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Channel Selection with Channel Pool Management in Multi-Interface Networks Using BPTT

Monika Rani
Research Scholar, IKG Punjab Technical University,
Department of Electronics & Communication Engineering,
Kapurthala, India

Kiran Ahuja
Assistant Professor,
DAV Institute of Engineering & Technology
Department of Electronics & Communication Engineering
Jalandhar, India

Abstract: In wireless networks, every wireless node has a set of the available channels. A channel or medium is the band of RF used to exchange the information. Each of the wireless network nodes need to select one channel from its available channels to transmit signal information with its neighbor nodes. Channel selection is among the most important wireless communication elements in heterogeneous environments wherein, a user can experience improved communication quality by choosing a better channel. A smart phone should always be in search of best interface connectivity in a heterogeneous environment to provide flawless and fast communication continuously. This paper presents an emerging approach to artificial intelligence in Interface management in the WHN environment. In this paper, back propagation through time, one of the artificial intelligence (AI), is used to select a channel from the channel pools based on target output and test data. The channel with high output at a particular time interval is chosen for further communication. For dynamic channel selection, BPTT is a fast method and the efficiency of this is better than traditional methods. Pseudo code is provided to clarify the algorithms.

Keywords: Interface Management, Channel pool Management, Artificial neural network, Back Propagation Through time

1. Introduction

Today world is the world of automation. Everything humans can think is possible to be in real life. So as in a wireless heterogeneous environment, every new prospect of technology can be turned into real/practical within a year. This means thinking of a person or even a device can easily be interpreted. Artificial intelligence took all the credit for doing that. Advancement in AI has widely opened new possibilities in every field including wireless communication. In this chapter, we describe specific AI use in interface management. The capabilities of AI – its supremacy to integrate wide and different data/parameters, analyses, identify concepts and implements in different conditions, etc. AI is a key ‘enabling technology”.

1.1 Interface Management:

Managing different interfaces during vertical and horizontal handover is known as interface management (IM). The function of IM is to provide the best and flawless connectivity during handovers by choosing the best network. The interface management process consists of planning, identification, approving, auditing, and closing-out interfaces. Interface management should be able to manage the various channels and interfaces during data communication and operation efficiency.

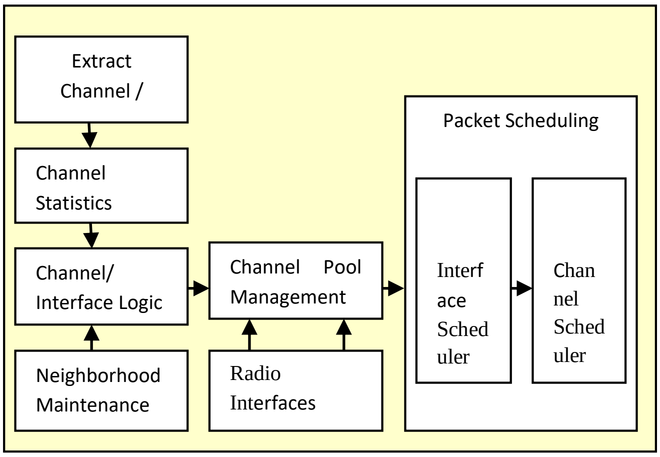


Fig.1. a general view of interface management

A general view of interface management with its operational blocks is shown in fig.1. Once a usable access point is discovered the interface can associate with it and start communication. The different blocks have their task to make the whole system operational. The various blocks are explained in brief as follows:

Channel Statistics (CS): CS shows the statistical characterization and properties of the channel. It is also known as channel state information (CSI). This describes signal propagation from the source to the destination with the effect of channel losses: scattering, fading, and power decay throughout the communication.

Channel & Interface Selection Logic: A communication channel refers either to a physical transmission medium such as a wire or to a logical connection over a multiplexed medium such as a radio channel in telecommunications and computer networking. A channel is the band of RF used for wireless communication. Each IEEE wireless standard specifies the channels that can be used. For example, the 802.11a standard specifies radio frequency ranges between 5.15 and 5.875GHz. , 802.11b and 802.11g standards operate in the 2.4 to 2.497GHz range etc. A channel is used to convey an information signal, for example a digital bit stream, from one or several senders (or transmitters) to one or several receivers. A channel has a certain capacity for transmitting information, often measured by its bandwidth in Hz or its data rate in bits per second.

In mobile communications, the interface is the radio-frequency portion of the circuit which acts as an interconnection between the cellular phone set or wireless mobile and the active base station. As a subscriber moves from one cell to another in the system, the active base station changes periodically. In short, the interface is the point to point link between the mobile and the base station.

Neighborhood Maintenance: Neighborhood management/maintenance is facilitated by the exchange of link layer control packets during communication.

Packet Scheduling: Scheduling is the action of assigning resources to perform tasks. A packet scheduler is also called a network scheduler, queuing discipline or queuing algorithm. It acts as an intermediary on a node in a packet-switching communication. It manages the sequence of network packets during transmission and reception. The packet scheduler is the traffic control module that regulates how much data an application (or flow) is allowed, considering QOS parameters that are defined for a particular communication. In simple words, it is the process used to select which packet to be serviced or which to be dropped.

1.2 Artificial intelligence

Artificial intelligence (AI) is the implementation of human brain power by technology, especially computer systems. AI processes large amounts of data much faster and makes predictions more precisely than humanly possible. Specific applications of AI include machine learning, natural language processing (NLP) and machine vision. AI system works in three steps: learning, interpretation and self-correction. The first step data is acquired from different sources and a set of rules in form of an algorithm is prepared. These rules provide the direction to complete a work. Choosing the right algorithm to reach the desired output is the second step to moving ahead. The no. of the training process is performed to provide the most accurate results in the third step.

The combination of AI techniques and wireless communications can fulfill the increasing and diverse requirements of a heterogeneous environment with multiple applications. Artificial intelligence (AI) has made smart wireless communications for complex radio frequency (RF) systems by employing powerful machine learning algorithms and significantly improving RF parameters such as channel bandwidth, antenna sensitivity and spectrum monitoring. The system has many benefits like reduce power consumption, less computational requirements, increased throughput, minimum latency, range and power consumption. The various methods used for wireless communication are shown in fig.2. As the technology evolves, complexity increases so the new technology evolves to meet the requirements. Traditional methods are replaced with new smart methods: artificial intelligence. Wireless mobile communication is a vast field where different management techniques are used to communicate. One simple call, audio and video needs a proper management system to reach the destination. Earlier there was a very limited resource to follow but nowadays different channels, and different interfaces are available. The various traditional techniques and artificial techniques used for channel selection were discussed in the next section.

2. Related Work

Each IEEE wireless standard specifies the channels that can be used. To provide a channel selection method of a wireless communication in a wireless heterogeneous environment number of channel selection algorithms and

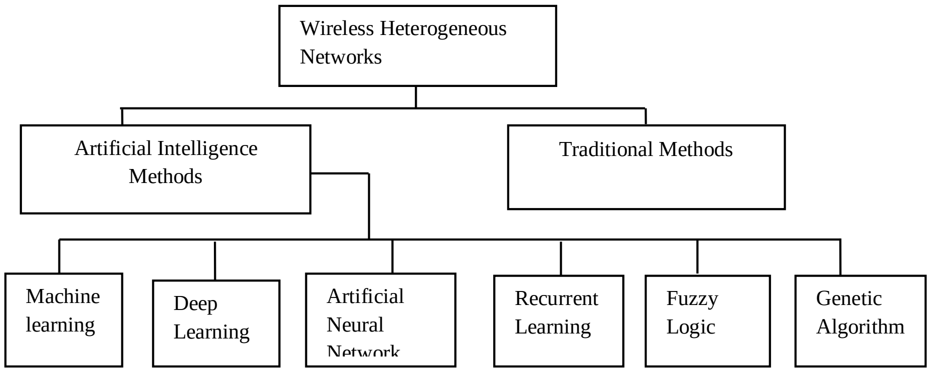


Fig. 2. Methods of wireless communication

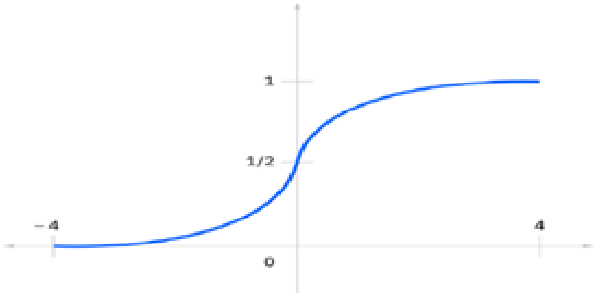
techniques have been extensively studied in the literature in different contexts. In [1] a group of wireless access points self-configured their channel selection without the need for any algorithm. To avoid interference between one another's access points standard hardware was used. This method was very simple, and robust also increase network capacity. The concept of interference was also taken by different authors to select channels. An ANN-based method, the genetic neural mathematic method (GNMM) had been applied to provide brain–computer-interface (BCI) [2]. This method was implemented in three parts. The input was selected with a genetic algorithm (GA-based). Modeling and training were done with multi-layer perceptron and rule extraction respectively. EEG channel selection and classification problems include least-square (LS) approximation to determine the overall signal increase/decrease rate; locally weighted polynomial regression (Loess) and fast Fourier transforms (FFT) to determine the signal strength and variations. Authors introduced a channel selection metric in [3] based on channel utilization and channel quality. Channel quality was measured through SINR. SINR was considered based on received signal strength and interference. A Non-Utilized Outage Capacity (NUOC) as a cross-layer channel metric was calculated by adding the utilization ratio to the outage capacity. The proposed mechanism was implemented in IEEE 802.11 standard which made it very desirable and practical for these networks. The authors [4] used a control channel to transmit signal information between wireless networks. The authors focused on the selection of a control channel instead of the data channel as it required less bandwidth. The proposed algorithm minimizes the usage of the total spectrum bandwidth of the set of control channels. A novel Dynamic Channel Selection (DCS) algorithm was proposed in [5] for a Wi-Fi cell network. The algorithm continuously monitors and identifies Wi-Fi interference sources and updates the channels across the network. The algorithm's performance was evaluated as improved spectrum efficiency as well as robustness to variations in the interference. An overview of the CORAL platform also summarized its major components and capabilities. The authors investigated the feasibility of using machine learning techniques for estimating user-channel features at a large-array base station (BS) in [6]. The neural network was trained with different combinations of measured features of the channel like received signal strength and the relative path delay to infer the unknown parameters of the users. Authors [7] proposed an LTE channel selection mechanism considering Wi-Fi access point's interference. The other LTE operators in the unlicensed band also improve their channel selection by collecting channel utilization statistics. The reinforcement learning, algorithm, introduced a similarity metric, to balance the Q-value impact and expected network capacity during calculating channel selection probabilities. Multi-armed bandit (MAB) algorithm was used in reference [8] for dynamic channel selection of IEEE802.11a-based, four-channel WLAN. MAB algorithm incorporated laser chaos time series in a wireless local area network (WLAN). Authors demonstrated the application of ultrafast chaotic lasers for future high-performance wireless communication networks. Authors reviewed the traditional methods of spectrum allocation in [9] having problems of spectrum underutilization and scarcity in wireless networks. Cognitive radio technology was proposed to access the spectrum dynamically. Some adjustments were made in Medium access control (MAC) layer functionalities such as sensing and channel allocation. Channels are ordered and grouped to allow faster discovery of channel access opportunities. A Generalized Predictive Channel Selection algorithm was used to reduce delays and maximize the throughput.

3. Channel Pool Management with BPTT

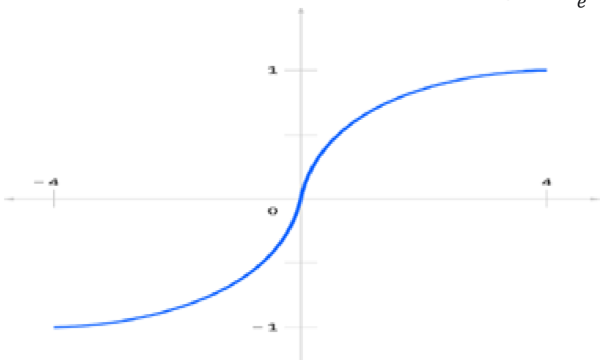
When data packets need to be transmitted over a node link, the link layer determines which radio(s) and channel(s) to use. Wi-Fi channels are smaller bands within Wi-Fi frequency bands that are used by wireless networks to send and receive data. To select a wireless channel dynamically from an insufficient number of wireless channels or channel pools, a proper channel selection method is prepared. It comprises different kinds of scanning/checking or monitoring: whether any one of the plurality of wireless channels is left unused by other wireless stations or not. A wireless channel can be shared with other wireless stations. Channel switching is next step to be taken during an ongoing communication. A node in a wireless communication system announces a channel switch operation to facilitate a smooth transition to another channel.

A recurrent neural network (RNN) is a type of artificial neural network which uses sequential data or time series data. In BPTT the model trains itself by calculating errors from its output layer to its input layer. Once the network has trained on a time set and given an output, that output is used to calculate and accumulate the errors. These calculations allow for adjusting and fitting the parameters of the model appropriately. BPTT is different from BPNN (back propagation neural network) approach, in BPTT sums errors at each time step whereas BPNN does not need to sum errors as they do not share parameters across each layer. An activation function is applied at each layer to determine whether a neuron should be activated. These nonlinear functions typically convert the output of a given neuron to a value between 0 and 1 or -1 and 1. Some of the most commonly used functions in BPTT are defined as follows [10].

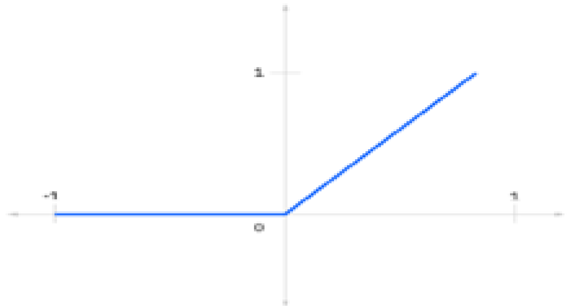
Sigmoid: This is represented with the formula $g(x) = \frac{1}{1+e^{-x}}$



Tanh: This is represented with the formula $g(x) = \frac{e^{-x} - e^{-x}}{e^{-x} + e^{-x}}$



Relu: This is represented with the formula g(x) = max (0, x)



4. System Model

We associate with each interface a pool of channels, from which the current channel is dynamically selected. Thus, interface management has two aspects, viz., channel pool management, and channel selection. $C(x)$ denotes the set of channels on which interface *x (802.11a, 802.11b)* is capable of operating, each interface *x* has an associated channel-pool $P(x)$ with no. of channels $C(x)$, and the current channel of an interface *x* is denoted by $c(x)$. At the time of starting up, each interface is assigned a set of *f* channels chosen uniformly at random. The Channel Pool Manager uses a timer that is scheduled at start-up after an interval uniformly distributed between 0 and T_{pool} seconds, and thereafter rescheduling every T_{pool} seconds. On completion of each time interval, a pool-management algorithm (BPTT) is run by an interface. The output of different channels of interfaces is calculated according to the input values. The interface with the highest output is selected.

Types of interface	Received power	Delay (microseconds)
802.11a	20-54Mbps	0-20
802.11b	5-11Mbps	0-10

We apply pseudo code to select the best channel based on highest output.

// To select the best channel from the channel pool //

DETERMINE the radio interfaces

DETERMINE the channels of the radio interface

COMPUTE min and max value of the input.

SET hidden layers(1-n)

SET output layer (1-n)

COMPUTE the activation function hidden and output layer.

SET No.of epochs

SET error value

SET learning rate (0-1).

Train the network with inputs

CALCULATE the output.

SELECT the interface with high output

5. SIMULATION AND RESULTS

The IEEE 802.11b standard provides data rate options of 1, 2, 5.5 and 11 MB/s in the 2.4 GHz band. The IEEE 802.11a standard operates in the 5 GHz band and uses the orthogonal frequency division multiplexing (OFDM) technology. It can support data rates of 6, 9, 12, 18, 24, 36, 48, and 54 MB/s.

We have taken input values of two interface 802.11a and 802.11b as input to train the network. To quantify performance, we use the user perceived throughput / Target for test and train the network. Inputs are divided into any ratio (5:5) to test and train the neural network system. The error is calculated and fed back to optimize the outputs. The channel of interface with the highest output is chosen. Figure shows the neural network with input layer, hidden layer, and output. Different and random inputs are applied to train the data. The learning rate (lr) is set at 0.05 and the error is 0.0001.

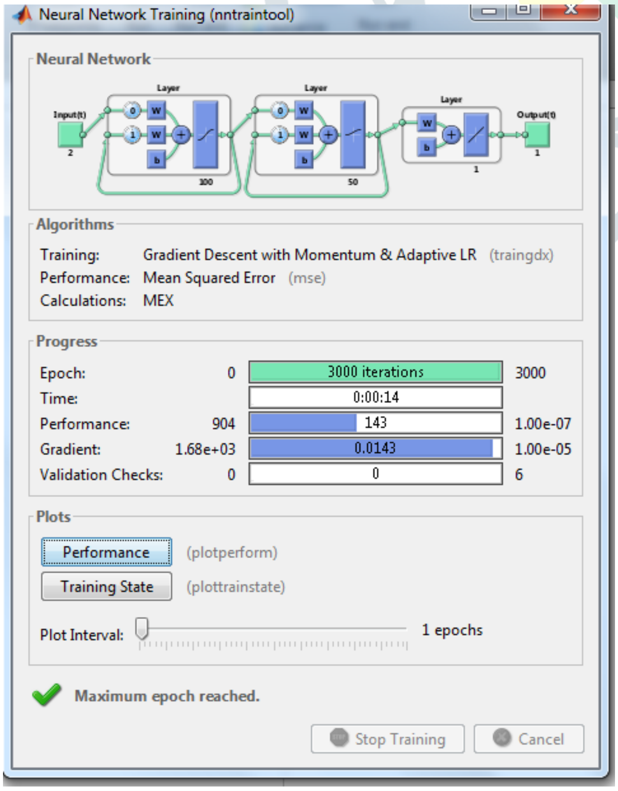


Fig.1: View of neural network tool

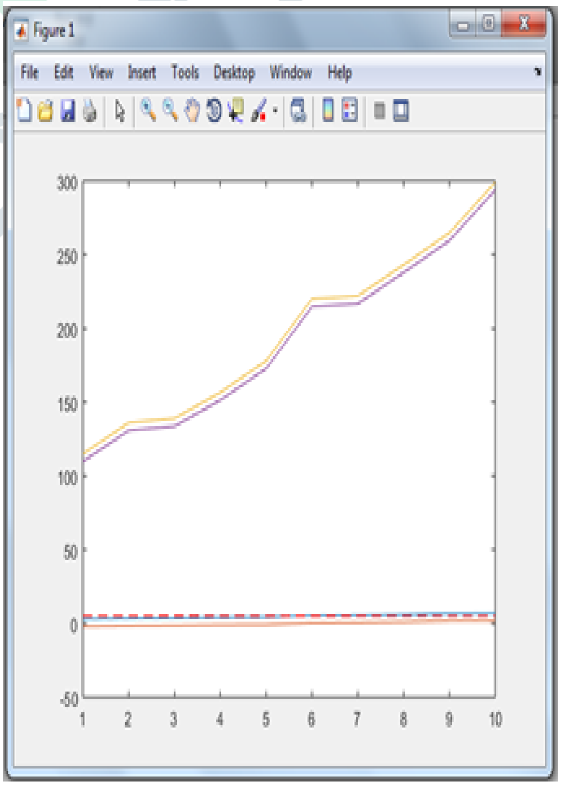


Fig.2: Output Vs Target output

We use neural network tool for the simulation. NNELM is used for the inputs. The other parameters like learning rate, error, and number of layers are manually set. More the number of layers, more the efficiency, and more complexity.

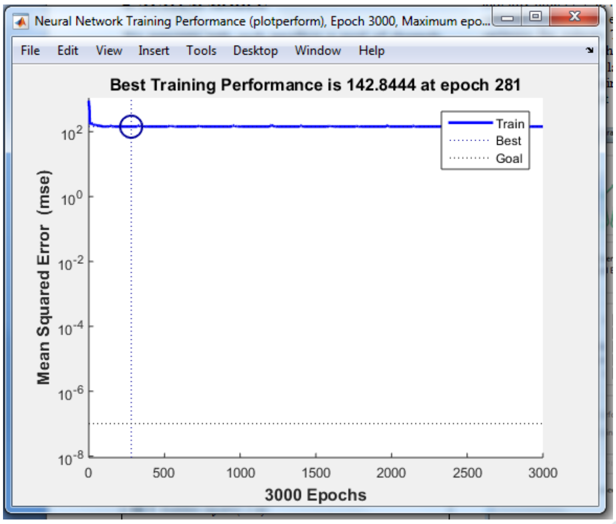


Fig.3: Mean squared error vs Epochs

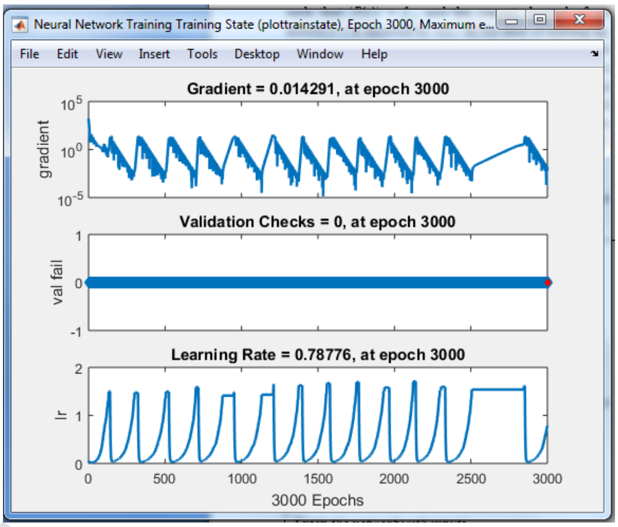


Fig.4: Training performance Vs epochs

6. CONCLUSION AND FUTURE SCOPE

The two inputs delay and received power of two interfaces 802.11a and 802.11b are taken for selection criteria. A neural network toolbox is used with some user-defined values. Learning rate, no. of epochs, and no. of input, output &hidden layers can be pre-set for simulation of an algorithm. The result shows that output is more accurate, reliable and approach to target. In the future, more interfaces can be compared for the best selection.

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Authors' Profiles

Kiran Ahuja has done outstanding research in the fields of optical and wireless communication. She received her B.Tech & M.Tech degree in Electronics and Communication Engineering from Punjab Technical University, Jalandhar, India and Ph. D in Electronics & Communication Engineering in wireless communication and networks field from Thapar University, Patiala, Punjab, India. She completed her post-doc from NIT, Jalandhar under N-PDF scheme of SERB, India. She is working as faculty in the Department of Electronics and communication Engineering at DAVIET, Jalandhar in India since 2006.

Monika Rani is motivated and determined research scholar. She has completed her B.Tech and M.Tech from state university, IKG Punjab Technical University. Presently, she is pursuing Ph.D in Electronics and Communication Engineering in wireless communications from IKG Punjab Technical University, Karurthala, India. She has published research papers in SCI journals and presented in national and international conferences as well.