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Cyberworld Modeling
- Integrating Cyberworlds, the Real World and Conceptual Worlds -

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Abstract

The globalization of the real world we live has been almost exploding in its speed and scale spatiotemporally in all the key aspects including business, economy, industry, education and culture, making it hard for human beings to cognize what's going on and deal with them . Thus the links between the real world and conceptual world is getting weaker. The globalization is mainly driven by the Web-based activities in their cyberspaces creating cyberworlds as seen in e-business, e-commerce, e-manufacturing and cultural heritages through the Web and on the Web. Thus the links between the real world and cyberworlds are ever becoming tighter nonlinearly in time and space.

It is now crucial to find a way to automatically integrate the dynamically changing worlds, namely the real world, cyberworlds and conceptual worlds, fast enough to cope with the rapid changes. It is a hard task owing to the vast complexity of the worlds to be integrated, and it requires an advanced abstraction modeling. This is an interim progress report on it, presenting the outline based on the previous works on the abstraction hierarchy modeling of cyberworlds to realize an incrementally modular hierarchical modeling of cyberworlds via attaching spaces as quotient spaces and attaching maps. Attaching spaces are also for unique integration of the worlds that are real, cyber, and/or conceptual. They also guarantee liner interoperability of the integrated worlds to eliminate the combinatorial explosion of the computing in their complexity.

1. On conceptual evolution of cyberworlds

I have defined *cyberworlds* as worlds created on cyberspaces as computational spaces either intentionally or spontaneously, with or without design [1, 2, 12, 22, 23]. Actually, my personal experience of discovering cyberworlds goes back to 1969 [3]. A proposal to study cyberworlds as an academic discipline was filed to the Government of Japan creating Information Science Laboratory at the Faculty of Science of the University of Tokyo in 1970 with Graduate Course of Information Science with Master of Science and Doctor of Science degrees. In 1975 it was upgraded to Information Science Department.

Cyberworlds are closely related to the real world we live, intentionally or unintentionally. In certain areas, they have grown in their scales far beyond those of the real world. For example, in financial trading, a daily trading in the cyberworlds as e-trading in its amount is far beyond that of GDP. Let us look at the real world. The globalization of the real world we live also has been almost exploding in its speed and scale spatiotemporally in all the key aspects including business, economy, industry, education and culture, making it hard for human beings to cognize what's going on and to deal with them . Financial experts cognize the global capitalism to be in crisis [7], and the money is dead. Economists took ten years to cognize it [6]. One of the positive aspects of globalization is making open education plausible to resolve economic divide [4, 21].

The links are getting weaker between the real world and conceptual worlds that represent what we human beings cognize. As stated before, the globalization is mainly driven by the Web-based activities in their cyberspaces creating cyberworlds as seen in e-business, e-commerce, e-manufacturing, e-education, and e-cultural heritage. Thus, in contrast with the links between the real world and conceptual world, the links between the real world and cyberworlds is ever becoming tighter nonlinearly and spatiotemporally. However, the links between the cyberworlds and conceptual worlds are still weak in spite of fast progress of Web search engines such as Google http://www.google.com, Yahoo http://www.yahoo.com, and MSN Search http://search.msn.com, but are improving rapidly having sky high investments.

In the previous works [22, 23] we have clarified the reasons of such fast growth of cyberworlds and have matured the clarification to the level high enough to place the academic discipline of cyberworlds at the level of exact sciences such as mathematics, physics and chemistry, by first axiomatizing (or hypothesizing) cyberworlds, deriving theorems (or theories), and proving that they meet the axioms as Euclid of Alexandria has done it in geometry in around 300 BC [5]. Our researches [12, 13] have invalidated a popular theory of the real world evolution by Paul Kennedy [11].

The problem of weak links between conceptual worlds and the real world, and between conceptual worlds and cyberworlds resides in the immaturity of the understanding and modeling of conceptual worlds. We have tried to visualize cyberworlds by computer graphics for improved cognition [14, 15, 29]. Visualization is serving as a mere aid. Still, conceptual worlds are hardly understood.

To do it on a firm ground, we have to go to our own experiences on conceptual worlds in relation with the real world and cyberworlds. So I have to start the undertaking from my own experience to begin with. As I stated at the beginning, my experience of discovering cyberworlds goes back to 1969 [3]. The moment of the discovery was truly thrilling. I felt my whole body and soul was sucked into cyberworlds just found in front of me. In 1968 a year after the doctoral degree in molecular chemistry to investigate molecular biology, I faced with the fact my program, to automatically synthesize molecular structures inside computers for deriving the electronic states and spectra of biomolecules to find out biomechanisms such as carcinogenesis, had presented molecules that were non existent in nature. I first thought it was a mistake of my program. But soon the thought came to my mind that the program synthesized its own information worlds in computational spaces. Information worlds could abstract any worlds including the real world. Worlds are types of systems, and information systems are generic abstract systems that we knew very little. Finding computers conducting their own genesis was shocking. Having dedicating my life to natural science since at the age of 8 [4, 20], discovering new worlds had driven me to start writing a proposal to explore the new worlds in computational spaces as an academic discipline by establishing a new department of information science. It was fortunate that numbers of authorities had supported me, just a new postdoctoral guy. At the Government of Japan, Mr. Isaji Tanaka, Minister of Justice, had trusted my idea of the genesis of information worlds, and gave me his book "The Heart of the the Constitution of Japan" to express his sympathies with my intension to work in the discipline of the creation of information worlds with his hope to see justice enforced there by a type of constitutions. At the University of Tokyo, Professor Hidetosi Takahsi, Director of Computer Centre was my supervisor and held the position of Professor of Physics. He was among the first in developing computers in Japan. His strong support was persuasive enough for the proposal to be accepted in steps at the Faculty of Science. The core of the whole thing was conceptualization of information systems as information worlds in computational spaces [13]. I realized in concept they were a type of synthetic systems and also a type of abstract systems. Later more generic name was used to rename them: first to *synthetic worlds*, then to *cyberworlds* [1].

37 years have elapsed since the first discovery that was conceptual. I feel I am still at the entrance door of the conceptual worlds looking into cyberworlds. So, to talk about and research on conceptual worlds, the best vista point is naturally my original writing on the subject in 1969 printed as an essay in a journal in Japanese. With the permission of the publisher, Science Publishing Co. Ltd., Tokyo, Japan, to publicly distribute it, for CW2005 in particular, I have translated and posted it here as **2.** The core of it is modeling cyberworlds as generic systems and it is still on its way, needing a lot more research.

2. Invitation to System Sciences -Poetry, Philosophy and Science in the Computer Age-

Tosiyasu L. Kunii

2.0 Prologue

"Where can poetry find a place in the computer age?" This is a question coming to the mind of people going back home after a hard day, worn out in body and mind. Many people feel computers have deprived peace of mind in compensation for activating the society. The essay I present here tells the opposite – it is a tale on poetry and philosophy born mediated by computers, and also a tale on the dream of crystallizing them into science. Computers handling all kind of problems as abstract entities named information are dreaming the tale – the dream is evanescent and transitory but is with strength alike love of the youth. It will create the next era.

2.1 Phenomena and substances

The word "system" is popular and is generally understood to mean a set with some sort of order. It may seem there is no particular problem related to it. Is it really so? The meeting of two properties, one a "set" as a mere assembly and the other "order", reminds us of the following sentences:

> ……The earth was without form and void, and darkness was upon the face of the deep The Spirit of God moved upon the face of the waters.
> God said "Let there be light" and there was light…….

The sentences above are at the beginning of Genesis, and similar sentences appear in numerous legends of the world. They tell us symbolically how the world was created through the meeting of a set called chaos and order representing God. The generic nature of systems has been the basic problem thought about by human beings historically. A part of it has been abstracted and theorized by mathematicians as set theory and established as a branch of science. Order – the formidable being, however, has been made less the target of scientific study compared to nature as the world of matter created by a couple of a set and order itself as the parents. From ancient times order has been considered another name of God, its mystery being studied by divinity as a major theme.

Gradually, the empirical study of nature as the matter system has clearly revealed the relationships of order and the states of systems. The entropy of a system that is proportional to the logarithm of the number of the states of the system has been used as the measure of the order of the system. Entropy originally used as the thermodynamic and statistical mechanical measure of order is now adopted to represent the order of an information system as the measure of the property of an information system. It means that one of the substances of order is represented as entropy. The discussion from now on is not on entropy *per se*. What is important to know is that characterization of order is made not by the study of order itself but by the study, statistical study in particular, of the substance of the system with order.

A mainframe computer for shared academic use is sitting in a building of the Computer Centre on the Yayoi Campus of the University of Tokyo where prehistoric earthenware of the Yayoi Period was discovered. To the Computer Centre, computational problems in all academic disciplines including natural and social sciences and engineering are brought in. There the computer system is continue to process all the systems such as natural systems of atomic nuclei, electrons, molecules, crystals and biological bodies, and human systems of organizations and societies, economic systems of production, sales and profits as information systems – a type of logical systems. The phenomenon taking place there is: All concrete systems of the world we live are abstracted and generalized as information, and reconstructed on computers as information systems. It suggests the possibility of creating a novel and fundamental research discipline regarding the essentials of systems in general. The possibility is grounded on the fact that objects unbelievably versatile in kind and in nature are brought into the computer there after conversion to a single type of system called a digital information system that is a type of discrete time systems. It might be an evanescent dream. Still it is a dream of the computer there just being used without anyone listening to its whisper. I wish to see there someone listening quietly. The dream might be handing out a precious crystal extracted from an endless job of classifying numerous phenomena of systems to yield types, of studying the types to reveal their substances, and of extracting the essentials of the systems as the common entities of the substances.

2.2 Micro and macro

Here is one thing we have to point out explicitly. It is a fact that clarification of statistical aspects of systems never reveals the essentials of the systems.

The reason is simple. What statistical analysis and modeling give are the distribution functions of properties and the properties derived from the distribution functions. Consequently, the microscopic properties of the elements of the systems and the macroscopic properties of the systems are related mainly by the distribution functions leaving big gaps between the microscopic properties and the macroscopic properties. In other words, the effectiveness of statistical methods is limited to the cases where there are big gaps between the microscopic properties and the macroscopic properties. Hence, given a system, when we need to clarify the relationships between each state of the elements of the system and the macroscopic states of the system to a certain extent, statistical thinking and methods have to retreat.

It is the antithesis of the universal dominance of statistics of the modern society beyond the limit of the applicability, and we never intend to reject the idea of considering statistics to be widely useful in general. There is a promising direction to find a better statistical modeling of systems by reflecting the detailed structures of the elements of the systems and their interactions on the distribution functions. The thesis we are going to present is quite apart. It is stated as follows:

> The first step is the identification of each element of a given concrete system, its properties as microscopic properties and the logical relationships of the properties as microscopic relationships. Likewise, the properties of the system and their logical relationships are identified as macroscopic properties and macroscopic relationships. Then, as the next step, we can start to build up a method to define any system by its macroscopic properties and their macroscopic relationships grounded on the microscopic properties of the elements and the microscopic relationships. The method consists of 3 sub steps of analyzing individual concrete systems as phenomena, abstracting the commonality as types, identifying the substances of the systems from types, and finally abstracting the essentials from the substances. Let us name it a system scientific method.

By converting any concrete system to an abstract system based on the statements above, hence an abstract system is directly convertible to an information system, we can process any complex system directly on computers. It make it possible to clarify complex systems, that have been handled only statistically so far, in a scientific manner starting from microscopic structures and functions and ending with macroscopic structures and functions of the systems. It further make it possible to make diversified and discipline dependent research methods in mathematical systems, natural systems, and social systems interoperable, and to realize an advanced generic discipline, say general system theory, by integrating all individual disciplines systematically. We thus are filling the gaps of micro and macro within individual disciplines and interdisciplinary areas of study.

2.3 System sciences

Let us organize what stated in **2.** to make it clearer. Let system science be defined as constructed by sequential steps as follows:

1) The abstraction step: The step to abstract microscopic properties and their relationships, and macroscopic properties and their relationships from individual concrete systems.
2) The structure definition step: The step to represent the macroscopic properties and their relationships of the abstract system by the microscopic properties and their relationships.
3) The semantic step: The step to identify the possibility and the method to transformation one abstract system to another abstract system.
4) The computational step: The step to transform an abstract system to an information

system, and then collect input output pairs by running the information system.

5) The validation step: The input output pairs derived at the computational step are compared with the observed input output pairs of the individual concrete systems to validate the steps 1) ~ 4).

6) The natural history step: The step to apply steps 1) ~ 5) to many and varieties of concrete systems as have been practiced historically in natural sciences to establish science as a general discipline, in biology in particular.

7) The classification step: The step to classify the results of the step 6) and clarify the characteristics of individual types.

8) The generalization step: The step to clarify the commonality among the types to abstract substances and essentials.

We make some comments on the steps. The step 3) on semantics borrows the term "semantic" from linguistics simply to mean how a given term is explained or replaced by other terms, or transformed to some other terms. The step 4) on computing can be divided into two sub steps:

4-1) The programming step: The step to transform an abstract system to an information system.

4-2) The information processing step: The step to derive and collect the outputs of the information system for given input data sets.

The definition of system science here is merely the generalization and the procedure definition of the methods in science. System science is more interested in the relationships of the whole and the elements and in abstract properties and their relationships rather than in concrete properties and their relationships. The first aim of the definition is for synthesizing academic disciplines and art, currently torn into many isolated branches and blocked in communications; it includes the provision of the common ground and methods for it. The second aim is reorganizing culture into systems controllable in totality to get out of cultural isolations of valued areas through the provided common ground and methods. There is no guarantee that such system science can realize the second Renaissance following the Renaissance symbolized by Leonardo [Lionardo] da Vinci (1452-1519) who synthesized academic studies, art and technology. Considering the fact that only direction of the progressive evolution of life is the evolution of societies and organizations of human beings rather than the evolution of individual human beings sitting on the top of the evolution tree of life, isn't it wrong to say that what system science aim to synthesize and generalize individualized cultures is the main stream of the evolution of the future culture? The statement is grounded on the fact that turning anything concrete into general systems, say systemization, is another way of representing the integration of socializing, synthesizing, organizing, and generalizing.

2.4 Epilogue

Wonders come from meetings of people. Sprung are what beyond individuals. Human beings are the highest order systems nature has created. Splendid are stories woven through human contacts. It stands symbolically the beauty of the characteristics of systems beyond their elements.

The information age, often called computopia in a utopian view, depicts the age of highly organized societies mediated by computer processed information. Important is the system oriented viewpoint for deriving the inter-related totality of systems through system analysis and planning beyond organizing media. It is plausible that the system age is considered to be desirable more than the information age, and system science is above computer science having more potential. Ripples are coming to the foot of our lonely computer at the Computer Centre, sounding it. System science needs abundance of flexible and unconstrained intelligence and systematic thinking in constructing a unified brain and intelligence that are self organizing and self advancing, breaking the barriers of specialists in divided fields of studies of art, science and technology. This essay is dedicated to the souls looking toward such a direction.

(Tosiyasu L. Kunii, Director of Planning Office, Computer Centre, the University of Tokyo)

Tosiyasu L. Kunii, "Invitation to System Sciences -Poetry, Philosophy and Science in Computer Age-", (in Japanese), Journal of Mathematical Sciences, pp. 54-56 (October 1969), Science Publishing Co. Ltd., Tokyo, Japan.

3. Modeling conceptual worlds

Among the advances of information systems as abstract systems after the writing of the essay in 1969 to integrate art, science and technology to create integrated culture, the most influential has been the evolution of cyberworlds to create e-financing, e-commerce, e-manufacturing, e-education, and even e-governments.

The most difficulty, however, is now in conceptual worlds to keep us aware of what is going on in the global real world and cyberworlds. To overcome the difficulty of conceptual world modeling in association with the real worlds and cyberworlds, various "formal models" have been devised. Among them, graph theoretical modeling is most popular. Given any system, it is defined as a set of (input, output) pairs as has been practiced in natural sciences to find out unknown systems in nature through observation. Equivalently, it can be defined as a set of (state, output) pairs, or as a set of (input, state) pairs. A process is defined to specify an abstract action for the given system to get an input or an output. Any input causes a state transition of the system, and then an output is made. A process graph abstracts this as a directed acyclic graph (DAG). Since a process graph is abstract, it can represent any system such as a manufacturing system, a sales system, and a financing system as shown in Figure 1 [24].

One problem with a graph is it tends to become complicated in modeling systems in practice, making it hard for human cognition. A graph tends to extend in space and tangled. We developed a hierarchical graph as a remedy where a graph is recursively represented [25], and used it to model fairly complex systems such as oil refinery systems [26].

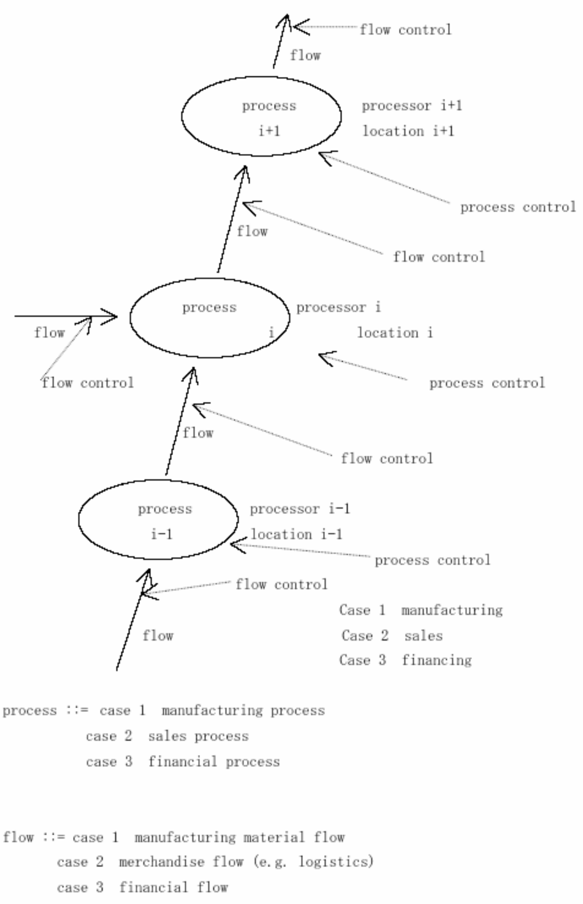

Fig. 1 A process graph as a DAG.

Another, but quite fundamental problem has been difficult to identify and resolve it. It stems from the graph theory itself. In a graph $g \in G = (N, E, \Phi)$, an ark $e \in E$ relates a pair of nodes $(a, b) \mid a, b \in N$ via an incidence function $\phi \in \Phi$, where N, E, Φ are a set of nodes, a set of arcs and a set of incidence functions. An arc relates any pair of nodes, and there is no invariance we can enforce to the relationship. It means any knowledge of invariance we have cannot be guaranteed to be observed in a newly established relationship.

In a physical world, for example, the concept on the laws of physics such as the preservation of energy and mass cannot be enforced, and hence susceptible to the violation of the fundamental laws to create a nonsense relation.

In e-trading, relating a trading company and a customer by an arc has been practiced in many e-trading systems to first specify its conceptual design. The concept of of the equivalence of traded merchandise in trading between a trading company and a customer is not enforced and hence not necessarily observed. It means the concept of fair trading is not enforced by arcs in graph theory to make it inappropriate to specify the conceptual design of trading systems irrespective of physical world trading or e-trading. Observing the overwhelming growth of e-trading, e-commerce in particular, far above the physical world trading, this creates serious social disturbances.

Now the problems are identified. Then how to resolve them is a question.

I have given the answer in numbers of recent papers [22, 23]. Figure 2 presents a case of e-trading to illustrate how the attaching space represents e-commerce and enforces an equivalence relation, the equivalence of merchandise for trading. Suppose in e-commerce a customer X has found interesting merchandise Y_0 posted on the Web by a trading company Y during Web surfing as we do window-shopping for goodies. It is a Web window-shopping process and since the customer X and the trading company Y do not yet share the merchandise, X and Y are disjoint as denoted by $X \sqcup Y$. Let us also suppose for generality that X and Y are topological spaces. Since the merchandise Y_0 are a part of the properties of the trading company Y, $Y_0 \subseteq Y$ holds. Then, how the customer X is related to the trading company Y after the merchandise is identified for trading? The Web information model we present here precisely represents the relation by an *attaching map* f, and also represents the situation "the merchandise are identified for trading" as an *attaching space* (also called the *adjunction space*) of two disjoint topological spaces X (the customer) and Y (the trading company), obtained by starting from the customer X and by attaching the trading company Y to the customer via a continuous function f by *identifying* each point $y \in Y_0 \mid Y_0 \subseteq Y$ with its image $f(y) \in X$ so that $x \sim f(y) \mid \forall y \in Y_0$. Thus, the *equivalence relation* denoted by ~ plays the central role in information system modeling and cyberworld modeling to compose an attaching space as the *attaching space model* (also called the *adjunction space model*) of cyberworlds. The reason is, unlike graph theoretical models, the attaching space model enforces to observe equivalences to preserve invariants. Thus, in trading and commerce, the concept of fair trading is enforced by using the attaching space model. Actually, commerce and trading are just an example for illustration. It guarantees invariance preservation in modeling any systems, irrespective of real, conceptual or cyber. Clearly attaching space modeling can be generated completely automatically because from the information on real-, cyber- and conceptual- systems, computers can abstract it automatically.

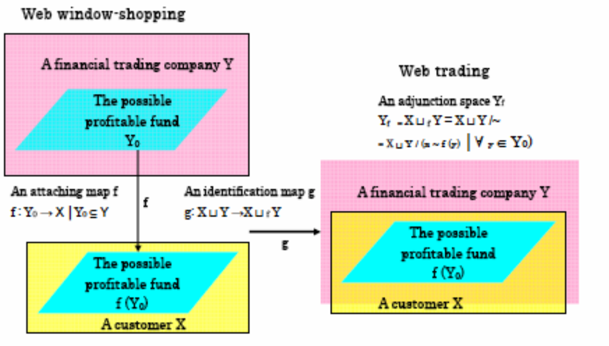

Fig. 2 An e-trading process represented as an attaching space.

Actually attaching space modeling serves to achieve our goal in a way to automatically integrate the dynamically changing worlds of the real world, cyberworlds and conceptual worlds, to cope with the rapid changes. Making systems incrementally modular as an abstraction hierarchy is the way to guarantee liner interoperability of the integrated worlds to eliminate the combinatorial explosion of the computing in their complexity [8].

It has been human nature to grasp any concept from global to details, from details to global, or from some levels of details to other levels of details. It means conceptual multiresolution is important in human cognition. For cognizing, we first analyze systems. We consider conceptual multiresolution analysis [27] based on the following levels of an abstraction hierarchy that is incrementally modular [2, 28]:

1. An Extension Theory Level, a Homotopy Theoretical Level as a special case.
2. A Set Theoretical Level.
3. A Topology Theoretical Level, a Graph Theoretical Level as a special case.
4. An Adjunction Space Level.
5. A Cellular Structured Space Level.
6. A Representation Level.
7. A View Level

At the level 3, the topology we adopt for modeling is *discrete topology*. The levels 6 and lower are application domain dependent, and they are defined here for the conceptual multiresolution analysis domain. Here, we elaborate on the adjunction space level 4 and the cellular structured space level 5 to model conceptual multiresolution analysis in necessary details.

At the adjunction space level, a dynamic relation of the type we explained above is expressed by an equivalence relation f (symbolically denoted by ~) between properties such that a property X has become related via f with another property Y by sharing a part $Y_0 \subseteq Y$ such that $x \sim f(y) \mid \exists x \in X, \forall y \in Y_0$. There are numerous cases of adjunction spaces; for example, those when industrial products are assembled and those when any trading is conducted (Figure 2).

At the cellular structured space level, the *inductive dimension* n of each property defined at the adjunction space level is added as the degrees of freedom of the property. We abbreviate an inductive dimension to a *dimension* for simplicity. For example, usually the shapes of industrial products are 3 dimensional, and the commodities traded have numbers of features as their dimensions.

The representation level corresponds to the multiresolution in representing properties. At this level, representations of properties such as a coding system and the numbers of bits are added to the properties at the cellular structured space level. Since there are abundant researches on multiresolution analysis at this level, particularly for image analysis [30], we do not elaborate the representation level any further.

Let us briefly look at the higher levels of the incrementally modular abstraction hierarchy. For any properties to be computable by computers that are set theoretical automatic machines, they have to be defined in set theoretical spaces. We say properties are at *the set theoretical space level*.

There is one level higher abstract level that is the homotopy theoretical level that is a typical case of extension theoretical levels. At the *homotopy theoretical level*, homotopy can be preserved by making any changes reversible [10]. By defining reversible operations to add elements to a given set or delete them from it, we can create a level one level higher than the set theoretical level. That is the homotopy theoretical level, and is more abstract than the set theoretical level.

Any properties we look at usually have subsets as their elements, and hence, by definition, they are *discrete topological spaces*. For example, in a case of online book shopping, a customer X has the given name, the middle name and the surname as the 'name', making a subset {(the surname, the middle name, the given name)} as an element 'name' of X. Any set theoretical space with its subsets as elements is basically a discrete topological space. Likewise, since an online bookstore Y has subsets, new books and used books, as its elements, Y is a discrete topological space too. Hence, X and Y are at the *discrete topology theoretical level*. Hereafter, we omit 'discrete', and denote discrete topology simply as topology.

4. Epilogue

To cognize and conceptualize the future of the real world, now driven by cyberworlds that deal GDP equivalent of one of the richest nations in less than a day, it is crucial to establish a durable theory on the evolution of cyberworlds. Learning from the evolution of life, allometry [17-19, 22, 23] in particular, is essential to understand the evolution of the intellectual functions of cyberworlds as the brains if any. Allometry tells that only adaptive, hence continuous, evolution comes from utilizations, not from holding of property; the directions of evolution to expand and own nonintellectual body functions have been dead ended [16]. Conceptualizing open and global education through e-education based on open sources is very powerful in interactively creating adaptive intellectuals as the cyberbrains through fast and mutual interactions [4, 20]. Allometric study of cyberworlds is very promising and essential for adaptive evolution of worlds, real-, cyber-, and conceptual-, although researches on allometric study of human societies have not been settled in their directions [29]. Let us share knowledge and advances by openly and interactively participating in further researches.

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