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Influence of data burst collision on transmission of AWS data through satellite

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सार – स्वचालित मौसम केंद्र (ए.डब्ल्यू. एस.) वह प्रणाली है जिसमें सवेदकों के साथ उस क्षेत्र की उप प्रणाली और संचार उपकरण सम्बद्ध रूप से कार्य करते हैं जो स्वचालित रूप से और लगातार सही समयानुसार उस स्थान की मौसम की स्थितियों की माप करते हैं तथा मौसम विज्ञान के मापदण्डों के अनुसार घंटावार लिए गए प्रेक्षणों को केंद्र से जुड़े उपग्रह के द्वारा केंद्रीय स्टेशन को तीन बार स्वयं निर्धारित पद्धति द्वारा अगला प्रेक्षण लेने के पूर्व 60 मिनट के अन्दर निर्धारित 10–10 मिनट के अन्तराल पर बिना किसी क्रम के आभासी संकेतों को भेजते रहते हैं । कभी कभी दो या अधिक स्वचालित मौसम केंद्रों से आँकड़े एक ही समय में संप्रेषित होने पर उनके मिश्रित हो जाने के कारण ए. डब्ल्यू. एस. के आँकड़े ठीक से प्राप्त नहीं हो पाते हैं । मुख्यतया ए. डब्ल्यू. एस. के आँकड़ों का संमिश्रण उनके संप्रेषण के समय अथवा संप्रेषण की गति संजाल में ए. डब्ल्यू. एस. की संख्या तथा ए. डब्ल्यू. एस. के आँकड़ों के संमिश्रण की मात्रा पर निर्भर करता है । इस शोध पत्र में ए. डब्ल्यू. एस. के आँकड़ों के उपग्रह के माध्यम से संप्रेषित आँकड़ों के साथ आपस में संमिश्रित हो जाने से पड़ने वाले प्रभाव के बारे में बताया गया है ।

ABSTRACT. Automatic Weather Station (AWS) is a system consisting of sensors, associated field sub-systems and communication equipment, which automatically and continuously measure real time surface weather conditions and sends three times the hourly observed meteorological parameters to the central station through satellite link in a self timed pseudo random manner in its prescribed 10 minute time slot within the next 60 minutes before the next observation takes place. Loss of AWS data is due to collision of data burst transmitted simultaneously by any two or more AWS. Generally, the collision of AWS data burst depends upon the transmission time or transmission baud rate, number of AWS in a network and total number of bits in AWS data burst. This paper describes the influence of data burst collision on transmission of AWS data through satellite.

Key words – AWS, Pseudo random burst sequence, BCH code, Data relay transponder.

1. Introduction

The increasing demands of high quality meteorological information at frequent intervals in real time mode paved the way for development of new technologies and techniques for monitoring, acquisition and logging of various meteorological parameters. One of the outcomes of such developmental modes is the concept of automatic weather observing system. After the launch of geostationary INSAT series of satellites, India Meteorological Department had installed (Datar *et al*. 1979) Automatic Weather Stations (AWS) in different parts of the country to provide real time surface meteorological data at hourly intervals using satellite communication techniques. The collection, processing and dissemination of real time meteorological data from inhabited as well as from remote and inaccessible area are of greater importance in country like India for timely disaster and cyclone warning. Automatic Weather Station are unmanned station and operate on a single maintenance free battery which is charged through solar panel. At present IMD is having a receiving earth station at Delhi and Pune to receive the AWS data from all field stations. The redundancy is employed in AWS data transmission through satellite to improve the efficiency of the data reception and to avoid the loss of data due to collision, attenuation due to rainfall and bit error rate problems. Forward error correcting code (BCH code) is used in station ID to detect and correct error in station ID. Parity bits are used in the meteorological parameters data format. Bi Phase Shift Keying (BPSK) technique is used in the AWS data burst transmission.

2. System description

The INSAT Data Collection System consists of three main systems such as

(*i*) Automatic Weather Station or Data Collection Platform

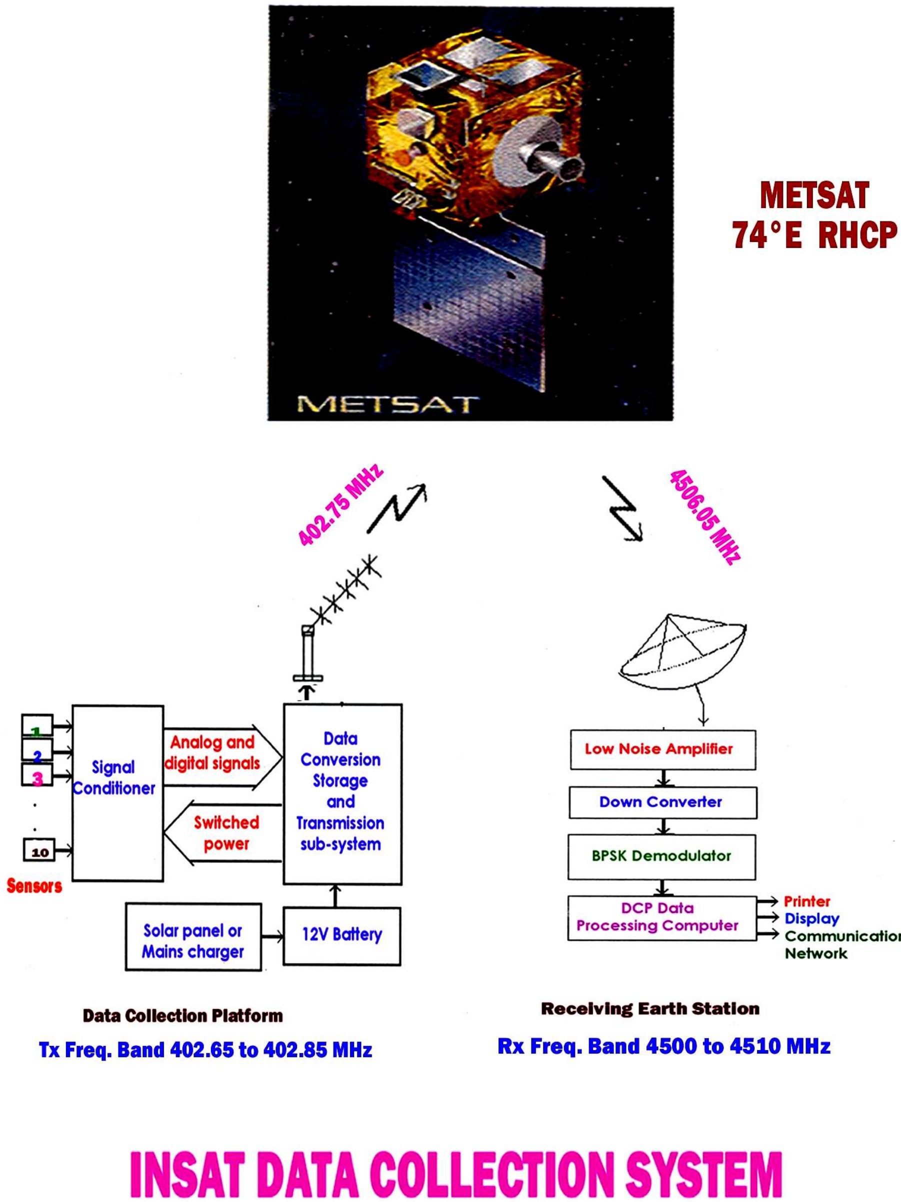

Fig.1. INSAT Data Collection System

(*ii*) Data Relay Transponder

(*iii*) Receiving Earth Station

Fig. 1 shows the complete description of the INSAT Data Collection System.

2.1. *Automatic weather station*

The AWS system employs sensors (Datar *et al*. 1983) for temperature (dry bulb, wet bulb and AWS housing), pressure, humidity, wind speed, wind direction, rainfall and duration of bright sunshine. Changes in the physical properties such as resistance/capacitance of a sensor which varies linearly with change in meteorological parameters form the basis of observation.

The AWS system (Madan *et al*. 1995) controls the entire operation of an AWS field station. It consists of power supply regulator, timing generator, control logic circuit, multiplexer-cum-A/D converter, health monitor circuit, memory, pseudo-random burst sequence

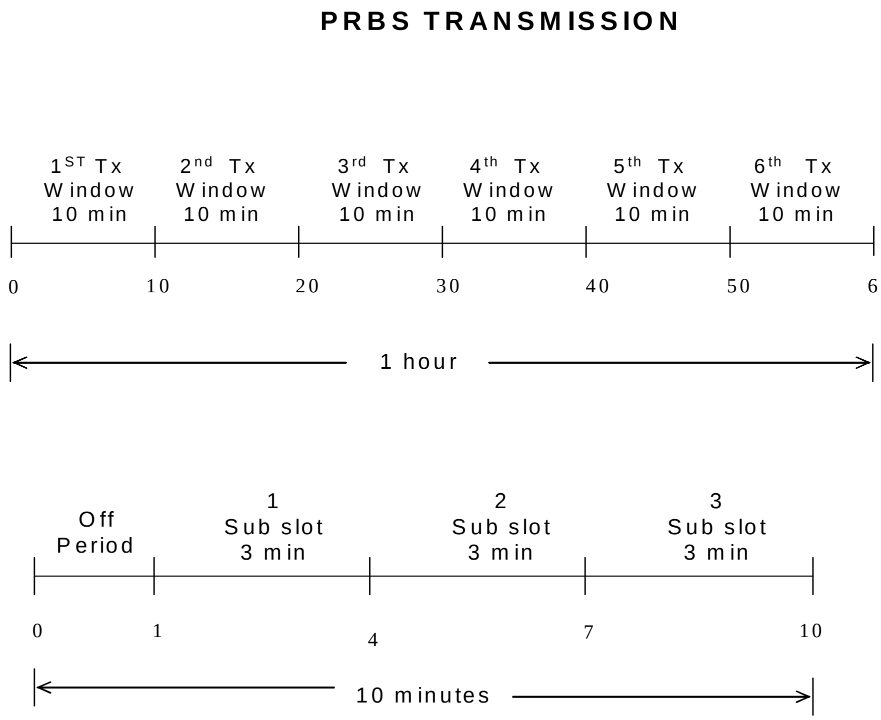

Fig. 2. Pseudo Random Burst Sequence Transmission

generator and a UHF transmitter. It operates on single +12V maintenance free battery charged through solar panel. The hourly sequence of operations performed by AWS system is as given below :

(*i*) Provides switched power to powered sensors during measurement and takes observation at hourly interval or any defined interval.

(*ii*) Converts the sensor physical property data to meteorological parameter and stores in memory.

(*iii*) Generates (Mishra and Srivastava, 1982) one pseudo random burst command in each three minutes 3 sub slot during the allotted ten minutes transmission window of a particular AWS to enable the random transmission of stored data three times. These data along with station identification code, start and end signals are transmitted to INSAT / METSAT (KALPANA-1) at carrier frequency 402.75 MHz @4800 bits/second. The length of the message is 422 bits.

2.2. *Data relay transponder*

The DRT onboard INSAT/METSAT (KALPANA-1) satellites receives the data bursts at 402.75 MHz from the AWS, down converts to 28 MHz, filters and up converts to the down link frequency of 4506.05 MHz (for METSAT), amplifies and transmits towards the Earth.

2.3. *Receiving earth station*

The AWS data transmitted by the satellite are received and processed at IMD's Earth station at New Delhi and Pune. The processing involves down conversion, demodulation, and checking the incoming message for correct format, the best of the 3 incoming messages from each AWS hourly transmission is selected which is then processed and converted to engineering units. The data in engineering units is suitably formatted and converted to WMO format for dissemination to user agencies through the communication computer at India Meteorological Department.

3. AWS data transmission and collision

Pre-assigned access systems work best when relatively constant amounts of traffic are being passed between a small number of stations. Demand access becomes more attractive when a network must carry traffic whose volume, origins, and destinations are highly variable. Demand access requires an overhead investment

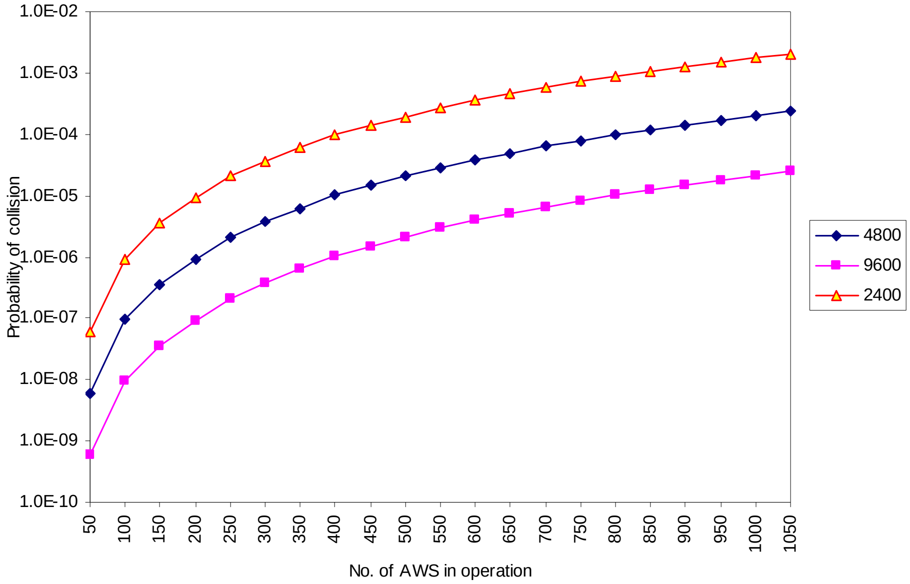

Fig. 3. Collision of AWS data burst

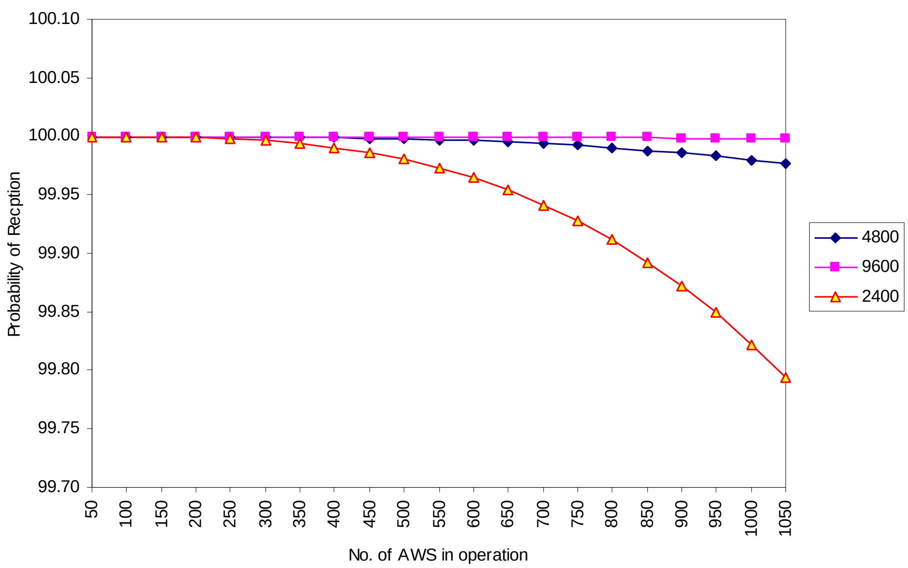

Fig. 4. Reception performance of AWS data burst

in system control and this overhead reduces overall transponder capacity. If the traffic involved consists of short data bursts occurring at random times, then the system control overhead may be eliminated by allowing each station to transmit at will. Some transmissions will be lost to interference (Pratt and Bostian, 2000) and will have to be repeated but the overhead involved in acknowledging correct messages and repeating lost ones may be less than that which would have to be invested in a demand access scheme.

The basic analysis (Abramson, 1977) of random access scheme assumes that packets are generated by a Poisson process in which the probability of a packet

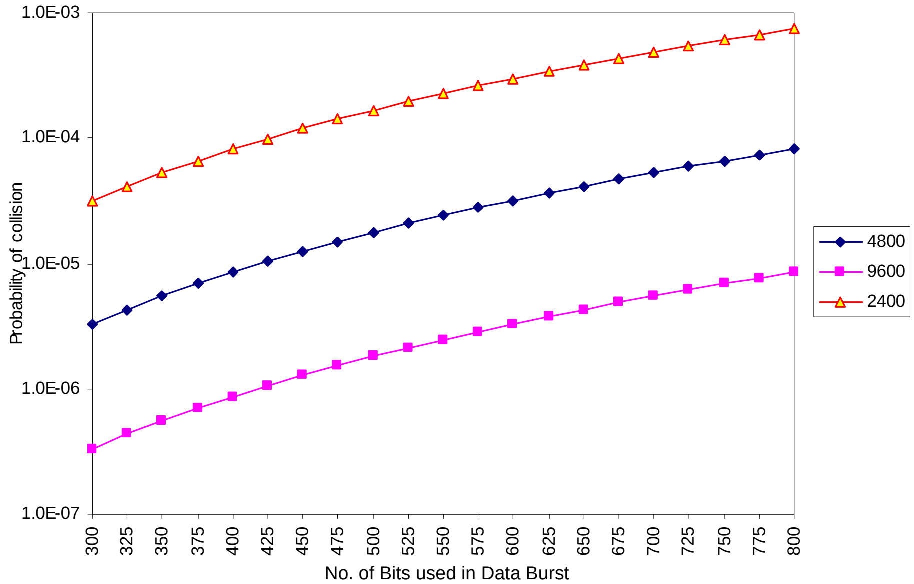

Fig. 5. Collision of AWS data burst

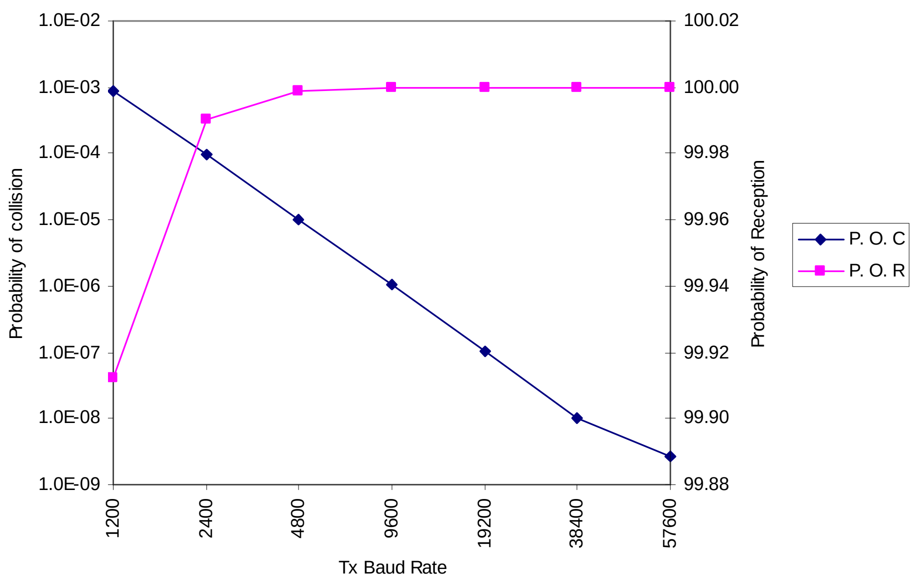

Fig. 6. Performance of 400 AWS stations

originating in time interval ΔT is proportional to ΔT. The packets all have the same length T_S, and the rate at which packets are transmitted is λ packets/second. Some packets collide and are lost. The rate at which packets are successfully received is λ' packets/second and $\lambda' < \lambda$. The normalized channel utilization G, which Martin (Martin, 1978), commending on Abramson's paper defines as the fraction of the time that the channel is used for sending original (*i.e.*, not repeated) packets is given by $G = \lambda T$ and the two rates are related by $\lambda = \lambda' e^{-2\lambda' T}$. Martin shows that the mean number of times that a packet will have to be retransmitted to overcome collision is given by $N = e^{2\lambda' T}$ and that G may be calculated from $G = \log_e(N)/(2N)$.

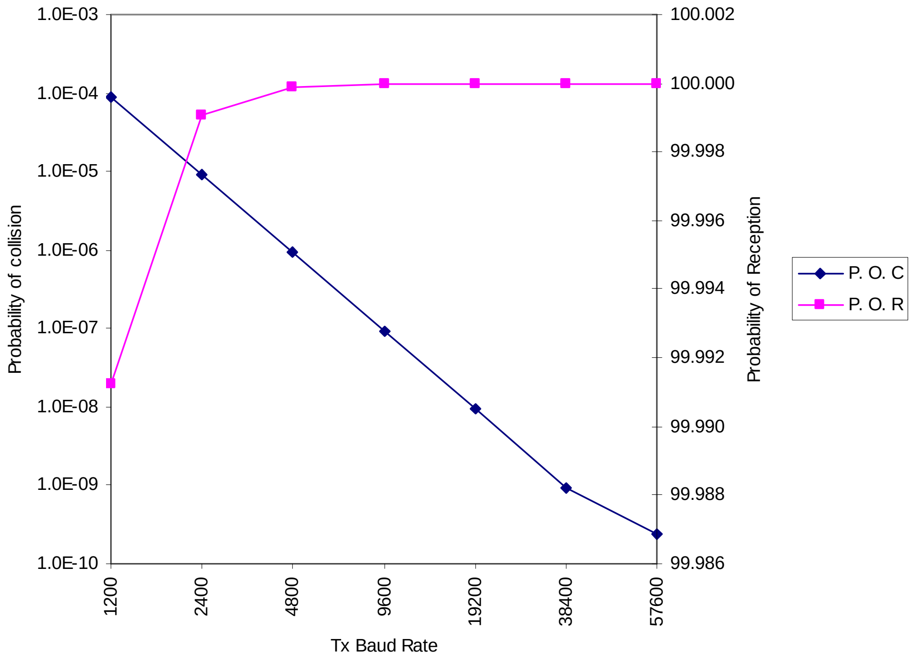

Fig. 7. Performance of 200 AWS stations

The maximum value of G is 1/2e or 0.184; this corresponds to an N of 2.7 *i.e.*, N = 3. This N = 3 is followed in AWS data burst transmissions to overcome collision of AWS messages simultaneously transmitted by two or more AWS. The likelihood of a collision during a retransmission can be reduced by having each station use a random number generator to determine the waiting period before retransmission. This decreases the probability that the same two packets will collide a second time without forcing any one station always to wait longer than the others before retransmitting.

Each AWS (Vashistha *et al.*, 2000) will automatically take the environmental observations once every hour at full hour GMT, store the observational data in its memory, and will transmit it in a self-timed pseudorandom manner in its prescribed time slots within the next 60 minutes *i.e.*, before the next observation is taken. All the AWS will be (IMD, 1988) grouped into 6 groups, each group being allotted one of the 6 available transmission windows, each of 10 minutes duration. There will be 6 transmission windows for a given hour of observation at 0-10 min., 10-20 min., 20-30 min., 30-40 min., 40-50 min., and 50-60 min., starting from full hour GMT as shown in Fig. 2. Each transmission windows will consist of 3 time slots, each of 3 minutes duration. Every AWS will transmit its hourly data in a burst of 87.9 mille seconds duration (at a data rate of 4.8 kbps) 3 times within its allotted transmission window, *i.e.*, once in each time slot in a pseudorandom mode. An hourly message from an AWS will thus be repeated 3 times in order to obviate the loss of data due to communication errors and collision of message transmitted simultaneously by any two or more AWS.

The probability of transmission failure due to collision or interference in Pseudo Random Burst Sequence (PRBS) mode of data transmission is given by

$$P_t = [1-(1-t/T)^{\{M-1\}}]^K \ [1-(1-t/T)^{M-1}]^{\{(W-KT)/T\}}$$

Where

t - duration of data transmission = 87.9 m. sec for 4.8 kbps

T - time duration of slot = 180 sec

W - time duration of transmission window = 10 minutes

M - number of AWS transmitting in slot T

K - number of transmission slots = 3 (K is integral part of W/T)

4. Simulation and results

The probability of collision of AWS data burst for different number of AWS stations are calculated for

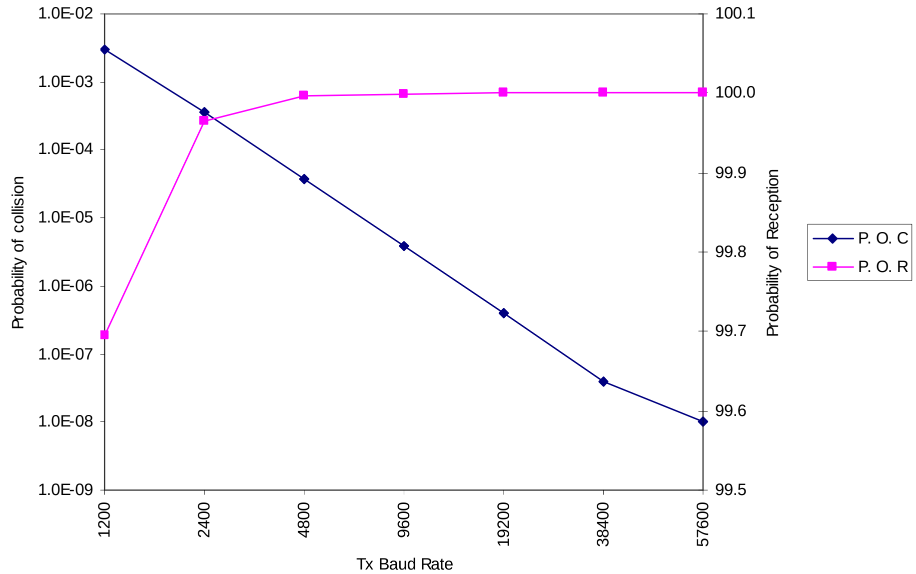

Fig. 8. Performance of 600 AWS stations

various baud rates such as 2400 bps, 4800 bps and 9600 bps *i.e*., different transmission times using MS Excel and the results are shown in Fig. 3 Collision of AWS data burst. In this graph, the relation between probability of collision and number of AWS in operation may be shown for the various baud rates such as 2400 bps, 4800 bps and 9600 bps and number of bits used in AWS data burst is 422 for all cases. It also shows that the probability of collision is increasing with the increase of number of AWS stations in operation and with the decrease of transmission baud rate.

The probability of reception of AWS data burst for different number of AWS stations are calculated for various baud rates such as 2400 bps, 4800 bps and 9600 bps *i.e*., different transmission times using MS Excel and the results are shown in Fig. 4 Reception performance of AWS data burst. In this graph, the relation between probability of reception and number of AWS in operation may be shown for the various baud rates such as 2400 bps, 4800 bps and 9600 bps and number of bits used in AWS data burst is 422 for all cases. It also shows that the probability of reception is decreasing with the increase of number of AWS stations in operation and with the decrease of transmission baud rate.

The probability of collision for different number of bits used in AWS data burst are calculated for various baud rates such as 2400 bps, 4800 bps and 9600 bps *i.e*., different transmission times using MS Excel and the results are shown in Fig. 5 Collision of AWS data burst. In this graph, the relation between probability of collision and number of bits used AWS data burst may be shown for the various baud rates such as 2400 bps, 4800 bps and 9600 bps and number of AWS in operation is 400 for all cases. It also shows that the probability of collision is increasing with the increase of number of bits used AWS data burst and with the decrease of transmission baud rate. The probability of reception and collision of AWS data for network of 400, 200 and 600 AWS stations are calculated for various baud rates such as 1200 bps, 2400 bps, 4800 bps, 9600 bps, 19200 bps, 38400 bps and 57600 bps *i.e*., different transmission times using MS Excel and the results are shown in Fig. 6, Fig. 7 and Fig. 8 Performance of 400, 200 and 600 AWS stations respectively. In this graph, the probability of collision and probability of reception is related with various standard baud rates for a AWS network of 400, 200 and 600 AWS stations and number of bits used in AWS data burst is 422 for all cases. It also shows that the probability of collision is increasing with the decrease of transmission baud rate and the probability of reception is increasing with the increase of transmission baud rate.

5. Conclusion

The collision of AWS data burst depends on mainly the number of AWS stations in operation, transmission baud rate or burst transmission time and the number of bits used in AWS message format. In this analysis, the probability of collision is increasing with the increase of number of AWS stations in operation, the number of bits in AWS message format and with the decrease of transmission baud rate. The probability of reception is decreasing with the increase of number of AWS stations in operation, the number of bits in AWS message format and with the decrease of transmission baud rate. By considering the number of bits in the message format as fixed, The number of AWS station and transmission baud rate can be chosen to achieve the best quality data with minimum data loss by fixing allowable collision rate and constant number of bits in the AWS data burst.

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