchange points, and fibre-optic cables – OSE not only communicated the existence of their project to a distributed audience



but managed to raise the capital required for the project to sustain itself. Again we see that in practice the scales of hardware, software, and content cannot be functionally separated here, further supporting the thesis of scalar entanglement within media systems.

Where OSE goes somewhat further than *Phone Story* is in implementing an ecological ethics through producing systems whereby supporters can become involved in contributing towards a project – which if successful presents an eco-ethical alternative to industrial production. In addition to contributing financially towards the project supporter/participants can get involved through the following methods: volunteering on dedicated project visits at the farm; contributing technical expertise towards prototyping and fabrication; assisting with project management; peer-reviewing designs; programming elements of the scalable open-source product development platform; creating documentation for each design and/or the overall project (including tasks such as distributed off-site video editing); composing artwork, animations, and other design assets; and contributing to the OSE website's forums and wikis. This presents a broad variety of ways that allow people to become actively involved in the project. Rather than simply critiquing existing processes, encouraging people to feel guilty about behaviours and consumptive practices, OSE provides opportunities for individuals to create the world they would like to inhabit, with these opportunities encompassing the entangled scales of hardware, software, and content. Consequently the potential problematic associated with the awareness-raising strategy of *Phone Story* – that while people attain critical insight into technology, they feel powerless to intervene in ways which create positive change – is negated through encouraging participation in the process of building ethically-orientated alternatives. Indeed, without the collaborative efforts of a distributed community in the design, prototyping, refinement, documentation, funding, and publicity surrounding OSE and the GVCS the project itself would present a near-insurmountable challenge for the core team. As a result OSE exemplifies the hypotheses central to this article – that there exist entangled relations between hardware, software, and content, and that reading across and between these scales is pivotal to materialist considerations of contemporary media assemblages.

## Conclusions

The two case studies outlined here demonstrate in different ways that ethical and political issues relating to the materiality of media systems

extend across the scales of content, software, and hardware. *Phone Story* presents an example of media content pertaining to the ecological costs of ICTs, which exists as a form of software (a videogame) and is played on precisely the type of device whose detrimental ecological impacts are critiqued through the content. Consequently, playing the game implicates the user within this destructive system and by drawing attention to their complicity in a range of unethical actions the user is compelled to affect changes to their consumptive behaviour, highlighting some of the material consequences of discursive content. Issues which exist across the scales of subjective, social, and environmental issues – such as the manufacture of desire by technology corporations, child/slave labour at Coltan mines, and environmental degradation caused by toxic e-waste – are addressed as part of a systemic crisis surrounding contemporary technocultural practices which goes beyond issues surrounding content and symbolic representation, additionally addressing the material impacts of software and hardware systems and directly implicating the user within these systems through both their symbolic engagement with the game and their material relationship with the technology required to experience the content.

OSE by contrast is ostensibly a project to create open-source hardware, with a series of tendencies which create positive ecological impacts in comparison to the currently hegemonic globalised industrial model. OSE is dependent upon global groups of contributors using networks of hardware and software in order to produce the communicative content which allows the OSH designs to evolve; it additionally produces mediated content using networks of software and hardware to both document projects and promote and raise funds required for their continuation. Again we see that, functionally, we cannot separate content, software, and hardware, as each scale of inquiry is entirely dependent on the existence of the other scales. Consequently OSE supports the notion that content, software, and hardware present entangled scales which cannot be understood to pre-exist each other in isolation but instead provide overlapping apertures with which to probe dynamic media assemblages.

One of the key points surrounding the application of scale within this article is that it demarcates a relational distinction between different types of systems rather than presenting differentiation predicated upon absolute spatio-temporal values. Consequently we can align this type of scalar analysis with approaches found within ecology, eco-philosophy, music, and paleontology, whereby scale references types of relation existing between phenomena as opposed to the understanding of scale implemented within cartography, whereby scale refers to a quantitative spatial relationship.

A critical departure from existing versions of media ecology presented here is the treatment of the materiality of multiscale media systems – not only via a consideration of the ways that media technologies and systems affect human cultures (which in turn feed and affect media technologies) but also through exploring the ecological costs incurred by the technologies themselves, the ways that hardware as material entities directly impact upon social and environmental systems. Treating media as material entities operating across relational scales entails examining not only what media might mean, represent, or signify but what they *do*; also, as material assemblages, how do they impact upon other bodies, systems, and assemblages across varying scales.

While media studies has traditionally existed on the discourse side of a discourse/materiality dualism which entailed that studying media meant paying attention to representation, symbols and ideas, media ecology suggests that adopting a methodological approach derived from new materialisms and non-representational theory requires examining the material impacts of media architectures alongside the representational work that has previously dominated the field. However, media ecology resists reducing discourse and materiality to a binary opposition or a dialectic and instead posits both terms within an entangled meshwork, a knotted bundle of lines containing multiple feedback loops wherein discourse and materiality reflexively inform and transform one another.

## Notes

1. Fuller 2005. As Goddard (2011) explicates, Fuller's text was ground-breaking in terms of the formulation of media ecologies as an approach. However, it does contain theoretical inconsistencies, particularly with regards to its embrace of neo-Darwinism and memetics – a reductionist paradigm which was explicitly rejected by a number of Fuller's primary theoretical resources such as Deleuze and Guattari.
2. Fuller 2005, p. 2.
3. *Ibid.*, pp. 18-19.
4. Postman 2000, p. 11.
5. Grossweiler 2002.
6. Parikka 2010, p. xxiv.
7. Parikka 2011.
8. See DeLanda 2002.
9. E.g. Ess 2009.
10. E.g. Hardt & Negri 2000; Franck 1999; Goldhaber 1997.
11. E.g. Miller & Maxwell 2008, 2012; Cubitt 2009; Hertz & Parikka 2012; Gabrys 2012.
12. E.g. Fuller 2008; Kithcin & Dodge 2011.
13. Ordinance Survey 2012.
14. Gradstein et al 2012.

15. Howitt 2002.
16. Howitt 1998.
17. Marston et al. 2005.
18. *Ibid.*, p. 423.
19. Hoefle 2006; Moore 2008; Jones 1998.
20. Jones 1998, p. 27.
21. Schneider 2001; Levin 1992.
22. Begon et al. 2006, p. xi.
23. Here my notion of media ecology departs from that of Parikka and Goddard's notion of media ecologies and unnatural ecologies, which seems so simply reinsert a (barely) modified version of a nature/culture dualism as natural and unnatural ecologies.
24. Bateson 1972.
25. *Ibid.*, p. 457.
26. Bateson 1972, p. 470.
27. Maturana & Varela 1980.
28. Guattari 1993, p. 17.
29. Guattari 2000, p. 42.
30. Manovich 2008, p. 15.
31. Barad 2007, p. ix.
32. Ingold 2008.
33. Molleindustria 2011.
34. See Nest 2011 and Taffel 2012a, pp. 7-10 for more detail on Coltan's history as a conflict mineral and its applications within microelectronics.
35. For more detail on outsourced production and the globalised microelectronics industry see Luthje 2006.
36. Which often emanates from the types of contract offered by corporations such as Apple, whereby a quota of units of a new product are required for a product launch and the financial penalties for contractors failing to meet quotas are severe, entailing that contractors enact extremely high levels of compulsory overtime to fulfill them. See Chan & Pun 2010.
37. SACOM 2012.
38. Under international legislation such as the United Nations Environment Programme's Basel Convention or the European Union's Waste Electronics and Electrical Equipment Directive. See Taffel 2012a, pp. 16-20.
39. Roman & Puckett 2002.
40. Water in Guiyu, China, a major e-waste processing zone, was found to contain lead levels 190 times higher than the maximum safe level prescribed by the World Health Organisation, Barium ten times the United States Environment Protection Agency risk level, and Chromium at 1,338 times the EPA threshold. See BAN and STVC 2002, p. 22.
41. Moulthrop 2004.
42. Dredge 2011.
43. Brown 2011.
44. OSE 2011.
45. Benkler 2006, pp. 85-86.
46. The successes of projects including Mozilla's Firefox Web browser, Wikipedia, Apache/Linux as a Web server, and WordPress and Drupal as content-management-systems are frequently cited as prime examples.
47. Bauwens 2005.
48. Taffel 2012b.
49. Berardi 2009, p. 169.
50. Jakubowski 2011.

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