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A Rate adaptation algorithm for IEEE802.11 wireless networks for commercial applications

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ABSTRACT

The industrial communication systems, the performances of IEEE802.11 are essential. In which the actions of IEEE802.11 wireless LANs are attracted by the characteristics of the wireless channels which reflects the Signal-to-interference-Noise Ratio. Since the y operate in harsh environments of the Industries. If the modulation techniques are adopted at lower data rate and they are considered to be as robust full so IEEE802.11 WLAN specifications are must to adapt with the transmission rate. But these standards are not defining any rate adaptation techniques and they are submitting the adjustment of transmission rate to the device holder's choice. This paper is mainly focusing on the Rate Adaptation technique for the Communication systems on the industries wish is always facing high reliability and other timer requirements. Here we are comparing the performance of this Rate Adaptation technique with the traditional Auto Rate Fall-back mechanism with set of special experiments.

KEYWORDS: IEEE 802.11, SNR ratio, Auto fall-back, Wireless LAN, Automation systems, Rate Adaptation, RBAR, CARA.

1. INTRODUCTION

The various applications of IEEE802.11 Wireless Local Area Networks (LANs) (IEEE 802.11) in industrial applications are very high due to many of its inbuilt functions. In industrial applications, IEEE802.11 be considered as the extension of Ethernet standards (Cena, 2008). So IEEE802.11 is widely used in industries for implementing wireless extensions in the already 802.11 ad hoc networks are also having various configurations for Industrial application facilities (Cena, 2010).

As for long time, the traffic and complexities in communication of the industries are believed to be as from the communication services and also lowest factory automation systems. Because of the problem of little amount of data are shared between the controller equipment and the sensor equipment. So this type of traffic is blindly referred to be as Industrial traditional traffic. Currently multimedia applications like Video Intrusion control, Image processing (Sempere, 2003) are considered to be as the industrial automation systems. So these applications lead to a great traffic in the network and this traffic is called as Traffic in Industrial Multimedia. In the wireless network, low packet transmission success probabilities are considered to be the critical problem which always results in unsatisfied reliability. For facing this problem, the IEEE802.11g standard makes use of various transmission rates available from the lowest 6Mbps to high 54Mbps data rate. Multi rate support is a mechanism followed by the IEEE802.11 environment for performing dynamic rate switching mainly for improving the performance of the network (Qiao, 2002), (Heiskala, 2011) and (Gamba and Vitturi, 2010). But this standard is not specifying any rate adaptation technique and it was completely on the manufactures wish. In the literature review, there are various rate adaptation mechanisms were explained. Normally the rate adaptation techniques were fall under two categories.

So in the first category, they are checking the history of the previous transmissions and on that way the rate will set. Examples of the rate adaptation technique based on this category is Auto Rate fall back (ARF) and Adaptive Auto Rate fall-back (AARF) (Xi Y, 2006) and (Kulkarni and Quadri, 2009). But the second category of adaptation is selecting the rate of transmission is based on the SNR level of the receiver during exchange of control functions. Examples of this category are Receiver-Based Auto Rate (RBAR) (Holland, 2001) and Chance Based Auto Rate (CBAR) and the Collision Aware Rate Adaptation (CARA) (Sadeghi, 2002) and (Kim, 2006). But this technique needs two added control frames for performing rate selection technique. So this is not suitable for industrial communications due to the channel conditions. But in industrial applications, the first category adaptation techniques are accepted by people but there is lack of dynamic rate switching is an issue here. But Auto Rate fall back techniques are mainly utilized for various applications for the industrial communication systems in different ways.

Here we are focusing a Rate Adaptation technique of the IEEE 802.11 networks mounted on the usage of Industrial link communication systems. At first we are comparing the performance of the Auto Rate fall back technique with the Rate Adaptation (Hong, 2009) and (Seno, 2011) techniques of two available access points mounted on an IEEE802.11 network. This comparison will be done using Markov chain model (Lo Bello and Toscano, 2009) of the fall-back technique and its prototype implementation. Here we proposed new Rate Adaptation techniques for Industrial network systems and their behavior can be studied by its simulations and the results.

Industrial wireless channel models: In the telecommunications and the computer networking, a wireless communication channel is generally referred to be as the physical transmission medium like cables in a wired network or to a logical connection like radio channel. A communication channel is used to convey information or signals in a digital bit stream. Generally a wireless communication channel is subjected to various phenomena like loss of path, fading of signals, propagation of multiple paths, Signal to Interference Noise etc. As highly said, in industrial environments they are highly affected with harsh environmental conditions. So these conditions make the degradation of the received signals and incorrect and dropped reception of messages in the destination.

On taking account of IEEE 802.11g, the measure of success rate of transmission probability is having a very narrow SNR range of threshold value ranging from (1-2 DB), which lies between the value zero and one. Where beginning with a state that is having successful transmissions with a state that is having successful transmissions with a high probability and a mild decrease in the SNR will takes the probability to zero or very less unless the reduction of the transmission rates.

Table.1.IEEE802.11g Parameters

Description	Value
Transition rates	6, 12, 24, 36, 54 Mbps
Distributed Inter Frame Space (DIFS)	28 µs
Short Inter Frame Space (SIFS)	10 µs
Slot Time	9 µs
Maximum number of retransmissions	7
Payload size	46 Bytes

The probability to zero or very less unless the reduction of the transmission rates. This feature is mentioned clearly for the presence of the two state channels because of indulgence of bad state overlaps with the quick reduction of the Signal to Noise ratio. In order to adopt with possible successful transmission rate many of the Rate Adaptation techniques will reduces its rate of transmission.

With considering both the above cases, the first case is referred to be as a Static channel and it was having a constant signal to noise ratio (SNR). This static channel consideration is useful in analyzing the Rate Adaptation techniques in the steady state conditions. The second case is said to be as the dynamic channel condition and this gives the alarm about the error robustness. Here the Signal to Noise Ratio will be switches from high level to low level value by selecting the best Adaptation technique to adapt transmission rate for the sudden difference in SNR.

2. EXPERIMENTAL SETUP

The hybrid network model is shown in the figure is clearly saying the behavior of the Rate Adaptation techniques. This hybrid network consisting of two stations come in connected with various segments like on Ethernet and the IEEE802.11g standards interconnected with an Access Point. For getting best results, the network has been implemented by mounting both stations on the same PC. So an application was allowed to send the data packets from one station to the other station with the selected time. ARF Signal Generator was maintained as a main source of AWGN noise. In this case analysis was done to calculate the total latency in the experimental procedure for accurate results.

To accurately find the behavior of the Rate Adaptation method for the wireless communication devices explained in the experimental setup, the Access Point is considered because it is a type configuration tool of the manufacturer. With the help of this tool there is possibility executing some actions on the Access Points such a select/deselect multi hop networking support and disable and enabling multimedia functions. The applications can be used to send and receive data frames from the wired stations to the wireless stations. During the experimental time there are two various industrially available Access points were considered which shows the component used in the experimental setup. The wireless station was known to be as an IEEE802.11g network standard in which segments are adopting the Distributed Coordination Function (DCF) to access to the physical state.

ARF (Auto Rate Fallback): ARF was a rate adaptation algorithm for improving the performance of Local Area Network devices with the transmission rates 1 Mbps, 2Mbps but it is effective up to 10 Mbps. In ARF specification the supported transmission rate was given as, $TR = \{tr_{1,} \, tr_{2,} \, \dots \dots tr_q \}$, here a station will reduces its transmission rate from r_j to r_{j-1}. After a lot of t of consecutive failed transmissions. Then the station increases its transmission rate from r_j to r_{j+1} after various successful consecutive transmissions of the network. Here after the transmission rate increased and if any transmission attempt fails after that, then the base station will rolling back to the original rate of transmission and quits the transmission. ARF added another one best feature that is the timer concept. In timer function once station decreases transmission rate then timer get expired and give way to the station to go to a higher transmission rate after many successful consecutive transmissions not followed.

Requirements of wireless industrial communications: In the scientific literature there are many studies about the various traditional industrial communication systems as well as its performance. These systems are mainly go with the accurate transmission of messages that carries small amount of data that shows the functionality of networks that operate at the lower stages of the Automation systems of the industries. Generally these techniques are forced to give an adequate scheduling of messages by keeping their value of delay below a maximum threshold value. Here the real -time capabilities are also mentioned correctly. When we consider the multimedia traffic of the factory, special requirements are taken in account with the capability of providing an adequate quality of service (QOS) parameters. This results in concerned deadlines to compete with the communication systems. The usage of wireless network systems for giving support to the certain type of industrial traffic needs some extremely careful investigations, because of the error nature of the medium of transmission. As addressed by several contributions (see for example and the references therein for a complete description of this scenario).In order to control collisions while getting the physical medium, wireless factory communication systems which works under the time-division multiple access (TDMA) techniques that requires all of the stations with an correctly ordered access to the network. Such a strategy ensures that there is no collisions between stations transmit can occur. Consequently, the most common cause of delay and error for industrial wireless networks is given by phenomena like fading, path loss, and interference from external communication systems that cause packet corruption. This is particularly negative for the traditional industrial traffic, since the limited payloads of the packets make their transmission times lower than (or, at least, comparable with) the duration of the back off intervals that have to be waits in between an attempt of transmission and following one corrupted data packet, which results in real transmission times which was relatively greater than the lower ones, which possibly compromises the satisfaction of both the real-time requirements. Thus, an accurate performance indicator of wireless networks for factory applications is presented by the number of various transmission attempts needed by a data packet. Such kind of indicator has a serious impact on a further feature is the service time, which is denoted as the time needed to complete a packet transmission that includes the reception of the ACK frames, as evaluated in for IEEE 802.11 networks and, more often for industrial applications as described in. The service time is a fundamental performance index for factory communication systems which is used as a basic for the calculation of various other indicators such as the minimum cycle time and some of those defined by the IEC 61784 International Standard, which are the delivery time and the throughput real time as shown. These indicators are actually been used for real-time Ethernet networks, and now they can be extended to all types of industrial communication networks. As a common point, it is mainly used both the number of transmission trials and the service time as meaningful performance indicators of the rate adaptation techniques adopted by IEEE 802.11, as we will show in the next sections.

Proposed rate adaptation techniques: In this section we two alternative RA techniques were proposed here. Both techniques are analyzed with its numerical results base on their performance. Here both of these Rate Adaptation techniques represent the two different ARF techniques specially structured to face the most critical requirements of the Factory communications. These techniques have a high range of flexibility and simplicity, which shows limited efforts are needed to get to the practical and theoretical implementation. In the two methods of ARF variations, the first one is said to be as Static Rate of Retransmission ARF (SARF) and another one is Fast Rate Reduction ARF (FARF). SARF that performs just like ARF performance and the difference is it is limiting the attempts of number of transmissions and the retransmission can be carried at a low rate of 6 Mbps with a high success probability. Here the Successful retransmission of a data packet is not considered as a feature that resets the number of continuous failures. After two continuous unsuccessful transmissions at the transmission rate interleaved by successful retransmissions at 6 Mbps rate, the SARF chooses the data rate for transmission of the next data packet. The second technique FARF is said to be as a modified version ARF as this technique selects the next transmission rate of 6 Mbps if any failure of transmission occurs.

3. RESULTS AND DISCUSSION

Analysis of SARF and FARF for traditional traffic: Figure 1, 2 and 3 shows the performance of the two techniques in the selected transmission rate for the static channel in the occurrence of the traditional industrial traffic for the first technique SARF and next figure shows for FARF. In the evaluation it is noticed clearly that both the techniques SARF and FARF may have the feature of getting almost two attempts of transmission to deliver a data packet. This is because each transmission is taken place at 6 Mbps. These two techniques are also giving high improvement in service time. In the dynamic channel, the changes in the transmission rate are shown at the time of noise burst shown. In the figures the burst of error will show after 10mins of simulation of transmission. These two techniques perform better than the traditional ARF technique. Here the packets transmit at the rate of 6Mbps and also it does not need more than one retransmission for delivering correctly. In the case of retransmission strategy FARF performs better than SARF in some certain situations. At the time of error burst, FARF immediately reaches to the rate of 6Mbps and SARF need to pass through various rates to find the correct transmission rates.

Analysis of SARF and FARF for Different traffic profiles: For studying about the proposed Rate Adaptation technique with various parameters, the analysis of their behavior for various applications that shows the transmission of data packets with a high payload measurement. This scenario suits correctly for the multimedia traffic in the industries where each data packet has to carry a more complex file. This type of data packets are mainly used at high levels of the distributed automation system's where similar amount of information has to be exchanged in the environment. In the first section the simulation was executed in a static channel using the previous session parameters and with a payload size of 500 bytes. The simulation results show that the performance of SARF and FARF is better than the traditional ARF mechanism. But evaluation of service time gives better value for ARF than the other two Rate Adaptation techniques.

Here for the payloads the variations between the times of transmissions are 54 Mbps and 6 Mbps and the back off procedure have drawback on the service time. This is because the transmission time of packets are said to be higher than the jitter established by the back off timer intervals. In this condition the strategy has given by Static ARF and Fast reduction ARF which they retransmit at 6 Mbps which not only effective channel. Here it leads to a higher value for mean the standard deviation of the service time given by the ARF even the other Ra techniques have lower retransmission attempts. When a dynamic channel is considered the structure will completely change. The statistics of both techniques service time will be given in the table given. This table shows clearly the performance of both Rate Adaptation techniques performed well than in the ARF. Since the higher number of transmission attempts employed by this latter technique to reach the final transmission rate when a noise burst occurs becomes prominent in determining the service time. Such a relevant number of retransmissions, particularly, have a strong negative effect on the standard deviation that results very high accounting for a considerable randomness.

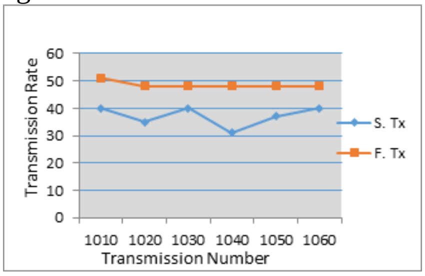

Figure.1.Transmission rate behavior of SARF technique in Static channel

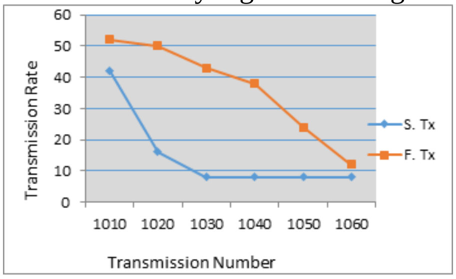

Fig.3.Transmission rate behavior of SARF technique in Dynamic channel

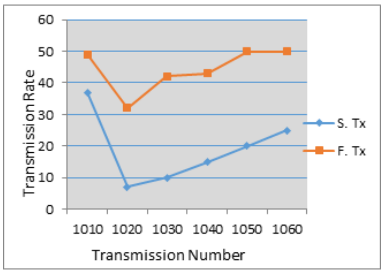

Figure.2.Transmission rate behavior of FARF technique in Static channel

4. CONCLUSION AND FUTURE WORK

Traditional Rate Adaptation techniques and Auto ate fall-back techniques are not suitable for industrial applications. These are happened because of irrelevant randomness they introduce and the analysis of their service time. In this paper two Rate Adaptation techniques were proposed SARF and FARF. These Rate Adaptation techniques mainly designed for meeting the needs of the industrial commercial applications. The implementation of these techniques does not need any special changes to the existing standards. The performance analysis can be carried out through simulations and they perform much better than the traditional ARF techniques. While considering the normal traffic profile, ARF is providing better result for a static channel model and the new techniques provides better performance in the dynamic channel. As a consequence, the given results helps to get a conclusion that the two proposed Rate Adaptation techniques represent an opportunity for the multi rate transmission support of IEEE 802.11 devices designed for industrial communications. Finally, the full validation of the two techniques may be obtained by means of practical experiments in clear. The future activities are represented by the actual implementation of both the SARF and FARF techniques on IEEE 802.11 devices.

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