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SURVEY PAPER ON ADVANCED NETWORKS INCLUDING COGNITIVE AND GGL ARCHITECTURE NETWORKS

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ABSTRACT

The area of information and communication technologies is one of the fastest changing areas, with related services and applications having enormous and almost immediate impact on diverse aspects of the modern society, including inter-human relations, economy, and education and entertainment. This paper describes about the next generation networks, the cognitive networks and global communication grid architecture. Next generation network is a packet based network able to provide telecommunication services and able to make use of multiple broadband QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. The cognitive network includes a cognitive process that can sense current reality, plan for the future, make a decision and act accordingly. It is generally agreed that cognitive networks have the ability to think, to learn and to remember. and Global Communications Grid (GCG) or Global Grid (GG), seven-layer Reference model consisting of Mission, Application, Service, Transport, Network, Link, and Physical Layers is introduced; the GG corresponds to the Transport and Network Layers.

Keywords—cognitive network, cognition plane (CP),global grid(GG), Next generation networks (NGN).

I.INTRODUCTION

Given the existing “universal nature” of the Internet and its associated infrastructure, which includes an addressing plan, address assignment and resolution by domain name servers, and applications such as email, file transfer, and the World Wide Web, it can be assumed that IP-based systems will form the basis of a next-generation network (NGN).Thus, we conclude that an NGN is an enhanced. IP-based network. [1] .

Next-generation network (NGN**):** A packet based network able to provide telecommunication services and able to make use of multiple broadband QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and competing service providers and/or services of their choice. It supports generalized mobility that will allow consistent and ubiquitous provision of services to users. **[**2]The conceptual model and its functional layers of NGN as shown in figure1.

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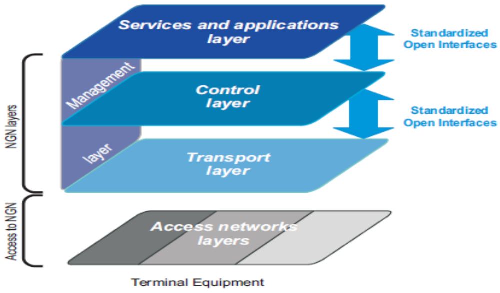

Figure 1: NGN Conceptual model and its functional layers.

The functional layers are as follows.

The access layer provides the infrastructure, for example an access network between the end user and the transport network. The access network can be both wireless and fixed and it can be based on various transport media. The transport layer ensures the transport between the individual nodes (points) of the network, to which are connected access networks. It connects physical elements deployed in the individual layers It also enables the transport of different types of traffic, media (signaling, interactive data, real-time video, voice communication, etc.)The control layer includes the control of services and network elements. This layer is responsible for set-up/establishing, control and cancelling of the multimedia session. It ensures the control of sources as well, depending on the service requirements. One of the fundamental NGN principles is the separation of control logic from the switching hardware.The service layer offers the basic service functions, which can be used to create more complex and sophisticated. [3][4]

Cognitive Networks (CN): Internet traffic increases constantly in a very fast pace, but technology behind it has not changed much in decades. Current technology is designed to simplify designs by hiding information. Network layers tell each other only what needs to be transferred and very little status information is transferred between network nodes. Computer networks are statically configured which might be highly suboptimal for many usage patterns. Routers forward packets with strict rules and knows very little of conditions of other parts on networks. Protocols cannot do intelligent decisions, only react when problem occurs. For example TCP congestion control just slows down the transfer speed when packets are lost and tries slowly increase the speed until next packet is lost. If it had knowledge of network status before transfer, it could optimize transfer speed and avoiding packet loss.Cognitive networking has a different approach. It knows status of every member of network from hardware level to protocol stack and can adjust itself to application requirements even before user sends anything. Goal is to provide optimal end-to-end performance. here are multiple research questions how to make net-working cognitive. One target is traditional TCP/IP protocol stack, which simplifies transfers by isolating layers from each other. This contradicts thinking of cognitive networking, which aims to be aware of state of everything in every level of network. One goal is to augment current stack with cognitive capabilities. [5]

Another question is how to predict what is going to happen in network soon. Game theoretic and artificial intelligent methods are best candidates for achieving this goal. Third related question is how to utilize current radio frequencies better for mobile data communication. Currently data communication has fixed frequencies for use, while at same time there are lot more frequencies reserved for low traffic uses. Cognitive radio tries to take these low traffic frequencies in use by listening which frequencies are not sending anything and loan that bandwidth for a short period of time. Single cognitive radio does not have same end-to-end scope as cognitive networking. When multiple cognitive radios are grouped together in cognitive radio network, it can operate as a part of cognitive network. Cognitive radio is proposed to be included in fifth generation mobile wireless standard (5G).

Cognitive network is a data communication network, which consist of intelligent devices. Intelligence means that they are aware of everything happening inside the device and in the network they are connected to. Using this awareness they can adjust their operation to match current and near future network conditions. Cognitive Network aims to be proactive, so that it can predict most of the usual use cases before they occur and adapt to those beforehand. If predictions fail it falls back to reactive method and tries to solve optimal way of handling the new situation. In any Case Cognitive Network learns from every situation it encounters and uses that information for future cases Main goal of Cognitive Network is to increase network efficiency and performance. Important aspect of cognitive network is that it optimizes data communication for whole network between the sender and the receiver to meet required end-to-end goals of users of the network.

Network becomes cognitive when all the statically configured parts of network are replaced with self-adjusting and self-aware components. Statically configured nodes are not cognitive, because they need an external operator (human) to make decisions and take care of configuration. Promise of cognitive networking is that network itself can find optimal ways of connecting devices and tuning network parameters to achieve best performance for data transfers. It can even optimize for events that are not happened, but are likely to happen. Conventional network forwards packets using routing algorithms and detect failures after packets are lost. Cognitive network knows status of every node, so it doesn't send data using a route that cannot deliver the packet and so it prevents congestion. [6]

Thomas et. Al defines CN as: A cognitive network is a network with a cognitive process that can perceive current network conditions, and then plan, decide, and act on those conditions. The network can learn from these adaptations and use them to make future decisions, all while taking into account end-to- end goals.

Li et. al defines CN as: A cognitive network is an intelligent network consisting of a programmable network and a cognition plane. The cognition plane gathers network conditions, reasons, learns, makes judgment, and adapts the programmable network based on network-wide goals. Cognition plane is currently best candidate for making network nodes aware of the status of the network, so it is justified to including the definition itself. Programmable network can be adjusted with software. It uses sensors to collect network information and forward the information to the cognition plane. Inside every node protocol layers have tiny interface with cognition plane to feed the sensor data into it. Cognition plane gathers network conditions, makes analysis and decisions how to adapt the network. Actuators are used to reprogram the network using the decisions by cognition plane. Cognitive network includes all types of communication networks. Most research has been done around the wireless technologies, because wired networks are not limited in bandwidth like the radio networks are and best performance gains are expected from cognitive radio networks. Cognitive radio networks are needed because current scheme for assigning fixed radio frequencies for wireless networks results in congestion in high traffic bands and under utilization in most of the bands.

II. RELATED TECHNOLOGIES

While Cognitive Network has much in common with Cognitive Radio and Cross-layer designs, there are lots of differences as well. Cognitive Radio is only considering scope of single radio and tries to optimize conditions for single user only.The cognitive network has the capability to self-manage. The self management vision cited IBM's research on "autonomic computing", a term defined as a distributed system where a set of software/network components can regulate and manage themselves in areas of configuration, fault, performance and security in order to achieve some common user-defined objectives. According to the self management vision, the four *self* properties of autonomic computing are: self configuration which enables the entities to automate system configuration following high level specifications while self organizing desirable structures and/or patterns; *self optimization* allows entities to constantly look for improvement on their performance and efficiency while adapting to environmental changes without inputs from humans; *self healing* enables automatic detection, diagnosis and recovery from faults resulting from internal errors or external inconsistencies; lastly is the self protection capability which allows the entities to have automatic defense against malicious attacks while isolating attacks for the prevention of system-wide failures.[8]

III. COMPONENTS OF COGNITIVE NETWORK

Thomas et. Al describes cognitive network with three layer framework. At top level there are applications, which have their own end-to-end goals described in Cognition Specification Language. The bottom layer is the Software Adaptable Network, which is the physical layer with sensors monitoring the network environment. The middle layer is the Cognitive Process layer, which makes decisions based on goals from application layer and network status from physical layer. Decision making must balance between different end-to-end goals, information gathered from past sessions and current sensor information and predict which kind of adjustments would be optimal to meet the goals as good as possible. Decision making relies on Artificial Intelligence technologies and can incorporate many different solutions for different situations.

3.1.The Cognition Loop

All systems that are able to adjust their functioning according to changes in their environment are based on feedback information. Cognitive networks are no exception in this respect, so they will also use a control loop, also called cognition cycle or feedback loop or context based adaptation loop. According to Thomas et al. the loop employed by a cognitive network should be based on the concept of the Observe-Orient-Decide-Act loop originally used in the military, augmented by learning and following end-to-end goals to achieve cognition as shown in fig 2. The loop also has a communicating capability for communicating with other loops in a distributed environment.

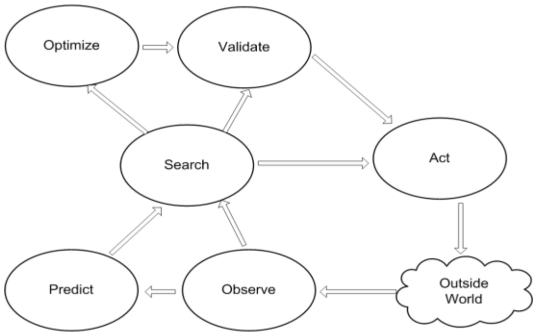

Figure 2: cognitive Framework

The cognition loop starts by observing the outside world or the network. Any changes of the network is reported by the observe module to the predict and search modules. The predict module predicts what will happen based on the current network conditions. The search module maintains a case database (not shown in Figure 1 for clarity reasons). Each case corresponds to one row in a case table. Each row has a case description field, actions field, and rewards or utility field. If the new case observed has high similarity with one of the cases stored in the case database and the stored case has a high utility value, then the actions can be used directly without optimization. Otherwise, the actions taken in the past are sent to the optimization module as seeds, and new actions will be produced by the optimizer. The optimal solutions are then validated against certain laws and regulations to ensure they don't violate the law (e.g., spectrum policies). Finally, the solutions can be applied to the network by the act module. It sends out configuration files to related nodes, so that they are able to reconfigure their protocol components or parameters.

The cognition cycle as described by Mitola features the following states: observe, orient, plan, decide, act and learn. define a reference cognition loop as depicted in Fig.3, consisting of six states (sense, plan, decide, act, learn, policy).In our view, the self-aware network will employ sensors to sense the environment (Sense). The observations captured by the sensors will be further used for planning(Plan), but they will also be fed to a learning module able to learn and remember (build a model from the) useful observations (Learn), which can aid the decision making module in the future (Decide). The planning module determines potential actions, i.e. strategies to be followed based on observations and policies stored in the policy module (Policy). The decision module decides on the actions to be taken based on possible moves (actions) and (learned) experience. Finally, the actuators (Act) are responsible with executing the adequate changes (reconfigurations). The learning module is the one best connected in the sense that it can learn from several sources: from sensor data, from strategies, from decisions and from actuators, and can correlate and infer from this knowledge.

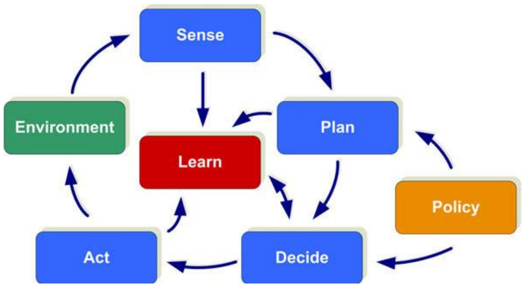

Figure 3: Cognition loop

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IV.GLOBAL GRID LAYERED REFERENCE MODEL

Fig.4 illustrates the ultimate military objective of providing total global connectivity for all information sources and information users with a military internet or network of networks called the Global Grid. The GG in this idealized vision is a "publish and subscribe", "plug and play" network, in which any application can be "plugged" into the network anywhere, at any time, to help achieve war fighting objectives.

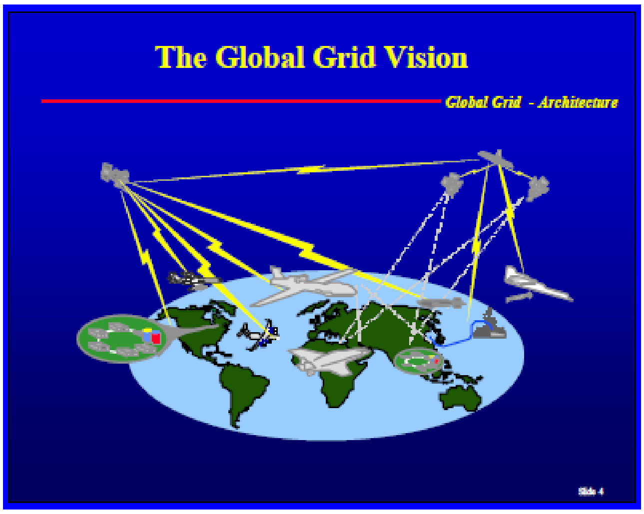

Figure 4: The global grid vision

The overarching goal of this GG layered architecture is to improve interoperability among users by fostering the horizontal integration of military communications systems. GG architectural tenets for supporting this interoperability include three time-phased steps – connectivity, capacity, and control. First, we advocate a way for any user to connect with any other user through a common networking protocol, namely, the Internet Protocol (IP). Secondly, we propose more capacity, or a higher degree of efficiency, through adaptive communication links that attempt to realize user quality of service (QoS) requirements on a packet-by-packet basis. Thirdly, we plan automated management control techniques to minimize the need for intensive manual interventions.

The well-known Open Systems Interconnection (OSI) and Transport Control Protocol/Internet Protocol (TCP/IP) models are shown in Fig. 5, along with the GG reference model (GGRM) that has created. The GGRM is based upon the OSI and TCP/IP models but has some features that emphasize military communications. We introduce a Mission Layer that has no corresponding layer in the other two models. Also, we rename a Service Layer from elements of the other two models. In the widest sense, the GG can be thought of as the communications transport medium consisting of the bottom four layers of the GGRM. However, the essence of the GG is in the Transport and Network Layers that are essentially common to all these reference models[9]

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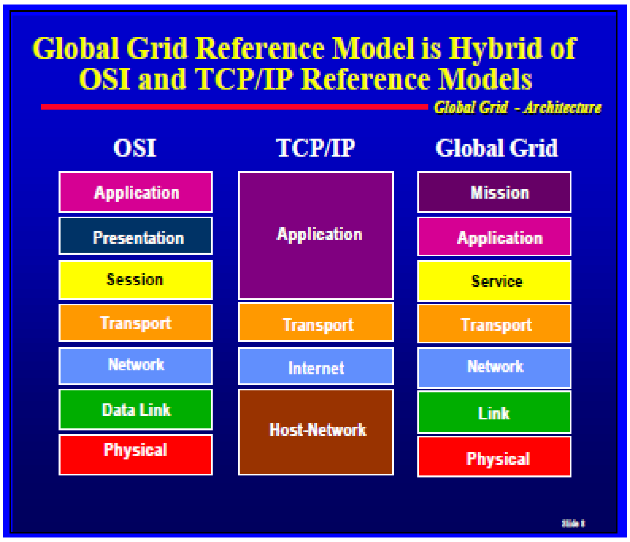

Figure 5: Global Grid Reference Model

V. CGGRM LAYER DEFINITIONS

The Mission Layer provides the specific aggregation of applications from the Application Layer necessary to perform a particular military mission.

The Application Layer provides common and mission- specific applications that are employee as utilities by users or other programs at the Mission Layer. For convenience in partitioning applications, by definition, the Application Layer contains only those applications directly accessible by a user.

The Transport Layer provides for reliable end-to-end_data transfer, flow control, error recovery, and may be concerned with QoS and/or optimizing network resources

The Network Layer consists of Internetwork and Subnetwork Sublayers that provides for data transfer_across a network_of networks or within a network, respectively. This includes addressing, congestion control, and associated usage accounting functions. These sublayers are the same as in the OSI reference model.

The Link Layer provides point-to-point data transfer. The Link Layer includes the addition of an Adaptation Sublayer (not present in the OSI or TCP/IP models) that serves to make Link Layer implementations network- centric, i.e., compatible with a common networking protocol, viz., IP. In addition, the Link Layer consists of the OSI model's Link Management Entity (LME) and Data Link Services (DLS) Sublayers that operate in parallel, and the Media Access Control (MAC) Sublayer. The LME Sublayer handles management (as opposed to communication or security) functions. The DLS Sublayer attempts to present the sublayer above with error-free data; breaks the data into frames; transmits/receives those frames sequentially with the necessary synchronization, error, and flow control; and returns acknowledgements back to the sender. The MAC Sublayer controls interactions with the physical media; multiplexes/ demultiplexes, and multiple-accesses/releases

In the GGRM the Physical Layer is partitioned into four Processing Sub layers that are present but not so explicitly identified in the OSI model. The Baseband Processing Sublayer organizes/transmits/receives channel symbols at appropriate rates and converts them between digital and analog signal representations. The

Baseband-Intermediate Frequency (IF) Processing Sublayer performs frequency translation and analog processing. The IF Processing Sublayer performs filtering and amplification. The IF- Radio Frequency (RF) Processing Sublayer performs frequency translation and analog processing. The RF Processing Sublayer performs filtering, amplification, and transduction with the physical media.[10]

VI. CONCLUSION

This article has presented the general principles and conceptual model for a next-generation network, cognitive network and global grid communication.

Cognitive Networking tries to redefine traditional statically configured networking into a dynamic, adaptive and intelligent networking. it has many applications like IOT etc.

The GGRM comprises seven layers that are defined somewhat differently from the standard 7-layer OSI model and 4-layer TCP/IP model. The Global [Communications] Grid corresponds to the Transport and Network Layers. The Network Layer should converge to a common standard protocol, the Internet Protocol (IP). It has more applications in military communication