RED PLENTY PLATFORMS

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Introduction: Red Plenty

Shortly after the great Wall Street meltdown of 2008, a novel about obscure and remote historical events provided an unexpected node for discussion of the ongoing crisis. Francis Spufford's *Red Plenty* (2010) offered a fictionalized account of the failed attempt by Soviet cyberneticians of the 1960s to establish a fully computerized system of economic planning. Mixing historical figures – Leonid Kantorovich, inventor of linear programming equations; Sergei Alexeievich Lebedev, pioneering Soviet computer designer; Nikita Khrushchev, First Secretary of the Communist Party – with imaginary ones, and setting them all in motion through Kremlin corridors, rural collectives, industrial factories and the Siberian science-city of Akademgorodok, *Red Plenty* succeeded in the unlikely mission of making cybernetic planning a page-turner. But the interest it attracted from economists, computer scientists and political activists was not solely due to its narrative of scientific endeavor and political intrigue; it also owed much to timing. Appearing amidst austerity and unemployment, as the world market still teetered on the brink of collapse, *Red Plenty* could be interpreted in different ways: a) as a cautionary tale that, recalling Soviet debacles, reminds us capitalism remains the only game in town, even if it has behaved badly ('There Is No Alternative'); or b) contra-wise, as a recollection of unrealized potentialities, whispering not just the quaint *altermondialiste* slogan, 'another world is possible', but what David Harvey (2010: np) identifies as the more cogent and subversive possibility, that of 'another communism'.

This paper takes Spufford's novel as a starting point from which to embark on an examination of the computing platforms that would be necessary for a contemporary 'red plenty'. It is not a discussion of the merits and demerits of hacktivism, digital disobedience, electronic fabrics of struggle, tweets in the street and Facebook revolutions, but of digital communism. This is a topic that has already been touched on by the wave of rethinking life after capitalism triggered by the 1989 implosion of the USSR, in proposals for 'participatory economics' (Albert & Hahnel, 1991), a 'new socialism' (Cockshott & Cottrell, 1993), 'twenty first century socialism' (Dieterich, 2006), or forms of 'commonwealth'(Hardt & Negri, 2009). Unlike some of these sources, however, this essay does not aim to provide detailed, often competitive, 'blue-prints' for a new society, but rather what Greig de Peuter, in a personal conversation, once called 'red-prints'- approximating orientations to revolutionary possibilities.

In discussing computing and communism it is almost impossible to escape accusations of abandoning struggles and subjects to a machinic determinism. Certainly all automatic, teleological, and evolutionary models, including schematic choreographies of forces and relations of production, should be rejected. Just as important, however, is the avoidance of a contrary humanist determinism, which overstates the autonomy and ontological privilege of 'man versus machine'. Here, modes of production, and the struggles that convulse them, are understood as combinations of human and machine agents, entangled, hybridized and co-determined Deleuzo-DeLandian 'assemblages' (Thorburn, 2013).

That is why the estimate sent to me by Benjamin Peters, historian of Soviet cybernetics, that, compared with the machines available to the planners of *Red Plenty* in, say, 1969, the processing power of the fastest computer in 2019 will represent 'roughly a 100,000,000,000 fold increase in operations per second', is exciting, a factoid that is, as Peters remarks, 'not itself meaningful but still suggestive'. The argument that follows explores this suggestivity. This article thus looks at the most direct through-line from Soviet cybernetics' continuing attempts to theorize forms of economic planning based on labour time algorithms and super-computing. It then discusses how concerns about authoritarian central planning might be affected by social media and software agents, before going on to consider whether planning is redundant in a world of automata, copying and replication. In partial answer to that last question, 'Red Plenty Platforms' scans the role of cybernetics in the planetary bio-crisis, concluding with some general observations about cybernetics on today's 'communist horizon' (Dean, 2012). First, however, it reviews some of the problems, both practical and theoretical, that were grappled with by the Soviet planners depicted in *Red Plenty*.

Is Capitalism a Computer?

Digital philosophers suggest the universe may be a computer simulation programmed by aliens: without engaging this position, there are grounds for considering a more mid-range proposition, namely that capitalism is a computer. This is the contention implicit in one of the most serious intellectual challenges mounted against communist thought, ‘the socialist calculation problem’, formulated by ‘Austrian school’ economists such as Ludwig von Mises (1935) and Frederick Hayek (1945). Writing in the period defined by the success of the Russian revolution, these economists attacked the premises and feasibility of the centrally planned economy. All social systems, they recognized, need some form of resource planning. The market, however, enacts a distributed, spontaneous and emergent, non-coercive plan – what Hayek (1976: 38) called the ‘catallaxy’. Prices provide a synoptic, abstracted signal of heterogeneous and changing needs and conditions, to which entrepreneurial investment responds. A command economy, in contrast, must be both despotic and impractical, as calculating an optimal distribution of scarce resources depends on innumerable local knowledges about consumption needs and production conditions that no central reporting method could compile and evaluate.

The Austrian economists thus offered an update of Adam Smith’s celebration of capital’s ‘invisible hand’, now re-envisioned as a quasi-cybernetic information system:

> It is more than a metaphor to describe the price system as a kind of machinery for registering change, or a system of telecommunications which enables individual producers to watch merely the movement of a few pointers as an engineer might watch the hands of a few dials, in order to adjust their activities to changes of which they may never know more than is reflected in the price movement. (Hayek, 1945: 527)

Although he referred to telecommunications and engineering, Hayek, writing in the final year of the Second World War, might as well have invoked the giant mainframe computers of the Manhattan Project, for what he proposed was that the market acted as an automatic calculating engine: a computer.

This was, however, a two-sided argument deployed polemically against socialism. For if the market acts *as* a computer, why not replace it *with* a computer? If central planning suffered from a calculation problem, why not just solve it with real calculation machines? This was precisely the point made by Hayek's opponent, the economist Oskar Lange, who, retrospectively reviewing the 'socialist calculation' debate, remarked: 'today my task would be much simpler. My answer to Hayek … would be: so what's the trouble? Let us put the simultaneous equations on an electronic computer and we shall obtain the solution in less than a second' (1967: 159). Such was the project of the cyberneticians featured in *Red Plenty*, a project driven by the realization that the apparently successful Soviet industrial economy, despite its triumphs in the 1940s and '50s, was slowly stagnating amidst organizational incoherence and informational bottlenecks.

Their effort depended on a conceptual tool, the input-output table, whose development is associated with two Russian mathematicians: the émigré Wassily Leontief, who worked in the US, and the Soviet Union's Kantorovich, the central protagonist of *Red Plenty*. Input-output tables – which, it was recently discovered, are amongst the intellectual foundations of Google's PageRank algorithm (Franceschet, 2010) – chart the complex interdependence of a modern economy by showing how outputs from one industry (e.g. steel or cotton) provide inputs for another (say, cars or clothing), so that one can estimate the change in demand resulting from a change in production of final goods. By the 1960s such tables were an accepted instrument of large scale industrial organizations: Leontief's work played a role in the logistics of the US Air Force's massive bomber offensive against Germany. However, the complexity of an entire national economy was believed to preclude their application at such a level.

Soviet computer scientists set out to surmount this problem. As early as the 1930s, Kantorovich had improved input-output tables with the mathematical method of linear programming that estimated the best, or 'optimizing', combination of production techniques to meet a given target. The cyberneticians of the 1960s aimed to implement this breakthrough on a massive scale by establishing a modern computing infrastructure to rapidly carry out the millions of calculations required by Gosplan, the State Board for Planning that oversaw economic five year plans. After a decade of experimentation, their attempt collapsed, frustrated by the pitiful state of the Soviet computer industry – which, being some two decades behind that of the US, missed the personal computer revolution and did not develop an equivalent to the Internet. It was thus utterly inadequate to the task set for it. All this, alongside political opposition from a *nomenklatura* that, seeing in the new scientific planning method a threat to its bureaucratic power, compelled abandonment of the project (Castells, 2000; Gerovitch, 2008; Peters, 2012).

This was not the only twentieth century project of 'cybernetic revolutionaries'; as remarkable was the attempt by Salvador Allende's Chilean regime to introduce a more decentralized version of electronic planning, 'Project Cybersyn' (Medina, 2005). Led by the Canadian cybernetician Stafford Beer, this was conceived as a system of communication and control that would enable the socialist regime to collect economic data, and relay it to government decision makers, even while embedding within its technology safeguards against state micro-management and encouragement for many-sided discussions of planning decisions. This was an attempt at socio-technical engineering of democratic socialism that today perhaps seems more attractive than the post-Stalinist manoeuvres of the Soviet computer planners. But it met an even more brutal fate; Project Cybersyn was extinguished in the Pinochet coup of 1973.

In the end the failure of the USSR to adapt to a world of software and networks contributed to its economic/military defeat by the United States. Its disintegration, in which, as Alec Nove (1983) demonstrated, information bottlenecks and reporting falsifications played a major role, seemed to vindicate the Austrian economists. Hayek's praise of market catallaxy thus became central to the 'neo-liberal thought collective' (Mirowski, 2009) that led the subsequent victory march of global capitalism.

The combined pressure of the practical disaster of the USSR and the theoretical argument of the Austrian school exerted immense force inside what remained of the left, pressuring it to reduce and reset the limit of radical aspiration to, at most, an economy of collectively owned enterprises coordinated by price signals. The many variants on such 'market socialist' proposals have evoked rebuttals from Marxists who refuse to concede to commodity exchange. Perhaps because they grant to the market the automatic information-processing functions ascribed by the Austrian economists and market socialists, they may address issues of technological innovation or public data availability, yet do not seem to engage deeply with the potentialities of contemporary computing.

Today, post-crash, claims that markets are infallible information machines may seem less credible than they did a quarter of century ago. The parasitic energy-theft that underlies price-signal transmissions (exploitation at the point of production); the inability of individual commodity exchanges to register collective consequences (the so-called 'externalities'); and the recursivity of a chrematistic system that loops back on itself in financial speculation, have all become more salient in the midst of global capital's economic and ecological implosion. But identifying such flaws does not excuse communists from the requirement to specify how another system of resource allocation – one avoiding the 'serfdom' of the statist subjugation Hayek (1944) predicted – might work.

Labour Algorithms

Despite the fall of actually-existing socialism, the idea of computerized economic planning continued to be developed by small groups of theorists, who have advanced its conceptual scope further than anything attempted by Soviet cyberneticians. Two schools have been of particular importance: the 'New Socialism' of Scottish computer scientists Paul Cockshott and Alan Cottrell (1993); and the German 'Bremen School', which includes Peter Arno (2002) and Heinz Dieterich (2006), the latter an advocate of Venezuelan-style 'Twenty First Century Socialism'. These tendencies have recently converged (Cockshott, Cottrell & Dieterich, 2010). However, because little of the Bremen group's work is translated, the focus here will be on the New Socialism of Cockshott and Cottrell.

The distinguishing mark of the New Socialist project is its classic Marxist rigor. Accordingly, its twenty-first century super-computer planning follows to the letter the logic of the late nineteenth century *Critique of the Gotha Program* (Marx, 1970), which famously suggests that at the first, 'lower' stage to communism, before conditions of abundance allow 'to each according to his needs', remuneration will be determined by the hours of socially necessary labour required to produce goods and services. In the capitalist workplace, workers are paid for the reproduction of the capacity to labour, rather than for the labour actually extracted from them; it is this that enables the capitalist to secure surplus value.

The elimination of this state of affairs, Cockshott and Cottrell contend, requires nothing less than the abolition of money—that is, the elimination of the fungible general medium of exchange that, through a series of metamorphoses of money in and out of the commodity form, creates the self-expanding value that is capital. In their new Socialism, work would be remunerated in labour certificates; an hour's work could be exchanged for goods taking, on a socially average basis, an equivalent time to produce. The certificates would be extinguished in this exchange; they would not circulate, and could not be used for speculation. Because workers would be paid the full social value of their labour, there would be no owner profits, and no capitalists to direct resource allocation. Workers would, however, be taxed to establish a pool of labour-time resources available for social investments made by planning boards whose mandate would be set by democratic decisions on overall social goals.

Labour time thus provides the 'objective unit of value' for the New Socialism (Cockshott & Cottrell 2003: 3). It is at this point that its proponents invoke the capacities of information technology. Such a system would require an enumeration of the labour time expended, both directly and indirectly, in the creation of goods and services, to assess the number certificates for which these goods and services can be exchanged, and to enable the planning of their production. The basic tool of the input-output table reappears, with special attention to labour time, both as an input necessary for the production of goods, and as an output that itself requires the inputs of training and education. However, here the New Socialists have to confront a basic objection. Since the fall of the USSR it has been conventionally accepted that the scale of information processing attempted by its cyberneticians was simply too large to be feasible. Writing in the 1980s, Nove (1983) suggested that such an effort, involving the production of some twelve million discrete items, would demand a complexity input-output calculation impossible even with computers. This claim was repeated in recent discussions of *Red Plenty*, with critics of central planning suggesting that, even using a contemporary 'desktop machine', solving the equations would take 'roughly a thousand years' (Shalizi, 2012).

Cockshott and Cottrell's answer involves new tools, both conceptual and technical. The theoretical advances are drawn from branches of computing science that deal with abbreviating the number of discrete steps needed to complete a calculation. Such analysis, they suggest, shows their opponents' objections are based on 'pathologically inefficient' methods (Cockshott, in Shalizi, 2012). The input-output structure of the economy is, they point out, 'sparse'—that is to say, only a small fraction of the goods are directly used to produce any other good. Not everything is an input for everything else: yogurt is not used to produce steel. The majority of the equations invoked to suggest insuperable complexity are therefore gratuitous. An algorithm can be designed to short-cut through input-output tables, ignoring blank entries, iteratively repeating the process until it arrives at a result of an acceptable order of accuracy.

The time would be further reduced by massive increases in computer processing speed yielded by Moore's Law. Suggesting high-level economic planning is done on a 'desktop machine' is disingenuous. The issue is supercomputing capacity. According to an email communication from Benjamin Peters, in 1969, the time of *Red Plenty*, the 'undisputed workhorse' of the Soviet information economy was the BESM-6 ('bol'shaya electronicheskaya schetnaya mashina' – literally the 'large/major electronic calculating machine'), which could perform at an operating speed of 800,000 flops or 'floating operations per second' – that is, at 8 megaflops, or 10^6 flops. By 2013, however, supercomputers used in climate modelling, material testing and astronomical calculations are commonly exceeding 10 quadrillion flops or ten 'petaflops'. The holder of the crown at the time of writing is Cray's Titan at the Oak Ridge National Laboratory achieving some 17.6 petaflops (10^15) (Wikipedia, 2013). Supercomputers with an 'exaflop' capacity (10^18 flops) are predicted from China by 2019 (Dorrier, 2012). Thus, as Peters (2013) says, 'giving the Soviets a bit generously 10^7 flops in 1969, we can find (10^18 - 10^7 = 10^11) . . . a 100,000,000,000 fold increase' by today.

With these capacities, Cockshott and Cottrell's suggestion that the computer requirements for large scale economic planning could be handled by facilities comparable to those now used for meteorological purposes, seems at least plausible. The 'calculation problem', however, involves not just data processing but the actual *availability* of data; Hayek's claim was not merely that central planners cannot crunch economic numbers fast enough, but that the numbers in a sense do not exist prior to price setting, which provide an otherwise absent measure of production performance and consumption activity. Again, Cockshott and Cottrell suggest the answer lies in computers being used as a means of harvesting economic information. Writing in the early 1990s, and invoking levels of network infrastructure available in Britain at the time, they suggest a coordinating system consisting of few personal computers in each production unit, using standard programming packages, would process local production data and send it by 'telex' to a central planning facility, which every twenty minutes or so would send out a radio broadcast of adjusted statistical data to be input at local levels. This is a scenario too reminiscent of the ramshackle techno-futurism of Terry Gilliam's *Brazil*. To bring the New Socialists up to date we should instead refer to Fredric Jameson's iconoclastic vision of Wal-Mart as 'the shape of a Utopian future looming through the mist' (2009: 423). His point is that, if one for a moment ignores the gross exploitation of workers and suppliers, Wal-Mart is an entity whose colossal organizational powers model the planned processes necessary to raise global standards of living. And as Jameson recognizes, and other authors document in detail (Lichtenstein, 2006), this power rests on computers, networks and information. By the mid 2000s Wal-Mart's data-centers were actively tracking over 680 million distinct products per week and over 20-million customer transactions per day, facilitated by a computer system second in capacity only to that of the Pentagon. Barcode scanners and point of sale computer systems identify each item sold, and store this information. Satellite telecommunications link directly from stores to the central computer system, and from that system to the computers of suppliers, to allow automatic reordering. The company's early adoption of Universal Product Codes had led to a 'higher stage' requirement for Radio Frequency Identification (RFID) tags in all products to enable tracking of commodities, workers and consumers within and beyond its global supply chain.

Wal-Mart is significant because it stands 'at the front-edge of a seismic shift in the corporate imaginary'. It is a shift that links the notion of a 'logistics revolution' with 'just-in-time-production', and 'harnesses emerging digital and cybernetic technologies for managing production, distribution and sales in as swift and efficient a manner as possible' (Haiven & Stonemouth, 2009: np). This shift is spurred by the emergence of an 'Internet of Things', relating digital information to real world physical items through a network of sensor-instrumented products, users and locations. Enabled by the spread of sophisticated 4G Wireless networks, data storage-on-demand services via the 'cloud' from firms like Amazon, and, especially, by the latest internet protocol IPV6's enlargement in addressability, which provides unique digital identifiers for a 'truly humongous 340 billion billion billion billion' items, such device to device communication by now probably exceed in data volume the person-to-person traffic of the Internet (Economist, 2012; np). As Benjamin Bratton (2013) observes, such addressability, combined with digital coding compressed to the sub-microscopic level, opens up a virtually limitless capacity for the identification of not just of things and people, but also of their most elementary components and their relationships.

Thus the trajectory of both information processing speeds and data gathering capacities points to the suppression of the 'socialist calculation problem.' However, to speak of planning in such panoptic contexts is to inevitably invoke fears of omniscient state control. The New Socialists come from a vanguard Marxist-Leninist lineage, with a self-avowed 'Jacobin' centralist perspective (Cockshott, Cottrell, & Dieterich, 2011). To consider how cybernetic planning might be developed in more transparent and participatory modes, we need to look to different communist traditions.

Communist Agents

Historically, the anti-statist tendency in Marxism has been largely carried in a very different 'worker council' tradition, that, against the powers of party and state has insisted on the role of workplace assemblies as the loci of decision-making, organization and power. In an essay antediluvian by digital standards, 'Workers' Councils and the Economics of a Self-Managed Society,' written in 1957 but republished in 1972, immediately after the Soviet crushing of Hungary's Workers Councils, Cornelius Castoriadis noted the frequent failure of this tradition to address the economic problems of a 'totally self-managed society.' The question, he wrote, had to be situated 'firmly in the era of the computer, of the knowledge explosion, of wireless and television, of input-output matrices', abandoning 'socialist or anarchist utopias of earlier years' because 'the technological infrastructures … are so immeasurably different as to make comparisons rather meaningless' (Castoriadis, 1972: np). Like the planners of *Red Plenty,* Castoriadis imagines an economic plan determined with input-output tables and optimizing equations governing overall resource allocation (e.g. the balance between investment and consumption), but with implementation in the hands of local councils. His crucial point, however, is that there should be *several* plans available for collective selection. This would be the mission of 'the plan factory', a 'highly mechanized and automated specific enterprise', using 'a computer' whose 'memory' would 'store the technical coefficients and the initial productive capacity of each sector' (Castoriadis, 1972: np). This central workshop would be supported by others studying the regional implications of specific plans, technological innovations, and algorithmic improvements. The 'plan factory' would not determine what social targets should be adopted; merely generate options, assess consequences, and, after a plan has been democratically chosen, up-date and revise it as necessary. Castoriadis would agree with Raymond Williams's (1983) later observation that there is nothing intrinsically authoritarian about planning, providing there is always more than one plan.

This early concept of cybernetic self-management is a precursor of a more recent envisioning of post-capitalism, Michael Albert and Robin Hahnel's (1991) 'Participatory Economics' or 'Parecon'. This too emerges from a 'workers council' tradition, though from an anarchist, rather than Marxist line of thought. Their work is famous for its model of 'decentralized participatory planning' (Albert, 2003: 122), alternative to both market mechanisms and central planning. Councils are, again, the basic societal units for democratic decision, but in Parecon these include not just worker but consumer councils, too. Resource allocation is determined by these organizations' bids for different levels of production and consumption, which over a series of rounds of negotiation are progressively reconciled by Iteration Facilitation Boards. At successive stages of the planning process, worker and consumer councils are encouraged by the IFBs to revise their proposals in knowledge of each other's inputs, until enough convergence is produced to put a few possible plans to a vote.

Parecon has been the topic of considerable controversy. One of the most frequent objections is that it exemplifies the problem Oscar Wilde identified when he remarked that 'socialism is a good idea but it takes too many evenings' – i.e. it seems to require endless meetings. Hahnel (2008: np) suggests both that increased social interactivity is a positive feature of Parecon, and that its complexity would not necessarily be greater than that of many routine requirements of capitalist everyday life – shopping, taxes, finances, etc. But it does appear that conducting the tiered and iterative planning cycles they imagine at a speed sufficient to get anything done, would demand a very sophisticated network infrastructure and a high level of technologically mediated participation: extensive data banks accessed by councils and individuals subjects, electronic swipe cards for the measurement of labour and consumption, off-the shelf software for proposal preparations, and just-time-inventory systems for production (Albert, 2003: 133).

In fact Parecon seems to call for a digital development that post-dates its proposal: social media. A society of participatory, informed, democratic and timely collective planning would require fast, varied and interactive communicative platforms where proposals could be circulated, responded to, at length or briefly, trends identified, reputations established, revisions and amendments generated, and so on. It would, in short, demand that Facebook, Twitter, Tumblr, Flickrr and other Web 2.0 platforms not only themselves become operations self-managed by their workers (including their unpaid prosumer contributors), but also become fora for planning: Gosplan with 'tweets' and 'likes'. We also have to think of these organs transformed in directions pioneered by experiments in alternative social networks, such as Diaspora, Crabgrass, Lorea, freed of profit incentives and centralized control and taking more 'distributed' and 'federated' forms (Cabello et al., 2013; Sevignani, 2013), becoming, as Hu and Halpin (2013) propose, networks that in their very format prioritize group projects over individual identities, or as platforms of 'collective individuation'; not, perhaps social media as much as 'council media'.

Yet perhaps the idea of everyone watching mobile screens lest they miss, not a Facebook poke, but voting the seventh iteration of the participatory plan, duplicates unattractive features of everyday life in high-tech capitalism. So we might speculate further, and suggest that what decentralized collective planning really needs is not just council media but communist agents: communist software agents. Software agents are complex programmed entities capable of acting 'with a certain degree of autonomy… on behalf of a user (or another program)' (Wikipedia, 2013b: np). Such agents manifest 'goal-direction, selection, prioritization and initiation of tasks'; they can activate themselves, assess and react to context, exhibit aspects of artificial intelligence, such as learning, and can communicate and cooperate with other agents (Wikipedia, 2013b: np).

Commercially, software 'bidding agents' are able to consistently outperform human agents so that 'Humans are on the verge of losing their status as the sole economic species on the planet' (Kephart, 2002: 7207). The ability of such entities to create 'perfect competition' in electronic markets makes them a favorite of Austrian School-influenced economists (Mirowski, 2002). As pre-programmed buyers and sellers capable of processing vast amounts of market data, software agents have transformed electronic commerce because of their ability to quickly search the Internet, identify best offers, aggregate this information for users, or, indeed, make purchases autonomously. However, the arena in which such agents truly excel is in the financial sector, where high frequency trading is entirely dependent on software 'bots' capable of responding to arbitrage possibilities in milliseconds.

One can't help but ask, however, what if software agents could manifest a different politics? Noting that Multi-Agent System models can be thought of as a means to answer problems of resource allocation, Don Greenwood (2007: 8) has suggested they could be geared toward solving the 'socialist calculation problem'. As planning tools, Multi-Agent Systems, he notes, have the advantage over real markets that 'the goals and constraints faced by agents can be pre-specified by the designer of the model' (Greenwood, 2007: 9). It is possible to design agents with macro-level objectives that involve more than just the maximization of individual self-interest; two 'welfare' principles that economists have experimented with incorporating are equality and environmental protection sustainability.

Perhaps, then, we should envisage the repeated decision-cycles of democratic planning as being, not just debated and deliberated in social media, but partially delegated to a series of communist software agents, who absorb the attentional demands of the process, running at the pace of high-speed trading algorithms, scuttling through data rich networks, making recommendations to human participants ('if you liked the geo-engineering plus nanotechnology but no-nukes five year plan, you might like ... '), communicating and cooperating with each other at a variety of levels, preprogrammed to specific thresholds and configurations of decision ('keep CO2 emissions below 300 parts a million, increase incomes of the lower quintile ... and no rise in labour hours necessary for a cup of coffee'). In the age of autonomous machines, this may be what a workers' council would look like.

Automata, Copies and Replicators

Yet, is planning necessary at all? Centralized, neo-socialist planning schemes and decentralized, networked councilist versions both see computers as calculative instruments, a means to measure, particularly to measure work: their aim is to abolish capitalist exploitation by returning to workers the full worth of their labour time. There is, however, another line of communist futurism which understands computers not so much as instruments of planning as machines of abundance. There are, we might say, two ways to beat Hayek's capitalist catallaxy. One is to out-calculate it. The other is to explode it: scarcity is replaced with plenitude, ending the need for either prices or planning. For Marxists, 'plenty' yields the transition from the 'lower' phase of communism, which still must grapple with problems of scarcity, to the higher phase of 'from each according to his abilities, to each according to his needs'. A popular metaphor for the technological conditions necessary for this latter moment is the Star Trek 'replicator', which automatically, and with a limitless energy, provides for human needs (Fraise, 2011). This essay is not going to adjudicate what level of needs satisfaction should be considered 'enough', or what combination of growth and redistribution is adequate to attain it: this surely would be *the* issue facing the collective planners of the future. It will, however, identify three cybernetic tendencies that point towards the 'higher' phase of communism: automation, copying and peer-to-peer production.

Automation has been the most central to the communist imagination. Its classic statement is the now-famous 'Fragment on Machines' in *Grundrisse,* where, looking at the industrial factory of his age, Marx (1973: 690-711) predicts capital's tendency to mechanize production will, by destroying the need for waged labour, blow up the entire system. The founder of cybernetics, Norbert Weiner (1950), saw its main consequence to be the computerized elimination of jobs. This digital 'end of work' thesis has been developed very bluntly by thinkers such as Andre Gorz (1985) and Jeremy Rifkin (1995). Over the late twentieth century, however, capital has notably avoided this scenario. Far from totally automating work, it has both sought out global reservoirs of cheap labour, and followed a 'march through the sectors' that pushes a moving front of labour commodification through agriculture, industry and services.

Since 2000, however, the automation debate has been renewed. Continuing reductions in computing costs, improvements in vision and touch technologies, the military investments of the 9/11 wars in drones and autonomous vehicles, and wage demands by workers in China, India and other sources of formerly cheap labour has spurred a 'new wave of robots… far more adept than those now commonly used by automakers and other heavy manufacturers', more flexible and easier to train, that are now replacing workers not just in manufacturing but in distribution, circulation and service processes such as warehousing, call centres and even elder care (Markoff, 2012: np). Erik Brynjolfsson and Andrew McAfee (2011: 9), economists at the Massachusetts Institute of Technology, have sounded an alarm that the 'pace and scale of this encroachment into human skills' is now reaching a new level with 'profound economic implications.' These concerns are being echoed by mainstream economists (Krugman, 2012).

Within capital, automation threatens workers with unemployment or production speed-up. If, however, there were no dominant structural tendency for increases in productivity to lead to unemployment or greater output without reduction in labour time, automation could systematically yield to less time spent in formal workplaces. In a communist framework that protected access to the use value of goods and services, robotization creates the prospect of a passage from the realm of necessity to freedom. It reintroduces the goal – closed down both within the Stakhanovite Soviet experiment and in the wage-raising trades unionism of the West – of liberating time from work, with all this allows both in terms of human self-development and communal engagement.

Juliet Schor's (1991) estimate, that if American workers had taken gains won from productivity increases since the 1950s, not in wages but in time off, they would by 2000 have been working a twenty hour week. It indicates the scale of possible change. Proposals for a 'basic income' have recently figured in left politics. There are certainly criticisms to be made of these insofar as they are advanced as a reformist strategy, with the risk of becoming merely a rationalized welfare provision supporting neoliberal precarity. But it would be hard to envision a meaningful communist future that did not institute such measures to acknowledge the reductions in socially necessary labour time made possible by advances in science and technology, destroying Hayek's calculation problem by progressively subtracting from it the capitalist *ur*-commodity, labour power.

If robots undermine the centrality of the wage relation, the Internet presents a parallel possibility, priceless goods. Mainstream economists have long recognized the anomalous features of non-rivalrous informational goods, which can be endlessly copied at almost zero cost, all but instantaneously circulated, and shared without detracting from their use value. As intellectual and cultural production have become increasingly digitized, these tendencies to make the Internet 'a place of plenty' (Siefkes, 2012: np) have become increasingly problematic for the price system. Capital has struggled to maintain the commodity form in cyberspace, either by attempts to enforce intellectual property, or by treating informational flows as advertising accelerators for other commodities. Nonetheless, the drift to software decommodification has proven ineradicable, and been intensified by the capacities to conduct this circulation outside of centrally controlled servers, through peer-to-peer networks. Piracy, which now accounts for the majority of digital music, games, film and other software distributed in Asia, Africa, Latin America and Eastern Europe (Karaganis et al., 2011) is the clandestine and criminalized manifestation of this tendency; and the free and open source software movement its organized expression.

The latter has been the focus of interest on the libertarian left since the inauguration of the Free Software Foundation (by Richard Stallman in 1984), which released code under a General Public License (GPL), guaranteeing users the freedom to repurpose, study, customize, redistribute, and change it. As Jacob Rigi (2012) observes, the so-called 'copyleft' clause in the GPL, which requires that any program using GPL code is itself issued under GPL, is a 'dialectical negation' of copyright, because it simultaneously preserves and abolishes property in software, formulating 'an all-inclusive global property right'. This development was elaborated by Linus Torvalds' organization in the early 1990s of the online voluntary collective cooperative method for open-source software production. As Rigi (2012) says, the combination of GPL license and Linux-style open source collective programming 'represents the gist of the P2P [peer-to-peer] mode of production'; he sees in this an instantiation of Marx's 'higher communism', acknowledging the collective nature of scientific knowledge, and rejecting any scarcity-based demand for 'equivalence between contribution to social production and share of social product'.

Open source software has attained considerable practical success (Weber, 2004), while P2P production has developed in various directions, with its political inflection ranging from libertarian capitalism, to liberal views of the new 'wealth of networks' (Benkler, 2006) as supplementary to and compatible with markets, to specifically communist versions, such as the Oekonux project (Meretz, 2012), with the ecumenical Foundation for P2P Alternatives (Bauwens, 2012) working across the entire spectrum. However, even if one regards open source and P2P as a germinal of a new mode of production, difficulties in cultivating this seed have become apparent. One such difficulty is the relative ease with which capital has incorporated this seed as a contribution to downstream commodification processes: indeed, the whole tendency of Web 2.0 could be said to be the containment of 'new' P2P production and circulation methods firmly within the shell of capitalist 'old' commodity forms. The other issue has been what Graham Seaman (2002) terms the 'washing machine problem' – the gulf between virtual and material production, cornucopian software and industrial production, which seems to restrict P2P practices, however progressive, to a small subset of total economic activity.

Over the last decade, however, this gap has been narrowed by the rapid development of forms of computer controlled micro-fabrication devices: additive 3D printing is the most famous, but there are a variety of others, including subtractive micro-mills and other miniaturized and digitized engineering devices that put industrial capacities within the grasp of 'hack labs', households and small communities. These have provided the basis for an emerging 'maker' movement, which links these digital manufacturing units to the networked circulation of design, suggesting to some that the 'P2P mode of production can be extended to most branches of material production' (Rigi, 2012). These technologies are also associated with the proliferation of robots and small-scale automata; indeed, the holy grail of the 'maker' movement is the self-replicating replicator, the perfect von Neumann machine. Extrapolation from these tendencies places the 'fabbers' and 'replicators' of sci-fi imagination much closer to realization than seemed possible even quite recently.

Even the most market-oriented of 'makers' don't hesitate to point out that such developments appear to return the means of production back to popular hands (Doctorow, 2009; Anderson, 2012). But as the example of open source suggests, there is no intrinsic communizing logic in the maker movement, which could as easily result in a proliferation of micro-entrepreneurship as in a micro-industrial commons. In his critique of liberal P2P enthusiasts, Tony Smith observes that full development of commons-based peer production is 'incompatible with the property and production relations of capital' (2012: 178); as long as these relations persist those involved in volunteer peer production will continue to be explicated in the wage work on which they depend, their creations will be appropriated by capital as 'free gifts', and the wider development of such projects starved of resources.

However, in a world where investments were determined without systemically favouring the commodification of knowledge, and without the possibility of combining common goods with proprietary knowledge, the 'immense emancipatory promise' of peer-to-peer production could be fulfilled (Smith, 2012: 179). As Smith remarks, capital contains within itself a tendency to develop technologies 'that allow certain types of use-values to be distributed in unlimited numbers to individuals at marginal costs approaching zero' (2006, 341): 'In any form of socialism worthy of the name, the costs of the infrastructure and social labour required to produce products such as these would be socialized and the products would be directly distributed as free public goods to any and all who wanted them'. Although Smith is sceptical that this tendency could, 'in the foreseeable future' become prevalent throughout the economy, he concedes that if it did, the Soviet experience, 'plagued by scarcity issues', would be 'completely irrelevant to the socialist project' (2006: 241-2).

Anthropocene Knowledge Infrastructures

An abundant communist society of high automation, free software, and in-home replicators might, however, as Fraise (2011) suggests, need planning more than ever – not to overcome scarcity but to address the problems of plenty, which perversely today threaten shortages of the very conditions for life itself. Global climate change and a host of interlinked ecological problems challenge all the positions we have discussed to this point. Bio-crisis brings planning back on stage, or indeed calculation – but calculation according to metrics measuring limits, thresholds and gradients of the survival of species, human and otherwise. Discussing the imperatives for such ecosocialist planning, Michael Lowy (2009) points out how this would require a far more comprehensive social steering than mere 'workers control', or even the negotiated reconciliation of worker and consumer interests suggested by schemes such as Parecon. Rather, it implies a far-reaching remaking of the economic systems, including the discontinuation of certain industries, such as industrial fishing and destructive logging, the reshaping of transportation methods, 'a revolution in the energy-system' and the drive for a 'solar communism' (Lowy, 2009: np).

Such transformations would involve cybernetics along two major axes, as both contributors to the current bio-crisis and as potential means for its resolution. On the first of these axes, the ecological costs of nominally 'clean' digital technologies have become increasing apparent: the electrical energy requirements of cloud computing data-centres; the demands of chip manufacture for fresh water and minerals, the latter from large scale extractive enterprises; and the resulting prodigious quantities of toxic e-waste. Making every home a fab-lab mini-factory will only speed-up planetary heat death. Contrary to all idealistic notions of virtual worlds, cybernetics are themselves inextricably part of the very industrial system whose operations have to be placed under scrutiny in a new system of metabolic regulation that aims for both red and green plenty.

However, cybernetic systems are also a potential part of any resolution of the bio-crisis – or, indeed, of even fully recognizing it. Paul Edward's (2010) *A Vast Machine* analyzes the global system of climatological measurement and projection – the apparatus of weather stations, satellites, sensors, digitally archived records and massive computer simulations, which, like the Internet itself, originated in US Cold War planning – on which comprehension of global warming rests. This infrastructure generates information so vast in quantity and from data platforms so diverse in quality and form that it can be understood only on the basis of computer analysis. Knowledge about climate change is dependent on computer models: simulations of weather and climate; reanalysis models, which recreate climate history from historical data; and data models, combining and adjusting measurements from multiple sources.

By revealing the contingency of conditions for species survival, and the possibility for their anthropogenic change, such 'knowledge infrastructures' of people, artifacts, and institutions (Edwards, 2010: 17) – not just for climate measurement, but also for the monitoring of ocean acidification, deforestation, species loss, fresh water availability – reveal the blind spot of Hayek's catallaxy in which the very grounds for human existence figure as an arbitrary 'externality'. So-called 'green capital' attempts to subordinate such bio-data to price signals. It is easy to point to the fallacy of pricing non-linear and catastrophic events: what is the proper tag for the last tiger, or the carbon emission that triggers uncontrollable methane release? But bio-data and bio-simulations also now have to be included in any concept of communist collective planning. Insofar as that project aims at a realm of freedom that escapes the necessity of toil, the common goods it creates will have to be generated with cleaner energy, and the free knowledge it circulates have metabolic regulation as a priority. Issues of the proper remuneration of labor time require integration into ecological calculations. No bio-deal that does not recognize the aspirations of millions of planetary proletarians to escape inequality and immiseration will succeed, yet labour metrics themselves need to be rethought as part of a broader calculation of the energy expenditures compatible with collective survival.

Conclusion: For K-ommunism?

Marx (1964), in his famous, or notorious, comparison of the 'worst of architects' and the 'best of bees', saw the former distinguished by an ability to 'erect in imagination' the structure he will create. Today, with our improved knowledge of bee communities, this distinction reeks of anthropocentricism. Yet even alongside bees, beavers and other primates, humans manifest a hypertrophic planning capacity. The Soviet experience, of which the cyberneticians featured in *Red Plenty* were part, was only a narrow, historically specific and tragic instantiation of this capability, whose authoritarianism occludes the most crucial point in the Marxist concept of planning, namely that it is intended as a means of communal election of which, of a variety of trajectories, collective human 'species-becoming' might follow (Dyer-Witheford, 2004).

A new cybernetic communism, itself one of these options, would, we have seen, involve some of the following elements: use of the most advanced super-computing to algorithmically calculate labour time and resource requirements, at global, regional and local levels, of multiple possible paths of human development; selection from these paths by layered democratic discussion conducted across assemblies that include socialized digital networks and swarms of software agents; light-speed updating and constant revision of the selected plans by streams of big data from production and consumption sources; the passage of increasing numbers of goods and services into the realm of the free or of direct production as use values once automation, copy-left, peer-to-peer commons and other forms of micro-replication take hold; the informing of the entire process by parameters set from the simulations, sensors and satellite systems measuring and monitoring the species metabolic interchange with the planetary environment.

This would indeed be a communism heir to Lenin's 'soviets plus electricity', with its roots in red futurism, constructivism, tektology and cybernetics, together with the left-science fiction imaginaries of authors such as Iain M. Banks, Ken McLeod and Chris Moriarty. It would be a social matrix encouraging increasingly sophisticated forms of artificial intelligence as allies of human emancipation. For those who fear the march of the machine it holds only this comfort: whatever singularities might spring from its networks would not be those of entities initially programmed for unconstrained profit expansion and the military defense of property, but rather for human welfare and ecological protection. Such a communism is consonant with a left accelerationist politic that, in place of anarcho-primitivisms, defensive localism and Fordist nostalgia, 'pushes towards a future that is more modern, an alternative modernity that neoliberalism is inherently unable to generate' (Williams & Srnicek, 2013). If it needs a name, one can take the K-prefix with which some designate 'Kybernetic' endeavors, and call it 'K-ommunism'. The possibile space for such a communism now exists only between the converging lines of civilizational collapse and capitalist consolidation. In this narrowing corridor, it would arise not out of any given, teleological logic, but piece by piece from countless societal breakdowns and conflicts; a post-capitalist mode of production emerging in a context of massive mid-twenty-first century crisis, assembling itself from a hundred years of non-linear computerized communist history to create the platforms of a future red plenty.

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