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How to Improve the Independent Ability of ForCES Routers

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Abstract

As network requirement of a new generation emerges, such as the endless stream of multimedia services and data center network, network management is heavy, extremely difficult and prone to error. How to achieve the self-management of the network, reduce manual input and improve stability and high efficiency of network is a hot topic in the field of network technology. As we known, network element needs to support the capability of self-management. But in the ForCES architecture, the self-management of network nodes is clearly insufficient. Based on the cognition with the characteristics of artificial intelligence, we explore the ForCES architecture introducing cognizance. So it has the capable of self-learning and self-management. This paper focuses on introducing the basic features, architecture and key technologies of cognition-based ForCES by means of the traditional definition and features of ForCES.

Keywords*: ForCES, cognizance, self-learning, self-management*

1. Introduction

With the popularity of Internet, it has become more and more uncontrollable and unmanageable. What's more, the drawbacks mentioned above have lead to no guarantee of Qos [1]. In future networks, nodes can not only sense the external environment at any given time, but can also make themselves self-configuring and self-adapting intelligently. In addition, they must be able to achieve the goal of optimizing utilization of resources and maximizing overall satisfaction degree of different transactions, which requires that they must possess self-awareness and be equipped with the ability of self-learning. Cognition provides an effective method for the future network implementation. It shows a new direction for the management of complex networks. Artificial intelligence-related technology is introduced to the network. With the ability of self-management, self-learning, self-optimizing, the network will be able to be controlled, managed and trusted.

2. The Basic Concepts of ForCES and Cognition

Forwarding and Control Separation [2] is a working group of the IETF routing field. In order to better meet the requirements of openness and flexibility of the next generation network, there is a growing concern to open programmable network studies. ForCES Working Group proposes a router architecture which forwarding parts and control parts are separated. This architecture router is able to meet the requirements of openness and flexibility of the next generation network. It is the development direction of the next-generation routers. The basic idea of ForCES is a network element will be divided into two parts in the structure. The two parts are FE (Forwarding Elements) and CE (Control Elements). And IP router consists of multiple (up to several hundred) FE, at least one (or more, for redundancy) CE. ForCES protocol is used to communicate between CE and FE. On this basis, ForCES achieves the separation of the control software of the device and the underlying hardware physically, and the virtualization of a variety of basic network functions module. The ForCES Working Group has completed the formulation of the ForCES Requirements [3], the ForCES Framework [4]. The formulation of ForCES protocol and ForCES FE Model has been basically completed.

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Integrated traffic process, high performance and virtualization [5] are the development directions of the current network architecture [6,7]. Virtualization consists of four levels: data plane virtualization, control plane virtualization, network level virtualization, and traffic level virtualization. The network level virtualization [13] adds an abstraction layer between the underlying physical network and network user. This abstraction layer is providing divided resources of the physical network to the bottom, virtual network to the upper. It achieves the goal of implementing the open network architecture through software-defined programmable. Implementations of network level virtualization require that node devices support virtualization. In virtual network and service model of ForCES, the Plantlab proposed an automatically management architecture based virtual network model. This automatic management architecture completed the transaction automation deployment through the identification of various network resources and traffic, the standardized modeling. Through making abstract model of CE and FE, it puts forward a network resource model of ForCES. The most research of this model focused on physical resource modeling of network nodes, such as CNIS, NDL, NM / PerfSONAR, VGDL etc. ForCES mainly focus on the model of forward nodes of internal parts, does not research the model of the various types of hardware and software resources in the CE. In accordance with different transaction needs, problems such as limited services, resource sharing and competition have come into being in ForCES network elements' transition to virtualization. The reason is that under the traditional framework, CE can't monitor ego resource state and meet transaction requirements. What's more, CE don't have the aims of solving problems, let alone the related knowledge of such goals. So, it can't reason own actions. It fellows that, lacking of self-cognitive between network nodes of ForCES, which largely restricts future traffic effective management of resources in the ForCES architecture.

W.Thomas firstly gives the definition of cognitive network [8]. Its core idea is: the network system can perceive current network conditions, plan, decide, act on those conditions to adjust configuration of the entire system in real time and learn from the consequences of its actions to guide self-decisions intelligently in the future, which means that it imports biological self-regulation into network to emphasize its capability of adjustment and cognition. Up to now, researches about cognitive networks [9-11] mainly on its definition and architecture, which focus on network protocols, routing mechanisms lacks of basic work of the key technologies of awareness of network information and system theoretical model. The ForCES architecture network element nodes are short of self-awareness. According to the characteristics of the cognitive network, it makes the ForCES structural network element equipment having abilities of observed, perception, intelligent decision-making and adaptive[12] adjusting resource allocation and behavior intranet node (such as routing, resource allocation, etc.) by introducing cognitive plane, and thus achieves intelligent optimization of resource management and control of the network element equipment.

3. Characteristics of the Cognitive ForCES

In the the ForCES structure of the network elements, around the process of perception of the CE and FE resources, the characteristics of transaction, resources and services mapping strategy, cognitive ForCES network element nodes should have the following basic features: a) self-perception: CE can actively perceive attribute configuration, query messages, the ability and reported news from FEs. b) self-management: in the case of no or only a few intervention, the internal nodes of network elements under ForCES architecture guarantee the needs of the traffic according to certain services, applications, and security strategies to manage their own resources and acts. For example, CE monitors and manages of traffic and delay to each FE. c) Self-learning: CE can learn from the current status monitored from FE, the specific requirements of the application, the planning and decision-making process. It dynamically adjusts itself to accomplish various tasks, and will store the knowledge learned in repository for use of decision-making in the future. d) Self-optimization: when network performance drops, CE itself can adjust relevant parameters to optimize the allocation of resources and improve their own performance according to a preset target. For example, when the CE detects an FE's flow reaches a peak value, it automatically split flow to prevent network congestion. e) Self-healing: when network is failure or abnormal, in the case of network systems running without interruption, CE can automatically discover, diagnose and repair the fault. f)Self-configuration or Re-configuration: self-configuration refers that the ForCES structure network element dynamically adjusts management methods and control strategies to virtualize resources intelligently, dynamically and evenly, through adaptive network transaction environment, lay the foundation for the establishment of self-management of resources, services adaptive, the fault self-healing of the cognitive ForCES system.

4. The Architecture of Cognitive ForCES

As shown in Figure 1, the cognitive ForCES architecture consists of the virtualization plane based on the data plane and the control plane, the management plane, the traffic-driven plane, and introduces a cognitive plane, according to foundation of abstract and dividing of control and plane forwarding plane of the original ForCES architecture. The different layer of this architecture is proposed from the laying virtualization of internal resources of the network elements. The resource virtualization plane is an abstract model of FE and CE resource information. When the requirement reaches the traffic-driven plane, the management plane takes effectively optimized configuration of resources. It is guided by knowledge base of the cognitive plane. There are two feedback loops in the cognitive plane. One is a closed loop of resources business needs to cognition. The other is resource cognition to configuration. The feedback loop is proposed in order to increase the intelligence of the cognitive decision. In the cognitive process, constantly enriching knowledge, it realizes decisions of business requirements and network resource allocation with the changes in the environment, continues learning and optimization.

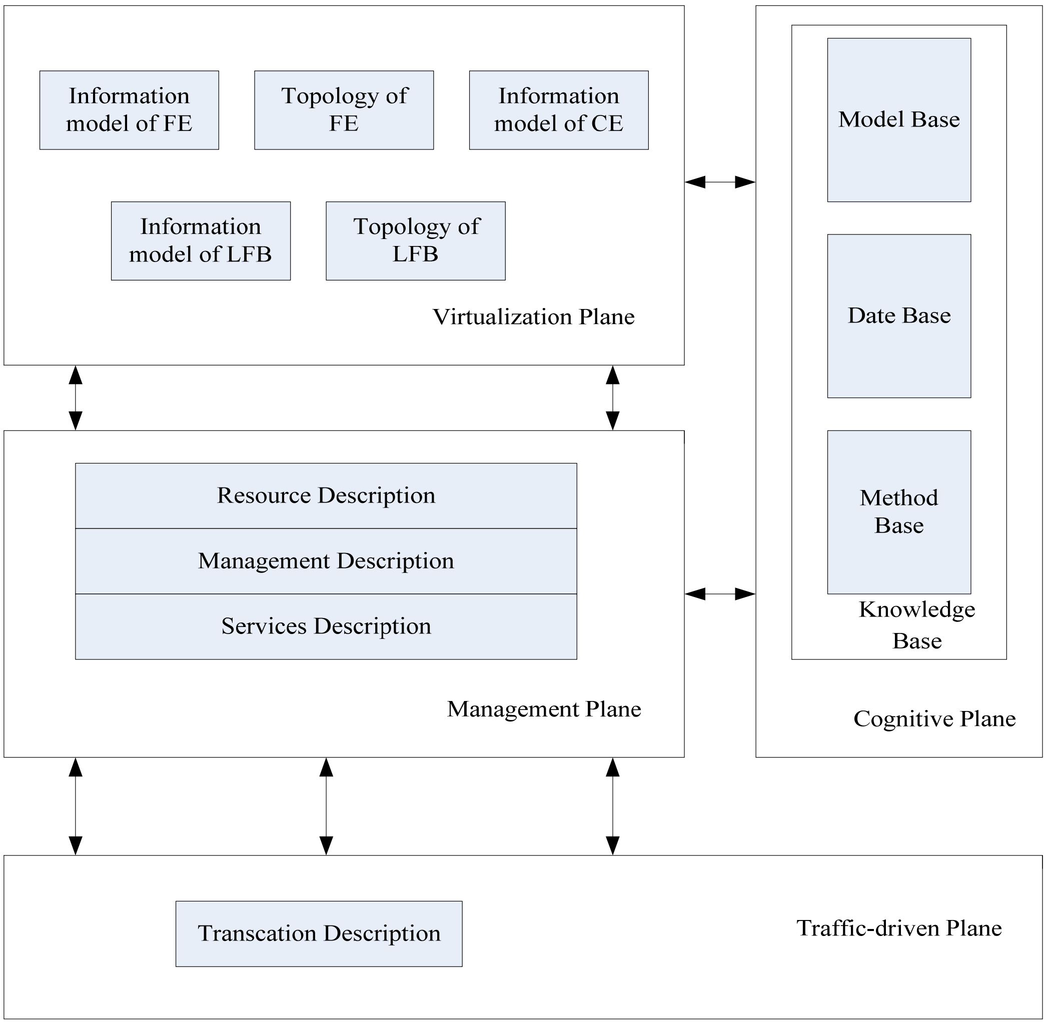

Figure 1. The architecture of cognitive ForCES

5. The organizational structure and the cognitive ring of cognitive ForCES Model

The premise of managing and controlling a node of ForCES intelligently is to acquire resource information and produce a precise and proper abstraction or description for it. What's more, a repository model for resources must be established and consummated with reasoning and self-learning mechanism.

5.1. The Organizational Structure of Cognitive Model Plane in the ForCES

Cognitive plane contains three libraries. It is made of a model base, a date base, a method base. The model base includes trade forecasting model and resource use predictive models, and provides a unified set of mechanisms to manage these models. The date base is used to store time series data, the predicted intermediate results, the predicted final result and the basis of the data table for system administration and maintenance. The method base stores knowledge learned by forecasting system, such as the coupled mapping method providing by transaction and resource services. After a period of time running or training, the prediction system will form a very large forecast error matrix. Through error matrix analysis, the prediction system can learn some related information. The learned knowledge will be used to improve prediction effect, make predictions tend to be accurate.

5.2. The Cognitive Ring of the ForCES Cognitive Plane

As shown in Figure 2, when the CE perceives the FE node information changing, it logs changes and learns autonomously. If there is decision-making method in the method base, it makes self-configuration and returns information to the FE. If the method base has no decision-making method, it makes demand analysis according the feedback on demands. The act of deducing is in accordance with the characteristics of abstracting. The reasoning results are imported into the method library. At last, CE makes decisions and re-allocation of resources, then sends to FE.

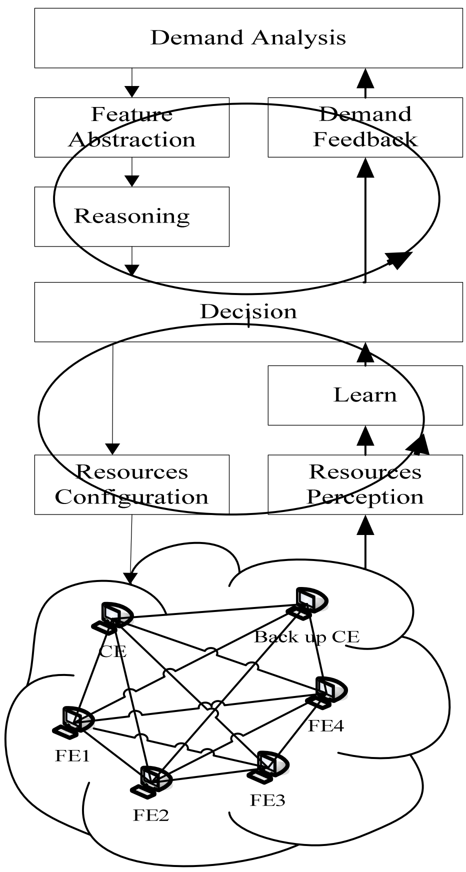

Figure 2. The cognitive ring of the ForCES cognitive plane

6. The Key Technologies of Cognitive ForCES
6.1. Cognition between Environment and Context
Being aware of network environment information quickly and accurately plays an important role in the ForCES nodes. ForCES nodes need to observe the current network environment information at real time. This information will not only be used in the planning, decision-making and other cognitive processes, but also be used to determine whether the network meets demand. If the needs are not satisfied, it is necessary to take the reconfiguration to improve this situation. The contents of the environment perception is that will affect end-to-end transmission performance, such as the state information of the network type, the network topology, the available resources, interfaces protocols, network traffic, and so on. Context-aware is an important way to improve the cognitive network intelligence. It focuses on how to find the change of context information, and adaptively adjust according to changes in the context. When the network environment dynamically changes, the network should make the appropriate adaptive adjustment. The context adaptive method bases on the reflection mechanism and policy mechanisms to achieve context-aware. CE can adjust the pre-established through policy definition when the context changes.

6.2. Knowledge Representation
If the CE can effectively perceive FE, FE must first are fully-aware of own resources. It means that FE should have its own knowledge. After transferring to CE, theses messages can’t be learned and ratiocinated without converting them to the form which cognitive plane can understand. How to express the cognitive ability is the basis issue,which needs to be resolved in cognitive ForCES nodes. The cognitive plane has local and global knowledge of FE and CE. Knowledge of the different areas and the way they presented are different. Such as the knowledge of the network management can be presented by ontology and Bayesian neural network, and OWL (Web Ontology Language) of safety knowledge.

6.3. Learning and Reasoning
ForCES node information is complex. Learning and reasoning is the basic mean to solve complex problems. The process of ForCES nodes is a procedure of learning and reasoning. CE enrich itself by studying the results and process of ratiocinating. Increased knowledge can be used to improve the future of reasoning. So, learning and reasoning are closely linked. There are many ways of learning and reasoning. For ForCES nodes, the most important thing is choosing the appropriate method. FE itself has distributed feature. So, distributed learning and reasoning methods may be more appropriate for ForCES node cognition, such as distribution of Bayesian network inference and distributed Q-learning method.

6.4. Node reconfiguration
If the current FE function does not support the service bearer, CE need to adjust the configuration of the parameters and function of the relevant FE according to transaction needs. This adjustment process is the reconfiguration of the network. The goal of reconfigurable technology is optimal use of FE and maximizing meet transaction needs. For example, when carrying of a FE is too heavy, CE implements load balancing of its FE. It carries packages from heavy FE to less FE to forward, preventing blocking. Or a FE does not provide Qos while forwarding the packet, but the forwarded packet requires FE to provide the guarantee of QOS guaranteed. CE will need to add the function on the FE, activating QOS on the FE module to meet the business needs.

7. Conclusion
The realization of the cognitive ForCES will be able to improve resource effective deployment of resources in ForCES architecture in the future. This paper combines the basic concepts of cognitive and ForCES characteristics. It first mainly studies the basic characteristics, architecture and some implementations of key technologies of the cognitive ForCES. The cognitive ForCES research will play a tremendous role of the development of large-scale complex heterogeneous network management technology and the improvement of network quality of service in the future.

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