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LZW Based Power Control with Distribution Uncertainty in COG MAC

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ABSTRACT: Energy efficiency has been the main factor behind the design of communication protocols for battery-powered wireless sensor networks (WSNs). The energy efficiency and the performance of the protocol stacks degrades when the low powered WSNs experience interference from high power Wireless Local Area Networks(WLANs). This thesis propose Cognitive Medium Access Control(COG-MAC) scheme for IEEE 802.15.4-compliant WSNs and enhancement of COG-MAC in terms of LZW(Lampel Ziv Welch) based power control with channel uncertainty. LZW based power control with distribution uncertainty in COG-MAC is a novel cognitive medium access control scheme for WSNs that minimizes the energy cost for multihop communications by deriving energy optimal packet lengths and one hop transmission distances based on the experienced interference from IEEE 802.11 WLANs. This technique can model the uncertain channel gain to be a random variable following a state-dependent distribution function and then propose a power control mechanism that is robust against the channel uncertainty. The advantages of this technique are the improvement of QOS parameters, energy efficiency, lifetime and reduce the packet loss rate and transmission delay.

KEYWORDS:COG-MAC, Power Control Techniques,WSN, Energy Efficiency, Cognitive Networks,Coexistence, IEEE 802.11, IEEE 802.15.4, LZW.

I.INTRODUCTION

Interest in wireless technology has experienced large growth over the past decade. Increasing number of different wireless technologies sharing the 2.4GHz ISM band, which demands the rethinking of the protocols regulating the spectrum access. Since Medium Access Control (MAC) protocols are designed for one given technology, they are not able to achieve the efficient and "fair" sharing of the wireless resources when operating under interference from heterogeneous technologies.

This paper consider the specific case of the coexistence of IEEE 802.11 wireless local area networks (WLANs) and IEEE 802.15.4-based wireless sensor networks (WSNs). WSNs try to locate the narrow frequency band with less harmful interference for their operations. But these techniques do not avoid high interference and packet losses in the WSN, which are mainly caused due to different transmission bandwidths and powers of the two technologies competing for the same resource. WLAN terminals operate in a relatively broad channel and at a higher transmission power than WSNs. Therefore they do not detect the narrow-band, low-powered WSN transmissions and do not defer channel access due to the overlapping WSN packet transmission. As a result WLAN transmissions remain unaffected by the low WSN interference, while WSN packets are lost. Different measurement results show that WLAN traffic is bursty with long white spaces when the channel is idle .Therefore, in order to maximize the performance of WSN it should transmit in these long interference-free times.

This paper propose and evaluate a new power controlled COGnitive MAC (COG-MAC) protocol for wireless sensor networks that is robust against the uncertainty in the transmission channel. The main aim of this technique is to minimize the energy loss due to unsuccessful transmissions over the interfered channel. The main contributions of this work are 1) It gives the characterization of the WLAN channel usage patterns as seen by the sensor nodes and considering the nodes' limited channel estimation capabilities. 2) Based on the resulting WLAN channel usage characterization LZW based power controlled COG-MAC is designed that is robust against the channel uncertainty and it optimizes the packet length and the transmission distance, and performs WLAN activity-aware channel access to

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ensure that WSN nodes transmit in the long WLAN white space periods. 3) This shows that all the basic components of LZW based power controlled COG-MAC essential for achieving the objective of energy efficient communication, andit is compared to previous access schemes such as COG MAC without LZW compression. The result shows that LZW based power controlled COG MAC reduces the normalized energy cost and can significantly decrease the end-to-end energy cost in a multihop WSN without increased delay.

II.SYSTEM FRAMEWORK

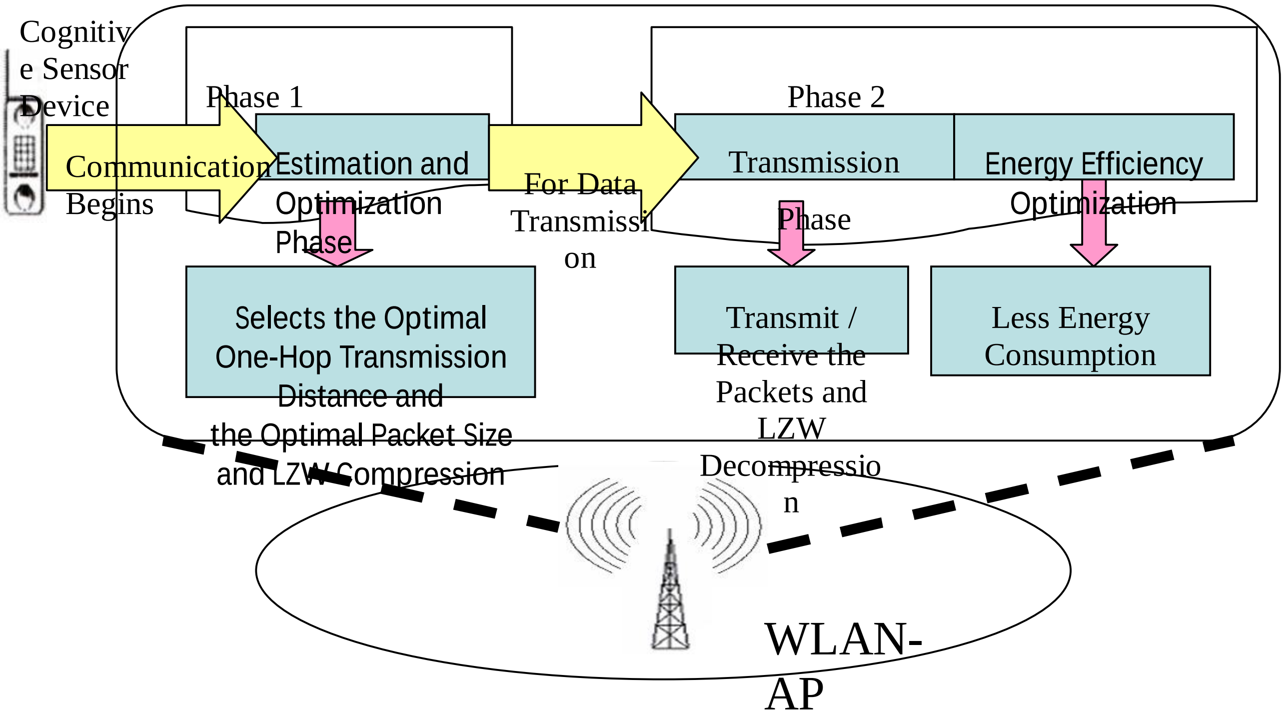

Fig 1: Frame Work of LZW based Power Control with Distribution Uncertainty in COG MAC

LZW based power control with distribution uncertainty in COG-MAC is a novel cognitive medium access control scheme (MAC) for IEEE 802.15.4-compliant WSNs that minimizes the energy cost for multihop communications by deriving energy-optimal packet lengths and one-hop transmission distances based on the experienced interference from WLANs. WSN COGnitive Medium Access Control (COG-MAC) employs WLAN usage prediction and channel sensing so it will minimize the energy cost for unicast WSN communication under WLAN interference. It aims at minimizing the transmission energy spent by sensors for transmitting and receiving data packets. LZW based power control with distribution uncertainty in COG-MAC can be combined with some duty-cycling or wake-up enabled solution that is responsible for minimizingthe energy spent due to idle listening. Therefore the design of this technique does not considerthe idle listening energy costs.

In LZW based power control with distribution uncertainty in COG MAC the operation is divided into two main phases. The first one is the estimation andoptimization phase. During this phase a sensor listens to the channel and gathers samples of theactive and idle times, estimates the Local View parameters and selects the optimal one-hop transmission distance and the optimal packet size. Then by using LZW compression algorithm the data packets are compressed. The second one is the transmission phase, where the sensor transmits and receives data packets. When a packet receives to the receiver node, LZW decompression algorithm is used to decompress the packet to original size.The sensor moves back to the first phase either periodically or when it experiences a performance drop, suggesting that the estimated WLAN activity parameters are not valid.

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III.ESTIMATION AND OPTIMIZATION

During the estimation phase the transmitter (TR) and receiver (RR) sensors listen to the channel and gather active and idle times for estimating the WLAN channel activity. This is shown in figure below.

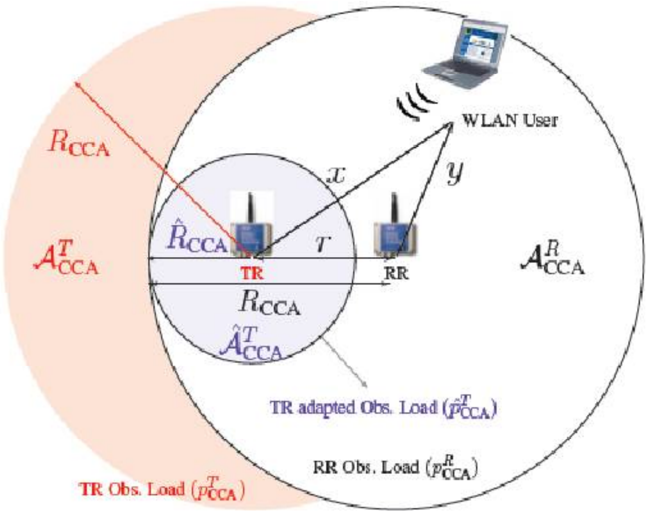

Fig 2: TR and RR CCA Areas and the Adapted CCA Area

They perform the measurements for the maximized Clear Channel Assessment (CCA) area A_{CCA} (denoted by A^T_{CCA} and A^R_{CCA}, CCA for TR and RR respectively) by using the maximum sensitivity level ψ_0, which leads $R_{CCA} = R_{CCA}(\psi_0)$. Based on these measurements they derive the Local View parameters. Based on this local view parameters it finds the optimal packet length. Then by using LZW compression it compress the data packets. At the receiver node it uses the LZW decompression algorithm to decompress the data.

LZW Compression

w := NIL;
while (there is input) {
K := next symbol from input;
if (wK exists in the dictionary) {
w := wK;
} else {
output (index(w));
add wK to the dictionary;
w := k;
}
}

The LZW compression algorithm generates a string translation table from the text being compressed. The string translation table maps fixed-length codes (usually 12-bit) to strings. The string translation table is initialized with all single-character strings. The compressor serially examines the text and it stores every unique two-character string into the table as a code/character concatenation with the code mapping to the corresponding first character. As each two-character string is stored, the first character is sent out. Whenever a previously encountered string is read from the input

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such previously encountered string is determined and then the code for this string concatenated with the extension character (the next character in the input) is stored in the table. The code for this previously encountered string is sent out and the extension character is used as the beginning of the next string.

IV.TRANSMISSION

Estimation and optimization phase is followed by the transmission phase when actual network operation occurs. We assume that the WSN operates under a duty-cycling or wakeup radio based protocol to limit the energy that is spent during idle listening. In the case of duty-cycling WSN nodes are synchronized. Synchronization gaps are expected as a result of CPU clock drift. Their maximum value $t_{SYNC}^{\max}$ is determined by the frequency of synchronization data exchange.

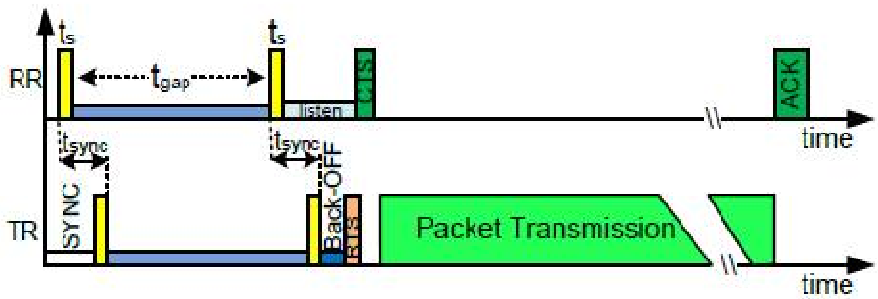

Fig 3: Time Diagram of Transmission Operations.

Fig 3 shows the COG-MAC operation within a duty-cycle for potential transmitters (TR) and receivers (RR). The duty cycle of the TR nodes starts with a guard time (denoted as SYNC in the Figure) equal to $t_{SYNC}^{\max}$ ensuring that channel sensing and transmission do not overlap due to the lack of perfect synchronization. The medium access control is a modified COG MAC with the key component of dual channel sensing. In Fig the on time of the receiver duty cycle begins with two short channel sensing measurements with a duration of t_s separated by a time gap of t_{gap}, where $\alpha_{ON} \geq t_{gap} \geq \alpha_{BK}$. The sensors RF circuit can be powered-off between the short channel measurements. If the channel state is correctly detected as idle at both measurements the sensors can safely assume that the spectrum was idle in the entire time and characterize the idle period as a white space. The operation in the rest of the cycle is determined by the sensing result. If any of the measurements have indicated an active state the sensor immediately transitsto sleep mode to save energy. After receiving the data packet the receiver node use the LZW decompression algorithm to decompress the data.

LZW Decompression Algorithm

```
read a character k;
output k;
w = k;
while ( read a character k )
/* k could be a character or a code. */
{
entry = dictionary entry for k;
output entry;
add w + entry[0] to dictionary;
w = entry;
}
```

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The decompression algorithm uses the stream of codes output from the compression algorithm and use them to exactly recreate the input stream.LZW algorithm is more efficient because it does not need to send the string table to the decompressioncode. The string table can be built exactly as it was during compression by using the input streamas data. This is possible because the compression algorithm outputs the STRING and CHARACTER components of a code before it uses it in the output stream. This means that the compressed data is not burdened with carrying a large string translation table.

V. RESULT AND DISCUSSION

In the fig 4, it shows the graph of time Vs delay of receiving packet.The delay of a network specifies how long ittakes for a bit of data to travel across the network from one node to another. Here thedelay is measured in fractions of seconds. The graph shows the delay of the system withLZW compression and without LZW compression. In COG MAC it first estimates the WLAN channel activity pattern and find the interference free channel and a one hop transmission distance, this will minimize the packet loss rate and delay. Therefore by using LZW based COG MAC thedelay becomes less and constant after a particular time interval.

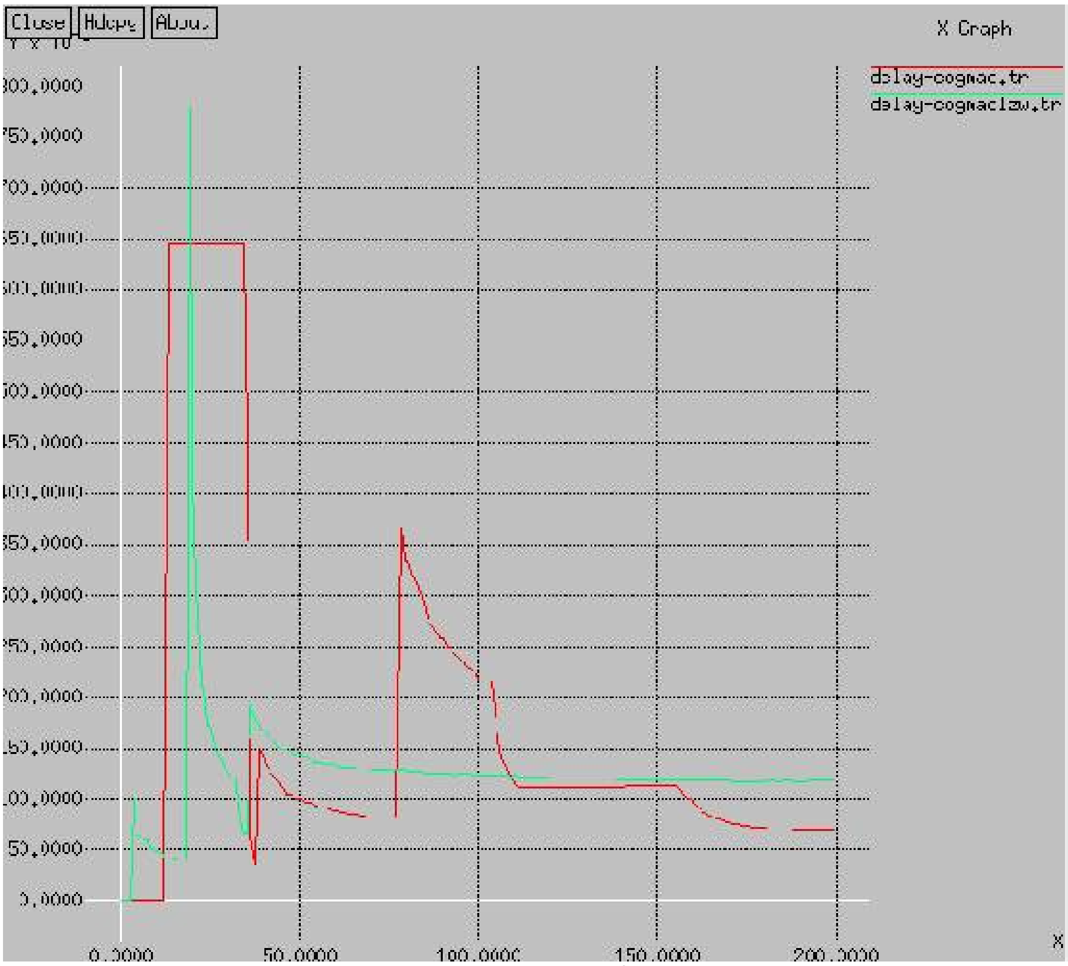

Fig. 4: Simulation time Vs delay of receiving packets

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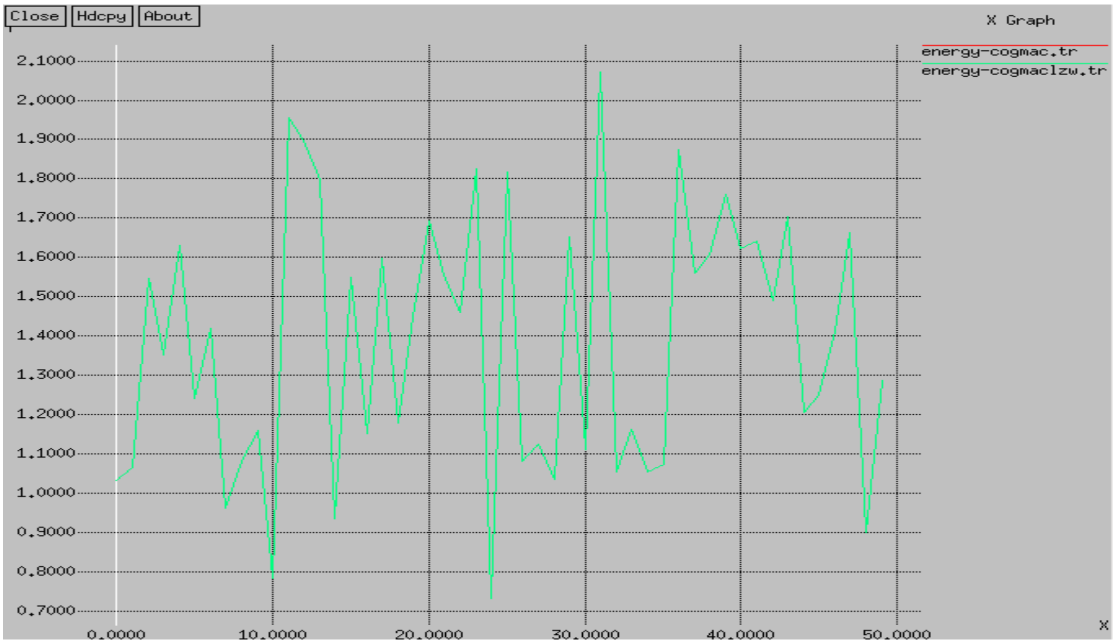

Fig. 5: Simulation time Vs energy of COG-MAC

In the fig 5, it shows the graph of energy Vs simulation time of COG-MAC with and without LZW compression. The LZW based COG MAC will increase the energy efficiency because in estimation and optimization phase it calculate the idle and active time of WLAN and calculate a one hop transmission distance for packet transmission. Then by using LZW compression the packets are resized, hence more number of information can be transmitted at available idle time. By using this it will minimize the packet loss rate due collision of packets and the packet retransmission. This will increase the energy efficiency of the COG MAC.

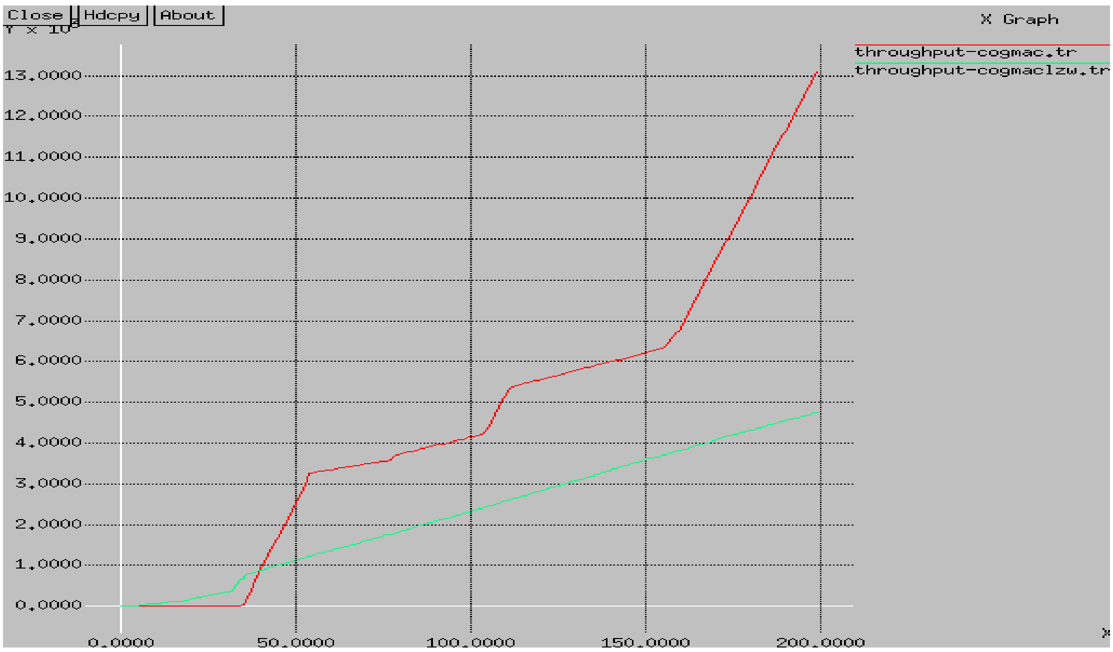

Fig 6: Throughput of sending bits Vs simulation time

In the fig 6, it shows the graph of throughput of received bits Vs simulation time. Throughput is the rate of production or the rate at which something can be processed. The data these messages belong to may be delivered over a physical or logical link, or it can pass through a certain network node. In LZW based COG MAC by using LZW compression the energy efficiency can achieved with smaller throughput.

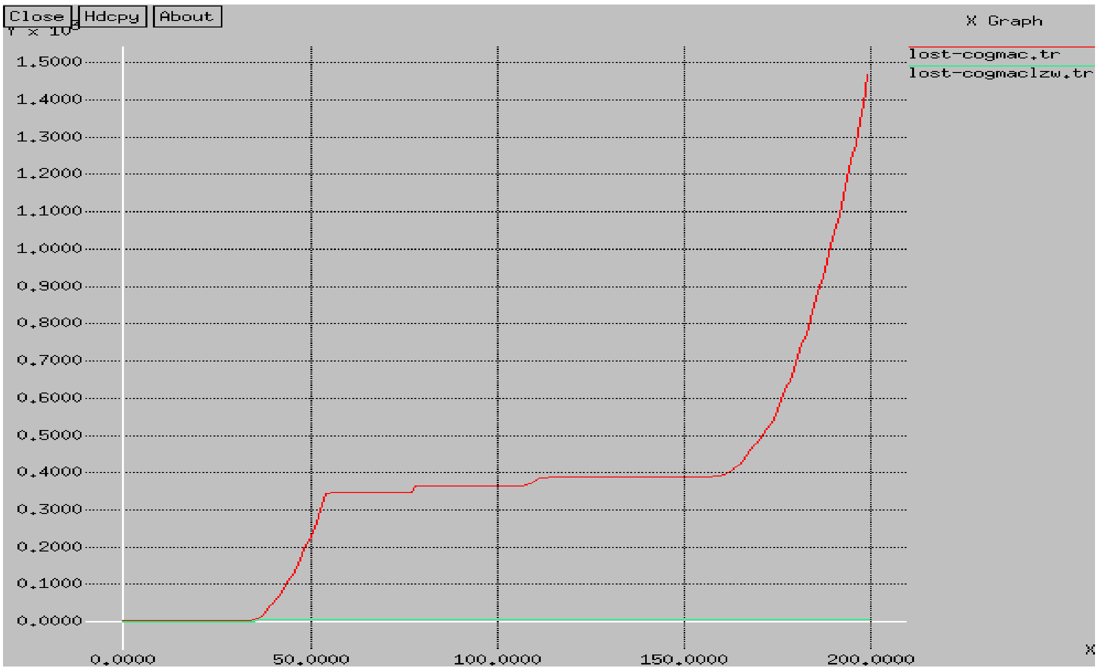

Fig 7: Loss rate Vs simulation time

In the fig 7, it shows the graph of packet loss of COG-MAC Vs simulation time.Packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. Packet loss is typically caused by network congestion. In COG MAC the network congestion can be minimized by sing estimation and optimization phase. Graph shows the comparison of loss rate of the robust power controlled COG MAC with LZW compression and COG-MAC without LZW compression. By using LZW compression the packet loss rate becomes negligible.

VI.CONCLUSION

LZW based power control with distribution uncertainty in COG MAC is a cognitive MACscheme for energy efficient WSN operation under WLANco-existence. The energy efficiency will degrade when the low power WSNs experienceinterference from high-power wireless systems such as WLANs.Energycost minimization is achieved by optimizing the WSN packet length and single hop transmission distance based on theestimated parameters of the WLAN channel usage model then a power control technique such as LZW compression algorithm is used for resizing the packets. It minimizing the energy loss due to unsuccessful transmissionsover the interfered channel.The numerical evaluation shows that LZW base power controlled COG-MAC outperforms other MAC protocols especially in the caseof severe WLAN interference. The main advantages are it improves the energy efficiency, minimizes the packet transmission delay and packet loss rate etc.

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