# Learning-Based Routing in Cognitive Networks

Tahir Alyas, Nadia Tabassum, Qura-Tul-Ein, Shahid Naseem, Fahad Ahmed

**Abstract**— Intelligent Routing can influence the overall performance of a communication network's throughput and efficiency. Routing strategies is required to adapt to changing network loads and different topologies. Learning from the network environment, in order to optimally adapt the network settings, is an essential requirement for providing efficient communication services in such environments. Cognitive networks are capable of learning and reasoning. They can energetically adapt to varying network conditions in order to optimize end-to-end performance and utilize network resources. In this paper we will focus machine learning in routing scheme that includes routing awareness, a routing reconfiguration.

**Index Terms**— Intelligent Routing, Machine Learning, Cognitive Networks, Routing Awareness, Routing Reconfiguration, Cognitive Agent

## 1 INTRODUCTION

Cognitive networking is an promising paradigm that deals with how heterogeneous systems learn relationships among network parameters, network events, and observed network performance, plan and make decisions in order to achieve local, end-to-end, and network-wide performance as well as resource management goals. Cognitive wireless networks are capable of reconfiguring their infrastructure, based upon experience, in order to adapt to continuously changing network environments. Cognitive networks are seen as a main facilitator of future heterogeneous internetworking and management, capable of continuously adapting to fluid network characteristics.

The term "cognitive network" has different interpretations with different emphasizes on the node behavior, operational objective, or the scope of the target problem.

Cognitive Radio (CR), with the ability to observe the surrounding network environment and reconfigure to adapt to network changes, is one of the most promising solutions. The core of cognitive radio as described by Mitola is the cognitive cycle, which consists of six processes observe, orient, plan, decide, act, and learn [1]

Among diverse wireless technology supporting Internet access and other stream traffic services, a different vision is to integrate different wireless systems/networks and to appropriately use one of them based on the communication environments and the application requirements, based on reconfigurable communication and networking. Cognitive radio pioneered by J. Mitola III from software defined radio (SDR) was originally considered to improve spectrum utilization. [2]


- *Tahir Alyas is currently PhD Scholar in Computer Science in NCBA&E, Lahore, Pakistan and lecturer in Lahore Garrison University, Lahore, Pakistan tahiralyas@gmail.com*
- *Nadia Tabassum is currently working as Lecturer in Virtual University, Pakistan, nadiatabassum@vu.edu.pk*
- *Qura-Tul-Ein currently working in Lahore Garrison University, Lahore, Pakistan Ainy16@gmail.com*
- *Shahid Naseem is currently PhD Scholar in Computer Science in NCBA&E, Lahore, Pakistan and working as Assistant Professor in Lahore Leeds University, Lahore, Pakistan shahid.naseem@gmail.com@gmail.com*
- *Fahad Ahmed is currently PhD Scholar in Computer Science in NCBA&E, Lahore, Pakistan. fahadahmad84@gmail.com*


Cognitive networking is a promising paradigm that deals with how heterogeneous systems learn relationships among network parameters, network events, and observed network performance, plan and make decisions in order to achieve local, end-to-end, and network-wide performance as well as resource management goals. Cognitive wireless networks are capable of reconfiguring their infrastructure, based upon experience, in order to adapt to continuously changing network environments. Cognitive networks are seen as a main facilitator of future heterogeneous internetworking and management, capable of continuously adapting to fluid network characteristics.

The term "cognitive network" has different interpretations with different emphasizes on the node behavior, operational objective, or the scope of the target problem.

Cognitive Radio (CR), with the ability to observe the surrounding network environment and reconfigure to adapt to network changes, is one of the most promising solutions. The core of cognitive radio as described by Mitola is the cognitive cycle, which consists of six processes observe, orient, plan, decide, act, and learn

## 2 DIFFERENT MACHINE LEARNING METHODS FOR PACKET ROUTING

In current era, communication networks are growing, developing and evolving at a rapid rate. Telecommunication systems provide a myriad of services that use much of the network's resources inefficiently. For computer systems to optimize their own performance without human assistance, they need to learn from experience. Achieving good performance in such a network using fixed algorithms and hand-coded heuristics is very difficult and prone to inflexibility. Instead, we used reinforcement learning that are efficient, robust, and adaptable in intelligent routing.

### 2.1 Q-Routing

Q-Learning is a reinforcement learning algorithm that is able to learn an optimal sequence of actions in an environment which maximizes rewards received from the environment. Q-Routing is an adaptation from Q-Learning that is able to distributively route packets in a network. Q-routing is an online learning technique in which reinforcement learning modules are inserted into each node of the network. Reinforcement

learning agents attempt to learn effective control policies by observing the positive and negative rewards they receive from behaving in different ways in different situations. In Q-routing, the agents do not attempt to maximize a reward function but instead to minimize a *time-to-go function*, which estimates how long a given packet will take to complete.

### 2.2 Ant-based Routing

Ant-Based Routing is a novel variation of reinforcement learning that is based on simple biological "ants". These "ants" explore the network and rapidly learn optimal routes inspired by the stigmergy model of communication observed in ant colonies. This algorithm is more resilient than traditional routing algorithms, in the sense that random corruption of routes has limited effect on the computation of the packet routes.

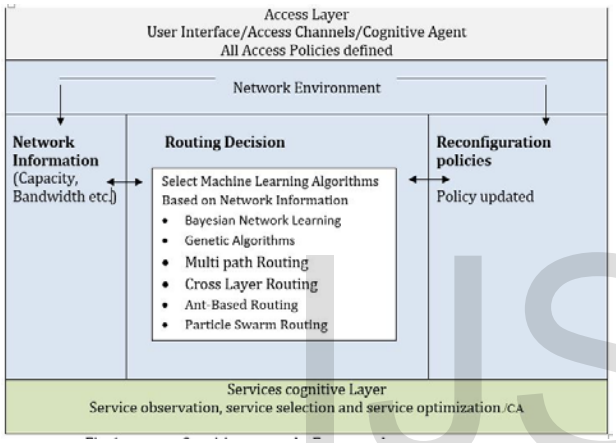


Fig. 1. Propose Cognitive networks Framework

Ant colony algorithm is a kind of evolutionary intelligent algorithm that inspired by the activities of real ant in nature. Ant colony algorithm has characteristic of probability seeking and adopts the catalytic mechanism of parallelism and positive feedback. Ant colony algorithm has strong robustness and excellent distributed computing mechanism and is easy to combine with artificial neural network, genetic algorithm, artificial immune algorithm and particle swarm optimization algorithm. [5]

It was first proposed by M.Dorigo, an Italian researcher, who makes full use of the similarity between the paths of ant colony searching for food and the famous travelling salesman problem, to solve by artificially replicated the process of ant searching for food, namely finding the shortest path from ant-colony to food reserves through exchange of information and mutual cooperation.

### 2.3 Particle Swarm Routing

Particle swarm optimization is a population based stochastic optimization technique developed by Dr. Russ Eberhart and Dr. James Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. Particle Swarm Routing is initialized with a group of random solutions and then searches for optima by updating generations [3].

## 3 Proposed Network Model

We will design such cognitive function which can learn the demand base request and discover more-optimal paths and update our repository.

Designing the machine learning base routing algorithm in heterogeneous networks is a big challenge. In a cognitive network, the performance of routing links belonging to different networks is quite different. The complex heterogeneous network environment often varies. Consistent Link management, transmission data rate and reliability change with the environment. In an overlapped network scenario it is very difficult to predict and control spectrum interference of wireless links. Routing strategy in cognitive network is affected by factors such as the ability to access multiple networks, throughput, user preference, Quality of service requirements, and location.

The Different cognitive design based functions can be implemented as distributed intelligent agents. Cognitive Agent will observe the Network Environment by keeping the focus on following parameters.

1. Reconfiguration Policy
2. Routing Decision
3. Network Information

Agents with different machine learning algorithms and having reasoning capabilities can be deployed on each layer in the network to monitor and collect network environment information. These functions cooperate and exchange information so that the complex network can perceive its current status. In Fig. 1 if we know the entire network environment, in certain or uncertain machine learning algorithms, and select the best possible route and reconfigurable policy has been determined and appropriate services are triggered.

In Complex network, there is no mechanism to infer when congestion is to about occur and therefore it waits till some important packets are lost for reacting to face congestion in the network. In fig. 2 suppose that our network is facing congestion, and then Cognitive Function will be work like brain of the cognitive network node where the optimization decisions for protocols within the layer are made.

For Building a cognitive network, first of all we will defined the policy for network. By understanding the network load parameter, the policies are redefined according to the environment. The Cognitive agent will learn the environment and select routing algorithm which are suitable in such environment.

## 4 Learning through Bayesian Network

A Bayesian Network is a probabilistic model in the form of directed acyclic graphs (DAG) that represents a set of random variables by its nodes and their correlations by its edges. Bayesian Networks has an advantage that they visually represent all the relationships between the variables in the

system via connecting arcs and they can handle situations

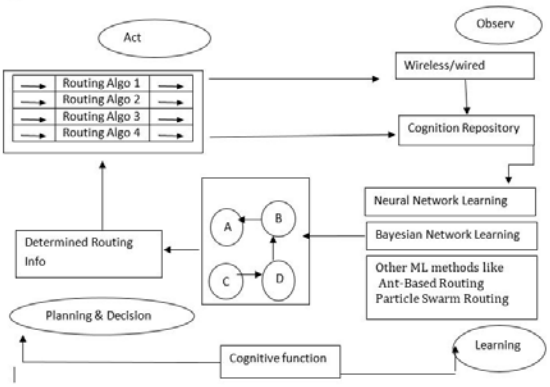


Fig. 2. Proposed Learning in Cognitive Network

where the data set is incomplete. In complex network there is uncertain and inconsistent data flow comes [4].

In our proposed model the cognitive Function realizes the learn phase and decide phases of the cognition cycle. Cognitive cycle consist of four parameter.

1. Observe
2. Learn
3. Plan
4. Act

The Learning phase is a key phase in the cognition process, where the cognitive node exploit the information collected in the observe phase to infer a probabilistic arrangement that connects the parameters of interest, using the Bayesian model and predict the network.

This prediction can be very important in the Plan and Decide phase to optimize a controllable parameter, or to predict an unwanted behavior of the network, e.g., congestion, and take the necessary actions in the protocol stack before this happens. Finally, in the Act phase, the decisions made in the Plan and Decide phase are effected, e.g., controllable parameters are modified to optimize the network performance.

## 5 Cognitive Network Route Protocol

Network Communication routing protocol is a mechanism of transmitting data from the source node to destination node. The main objectives are to meet the requirement while minimizing the network cost, to obtain the overall effectiveness of the use of resources, to expand the network throughput. The requirement generally refers to delay, delay jitter, packet loss rate and other factors like congestion and network overload.

Network routing protocol is the most significant and the core of the problem for network communication. The cognitive network routing protocol includes the routing path generation, path routing selection and maintenance of the routing path. The routing path is generated according to network status information and shortest path is selected as shown in fig.1. The routing selection is based on network status information and Operational status to select the most appropriate path.

## 6 Conclusion

In evolving different networks, network configuration cannot be optimized manually. The coexistence of heterogeneous networks also brings a more complicated networks environment. Cognitive technology provides a way of configuring networks dynamically, and best optimizing in performance, and user resources. In this paper, a cognitive routing scheme for heterogeneous networks has been proposed. This scheme involves a routing algorithm frame composed of a situation awareness, route reconfiguration by learning element in cognitive function.

## References

[1] Friend, Daniel H. "Cognitive Networks: Foundations to Applications." Dissertation, Blacksburg, Virginia, 2009.
[2] K. –C. Chen, Y. –J. Peng, N. Prasad. Cognitive Radio Network Architecture. National Science Council, Taiwan, 2008.
[3] Edwill Nel, C.W. Omlin. "Machine Learning Algorithms for Packet Routing in Telecommunication Networks." Bellville, South Africa.
[4] Giorgio Quer, Hemanth Meenakshisundaram, Bheemarjuna. "Using Bayesian Networks for Cognitive Control of Multi-hop Wireless Networks." The 2010 Military Communications Conference, 2010: 6.
[5] Zhao, Y., & Zhong, B. (2011). Ant Colony Algorithm's Shortest Path Principle and Its Convergence Performance. *Elsevier Ltd* , 9.