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THE 'CRISIS OF NOOSPHERE' AS A LIMITING FACTOR TO ACHIEVE THE POINT OF TECHNOLOGICAL SINGULARITY

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ABSTRACT

One of the most significant developments in the history of human being is the invention of a way of keeping records of human knowledge, thoughts and ideas. In 1926, the work of several thinkers such as Edouard Le Roy, Vladimir Vernadsky and Teilhard de Chardin led to the concept of noosphere, the idea that human cognition and knowledge transforms the biosphere into something like a thinking layer of the planet. At present, it is commonly accepted by some thinkers that the Internet is the medium that will give life to noosphere. According to Vinge and Kurzweil's technological singularity hypothesis, noosphere would in a future be the natural environment in which a 'human-machine superintelligence' would emerge to reach the point of technological singularity. In this article we show by means of numerical models that it is impossible for our civilization to reach the point of technological singularity in a near future. We propose that this point could be reached only if Internet data centers were based on "computer machines" that are more effective in terms of hardware and power consumption than the current ones. Finally, we speculate about 'Nooscomputers' or N-computers, as hypothetical machines oriented not only to the management of information, but also knowledge, and much more efficient in terms of electricity consumption than current computers. Possibly a civilization based on N-computers would allow us to successfully reach the point of technological singularity.

KEYWORDS

noosphere, technological singularity, omega point, energy consumption, Malthusian growth model, S-curve, N-computer

CLASSIFICATION

JEL: O10, Q55

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INTRODUCTION

One of the most significant developments in the history of human being is the invention of a way of keeping records of human knowledge, thoughts and ideas. The storage of knowledge is a sign of civilization, which has its origins in ancient visual languages e.g. in the cuneiform scripts and hieroglyphs until the achievement of phonetic languages with the invention of Gutenberg press. In 1926, the work of several thinkers such as Edouard Le Roy, Vladimir Vernadsky and Teilhard de Chardin [1] led to the concept of noosphere, thus the idea that human cognition and knowledge transforms the biosphere coming to be something like the planet's thinking layer. At present, is commonly accepted by some thinkers that the Internet is the medium that brings life to noosphere. Hereinafter, this essay will assume that the words Internet and noosphere refer to the same concept, analogy which will be justified later.

In 2005 Ray Kurzweil [2] published the book *The Singularity Is Near: When Humans Transcend Biology* predicting an exponential increase of computers and also an exponential progress in different disciplines such as genetics, nanotechnology, robotics and artificial intelligence. The exponential evolution of these technologies is termed as Kurzweil's 'Law of Accelerating Returns', leading this rapid development of human beings to a situation that is known as 'technological singularity'. According to Vinge [3] and Kurzweil's technological singularity hypothesis, noosphere would be in the future the natural environment in which human-machine superintelligence will emerge after to reach the point of technological singularity.

According to James Lovelock's Gaia hypothesis (Fig. 1) the living and non-living parts of the planet form a self-regulated complex system maintaining life on Earth [4]. Such whole system is known with the name of biosphere. Somehow the living and non-living beings evolve together [5, 6], having organisms an influence on their environment [7] and the environment in turn affects the organisms by means of Darwinian natural selection. For instance, photosynthetic organisms regulate global climate, marine microorganisms may be keeping the oceans at a constant salinity and nitrogen-phosphorus concentrations, etc. In agreement with [8] a prerequisite for the coming of the noosphere is the existence of the technosphere. In some way the biosphere is a stable, adaptive and evolving life system with sufficient free energy to power the launching of a technosphere [9]. Therefore, technosphere emerges as a physical environment on Earth being a new layer inhabited by machines, cities and industry with an influence into the biosphere (Fig. 1).

However, and according to the data available today, how realistic is the technological singularity hypothesis? In this essay we present a criticism of Kurzweil's 'Law of Accelerating Returns' focusing on the fact that the exponential growth assumes unlimited resources and energy. Our criticism of Kurzweil's ideas is inspired by computer video games simulating the course of a civilization or a city, e.g. SimCity, and the predictions obtained with simple simulation experiments of population dynamics based on differential equation models.

In this essay we show that if we consider the energy that sustains the noosphere, i.e. Internet, and its growth is simulated by means of an exponential numerical model then it is impossible that our civilization reaches the point of technological singularity in the near future. Our model is based on some fundamental assumptions and simple simulation experiments, obtaining as a plausible scenario what we have called as 'crisis of noosphere'. Assuming that at the present time Internet stores at least 1000 Exabytes (1 Exabyte = 10^{18} bytes) and human knowledge doubling occurs every 12 months, will come a point in the next 50 years (by the year 2063) or maybe before when Internet will consume the total electricity produced worldwide. With current technology this energy would

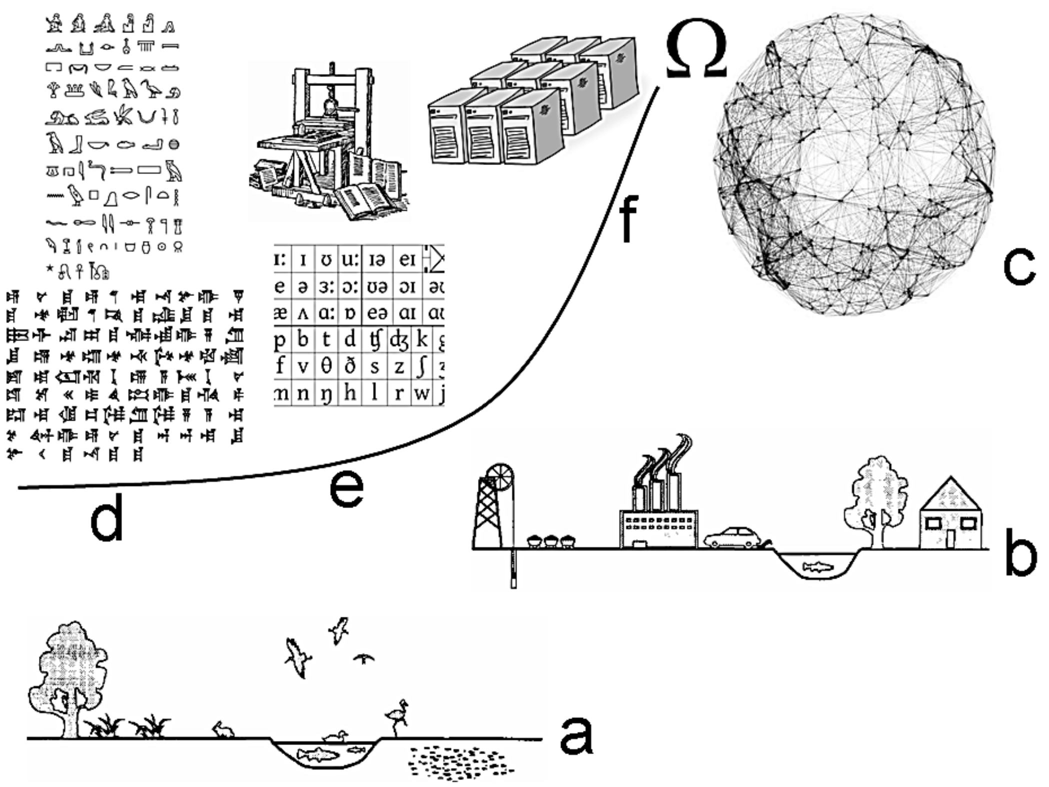

Figure 1. Vernadsky's hypothesis of Gaia states that noosphere (**c**) is the third layer of development of the Earth, after biosphere (**a**) and technosphere (**b**). For Vernadsky noosphere is "the last of many stages in the evolution of the biosphere in geological history". Teilhard de Chardin states that noosphere is growing towards the Omega point (Ω). Initially the ancient noosphere was very primitive and knowledge was stored in stone or papyrus (**d**, cuneiform scripts and hieroglyphs), later in paper (**e**, Gutenberg press) and currently as a global network of computers (**f**, Internet). Therefore, with the passage of time has changed the information storage media. Now, we must ask the question, is the noosphere energetically sustainable?

be equivalent to the energy produced by 1 500 nuclear power plants. Once this happens there will be a collapse of the noosphere and possibly also from biosphere. Therefore, we believe that with the current technology we are really far from reaching the point of technological singularity.

However, we believe that if a 'paradigm shift' occurs first – somewhat like a Cambrian explosion but of technology – then the singularity point could be reached later. Thus, the point of singularity could be achieved with a paradigm shift, namely the design of a noosphere which hardware be adaptable to available energy and designing a more efficient computer machines that the current ones. A sistemic model of a noosphere ranging in size according to the available energy is simulated based on Lotka-Volterra equations, assuming that Internet is a *predator* specie that feeds voraciously on a *prey*, the electric power. A hardware architecture with this dynamic behaviour would make it possible to have an Internet being sustained by 'computer machines' more effective in terms of power consumption than current ones. And in this respect the Volterra-Lotka model could give us some clues about how the Internet should be designed.

Moreover, we propose the use of non-conventional technologies for the design of a new class of computer-oriented to the implementation of the noosphere. In this essay we speculate about what we have called 'Nooscomputer' or *N-computer*, a hypothetical machine, resembling a Turing machine, but capable of storing and processing human knowledge through emerging computational paradigms, i.e. quantum computation, DNA and Egan's *Permutation City* algorithms. The use of N-computers in data centers would make available a new class of Internet consuming far less power, which would probably help to our civilization to reach the point of technological singularity.

IS THE INTERNET THE NERVOUS SYSTEM OF THE NOOSPHERE?

Noosphere is a term that was introduced by Édouard Le Roy (1870-1954), Vladimir Vernadsky (1863-1945) and Teilhard de Chardin (1881-1955) referring to the sphere of human thought [10]. Edouard Le Roy was the first who used the notion 'noosphere' in a scholarly publication entitled *L'exigence idéaliste et le fait l'évolution* published in 1927. Le Roy wrote [1]:

"*Beginning from a man, evolution carried out with new, purely psychic meanings: through the industry, society, language, intellect etc, and thus biosphere transforms into noosphere*".

However, the explanation of how noosphere arises varies from one thinker to another. The noosphere term was coined by the French theologian and scientist paleontologist Pierre Teilhard de Chardin in 1925 and disseminated in posthumous publications in the 1950's and 1960's. According to Teilhard [11, 12] the noosphere emerges as a result of the interaction among humand minds. However, for [8] Vernadsky and although the noosphere is not a material layer it emerges once of human beings sufficiently progress, for example reaching the ability to create new material resources. In the point of view adopted by Teilhard the noosphere will grow up to the point called Omega, the end of history (Fig. 1). For Teilhard the 'Omega point' is the maximum level of complexity and consciousness towards which he believed the universe is evolving. The evolution of humanity toward some ideal situation has received several names, whether Omega point or technological singularity. Now, while the first term has a spiritual meaning the second one has a technological taste. The concept of technological singularity was introduced in the 1950's by John von Neumann [13] who thought that humanity is approaching some a point where once reached would change the course of humanity. At present the singularity advocates predict an explosion of intelligence in which powerful supercomputers and other machines will be well over human skills and intelligence. Among other factors, this explosion of intelligence will result from a dramatic breakthrough in artificial intelligence. So while the concept of Omega point is characteristic of theistic evolutionists, e.g. Francis Collins [14], the concept of technological singularity usually is defended by scientists for whom science promises a limitless evolution of humankind. No matter how this critical point is named, in this essay we will denote it by Ω. At present, at the time of writing this paper, there are several predictions of possible dates in which our civilization will reach this point. All the proposed dates have a common feature, whether it is 2045 predicted by Kurzweil or 2030 foreseen by Vinge, in just a few years we will have reached the Ω point.

At present, there are several opinions that support the role of Internet as the nervous system of the noosphere. For example, Hagerty [15] thinks that Internet is playing the role of Teilhard's mechanical apparatus of the noosphere. Shenk [16] believes that even when the World Wide Web is a repository for the knowledge of humankind, it is only the beginning of the development of the global mind, and therefore the noosphere. According to Heim [17], Teilhard envisioned the convergence of humans in a single massive noosphere or 'mind sphere', maybe the 'virtual communities' mentioned by McLuhan's global village or Teilhard's Omega point. In accordance with Heim, a thinker and philosopher concerned with virtual reality, we have enriched the process of creating further realities through virtualization. Taking a step forward in this reasoning and assuming that such virtual realities are 'windows to the noosphere' then we arrive to the conclusion that Internet is the hardware of such virtualization.

Now then, how does the noosphere originate from the technosphere? In this essay, we propose the following model. According to Figure 2 technosphere would be an open system since it meets the following characteristics: (i) It is made up of parts that interact with each other, (ii) it is oriented to a purpose, (iii) consumes materials producing a product or service, (iv) consumes energy, (v) interacts, reacts and affects the environment, (vi) it grows, changes and adapts, that is evolves and finally (vii) it competes with other systems, for example with the biosphere. Accordingly as such open system, technosphere would have an *input* (information, money, energy, resources, etc.) and *output* (information, money, goods, services, etc.). The input processing would results in several outputs, including information. The technosphere also produces other undesirable outputs, such pollutants and wastes. Then a part of or all the information obtained can be processed again becoming knowledge. Transforming information into knowledge means that technosphere was able to discover patterns, relationships and trends resulting in formalized and objective contents. Therefore, while the information may be stored in a databases, the knowledge requires more sophisticated media, for example in the knowledge base of an expert system [18]. Another possibility is that the information is forwarded to the input to be processed again. Finally, as the technosphere produces information and knowledge, over and over again, these are embodied in a new entity: the noosphere.

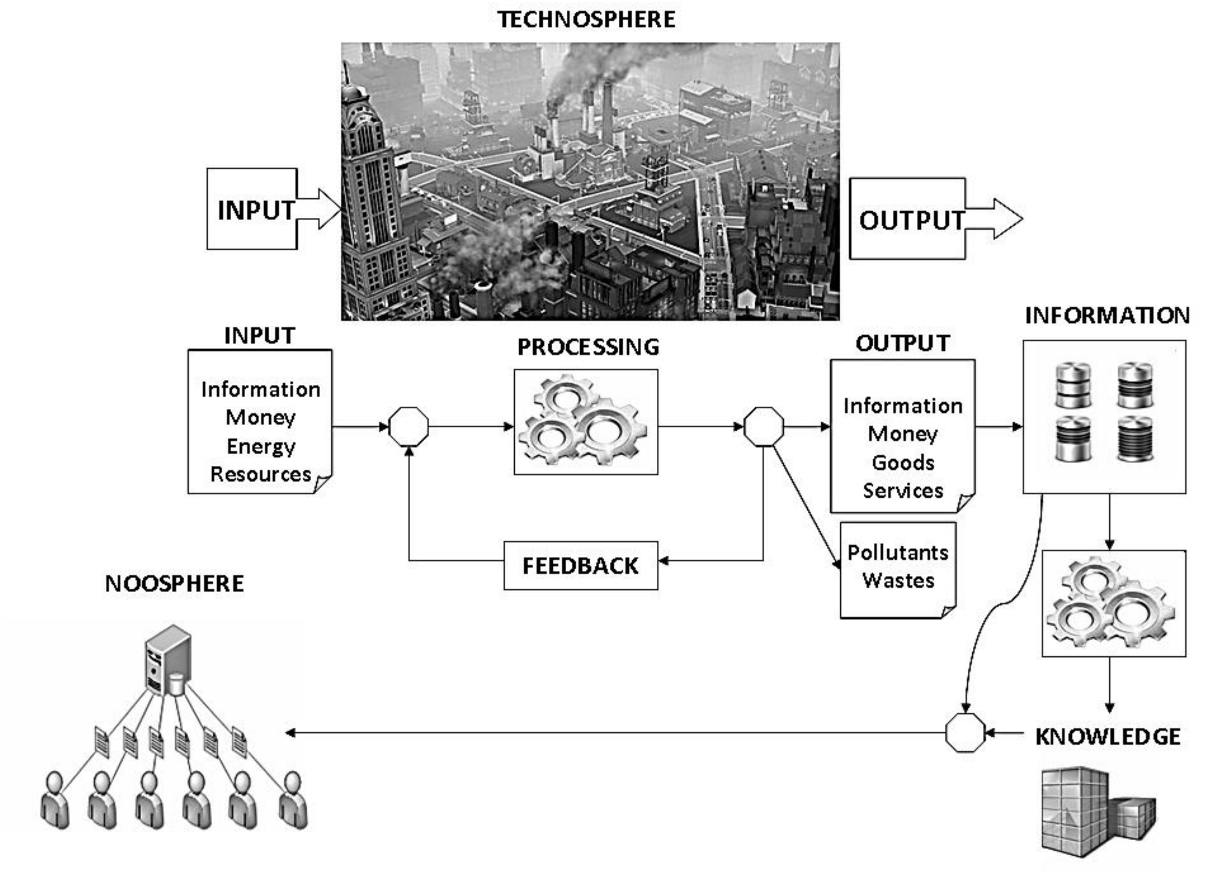

Figure 2. A possible explanation of the origins of the noosphere from the technosphere.

THE ORIGINS OF THE CRISIS: TECHNOSPHERE COMPLEXITY AND ENERGY CONSUMPTION

In accordance with previously described model the noosphere is arising from development of technosphere. This means that the noosphere inherits all the strengths and weaknesses of its predecessor, the tecnosphere. Consequently, what are the causes of the noosphere crisis? Let us consider the following possible explanation.

Recently Arbesman[1] used *SimCity* -an open-ended city-building computer video game- to measure a city's Kolmogorov complexity. Thus, the complexity of a city could be measured as the shortest algorithm required to reproduce it. Since the technosphere includes the cities of our planet Earth, this method could be used to estimate a minimum value of complexity of the technosphere from the complexity value obtained in the cities. In a theoretical realm, using a small dataset of population sizes and file sizes of some cities constructed with SimCity 3000, Arbesman found how complexity linearly scales with population size. Furthermore, it is interesting to note how this result coincides with other similar results obtained with real cities. Bettencourt et al. [19] demonstrated as most aspects of a city, such as electrical use, employment, or population growth, increase linearly based on the city size.

Within the above framework human societies are distinguished by their dominant pattern of energy harvesting, a behaviour which has been called the *energy paradigm* [20, 21]. For example, Garrett [22] modelled the civilization as 'heat engine' because of the need to consume energy. In accordance with this paradigm collapsing civilizations are complex systems that continued to grow beyond the limits of their energy budget. This would be true unless such civilization makes the effort to find an efficient mechanism of technological transition. Therefore, there is a limit to the unlimited growth of the technosphere unless we are able to find a new technology that allows us to build a new technosphere energetically more efficient and therefore energetically sustainable. That is, the 'crisis of noosphere' would be a consequence of the high energy consumption and therefore the noosphere would be inheriting from technosphere this major flaw. Today, Internet – the nervous system of the noosphere – has become a true electric power predator.

A NUMERICAL MODEL OF NOOSPHERE

Numerical models are mathematical models that use some sort of numerical time-stepping procedure for predicting the system behaviour over time. One application of the numerical models is the study of complex societies as a predictable phenomenon, making predictions according to a mathematical model. Whether using differential [23, 24] or probability theory [25], it is possible to explain from collapse societies such as the Maya civilization to the effects of warfare or some social policies. In fact, some popular computer games, for example *Civilization V*, behave according to some differential equations such as the Malthusian model and simple polynomials of different degrees (ref.: see in Internet the blogs about this game).

In this section and using an exponential (1) or Malthusian growth model [26], we build a simple model (see Appendix, *Scenario 1*) that illustrates what we have called as 'crisis of noosphere':

$$y_1' = k_1 y_1, \tag{1}$$

where y_1 is the amount of information stored in Internet, i.e. the noosphere, and k_1 is the Malthusian parameter, thus the information growth rate.

Based on the reasoning made in the previous section, we will consider the following features about the Internet, the hardware that gives life to the noosphere:

1. Digital information is housed in data centers around the world, doubling in size every 2 years. There are over 500 000 data centers in the world[2].

Internet and other forms of information technology account for 2 % of all electrical energy used globally. Most data centers that house computer servers rely on non-renewable energy resources, i.e. nuclear and coal-powered energy[2].

According to estimates made by US industry experts: Internet consumes 30 billion watts or 30 nuclear power stations[3].

2. Moore's law can be applied to the amount of information that people feed into the Internet each day. Only USA stores approximately 898 exabytes (1 EB = 1 000 Petabytes = 1 000 000 Terabytes = 1 billion gigabytes) – nearly a third of the global total information (Western Europe has 19 % and China has 13 %)[4].

Assuming that digital information housed in data centers is doubling its size every 2 years, $k_1 = 2$, and setting an initial amount of information y_0 equal to 1000 EB, likely an underestimation of the global actual value, we obtained the results shown in Figure 3:

$$y = y_0 \exp(k_1 t) . \quad (2)$$

Since to date, 30 nuclear plants represent 2 % of the electrical energy consumed globally, we deduce that by the year 2062 the noosphere will require about 1 500 nuclear power plants, i.e. 100 % of the overall electric energy produced on Earth. According to Figure 3 from the year 2030 the amount of information stored in the noosphere will be around of 10^{17}. This amount of information will have almost doubled the age of the universe (10^9 according to NASA's WMAP Project) and account for 21 % of the number of atoms in the universe (10^{78}).

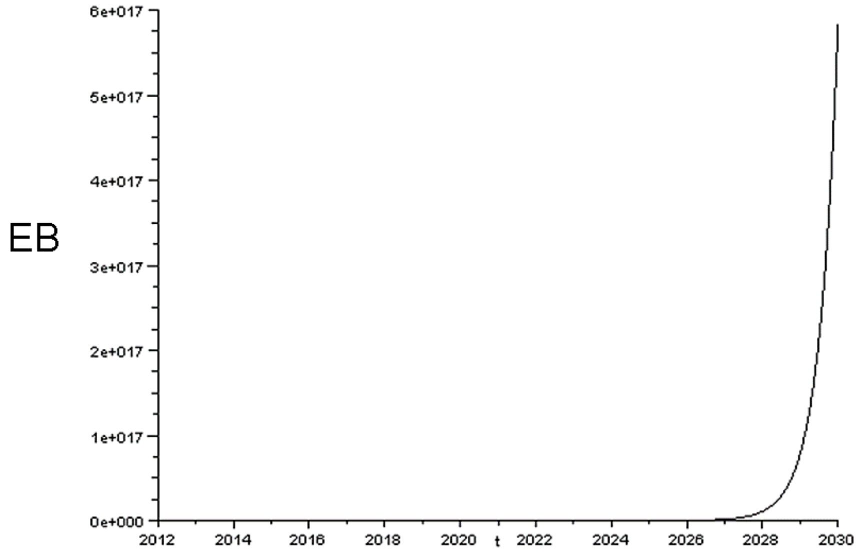

Figure 3. Exponential growth of the size of the noosphere (EB) under the assumptions of the "technological singularity" hypothesis.

Is this technology scenario sustainable? Obviously, it doesn't seem that way. According to the excellent essay "The Sigularity Myth" [27] written by Theodore Modis[5] there are several reasons why the singularity is not so near. We do not say that it is impossible to achieve in the future, we say that singularity is unattainable with current technology. Among other reasons, the most important are (*i*) all natural phenomena grow according to the S-curve or logistic function which can be approximated by an exponential or Malthusian model in its early stages. For instance, Modis shows how world population has grown significantly during the 20th century depicting an exponential model during early decades which becomes a logistic after World War II. A similar behaviour can be seen with the cumulative oil production in the US and Moore's law, concluding that all exponential natural phenomena will eventually turn into logistics (Modis, 2003) [28]. Therefore, if the exponential is replaced by a logistic or S-curve, what effect will this change have on the predictions made by Kurzweil?

One of the Kurzweil’s predictions claims that singularity will be reached by 2045. However, in agreement with our model (*ii*) by that date and if our civilization continues with current technology, the noosphere will store an amount of information equal to $4{,}295\times10^{12}$. On that date the noosphere will consume a 66 % of the overall electric power produced on Earth, i.e. the electrical energy produced by 990 nuclear power plants.

In agreement with Modis (*iii*) the date on which the singularity is reached will depend to a large extent on the evolution of computing performance. Moreover, we think that the von Neumann architecture, i.e. the design logic behind today’s computers, is not the most suitable to manage information and knowledge. For this reason we believe that our civilization will have to face in the near future a *technological transition* resulting in a new kind of computer architecture. Assuming the trend of exponentially growing will continue until 2045 then the computer power will reach 6×10^{23} Flops (floating-point operation per second) or according to Modis and assuming a model of growth in S-curve after 2045 computers will reach a maximum value of 10^{25}. In other words, the computational efficiency of computers will be well below that of Kurzweil’s prediction of 10^{50} and above.

The scientific and technological criticisms mentioned previously (*i*, *ii* and *iii*) seem sufficient to justify the need for a technological transition. This technological transition will be a precondition before our civilization can reach the point of singularity. Therefore, so is our civilization today ready for this technological change? At present we know that (*iv*) technological breakthroughs emerge in a similar manner to the evolution of species, thus according to the punctuated equilibrium principle. This principle introduced by the naturalist Stephen Jay Gould states that speciation occurs in spurts of major changes that punctuate long periods of little change. According to theoretical predictions [28] in the case of technological breakthroughs the future milestones will appear progressively less frequently. In fact, there are thinkers, such is the case of Huebner [29], who argues that the rate of technological innovation is at present decreasing as shown by the fact that the number of patents has been declining since the period 1850-1900.

In short, if we want our civilization to reach the point of singularity in the future, we must previously change the technology that currently supports the noosphere.

A SYSTEMIC MODEL OF THE NOOSPHERE

In this section we will propose an alternative numerical model for the noosphere. Although the model is actually a metaphor, it may help us to find the conditions under which the Internet would be energetically sustainable. Inspired by models in ecology we assume in the model that Internet is a *predator* specie (for example foxes) that feeds voraciously on electric power. Hence, we assume that electrical energy represents the other specie, specifically the *prey* (for example rabbits). The Lotka-Volterra equations (3) [30, 31] arise when the predator y_2, thus Internet, is related with the prey, the electrical energy y_1, resulting the coexistence of both species (Fig. 4):

$$\begin{aligned} y_1' &= y_1(k_1 - k_3 y_2), \\ y_2' &= y_2(-k_2 + k_3 y_1), \end{aligned} \tag{3}$$

where k_1, k_2 and k_3 are parameters describing the electric energy production, the loss rate of noosphere (in size) and the interaction (predation rate) of the two ‘species’, respectively. Equations (3) allow us to have a systemic model of the noosphere since this model shares some features with other phenomena in which the equations have been applied, e.g. predator-prey interactions, in the theory of autocatalytic chemical reactions as well as in economic theory and modelling historical civilizations [23]. However, since this model is a metaphor, indeed a thinkertoy, it is assumed that the size of the noosphere varies (e.g. EB, number of data centers, servers etc.). Of course, the variable size of the noosphere is an Internet feature that should be included in the future to make Internet energetically sustainable. That is, its size varies according to the increasing or decreasing of the amount of electrical power available on Earth. Also we assume that the amount of electric energy is measured, e.g. as number of nuclear power plants, by varying the number of nuclear plants according to the size of the noosphere. Using the model (3) and setting up parameter values and initial conditions (see Appendix, *Scenario 2*) we illustrate a plausible systemic model of the noosphere (Fig. 5).

Following, we propose an alternative model in which the electrical energy equation is modified according to what is known as the energy paradigm. In agreement with Karakatsanis [21] the dynamics of an energy paradigm could be expressed by the following equation:

$$y_1(t) = \varepsilon_t y_1(t-1) - \frac{(1-\alpha)\varepsilon_t}{A_t} y_1^2(t-1). \tag{4}$$

In equation (4) the ratios between the parameters ε, α and A define the model dynamics. Inspired by (4) we included $k_4 y_1^2$ term in the first equation of the Lotka-Volterra model (3).

Using this modification it is possible to simulate a civilization, for example our civilization, evolving its energy consumption policy under the threat of energy depletion:

$$\begin{aligned} y_1' &= y_1(k_1 - k_3 y_2) - k_4 y_1^2, \\ y_2' &= y_2(-k_2 + k_3 y_1), \end{aligned} \tag{5}$$

Based on these new expressions we can simulate a new scenario for the noosphere (see Appendix, *Scenario 3*) under the influence of so-called energy paradigm. In the model (5) k_4 is the resource depletion pressure, i.e. electric energy.

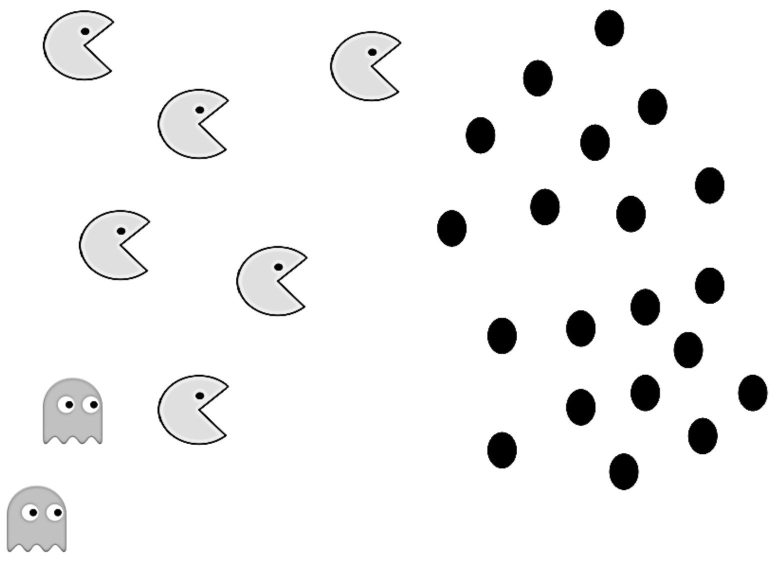

Figure 4. 'Pacman game' without ghosts (they eat the Pacs) is a good metaphor for a systemic model of the noosphere (the dots represent the energy/prey, the Pac represents Internet/predator). In this case the number of Pacs and dots available could coexist in equilibrium according to a Volterra-Lotka model.

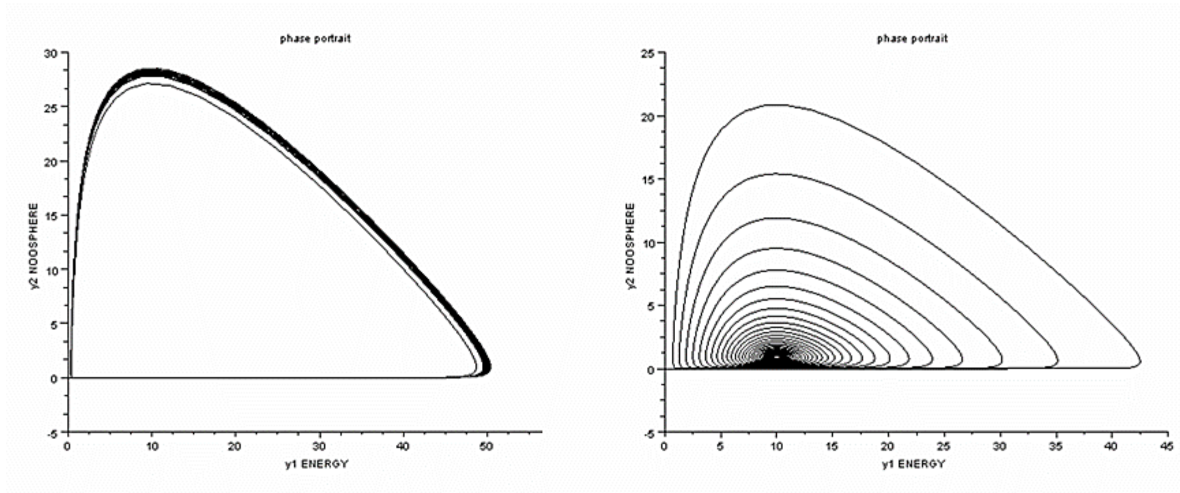

Figure 5. Cycles solution for coexistence between noosphere and electrical energy. Left(right) graph shows *Scenario 2* (*Scenario 3*).

BUT IS THERE ANY CHANCE OF GETTING TO THE Ω POINT? THINKING ABOUT N-COMPUTERS

As referred to in the introduction in this essay we speculate about *N-computers*, an abbreviation for 'Nooscomputer', thus a hypothetical machine resembling a Turing machine but capable of storing and processing human knowledge. At present such machine could be imagined as a result of very diverse technologies, namely through quantum computation [32], DNA and Egan's *Permutation City* algorithms. One goal in this essay is to give some highly speculative solution to criticisms that we discussed earlier.

The use of N-computers in data centers would have two advantages. On one side, future generations will have a new class of Internet with (*i*) electric power *consumption* well below the current one, on the other hand an Internet designed according to a (*ii*) *scalable architecture*, i.e. the number of servers would increase or decrease depending on knowledge storage needs and electric power availability.

Figure 6 shows a sketch of the elements and logical organization of an N-computer. At right, and inside of a box, the sketch shows the main memory, control unit (CU), registers (AX, BX) and the arithmetic logic unit (ALU). Although in principle this architecture is similar to the current computers based on von Neumann architecture, our proposal varies significantly by the 'hardware' from which elements are made. For example, while main memory is DNA, the ALU operates based on cellular automata. Thus, the microprocessor is a cellular automata engine combined with DNA-based computing. On the left, the figure shows how the N-computer is provided with a von Neumann self-replicating automaton[6]. This automaton would allow the self-replication of N-computer like a 'predator specie' growing Internet, and therefore the noosphere, according to Volterra-Lotka model. Thus, while a significant portion of the DNA memory is dedicated to storing knowledge, a small portion of DNA is devoted to encode the information for self-replicating a copy of the N-computer. Of course, an N-computer also can be 'killed', i.e. shutdown, if required by the Volterra-Lotka dynamics.

In 2012 Church et al. [33] stored a few petabytes (10^{15}) in a single gram of DNA. They encode one bit per base: adenine (A) or cytosine (C) for zero, guanine (G) or thymine (T) for one, synthesizing strands of DNA that stored 96 bits. In order to read the data stored in DNA the sequence of bases (A, T, G, and C) is translated to a binary string. Each strand of DNA has a 19-bit address sequence playing the role of a memory address. One of the most interesting features of the 'DNA memory' is its great stability. Nearly a year after this finding

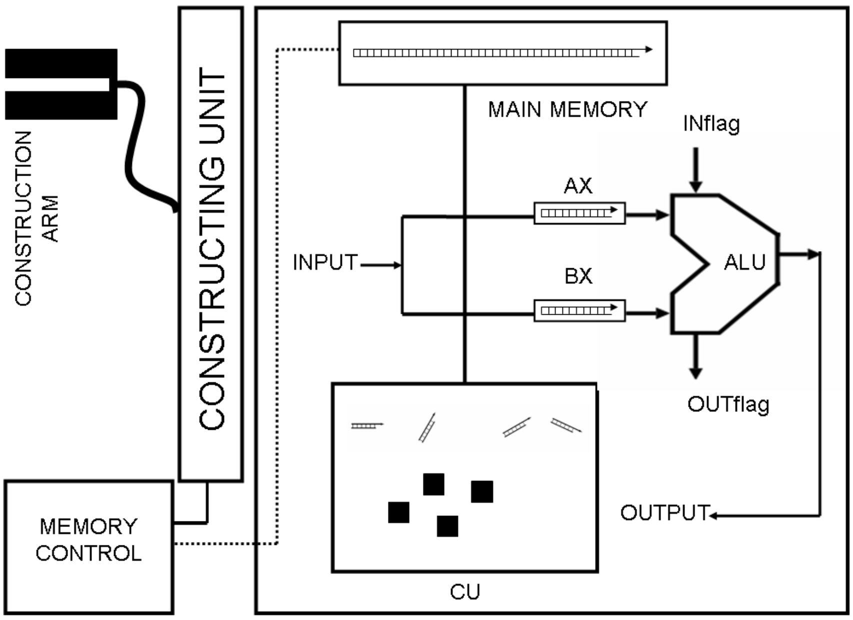

Figure 6. *N*-computer architecture. In the 'Pacman game' in Figure 4 each Pac would have a skeleton as shown in this sketch.

Goldman et al. [34] were able of encoding all 154 of Shakespeare's sonnets in DNA, 26-second audio clip from Martin Luther King's famous "I have a dream" speech and a copy of James Watson and Francis Crick's classic paper on the structure of DNA.

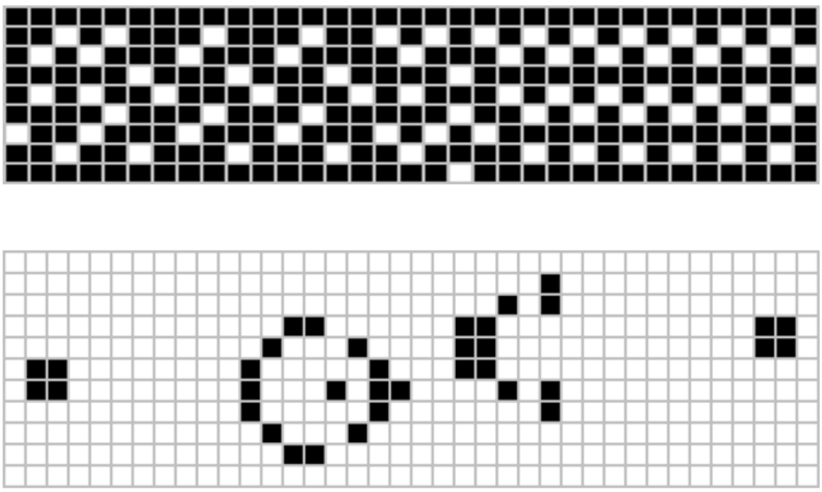

Figure 7. Garden of Eden (top) and spacefiller (bottom) configurations.

Based on previous experiments we envision N-computer main memory implemented with DNA strands. Registers (labelled in the sketch as AX and BX, obviously N-computers can have more than two) implemented too with small DNA memories while the CU is built by a mixture of DNA and enzymes[7]. The CU performs very different functions, either converting a DNA sequence to binary, the inverse operation, or such as a search engine (maybe a version of Google but at molecular level or 'Moolgle') identifying certain sequences in the DNA strand. CU also controls which DNA sequences are read, written or deleted, ruling an important mission: CU includes the molecular machinery necessary for DNA replication. The latter task is required when von Neumann self-replicating automaton comes into operation resulting in one or more N-computer 'children'.

Consider the following example. If a DNA sequence is TATAGCCG storing some knowledge about the Roman Empire, establishing that subunits T and G are equal to 1 and adenine A and C are equal to 0, then CU transforms this sequence to 10101001. This binary sequence is temporarily stored in the AX register and defines the initial state of the cellular automaton in the ALU. Applying this procedure, the N-computer can perform the processing of knowledge, conduct operations with the knowledge stored in the DNA, e.g. change data, delete data, relate two DNA sequences storing related knowledge, etc.

So how can we implement the ALU on this new computer? In 1994 Greg Egan wrote *Permutation City* [37], a hard-core science fiction novel that explores a model of consciousness and reality. Despite being a science fiction novel the computational paradigm that underlies is extremely interesting and suggestive. The author assumes that consciousness is Turing computable and consequently it could be simulated by a computer program. Although it is a science fiction novel, in reality the idea is not so far-fetched. In the 1990’s Roger Penrose and Stuart Hameroff [38] proposed that consciousness takes place within neurons in structures called microtubules. Recently, Alfonseca et al. [39] were able to simulate with a new class of cellular automata, the mechanism at cellular level that could support consciousness according to the Hameroff-Penrose hypothesis. Our model was based on a new class of hybrid cellular automata (QvN), capable of performing as either a quantum cellular automata (QCA) or as a classical von Neumann automata (CA). In the simulation experiments we showed how the mechanisms conjectured in the Hameroff-Penrose hypothesis could take place in the microtubules. Thus, how classical von Neumann automata states leads to emergence of quantum coherent superposition, taking place transitions between the quantum and classical worlds. According with this hypothesis some high level brain faculties, e.g. consciousness, occur in the transitions from quantum steps to classical ones. Therefore, consciousness could be computed with a very simple machine which is restricted to a few simple operations, named Turing machine. In addition it is also assumed that it is possible to “copy” the consciousness of a human brain, “living” these copies or brain emulations as objects in a virtual reality (VR) environment. From these assumptions a VR city is created, Permutation City. In this VR environment copies are the only objects simulated in full detail, while the remainder of the objects are simulated with varying the rendering grain, using lossy compression and hashing algorithms[8]. At one point the Egan’s novel explains that the city is a fragment of a Garden of Eden[9], configuration of an expanding massively celullar automata [18, 40] universe known in this fiction as TVC (Turing, von Neumman, Chiang). Since Garden of Eden configurations can only be obtained if the simulation has been designed for this purpose by an intelligent being, then this configuration is used as clue to show that a copy is ‘living’ in a simulated world. However, and this is the scientifically interesting aspect of the novel, this cellular automata universe has properties that make it similar to the *spacefiller* configuration in Conway’s Game of Life[10]. Consequently, taking inspiration from this novel we could design and build the ALU of N-computers.

In an N-computer we replace consciousness by knowledge. An important feature of this change is that whereas it is assumed that consciousness is not computable [38], although the mechanism that generates it may be, and therefore cannot be simulated by a Turing machine as in the Egan’s novel, knowledge is computable and therefore treatable with a Turing machine. An example of the latter are expert systems [18]. Since the binary sequences representing some knowledge, e.g. 10101001, are the *input* data or initial cellular automata configuration of the ALU, it seems appropriate that ALU performs operations based on something similar to some configurations found in Conway’s Game of Life. This procedure is what we call in this essay as *Egan’s algorithm*. Finally, the *output* will be the final state of the automata (at equilibrium, or at a given iteration, etc.) which can be transformed from a binary code (0s and 1s) to a DNA sequence of A, T, G and C.

One of the hard problems to be solved on the N-computers is their construction. Although this is surprising some authors have been able to combine DNA, quantum computing and cellular automata in the same recipe [41] getting to know this cocktail as the *femtocomputing* paradigm. De Garis [42] shows theoretically how the properties of quarks and gluons can be used to perform computation at the femtometer (i.e. 10^{-15} meter) scale. Therefore, an N-computer could be build using non-standard hardware, thus with unconventional computational hardware.

CONCLUSIONS

In 1962 Arthur C. Clarke wrote the novel *Profiles of the Future: An Inquiry Into the Limits of the Possible*, writing the following thought:

"Any sufficiently advanced technology is indistinguishable from magic."

Thirty-two years later Greg Egan wrote *Permutation City*, stating in the novel:

"computers aren't made out of matter."

At present human beings from most developed countries own smart phones, laptops, tablets and other inventions with which they communicate with other humans or receive information on news, weather or predictions about the stock market. All these gadgets use to communicate with each other and feed on the invisible layer that stores the information and knowledge, the noosphere. The speed of communication and the fact that the complex mechanisms that enable this technology are not transparent to the user, have led to a false impression that these inventions are a kind of magic. However, and for the same reason that genetic information requires a material substrate, DNA, the noosphere and all the gadgets that live in the noosphere, also require a substrate, Internet. With current technology, Internet has become a true electric power predator and it is for this reason that we see difficult to achieve in a few decades the Ω point. Obviously, when thinkers like Teilhard de Chardin introduce the idea of an omega point, his idea is spiritual and has nothing to do with a still non-existent Internet or cyberspace [43].

In accordance with our reasoning, if we ignore the energy paradigm then we will easily fall into the trap of assuming exponential models of resources, energy and space available, which are not unlimited. A simple model like the one we have called *Scenario 1* is crumbling down when we consider the energy consumption, concluding that in the future the noosphere will not be sustainable. Also in this essay we discussed other minor criticisms (*i*, …, *iv*) to the hypothesis of singularity, taken from studies conducted by other thinkers. Our position does not deny the possibility of reaching Ω point, quite the contrary we propose that this would be possible but only if we are able to redesign the hardware with which the noosphere acquires material form. A systemic model of the noosphere as simulated in *Scenario 2*, shows the possibility of a balance between the size of the noosphere and the available electrical power. Moreover, in *Scenario 3* we have shown how this equilibrium is even possible under the moderate effects of the energy paradigm. Finally, the idea of N-computer is highly speculative but has the purpose of provoking a mental brainstorm that allows us to find a new computer design more efficient and oriented not only to information management but also knowledge. Internet, evolution, consciousness and noosphere are interrelated concepts [44]. Now, as important as the meaning of such concepts is the hardware in which such concepts acquire their material form. In this context and under the perspective of sustainability, despite all the criticism and arguments made, the main question remains open: when our civilization will reach the Ω point or singularity?

REMARKS

[1]See S. Arbesman. 2012. *The mathematical puzzle that is the complexity of the city*. http://www.theatlanticcities.com/politics/2012/06/mathematical-puzzle-complexity-city/2261.

[2]See C. Keenan. 2011. *How much energy does the Internet consume?* http://planetsave.com/2011/10/27/how-much-energy-does-the-internet-consume.

[3]See M. Tyson. 2012. *The Internet uses 30 nuclear power station's energy output*. http://hexus.net/tech/news/industry/45689-the-internet-uses-30-nuclear-power-stations-energy output.

[4]See S. Forman. 2013. *The US is home to one third of the world's data – here's who's storing it*. http://qz.com/104868/the-us-is-home-to-one-third-of-the-worlds-data-heres-whos-storing-it. In reference to this matter, see Gantz, J.F., ed.: *The Diverse and Exploding Digital Universe*. An IDC White paper, 2008.

[5]Modis, T.: *The singularity myth*. http://www.growth-dynamics.com/articles/Kurzweil.htm#_ftn1, 2006.

[6]It is a self-replicating machine designed by John von Neumann. Using a construction arm or a writing head the machine can construct or print out a new copy of itself. The sequence of operations to be performed by the machine are encoded into a 'tape', i.e. DNA memory. A very interesting idea relating this self-reproducing automaton (universal constructor) with the ALU automata depicted in Figure 7 (top), is the existence of Garden of Eden configurations. However, we will not explain here this notion to be outside the scope of this essay.

[7]Enzymes are proteins that catalyzes a chemical reaction transforming a molecule or substrate to a new molecule or product [35, 36].

[8]Lossy compression algorithms are multimedia data encoding methods (audio, video, images), e.g. JPEG, MP3. Hash functions are procedures for transforming data of variable length to data of a fixed length, e.g. using http://www.fileformat.info/tool/hash.htm we transformed the text *Singularity hypothesis* to MD5 *a51129b92a02a1f932e63ce0ea586381*.

[9]It is a cellular automata pattern or configuration that has no parents or a predecessor configuration. For instance, in the *Game of Life* the pattern depicted in Figure 7 (top).

[10]It is a cellular automata introduced by John Horton Conway in 1970. Once initial configuration is created (the only input), the player only observes its subsequent evolution. Each cell in the grid can be live (state 1) or dead (state 0). A live cell with two or three live neighbors stays alive and has a neighborhood consisting of the eight cells. The state of the cells is updated according to the following rules: (i) A dead cell (0) with 3 live neighbours becomes a live cell (1); (ii) a live cell (1) with 2 or 3 live neighbours stays alive (1); (iii) in all other cases, a cell dies or remains dead (0). A spacefiller is any pattern that grows at a quadratic rate by filling space with a periodic configuration in both space and time. For instance, in the *Game of Life* the pattern depicted in Figure 7 (bottom).

APPENDIX

The numerical model simulations were conducted on Scilab 5.4.1 environment [45].

Scenario 1

```
//Noosphere equations
//Exponential model

function [w] = f(t,y)
w(1) = y(1)*k1;
endfunction
k1 =2;
t0 = 0; y0 = [1000];
t = [0:0.01:17];
```

```
y = ode(y0,t0,t,f);
xset('window',1)
y1 = y(1,:);
clf;
plot2d(t+2013,y1,style=1);
xtitle('Noosphere collapse','t','EXABYTES');
//end script
```

Scenario 2

```
//Lotka-Volterra equations
//y1 = prey-energy population, y2 = predator-noosphere population
//dy1/dt = y1*(k1-k3*y2), dy2/dt = y2*(-k2+k3*y1)
//Use k1 = 1, k2 = 10, k3 = 1 for 0 < t < 100
//y1(0) = 30, y2(0) = 80
function [w] = f(t,y)
w(1) = y(1)*( k1-k3*y(2));
w(2) = y(2)*(-k2+k3*y(1));
endfunction
k1 = 1; k2 = 10; k3 = 1;
t0 = 0; y0 = [0.02;1];
t = [0:0.01:100];
y = ode(y0,t0,t,f);
y1 = y(1,:); y2 = y(2,:);
mtlb_subplot(2,2,1);plot2d(t,y1);xtitle('Energy','t','y1');
mtlb_subplot(2,2,2);plot2d(t,y2);xtitle('Noosphere population','t','y2');
mtlb_subplot(2,2,3);
plot2d(y1,y2);xtitle('phase portrait','y1 ENERGY','y2 NOOSPHERE');
//end script
```

Scenario 3

```
//Lotka-Volterra equations under Energy Paradigm dynamics
//y1 = prey-energy population, y2 = predator-noos population
//dy1/dt = y1*(b-c*y2), dy2/dt = y2*(-d+c*y1)
//Use k1 = 1, k2 = 10, k3 = 1 for 0 < t < 100
//y1(0) = 30, y2(0) = 80
function [w] = f(t,y)
w(1) = y(1)*( k1-k3*y(2))- 0.01 * y(1)^2;
w(2) = y(2)*(-k2+k3*y(1));
endfunction
k1 = 1; k2 = 10; k3 = 1;
t0 = 0; y0 = [0.02;1];
t = [0:0.01:100];
y = ode(y0,t0,t,f);
y1 = y(1,:); y2 = y(2,:);
clf
mtlb_subplot(2,2,1);plot2d(t,y1);xtitle('Energy','t','y1 ENERGY');
mtlb_subplot(2,2,2);plot2d(t,y2);xtitle('Noosphere','t','y2 NOOSPHERE');
mtlb_subplot(2,2,3);
plot2d(y1,y2);xtitle('phase portrait','y1 ENERGY','y2 NOOSPHERE');
//end script
```

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