

Energy Efficient Throughput Maximization for Wireless Networks Using Piece Wise Linear Approximation

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Abstract

The amount of power requirement is a main issue in wireless network nodes. We recommend a new piece-wise linear approximation to convert nonlinearities into linear restrictions. In this paper, we considered the energy required for the battery, which is most important. We proposed that this issue can be overcome by a mixed-integer nonlinear program (MINLP). To make our concept as energy efficient, we characterize its scientific expressions, then suggest a new piece-wise linear approximation which will give prime solution. This method allows converting the nonlinearities into linear constraints. In this paper both network throughput and energy requirement were optimized through a multi criteria framework which is optimized, i.e., by optimizing the network output by reducing the maximum power consumption. In telecommunication the source coding, channel coding, and finally the, line coding are at the transmitting point to generate the baseband signal. In some systems they use modulation to multiplex these signal to generate many baseband signals. During the active wireless link for communication, the energy consumption is in the form of two things 1. Energy required for the purpose of broad casting and the other is energy required for the instruments involved during the communication. The utilization of power depends upon the whether the link is active or not. From the above consideration our work is vary from the existing work in the same area. The energy used by the LCD for the existing is always used and hence the usage of power for one node is more when compared to proposed system.

Keywords: Piece-wise linear approximation, MINLP, Energy efficiency, Energy consumption, Network through put, PIC Microcontroller.

1. Introduction

The usage of Wireless Networks is very huge, this can be used in major areas like military surveillance, physical security, traffic surveillance, automation control, inventory management, national border monitoring, building and structural monitoring⁴.

In most of the Wireless Networks the active nodes transmit its generated data to the common ground station.

Here, the energy feeding is high when all nodes transfer data directly to the Base Station².

In general the communication between the nodes (source) and central location called sink³ is established through the multi hop wireless networks which uses two or more wireless hops. The data communication between network entities is performed by directly or through multiple hop relays. Despite wide exploration in wireless networks, many tasks remain in the study of

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mobile adhoc networks including expansion of multiple access procedures that exploit advanced physical layer technologies like MIMO, OFDM, and intrusion dissolution, examination of the essential limits of mobile ad hoc network capacity, practical depiction of achievable throughputs taking into account network overheads.

To increase the life time of the wireless network, we should manage the energy carefully, because each node contains some unit of non-rechargeable battery power¹.

2. Literature Survey

2.1. Cooperative Transmission for Wireless Networks with the help of Mutual-data Growth

In this Y. Shi et.al discussed about the cooperation between the nodes, which increases the reliability of communication and reduces the energy required for the communication and also reduces the latency. Here the conservative smallest route in a via different node sustain more delay with more power consumption is in the order of seventy percentage, when related to the projected cooperative routing solution by Y. Shi et al.

2.2 Dispersed Multi-hop Supportive Communication in Solid Wireless Sensor Networks

Lin et al. found that the building of an organization depend on a pre-defined lane, while they investigating the applications of supportive communications to yield maximum amount of data broadcasting in solid systems. Here a common method creates REER un scalable during a unstable network structure¹⁶.

2.3 Cooperative Multi-hop Broadcast in Networks

When information is broadcasted via channel, every node will have different chances to consistently collect the data. For every retransmission the network consumes more energy.¹⁷ So I. Maric and R. D. Yates formulate an experimental algorithm and simulated results to find a good ordering and it shows the performance of the algorithm to be close to optimum and a considerable development over the recognized BIP algorithm for initiating energy-efficient transmission trees.

2.4 Energy Optimization for Reliable Point-to-Point Communication in Energy Constrained Networks

In this paper, the author frame the problem of energy consumption by using the association between network capacity of MQAM variation in passage and to SNR¹¹, to minimize the power requirement in an end-to-end connection, the author scrutinize all improved constraints.

2.5 Maximizing throughput with an eye on Network-wide Energy Consumption

In general the effort of power requirement becomes an increasingly vital role for the users in the wireless network. Here the author studied about the network-wide energy preservation problem which offers visualizations to the customers. As an initial work of their research, the author analyzes that how to improve the output in a maximum power limitations and they framed this difficult as a MINLP^{8, 12}. Finally they recommend a unique piece-wise linear approximation to convert nonlinearities into linear restrictions.

3. Proposed System

In our paper, we focus on energy-based issues that concentrate on much power requirements in network. First, we discussed on how to improve the output in power restriction and this issue can be expressed as a MINLP.

Later, we simplify the issue happened in the beginning using a multi criteria optimization context, this frame work concurrently improves the output and the entire power required for the network. This paper discuss about a proper optimization context and proposing a performance guarantee for the final solution. When we compare it with the other associated mechanism which accept the formal optimization frameworks^{9, 12}. We come to a conclusion that maximum of these mechanism reflect only per-link energy limitations or per-node energy limitations.

Here the main concentration is on maximum power utilization in a network, this is a very high significance to the users in a network. Especially, the subsequent 2 issues were discovered: (i) Way to optimizing the output of a network by satisfying the entire power limitation in the network. This will helps the users to bring maximum

output for a particular power cost¹³. (ii) Way to improve the output of a network and the total power requirement concurrently.

4. System Design

In telecommunication, the node-to-node data communication is handled by the data link layer and the physical layers present in the OSI model. The source coding, channel coding, and finally the, line coding are at the transmitting point to generate the baseband signal. In some systems they use modulation to multiplex these signal to generate many baseband signals into^{11, 18}. The output U is the summation of weighted session rates and it can be derived as,

$$F w(f) \cdot r(f) \quad (1)$$

Multi-hop relaying is necessary during the broadcast of data from the Txr to the Rxr which has more than one-hop away. Due to the sub-optimality nature the single-path flow routing is restricted^{5, 6}. Hence the flow splitting is allowed so that the information is transported along different routes and it can be given as below.

The sum of drift rate on relation l is denoted as $rl(f)$ and it is credited to the period F . Similarly the group of potential incoming links at node I is denoted as Li and it can be given in the following Figure 1. Let k be the Txr node of period h , i.e., $k = s(h)$, then

$$\sum_{l \in Li \text{ out}} rl(f) = r(f) \quad (2)$$

Let i be the intermediary communicate node of the period f , i.e., $i = s(f)$, $i = d(f)$,

$$\sum_{l \in Li \text{ out}, l \neq (i, s(f))} rl(f) = \sum_{m \in Li \text{ in}, m \neq (d(f), i)} rm(f) \quad (3)$$

During the active wireless link for communication, the energy consumption is in the form power required

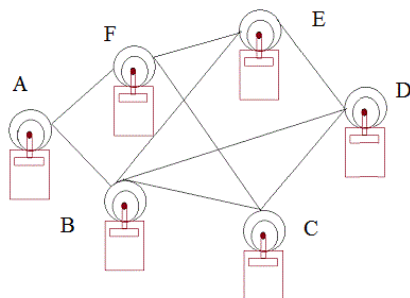


Figure 1. Node Diagram

for the broadcast and the power required for encoding, modulation, decoding, demodulation, etc. Denote $pl \geq 0$ as the broadcasting energy required for the source connection l , and it can be differed based on the broadcast necessities. Pd can be assumed as a fixed device power as soon as the dynamic relation is present¹⁹.

Let yl be the indicator to say liveness of the relation l ,

$$yl = \begin{cases} 1, & \text{relation is live;} \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

The utilization of power depends upon the whether the link is active or not, if the connection is energetic, then the power Pd can be utilized; otherwise, we do not. This characteristics is readily modeled by multiply Pd by yl (the relation action pointer). Integrating the broadcast power pl , and the link l is derived as $pl + yl Pd$. Let the maximum broadcast energy consumed by a node is $P \max$. Then, the association among pl and yl can be given as:

$$pl \leq yl \cdot P \max(l, L) \quad (5)$$

For all dynamic relations in the network node, the node-level communication power limit can be given as below:

$$\sum_{l \in Li \text{ out}} pl \leq p \max(i \in N) \quad (6)$$

Here Li Out i be the group of possible outbound associations at node I . The amount of entire energy consumed on all dynamic relations in the network can be denoted as P , and it can be given as below^{7, 20},

$$P = \sum_{l \in L} (pl + yl Pd) \quad (7)$$

The operating cost P net of network-wide energy, can be written as

$$p = \sum_{l \in L} (pl + yl Pd) \leq p \text{ net} \quad (8)$$

In general, the MINLP problems are very hard to solve due to the nature of nonlinearity and the combinatorial and this kind of problems can be addressed by some existing techniques^{7, 20}, any how these methods can be used only with the small-sized problems because it cannot help us to solve our problem-specific structures and properties.

In our proposed approach, we brought a matchless scientific configuration for our MINLP issue and also we developed a new close to-optimal key technique which

yields a guaranteed performance. In OPT problem, the link capacity be the only nonlinearity constraint which holds logarithmic function. Our proposed piece-wise linear approximation technique can address this problem to transform the nonlinear constraints, which guarantees the linear approximation error does not exceeds an explicit threshold.

OPT-R indicates the linearized optimization problem which are used to represent the replacement of nonlinear constraints in OPT to linear constraints. Since this OPT-R problems are MILP (Mixed Integer linear Problems) which are very easier to solve when compare to that of MINLP. In this case we apply a solver namely CPLEX to derive the solution efficiently. Cracking OPT-R produces prime solutions to the actual OPT problems. Let γ be the preferred performance gap for the near-optimal solution, i.e., the difference in the objective values between the optimal solution and the near-optimal result to OPT. The association among this γ and the linear approximation error was examined. To obtain the exact desired γ , we calculate the extreme permissible linear approximation error and consequently, the linear approximation restrictions and concept of OPT-R were derived.

The nonlinear limitation can be revised as follows^{8, 20},

$$\sum_{f=F} rl(f) \leq Bl \ln(1 + pl, hl) \quad (9)$$

We denote

$$Sl = pl hl \quad (10)$$

after simplification

Then, the nonlinear term becomes $\ln(1 + sl)$. Note the array of sl given as $[0, s \max l]$, and $s \max l = (P \max hl) / (\eta Bl)$.

The main aim of our approach(as given in the Figure 2) is to use a group of successive linear parts to estimate

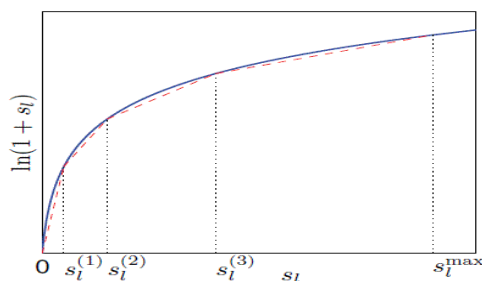


Figure 2. Linear segmented (4 segments) piece-wise linear approximation.

$\ln(1 + sl)$ for $sl \in [0, s \max l]$. Denote the maximum permissible fault for this linear approximation and Kl be the no. of linear parts needed to encounter the above fault condition (here the value of Kl will be calculated in future). Denote $s(k)l$, $k = 0, 1, \dots, Kl$ as the sl -axis values of the destination points for these Kl parts, with $s(0)l \equiv 0$ and $s(Kl)l \equiv s \max l$. A new method is adopted to produce a linear approximation is to have $s(k)l$, $k = 0, \dots, Kl$, consistently dispersed between $[0, s \max l]$.

By setting the value of Kl as large as possible we can satisfy the linear approximation error requirement. As this approach is a straight forward one and also very easy to implement, we will generate 'n' number of linear segments to approximate $\ln(1 + sl)$. Here the derivative of $\ln(1 + sl)$ and 'sl' are inversely proposnal to each other. This encourages us to increase the size of an interlude as sl increases.

Hence, we want to implement an algorithm that optimally divides the Kl intervals within $[0, s \max l]$. By "optimally", we refer to finding the minimum Kl such that the maximum approximation error of each line segment is no more than.

Denote $m(k)l$ as the slope of the k -th linear segment^{7,20}, i.e.,

$$M(k) = \ln(1 + sl(k)) - \ln(1 + sl(k-1)) \quad (11)$$

The values of $m(k)l$ and $s(k)l$ are calculated by using the Bisection or Newton's method in numerical method. The following diagram Figure 3 shows our linear approximation method with the least no. of linear parts to approximate $\ln(1 + sl)$ for $sl \in [0, s \max l]$, which fulfills the linear approximation error condition. We formally state these rights as lemmas which is given as, *Lemma 1*: For the piece-wise linear approximation produced the extreme approximation error of each linear part at most.

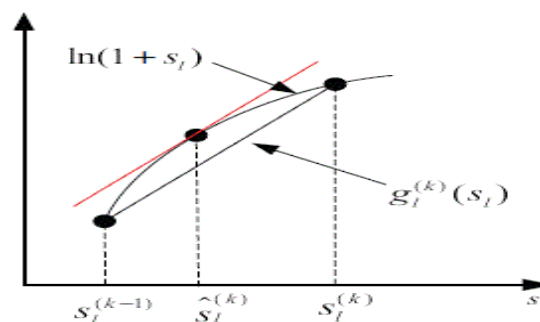


Figure 3. Maximum approximation error for the k -th linear segment.

Where $cl = Bl \log 2(1 + pl \cdot hlnBl)$. If we fix the power variable in OPT to the values $(yl, pl)^{5,10}$, then the OPT(yl, pl) becomes LP.

5. Results

We implement our approach using the PIC simulator ISIS professional, the following shows the user interface screen shots of the same. With the help of this ISIS Professional simulator we validate with different tests to show the efficiency of our method.

5.1 Before Loading the Program

It consists of PIC Microcontroller transmitter, PIC Microcontroller receiver, relay, power supply, keypad, LCD display as shown in the Figure 4. And also the switch is used as a keypad in this software¹⁵. After the construction we have to load the program in the transmitter and also the receiver. By loading their program the PIC Microcontroller starts to work.

5.2 After Loading the Program:

The LCD consists of 16x2 characters bit. It programmed up to 16 characters in 2 rows. The programs are write in embedded c language. MPLAB is used to write the program in the PIC Microcontroller. After loading the program in both the data will display on the screen as shown in the above Figure 5. Then the data will reset by manually it will ready for next data transfer.

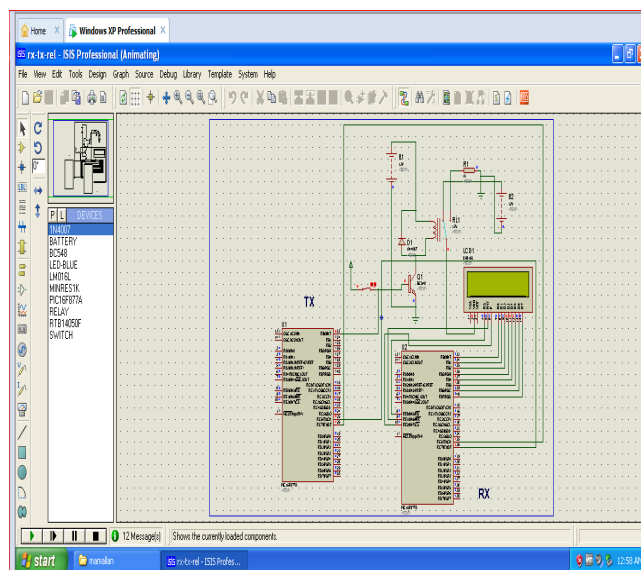


Figure 4. Before Loading

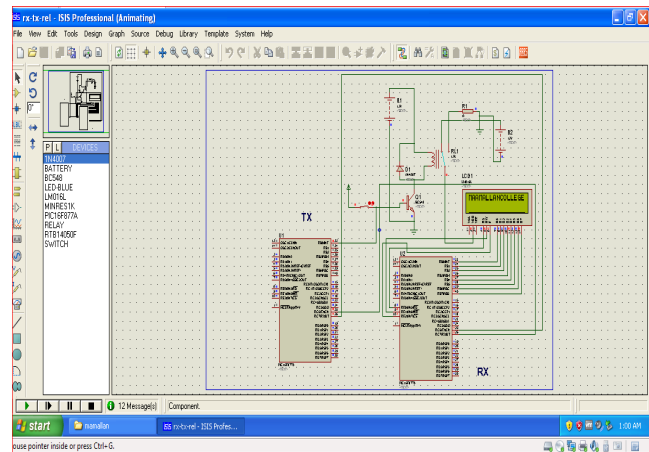


Figure 5. After Loading

6. Conclusion and Future Work

Our system consumes energy only during the energy transmission and the remaining times it is in sleep mode. In our paper we discovered different issues related to the entire network energy and it becomes very important for the people who are all working in the network. Specifically we examined the problem, way to improve network outputs along with the wide energy consumed by the whole network. In our forth coming research works the extreme throughput can be obtained by using Nano components. Even in future the Wi Fi can be applied for the data communication between nodes. In real time this can be applied in mobile nodes for saving power.

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