Internet and Telecom Network Technologies Study

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Abstract:
The existing Internet technologies and the original Internet design concept cannot meet the requirement of development, due to the fast development of the Internet, great changes of the Internet user groups and the tremendous transformation of the Internet external environment. The Internet is at a development crossroad; and its direction of development has attracted great attention from the world. On the other hand, the telecom industry is in a rather passive position as the result of the great impact the Internet technology has posted on it. The telecom industry has failed in defining its own developing direction and technology breakthrough; therefore, it is also at a crossroad. The development of both the Internet and the telecom networks will lead to the development of Next Generation Network (NGN) technologies. Industrial attention and research should be focused on the key NGN technologies, solutions to problems in the development of these technologies, and their commercialization in a short term.

1 Internet Technologies

1.1 The Status Quo of Internet Technologies

The Internet has become an important component of the main network of national information infrastructure, making great contribution to the informationalization of the society. Without the Internet, the information society can not be popularized to such degree. Astonishing development speed and strong scalability feature make the Internet a global network peer to the telecom networks. The Internet has not only broken the monopoly of the telecom networks, but also accelerated and promoted the development of communication and information industry. Based on creative thinking, technological innovation and the separation of services and the bearer, the Internet has fulfilled the diversification and complexity of services; besides, it provides an open information platform which has triggered the innovative potential of the whole society and created many new services. Hundreds of millions of users benefit from the Internet services.

The Internet has been developing for about 30 years, during which the user groups, application scenarios and external environment of the Internet have changed greatly, but the Internet core technology, Transfer Control Protocol/Internet Protocol (TCP/IP), has not changed; IP network has not changed in any fundamental way either. The Internet has been showing lack of ability to meet the demands in development.

Security is the biggest problem in the Internet which guarantees neither basic network security nor reliability. Such unsafe and untrustworthy network leads to the abusive use of encryption technologies. The out-of-control encryption technologies not only greatly increase the cost for Internet security, but also bring a huge threat to national security and social stability.

Internet applications, especially the applications of Web 2.0 and Web 3.0 and the irrational use of Peer-to-Peer (P2P) technology, greatly speed up the generation and widespread of malicious information and strengthen its abilities. Web 2.0 and Web 3.0 enable one person to do the job which previously needed a website to finish. The irrational use of P2P technology easily fulfills the services that previously required large-scale equipment and transport channels. The development of the Internet technologies, especially Web 2.0, Web 3.0 and P2P, on one hand greatly promotes the development of Internet services and applications, but on the other hand provides paths and channels for quick generation and widespread of malicious information. It is difficult for the Internet to position and trace information, therefore, it is hard to control and manage fraud and crime on the Internet. In one word, social problems relating to the Internet are getting more serious.

With the fast development of the Internet, the whole society expects more from and relies more on it. In fact, the Internet is becoming the main network of information infrastructure. The public is fully aware of the benefits and significance of the Internet; however, people have not got enough sense to realize the downsides of the Internet, especially the serious security problems

caused by the holes in Internet technology and their negative impacts on the society and the Internet development.

The Internet has not established any business models for rational and sustainable development. Service networks in the Internet neither have nor control any transport resources.

The advantage of such the service networks is the cheap network operation cost, because the transport resources are totally free; while the disadvantage is no Quality of Service (QoS) guarantee for service users, because the service networks cannot own or control transport resources. Therefore, such services can only be offered freely, but not be run as a business. Seen from another aspect, free transport resources bound to result in best–effort resource usage in order to improve QoS, which further intensifies the conflicts between service and bearer network operators and damages the stability of the industrial chain.

The Internet was designed based on the principle of self–regulation, assuming Internet users were self–disciplined gentlemen who restrain themselves from taking too much resources. TCP is a well–known Internet protocol based on the principle of self–regulation. In a long period of time, Internet users strictly followed this principle, and the Internet could, accordingly, sustain stable operation. However, with the explosion of Internet services and applications, the self–regulation principle has completely been destroyed, which has caused unceasing and increasing network resource consumption. After the extensive application of P2P technology, such unrestricted resource usage has become worse in order to improve and enhance users' experience, and the self–regulation principle has gone forever in new–generation Internet users' hearts. Unfortunately, the Internet technologies have not been improved fundamentally. The network operators (IP network operators) and service operators kept a harmonious and coexisting relationship for quite a long time, but now the conflict between them intensified. The service network is trending toward malicious parasitic from previous benign parasitic, and such a tendency will generate serious impacts on the telecom and information industry and possibly lead to seriously twisted or even broken industrial chain.

1.2 Development Direction of Internet Technologies

The design concept of the Internet will change greatly because of the new requirements in the Internet development. The end–to–end transparence will be changed for network security, so as to ensure users' security and to facilitate lawful interception. To meet various demands from users and provide satisfying real–time or non–real–time services, the Internet should also have resource guaranteed transport capability, besides best–effort transport capability. The network will become controllable and manageable; Internet users will be properly controlled, with necessary freedom on the network. It is necessary to develop a healthy business model for the sustainable development of the Internet.

The Internet will definitely change in the future. Its development directions should be as follows:

- Safe and trustworthy network;
- Operable and manageable network;
- Knowable network resources;
- Reasonable, economical and highly efficient resource consumption.

However, the essence of the Internet will be unaltered: it is such a network platform that gives every person a chance to participate in innovation. This is also the vitality of the Internet.

Therefore, it is necessary to deeply study the bearer network (IP network) technologies and make fundamental changes on the network to meet the development requirements of the Internet. Service networks of the Internet also need to be further studied in order to make it in line with business rules and realize sound and sustainable development.

The service network can be classified into the non–operational and operational. The non–operational network aims at its own profit maximization without considering the willingness and endurance of bearer network operators in its design and operation. Therefore, the non–operational service network tends to consume resources without self–regulation. The operational service network has its own bearing resources. Therefore, it is bound to result in effective and rational resource usage to reach the highest performance/price ratio per resource unit.

In current Internet, non–operational service networks are the mainstream, because it has no need to pay for bearing resources; low costs make them easy to grow up. As non–operational, they do not need to establish huge and complicated service operation and maintenance system. Their low operation costs enable them to provide free services. However, non–operational service networks can hardly develop in a continuous way since they cannot gain development initiative, therefore, it should not be the development direction of Internet services.

Operational service networks presently receive no attention from the Internet industry, because people would seldom pay for "a meal" when they can get it for free. However, they should be the development direction, because they conform to business rules and can fulfill sustainable development.

2 Telecom Network Technologies

2.1 The Status Quo of Telecom Network Technologies

In recent years, the telecom industry has apparently gone through the predicament, as telecom services in many countries started to rebound. However, essentially speaking, the telecom industry still has no development direction; it is testing each step before taking it at the development crossroad.

What problems has the telecom industry encountered? Why has the industry not found its direction after more than ten years? The root cause is whether it needs transition. Why does it require transition when it has smooth development?

The primitive motive for transition comes from the telecom industry itself. With the development of society and technology, people have increasing demands for communications information services. On the one hand, dissatisfied with single voice services, telecom users expect diversified services to meet their

various demands. On the other hand, telecom operators are eager to offer more new-type services to support their economic growth, which pushes the telecom industry to keep launching new telecom services to the public.

In 1980s, the international telecom industry was working in this direction by keeping introducing new technologies and services. There were three technologies worth mentioning: the first was Telematic, which could provide information services through voice band data on telephone networks, and Videotex, Telex, X.400 Email were three well developed Telematic services in that time; the second is Fax which, using voice band data to transmit image text, and Faxes are still an important communication method even at present; the third is packet switching network (X.25 network) which played an important role in 1980s and was the core network for data communications. In the time when telephone services took the most important position, the emerging of these three technologies had good impact on the development of telecom industry, but the emerging did not touch telecom transition.

From late 1980s to early 1990s, multimedia services emerged and became revolutionary telecom services. As a rate variable service, the multimedia service requires quick rate adaption within the entire network. However, Time Division Multiplexing (TDM) system is obviously incapable of fulfilling the adaption, which initiated the issue of telecom transition. The TDM-based telecom network fails to meet the requirements of multimedia services, so future telecom network should be based on data packet technology. Under this background, Asynchronous Transfer Mode (ATM) was proposed. The idea of ATM was technologically right. However, ATM was born at an unlucky hour, and it finally failed because of a wrong marketing strategy and initial high service positioning. It should be said that telecom transition started from ATM and its service system.

The second motive for telecom transition comes from the high-speed development of microelectronics, progress of wireless channel coding technologies, and definition of mobile service functional modules.

Personalization and mobility of communications is the natural desire of every person. However, handheld communications terminals emerged until early 1990s, due to the technology development, especially the fulfillment of microelectronic System on Chip (SOC). The superiority of mobile communication had stolen the show from the fixed network; communication mobility is another motive for telecom transition. In the 2G mobile communications, the core technology is still TDM without the pressure on core network transition from the technical aspect, but mobile communications have already posted huge impact on telecom transition. In the 3G mobile communication, TDM cannot support various multimedia services anymore, so a telecom transit to data packet technology becomes the trend.

Both of the abovementioned motives come from within the telecom industry. However, they are not powerful enough to push the industry to conduct telecom transition actively. In fact, though the industry has realized the necessity of transition long time ago, the transition attempts stopped after the ATM failure, with no pleasant surprise in the telecom technology development.

The real and greatest motive for telecom transition comes from the Internet. Telecom technology experts scorned IP technology for the Internet at first, and they proposed ATM instead. However, the Internet succeeded due to its innovative design concept. In only 10 years, the Internet has become the second biggest network in the world. Its data traffic has highly exceeded service traffic of the telephone network. The development of the Internet has seriously threaded the existence of telecom industry (blocking P2P services such as, Skype and BT).

Challenge from a heterogeneous network creates great motive for the telecom industry to make transition. Under the greatest danger and challenge, the industry has realized that it cannot just say the transition but actually needs prompt actions.

2.2 Development Direction of Telecom Network Technologies

The telecom network is a commercial network for which a good business model is critical. Before being attacked by the Internet with its free services, the telecom network had a clear business model, i.e. charges by services, and operated well. However, facing Internet's free services, telecom operators have lost confidence in the original business model. The current business model for telecom networks is unclear. Whether to insist on using the old telecom business model or not and how to guarantee such the business model through technology are the problems that need immediate consideration and tackling. The following questions need to be focused on and studied:

(1) Do the telecom operators need to provide differentiated services with different characteristics, grades and charging standards, and how?

(2) Any business models must provide abovementioned differentiated services. Is it necessary for telecom operation networks and services to be differentiated?

(3) Is it in accordance with the business model to charge access fees by monthly packages, to offer free services and to maintain operation by advertisement revenues and capital employment? Can these means help the sound development of the industry?

(4) After the service network and the bearer network are separated, can the service network stand on its own and progress independently? At present, the service network is a parasitic network which cannot independently develop itself well. Will the parasitic network be the existence form of the service network?

At present, the real problem in telecom is lack of technology. Taking the Internet technology as its own without either analyzing or digesting cannot support any business model for telecom operation. Therefore, the design of both bearer and service networks requires deep thinking and technology innovation in order to enable the telecom network to operate in accordance with the business mechanism and to develop soundly.

Until now, the telephone networks (including fixed and mobile networks) are the only completed telecom service network. They have integrated communication functions, complete standard system, and reliable supervision methods. They are the important national information infrastructure, guarantee for social stability and security, main communication approach for the mass, and the main revenue source for telecom operators. Broadband service network is prioritized in future telecom development, and will be a critical revenue source for telecom operators. However, currently there is neither complete thinking nor published standards for broadband services; therefore, broadband services cannot form a related industry chain. With broadband service network, telecom operators having bearer networks are not able to have complete telecom operation capability.

Internet services are an important part of telecom services. They have become the main body of broadband IP telecom services. There is strong dependence relationship between Internet services and telecom bearer networks. Though the Internet services coexist with the bearer networks in the form of parasitic network, they are currently in a benign coexisting state, depending on each other. However, since the business models for Internet services and bearer networks are opposite, such a coexisting state cannot sustain in the long run, such a honeymoon relationship is temporary and unstable. With the application of Web 2.0 and P2P, the malicious degree of the parasitic network becomes worse: Resources are consumed recklessly; and the supervision difficulty is increased. This is greatly increasing the risk of telecom networks taking Internet services as their main services (including commercial and policy risks).

The telecom bearer network (IP network) is the foundation of both telecom service network and the Internet. However, there are serious problems in the IP network, which in fact cannot meet the development requirements of telecom services and also hinder the expansion of Internet services. The IP network has three problems requiring most attention and urgent solutions: network security, QoS, and large-scale networking. These problems have become difficulties worldwide, and many nations are carrying out research in order to make a breakthrough. ITU-T has presented the technical requirements for future packet bearer networks and pointed the direction for future research.

The proposed requirements for future telecom bearer network are as follows:

(1) The next generation bearer network should be safe and trustworthy.

(2) The network can guarantee basic security. Its users or any service networks established on it need not adopt special encryption technologies to obtain satisfied security.

(3) The network should be able to bear all the services in the existing telecom networks and predictable new services in the future as well. Moreover, it should have the bearing capability to meet various QoS requirements.

(4) The network resources are knowable, while the network is controllable, manageable, operable and scalable.

(5) The next generation bearer network should be capable of coexisting, internetworking and smooth evolution with the current networks (including connection-oriented and non-connection-oriented networks).

Explained in detail, the key point of security in the next generation bearer network is to guarantee the high usability and high accessibility of network, and highly reliable node equipment.

(1) Network has enough robustness, capable of quick protection swapping under link and node malfunctions.

(2) It is non-accessible for operational network users. User-to-Network Interface (UNI) and Network-to-Network Interface (NNI) must be separated. The operational network topology should be completely isolated from users' access network topology, that is, when the operational network is totally unseen from the users' access network.

(3) The logic planes (including the control plane, management plane and data plane) have independent resources, and will not mutually occupy resources of others. Information between them is manageable.

(4) The next generation bearer network should have enough independent data planes, isolated information and independent resources.

(5) Information communications are safe, easy for lawful interception, traceable, and capable of providing emergency communications.

The operability of the next generation telecom bearer network includes good network scalability, flexible network scale expansion, bandwidth and topology extension, and the amount increase of users and services. The next generation bearer network must have enough independent data planes; the planes have independent resources, and information between them is isolated; the data plane resources are knowable, controllable and manageable, providing a suitable Operation, Administration and Maintenance (OAM) function to every plane to ensure good performance and operation of service networks established on the bearer network. The next generation bearer network should ensure the resources required by services, in order to implement QoS guarantee; it should support absolute QoS under both connection-oriented and non-connection-oriented working modes. The bearer network should be able to effectively bear multiple service networks. In order to keep the bearer network safe and stable under great pressure, it should be ensured that the data flow on its control and management plane is protected from any external attacks, and that its resources will not be

taken away. The management plane should be fully protected from any unauthorized access.

With regard to its multiple service support capability, the next generation telecom bearer network should support both connection–oriented and non–connection–oriented services. According to service requirements, it should effectively transport users' service flows with high quality, ensure users' basic privacy and information security, and meantime provide effective and easy lawful interception capability. Moreover, it should support point–to–point and point–to–multipoint services.

The whole telecom bearer network consists of the access network, Metropolitan Area Network (MAN) and backbone network. To solve the end–to–end problem, the network should not be divided into several parts, but studied as a whole. One possible scenario is: A technology, for example, Multi–Protocol Label Switching (MPLS), is feasible for partial bearer network, but infeasible for the whole network. Essentially, the end–to–end problem is the scalability problem in network technology, therefore, scalability should get special attention when the bearer network is studied and deployed[1–2].

3 Telecom Network and Internet

The telecom network and the Internet are using the same technology. The newly developed telecom services have fulfilled all–IP. Telephone services, the main revenue sources for telecom networks, are also moving toward IP. Besides, the telecom network has fulfilled all–IP enterprise network services. Therefore, all–IP services are definitely the trend in the telecom network. This service trend decides the usage of network technologies: The telecom network will be based on IP technologies. The IP–based Internet has achieved success, though there are several existing problems, even serious ones, in its development. These problems will not change the application of IP technologies in information services in the future.

The requirements and design concept for the IP bearer network of the telecom network has no significant difference from those for the IP network of the Internet. Current IP networks not only fail to meet the requirements of future telecom services, but also hinder the development of real–time Internet services and the Internet service range extension in the future. Therefore, both the telecom network and the Internet require their IP bearer networks to be safe, trustworthy, controllable, manageable, and QoS guaranteed. Moreover, they need IP bearer networks with large–scale networking capability. However, the telecom network and the Internet have totally different design concepts for the service network. The biggest difference lies in business models of the service network. The service network in the Internet was designed basically in the form of parasitic network (separating the service network from the bearer network completely), lacking a sound business model, The Internet is spoiling towards malicious parasitic from benign parasitic, which may someday endanger the whole industrial chain. But at the same time, the telecom service network was designed in accordance with the principle of operational service networks, but the design with limited openness has failed to adapt to the IP bearer network, and has also a negative effect on the service innovation. Seen from the current situation, neither the telecom network nor the Internet will follow their current development roads; instead, they will learn from each other, shorten the difference gap on their way of development, and finally converge. However, the convergence will not take place in the short future because the differences between the two leading technology groups are huge.

The IP bearer network is the foundation for the convergence of the telecom network and Internet. As for the service network, both networks have their strengths and weaknesses, and they are actually learning from each other. Since the telecom network and the Internet are constructed on the foundation of IP technology, and their services are integrating and overlapping, their development is bound to result in the network convergence. Certainly, the convergence is not the telecom network's simple merging into the Internet, or vice versa. The convergence will bring a next generation IP–based network, which has a convincing proof that all the leading telecom operators now have double IP networks with the same architecture.

4 Conclusion

Both the telecom network and the Internet are at the development crossroads, demanding a clear direction. Technically, there is a good foundation for their convergence, and the convergence will integrate their different strengths into a new next generation network, which should become the main body of national information infrastructure in the future. Such a network should have the following features:

- Safety and trustworthiness, with ability to protect consumers' rights and benefits and to help guarantee national security and social stability;
- Sustainable development and good scalability;
- Ability to coexist and interconnect with the existing Internet and main telecom networks, and to smoothly evolve from them;
- Offer of a network platform for everyone to participate in innovation.

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Biography

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Jiang Lintao is the chief engineer of China Academy of Telecommunication Research of the Ministry of Industry and Information Technology (MIIT) of China. He also serves as the chairman of IP & Multimedia Standard Working Group of China Communications Standardization Association, vice chairman of ITU–T SG 13, and a member of the 1st, 2nd and 3rd sessions of Multimedia Expert Group of Communication Technology Area of High–Tech R&D Program of China (i.e., 863 Program). Over the years, he has been engaged in the R&D and standardization of multimedia, digital communications and IP technologies. He has been receiving special government allowance since 1992, and was awarded "Youth Science & Technology Expert with Significant Contributions" by the government in 1996.