- It identifies and solves collisions due to hidden terminal problems.
- Performance degradation due to collision is reduced.
- Improves spatial reuse and diversity without consuming additional time slots.
- It increases scalability and efficiency in broadcasting.

3.1 Collision Resolution: The PHY design

We introduce a physical layer collision resolution in Chorus. When two packets collision occurs, then they have to detect, decode and combine to achieve diversity gain.

3.2 Detecting collided packets:

In Chorus, when data is transmitted, a transmitter attaches a known random sequence called preamble at the beginning of each packet. At the receiver, a matched filter is used to detect the exact time arrival of this preamble. A matched filter is an optimal correlator that maximizes SNR when correlated with unknown sequence with known sequence [5]. When preamble is detected it outputs a peak value, even if preamble is hidden in strong noise. Matched filter is operated continuously so that preambles overlapping with other packets can be identified.

3.3 Iterative collision resolution:

When a packet is transmitted, a packet usually consists of thousands of symbols, the probability of two collided packet being align is perfectly zero. At transmitters, further randomness is introduced which results in asynchronous arrivals. We will identify natural offset by detecting their preamble between two collided packets. Collisions will not occur within the offset region. We first decode clean symbols and then iteratively subtract known symbols from collided packets so that desired symbols are obtained.

For example, Figure 2 shows collisions of two packets, one is head packet P1 and other is tail packet P2 from different transmitters. First we decode two clean symbols A and B in head packet P1. Symbol C is corrupted as it collides with A' in tail packet P2, which results in combined symbol S. The symbols A and A' carry same bits which are used to recover bit C, but their analog forms are different because of channel distortion. An image of A' is reconstructed by emulating the channel distortion with the known bits of A. The amplitude attenuation, frequency offset, phase shift and timing offset can be estimated accurately by using standard communication technique [4].

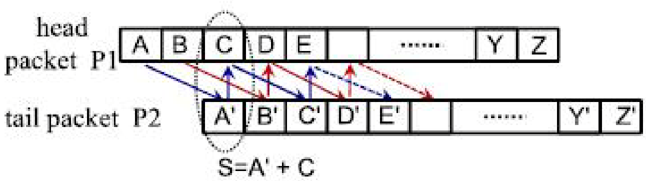

Figure 2: Iteratively decoding two collided packets

After reconstructing, we will subtract the image A' from symbol s, and obtains a decision symbol C. The channel estimation is used for normalization of decision symbol for P1, and slicer decides if bit is 1 or 0. For BPSK, if normalized value is negative real part then slicer outputs 0 and vice versa. The decoded bit C is used to reconstruct C" and decode E. This iteration process continues till the end of packet is reached. An iterative decoding process proceeds in forward direction, Chorus can works in backward direction, starting from clean symbol in P2, to its beginning and obtains different estimation of packets [4].

3.4 Packet Combination to Improve Diversity

Packets P1 and P2 have different strengths and their decoding confidence also differs. The decoding confidence is denoted by magnitude of decision symbol. The bit with highest threshold can produce correct bits, since it is equivalent to higher SNR. The decoding confidence can be increased by combining two decision symbols which carry same bits (e.g.: A and A'), While noise within the two symbols is not combined coherently.

3.5 CSMA/CR: The MAC Design

Now we introduce Mac layer of CSMA/CR and extend 802.11 CSMA protocol, but integrate with collision resolution PHY. Chorus physical layer must be integrated with MAC layer to reduce irresolvable collisions which occurs when packets with different data collides.

3.6 MAC Layer Cognitive Sensing and Scheduling

Chorus' MAC layer maintains carrier sensing and backoff in 802.11 based CSMA protocol, but adopts cognitive sensing which exploits collision resolution to avoid unresolvable collisions. The basic principle of cognitive sensing is to detect the identity of packet which is on air and make transmission decision according to it. At the end, chorus will add new header field to 802.11 packets.

3.7 Chorus packet format

The broadcast packet in chorus is illustrated in Figure.3, First, at the beginning a known random sequence is attached to make easy packet detection and offset identification. Next, a Chorus header packet is added, that informs packet identity of the receiver, which includes packet sequence number and broadcast source ID. A 16-bit Cyclic Redundant check (CRC) is added to header packet[5]. If CRC fails, packet id discarded as it provides wrong information.

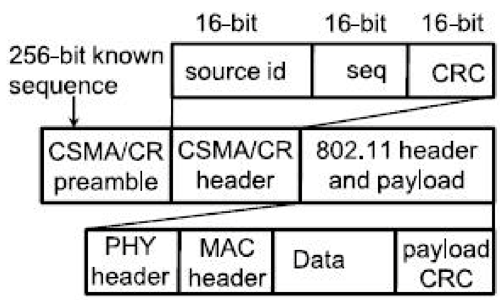

Figure 3: Frame packet in CSMA/CR

When header of two packets collides, Chorus will follow iterative decoding process assuming that packets will have same identity. When decoding process is completed, it will perform CRC checking over header of each packet to make sure that they are identical. If decoding process failure occurs both packets will be discarded.

3.8 Scheduling of sensing and transmission

With collision resolution protocol, a SEND procedure is called by each transmitter to perform cognitive sensing as shown in figure.4, Transmitters perform scheduling decision following certain rules:

- R1. If the channel is idle forward a packet immediately.
- R2. If the channel is busy, and packets which are transmitted on air is same as in transmit queue, then start transmitting pending packet.
- R3.If channel is busy and if preamble cannot be decoded then start backoff procedure according to 802.11.

Rule R1 is typically CSMA protocol. Rule R2 is similar to Chorus's CSMA/CR. The principle of Chorus is overlapping packets carrying same data cannot cause collisions. By collision resolution, a sender node such as B in fig: can forward its pending packet if it has same identity as that of one on air. Whenever channel is busy CSMA/CA transmitters will do backoff.

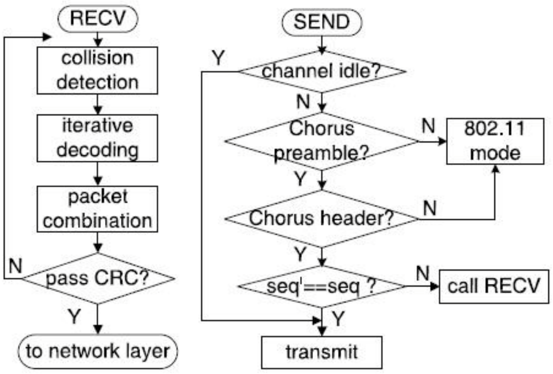

Figure1: MAC layer control flow in CSMA/CR

Rule R3 will ensures friendliness to traffic and is used for multisource broadcast and exist with CSMA/CA based Unicast traffic. Chorus starts 802.11 backoff to prevent unresolvable collisions if it senses that channel is occupied by alien traffic. Chorus will backoff packets, if the identity of packet on air is not detected so that interference is reduced.

If any neighbor overhears this packet, FORWARD procedure is followed to forward that packet once. Collision resolution is performed by overlapping packets before continuing to packet relaying by receivers. In order to resolve unresolvable collisions, a receiver flushes those pending packets with sequence numbers. In continuous broadcasting, the source distributes batch of packets, in such case Chorus controls source rate to prevent to avoid collision and congestion between packets

4. Results

4.1 Packet Delivery Ratio

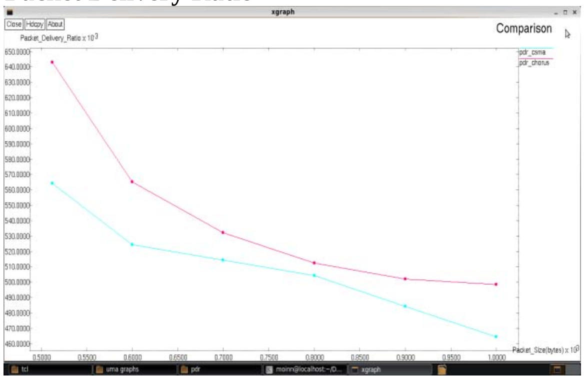

Figure 5: Comparison Graph 0f PDR for Chorus & CSMA

Delay:

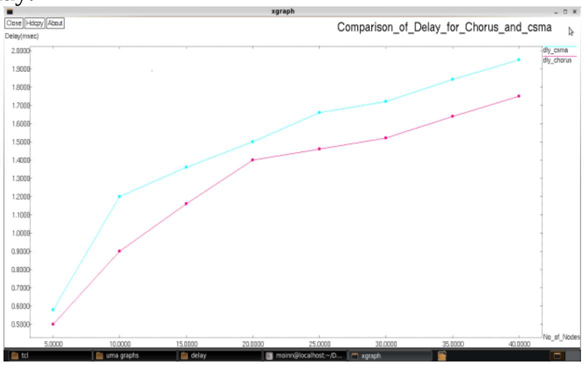

Figure 6: Comparison Graph for DELAY of Chorus & CSMA Throughput

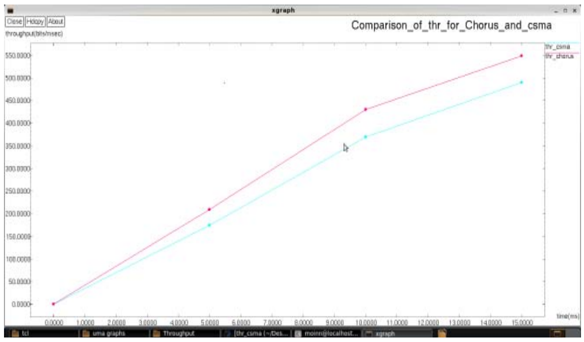

Figure 7: Comparison Graph of THROUPUT for Chorus & Csma

5. Conclusion

In this paper, we provide solution to resolve collision in wireless networks in presence of hidden terminals. The advantages and feasibility for wireless broadcast is demonstrated. Here chorus protocol will allows nodes to forward continuously at same time with same data packets. Physical-layer iterative decoding was employed to resolve collisions at receiver. Transmit diversity and spatial usage is improved. Delay, PDR and throughput are improved.

References

[1] R. Gandhi, S. Parthasarathy, and A. Mishra, "Minimizing Broadcast Latency and Redundancy in Ad Hoc Networks," Proc. ACM MobiHoc, 2003.

[2] IEEE 802.11 Standard: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, IEEE, 2007.

[3] S. Huang, P.J. Wan, J. Deng, and Y. Han, "Broadcast Scheduling in Interference Environment," IEEE Trans. Mobile Computing, vol. 7, no. 11, pp. 1338-1348, Nov. 2008.

[4] S. Gollakota and D. Katabi, "ZigZag Decoding: Combating Hidden Terminals in Wireless Networks," Proc. ACM SIGCOMM, 2008.

[5] B. Sklar, Digital Communications: Fundamentals and Applications. Prentice Hall, 2001.

[6] P. Chatzimisios, A. C. Boucouvalas, V. Vitsas, A. Vafiadis, A. Economidis and P. Huang1"A simple and effective backoff scheme for the IEEE 802.11 MAC protocol "

[7] D. Halperin, T. Anderson, and D. Wetherall, "Taking the Sting Out of Carrier Sense: Interference Cancellation for Wireless LANs," Proc. ACM MobiCom, 2008.

[8] C. Fragouli, J. Widmer, and L.B. Jean-Yves, "Efficient Broadcasting Using Network Coding," IEEE/ACM Trans. Networking, vol. 16, no. 2, pp. 450-463, Apr. 2008.

[9] J. Yang and R.W. Brodersen, "Time Domain Interference Cancellation for Cognitive Radios and Future Wireless Systems," PhD thesis, Electrical Engineering and Computer Science Dept., Univ. of California, Berkeley, May 2010.

[10] J. Bicket, D. Aguayo, S. Biswas, and R. Morris, "Architecture and Evaluation of an Unplanned 802.11b Mesh Network," Proc. ACM MobiCom, 2005.

[11] R. Mudumbai, D.R. Brown, U. Madhow, and H.V. Poor, "Distributed Transmit Beamforming: Challenges and Recent Progress," IEEE Comm. Magazine, vol. 47, no. 2, pp. 102-110, Feb. 2009

[12] W. Lou and J. Wu, "Toward Broadcast Reliability in MobilebAd Hoc Networks with Double Coverage," IEEE Trans. Mobile Computing, vol. 6, no. 2, pp. 148-163, Feb. 2007.

[13] J.I. Choi, M. Jain, K. Srinivasan, P. Levis, and S. Katti, "Achieving Single Channel, Full Duplex Wireless Communication," Proc.ACM MobiCom, 2010.

[14] B. Roman, F. Stajano, I. Wassell, and D. Cottingham, "Multi-carrier burst contention (MCBC): scalable medium access control for wireless networks," in *2008 IEEE Wireless Communications and Networking Conference*.

[15] P. Wan, O. Frieder, X. Jia, F. Yao, X. Xu, and S. Tang, "Wireless link scheduling under physical interference model," in *2011 IEEE INFOCOM*.