Cognitive Approaches for Intelligent Networks

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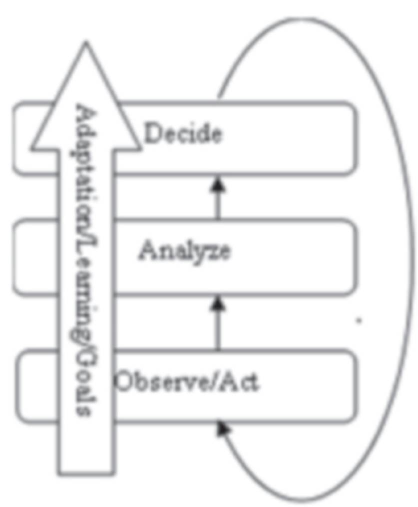
INTRODUCTION

Application of intelligence into networking is one of the ambitious targets in the research field, which is expected to produce a transformational impact on the performance of current networks. One of the major demands for future intelligent network is its ability to support the vastly increasing number of applications. Future smart networks also call for a successful scenario where it will co-exist with the present infrastructure. The existing infrastructure tends to lack the ability to learn and understand the ways and means of operation of applications, which often leads to various anomalies. In this context, it is necessary to view the network as a whole and establish appropriate intelligence in and around the nodes to recognize the properties of the environment of a communication point in relation to multiple hop circles around it. Currently network systems are much dependent upon old approaches of design having predetermined forward routing technology which produces usually non-optimal performance (Ciancetta, Colombo, Lavagnolo, & Grillo, 1999).

The routing decisions in the existing networks are generally based on table driven systems, provided at the node level. This system usually has no awareness of the environment around it. This is where intelligent networks can play a significant role. Many researchers are working in the area of autonomic network (AN) since 2003. The companies like Motorola and IBM were some of the players in this domain. Aspects of game theory, probability, linear programming, evolutionary algorithm, genetic algorithm, artificial immune system, artificial intelligence and many more stochastic approaches have been applied to achieve the awareness and learning capabilities in the network. Once there is awareness about the network, routing can be performed effectively. In order to meet the demand for improved network, the nodes need to be intelligent and capable of making decisions on their own. The current nodes and systems do not have the information regarding the topology which might have been formed during the routing. This will demand a process for collecting the knowledge about the environment. Hence the nodes need to have a mechanism to collect the data and become aware of the vital parameters of the network and if required, communicate this intelligently to other participating nodes. This will enable the network to realise the ability to learn, remember and reason out in a way as presented in Figure 1, as Cognitive cycle, which was initially proposed by Mitola (2001).

Internetwork routing is evolving into a complex process and structure, where the ongoing functions like *monitoring*, *control* and *management* have become either challenging or less effective. It is increasingly becoming difficult to operate large networks, perform diagnostics, prevent cascading failures, and deliver dependable services. Hence there is a requirement for networks to be enabled to think and learn from

Figure 1. Cognitive cycle



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a continuously changing environment. This is where the cognitive approach plays a vital role to overcome the shortcomings (Nair, Sooda, &Abhijith, 2008). In spite of becoming more and more complex, the Internet hasn't started using the intelligent approaches present in nature to overcome the problems of increased data traffic. The self-regulation mechanisms existing in the current network are more or less primitive; it can neither learn nor adapt its behaviour based on the patterns and emergent conditions of the environment. Cognitive Network is an improved version of network with abilities to effectively *self-regulate*, *learn* and *evolve* in time. When a system is subjected to a complex and varied set of stimuli, which is certainly the case of the fast-evolving Internet of Things, aspects of Cognitive Network (CN) becomes crucial. CN implements an approach whereby each node cooperates with the data-distribution process and makes use of an information-rich dataset about networks. To enable the CN to work, there is a need to rethink about the architecture and protocols of the components in the global communication infrastructure (Ghys & Vaaraniemi, 2003). A prominent direction of research looks at how to mimic nature-like mechanisms to realize smarter communication networks. This could be an approach that can make sense of the hidden communication patterns and self-regulate the topology. The routing approaches for Cognitive Networks are mainly based on learning and reasoning techniques. The available learning methods include reinforcement learning, Q-learning, foraging algorithms, evolutionary algorithms and neural networks. The learnt aspects are later rearranged and made available in an information database. The learned knowledge facilitates a useful information database for further references on network status. This concept of further reference is depicted in Figure 2, Knowledge base design. The reasoning techniques include proactive, reactive, inductive, deductive, one-shot, sequential, centralized and distributed methods. The reasoning technique helps the extraction of quality nodes while exploring the optimal path. Routing is a fundamental function to create dynamic interconnections between end nodes that are not directly linked. Current networks and nodes have only a rudimentary mechanism to build paths and respond to congestion. These networks are not able to adjust to different types of stimuli and contextual conditions with their deterministic way of functioning.

The following section deals with the work done in the field of Intelligent Networks which are discussed along with the developed products.

BACKGROUND

The section presents a detailed description on the existing technology depicting the concept of intelligent network in cognitive domain. One of the initial incor-

Figure 2. Knowledge base design