



## **Research on Info-com Meaning Evolution and Metrics Based on Shannon Idea**

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### **Abstract:**

In 1940's, Shannon firstly offered communication model and information concept. This theory not only builds a key fundament in the communication field, but also provides a significant meaning to study on this academic for later. This paper adopts data analysis and comparison, model evolution, and multi-metric study. Then it specifies on approaching info-com meaning, bit information expression, and measurement formula. Thus the paper puts forward an evolution idea of info-com meaning and related innovation metric formula. It is grand of theory value and application significance for the modern ocean data info-com.

**Key Words:** Communication model, info-com meaning, ocean data, measurement formula, Shannon idea

### **1. Introduction**

Human uses message and communication for long history. However with Shannon idea born in last century, it delivers a complete message concept in information aspect. Moreover it sets

clear communication fundament. But with stepping into 21 century, the information times comes. It is unexpected to most of scientists that information explosion and big data exponential growth, e.g. mobile multimedia, e-commerce, internet of things, interactive game etc. Meanwhile the related theory study is far behind times quick development. Especially, information and information (in paper brief as info-com) meaning and metric has become a bottleneck to ocean data applications. The info-com connotation becomes really important topic. Until now it is rarely to read this kind of approach and paper. By means of data comparison method, model evolution, and multi-degree analysis, this paper studies this issue based on the combination of the character of modern info-com and Shannon idea. Then it provides a definition of today info-com meaning, evolution model as well as formula. It must highly produce valuable significance in info-com field for reference and study.

## 2. Info-com Meaning Comparison

### 2.1 Expression of Shannon Idea

Since Shannon delivering “A Mathematical Theory of communication“ and “Communication on the Noses “ in 1940’s, it becomes well known definitions of information<sup>[1]</sup>. This fixes the fundament of info-com aspect. Not only is it of revolution meaning but also pushes the development in info-com fields at that time.

Firstly Shannon explains this information could be measured, and provides the exact information definition as well as its probability rule as below<sup>[2]</sup>:

- 1)  $I = I[p(x)]$ , Information “ I” is function of probability “ p(x)”, I is decided by p(x).
- 2)  $P(x) \downarrow \rightarrow I \uparrow$ , that means if p(x) is more littler, the I is more bigger, vice versa. If  $p(x) = 1$ ,  $I = 0$ .
- 3) Each independent event containing message, then total information is sum from each event containing message.

The definition of information:

$$I = \log_a [ 1 / p(x) ] = - \log_a p(x) \quad (1)$$

When  $a=2$ , the unit is bit. This theory discloses the feature of information, moreover it is could be measured. In this communication model theory, explains that information can be transmitted by electronic signal. When  $P(x) = 1 / 4$ ,  $I = 2$  bit, that needs 2 bits binary pulses to

sending. It is showed that information quantity uses the less binary pluses when bit expresses this message of information. Hereby, the information is transformed into bit stream in electronic signal. After collection, processing, transmission, storage, and operation, up to the information is displayed. This is a complete communication system. It is brief definition and full of initiative meaning.

The communication second theorem by Shannon <sup>[2]</sup>, the formula is following:

$$C=B \text{Log}_2 ( 1+S/N) \quad (2)$$

That expresses the definition dynamic relation among capacity, bandwidth and signal-to-noise ratio (SNR). Meanwhile it provides the dialectical relation that better quality signal transmission could be gained when channel with noise. Then it produces two useful conclusions. 1), Using suitable channel coding could realizes the reliability of transmission ( or error rate approach zero ) when transmission rate is less than capacity in channel, vice versa. 2), To enhance bandwidth must reduce value of SNR when channel capacity is certain, vice versa.

Shannon idea is definitely of historical meaning. Furthermore this still produces active effect for later<sup>[1]</sup>. However due to historical limitation and rapid development of modern info-com, the new issues are becoming obvious such as multiformity of info-com meaning, variety of message carrier, batch of bit transmission, bottleneck of message concurrency etc. This paper does the research so that match today info-com.

## **2.2 Info-com Type Comparison**

Information is a cognitive subject receipts and expresses statue and method for things movement<sup>[3]</sup>. “ Information is characterization of universal attribute to objective things” .

At Shannon times, message types are mainly letter, newspaper, telegram, telephone and broadcast etc. According to the statistic abstract coming from American Census Bureau, up to 1948, America has 125 million times telephone voice which passed 222 millions kilometer (km) cable in each day. There are 3.1 millions voices for transmission. In addition, there is nearly 3.2 thousands broadcast stations working<sup>[4]</sup>. Thus voice and broadcasting signal are main transmission type.

However in today information times, information multiformity has covered various aspects, such as music, blog, searching, photo, television, news, game, e-mail, film and so on. The transmission type includes very wide aspects, for example, picture, words, file, flash, video,

multimedia, 3D, AR, VR etc. The related comparison is as following table 1 and table 2.

**Table 1. Information type expression**

Times	Information expressing main form										
In mid. of 20 Cen.	Telephone	telegram	broadcast	-	-	-	-	-	-	-	-
In beg. of 21 Cen.	e-mail	voice	word	photo	blog	TV	APP	search	game	We Chat	Web

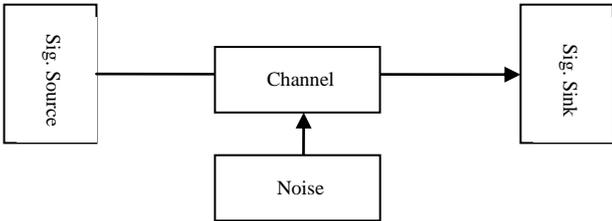
**Table 2. Transmission main type**

Times	Transmission main type								
In mid. of 20 Cen.	voice	Radio voice	-	-	-	-	-	-	-
In beg. of 21 Cen.	voice	picture	file	video	flash	multimedia	3D	AR	VR

Obviously, all of that is unforeseen by Shannon at his times. Thus it is not to be named in the same day with info-com expression. Today digital message is much rich and variety<sup>[5]</sup>. The above formula (1) can not cover this characterization of bit data. Hence today information is becoming ubiquitous.

**2.3 Communication Model Comparison**

Shannon’s communication model is as figure1. It defines for the modules functionality from Signal source to Signal sink as well as system type. In quite long time, it is a classical theory and base knowledge in communication field. Furthermore it still has active pushing effect for today communication rapid development.



**Fig. 1. Communication system model**

But with today data explosive growth, the related modules meaning greatly changes. From earlier point to point (P to P) communication pattern, now it has evolved as point to multipoint (P to M), multipoint to multipoint (M to M), and multipoint to point (M to P) etc

pattern. The signal source and sink has developed as two way (including one way) working pattern. The limited transmission of single channel has been changed into interactive network for ocean data. It is extremely change for the system model meaning.

## **2.4 Data Quantity Growth and Data Carrier Development**

Mentioned as above, America produced 125 million times telephone voice in each day up to 1948. There were 3.1 million voices transmission. This is quite data quantity at that time.

However today internet is becoming main information way and data production quantity dramatically increase. According to consultancy from QQ-global, today each 60 seconds, there are 170 thousands voice traffics, 168 millions e-mails, 1100 plus music on-demands, 694 thousands web searches, 600 more films watched and 11 thousands more I-phone browses. It has to say that extreme multiple applications produce ocean data.

With Internet of Things (IOT) beginning mature, the related application has stepped on express lane since 2010. That initiates a completely new phase in bit times. The interactive of information is not only limited in person to person (P2P), but also evolves to person to things (P2T), thing to thing (T2T). The information interaction starts to permeate society, earth, sea, and sky etc. That data production sum is an exponential ramp comparing to internet base. Kent Walker, Google SVP, points out that there are about storage 12 extra bytes (EB) data up to 2000 year in human, but now we produce 2 EB data in every day<sup>[6]</sup>.

Thus although the time passed only 60 years around, data quantity growth is far more than six thousand times above.

70 years ago, data carrier is mainly using electricity. The voice or magnetic property of thing is transformed into electronic signal for sending and receiving. Usual form is line signal like telephone or radio signal such as broadcast.

But today, in addition electricity, there are optical, wave, gas, cell, neutron, and quantum etc. for data storage and transmission. The development of technology grandly increases the diversity of storage and transmission.

## **3. Info-com Meaning Evolution and Model**

### **3.1 Succession and Creation**

From above comparison and analysis, Shannon thought is revolutionary progress, pushes the

data times coming. The theories are penetrated each other, overlapped themes from earlier narrow communication to today general information field. That changes each scientific discipline<sup>[7]</sup>.

However it is really difficult to predict speed of data development, multiform of application and ocean quantity of data in 21 century to Shannon. Hence his theory is of some limitations, such as information concept not including content and value of data, Theoretical value in single channel being unlimited, but no dealing with batch and concurrency data, no mentioning if other data carrier exist except for electricity signal transmission etc.

Facing today rich information type, quite lots of data interaction, how to give a definition and measurement? With developing view, this paper provides info-com meaning research achievements.

### ***3.1.1 Info-com Meaning Definition***

In order to fully reflect the property of today info-com meaning, this paper provides the definition as below.

- 1) Information is characterization of universal attribute to objective thing.
- 2) Information is thing attribute being cognized.
- 3) Information value is higher when its probability is lower, vice versa.
- 4) With information safety being larger, its connotation value becomes bigger, vice versa.
- 5) The information is can be expressed<sup>[8]</sup>.

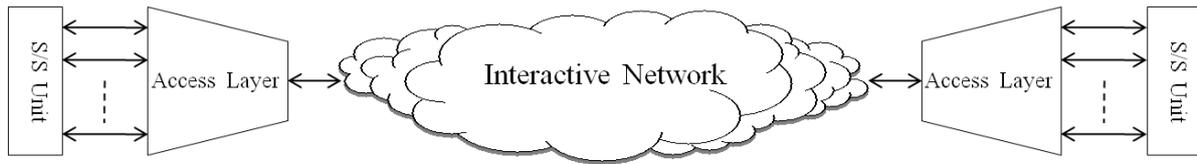
Thus the collection definition is in mathematical expression as following.

$$I ::= \{ Mc, Mt, Mp, Ms \} \quad (3)$$

Hereby, I expresses Information connotation, Mc refers as message content, Mt shows transmission object of message, Mp is message probability, and Ms conveys safety of message. In which Mt means communication transmitting object being different like P2P, P2T, T2T patterns. In this concept, it covers characterizations of modern information.

### ***3.1.2 Info-com Evolution Model***

In order to infect the ocean data characterization of info-com, this paper offers system model as below figure 2.

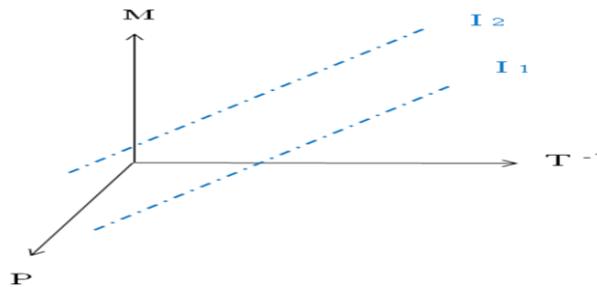


**Fig. 2. Info-com evolution model**

Hereby, S/S unit is signal source and sink module group that is of sending and receiving two way functions. Access Layer unit is of data concentrating and disassembling function. The unit includes but not limited to cell encoding and decoding device, channel modem, and data encryption and decryption device etc. While interactive network represents data interactive that can deal with real time and non-real time data service, work out the batch data transmission and cover long distance and wide space <sup>[9]</sup>. This unit could be but not limited to Public telephone network, Internet, Internet of things, Mobile network and so on.

### 3.1.3 Coordinate Relation Model

By way of multi-dimension showing the information statue and relation, this section adopts relation model to explain the characterization of info-com meaning.



**fig 3. Coordinate relation model**

Hereby,  $M$  means information quantity;  $T$  represents the information changing appearing period;  $P$  is the probability of emerging information <sup>[10]</sup>;  $I$  shows info-com meaning.

The relation describes as:  $I$  increases with  $T$  period decreasing; While  $M$  rising,  $I$  becomes bigger; When  $P$  decreasing,  $I$  gets larger. The difference between  $I_1$  and  $I_2$  is information safety factor  $\mu$ , the safety factor is higher, then  $I$  becomes bigger.

### 3.1.4 Metric formula

Combining modern data features, this paper uses multi-dimension calculation method to measure the quantity of data based on info-com meaning. The deduction process is as below.

1) The bit is the least unit from thing information, while thing message consists of a lot of bit. Obviously  $m$  (message) is in proportion to bit.

- 2) The thing information is composed of many messages, when m becoming larger, I (information) gets more bigger. Then I is also in proportion to m.
- 3) From formula (1), the thing probability is lower, thus its Information value is higher. Hence I is inverse proportion to p.
- 4) Based on the information theory, thing information changes faster (period t is smaller), then its information quantity is more much. So it is deducted there is an inverse relationship between t and I.
- 5) All of the thing message is safely received and stored only, that messages can completely represent the characterization of thing. Thus the safety factor  $\mu$  is direct ratio with I.

Finally the related formula shows as following.

$$I = \frac{m \mu}{p} t^{-1} \quad (\text{unit : S}) \quad (4)$$

In this metric formula, m is data capacity, its unit is bit; t represents the length of displaying information changing, the unit is second; p refers as the probability of producing information;  $\mu$  means information safety factor; I equals to value of info-com connotation, the unit is Shannon, brief as S .

The metric relationship describes as following. I is in proportion to m and  $\mu$ ; in term of p and t, there is inverse proportion relationship to I. (remark: p is same as one in formula (1)). Usually p is located in zero to 1 (  $0 < p < 1$  ); The  $\mu$  sets as different ratio based on the safety grade rule of international information. Generally  $\mu$  is in 1-7 due to seven grades on information safety.

Thus this metric formula fully represents data characterization in info-com meaning.

#### 4. Summary

Through studying Shannon’s basic theory, this paper focuses on the actual situation in today info-com and combines author’s long term professional experience. By the aid of full viewing angle methods, the paper provides the distinctive approach achievement. The connotation definition of info-com is firstly showed. Then paper sets up the evolution model. Furthermore it establishes the multi-dimension coordinate relation model. Finally it contributes the metric

formula in info-com as well. All of these achievements integrate different scientific disciplines. It must be of valuable for the reference and research in info-com fields. Moreover it is of profound application significance.

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