

Chapter 2

Telecommunication 4.0 Development Pursuit and Vision

As social animals, Communication between human beings is thus the essential condition for the existence and development of human society and also a fundamental social demand for individual human beings.

In 1943, Abraham Maslow, the American humanistic psychologist, published <*A Theory of Human Motivation*>, which elaborated Maslow's needs model. According to the theory, once the low-level needs are met, high-level needs will naturally emerge. The theory can also be applied to the communication needs of human beings. The primitive communication system such as letters could no longer satisfy the need of instant communication nowadays. And then this problem was solved by the modern telephone and telegraphs system thus the communication needs of human beings were pushed to a higher level. After the cellular telephone solved the general communication needs between people, the basic communication systems can no longer satisfy man's communication needs. More abundant information, massive connection and smarter capability become the future directions.

1 The New Maslow's Model for Communication: Hierarchical Communications Requirements Determine the Telecommunications Development Phase

Inspired by Maslow's needs model, we are happy to find that human beings communication needs can also be seemed as a hierarchical model, which can be divided into 5 levels as shown in Fig. 1: necessary communication, common communication, information consumption, sense extension, and self-liberation. Same as Maslow's needs model, these communication needs should also be satisfied level by level. The higher the communication level is, the more dependent on inner realization. And the more unbounded the need is, the higher its added-value is.

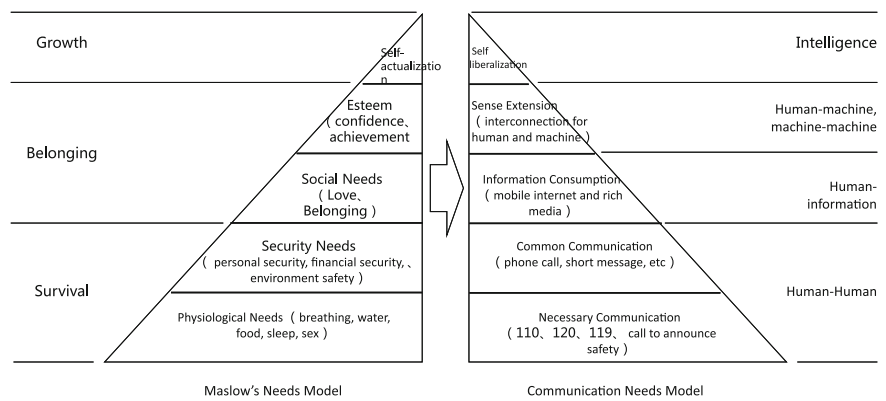


Fig. 1 Maslow’s hierarchy of needs and the hierarchy of communication needs

- Necessary communication: focus on the necessary communication needs of human beings. Due to the shortage and the high cost of means of communication, this level only meets the most urgent and necessary communication needs.
- Common communication: focus on the general communication needs of human beings. With the decrease of costs and the increase of communication tools, people can easily connect with each other and the amount of communication traffic spreads at a rapid rate.
- Information consumption: focus on the communication needs between human beings and information. People are no longer satisfied with the connection between each other. The core need in this level is the consumption of information and the increasing variety of communication tools, which will lead to the sharp increase of needs for internet broadband.
- Sense extension: focus on human-to-machine and machine-to-machine communication needs. Based on the information consumption, man’s sensory experience will further be extended and the communication network will cover all corner of the world. The key need of this level is the interconnection between human and machine. The number of network connections will rapidly increase.
- Self liberation: the previous four levels focus on the scale and type of connection. This level, however, pays more attention to the knowledge produced by the improvement of the connection. The communication system will become smart and thus enable human beings to realize self-liberation.

According to Maslow’s theory, the needs will drive behaviors while behaviors in turn satisfy the needs. The needs and behavior form an ascending spiral circle. To the communication needs model, the communication needs and communication systems form a circular relationship, that is to say the emergence of needs pushes the development of communication technologies and communication systems, while the improvement of the communication system pushes the communication needs to a higher level. Corresponding to the hierarchy of communication needs,

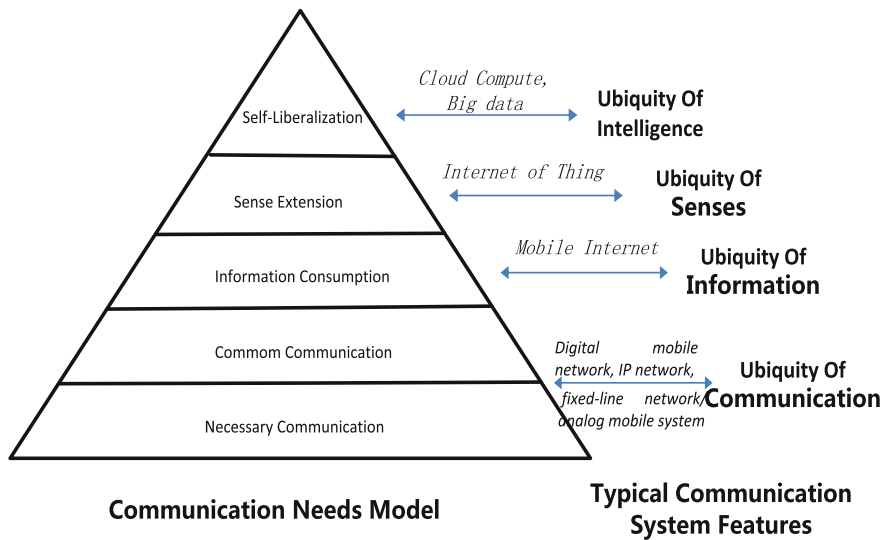


Fig. 2 Four levels of the communication system and their respective features

the typical human communication systems can be divided into four major phases, i.e., ubiquity of communication, ubiquity of information, ubiquity of senses, and ubiquity of intelligence, as shown in Fig. 2.

Currently, the growth of global population has slowed down. In developed countries and emerging market economics, which take the dominant roles in the global economy, their population has reached the peak and demographic turning point has coming. After years of development, the penetration rate of telephone and internet is becoming saturated. Meanwhile, the necessary communication need and the common communication need have been satisfied basically. The ubiquity of communication has thus been achieved. In the future, the communication need will move to a higher level and enter the information consumption era.

2 Ubiquity of Information Will Meet 3rd Level Need in the Model of Communication Needs

Once the fundamental communication needs among people have been satisfied, higher level ones will come out naturally. People needs for the acquisition and consumption of abundant information have become stronger as well as for the diversity and flexibility of communication methods.

With the rapid development of modern science and technology, human beings now have much more information and scientific knowledge. Since the 21st century, human beings have entered the information explosion era where all kinds of

information, such as news, entertainment information, advertisement and scientific information have been greatly enriched. This information explosion has enriched our everyday lives on one hand, and inspires us to further explore the world and ourselves on the other hand. Consequently, the information storage needs of human beings keeps growing.

According to the statistics from a British scholar James Martin, the sum total of human knowledge by 1800 was doubling every 50 years, by 1950, doubling every 20 years, by 1970, doubling every 10 years, by 1980, doubling every 3 years. Throughout the world, as much as 13,000–14,000 essays are published every day, 700,000 new patents are registered every year, and more than 500,000 kinds of books are published every year. New theory, new material, new skills and new methods constantly appear and accelerate the ageing of knowledge. Statistics also shows that the half-life period of one's knowledge was 80–90 years in 18th century, 30 years during 19th and 20th century, 15 years in 1960s. But after 1980s, it was reduced to 5 years. Some reports indicated that the amount of information printed around the world doubles every 5 years. Nowadays, the information amount in the *New York Times* in one week is as much as the total information amount one scholar in 17th century could receive in his whole life. The information amount produced in the last 30 years is more than that of the past 5000 years together.

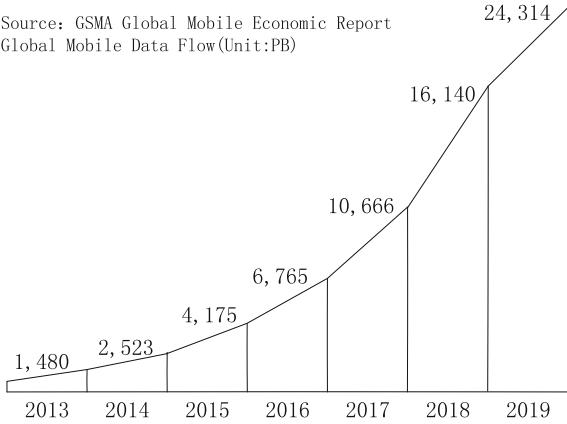
With the rapid growth of the amount of information, the propagation medium is enriched continually. In the last time, the medium mainly depends on books and newspapers. But thanks to the rapid development of electronic technologies, the medium is extended to Videos, digital books and digital newspapers. Meanwhile, with the development of internet and mobile internet, the speed and scale of information acquisition has reached to an unprecedented level. Now information can be shared and exchanged all throughout the world and the communication network has become an essential infrastructure in the information society.

The acceleration of information acquisition and spread has resulted in the growth and explosion of communication network traffic. According to the Ministry of Industry and Information Technology of China, the internet traffic from cell phones in China reached 432 million G-bits at the first two months of 2015. And the number has been doubling for 2 successive months was accounting for 89.3% of total mobile internet traffic. The GSMA's Mobile Economy Report, citing Cisco's Global Mobile Data Traffic Forecast 2015, claimed that during the period from 2015 to 2020, the compound annual growth rate of global mobile traffic is expected to be around 40–50%, and by 2020, the mobile traffic will be 9–10 times more than that of in 2014, as shown in Fig. 3.

All operators around the world are accelerating the deployment of communication networks in response to the traffic explosion. Since 2013, operators have started to extensively build 4G LTE networks. Taking China Mobile as an example, from the end of 2013 to the end of 2015, China Mobile built over 1 million 4G base stations, creating the largest 4G network around the world which can support more than 1 billion people. Such development of the 4G network greatly extends the channels for information consumption.

Fig. 3 Global mobile data traffic forecast

Source: GSMA Global Mobile Economic Report
Global Mobile Data Flow(Unit:PB)



The traditional simple and extensive development mode can no longer meet the needs of the explosive growth of traffic any more. Only the communication network with Information Ubiquity feature can satisfy the need at this stage. This needs the network can carry large amounts of information and support flexible network schedule capability.

On one hand, it requires the network to develop in a low-cost and high-efficient way. Only the new technology and new architecture with lowest cost and greater bearer capacity can meet the needs of great growth of the net traffic.

On the other hand, traditional operators can hardly handle the need of agile network scheduling requirement resulting from the traffic fluctuation and the changeable traffic flows. Thus, the future communication network should be capable of supporting the exact distribution of traffic. And by the refined dynamic schedule, the future network should be a resource-saving network.

3 Sense Extension Will Meet 4th Level Need in the Model of Communication Needs

Information consumption allows human beings to better understand the world and themselves, narrows the distance between man and man, man and animals, as well as man and the world. And it makes the information and knowledge is close enough to touch for everyone. Nevertheless, human beings will never stop exploring and conquering the world and are not satisfied with the known knowledge and the understanding and control of the known world. Human beings are always expecting to expand their sense to each corner of the world, and even to all the sands in the world.

Objectively, many places in the world, such as the deep seabed, the high mountains, the faraway Arctic, and the vast universe, are out of reach of human beings or unsuitable for long-time stay due to the hostile environments. However

Smart equipment and sensors are able to keep working under extreme conditions. Just like our fingers, they can help us to know and monitor the environment, and also provide real-time environmental reference data. All smart equipment and sensors can thus be regarded as an extension of the human body.

When human being’s sensory capability covers every corner of the physical world, the spreading and sharing of information cannot be achieved without the interconnectivity of related equipment through the network. Only with the full interconnectivity between man and machine and between machine and machine, the variety and timeliness of the information for human beings can be promoted greatly as shown in Fig. 4.

The Internet of Things complies with the trend of Internet of Everything. And it connects everything with relevant equipment in one region into a global network to realize the recognition, position, management, and control of each node in the network. Nowadays, the Internet of Things is mainly applied in data acquisition, mobile positioning, automatic control, and daily services. With the improvement of communication, sensory and control capability, the field of application will be further extended.

Currently, the Internet of Things has just started up. It is estimated that in 2020, 25 billion equipments will be connected to the network and the amount is equivalent to 4 times of the world population. With its development, the amount of

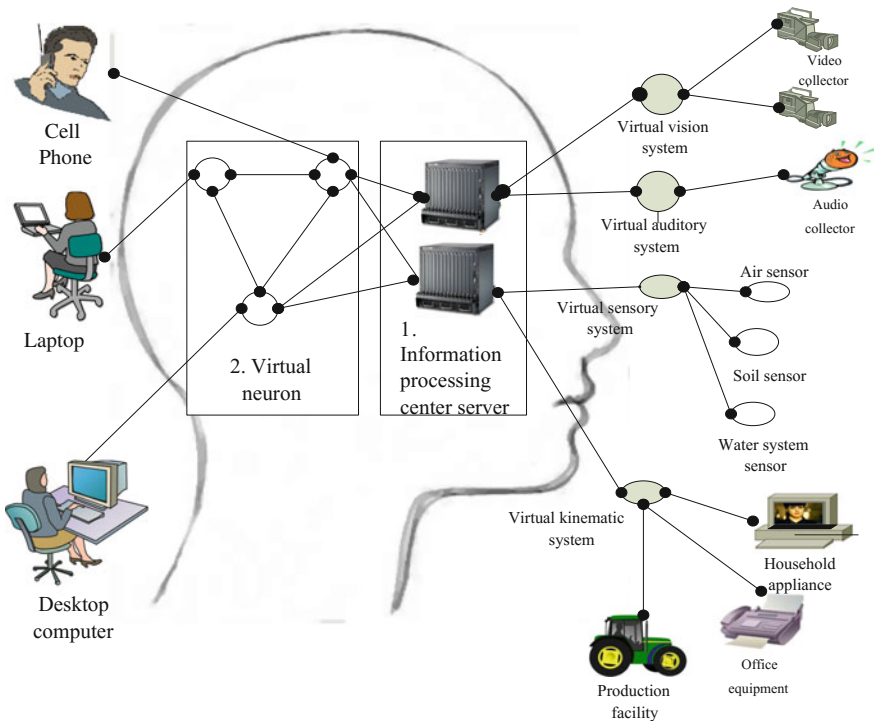
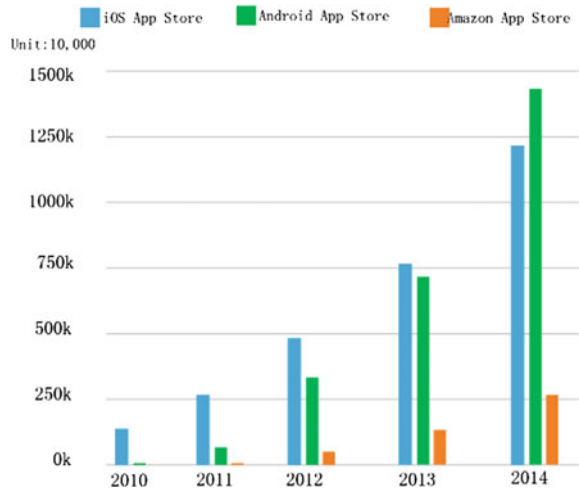


Fig. 4 Overall interconnectivity extends men’s sensory network

Fig. 5 Growth of the APP numbers



equipment connected will further increase. By 2025, the number is expected to reach 100 billion.

The extension of Information Ubiquity and Sense Ubiquity also promotes the development of smart phones and the smart APPs, as shown in Fig. 5. These creative APPs lower the costs of information acquisition and simplify the information acquisition mode, thus making it more convenient for human beings to control things. According to the statistics of the APP market from iiMedia Research, by the second quarter in 2015, the number of APPs for the iOS system has reached 1.21 million, for Android 1.43 million and for the Microsoft system over 0.3 million.

The need of Internet of Things raised higher requirements for the communication network, as demonstrated in the following four aspects:

- Massive connections will bring great impacts on the communication network. The huge number of connections needs to create substantial dynamic links and need the network to have great flexibility.
- Diverse connection types and transmission contents require the communication network to be differentiated and personalized. The internet of things, with a wide coverage, involves many types of equipment with different features. The communication network hence faces great challenges. For example, in the scenario of electronic meter reading for families, terminals of the internet of things only need to transmit a small amount of data regularly, and the requirement for connection is thus fairly low. In telemedicine scenario, however, several connections need to be created at the equipment, including audio and video connections, sensor connections, and instrument control connections and all the connections shall be highly synchronized. Those requirements are beyond the capability of the current communication network, and thus new fragile network architecture is needed.

- The connections among different nodes of the internet of things are quite complicated. There exist point-to-point connections, tree-structured connections, star-structured connections, and even net-structured connections. Meanwhile, the equipment of the internet of things in the tree, star or net-structured connections can also serve as nodes of higher-level networks and further form more complicated connections. The current single layer network control mechanism can hardly meet the need of the grid type network of the internet of things. A more open network architecture is needed.
- The connections should be low-cost and energy-efficient. The communication network needs not only to support the Internet of Things, but also to lower the cost of network equipment.

4 Ubiquity of Intelligence Will Meet 5th Level Needs in the Model of Communication Needs

In the stage of Sense Ubiquity, man's sense has already reached to the whole world and deepened man's understands of the world. But, human beings still have to make substantial intelligent efforts to study the world that is yet to be known actively and do active research on the objects and machines that need to be controlled. The objects and machines controlled by men cannot control themselves or learn by themselves, nor can they proactively communicate with human beings to help solving our problems. Human beings, while enjoying the benefit of the information era, have also been fall into the maelstrom cause by explosive amount of information. The world is filled by information garbage. To find out useful information and help human beings out of the information maze, artificial intelligence is the best way to help human beings to liberalize themselves and realize the ultimate pursuit of a intelligent world.

The need of self-liberalization is actually the need of making people "lazy", which mainly includes two major aspects:

(1) Intelligent needs: objects and networks will be endowed with intelligence through scientific approaches like artificial intelligence and neuron so that they can learn, feel, improve, and maintain themselves. Intelligent and labor work for men can thus be reduced. (2) Active needs: objects and networks will have the capability of providing active service through big data mining and human behavior tracking. Or they can provide more convenient and comfortable service without commands or only with few mutual communications.

The key technologies for the communication needs of the 5th level include artificial intelligence and neural networks and the latter can be seemed as a branch of the former. Artificial intelligence is a old and boring subject in computer science, with a history of over 50 years. With the major development and major breakthrough in mobile internet, the internet of things, big data, cloud computing and other key technologies, all hardware on the planet may become intelligent and

artificial intelligence revives. Neural networks, on the other hand, are an adaptive nonlinear dynamic system composed of a large number of interconnected basic neurons elements. The system can adapt to the environment on its own, summarize the rules, and finish certain kinds of arithmetic and do some recognition or process controls. The development of artificial intelligence and neural networks are based on many technologies, two of which are big data mining and high speed accessible communication networks.

According to analysis, the data produced every one year since the beginning of the 21st century is far more than the total of the past 2000 years combined. With the development of storage technology and the decrease of the storage cost, the data produced by the human being can now be stored at a low cost and, through the high-speed communication networks, they are also easily accessible to all. Meanwhile, data mining technology is now become maturity. Therefore, based on the massive amount of data, massive knowledge can be formed through data collection, arrangement and analysis. The development of intelligent technology will enable smart machines, with the help of massive data, to compete with or even exceed human wisdom.

With the rapid development of technologies like data storage, data mining, and artificial intelligence, the communication network and the service and experience it provides will also go through significant changes.

Firstly, the massive status data created by network nodes, plus data mining technology, allows the communication network to feel the change in the traffic and the network status. Meanwhile, with the help of the arithmetic of artificial intelligence, the self-organization, self-adaptation and self-improvement of the communication network can be realized. It will be unnecessary for human beings to do the operation and maintenance for the network anymore.

Besides, to better satisfy the needs of Intelligence Ubiquity, the communication network are not only responsible for carrying the information, data and the content, but also for integrating the data and the content. The network node, data and content will become a whole one.

Finally, we can image the more distant future. The network stores massive data of production and behavior. Through data mining and artificial intelligence, the network can understand itself better than humans and can predict individual behavior with the help of big data. At last, the network can be the assistant of all human beings to offer help in everyday life and work.

5 Vision of Telecommunication 4.0

The current communication system cannot meet human being's need for Information Consumption, Sense Extension, and Self-liberalization. Hence, a communication system featured with Information Ubiquity, Sense Ubiquity, and Intelligence Ubiquity is needed, as shown in Fig. 6.

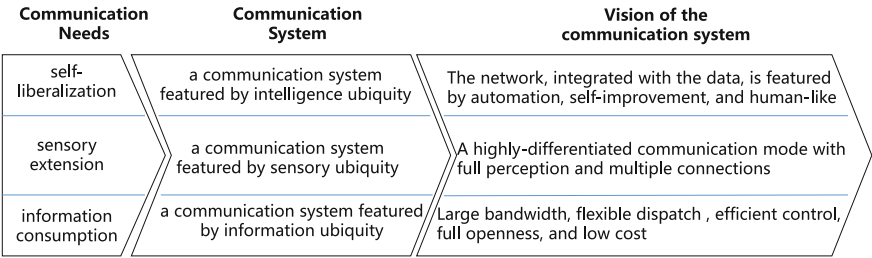


Fig. 6 Vision of the communication system

To support Information Ubiquity, the communication network should be featured with large bandwidth and low cost, support efficient and flexible deployment, be capable of delicacy management for traffic and to realize openness.

To support Sense Ubiquity, the communication network should support all kinds of perceptions and massive connections, as well as a dynamic communication mode that is highly differentiated.

To support Intelligence Ubiquity, network should be highly intelligent, and it can realize automation, self-organization, self-adaptation, and self-optimization, support the deep integration between the network, the content and the data.

Generally speaking, in order to satisfy the 3rd–5th level needs in the model of communication needs, the core vision of the future communication network should be an automatic and self-optimization network which can support large bandwidth, low cost, full perception, multiple connections, flexible dispatch, full openness.

<http://www.springer.com/978-981-10-6300-8>

Telecommunication 4.0

Reinvention of the Communication Network

Li, Z.

2018, XXIV, 145 p. 54 illus., 26 illus. in color., Hardcover

ISBN: 978-981-10-6300-8