Real-time LAQ Based Interference Minimization Model for Efficient Transmission in Radio Networks

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Abstract:The problem of interference in radio communication is well studied. There exist number of approaches to handle the issue, which consider angle of radio device and frequency as the key in handling the interference problem. However, they suffer to achieve higher performance in QoS requirements. To handle this issue, an efficient LAQ (Latency Availability Quality) based interference minimization model (LAQ-IM) is presented in this paper. The method focused on improving the transmission performance by choosing a optimal radio device with reduced interference. The method considers the set of radio devices available for transmission and considers the latency, availability and quality of the radio in the selection of transmission. Using all these features, the method computes Latency minimization support (LMS), Availability Support (AS) and Quality Support (QS) for the radio devices identified. Based on the value of LMS, AS and QS, the method computes the value of Interference Minimization Weight (IMW) based on which an optimal radio has been selected to perform data transmission. The proposed method improves the performance of radio transmission.

Keywords: Radio Networks, Interference Minimization, LAQ, LAQ-IM, IMW.

1. Introduction:

The radio networks have been a backbone for the entire communication in modern world. The network contains number of radio devices which are intended to perform wireless transmission. Any radio device comes with a transmitter which can transmit signals in specific transmission range and frequency. Any radio device is limited with its transmission range which makes them to perform cooperative transmission. They radio device perform transmission on a specific frequency and angle. However, there are number of radio devices would be located on a specific location and such huge transmission introduces signal interference.

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Presence of signal interference makes the transmission to be disturbed with packet drop and noisy signals. In order to achieve higher throughput and quality transmission, there should be no interference on the frequency. When more than one device performs transmission on a specific frequency, there will be interference and the receiving radio would not be able to distinguish the other data with its own. So it is necessary to identify the signal interference and based on that the specific radio device should be selected for the data transmission. When you have more than one radio device and by monitoring the quality and performance of the device, a specific one should be selected to complete the data transmission.

The selection of radio device is performed based on various aspects. For example, when a radio is selected for data transmission based on the angle of transmission, if the quality of the device is not upto the required data rate, then it introduces poor performance in data transmission. Similarly, the methods selects the radio device based on the bandwidth only, in this case, if there is higher interference, then it would affect the transmission performance. All these affects the performance of data transmission in radio networks.

By considering all these an LAQ based interference minimization model is presented to support the transmission in radio networks. The model is focused to select the specific radio device according to the latency, availability, and quality of transmission. Towards this, the method computes different measures like LMS, AS and QS, the method computes the value of Interference Minimization Weight (IMW) based on which an optimal radio has been selected to perform data transmission. By adapting the proposed approach for the selection of radio, the performance of the entire transmission as well as the network gets improved. The working of the model is briefed in section 3. The detailed introduction is presented in Section1, where the section 2 briefs set of methods related to the problem. Section 4 is furnished to provide the evaluation results with the conclusion at section 5.

2. Related Works:

Number of selection schemes is presented in literature for the support of radio networks in the sense to achieve higher performance. Such methods are briefed in this section for understanding the problem.

A Full Duplex Relay based SelfInterference Cancellation model is presented in [1], to achieve Ultra reliable low latency communication (URLLC). Towards interference alignment in two way relay networks, a selective coupling reweighted nuclear norm minimization scheme is presented in [2], which uses reweighted nuclear norm minimization algorithm according to the rule given and singular value decomposition matrix. Energy harvesting based interference cancellation is presented in [3], which uses cancellation coefficient and interference threshold are used towards the reduction of interference. An atomic norm based adaptive Interference Cancellation scheme is presented in [4], which uses atomic norm minimization and de-noising to reduce the interference. A cooperative interference management scheme is presented in [5], over the computation networks. A topological interference management (TIM) framework, is presented in [6], to support device to device network towards cancelling the interference by combining successive interference cancellation (SIC) scheme. A reconfigurable intelligent surface (RIS) based interference cancellation scheme is presented in [7], which combines with the millimeter wave (mmWave) channel characterized by sparse propagation paths. The RIS-mmWave model reduces the interference in the network. A two cell interference network is presented in [8], which uses devise higham algorithm in cancelling interference.

An interference and QoS aware resource allocation scheme is presented in [9], which consider the DAS behavior of nodes to perform interference minimization.

A theoretical model is presented in [10], to handle the inter cell interference with orthogonal multiple access andnon-orthogonal multiple access schemes. The OMA-NOMA schemes reduce the interference heavily. An energy efficient interference aware machine to machine communication protocol is presented in [11]. A systematic method using chordal distance (CD) decomposition is presented in [12], to obtain the balanced precoding, which improves the trade-off. A multi-agent deep deterministic policy gradient (MADDPG) based scheme is presented in [13], which uses centralized training with decentralized execution to handle the issue. A modified vector quantization based approach is presented in [14], which uses Interference Lloyd and the Inter-AP Lloyd algorithm towards cancellation.

3. LAQ Based Interference Minimization Model (LAQ-IM):

The LAQ (Latency Availability Quality) based interference minimization model (LAQ-IM) focused on improving the transmission performance by choosing an optimal radio device with reduced interference [15]. To perform this, whenever it has a data to be transmitted, the method considers the set of radio devices available for transmission and considers the latency, availability and quality of the radio in the selection of transmission. Using all these features, the method computes Latency minimization support (LMS), Availability Support (AS) and Quality Support (QS) for the radio devices identified. Based on the value of LMS, AS and QS, the method computes the value of Interference Minimization Weight (IMW) based on which an optimal radio has been selected to perform data transmission [16].

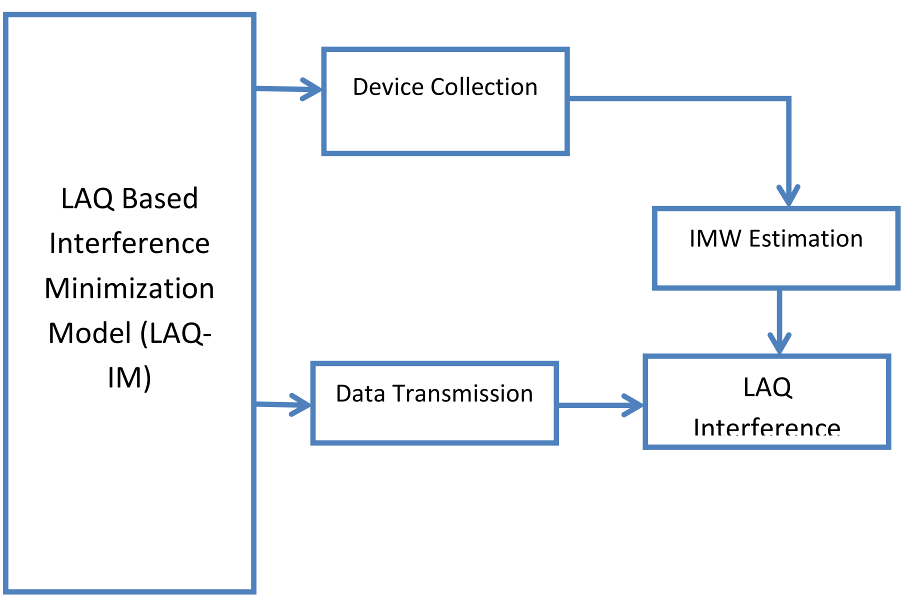

Figure 1: Architecture of proposed LAQ-IM Model

The working model of proposed LAQ-IM model is presented in Figure 1, where the functions are detailed in this section.

Device Collection:

The model always looks for the incoming data and receives the incoming data. When it has a data to be transmitted, it discover set of radio devices around its location. The set of devices around its location are identified and for each of them, the method collect the frequency, angle, bandwidth conditions. Such collected data are added to the set and being used towards interference minimization. The method generates the characteristic request to the neighboring radio devices and request Frequency F, Availability Av, Bandwidth B, Transmission T, Angle A. By receiving the characteristic reply from the radio device, it extract the features and add to the set.

Algorithm:
Given: Packet P
Obtain: Radio Device set Ds
Start
Read P.
Discover set of radio around its location Ds = $\sum Radio < Network >$
For each device d
Send characteristic request CR = {Source Id, F,A,B,T,Av}
Receive characteristic reply CP.
Update device set Ds(d) = {d.id,F,A,B,T,AV}
End
Stop

The device collection algorithm identifies set of radio devices and collects set of characteristics of the device to support the selection and interference minimization.

IMW Estimation:

The interference minimization weight represents the efficiency of any radio device towards achieving higher quality service and transmission with less interference. It has been measured by computing different other measures like Latency minimization support (LMS), Availability Support (AS) and Quality Support (QS). Here the LMS is measured based on the average latency present in the device for number of transmission, and AS is measured based on the number of times the device is selected and number of times it has been available. Similarly, the QS is the value measured based on the number of quality transmission performed and number of times selected with the average throughput. Using all these values, the method computes the value of IMW. Estimated IMW value has been used to perform device selection and transmission.

Algorithm:
Given: Trace T, Device Feature Df.
Obtain: IMW
Start
Read T and Df.

Compute LMS = $\frac{\mathop{Sum}_{i=1}^{size(T)}(T(i).latency?T(i).DeviceID==Df.DeviceID)}{\mathop{Count}_{i=1}^{size(T)}(T(i).DeviceID==Df.DeviceID)} \times \frac{DF.F}{DF.B}$

Compute AS = $\frac{\mathop{Sum}_{i=1}^{size(T)}(T(i).Available==yes?T(i).DeviceID==Df.DeviceID)}{\mathop{Count}_{i=1}^{size(T)}(T(i).DeviceID==Df.DeviceID)}$

Compute Qs =

$$\frac{\sum_{i=1}^{size(T)} Sum(T(i).TransmissionState==Good?T(i).DeviceID==Df.DeviceID)}{\sum_{i=1}^{size(T)} Count(T(i).DeviceID==Df.DeviceID)} \times \frac{\sum_{i=1}^{size(T)} Sum(T(i).THroughput?T(i).DeviceID==Df.DeviceID)}{\sum_{i=1}^{size(T)} Count(T(i).DeviceID==Df.DeviceID)}$$

Compute IMW = $\frac{QS}{AS} \times LMS$

Stop

The IMW estimation algorithm computes various support values to compute IMW to support radio selection for better transmission in radio networks.

LAQ Interference Minimization:

The proposed LAQ interference minimization algorithm receives the incoming packet and performs device collection. With the set of devices identified, the method computes the value of IMW for various devices. Based on the value of IMW, the device with maximum IMW is selected to perform data transmission.

Algorithm:
Given: Trace T, Packet P
Obtain: Null
Start
    Read T and P
    While true
        Ds = Perform device collection.
        For each device d
            Compute IMW = IMW-Estimation (T, d)
        End
        Device d = choose device with maximum IMW.
        Perform data transmission
        Receive packet P.
    End
Stop

The LAQ interference minimization model computes IMW value for various radio device and selects a device with maximum IMW to perform data transmission.

4. Results and Discussion:

The proposed LAQ-IM model has been implemented with Simulink and evaluated for its performance with different scenarios of network conditions. Obtained results are compared with the results of other methods.

Parameter	Value
Tool Used	Simulink
Number of nodes	200
Simulation time	10 minutes
Number of base stations	10

Table 1: Evaluation Details

The evaluation details considered for performance evaluation of proposed method is presented in Table 1.

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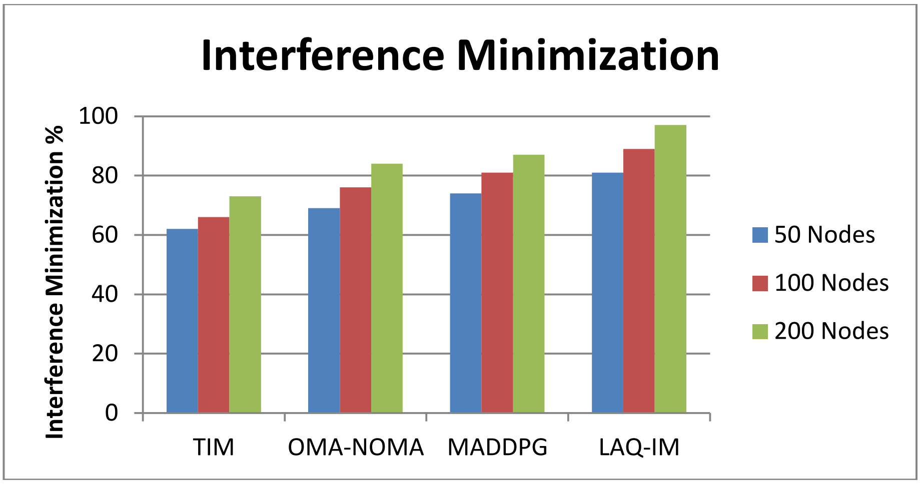

Figure 2 : Interference Minimization

The performance of methods in minimizing interference in communication is measured and compared in Figure 2. The LAQ-IM model introduces higher performance in interference minimization than others.

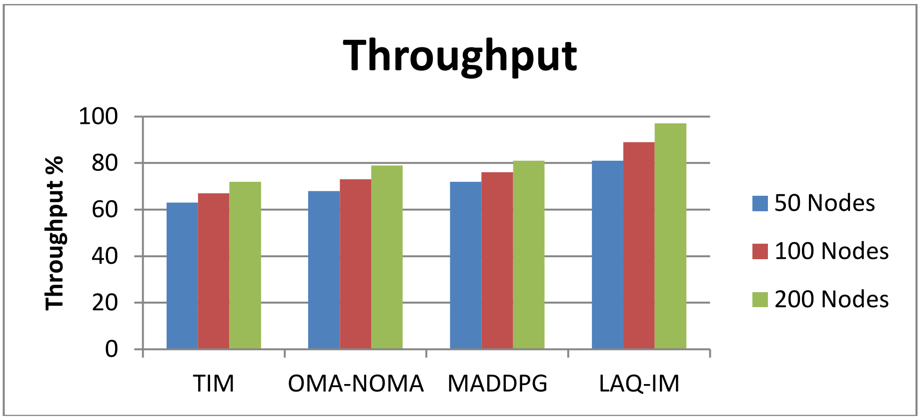

Figure 3: Throughput Performance

The performance in throughput achieved by various methods are measured and presented in Figure 3, where LAQ-IM model introduces higher throughput in all conditions.

5. Conclusion:

This paper presented a LAQ based interference minimization model towards the performance development of radio networks. The method receives the incoming packet and identifies set of radio nodes around the location. Further, for each of them the method collects the characteristics details like bandwidth, frequency, latency, throughput, availability and so on. Using all these details, the method computes LMS, AS and QS values. Based on these values, the method computes the value of IMW for all the devices identified. The method selects a device with maximum IMW to perform data transmission. The proposed method improves the performance of interference minimization and throughput.

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