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The Future Network Research Based on Reconfiguration and Expansible

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Abstract

With the development of network, the internet has more and more problems. Ubiquitous information services, diversified and comprehensive network business, different business may have different QoS requirements, and the safety credible information interaction, etc., these problems raise huge challenges to the supporting capacity of current network architecture system. Therefore, we should study out new future network architecture to meet the requirements of users. In this paper, we present a new network architecture based on reconfigurable and expansible, the core idea is to provide logic bearing networks with different QoS guarantees for different service. The architecture uses virtualization technology to abstract and divide the network resources, divide the network function module into business layer, ATS layer and ATC layer three functional surfaces from the point of view of whole network reconfiguration.

Keywords: *future network architecture, reconfigurable, expansible, virtual technology.*

1. Introduction

The development of Internet has been depended on its openness and a wide variety of inputs. As a platform, different organizations and users can establish infrastructure, develop software and create services on the Internet, and then release to the world. However, after nearly three decades of development, the original network communication and transmission model based on TCP/IP has become much harder to adapt to the complex business requirements in the network, and some people even consider that current Internet has “ossification”, and its scale and framework has been unable to meet the demands of new technologies. The current Internet network environment and businesses have rapidly changed, traditional Internet network system no longer adapts to the development of the future networks [1]. More and more research institutions begin to study the problems of the Internet.

Internet initially thinks that the network traffic is quite friendly, but now sees it as an opponent for the reason of the issue of the security network system, so we can see the inherent defect existed in current Internet network architecture. At present, information networks mainly depend on IP network layer, but the capacity of IP network layer is simple and weak, the network function system is single. The internal capacity and structure of the network is of poor adaptability on the business needs, resulting in that network has low support capacities on fusion, ubiquitous, quality, security, expansion, manageable and controllable, making the gap between business needs and network infrastructure capabilities increasingly significant. Therefore, establish reconfigurable and expansible network architecture to ensure the intrinsic function structure of the network can conduct self-adaptive according to the characteristics and requirements of business, achieve the effective adaption of diverse businesses.

There are two kinds of problems in the research of network. On the one hand, modern information networks take TCP/IP as a common basic carrying mechanism, but its function is extremely simple, so there are serious mismatches between network infrastructure capacity and upper user needs. On the other hand, in order to change these serious mismatches, researchers take various efforts to enhance network function instead of changing the carrying

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capacity of the TCP/IP, such kinds of repair type changes just “patch” the network. The result is that not only didn’t fundamentally solve the problems of network, but also makes the network more and more bloated, the Internet has changed from clean level architecture into a scrambled compound structure, as shown in figure1 and figure 2:

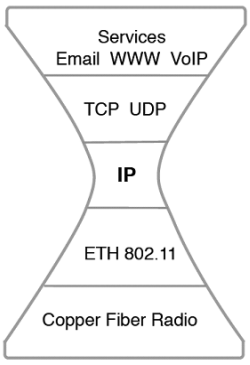

Figure 1. Clean Level Architecture

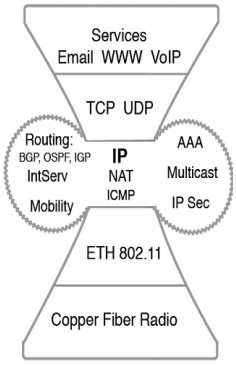

Figure 2. Scrambled Compound Structure

2. Several Problems of Modern Network Architecture

Ubiquitous information services, diversified and comprehensive network businesses, different businesses may have different QoS requirements, and the safety credible information interaction, etc., these problems raise huge challenges to the supporting capacity of current network architecture system. The gap between the network constant basic capabilities and the increasing requirements of users continues to expand; it will seriously affect many hands related to national economy and the people's livelihood [1, 2]. Modern Internet mainly exist fallowing problems:

First, Business model doesn’t match with network transmission mode, imbalance issues of used resources of substrate network [3]. Cisco Visual Networking Index forecasts that the global mobile data in 2015 will grow 26 times than in 2010. Such high speed, explosive growth of network data needs to be processed by a matching network transmission mode, otherwise, the mismatching between the business request mode and end-to-end principle will lead to a large number of duplicate data generation, aggravate the explosion of network flow.

Second, end-to-end-oriented constant connect mode doesn’t adapt to the dynamic of network and its nodes. The proportion of mobile terminal flow accounts for network flow is increasing. By 2016, mobile video will account for the lion’s share of mobile traffic growth because of its content has a higher bit rate than other mobile content. Cisco Visual Networking forecasts that in 2011-2016, mobile video will rise in a 90% CAGR (Compound Average Growth Rate) in the 2012 annual forecast report, which is growing faster than all the mobile applications that we have predicted. By 2016, there will be 10.8 Exabyte flow through the mobile network per month, of which 7.6 Exabyte is video traffic.

Morgan Stanley predicts that the traffic of mobile terminal has been far more than the PC, the total number of mobile terminals will outnumber PC in 2012, therefore, future network architecture should meet the service requests of dynamical node, however, the TCP/IP end-to-end-oriented constant connect cannot well adapt to the dynamics of network.

Third, the existing network architecture lacks self-evolution capacity, unable to adapt the fast developments of upper applications and underlying transport technologies. IP network architecture cannot achieve automatic evolution according to the upper applications and underlying transport technologies, so, network is faced with the problems of sustainable development. About every six months, the Internet service provider (ISP) has to manually upgrade the network, consumes a lot of manpower and material resources.

Fourth, the high energy consumption of network switching equipment makes the Internet into the energy crisis. In recent years, the problem of energy consumption is concerned by more and more people. Cisco’s analysis of data shows that bandwidth utilization rate of network backbone links is under 40%, a large number of routing equipments have low load, and

this is mainly because network core equipments, such as router, are designed based on full load principles. After tests, we found that the energy consumption under low load almost equals to under full load. Some high-end routers have huge energy consumption, the energy consumption of CRS-1 router is even as high as megawatt.

3. The Research Status of New Network System

In recent years, domestic and foreign people do positive researches and explorations on new information and communication network system from the different aspects, such as new network architecture, reconfigurable technology, network routing switch architecture and technology, etc.

3.1. Find Project

In the background of global generally agree that the current network architecture needs to be changed, America put forward FIND (Future Internet Network Design) project in 2005. Unite States National Science Foundation (NSF) launched NeTS plane, the sub-item NeTS-FIND is the medium and long terms research program related to “future network design” in the next 15 years to design a new next generation network architecture [4]. The research area is concerned by FIND mainly focus on the building of new core function, manipulate design, and the practical design based on needs, the support of wireless sensor network and embedded computing technology, the design of new overall network architecture and theory analysis, etc.

3.2. GENI

For the problem of network revolution, Unite States National Science Foundation (NSF) begins to support the research of *Global Environment for Network Innovations (GENI) platform. NSF officially announced the GENI plane on august 22, 2005. The plane explores new Internet architecture so as to promote the scientific development and stimulate innovation and economic growth.*

GENI mainly consists of two parts, one is GENI Research Program, another is Global Experimental Facility which provide R&D verification platform to research program [4]. The *Research Program* will mainly focus on the existing NSF-founded project, such as NeTS (network System and technology research programs), Cyber Trust, CRI and Distribute system. On one hand, GENI is devoted to building a global programmable experimental facility to provide support for the study of future network technology, on the other hand, takes the NSF existing founding project as the main founding target of research programs.

3.3. CNGI Project

CNGI (China Next Generation Internet) is the next Internet project, implemented by Chinese organizations, such as National Development and Reform Committee, the Chinese Academy of Engineering, etc [4]. The CNGI platform takes CERNET and five carriers as main body constitutes six core backbone networks, respectively connects 39 high-speed broadband nodes, links to the foreign through Beijing and Shanghai international centers, will connect 300CPNs (Customer Premises Network), including colleges and universities, research organizations and corporate R&D centers. At present, CNGI has begun to take shape, on this basic, conduct a further research of building a future networks with independent intellectual property rights has important significance.

3.4. AKARI Project

AKARI is a new generation of network research projects launched by Japan NICT (National Institute of Information and Communications Technology) in 2006. The goal of the project is to excogitate new network architecture before 2015, and complete the design of new generation of network based on this architecture. In AKARI point of view, the development of future network mainly exist two ideas, NxGN (Next Generation Network) and NwGN (New Generation Network) [5]. The former is the improvement of the existing network, cannot meet the future needs; the latter is new design of network architecture, represent the future direction.

As the representative project of Japan NwGN, the core idea of AKARI is: abandon the limitations of the existing network architecture, study new network architecture from the whole network point of view to solve all the problems of the existing network, meet the requirements of

the future network, then consider the filter issues with the existing network. AKARI emphasized that this new network architecture not only to design a network based on next-generation technology, but create an ideal network for the next generation of people.

3.5. PlanetLab Project

The PlanetLab project is an experiment platform that covers the network, Princeton University begun to build it at 2002. Truly operate various kinds of large-scale service experiments through PlanetLab slice, can be used in the research of distribute network systems, the research and test of future network technology and service, for example, file sharing, embedded network storage, routing and multicast, QoS overlay network, etc.

PlanetLab is an open global test bed platform, its goal is to build a bridge between the innovation technology and the real network world, through the test and verify in the real network to promote technology continue to progress and meet needs of human lives.

Currently, PlanetLab platform has 474 sites, a total of 950 nodes, is distributed in more than 40 countries, there are more than 600 experimental projects running on PlanetLab.

3.6. 4WARD Project

4WARD project is the representative subproject in the network technology field of EU 7th framework program FP7, was launched in January 2008 [6]. The purpose is to study reliable, ubiquitous collaborative network to promote the network and applications simpler, faster, provide more advanced, more economic information service, so as to improve the quality of life of the European Union residents, and enhance the competitiveness of EU network industry.

The goal of 4WARD project is to overcome the disadvantages of the existing Internet, excogitates a network architecture that allows multiple networks to coexist, interconnect and cooperatively work, and proposes a integrated solution for the next Internet, fundamentally solve the problems of the Internet.

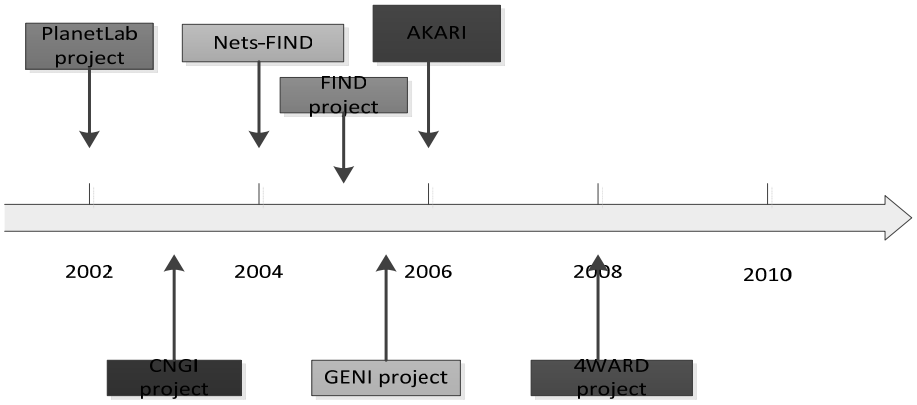

Figure 3. Various kinds of achievements of development

4. Future Network Architecture Based on Reconfigurable Thinking

As can be seen, the research about new network architecture has been a research hotspot. The research institutions at home and abroad have successively proposed their own viewpoint of development defects of the existing network, and carry out the related research work. The core idea of the new network architecture which is presented in this paper is: provide logic bearing networks with different QoS guarantees for different service, which is consistent with the mainstream thought on the research of new network system in the world.

4.1. Hierarchical Model

In the traditional virtualization hierarchical model, typically contains the following three-layer structure: the infrastructure layer, the virtualization network layer and business layer [7, 8]. The infrastructure layer consists of physical resources that are provided by number of infrastructure providers, the virtualization network layer is network that is composed of a series

of Virtual Private Networks which meet various business requests. This paper also puts forward a network hierarchical mode, as shown in figure 4.

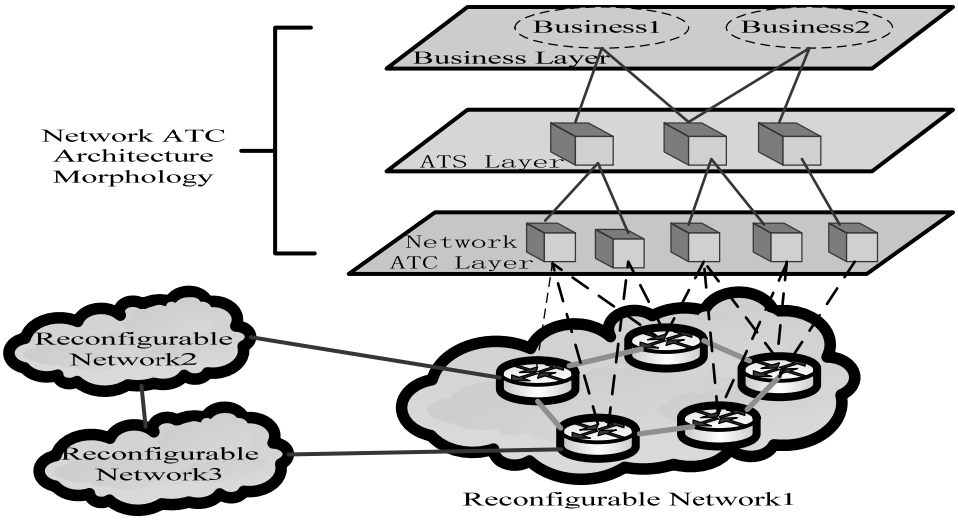

Figure 4. A network hierarchical mode

A major theoretical basis of reconfigurable network is “structure determines function”. As a new form of computing, reconfigurable computing integrates the programmability of the traditional processor with the computing mode of hardware design, brakes the boundaries between traditional software and hardware, which provides the higher computing capacity and density [9]. Using virtualization technology to abstract and divide the network resources, divide the network function module into business layer, ATS (Atomic Service) layer and ATC (Atomic Capacity) layer three functional surfaces from the point of view of whole network reconfiguration.

The ATC layer can be divided into PATC (Point Atomic Capability) and SATC (Surface Atomic Capability). PATC is the logical entity result from the reconfiguration and abstract of the isomerism heterogeneous resources in network nodes. PATC provides basic network bearer for the configuration of whole network, achieves the optimal scheduling and planning of the network resources of nodes through the logical entity formed by the virtualization of the underlying physical resources. PATC can be seen as the concept of virtual subnet. SATC is from the aspect of the whole network which certainly is the logic network based on virtualization technology, perceives business, and clusters and assembles the behavioral characteristics of data plane network resources, matches the ATS to achieve the universal of a variety of business. ATC layer perceives the node resources of whole network and the characteristics and the dynamic features of network resources, builds and reuses these resources selectively, provides network-wide basic network carrying capacity for ATS layer.

ATS layer uses the network-wide basic network carrying capacity provided by SATC, matches the business, clusters an abstracts the common features and requirements of a variety of business, the nodes of whole network collaborate, flexibly assemble the internal resources of nodes, achieve the universal of a variety of business. Compared to the supporting role of ATC layer, ATS layer serves the business more directly.

On the part of the business layer, different from other cases in which the single businesses are conducted by Virtual Private Network, the business in this paper can be complex business traffic formed from the fusion of a variety of businesses. For example, video business contains images, and voice, etc, can correspond to multiple sub virtual networks of ATS layer to be managed separately, namely, the relationship between business and service is no longer one-to-one, and may be one-to-many or many-to-many.

4.2. Hierarchical Network Reconfiguration and Dynamic Resource Allocation

In the hierarchical network model, when the business request arrives, analyses the business first, and issues to each layer of the model, the network architecture that has flexible reconfigurable mechanism can achieve the adjustment and overall optimization of network structure and function according to the features and requirements of business.

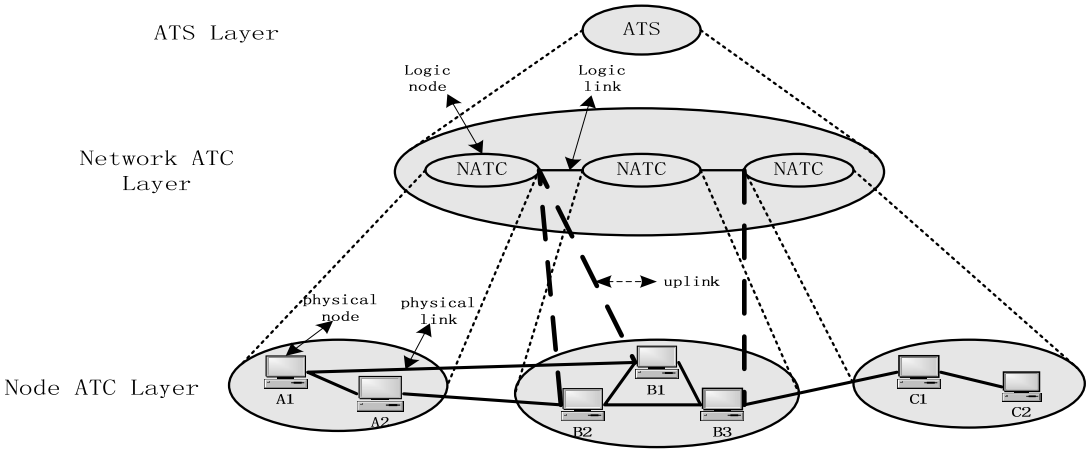

Figure 5. The configuration of Network ATC Layer

Specifically, the business layer clusters and abstracts the features and requirements of the network business through corresponding cognitive mechanism, extracts the basic network service elements that all kinds of businesses need, and then finds the matching abstract resources in ATS layer. ATS layer uses the basic network-wide carrying capacity provided by network ATC layer, perceives and matches the basic bearing function module, clusters according to the common features and requirements of a variety of businesses to form ATS. ATS layer is a virtual network layer, but distinguishes from the general proprietary network which has single feature, it is characterized by providing basic carrying capacity in the whole network, and providing network services according to the abstraction and clustering feature of business.

The main function of network ATC is to perceive the business, node resource and the dynamic behavior of the network resource. With this kind of function of perception, we can integrate and manage the infrastructure of the underlying network, achieve the optimal configuration, and provide basic carrying capacity for upper ATS layer. The support that SATC provides for ATS should be comprehensive, rather than simple one-to-one mapping. For example, an ATS may need to provide supporting for business through the collection of multiple SATC; a SATC is also likely to provide supporting for multiple ATS. In order to adapt to ATS, SATC will integrate the PATC, this process is the reconfiguration of SATC.

The network elements of the node ATC layer are the logic function blocks through abstracting the physical nodes and physical links, these logic function blocks form the network ATC by recombining through the reconfiguration mechanism.

The building theory of forming the bearing network for universal of business is that based on the features of business, network ATC and the standard of reconfiguration mechanism, provide self-adaptive bearer services for business by building logic bearing network. The above-mentioned hierarchical structure is consistent with this theme, the underlying layer provides supporting for the upper layer, provides the elements to build network, and provides services, ultimately to provide corresponding services for arrival services, improve the utilization rate of resources at the same time.

For the relationship of business layer, ATS layer and ATC layer of the above reconfigurable and expansible hierarchical network model may be analogous to different level services provided by cloud computing.

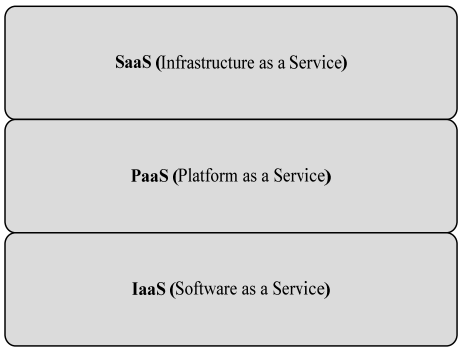

Figure 6. Cloud computing architecture

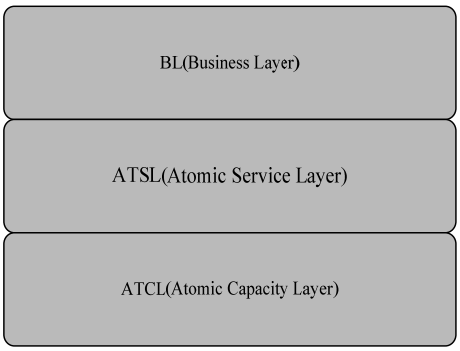

Figure 7. Reconfigurable architecture

Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services[10]. As shown in above pictures, we can divide the cloud computing services into IaaS (Infrastructure as a Service), PaaS (Platform as a Service), SaaS (Software as a Service) according to the service forms provided by cloud computing [11, 12]. Compared to the reconfigurable and expansible network hierarchical model, we make abstraction and division in the three function layer: business layer, ATS layer and ATC layer.

ISPs (Internet Service Provider) provide infrastructure, such as computing resources, storage resources and network resources, for the user through abstract reorganization at the ATC layer. Its specific characteristics can consult the IaaS service of cloud computing, Amazon AWS offered E2C Elastic Compute Cloud service is the most famous. Users can use the computer resources that they want through the Internet, and deploy their own operating system, software, services, etc, while they don't need to manage and maintain the infrastructure.

The ATS layer can be seen as a basic platform that is provided by ISP; users can develop or expand their own applications and services on the platform, while the operators are responsible for the development, maintenance and optimization of the platform's system. The platform that is provided by the ATS layer could be seen as the programmable interface that operators provide for users, takes the back strong Internet resources as supporting. For users, the platform could save the development costs and improve the R&D (research and development) efficiency. This platform is similar to PaaS of cloud computing model. GAE (Google App Engine) is famous.

The business layer is referred to ISPs deploy software on their own servers, and regards the software as services; users acquire the services via Internet. Users don't need to purchase software, can easily use software via browser, and don't need to manage and maintain the software. For example, when the user makes a request to business layer: need a company internal personnel management system software, the user only need to put forward the demands, then forward to the business to process. Finally, users can get the software they need, without the need to consider other issues, specifically, could compared to the SaaS service of cloud computing, such as Google Docs, Gmail, and so on. In cloud environments, large-scale data centers are exposed as a network of virtual services, providing applications to users from anywhere in the world on demand [13].

Business, ATS and ATC lie on three different layers. The ATC layer is at the lowest level in the figure above, because it is closest to the underlying physical resources, takes the abstraction of computer hardware resources as services to provide to users. The ATS layer is referred to the programming platform that is built on computer hardware, support the development of users. On the business layer, ISPs takes their software as services, users can visit the services via the Internet.

The common point of mentioned reconfigurable network in this paper and the most promising and groundbreaking network technology is SDN, namely, Software Defined Network [14]. The development trend of future network is bound to be Software Defined Network, the main features is to support open programmable, underlying basic equipments consist of programmable network devices, such as programmable router or switch, finally, achieve node programmable in whole network. The network architecture based on reconfigurable can be seen

as one form of the SDN, having all of the characteristics of SDN. The main idea of OpenFlow/SDN can be boiled down to: SDN use the separation of data plane and control plane, while OpenFlow is the API that is located between the data plane and control plane and has nothing to do with provider, to provide network operating system and network virtualization. The OpenFlow interface allows operators to mix and match equipments from different providers, and independently choose the providers of data and control plane. The significance of OpenFlow/SDN lies in its API interface is explicitly defined, so the third-part network users can develop and sales the applications used for control and management in the networks, and the ISP will have more choices.

Open programmable SDN is the development direction of the next new general network architecture. The new network architecture should not only support the IP-based network, but also would integrate different non-IP networks admirable, support the heterogeneous network architecture.

5. Summary and Outlook

Although this paper puts forward an idea of network architecture base on reconfigurable and expansible, according to the current status of network, it is a challenge of achieving further application. The key constrains is the device interfaces of underlying network is not open, don't support programmable, therefore, SDN can't be achieved.

However, the rapid emergence and developments of various applications provide a possibility to achieve the reconfiguration of whole network, that is, achieve the programmable of whole network according to the programmable of API on the application layer. Like P2P network, its nodes are distributed throughout the network, form their own network topologies, of course, these topologies are logically connected, supported by the underlying network [15]. In recent years, applications based on P2P technology are increasing, such as BT, MSN and QQ Games [16]. Therefore, the future network architecture must be programmable to achieve configuration and expansion.

Acknowledgments

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