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## A Computing Perspective on Scientific Chinese Trinity

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The unprecedented and rapid development of the Chinese economy has been vividly displayed in front of the whole world to see. The attention has been particularly acute for the academic community and career politician alike. Ironically, this rapid economic miracle of China has been built on an unsound and often even questionable foundation of Chinese words, Chinese language and Chinese culture, of which we call them "Chinese Trinity". This article deals with the Chinese Trinity from a computing science perspective. This article argues the reform in Scientific Chinese Trinity with an emphasis of the word "scientific" ought to play a key role for further Chinese economic development and to launch a much improved contemporary Chinese society on a solid foundation. In addition, this article proposes specifically ten computing paradigms and examines critically their potential impacts on Scientific Chinese Trinity. Finally, we feel the very focused approaches as proposed here might inspire as well as provide a much needed road map toward the goal of the Scientific Chinese Trinity. Judiciously chosen vigorous research projects appear to be indispensable. The unfortunate well known and long overdue reform has finally been rescued by the pressure of the information revolution coming of age.

Keywords: Scientific Chinese Trinity, Scientific Chinese words, Scientific Chinese language, Scientific Chinese culture, computing paradigm, information processing, contemporary Chinese society.

### 1. Introduction

The unprecedented economic advance of the Chinese economy displayed in front of the world has attracted a great attention in both academic communities and politicians. Ironically, the economic development has been built up on a questionable Chinese language, Chinese words and Chinese culture with unsound fundamental science foundation. Chinese language has continued to linger on and could be most likely to cause every Chinese eventually to feel the pains of all the troubles it is going to inflict upon us. Knowingly or unknowingly, most people's attitude toward the language would be: we are using it every day and we can get around just fine and, frankly, there is nothing wrong and why don't you just leave it alone? Well, that is precisely what we meant the 'hidden danger' which is invisible at all.

Closely associated question to the question just raised would be: Is Chinese language in some kind of danger? Majority of Chinese do not think so because they feel that more than 1.3 billion Chinese are using this language and how could it ever be in danger? Furthermore, there is no other natural language on the earth that has more people using their natural language as compared with that of Chinese language. One needs not to look very hard to discover that the English language has emerged to be the Latin of the globe replacing original Latin as the dominant language of the world in the 21st century! The great majority of international journals as well as the public media are already dominated by English language, and it also has undisputed become the official language in

scientific community. In other words, the English language is indeed the dominant force in the world culture landscape. However, the Chinese language has never been in any shape or the form even to be considered as any force to be reckoned with. Based upon this observation, the Chinese language may be argued to be in some kind of danger.

The most important issue facing them is that Chinese words are also in danger! However, this point is not for the majority of Chinese people who use Chinese words in their daily life. Some scholars in China and outside China are trying to push “Pinyin (Roman alphabet)” of Chinese words to replace the Chinese words (characters) (Chen S. , 2001). From their perspective Pinyin is the official Chinese words rather than the words (characters) they have been used over thousands of years. In this sense it is obviously that Chinese words are in danger.

Chinese culture is also in danger, because it is difficult for us to consider Chinese culture with sound fundamental science foundation just as Chinese medicine, because it is difficult to explain or reveal the secret behind Chinese medicine using modern science and technology although it is useful in Chinese world.

Another relevant question is: Will the Western world accept the dramatically economic development in the light of culture, language and the larger framework of the civilization? In terms of the reality it is hard to say that the Western people have accepted the peaceful economic development of China. In other words, the traditional Chinese trinity of China, consisting of Chinese language, Chinese words and Chinese culture, still is a puzzle for the Western people.

Our observations of the above mentioned issues have inspired us to examine closer in light of a new paradigm by adding the key word of "Scientific" on Chinese Trinity. That is, this article will address the scientific and technological impact to Chinese Trinity, especially their power to transform and to improve the quality of the Chinese Trinity. In fact, Chinese people have realized the importance of science and technology long ago. The world science and technology themselves are changing and improving in an amazing pace. Hence the concept of this Scientific Chinese Trinity has very deep double meaning. In this article, we will adopt logical analysis, closer examination and careful research to achieve effective results. So far as its constituents are concerned, the scientific Chinese Trinity, consisting of scientific Chinese words, scientific Chinese language and scientific Chinese culture, plays a significant role in further developing Chinese economy and Chinese society. This article proposes ten computing paradigms and examines their impacts on scientific Chinese trinity.

The organization of the rest of this article is as follows: Section 2 overviews science and computing and their relationships. Section 3 examines scientific Chinese trinity. Section 4 overview what Chinese trinity has been processing using computing technology in the past six decades. Section 5 proposes ten computing paradigms and discusses their impacts on Chinese trinity. Section 6 provides some research directions towards scientific Chinese trinity in the near future. Final section will end this article with some concluding remarks and our future work.

It should be noted that hereafter we use Chinese words and Chinese characters interchangeably through this article. In this article, we do not use “technological” because the technology is derived from science; we use scientific in general and computing in special, because we contributes ourselves to computing for decades. Moreover, “scientific” in our research means that the understanding of and investigation into either Chinese words or Chinese language or Chinese culture using all modern science and technology, especially computing science and technology. Computing is a modern science and technology moving us from traditional civilization to web civilization. Therefore, we use computing paradigm to examine Chinese trinity.

## **2. Science and Computing**

This section reviews science, scientific methods and computing as well as computing thinking. All these are the basis of the ten computing paradigms to be proposed in the later section.

## 2.1. Science and Scientific Methods

Science is about understanding the origins, nature, and behavior of the universe and all it contains; engineering is about solving problems by rearranging the stuff of the world to make new things (Petroski, 2010). Science is a general concept. At least in the past few centuries, we have pursued science as the underpinning force for the development of our society, economy and human lives. It is science that makes us understand the relationship between the sun and the earth, the mechanism of varieties of illness; produce locomotives, cars, airplanes, and iPhones, and enjoy the virtual world besides the physical world and mental world. It is also the science as a main driving force to transform the agricultural society to technological society via industrial revolution and eventually to contemporary information society.

Scientific method refers to a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge. To be termed scientific, a method of inquiry must be based on gathering observable, empirical and measurable evidence subject to specific principles of reasoning (Wikipedia, 2012). A scientific method consists of the collection of data through observation and experimentation, and the formulation and testing of hypotheses. At least from the late medieval period (1000-1450), the scientific method became the main revolutionary means to develop the world in which we live. The development of science not only promotes the growing of the economy and advance of society but also brings about the emergence of scientific management, scientific technology and scientific engineering. In turn, the latter (for short, we use management, technology, engineering for each of them respectively) promotes the development of science. For example, scientific management was introduced by Frederick W Taylor in 1911 (Robbins, 2012), and then forms the system of scientific management or 'Taylorism' (Sengers, 2006). Taylorism is, at heart, simply to apply science, technology, and engineering to optimize business processes, human behavior, and managerial behavior. Taylorism integrating with production line brings out the mass production and industry standards. Needless to say, countless work in science, management, technology and engineering has served this mass production in the last century.

Science as a political concept is not strange for Chinese people. Just a century ago (1910s-1920s) Chinese intellectuals brought "science" to China in the May Fourth Movement/New Culture Movement. Those pioneers announced that only "science and democracy (Sir Sai and Sir De)" can salvage China from backwardness and from subjugation and genocide (*Wangguo miezhong*) (Li Z. , 2004). However, we shall emphasize more on the science aspect of the movement in this paper because it is more relevant to the issues on hand. Unfortunately, the political issue had taken the overwhelming urgency after the commencement of the May 4th Movement in 1919. Little, if any, attention has been put on the needy reform of the Chinese language which has always been and even continues to be the case until now. One can imagine it was definitely put in the back burners all those turbulence period of the Chinese history of unfortunate civil war. In fact, the efforts on mainland China and Taiwan have had taken a completely different paths. Chinese people have no choice, but to spend more of their fortune and energy in violent conflict until, finally, the establishment of the People's Republic of China in 1949. During the civil war period, even though every citizen recognized the importance of the scientific methodology, but they could not do anything about it, not even to have a meaningful dialog on the reform of the Chinese language. Subsequently, the new China has taken yet another 30 years employed the socialist methods to transform China into a socialist nation with the independent industry and defense. The importance of science and technology finally have their rightfully attention. However, there were too much to be accomplished from a very weak foundation, to say the least. Another 30 years would be required, via aggressive "reform and openness" needed to rebuild and to transform China into a moderately prosperous society in all measures (Hu, 2011). This brings us to where we are today!

## **2.2. Computing and Computing Thinking**

Computing, as a scientific revolution, integrates science (including mathematics, chemistry and physics), technology, management, engineering, systems, tools and services under one roof. It is computing that literally has changed our society from manual time to digital time, from traditional era through smart era to smarter era because we have produced hundreds of millions of smarter citizens in the world. Computing has accelerated the transition from mechanization to automation and digitization of production processes and business processes. This has also changed our daily life, working style and social life thoroughly in the past 60 years. Computing will further influence our life, and working style as well as our society in the near future.

As a superdiscipline, computing covers computing science, computing technology, computing management, computing engineering, computing systems, computing tools and computing services (ACM, 2009). This is the first decomposition of computing at a disciplinary level. We also consider them as macro-computing thinking. In practice, we use different terminology to represent each of them, for example, we usually use computer science for computing science, information technology for computing technology, information/knowledge/network management for computing management; computer engineering for computing engineering; computer, operating systems for computing systems; firewall and routers for computing tools, and information/web services for computing services.

Computing scientists tend to approach work processes the same way as a Taylorist: We break complex processes down into simple steps, we figure out optimal procedures for each work step, and we eliminate wasteful steps and problems with intelligent methods (Sengers, 2006). These familiar processes are very visible should one observe the approaches and principles of Artificial Intelligence (AI), which has been with computing scientists for more than half a century (Russell & Norvig, 2010). Furthermore, computing scientists usually use one or some of the ten paradigms to solve any problems based on computing thinking, taking into account strong support of mathematics, engineering, physics and philosophy in particular and social requirements in general (see the next section).

Computational thinking and computing thinking have a long history accompanying computation and computer science (CS). The student enrolment crisis in CS since 2002 motivates to re-examine all aspects of computing in general and CS in special (Wing, 2006). One of these re-examinations is the debate on computational/computing thinking, which has drawn an increasing attention in the past few years in particular in the USA, Canada and China (Denning P. J., 2009) (Guo, Sun, & Zhao, 2009). These debates aim to find ways to attract more students to study CS or computing, and to collaborate with other disciplines (Denning P. J., 2009). However, there are confusions among computation and computational thinking, computing and computing thinking in the existing literature. This might hinder the healthy development of computing as a discipline. We distinguish between computation and computing, and between computational thinking and computing thinking, and explore their interrelationships.

Computation has been an important part in computer science. In the early 1980s, a Nobel Prize Laureate in Physics, Ken Wilson and his followers argued that computation, as a new sub-paradigm of science, had become the third leg of science besides theory and experiment (Denning P. J., 2009). In the mid-1980s, Ken Wilson advocated the formation of departments of computational science in universities to differentiate itself from CS. Computational science as an undergraduate program is still offered in Colleges of Mathematics or Physics of many universities in China.

Computational thinking has naturally accompanied computation or computational science, just as any science has its corresponding thinking. Therefore, computational thinking is not a unique characteristic of CS.

According to IEEE/ACM (ACM, 2009), computing as a superdiscipline is now recognized as comprised of five defined disciplines: computer science (CS), computer engineering (CE), software engineering (SE), information systems (IS) and information technology (IT). Computation has

penetrated each of the above five disciplines, and becomes a fundamental part of computing. Therefore computational thinking is a part of computing thinking (Sun, Sun, & Guo, 2008).

The significance of the philosophy of the computing thinking can never be ignored as it has far-reaching impact in every aspect of the science and technology. If we closely consider its past and its present impact on many engineering disciplines such as mechanical engineering, chemical engineering, civil engineering, environmental engineering, material engineering, genetic engineering, etc., computing thinking has indeed changed the disciplines as well as their professions in every shape and forms beyond recognition. We also believe its future impact even to be bigger. Furthermore, one may keenly observe the computing thinking also has much impact on every conceivable discipline in social sciences and humanity as well. All in all, the potential impact of the computing in Chinese trinity simply cannot and should not be ignored! This is the reason why we are dare to predict by employing the computing thinking philosophy as well as its computing power as the main thrust in this proposed Chinese trinity usage, a fairly dramatic results can be achieved for the wellbeing not only for Chinese society, but also the international communities as their interaction with that of the Chinese society and civilization.

From a practical viewpoint, computing corresponds to computing scientists or experts or professional workers whereas computing thinking corresponds to computing thinkers. One of the greatest computing thinkers in the computing field was Alan Turing. In fact, there are many great thinkers in computing fields who provide the strategic thinking and guide for computing research and development. Computation and computing are at disciplinary level whereas computational thinking and computing thinking are at methodological, epistemological and philosophical level. In other words, computing thinking has the function of methodology and epistemology that cannot replace but facilitate the research and development of computing (Guo, Sun, & Zhao, 2009); (Sun & Guo, 2010). If Taylorism is associated with optimization, such as mathematical optimization, human behaviour optimization, and social behaviour optimization, then computing has also its own methodology that pervasively influence not only our life, working style but also other disciplines such as management and engineering. The computing methodology, which we can call computing paradigm, at least includes the ten paradigms of computing that are to be examined in section 5.

### **3. Scientific Chinese Trinity**

As we shall make clear later, scientific Chinese words are the foundation for the development of scientific Chinese language, scientific Chinese language in turn is highly relevant to scientific Chinese culture. Hence these three aggregated together is called Scientific Chinese Trinity.

The Scientific Chinese Trinity aims, ultimately, to improve scientific Chinese civilization, and eventually to bring up (train or generate) hundreds of millions of scientific Chinese. It also aims for foreigners to learn and to comprehend Chinese words and language with ease. We sincerely believe both of these two aims are achievable. As long as Chinese economics continue to perform and to improve measured by Chinese GDP, it is entirely possible that the Scientific Chinese trinity's goal are realizable. Our assessment on the minimum skill set required for both Chinese and foreigners to participate and to contribute toward the goals of the Scientific Chinese trinity is nothing more than the expectation of an intermediate level of the education is mathematical skill.

Chinese can be here specialized as Chinese people, Chinese culture, Chinese language, Chinese words, Chinese society and Chinese civilization. As a specialization of scientific Chinese, computing of Chinese means that computing of Chinese people, computing of Chinese culture, computing of Chinese language, computing of Chinese words, computing of Chinese society and computing of Chinese civilization.

Computing of Chinese people means computing of the behaviours and thoughts of Chinese people, more specially, it applies computing technology, methods and theory to analyse, imitate, stimulate the behaviours and thoughts of Chinese people and then change Chinese to scientific Chinese. This is the basis for making Chinese into scientific Chinese.

Computing of Chinese culture means applying computing paradigms, technologies, methods and theory to analyse, imitate and stimulate Chinese culture to change Chinese culture into scientific Chinese culture.

Computing of Chinese language means applying computing paradigms, technologies, methods and theory to analyse, imitate and stimulate Chinese language to develop scientific Chinese language. Chinese information processing belongs to computing of Chinese language and computing of Chinese culture (see the next section for detail).

Computing of Chinese words means applying computing paradigms, technologies, methods and theory to analyse, imitate and stimulate Chinese words to develop a scientific system of Chinese words. Computing of Chinese words has been as an important part of Chinese information processing.

Computing of Chinese society means applying computing paradigms, technologies, methods and theory to analyse, imitate and stimulate Chinese society and social behaviours to develop scientific Chinese society.

Computing of Chinese civilization can be considered as the aggregated result of computing of Chinese people, computing of Chinese culture, computing of Chinese language, computing of Chinese words, and computing of Chinese society.

Similar to scientific Chinese trinity, computing of Chinese culture, computing of Chinese language, computing of Chinese words form computing of Chinese trinity.

Scientific Chinese trinity is closely related to modernization of Chinese society, economy and formation of knowledge economy and knowledge society in China in particular and the benefits will be extended to all Chinese speaking communities in general on the global basis. Scientific Chinese trinity, as a scientific development, begins with the reform of Chinese words and Chinese language because the latter are the carrier of Chinese information, knowledge and Chinese culture. They are also an important component of Chinese culture (Zong, Cao, & Yu, 2009)

Scientific Chinese words, scientific Chinese language and scientific Chinese culture are at three different levels. Scientific Chinese words are at a fundamental level. It is the basis for scientific Chinese language. Scientific Chinese language is at the intermediary level. It forms the basis for scientific Chinese culture. Scientific Chinese culture is at the top level. It forms the important basis for scientific Chinese civilization. Scientific Chinese civilization is the second highest level. The scientific Chinese is at the highest level and is the consequence of scientific Chinese civilization. Chinese words play a pivotal role in making Chinese civilization continuing without interruption in the civilization history of human being, as shown in Figure 1.

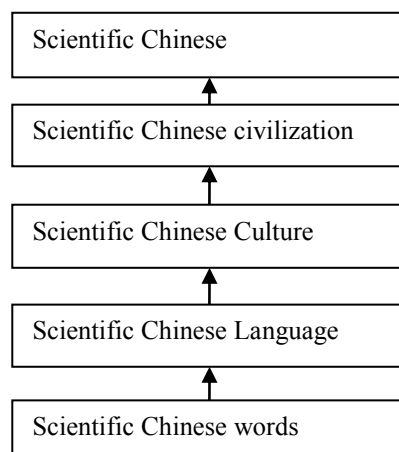


Figure 1. A hierarchical structure of Scientific Chinese civilization.

It should be noted that the hierarchical structure of scientific Chinese civilization ignores the impacts of other civilizations, cultures, languages and words to Chinese civilization, culture, language and words because of space limitation.

From a system perspective, Chinese words are a stable, closed system, which has not been influenced by other words system since Qin Dynasty (Chen S. , 2001). The ideographic feature of Chinese words provided a convenient communication means for Chinese to communicate with each other although they speak differently in significantly different Chinese dialects (Huang & Meng, 2001). From here we can claim that Chinese language and culture, and Chinese civilization are based on written words, rather than spoken language. For example, one can write English excellently and have published hundreds of top journal papers in English, but might not speak English very well. However, this phenomenon is nearly impossible to happen in China as far as the Chinese language is concerned. By nature of the Chinese language, Chinese people can easily speak well with oral utterance, should the Chinese people can publish hundreds of articles in top Chinese language journals.

Chinese language is a stable system. It has been influenced by other language systems such as Japanese language (Louie, 2008). Chinese culture is also a very open system that has absorbed and digested all the existing cultures in the history to some extent. For example, in the ancient time, Chinese culture has been influenced by the Arabic culture. In the medieval time, Chinese culture has been also influenced by the European culture. In the modern time, Chinese culture has been influenced by all other cultures existing in the worlds. In the recent decades, Chinese culture and Chinese language have been heavily influenced not only by culture, language existing in the worlds but also influenced by the scientific management, scientific technology, scientific engineering existing in the worlds thanks to dramatic development of science, technology, management and engineering in general, computing in particular.

Chinese people have infinitive patience of learning from other culture. For example, Chinese people are studying at universities in more than 100 countries including Australia and Fiji. They not only study science, technology, engineering, management in these countries, but also study the culture of these countries. This kind of scientific, technological, cultural exchange through the study of Chinese people in these countries has fostered the globalization of Chinese culture in the world. Meanwhile, it also has made the localization of the other cultures in China. It is an undisputable fact that Chinese culture has become more and more important in the course of globalisation.

The concepts of the Scientific Chinese words, Scientific Chinese language, Scientific Chinese culture may inherently been planted in most Chinese people's mind, but we believe the nomenclatures may be quite original. Even so, it is pivotal that reasonable nomenclatures should be designated for the sake of the communication and to popularize the concept in the public domain.

The above discussed scientific Chinese trinity is a grand vision ahead of us, just as scientific outlook on development as a national strategy for Chinese people (Hu, 2011). A big issue arising here is what our computing scientists as a group can best contribute to the scientific Chinese trinity using computing methodology. In order to address this issue, we shall first examine the scope of the problems that Chinese computing scientists have been taken up for their endeavor.

#### **4. Chinese Information Processing**

From a computing perspective, Chinese words, Chinese language and Chinese culture have been treated within the domain of Chinese information processing (CIP) in China since 1952. During that time, one of the big challenging issues for the Chinese government is how to educate hundreds of millions of illiterate Chinese such that the undesirable illiteracy can be removed as quickly as possible (Liu Y. , 1995). The Chinese government selected and promulgated 2000 commonly used Chinese words as the national standard for mass movement of educating illiterate Chinese. Since then, the simplified Chinese characters, the promotion of Putonghua, the development and implementation of Hanyu Pinyin have been identified as three main thrusts of the reform of Chinese words and Chinese language (Zhang P. , 2009).

With the development of computer industry, Chinese researchers undertook the machine translation between Chinese and Russian in the end of 1950s and Chinese information processing as a national systems engineering begun in the 1970s. Chinese information processing has been



developed in the context of the network, intelligence, digital, multilingual, multimedia environment. In the 1990s, Chinese words and language can be processed using computer in the same way as English, that is, a person can input Chinese words into a computer using a keyboard. The Chinese articles can be edited using computer and then printed using laser printer (Zhang P. , 2009); (Zong, Cao, & Yu, 2009). Currently, Chinese words can be typed into a computer with a faster speed than English for a non-career typist. Chinese words can also be typed into mobile phones with a remarkable speed thanks to the effective input methods of Chinese words. In contrary, there are not effective input methods for using existing software to input English words into a computer or mobile phone. The Chinese scholars believe that the last century is the century of Chinese words information processing, while the 21<sup>st</sup> century is going to be upgraded as the century of Chinese language information processing (Zhang P. , 2009); (Zong, Cao, & Yu, 2009). More specifically, Chinese information processing will focus on addressing the following issues:

- Chinese word frequency statistics, Chinese clause segmentation specification; automated Chinese clause (duanyu) segmentation system.
- Chinese natural language understanding, human machine communications require the Chinese linguistic knowledge such as syntax processing, semantic processing, text processing, contextual knowledge processing.
- Automated Chinese word segmentation, word tagging, syntactic analysis, machine translation, information retrieval, text classification, speech recognition, speech synthesis, etc.

A general architecture of CIP can be proposed here, as shown Figure 2. In fact, in the past half a century, China has transformed itself from non-computer country to a superpower in computer industry. China has produced its own CPU, input/output devices, memory and external storage. The majority of desktops and laptops used in the world are made in China. Chinese words, language, and even culture are processed by a computer. China has more than 513 million people who use the Internet (Li X. , 2012).

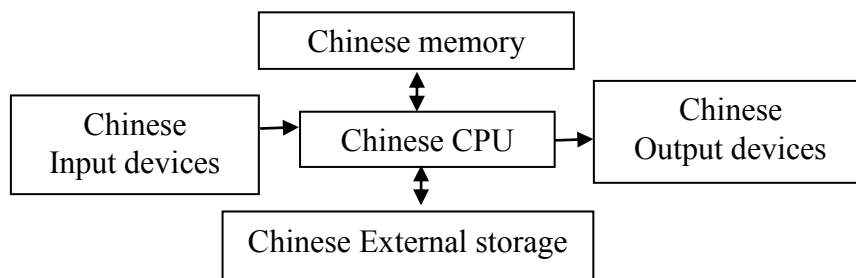


Figure 2. Exclusive Chinese- Language Computer

The basic goal of CIP is to make an independent computerized system, where every Chinese can use Chinese to write, speak, read and to listen in Chinese utterance fluently at a computer or mobile phone. The ultimate goal of CIP is to build an intelligent computerized system, with which every Chinese can write, speak, and listen in Chinese smartly with a computer or a mobile phone. The Chinese have realized the basic goal of having a cohesive intelligent computerized system. The meaning of the word 'independent' is with respect to the world dominant universal language, English. That is without English, the Chinese can also enjoy the advanced technology, science, engineering and management in the computerized kingdom although this computerized kingdom has been affected by English indirectly, if not direct. However, for an ordinary Chinese living in China, she/he does not care about this influence from the English Kingdom. The following list is a proof.

Table 1. A comparative list of the English world and Chinese world

Items	English World	Chinese World
Search engine	Google	百度( <a href="http://www.baidu.com">http://www.baidu.com</a> )
Online book shop	Amazon	当当网 ( <a href="http://www.dangdang.com/">http://www.dangdang.com/</a> )
Online social networking	Facebook	人人网; Qzone ( <a href="http://www.renren.com/">http://www.renren.com/</a> ; <a href="http://qzone.qq.com/">http://qzone.qq.com/</a> )
Online shopping	e-Bay	淘宝( <a href="http://www.taobao.com/index_global.php">http://www.taobao.com/index_global.php</a> )
Online news center	CNN	新华社 ( <a href="http://www.xinhuanet.com/newscenter/index.htm">http://www.xinhuanet.com/newscenter/index.htm</a> )
Forum	Google Groups	Qiangguo forum; Tianya community <a href="http://bbs1.people.com.cn/">http://bbs1.people.com.cn/</a> , <a href="http://tianya.cn">http://tianya.cn</a>

It should be noted that when the authors were writing this section, Facebook had 800 million registered users from every corner of the world, whereas Renren and Qzone have 620 million registered Chinese users from China. The Chinese net citizens have more interest in involving political and social issues in the online social network or forums as comparing with that of the Western net citizens. If one visits Qiangguo forum (see Table 1), one may conclude that the Chinese Internet world has exhibited some visible features to be quite democratic in character, and this trend may improve further to make everybody in the world happy.

Chinese information processing (CIP) and Chinese character information processing (CCIP) have dominated Chinese scholars' research and development endeavors during the past 60 years (Zong, Cao, & Yu, 2009). This domination will be continuing into the future for quite some time to come. For example, these are only a part of our scientific trinity, although they are indispensable (CIP and CCIP can only be at a technical level serving the above-mentioned scientific trinity) (see Section 3). This reflects a common-sense: We do not appreciate the essence of the forest, only because we are in the forest. Obviously, CIP and CCIP have no intention of extending Chinese character information and Chinese information beyond "processing" to more general layer, e.g. "computing" or the top layer, scientific. This is the critical weakness of CIP and CCIP. We select a computing perspective to study this issue, because we are computing scientists. Further computing is a revolutionary paradigm that acts like an engine to move science and technology as well society towards the more brilliant future of human being, just as what we have been enjoying from computing development such as the Internet and the Web.

It is necessary for us to stress the reason for our choice of computing as a primary driving force for further scientific development. It is well recognized that the technologies of the Internet and the Web have significant impact on the current communities. Analogously, it is clear that computing technology has played a similar role and to become the main driving force for further development of sciences and technologies. Consequently, the importance of the scientific Chinese Trinity is self-evident. It is perhaps that the scientific Chinese words, scientific Chinese language and scientific Chinese culture seem to be strange to Chinese researchers and developers. Therefore, scientific Chinese words, scientific Chinese language and scientific Chinese culture are still a big issue for us in order to develop scientific Chinese civilization.

## 5. Ten Computing Paradigms and Their Impacts on Chinese Trinity

There are many different paradigms in computing. This section focuses on the following ten computing paradigms: structured paradigm, hierarchical paradigm, process-oriented paradigm,

engineering paradigm, intelligent paradigm, humanized paradigm, mobile paradigm, service-oriented paradigm, networking paradigm, and digitalization (information) paradigm. This section will examine each of these ten computing paradigms and their respective Chinese Trinity in somewhat more detail.

## **5.1. Structured Paradigm**

Structured paradigm is a very useful paradigm, and has its origin in structured analysis, structured design and structured programming in structured software development or software engineering (Guo, Sun, & Zhao, 2009). Nowadays, various structured paradigms have emerged as a major well established characteristic of computer thinking. As a matter of the fact, whenever we are thinking about the possibility of using this paradigm to solve a computing problem, we think: Can this problem be structured? Structured paradigm is also an instantiation of the strategy of “divide and conquer’ or problem solving, because if we can structure a problem, then we can solve the problem by looking into its structure and components.

In the meantime, the Chinese words have evolved into more and more structured usage during the past two millenniums (Chen S. , 2001) (p. 81). This is of particularly true ever since the past millennium due to the invention of the printing technology in Song Dynasty (AD 960-1279), comparing to Arabic words. On the other hand, should one choose to compare the structural issue with that of the German language, especially from the syntactic or linguistic perspective, the German language is much more structured. For example, “Ich habe heute viel gearbeitet” (Today I worked a lot, 今天, 我工作了 很多), this sentence is structured in German by using “habe.... gearbeitet”, which is similar to that tagged structures in XML such as <title> Scientific Chinese </title> and <product> A book </product>. However, the German words are less structured as compared with that of Chinese words from a topological viewpoint, because the 99% of Chinese public media are only based on 2500 Chinese words (China, 2008). The structural issue, however, may be extended to be examined from the cultural viewpoint. The Chinese culture in this sense is also quite structured! Nevertheless, it is a real challenge to figure out exactly how to design the structures for Chinese words using computing technology (Xie, 2001). How to structuralize Chinese language and culture based on computing is still a huge 'inviting and useful' issue.

Now, should one apply the structured paradigm with the ever essential and inevitable science of computing, then we will have brand new challenging questions to be answered. Hence, we may have to establish this important emerging research problem to meet the challenge head-on!

## **5.2. Hierarchical paradigm**

Hierarchical paradigm is rooted and subsequently derived from the philosophy of the social organization and the division of labor (Robbins, 2012). Hierarchical structure of computing consists of computing science, computing technology, computing engineering, computing tools, computing service, and computing applications with the computer science as the top layer (Sun, Sun, & Guo, 2008). Later on, we also designate the thinking philosophy as well in corresponding five categories as computing science thinking, computing technology thinking, computing engineering thinking, computing tools thinking, computing services thinking, and computing applications thinking respectively (Guo, Sun, & Zhao, 2009).

Broadly speaking, the action of abstraction, formalization and engineering of the above mentioned six kinds of thinking facilitates the development of corresponding disciplines, that is, computing science, computing technology, computing engineering, computing tools, computing service, and computing applications. Analogously, the further development of the latter also brings about new computing science thinking, computing technology thinking, computing engineering thinking, computing tools thinking, computing services thinking, and computing applications

thinking. Furthermore, the more recently emerged technology of the Internet and the Web can be considered as an integrated development of computing science, computing technology, computing engineering, computing services, computing tools and computing applications. The thinking around the Internet and the Web can also be considered as the integrated thinking of the above mentioned six kinds of computing thinkings.

Chinese words historically were designed according to the principle of following a hierarchical structure; and the Chinese language has followed the same principle. It is also true to say that the Chinese culture has been deeply influenced by the hierarchical framework (Li Z. , 2004). Confucius School, Confucius (BC 551-479) together with his followers, apparently endorsed this hierarchical principle. From a computing perspective, it is of significance in uncovering the hierarchical structure of already embedded hierarchical Chinese words and language to fullest advantage. We use an example to illustrate the hierarchical structure of Chinese words, as shown in Table 3 below.

Table 3. An example of hierarchical structure of Chinese words (Xie, 2001)

Vocabulary Unit	Hierarchical structure	Explanation
clause	走后门 (Through the back door)	Solve a problem through a unprofessional way
words	走, 后门	go, back door
Chinese word	走, 后, 门	Go, back, door

### 5.3. Process Oriented Paradigm

Process-oriented paradigm, originated from engineering science and business management, is also a computing paradigm. For example, in the programming world, the philosophy of the process-oriented programming has deep root in using process-oriented paradigm. Process-oriented paradigm usually uses diagrams to represent processes or actions with respect to a computing problem. These diagrams capture, handle, model, store and disseminate the data and information of a system and its environment or data and information among the components in the system or system environment (Guo, Sun, & Zhao, 2009).

Any computer algorithms, programs or procedures or protocols can be considered an application or instantiation of process-oriented paradigm. Whenever we use process-oriented paradigm to examine a computing problem, we think: Can the problem be treated as a process?

The answer is "yes, we can". In our view, in the past three scores years, Chinese words, language and culture have been processed with the benefits of applying the process oriented paradigms (Zong, Cao, & Yu, 2009)(Zhang P. , 2009) (see Section 3). Just about every Chinese inside or outside the Chinese dominion has been enjoying the successful consequence of applying process-oriented paradigm to Chinese words, language and culture.

### 5.4. Engineering paradigm

The establishment of the engineering paradigm was originated from our experience derived from engineering science, computer engineering and software engineering (Pressman, 2001). Its core principle is that we use the effective engineering principles, ideas and methods to develop computing systems, software systems and intelligent systems (Guo, Sun, & Zhao, 2009).

Engineers are very pragmatic and always very focused. In fact, they as a group are often viewed as an isolated identity by other peer groups of their society. In a nutshell, an engineering project often involves no less than eleven task components as follows: technical, legal, political, environmental and social factors and systems analysis, design, verification, simulation, emulation and management (Larson & Gray, 2011). The invention of digital computers came much later

chronologically. The introduction, in fact, has had profound impact on just about every face of the endeavors. As it turns out, the engineering paradigm has also deeply embedded or emerged into essentially the same spirit and practice. Furthermore, computing being divided into computing science, computing technology, computing engineering, computing tools, computing services and computing applications is itself an application of engineering paradigm. Whenever we use the engineering paradigm to examine a computing problem, we think: Can the problem be engineered? In fact, the engineering paradigm is a platform that verifies any theory in computing science and any technique and engineering method in computing technology. Therefore, computing is one of the most pragmatic disciplines that integrate science, technology, management and engineering effectively and efficiently in the past more than half a century. In contrast, for example, the mathematicians have not really embraced such philosophy in order to become one of their characteristics. Their sole goal is to search for the truth, nothing but the truth. Engineers must be pragmatic enough to put the working products on the table.

As mentioned earlier, Chinese words, language and culture have been successfully engineered with the help of engineering paradigms (see Section 4). The main point we would like to stress here is the effectiveness of the power of "Engineering Paradigm". It is precisely due to this particular paradigm, we are able to achieve our originally envisioned: More than 1.3 billion Chinese have indeed enjoying the benefit of an open media in Chinese language. The Chinese can watch, read, and listen to any news occurred in every corner of the worlds in Chinese, although it might be originally in English, Russian or Japanese.

## **5.5. Intelligent paradigm**

Intelligent paradigm originated from computing machinery and intelligence, published by Alan Turing in 1950 (Turing, 1950). The development of Artificial Intelligence (AI) and intelligent systems (IS) over the past half a century makes the intelligent paradigm an important one in computing (Russell & Norvig, 2010). Intelligent systems such as expert systems, knowledge based systems, knowledge management systems and management intelligent systems have been facilitating our day-to-day life in social, economic, commercial and financial world (Negnevitsky, 2005). Intelligent devices such as smart phones and iPods have been helping us to deal with a number of business and daily activities (Turban & Volonino, 2011). Whenever we use intelligent paradigm to examine a computing problem, we think: Is the problem related to intelligence? Can this machine or device liberate us from heavy mind labor? Can we build an intelligent machine or device or system to solve the problem?

Let us examine what all these hypes and reality happenings mean to the issue of the scientific Chinese trinity. Intelligent processing of Chinese words, language and culture has been always drawing much attention to Chinese scholars. Nothing is more evident nowadays to observe that all Chinese are enjoying the intelligent transportation management systems as being expressed in Chinese language. Another example we would like to mention is that the intelligent Chinese words processing systems are available commercially. To illustrate our statement making the use of a concrete example; say, if you input and display a four-words Chinese phrase such as "mang ren mo xiang" (盲人摸象) into one's laptop or mobile phone, all you need to do is to key in four characters "mrmx" in the keyboard if your laptop or mobile phone has already installed a Chinese input software. For the purpose of comparison, should one has to use English language instead, one must key in, instead, the 33 clicks of "the blind man touches an elephant". The story also exemplify Chinese researchers can adaptively taking the advantage of the capability of an intelligent paradigm and to design a pragmatic system accordingly in order to enjoy the benefits of this wonderful capability.

## **5.6. Humanization paradigm**

Humanization is a social requirement of any technologies and products (Sun & Guo, 2010). It is perhaps easier to understand the humanization paradigm by examining the concrete example of humanoid. Humanoid is a mechatronic realization of humanization paradigm (Russell & Norvig, 2010). A great deal of the success of the contemporary science, technology, engineering projects and commercial products can be attributed to the paradigm of the Humanization. This also explains the need and incentive of creating a special nomenclature of the 'humanoid' simply to remind the scientists and engineers the importance of their endeavors in creating marketable of commercialized 'humanoids'. The Google Corporation has emerged as an envy of the society because it effectively captures the principle of the humanization satisfying the demand of the consumers who love to search for information useful or important to them: As soon as we access the Internet, it becomes immediately evidence that we do have the urge to search! The economic value of the Google Search is one significant example that exemplifies the importance of making the use of the humanization paradigm. Naturally, the researchers in computer industry cannot help it to bear in mind faithfully reminding themselves to check with the possibility of employing this paradigm first whenever there is a need arise to employ the computing technology. Therefore, humanization paradigm is one of the most important paradigms in computing. Whenever we use humanization paradigm to examine a computing problem, we usually think: Is this problem related to humanization? Can this machine or device be humanized?

It is interesting to observe that the more traditional engineers also ask similar questions whenever they encounter this sensitive issue because they do not want to miss the boat either, especially during the very early state of the project. These more traditional engineers would ask similar question such as: "Can we design this machine or device in a more humanized manner in order to satisfy our new culture or new way of life?" To say the least, this alternative or the added value must be examined before the next move is taken! As one can clearly see through, the humanized or personalized paradigm is a new paradigm not only can be important to e-commerce, but also is indispensable for many manufacturing sectors of the industry. Here one also reveals the true meaning of the reason why the information revolution has a profound impact on the contemporary society and new culture revolution as well.

Throughout the Chinese history, there was evidence that Chinese words have always been humanized because the evolution of Chinese words has taken into account of the writing tools that can be used to write Chinese words easily, fast and conveniently (Chen S. , 2001). On a higher level, Chinese language has also been highly humanized as well. Ever since the humanization paradigm of computing has been introduced to the Chinese society during the past six decades, Chinese words and language have become more humanized. Nowadays, you can write whatever you like in Chinese language with digital computer and you can communicate with ease using mobile phone as well. One can access and watch Chinese media in just every corner globally. Chinese people really have figured out and have known exactly what they want by making a good use of the Internet.

## **5.7. Networking Paradigm**

The concept of networking originated from sociology (social networks), economics (market networks, supply networks and business networks) and computer networks (the Internet) (Sun & Guo, 2010). As the Internet evolving over the past many years into our contemporary lives, the importance of the networking paradigm is, beyond any question, one of the most important paradigms in computing. Actually, networking has always been an important paradigm ever since human being has had meaningful civilization. The distribution of electricity to users, the power grids, has been the most recognizable networking. The car dealerships are connected via a distribution marketing networks. Any cocktail party you have ever attended is a social networking. The social networking is an indispensable daily living for a contemporary society as amplified by

the Facebook and other online social networks such as QZone. Equal importance is the gene regulation network which may provide the most important bio-informatics expected to reveal the secret of our lives and ever searching the cure of various diseases (Jarvis, Yu, & Wang, 2004)

To a narrower scope as we focusing on attacking our problem on hand concerning scientific

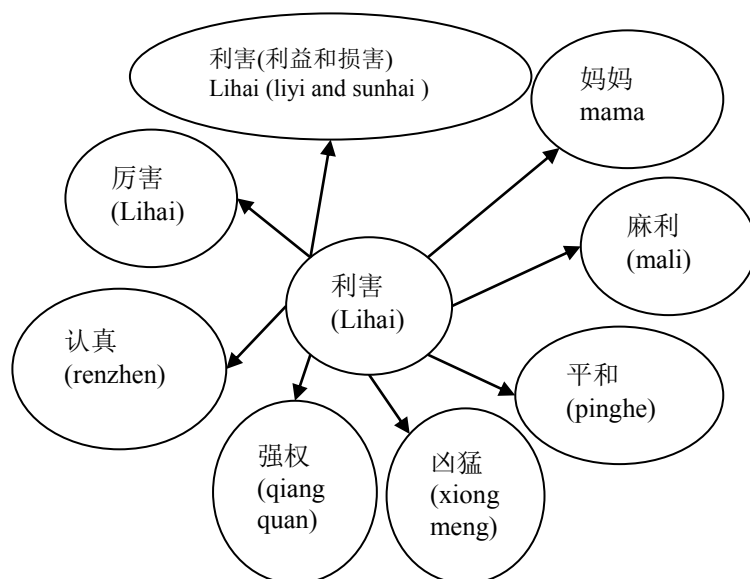


Fig 3. A networking structure of Chinese words, extracted from (Xie, 2001)

Chinese language, the Chinese words are being utilized by users for many applications in the computer networks as exemplified by the works of Wang et al. (Wang, Wang, Chi, & Chen, 2008). The dramatic development of the Internet and on-line social networking has literally brought the networking paradigms out in the front of the center stage of the computing technology and computing thinking. Knowingly or unknowingly, it becomes a habit for computing scientist confronting a problem to ask the following question; "Can we or it would be the best to solve this particular problem taking the advantage of the power of networking paradigm and sometimes, preferable to be executed on-line?"

It is also interesting to reflect that the theoretical foundation for networking paradigm is the mathematics of the finite graphs and networks discovered and extensively studied by our ancestors (Busacker & Saaty, 1965). Equally ancient, of course is the invention of Chinese words, strongly cognitively motivated. Chinese language, like any other languages, relies upon its semantic networks to exhibit its power of the usages. Chinese Words themselves, can be, and naturally ought to be networked, somehow. Throughout the long history of the Chinese language usage, it has been well established that the Chinese language has always been making the use of the networking paradigms for the growth and evolution. It is our deep conviction that the networking paradigms will play a pivotal role in improving the Trinity of the Chinese words, Chinese language and Chinese culture and really blossomed over the strong vehicle of the Internet technology. It is also well recognized that the Chinese culture has always been emphasizing the collectivist social relationship rather than that of the individual. This very fact itself will present in front of us a very challenging prospective! We finalize this subsection by illustrating the networking structure of Chinese words, as shown in Figure 3. In this figure, the Chinese words at the center circle and the Chinese words around it forms a star-networking structure with some relationships from a viewpoint of Chinese linguistics. Every Chinese word at the ring circle can form another star-networking structure, and then a complicated networking structure for all the Chinese words like a national map.

## **5.8. Mobile Paradigm**

Mobilization has undergone a number of evolutions or revolutions in human history. We use bicycles, automobiles, trains, aircrafts and spaceships to realize physical movement from one place to another, from one country to another country, even from from the earth to the moon and return to the earth. We use telephone, fax, email, teleconferencing, the Internet and online social networking to communicate with each other in every corner of the world successfully, effectively and efficiently. However, mobile computing and mobile communication just allow us to exchange information beyond time and space more naturally. Therefore, mobile paradigm is an important paradigm in computing and computing thinking (Sun & Guo, 2010). Whenever we use mobile paradigm to examine a computing problem, we consider: Can we contact or see a person to solve this problem no matter where and when s/he is?

Chinese culture prefers face-to-face communication and instant communication. Planned appointment and arrangement is not the first option for the most Chinese in China. The availability of the mobile telephone has literally made the Chinese culture realize the true characteristics of the Chinese culture as the Chinese society evolves into the mobile computing era. This is the reason why mobile communication has made a dramatic progress in China (Schenider, 2011). It is acknowledged that China has become the powerhouse of mobile phones production in the world. China is a country with the largest number of mobile phones users in the world. The majority of people in China mainly use mobile phone to communicate with each other. When you walked on campus, on the street or other public places in China, you will find a number of mobile phone users are communicating with others. Behind this social phenomenon is the relationship between Chinese culture and mobile communication. This a significant issue for studying in the near future.

However, email communication has not dominated the communication among Chinese people. To our knowledge and experiences in China, Chinese people prefer to instant communication rather than designed or arranged communication. This may be the reason why Chinese people select mobile phone rather than email as the dominated communication means in the web era.

## **5.9. Service-oriented Paradigm**

Service consciousness for a community has never been more important than today. According to IBM's prediction, China will be transformed from manufacturing-based society into a service-oriented society by 2020. Computing science and technology are the fundamentals for modern service-oriented economic development. This is the reason why software as a service (SaaS) and services computing become more and more important (Zhang, Zhang, & Cai, 2007). Therefore, the service oriented paradigm is one of the most important paradigms in computing and computing thinking. Whenever we use service oriented paradigm to examine a computing problem, we consider: Can we consider this problem as a service? For example, decision making is a number one priority for the majority of managers and public officials. With the development of the Internet, they have to change their traditional way of decision making into decision making as service or decision as a service (DaaS). DaaS should be a strategic choice of Chinese e-government in the Internet era and the coming age of smarter customers.

Chinese words as a service, Chinese language as a service, and Chinese culture as a service were popular centuries ago. For example, Japanese language has many words in common with that of the Chinese language called kanji (Kanji is itself a Chinese dialect, identical with current "Hanzi" in Mandarin) (Lu, 2002) (p. 384) (Chen S. , 2001). However, its syntax is quite different from that of the Chinese language. Japanese is written using Chinese words in combination with two syllabary's named hiragana and katakana. It is important to remember that the most important aspect of the Japanese comes from either Kanji or Chinese words, so it is true for the Korean language derived from the Chinese language (Lu, 2002) (p. 360). There are more examples, such as



Vietnamese language as well as others not discussed here. Equally significance is the fact that Chinese culture's service trait has also left over the undeniable marks on those other cultures. It is quite correct to conclude here that the trinity of the Chinese words, Chinese language and Chinese culture, evolved over the lengthy Chinese history, will be very much alive and hopefully, much improved due to the Scientific Chinese trinity.

## **5.10. Digitization (informatization) Paradigm**

Digitization or informatization has become now as a social requirement for computing development (Sun, Sun, & Guo, 2008). It is perhaps interesting to note only during the middle part of the 20th century, one of the heated debates was the digital computer and analog computer, which is more important? (Wang, William, & Hodgkiss, 1973). We point this out simply to remind ourselves the speed of technological advancing indeed is quite amazing! Furthermore, only during the 1990's, the United States Vice-president Al Gore promoted the information superhighway to advance scientific research and facilitate public services, which accelerated informatization or digitization. The Internet and the Web have fostered the vigorous development towards the informatization of governments, businesses, education, and information society. Therefore, digitization or informatization paradigm is one of the most important paradigms in computing or computing thinking. Whenever we use digitization or informatization paradigm to examine a computing problem, we consider: Can this problem be digitalized or informatized? In practice, any problem solving or project associated with digitization or informatization implies that it will be solved or undergone using information technology in particular and computing in general.

Chinese words have been digitized in the 1980s in the form of a national standard: GB2312-80 (Zhang P. , 2009). Chinese language has also been digitized with the development of computer and technology in the 1980s. Chinese culture has being digitized dramatically since the 1990s. Chinese government's promoted e-government is being digitized. Anyone can watch TV news, programs and movies in Chinese online at every corner of the world thanks to the development of the Internet and Web. The majority of the Chinese citizens can access a significant number of public services from e-government.

## **5.11. Interrelationships among the Ten Paradigms in Computing**

The above proposed ten core paradigms of computing and computing thinking are interrelated closely with one another in the manner as shown hierarchically in Figure 4. They are at three different levels. The first three paradigms are on the bottom level, which are the fundamentals for computing and computing thinking. The following three paradigms are at an intermediate level, which can meet the social requirements for computing and computing thinking through accomplishing computing services, systems, technologies and tools. The last four paradigms are on the top level. They correspond to the social requirements for computing and computing thinking. All these can be considered as the talking points of the meso-computing thinking (which is an intermediate computing thinking between macro computing thinking and micro computing thinking) and they can easily be distinguishable among themselves from the perspective of the computational thinking (as per our discussion on the micro-computing thinking to be presented in our future works).

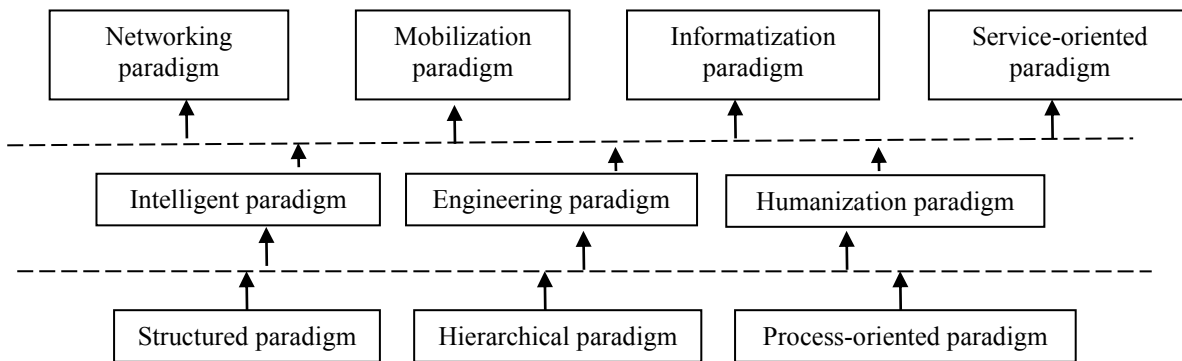


Figure 4: Interrelationship among the ten computing paradigm

## 6. Future Research Directions

As mentioned earlier, scientific Chinese trinity consists of scientific Chinese words, scientific Chinese language and scientific Chinese culture. The above-mentioned ten computing paradigms would indeed be strong vehicles to launch this unprecedented scientific reform movement. The following list represents only the beginning efforts on significant applications of the ten computing paradigms to Chinese trinity in order to develop scientific Chinese trinity as we envisioned:

- Computing with Chinese (like with natural language),
- Technologies with/of Chinese words or language or culture,
- Engineering with/of Chinese words or language or culture,
- Management with/of Chinese words or language or culture,
- Systems with/of Chinese words or language or culture,
- Reasoning with/of Chinese words,
- Reasoning with/of Chinese Language,
- Semantic net with/of Chinese words or Language,
- Ontology of Chinese words,
- Ontology of Chinese Language,
- etc.

More issues are still open in our exploration: How can we apply the above-mentioned ten paradigms of computing to scientific Chinese trinity? In other words, what are the hierarchical characteristics, structured characteristics, process-oriented characteristics of Chinese information in the context of Chinese culture, language and words? Processing of Chinese language or Chinese language information processing is used in China officially (Zhang P. , 2009). What are the advances of engineering Chinese information? What is the progress of intelligent Chinese information processing? What is the progress of humanizing Chinese information? What are the networked characteristics of Chinese culture? What are the mobile characteristics of Chinese culture? What is the progress of digitization of Chinese information/and what is the service-oriented characteristics of Chinese information? How can we apply the ten paradigms to Chinese syntax processing, Chinese text semantic processing, Chinese text processing, and context handling that have drawn significant attention in Chinese scholars in China? There are very few literatures on these interesting issues in the Chinese world. All these issues can be and should be addressed under

the roof of scientific Chinese trinity as the potential of future research agenda towards scientific Chinese trinity.

## 7. Conclusion

Scientific Chinese trinity consisting of scientific Chinese culture, scientific Chinese language and scientific Chinese words, is a comprehensive and complex issue facing Chinese people for sure and the rest of global population as well, since they cannot be insulated from its impacts. The upgrading of the scientific Chinese trinity, inevitably, requires the support of not only computing, but also the highly relevant fields of cognitive science, linguistics, philosophy, sciences, engineering, technology, management sciences and others not being mentioned here. Scientific Chinese trinity is not only the Chinese national grand objective with the hundreds of millions of creative Chinese, but also the rightfully expectation of all the people in the world. Scientific Chinese culture is a necessary condition for China to become one of the leading powers in the world in terms of economy, industry, services and defense. Scientific Chinese language and words are also the basis for a successful scientific Chinese culture that the world people and Chinese are looking forward to enjoying. For now, what we have accomplished is to come up with an outline of a vision or a primitive road map to realize the dream. Any attempts in this direction are invaluable.

In the past century Chinese have known and have understood what is the true meaning of being “scientific”. In this century, Chinese should try hard to realize the targeted scientific Chinese trinity and to build a scientific Chinese civilization for the world. What we have undertaken and will undertake is to contribute to the first step on this grand design for the benefits of the Chinese people and, for that matter, for the people all over the world.

In future works, we shall commence the new idea on Web Chinese trinity which consists of web Chinese words, Web Chinese language and Web Chinese culture. Web Chinese trinity is going to play an even more significant role in both Chinese trinity and scientific Chinese trinity alike.

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