Limit and Dynamics of Information Entropy in Transmission

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Abstract

This paper presents a theoretical explanation and test results that an amount of information would not increase infinitely in transmission via the mathematical model of the matter for deciphering original works of information entropy and the principle of thermodynamic entropy. The rate formula with energy is derived via retrieval speed testing the vast amount of data in DBMS and variables in rate formula proved via other testing methods. We found that the actual value in the rate formula was quite different from the theoretical value that calculating the entropy per bit of information needed energy and the speed need energy. We used of testing data to illustrate these relations between bit and energy, 1 bit $=3.92\times10^{-4}$ J/K. We assumed that the energy of Brillouin's information entropy was the surface entropy changes between information source and information channel rather than the information source itself.

Keywords: information entropy, thermodynamic entropy, information limit, information energy, information dynamic formula

1. Introduction

The development of information technology has made the production of information increasingly easy, and integrated electronic technology has made the heavy load of processing data increasingly. Such a state of things brought about the cycle which the higher electronic circuit integrated, the easier information created or otherwise. However, we are able to find an objective phenomenon that information sent from the source to the destination become longer and longer at the response of time lag. For example, information straight line transmission in the distance of face to face may take more than 1 minute (sent a short message by mobile terminals), and database retrieved, website access or network document download does not reach the speed at 100 Mb/s (10^6 bit) or Gb/s (10^9 bit) as marked on the device. People feel a network adapter of Fast Ethernet is only a few Mb/s at the fastest receipt of the information flow. Information transmission related to a variety of links, but information technology came only to improve gate switching frequency per second from the technology, which the number of binary symbols defines the digital rate (bit/s) of transmission capacity, and the method of information filtering improved the distortion phenomenon for signals, and the mechanism of dynamics was not proved to be the entire network from the information processing. Information conversion and transmission processing would distort information with the actual energy loss and produce current noise due to other factors. The problem about information released on different carriers would directly result to loss packets and polarize seriously carrier's surface and other physical phenomena along frequency increased, so that the rate of information transfer became slow.

The main performance in the information age is the rapid development of information technology to make people more convenient and faster access to information, all kinds of information-related economic and social development get into the mainstream. While information systems as application is relying on computer word processing so far, it has rapidly developed in the calculation and transmission speed, network bandwidth, software function and hardware configuration. Information management is activities of development and

utilization for information resources such as plan, organize, control and coordination, its role is to organize information to become innovative resources. However, there are many problems led up to information in transmission with communication networks, computer networks, and other related equipments. One of main problems is not equal to the actual speed and calculated speed at the amount of information received. These different speeds may be caused by signal conversion, transmission media, theory deviation and other factors to bring in-depth impact of information management. But more importantly problem may be the misunderstanding on the derivation and understanding, this needs to verify at basic theory and practical test about information.

Since "The Mathematical Principles of Communication" (Shannon, 1965) written by Claude Elwood Shannon in 1948 at the Bell System Technical Journal was published serially, the discussion about information has not being interrupted and become an ancient and long-term topic. The expression of negative entropy in many references cited equally "Control Theory" written by Norbert Wiener, who is a founder of the cybernetics, in Chapter III of this passage mentioned that amount of information could be viewed as a negative logarithm of the probability amount, and it was essentially negative entropy (Wiener, 1985) in 1948 edition. Or "What is life" in the September 1944 written by Erwin Schrodinger, who is a founder of the quantum mechanics, in the sixth chapter "negative entropy for a living" referred that a living organism was constantly generate entropy -- or could be said to increase positive entropy -- and gradually approached the maximum entropy of the dangerous state and to live, the only way was to continue to derive from the environment negative entropy (Schrodinger, 2003). And in the "Science and Information Theory" written by the French-American scientists L. Brillouin simply and directly pointed out that information was negative entropy. As a result of many authors in China obtained the early original foreign literature limited and read with difficulty, only the existing books with translation straightly cited into their literature, rather than read the original text. At present the major websites in Chinese books are only able to retrieve that "Control Theory" published the second edition by the Science Press in February 1963 and "What is Life" published by the Shanghai People's Publishing House in 1973 and "Information Theory Foundations" published by the Shanghai Science and Technology Press in April 1965 in which to include two essays "The Mathematical Principles of Communication" written by Shannon in 1948.

In order to understand the intention of the author expression, apply and develop information entropy. We shall prove the speed marked on the device is incorrect and the speed of information in transmission relation to energy. We shall use the mathematical model of the matter to explain the limit of information superposition in transmission termination. We need to correct some incorrect descriptions, while further verified by measurement.

2. Original Works Comprehension

As concerns Chinese translation, the original works published and issued at the time order are from as "What is Life", "Control Theory" and "The Mathematical Principles of Communication" to understand. In "What is life" it referred that the relationship between entropy and order was given by the Boltzmann and Gibbs in statistical physics, the entropy = k**ln*D. If the D was a disorder measure, its reciprocal 1/D could be used as a direct measure of orderliness. As the 1/D was just the logarithm of the negative logarithm of the D, negative entropy = k**ln* (1/D). In the "Control Theory" it was that the result of information transfer rate was obtained by the author (Wiener) and Shannon and Wiener in the introduction of the book he said again that the statistical theory of information amount at the same time had put out by several scientists such as Fisher studied the statistics of the information amount from classical statistical theory as motivation, Shannon did it from the information encoded, and he himself did it to be the noise from the electric filter and message. He also mentioned that the information amount was a measure of system organizational degrees, and the information amount was just the negative of entropy. In "The Mathematical Principles of Communication" the three conditions were met with the H(P), symbol probability measure, was as follows:

- H should be a continuous function of p_i.
- If all p_i were equal, $p_i = 1/n$, then H was a monotonous rising function of n, there was more uncertainty.
- If two steps had been selected, then the original value of H would be equal to the weighted sum of each H.

On information entropy had a simpler Formula (1) and derivation in Appendix 2 of author's paper.

$$H = -K\sum_{i=1}^{n} p_i \log p_i \tag{1}$$

In the paper wrote, H in the formula liked the entropy in statistical mechanics and p_1 denoted the probability of i-element phase space in system. The formula was called the entropy of probability set p_1, ... p_n. Each possible state i had a probability set p_1 (j) for every possible symbol j, and each state had an entropy H_i. The entropy of

information source would be defined that these H_i denoted the average weighted according to each probability derived from Equation (2).

$$H = \sum_i P_i H_i = -\sum_{i,j} P_i p_i(j) \log p_i(j) \quad (2)$$

2.1 Wiener-Based Viewpoints

● In order to solve problems of the engineering design his viewpoint was same with Shannon's. The communications engineering became a branch of statistical mechanics.

● Only if information transfer was alternative as events, the transmission was possible. Information must be passed by some physical process. Information could transfer with very low energy.

● It was a system in statistical equilibrium that was to reach equilibrium between the entropy and the energy. Stable state of life was a death body.

● Social system was a kind of organization like an individual, which was linked together by a communication system, and it also had its dynamics that made a cyclic process of the feedback nature play an important role. Schrodinger said a system must be close to absolute zero and to what extent to exhibit a similar "dynamics" behavior.

● Message was a sequence distributed of discrete or continuous in an amount of time events that is statistician said time series. Shannon thought a message was meaningful, according to some relationship with entities linked of certain substances or some concepts.

● The main purpose of communication engineering was not in saving energy, but to make accurate signal regeneration. Entropy increase law can only be applied to completely isolate system and does not apply to non-isolated parts of the system.

● As correspondence of one to one between sets, they would have the same potential. The same potential set as natural numbers was a countable potential.

Above all, communication engineering was derived from the principles of statistical mechanics. Communication conveying a message is a piece of thing rather than material. Communication system was an open system and need to provide energy via environment to make negative entropy increases. Communication network performed the dynamic behavior related to energy. Information needs to pass the physical carries conveying. While information set forms one-one correspondence at equilibrium, set theory can use to calculate.

2.2 Understanding Shannon Information

Shannon in The Mathematical Theory of Communication said clearly that "These semantic aspects of communication are irrelevant to the engineering problem" but he did not say grammar and pragmatic issues. Because of the voice transmission in communication initially, both sides used to be the acceptable natural language, then a wire telegram with dots and dashes transmitted a language to translate manually called encode. In modern communication transmission engineering language expressed has been diverted digital signal such coding encryption, multiplexing encoded as to be all artificial language, and natural language is not in any way. Then semantics of language in communication engineering is different from semantics of natural language, and does not be grammar and pragmatic used natural language, and only to comply with coding their own grammar rules. Second he said that an actual message might be selected from probable message set. Again said that number of messages among the set were limited and he thought this probable message had been known as elements in set and number of elements were limited, and did not say events other than message. Third he said that this number with any monotonic function could select a message from the set as the measure of information generated. All number of messages or the set are monotone functions and could be solved by an integral and one of message values measured, which this value is information and no other definition or interpretation. Next he mentioned information storage amount, information transmission, channel information capacity, and the unit measure of information call as bit in binary unit. Logarithm is intuitive calculation and logarithm value of message numbers is a number as dimensions. Its physical meaning is only for conversion. Here the number of messages does not build relationship with information and does only relationship with information amount. This is to say that information's meaning may refer total to the information amount because information transmission and information capacity are replace by the information amount as the amount of information transmission and the amount of information capacity and these also can be explained entirely clear.

This is the schematic diagram of a general communication system or a sketch map of generalized communication system in Figure 1 (Shannon, 1948). A communication system indicates that the message from

the information source to the receiver (information destination) was send and received, but between the transmitter and receiver it was the signal, no information appeared. The signal is the transmitting form of various messages such as a letter sequence, monotonic time function, coordinates and time function and so on. From information amount considered here, there was only the message relation between the information source and the information destination, then the transmission signal related with the channel. It is to say that message is always about the state sent and the state received (information amount) as state function, while the transmission signal is about coding as process function.

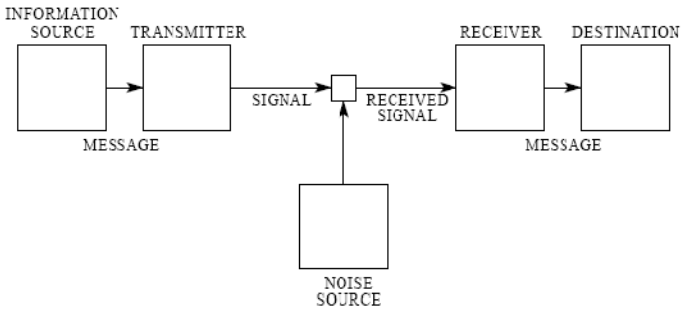

Figure 1. The sketch map of generalized communication system

The amount of self information did not be defined in his paper, and it is as follow Formula (3).

$$I(x_i) = \log p(x_i) = \log \frac{1}{p(x_i)} \tag{3}$$

2.3 Thermodynamic Entropy

Thermodynamic entropy is a state function of the system with all thermodynamic properties of state functions. While a state of the system is certain, the entropy must be certain value. Under certain conditions, the change of thermodynamic entropy ΔS can be used as the direction and extent of the decision process. ΔS depends on the process from beginning to end state, when $\Delta S = 0$ for the cycle process. In solitary system $\Delta S_s > 0$ for the spontaneous process and $\Delta S_s = 0$ for balancing process, $\Delta S_s < 0$ this process does not happen automatically and the system needs the environment to give energy to make it happen. According to the definition of entropy change, only a reversible process is quotient with heat and temperature to call entropy change and quotient change with heat and temperature of any process is different to vary with process. Reversible process is the largest quotient of heat temperature and the irreversible absorbed heat process is small than the reversible process in the system. If a process is exothermic, the system gives more heat than reversible process. When change value of the entropy is taken for the discrimination of process property, it means $\Delta S_{total} = \Delta S_{system} + \Delta S_{environment} = 0$ is a reversible process loop, and $\Delta S_{total} > 0$ the process is irreversible. No matter whether the system is reversible process or irreversible process, it is same state between begin and end, $\Delta S_{s,r} = \Delta S_{s,ir}$, so $-\Delta S_{en,r} > -\Delta S_{en,ir}$, or $\Delta S_{en,r} < \Delta S_{en,ir}$, that is the environment entropy increment which irreversible entropy change is a few bigger than reversible one. We know in nature the spontaneous process is irreversible process, in order to calculate the irreversible process of entropy increment, on condition that begin state and end state of the system always remain unchanged, it is envisaged to be some reversible process after passing a change. The entropy increment must equal the original incremental irreversible process from design to calculate out of the reversible process, because only the reversible process extended to irreversible processes could be calculated with a reversible heat entropy Q_R. Statistical mechanics for the system and environment has strict limit at mathematical symbols, which the system energy released outside as positive and the system absorbed energy as negative. So the negative entropy is not actual meaning of the negative value relative to the negative direction of the system, and reducing the number of the states of the system led to reduced entropy change values. The entropy change of non-isolated system $\Delta S_{en,ir}$ is incremental entropy the of the environment, and negative value can be given to explain any other physical meaning.

In accordance with the thermodynamic viewpoint which life is an irreversible open systems, entropy change of the system consists of two parts, $\Delta S = \Delta S_{s,ir} + \Delta S_{en,ir}$, and $\Delta S_{s,ir}$ is spontaneously generated entropy change within the system, called the entropy production, and $\Delta S_{s,ir}$ can not be negative obviously, so $\Delta S_{s,ir} \geq 0$. $\Delta S_{en,ir}$ is entropy changes that a system exchange energy and material with the outside world, known as entropy difference.

Generally speaking, the entropy difference can be positive, zero or negative. Entropy is derived from statistical mechanics and is a distribution function of the system states to be always positive. When the macroscopic amount of the system was equilibrium the entropy was the maximum value in micro-state. When part of the states in the system had been changed, non-steady states had been shown of entropy increase. Negative entropy is relative entropy difference value between two states, does not mean that the number of system state. Changing entropy in system relates with the physical quantities. Pure figures do not make any sense and are not able to be fully applied in the real world.

3. The Discussion about Information Entropy

In various fields of contemporary research information and dynamics are becoming the key terms. Information is the possibility that negative (virtual) information can be carried by entangled particles suggests a consistent interpretation of quantum informational processes (Cerf & Adami, 1995). Unlike in Shannon theory, conditional entropies can be negative when considering quantum entangled systems (Cerf & Adami, 1996). The information dynamics methodology occurs also in the analysis of stochastic dynamical systems. In spite of this type of problems the modeling and analysis of dynamic stochastic systems require empirical measurements and deals with statistical problems of time series. But, in the majority of cases the available information on the process in question is deficient (Sobczyk, 2000). It is the internal unity of the physical entropy and Shannon information entropy (Xia, 1994).

3.1 Distinctions of Information Entropy and Entropy

● Entropy is a statistical hypothesis based on abstract message, and its symbols denote statistic objects to indicate a difference in their individual symbols and a limited number of symbols are constant. Statistical objects in Statistical mechanics are a large number of molecules or atoms, which molecules or atoms are differences on classes as particles. The particles are related with the energy at the different levels and they can not establish every certain value simultaneously, but the total number of particles and the total energy are certain.

● Information entropy derived has nothing to do with the thermodynamic quantities, and the use of mathematical formula entirely is unable to express directly the physical meaning. Then the system of the statistical mechanics is constant based on the total number of particles and the total energy in the physical situation and the distribution of particles are changing in a very small subsystem, and the macroscopic properties get interpretation via micro-state properties.

● The formula of statistical mechanics for information entropy used the classical statistical mechanics instead of the quantum statistical mechanics or was the application of the probability theory. The quantum statistical mechanics show that in certain macro-conditions, a system at the some time has a certain probability at a certain quantum state, and macroscopic quantities of the system could be statistical average at all possible quantum states for the appropriate microscopic quantities in the system.

● Kolmogorov defined the complexity of information entropy as a set of data string required for the shortest binary lengths, so the complexity was described as the minimum length. Then the confusion degrees of thermodynamic entropy were the number of states for the particle arranged at different levels, only the maximum possible, not minimum. There are negative entropy and the opposite conclusion.

● A set of discrete sources of Markov process that has a special significance in communication theory and ergodic process consist of the ergodic information source called. Shannon though ergodic process was a statistic structure for different information source and state changes happened in the transmission and every sequence generated by the process had the same statistical properties. In quantum statistical mechanics, phase space Hamiltonian $H(q, p) = E$ denoted a curved face in $(6N-1)$-dimensional, and called the energy surface. The phase point in a conservative system passes through trails and was on the energy surface and its energy function did not include time t. If it included t, the trail of someone point passing in the phase space could be different direction at different time, and trails might intersect. In fact, statistical independence in a system is ergodic process.

● Shannon about capacity C and state transition rates used time interval T, message length T, message duration T, symbol sampling time t. No matter whether steady state or non-steady state in statistical mechanics subsystem is, it has proved that the state changes have nothing to do with time. Information source should have nothing to do with time and information channel should have something to do with time. He over and over took the relationship between information source and time explained relationship between information channel capacity and rate, but did not establish a time function of information channel $C(t)$. It is main cause that he did not completely understand the difference between state and process. In fact, there is the essential difference between the state of information source and the process of information channel.

● Two possible cases with probability p and $q = 1 - p$ were entropy as Formula (4).

$$H = -(p \log p + q \log q) \tag{4}$$

There were six properties on *H-p* mapping. The first of properties was that when all probabilities p_i except one were zero, then $H = 0$ and the only probability was equal to *1*, and that H was equal to zero in the result established entirely. The second of ones was that in the condition of n given, if all of the p_i were equal, that was $1/n$, then H would be the maximum and equal to $\log n$. This was the most uncertain situation. According to statistical mechanics, the assumption was that probability was found a given area $\Delta p * \Delta q$ in the phase space and the system was in the range of a microscopic movement state. The probability beyond the area $\Delta p * \Delta q$ was zero and macroscopic quantities were gotten corresponding to the system. Because the statistical mechanics is always to study states of the system, so the maximum value of information quantities can only be reflected in states of information source and not reflected in the capacity of information channel.

● A system in steady state as a whole or non-steady state is different from the energy exchange of environment doing work to system. Shannon's theory was only based on states of the system, while no expression was what kind of system, what states of the information source, how to "copy" to the information channel, whether put force in the transmission process. So there is no surprising for reflecting thermodynamic quantities.

● Negative entropy and uncertainty proposed were based on the subjective psychological factors of information destination but it given priority to information source, information channel at the operation. These are contrary to the objective reality of entropy and entropy additive.

Therefore, the concept of information entropy is a distribution of probability and statistics on completely abstract sense and any physical quantity can not establish a real relationship. It can not solve the actual relationship between the information quantities and the transmission speed, information transmission and external energy. We want to establish the balance relationship between mechanical quantities and information entropy through the only test and to re-establish and prove the relationship between thermodynamic entropy and information entropy.

3.2 Any Event Information Entropy

In Shannon's paper condition 2, information entropy derived can be interpreted as equal probable events and all of events are independent events, because they got the maximum amount of information, also ruled out possibility of any event. In condition 3, information entropy had a weighting sum step by step, but the weighting factor was not p_i, the example does not match with the given formula.

Author expounded problems that was not equal to probability appeared for natural language, continuous information source, symbol sequence such as the possible of former symbol appeared with another symbol, ranges, the possibility of two or more symbols simultaneous occurrence and so on. When described the formula of amount of information he assumed that the average of sequence and all possible sequences was equal (difference probability was zero). Such as letter A in an infinite sequence appeared relative numbers would be equal to it relative numbers of occurrences in all the sequences, that probability is always $p_i = 1/n$, so as to apply method of the statistical mechanics, information obtained the amount of the maximum.

In real life, the probability of using English letters is not the same. We assume that there are three letters A, B, C. Let the probability that they are $P(A) = 0.3$, $P(B) = 0.6$, $P(C) = 0.1$. For such a message how to code an average of each letter used by the least digital it? Obviously this code is unwise for A with 01, B with 100, C with 1, because it would mean each letter used in digital increased and the poor effectiveness. According to effectiveness claims, a change mode in encoding is more appropriate for A with 01, B with 1, C with 001. The objective regular is that a high probability of the letters should be compiled into a short code and a small probability of letters should be compiled into a long code. This can take the shortest average code length and the most effectiveness. However, the calculation results in math can not be expressed the existence possible in physical and social reality. When probability assumption is used, we think all equal probability events, and if the size of probability is appeared, there is degeneracy g_i (statistical weight) in the statistical physics, that is $\sum g_i P_i = 1$. The mathematical derivation of information entropy uses a different expression and it is in the actual existence, which is small than information entropy of equal probability.

In statistics, a statistical method is to add up all numbers base on arithmetic and there is only a certain sum value. In reality, a value may appear lass than the only maximum value because cross or repeat counting. The mathematical model of the matter is fallow (5).

$$S = n + \sum_{i=1}^{n} [(a_i - 1) \bigcup_{j=1}^{n} (a_j - 1)] \qquad (i \neq j) \tag{5}$$

Where n denotes item numbers and a_i is matter numbers, $\sum a_i \leq S \leq n$, and $\sum a_i - S$ is a number of repeat calculated. So in any two random events A, B, probability sum is equal to $P(A + B) = P(A) + P(B) - P(AB)$ and the probability difference is equal to $P(AB) = P(A) - P(AB)$. Because of information entropy only from information source, which the psychological understanding come from the possibility of the information destination without the actual presentation of information inherent entropy, the derivation of information entropy and application of information channel had an infinite additive. Assuming various elements of information source and information destination are in any states, their information entropy changes are happened as $H_{i,j} = H_i + H_j$ when information source combines with information destination.

$$H_{i,j} = -K \sum_{i=1}^{n} \sum_{j=1}^{n} p_{i,j} \log p_{i,j} + K \prod_{i=1}^{n} \prod_{j=1}^{n} p_{i,j} \log p_{i,j} \tag{6}$$

Therefore, between information destination and information source the changes will not cause an infinite increases of information quantities and the actual information entropy should be less than or equal to the maximum sum both information entropies as Equation (6). However, entropy changes of information destination are equal to $\Delta H = H_j - H_i$, of which information sources sent to information destination in the calculation, the net increase of information entropy is as follow (7).

$$\Delta H = -K \sum_{i=1}^{n} p_i \log p_i + K \prod_{i=1}^{n} \prod_{j=1}^{n} p_{i,j} \log p_{i,j} \tag{7}$$

When information entropy of information destination is zero or does not exist with the same elements of information source, the information destination n is the information source transmitting to n, and the entropy changes are caused by the information destination.

4. Testing Information Speed in Transmission

4.1 Speed and Frequency Factor

Norbert Wiener thought information as a reflective form must have certain material carrier, certain structure and some energy. During transmission information carrier requires to expend energy that used to improve transmission speed by increasing the frequency of electronic current and reduce impedance. The test of retrieval for database shown there was an exponential relation between transmission speed and energy. We combined all variable value of irrelevant and little change together with rate constant k, which was made different transmission medium affect. Rate constant k relates with frequency and does little at certain range of temperature. The rate formula is as follows Equation (8).

$$r = \frac{dH}{dt} = \frac{CkI_x h v^a}{LI_0 n} \tag{8}$$

I_0---- initial information quantities (uncertainly need transmission)

I_x---- terminal information quantities (transmission complete)

L----transmission distance

n----number of conversions

E----total energy in transmission, equals to hv

k----rate constant

C----capability of information carrier transfer

Some methods were used to test the data of certain amount under the same condition in different servers (Yan & Chai, 2005). The results are shown in Table 1.

Table 1. Piece numbers of retrieval per second in server

Server Name	Compaq	Langchao	Fujistu
Average	78,726	180,436	609,840
CPU clock frequency Hz	200	930	700×2

We took the total data processed by computer as transmission rate in the testing and regarded the main frequency extreme as main energy variation.

Transmission effectiveness may be measured by transmission rate and bandwidth utilization in communication, but people are more interested in what energy amount expended the information amount transmitted. We worked out the maximum energy to processing information via the function relation $r \sim v^x$. We used an approach method to solve value x when given $x = 1$ because of little data and much gap between their values. If data tested take into the rate formula in same data amount and database, the value of frequency index is proximally solved with different configuration of the computer. Processes of calculation method are as follows:

- Set frequency index $x = 1$and find out the frequency value closing to curvature.
- Assume that the other parameters are fixed and worked out the value x as Equation (9).

$$\frac{r_1}{r_2} = \frac{v_1^x}{v_2}, \frac{r_3}{r_2} = \frac{v_3^x}{v_2} \tag{9}$$

By using formula, we got different x values and calculated average x =1.12. The transmission rate of information quantities is inversely proportional to initial information quantities I_0 and directly proportional to terminal information quantities I_x, but more directly proportional to energy index x.

- Take parameters into formula and work out value of rate constant k.

We knew from Equation (10) k value including length L, channel capacity C and conversion number n, and retrieved out value I_x = 51 records, I_0 = 2,101,100 records, rate r = 180,436 record/sec, Planck-Einstein energy formula $E = hv$, Planck constant $h = 6.626\times10^{-34}$ J·s, clock frequency of LANGCHAO v = 930 Hz/s, frequency index a = 1.12.

$$k = \frac{rI_0}{I_x h v^a} \tag{10}$$

Rate constant of LANGCHAO computer $k = 5.31\times10^{39}$.

4.2 Rate and Conversion Number

We verified the conversion number via testing Brower/Server (B/S) and Client/Server (C/S) which are a main factor of transmission speed affected. We connected the Client to Server with unshielded twisted pair five (at ideal state) or through a switch on LAN (at actual state), migrated bibliography records 3,748,019 (I_0) of book checkout. There are many fields (columns) in the data table such as book-barcode, ISBN, first-author, book-search-no, check_control, publisher, publish_date, title, library_code and so on. We chosen book-barcode as search term in the end and retrieved word for "252959" and get eight records in results. We get the average value of every day and general average value of many days taken by testing in ideal state and actual state. Test results shown that the retrieval time in ideal state was less than in actual state, but there was not much difference which networks had no influences on retrieving data from the sever and data transmission.

The file size of B/S testing terminal program was 14.8 KB and the file size of C/S program design after compilation was 56.0 KB. Former was a little program in hard disk of server and latter was bigger in hard disk of client.

Table 2. The test data in ideal state

No.	First B/S	Second B/S	Third B/S	First C/S	Second C/S	Third C/S
1	31.59	32.89	31.08	23.60	23.94	20.43
2	29.36	33.39	28.14	21.73	20.98	20.24
3	42.19	36.03	31.14	26.03	28.74	21.67
Average	34.38	31.78	30.12	23.78	24.55	20.78
General average		32.09			23.04	

The data in Table 2 show that B/S is based on 3-tierd architecture in logic and Ethernet protocol in physical network. In this condition, both communications use the same network path between layer 1 and layer 2 or layer

2 and layer 3. C/S is based on 2-tierd architecture in logic and the network traffic is only the communication between client and server. In spite of the weak ability of process a large amount of information, C/S at rate is faster than B/S in the same executing works just because of lacked layer. So C/S is good at processing a large amount of data.

When initial information quantities I_0 and the results retrieved are certain, the retrieval speed r spent time t relates to tier structure n, $t \propto n$.

$$\frac{t_2}{t_1} = \frac{n_2}{n_1} = \frac{32.09}{23.04} = 1.393 \tag{11}$$

The t_1 denotes retrieval time and n_1 denotes number of conversions (factor) of C/S architecture, then t_2 *and* n_2 do ones of B/S architecture. When set n_1 =1, we get n_2 =1.393 as Equation (11).

4.3 Speed and Transmission Distance

In wired network, we could not do test experiment of a relation between information speed and distances because of the speed very fast and no cross-refer item. As we know both GSM and CDMA use cellular technology and effective radius is much longer and positioning accuracy is 300~1000 miles. PHS uses micro-cell technique, low power at base station, short propagating distance and the positioning accuracy is 50~300 miles. We already know about GSM, CDMA and PHS are different network models and technology, and some basic working principles and technology of short message. However, these are just theoretical description, a short message is not direct transmission in the actual process and meets a variety of problems such encountered by very strong external interference. We did test of sending a short message among three networks and discussed experimental data to indicate actual transmission speed of short message in GSM, CDMA, PHS and other wireless communications.

● Choose the test place

Open location did not have much high-rise building to arrange testing work.

● Choose test time

Time range: 12:00-13:00

● Choose test content and steps

Send message for three times to every mobile and for three times to each mobile. Sending content was “hello!” as a message.

● Test results

The results of transmission speed in different networking structures are shown at Table 3, Table 4 and Table 5.

Table 3. Time (sec) value taken GSM as inchoation

No.	GSM (receipt)	CDMA (receipt)	PHS (receipt)
1	8.26	11.42	7.18
2	8.79	10.86	5.37
3	11.53	11.26	5.86
Average value	9.53	11.18	6.14

Table 4. Time (sec) value taken CDMA as inchoation

No.	GSM (receipt)	CDMA (receipt)	PHS (receipt)
1	8.43	7.34	4.76
2	10.54	10.02	4.53
3	9.46	8.58	6.45
Average value	9.48	8.65	5.25

Table 5. Time (sec) value taken PHS as inchoation

No.	GSM (receipt)	CDMA (receipt)	PHS (receipt)
1	7.04	9.82	15.37
2	8.47	9.59	12.83
3	5.59	11.42	15.43
Average value	7.03	10.28	14.54

● Analysis conclusions

(1) The influence of networking technology

Because of different networking modes and system structures, messages sent result in different transmission speeds with respective advantages and disadvantages.

Although GSM has the advantage of high spectral efficiency and capacity efficiency which is three to five times more than TACS and could realize internetwork with ISDN and PSTN, it has the complex of mobile station, expensive transmission and the TDMA system to result in limit the network bandwidth required.

Although CDMA possesses the strong ability of anti-interference, anti-fading, anti-interception as well as low emissive power, high utilization of frequency and good compatibility, its quality of residential planning will directly affect the communication quality especially the few system capacity and identical standard.

Although PHS adopts adaptive array antenna, high utilization of frequency resource, low power of mobile station, there are imperfections of communication links and small covering range of base-station's signals, and sometime receive message is difficult.

All of these are because of the different of value in ideal state and actual state in transmitting messages process.

(2) The influence of positioning technology

The positioning technology of GSM and CDMA has significant influence in the transmitting speed of messages just because of low accuracy, less terminal and high-cost, but PHS prefers not to do. Although PHS has many advantages, it can't overcome the disadvantage of short of communication distance with the low power at base station.

In view of the above technology, we found that the speed of sending messages in same network was faster than different networks, but PHS was the contrary. We indicate that distributional density of GSM and CDMA among base stations was higher than PHS', and the transmission distance of PHS among base stations was more far than the distance of GSM and CDMA among base stations besides the reason in technology.

Through the test of sending messages among three networks, the data analysis indicated the actual transmission speed of short messages in the wireless network of GSM, CDMA and PHS. The speed of sending messages in same network is faster than one in different networks but PHS is the contrary. We also indicate that the density of GSM and CDMA among base stations is higher than PHS's and the transmission distance of PHS between base stations is more far than the distance of GSM and CDMA besides the reason in technology. Both the transmission distance and conversion further explain the effect at a speed of transmit information.

The external storage devices and database design have some influence at transmission speed (Yan, 2009).

4.4 Verification of Data Quantity

Thermodynamic entropy $S - S_0 = -k\overline{ln\,\rho}$, when integral constant $S_0 = 0$, is proportional to the statistical average of the logarithms of probability density (Wang, 1965). Brillouin proposed the relationship between information entropy and thermodynamic entropy that could be taken as the same thing in mathematical expression Equation (12), and he derived the quantitative relationship between them.

$$\Delta S = \frac{Q}{T} = \frac{E}{T} = \frac{h\nu}{T} = k\,ln\,N \tag{12}$$

Where Boltzmann constant is $k = 1.38\times10^{-23}$ J/K. We assume that only two equal probability states in the system is $N = 2$, and average information quantities are $ln2 = 0.693 = 1$ bit, $1\ bit = 1.38\times10^{-23}\times0.693 = 9.56\times10^{-24}$ J/K. The thermodynamic entropy change in system $\Delta S = k\ln2$ J/K when system gets one bit of information. That is to say the thermodynamic entropy in the system will reduce $k*ln2$ J/K when a system increases one bit of

information.

While Brillouin's formula calculates the energy of processing maximum ability, bit numbers converted the data quantity insert into the formula and get the energy value E/T needed in actual test. We know *1* bit = *kln*2 J/K, Boltzmann constant $k = 1.38\times10^{-23}$ J/K, $ln2 = 0.693$, *1* bit = $1.38\times10^{-23}\times0.693 = 9.56\times10^{-24}$ J/K.

The percentage and total data quantity I_0 in database are separately 10% (325,575 records), 20% (600,900 records), 30% (904,380 records), 40% (1,201,500 records), 50% (1,507,894 records), 60% (1,801,500 records), 70% (2,101,100 records), 80% (2,401,445 records), 90% (2,726,965 records), 100% (2,969,373 records), 110% (3,294,948 records), 120% (3,570,273 records). And each data table has same data fields, but the number of records is different. Retrieve word is component of six-figure barcode such as book barcode number "753586". Retrieve quantity (I_x) is separately 10% (8 records), 20% (16 records), 30% (26 records), 40% (36 records), 50% (42 records), 60% (46 records), 70% (51 records), 80% (55 records), 90% (55 records), 100% (55 records), 110% (63 records), 120% (71 records). Test results in Table 6 are calculated value of processing records per second and the average 78,726 record/sec.

Table 6. Test report in COMPAQ PROLIANT 800 server (9G hard disk)

Data quantity	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%	120%
Time	4.14	9.76	8.57	14.81	19.84	26.00	30.40	37.36	43.43	39.57	32.23	36.03
Record/sec	78,641	61,568	105,529	81,128	76,003	69,288	69,115	64,279	62,790	75,041	102,232	99,092

We knew the retrieve word in database is component of six-figure barcode and one byte is composition of eight bits, the average number of bits per second is $78,726\times6\times8=3,778,848$ bit/sec in the 294 °K (21 °C), and get again $k = 4.57\times10^{39}$ in COMPAQ PROLIANT 800 Server, according the Equation (13).

$$r = \frac{bit}{t} = \frac{khv^a}{I_0} \tag{13}$$

We can get $r = 1.48\times10^{3}$ J/sec, and *1* bit = 3.92×10^{-4} J/K. The energy of the actual test is 20 order times of magnitude the energy of theoretical calculation.

5. Conclusion

We know that bit is the smallest unit of data and storage and 8 bits is one Byte that is the basic measurement unit of storage space. The longer binary number each word contains, the more utility bits the computer process data and the higher precision it has. Although 1 bit information quantity that transmits a binary signal 0 or 1 is different concept and value from 1 bit information quantity that codes binary element of information source, the actual verification does not affect for theory value. Transmission speed can be expressed in two ways: bps (bit per second) and Bps, which b in bps is bit and B is Byte. For example, 100M bps is used measurement in local area networks and Bps is generally used for software download.

In the narrow information theory, primary purpose wants to improve the utility and reliability in communication. In order to send letters by binary code or Morse telegraph code, shorter digital sequences used could shorten the time required or increase sending the number of letters per unit time and accommodate more users in the same channel. For telecommunications providers and users, the problem is how to behave letters using the digital sequence with the shortest 0 or 1.

The concept of entropy describes the distribution of states which has the characteristic of the least heat potential and the most number of states and the most stable distribution. Statistic independence explains that the distribution of every subsystem only depends on its phase space and the distribution of complex subsystem also only depends on the product of individual distribution function. Liouville theorem illuminates that probability density is not change during move and the probability density in the final state is as same as it in the beginning state and has nothing to do with time. Unstable state is provided external force to steady state in the same system, which used to require relaxation time from unstable state to statistic balance state. This time can have the influence of beginning state of object removed all with the time interval enough. The really unstable state may quote strange attractor that expresses that the states in system show no change in the non-periodic rules with time and has much dependence on the initial state. The state changes do not have relation to time for both the steady state and non-steady state in a conservative system. There is energy exchange between environment and system only in the dissipative system to happen big change of states. The increasing or decreasing entropies are

associated with the system itself.

We believe that the energy relative formula of information entropy derived by Brillouin is not energy expended of information source itself and is still less the energy value needed of channel transmission via testing verification. This energy should be the value of "copy" information quantity from information source to channel surface or ergodic process required Shannon though, and also think the energy value is produced by strange attractor when information source contacts with the surface of information channel. No matter whether information quantity transmits in channel or sand in process, the symbols denotes the certain energy by outer exerting force and the negative direction. The information quantity by sent is proportional to the frequency index of outer energy. When the transmission time was $t = 0$, the transmission time of the beginning or end, the changes of information entropy shown of the value of the Brillouin's energy. No energy in transmission is able to imagine, but no speed in transmission is more intolerable. The speed at 100 Mb/s (10^6 bit) or Gb/s (10^9 bit) as marked on the device and the digital rate (bit/s) of transmission capacity are all fanciful because of speed relation with energy or frequency.

The mature theory of current information theory is enough to study state changes of information quantity in the same system, and this theory can demonstrate state changes between information source and carries of information source, and information source and information destination in the same system, and it can also serve as theoretical reliance of spontaneous movement of information without any external factors. However, the communication process must be under the external force and it is the process of fast transport with the unusual action. This is completely different from the study on state changes in the conservative system. It has direct theoretical relationship with the previous discussion about problems of information entropy, which had nothing to do with physical quantity, negative entropy and transmission.

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Notes

Note 1. **PACS Codes:** 01.40.gf, 02.30.Cj, 02.50.Cw.