

FINEGRAINED CHANNEL ACCESS IN WIRELESS LAN

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ABSTRACT: A local area network (LAN) is a network of computer that connects computers within a finite area. Developing the physical-layer (PHY) rate of information in present remote neighborhood (WLANs), the media access control (MAC) reliably undermines information output ability. It reflects a key bit of present MAC custom, circles channel as solitary asset as soon as possible. The report says, Wireless LAN with a high information rate, the network that separate as particular sub channels for which the width is for all intents and purposes indistinguishable of the PHY information proportion and common edge extent. Different locations can later battle aimed at and use sub networks in the meantime as indicated by their advancement requests, hence developing general capacity. We present FICA, a system which simplifies accordingly to MAC utilizing two works. In any case, it proposes an interchange PHY structural building in light of orthogonal repeat division multiplexing (OFDM) that holds Orthogonality among sub channels while depending singularly with the co-ordination systems in existing Wireless LAN, TV and sensing transporter. On the other hand, FICA utilizes a zone talk about organization that practices physical-layer Application to Guide/Clear to Show (RTS/CTS) hailing then rehash space back off to gainfully arrange sub channel control. We acknowledged FICA, which includes MAC and PHY layers, utilizing a thing radio stage, and examinations shows probability of FICA course of action. In addition, our preoccupation outcomes display FICA can inform the volume of WLANs since a limited part to 600% seem contrastingly in connection to existing 802.11.

KEYWORDS: Fine grained channel access, OFDM, cross layer, MAC, PHY, MRCS/MCTS, CP.

1. INTRODUCTION

Present day innovations are consistently increasing the physical layer (PHY) information rates in remote neighborhood (WLANs). Consider the case, the most recent confirmed 802.11n standard [1] has helped information rates to higher speeds (up to 600Mbps). The limit development is accomplished principally with more extensive channel transfer speeds and progressed PHY methods like MIMO (Multiple-Input Multiple-Output). The information throughput effectiveness — the proportion of the system output and the PHY information rate — debases quickly as PHY information rate increments because of the outline of the present 802.11 MAC convention

have not with standee. Consider the case, if we are given most IP parcels which will have the maximal transmit unit (MTU) which estimates it about 1500 bytes, the effectiveness degree in the 802.11n system which are around 300Mbps which is just 20%. The information rate maintains a output of just 60Mbps. The necessary explanation behind the wastefulness is that current MAC allots whole channel to a single station as a unique asset. The allotment procedure gets to be more when the width of the channel increases or the PHY information rate rises. Regardless of the fact that whenever a sender had a little measure of information which has to be sent, despite everything it should battle for the whole channel. The dispute determination time will consequently increase to the channel time utilized for information. The increase can't without much of a stretch be diminished because of imperatives of present physical and hardware laws. Subsequently, the more the PHY information rate, they bring down the output productivity gets to be. An approach which enhances the Media Access Control proficiency used to expand the helpful channel time to the information transmissions there by sending bigger casings. For sure, 802.11n permits outline total which is sending numerous edges in only one controversy time. On the other hand PHY information rate builds, collected edge size which needs to increment too: accomplishing a productivity of 80% in a 300Mbps system would oblige edges to be as huge as 23KB [2]. A superior approach to enhance WLAN effectiveness is to adequately decrease the width of the channel and make more than one channels, where width of the channel may be similar with the PHY information rate and average edge quantity. Large number of station fight for and utilize these small channels at the same time as indicated by their movement requests, consequently amortizing MAC coordination and expanding general efficiency. This is called as strategy fine grained channel access to higher information rate Wireless LANs. In any case, to separation of wide band channel into a number of sub channels by not losing the helpful channel transmission capacity. The regular procedure is that to distribute both the edge of two contiguous sub channels as "watchman band" so the valuable transmission which legitimately dispersed to abstain from meddling with one another. The watchman group indicates critical overhead, however, particularly if the quantity of sub channels is expansive. Case in point, 802.11a uses a bandwidth of 1.875MHz [1] at both edges of each channel. On the off chance that a 40MHz channel is partitioned into four sub channels of 10MHz, the increase should sum to 75% of the aggregate transmission capacity. Watchman band width can't be effortlessly decreased because of force cover necessities and the trouble of channel plans, free of size of a sub channel. Orthogonal recurrence partition multiplexing is a reasonable PHY sheet innovation which take out the gatekeeper groups, if the size of recurrence and sub channels are deliberately transmitted ad picked on every sub channel which is synchronized in the manner to end up "orthogonal", thus non-meddling, to each other. Albeit cell systems have proposed utilizing OFDM as a part of canal multi entree, doing as such necessitates fitted organization amongst client phones and they can't bolster irregular access. It along these lines stays another specialized test for how to utilize OFDM-sort channelization for the fine grained channel conveyed to offbeat stations which an irregular access in Wireless LAN, where it was illogical and pointless attain to comparable sync. In the papers, we display outline as well as usage of FICA which is a cross layer structural engineering in view of OFDM which empowers the fine grained sub channel arbitrary access in a higher information rate Wireless LAN.

FICA mainly has two key methods with location the previously stated difficulties:

- It proposes another PHY structural engineering taking into account OFDM. Singularly depending on coordination systems gave by existing Wireless LAN's, sensing transporters and television.
- It utilizes a novel recurrence space dispute technique that uses physical layer flagging and recurrence area back off for fighting sub channels. We show that recurrence area disagreement is a great deal more proficient than the customary time-space dispute system in good grained network entree. We have executed a model in the Sora programming receiver stage [3]. Our usage shows the possibility of our main methods for both MAC and PHY outline. We again utilize itemized recreation to assess FICA in substantial measure remote situations in different movement patterns. The result showed that the FICA has a 4-fold increase in proficiency contrasted with the present 802.11n with all of the enhancements.

2. CHALLENGES AND BACKGROUND

Inefficiency of Current Wireless LANs

Mack conventions in remote LANs touch upon the whole channel as a singular plus. The Mack convention mediates access among range of senders and chooses one of them because the victor, that once expends the whole channel plus to transmit [2]. On the off likelihood that varied senders transmit within the in the meantime, crashes might happen and recipients can most likely neglect to rewrite the transmissions. WLANs use bearer sensing completely different access with crash escape for his or her Mack convention.

At purpose once the channel is occupied, all fighting hubs delay till the channel gets to be free. The Mack utilizes a back off arrange to abstain from having varied hubs transmission, whereas each hub can willy-nilly choose variety within the dispute window and delay for time openings if it begins transmission. Within the event that a hub distinguishes the transmissions distinguished amount, it will solidify the counter till the channels are free all over. Within the event that 2 hubs willy-nilly choose a similar back off time, their transmissions can within the long haul impact. A crash is often known by a missing affirmation (ACK) from the collector. At the purpose once a crash is known, a sender can twofold its discord window CW as per the parallel exponential back down (BEB) calculation to any diminish the impact chance for the subsequent transmission. The Short Inter-casing house is that the briefest time interim require a recipient which allows back a message to the sender. t_{TxRx} that the time which is needed to vary obtaining mode to the transmission. Generally, SIFS is around 11–17 μ s. Distributed lay to rest casing house is resolute seeable of SIFS and therefore the back off house time. DIFS is characterized to bolster wants in CA/CSMA and got to be the larger than the SIFS[4]. The rear off house is basic. It is the negligible period of time which is needed by a hub to sense channel conditions and also to gain channel.

$$tsifs = trf_delay + tproc + tTxRx,$$

$$tdifs = tsifs + a \text{ pair of } \bullet \text{ tslot},$$

$$tslot = tcca + tTxRx + tprop + tproc,$$

Where: t_{data} is that time which is taken by it for the data transmission,

$t_{preamble}$ is the time used for to transfer each casing making ready pictures

t_{ack} is that the time used for the ACK.

ACKs area unit likewise expected {to distinguish to completely differentiate to tell apart} impacts and different misfortunes, consequently once all is alleged in done we'd like to not uproot t_{ack} .

3. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM):

OFDM gotten an increasingly famed in the gift day remote interchanges [2]. It's been grasped by varied existing remote tips. Psychological feature radio advancements likewise for the foremost half rely upon OFDM to utilize non-touching vary teams for correspondence. OFDM separates a variety band into varied very little and a part of the manner covering sign transfer return teams referred to as subcarriers. The subcarrier frequencies area unit picked in order that they area unit "orthogonal" to every different, implying the cross-talk between the subcarriers wholes up to the sum of zero despite the very fact that they're covering. OFDM will during this manner pack subcarriers firmly along while not between transporter electrical phenomenon, doing away with the necessity to own watcher teams. OFDM is profitably actual utilizing quick Fourier remodel.

At the purpose once OFDM is employed as a multi-access innovation wherever varied stations have a similar channel, image temporal arrangement are going to be a discriminating issue. Orthogonality are going to be lost and signs from each hubs can lead to shared obstruction. To ensure perfect image arrangement, a multi-access innovation referred to as OFDMA has been planned for OFDM cell systems [5]. OFDMA obliges all versatile stations to stay up tight temporal arrangement synchronization with the cell base station. It obliges a posh extending arrange to gauge the proliferation defer and calibrate each moveable station's temporal arrangement counterbalance at the specimen level roughness. OFDM any has associate implicit sincerity system referred to as the cyclic-prefix to create preparations for image placement as a result of the echoes. Each of the OFDM image is prefixed with replica of image's tailing examples so that the collector will in any case discover a legitimate FFT window the length of the placement within the CP length. CP is the characteristic for any Orthogonal FDM framework; in 802.11 n, the CP-to-image length proportion is 1:4.

4. FINE GRAINED CHANNEL ACCESS IN LAN

This proposed near utilize fine grained channel access the reinforce turnout effectiveness during a high-information rate local area network.

Symbol temporal arrangement placement in WLANs

In WLANs, transmissions from sent hubs area unit expedited seeable of bearer sensing and catching show outlines. Dissimilar to ancient MACs that utilization these elements to keep up a strategic distance from transmissions. The FICA misuses synchronous transmission to empower coinciding access from numerous hubs nevertheless in sub channel. In FICA, sensing transporter facilitates the transmissions of MRTS [4]. Once they sense associate unmoving channel for settled DIFS time, 2 hubs 'a' and 'b' might transmit their MRTS pictures all the whereas. Since there's perpetually a postponement to sense the channel and for a symbol to engender beginning with one hub then onto ensuing, these 2 MRTS pictures cannot be transmitted along and got exactly a similar time [5].

PHY design

Supported the examination in last segment, FICA must provide a watcher time which is sufficiently long to handle all the image temporal arrangement placement during a local area network taking into consideration sensing transporter (12 μ s) and television (3 μ s)[3]. We tend any ought to incorporate an extra of 1800ns watcher times to record traditional put over indoor things. We tend to define 2 watcher time sizes made-to-order to each coordination circumstance: a protracted cyclic prefix (CP) eleven.9 μ s and a brief CP of two 9 μ s. The long CP is connected to MRTS simply, whereas the brief CP is appended to every ACK OFDM, MCTS and DATA and pictures, and after is that the important concern [3]. To liquidate the short CP increase, we tend to need lot of drawn out OFDM image for data. Initial, an enormous N needs a lot of procedure force to work the modification following the unpredictability of the FFT is of O (N log (N)) [5]. With expansive N the near sub carrier's area unit divided nearly. During this manner, it's a lot of delicate to the return counterbalances of distinctive hubs. Since varied hubs may faithfully have some very little return balanced, the near subcarriers got to have enough partition to oblige such a counterbalance. By and by, subcarriers area unit generally divided by no but 15KHz. FICA, we tend to set the FFT size of information OFDM image to be the 512 focuses during a 20MHz channels [2]. ACK pictures have a similar structure as information pictures. Since the MRTS utilizes the CP, it got in to contain as few pictures as may moderately be expected. On these lines, we tend to choose an even bigger FFT size for M-RTS to implant all very important management information, that overall would oblige varied OFDM pictures for a littler FFT size [5].

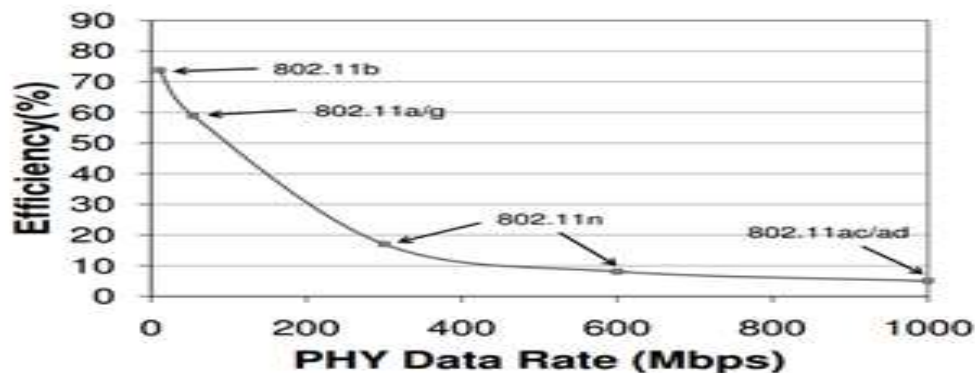


Fig. MAC at high data rates. [1]

On a basic level, FICA will distribute each subcarrier freely to allow outside ability. It's hard for a hub to utilize simply a solitary subcarrier to transmit data for 2 reasons. Utilizing one and solely subcarrier experiences return specific blurring. During this manner,

it's basic for a foreign PHY to code crosswise over completely different subcarriers to accomplish a variety variations develop. Second, associate introduction is also used for the channel estimation and remuneration, the remote channels might modification in middle the time of transmission. It's basic for beneficiary to trace the progressions within remote channels. This following is often done by as well as an additional making ready subcarriers aboard different data subcarriers. During this manner, once commonplace apply FICA bunches a meeting of subcarriers into a sub channel and uses it because the premise for the channel access [7].

Domain competition FICA

Utilizes the MRTS/MCTS sign trade for dodge sub channel impacts. M-RTS/M-CTS use easy paired abundancy balance to regulate a solitary bit on each sub channel [1]. Especially, BAM utilizes On-Off Keying which maps a twofold "0" to "0" during a subcarriers, associated it utilizes an discretionary number on that unit circle for the parallel "1". Collectors will beyond question establish BAM pictures by different the vitality on a subcarriers against the limit, while not necessity to recover image stage. The basic thought of return space conflict fills in as takes at the moment scrutiny sub channel once a SIFS delay [9]. There are a unit some of problems that require to be thought-about. Imagine a state of affairs wherever 2 hubs transmit on a similar discord subcarrier. It's really possible for 2 hubs to select a similar discretionary range and transmit on a similar discord subcarrier. Hence, their transmitted vitality is accessorial substance at the AP facet [7]. On the off likelihood that the AP picks the sub carriers because the champ, a crash can happen since each hubs can read themselves because the victor and send data pictures on a similar sub channel all the whereas. Any hub that catches MRTS transmissions will parley sub channel access. Synchronous transmissions of MCTS from numerous hubs area unit likewise allowable following, during a solitary show house, these MCTS pictures area unit prone to have a similar discord results and their vitality is accessorial substance on each subcarrier. [5]

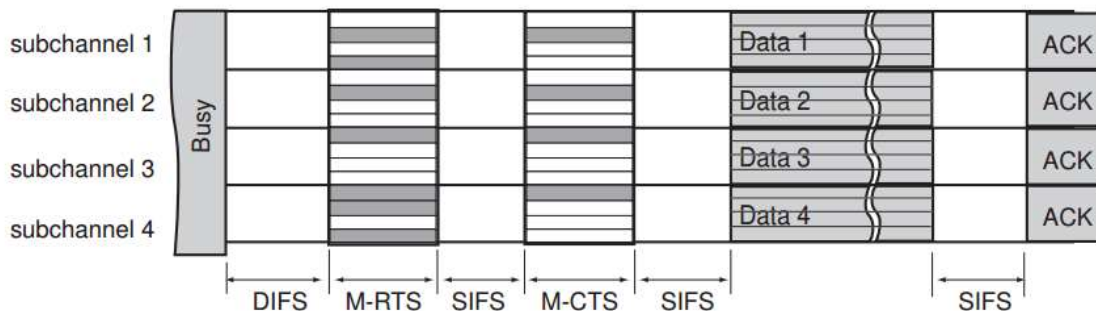


Figure 5: FICA uplink media access with four subchannels per channel.

Fig. FICA uplink media access. [3]

Frequency space back off

In FICA, hubs can choose what range of sub channels to demand by means that of discord taking into consideration their movement stipulations [3]. On the off likelihood that its movement requirements area unit less, a hub might evoke fewer sub channels, whereas associate intensely stacked hub might fight for a similar range of as all sub channels for many productive correspondence. In any case, if there are a unit varied hubs during a system battling for a few sub channels, the crash evasion instrument gave by MRTS/CRTS might not ample to talk to all or any contenders. Utilizing varied MRTS pictures will any scale impact evasion, nevertheless at the expense of to boot tired overhead as delineated antecedently [2]. The essential thought is to manage the best range of sub channels that one hub will get to in lightweight of the watched crash level. Each hub keeps up a state variable, Cmax that controls the best sub-channels the hub will access within the following transmission chance [10]. during this manner, once the channel is unmoving for DIFS, a hub might get to n sub channels to battle for, wherever $n = \min(C_{max}, l_{queue})$ and l_{queue} is that the amount of elements

within the hub's near causation line. Later, we tend to assess these 2 techniques and notice that AIMD is marginally superior to the reset-to-max technique [10].

Multiple entrance focuses and two-way activity

As of now, we've simply targeted on transmission access. Downlink access takes once a similar procedure with elements turned. For this case, the AP can convey a MRTS [11]. In FICA, there is a chance for the AP to transfer where as to numerous customers with the solitary communication blast. The collector IDs area unit encoded within the recipient band of M-RTS. All accepted customers got to come MCTS to the AP [2]. FICA differentiates transmission and downlink activity by appointing numerous DIFS times to stations and AP [11]. One with a brief DIFS, ought to get to the channel by causation a MRTS previous. To ensure reasonableness within the middle of transmission and downlink movement, we tend to utilize a simple part DIFS task system.

The AP picks the DIFS in time lightweight of the incidental guidelines:

- (1) Once associate AP gets to the channels with the brief DIFS, utilizes the extended DIFS for the succeeding entree.
- (2) Uncertainty associate AP gets a MRTS from station, it would utilize a brief DIFS aimed at the resulting coming access. This easy methodology guarantees cheap inter leaving of transmission and down link activity, not the decency among hubs as 802.11n [1] at the moment will primarily, it provides the AP varied a lot of opportunities to transmit.

5. Discussion

We tend to finish the depiction of FICA with some of other functions of thought. For the problems raised, we tend to comprehensively portray potential methodologies for tending to them, but once all is alleged in done leave an intensive exchange of them as future work. Shrouded terminals cannot be composed via transporter sensing [9]. After, there's an opportunity for MRTSs to impact if the placement of pictures from the hid stations surpasses the long cyclical prefix. To avoid MRTS impacts, once a hub misses a MCTS or it gets associate invalid MCTS once it sends a MRTS [12], the hub got to rest for associate discretionary time before causation a MRTS all over again. This discretionary holding up the time is very vital to de-synchronize the shrouded terminals. Then again, since MRTS/MCTSs area unit short, we tend to settle for the likelihood of MRTS/MCTSs crashes are going to be very little of remote framework outlines [11]. FICA to boot empowers an opportunity to journey multi-client variations in WLANs [1]. At the purpose once a hub picks sub channels to induce to, it would likewise take into account the character of each sub channel. Additionally, heterogeneous balance techniques is connected to numerous sub channels to match the conditions thereon specific channel band. There's as of currently a lot of analysis on plus allotment for multi-client differing qualities in each single and multi-channel cases, and applying these thoughts during a disseminated framework like FICA stays intriguing open difficulties. It's to boot possible for FICA to exist at the side of current 802.11. Since FICA remains taking into consideration CSMA [10], FICA hubs can concede within the event that they sense a transmission of 802.11 hubs, and therefore the different manner around. On the opposite hand, with FICA such hubs will demand access to less sub channels, effort alternate sub channels for utilization by completely different hubs. After, the final system proficiency stays at associate abnormal state, enhancing 802.11 from Sixteen Personality Factor Questionnaire till four whiles higher on the elevated PHY statistics degrees.

6. Implementation:

We have likewise dead essential systems of FICA utilizing Sora [6], totally programming radio stage taking under consideration product universally helpful computer architectures. Our FICA execution is seeable of SoftWiFi [4], a product usage of 802. 11a/b/g PHY/MAC [2].

One can generate the concomitant alterations:

- (1) One can modify FFT extent after 64-point to 256-point for pictures then 512-point for MRTS/MCTS [6] images;
- (2) We tend to utilize convolutional committal to writing in each sub channel and decipher info in each sub channel solely utilizing the Viterbi calculation.

(3) We tend to uproot the irregular time-area back off within the CSMA waterproof, and actualize the MRTS/MCTS handshaking when the channel is perceived unmoving. FICA utilizes a PHY edge structure and synchronization calculation like 802.11n. A preface goes before info pictures. The most image is used for image time synchronization. It utilizes a continuation toward oneself example within the time area so the collector will distinguish it utilizing auto-connection. The second image castoff for the assessment of channel. Towards backing 4x MIMO, associate degree alternate getting ready image is necessary. The latest image encodes the (PLCP) [1] caption operating committal to writing. The PLCP heading clenches the balance manner recycled as a neighborhood of the concomitant knowledge pictures for the beneficiary to line the most effective potential demodulating parameters.

In FICA, we tend to more utilize a modification toward oneself system to encourage this limit setting. We tend to utilize clear subcarriers within the MRTS/MCTS label band to align the clamor floor. At that time, we tend to decide a limit that's a regular varied clamor base. From judgements, discovers that footing 2– 5dB [9] beyond commotion base lives up to expectations faithfully in local area network settings. Return counterbalance alignment. In OFDM-arranges, return counterbalance amongst synchronous contributors need to be controlled within an explicit extent. During this manner, in FICA, all hubs need to have their return adjusted. Luckily, FICA will utilize the AP's return as a form of perspective. We tend to observe of that return alignment is way less complicated than time synchronization, since the return balance does not collect over the long-term. It takes too long to exchange the within the nick of your time regulated PHY outlines from the C.P.U. to the Radio board (RCB) [8] within the wake of obtaining tilt brings regarding the MCTS. Thus, it will miss the SIFS day of the month by to a small degree edge. To reinforce the circumstance, we are going to whichever want a quicker type Sora or create the stride moving piece of FICA usage for instrumentality [11].

7. EVALUATION

During this space, we tend to assess the credibility of FICA utilizing our model usage on four Sora hubs: one is the AP and also the others area unit stations. We tend to 1st show however well synchronic transmissions is composed in an exceedingly local area network. We tend to assess the greatest image temporal order placement at the beneficiary for 2 synchronic transmissions composed by methodology for transporter sensing and TV. We tend to demonstrate that even with our current programming radio usage, we will sure the greatest image temporal order placement within the reach talked regarding in Section three.1. At that time, we tend to assess the effectiveness and unwavering quality of identifying BAM-regulated PHY motions [6] in MRTS/MCTS. At last, we tend to demonstrate the decoding execution of our FICA decoder for 2 synchronic FICA senders. We tend to perform our tests within the pair of.4GHz band with 802.11b/g compatible RF front-closes. As a result of temporal order imperatives, we have got restored all needed PHY casing specimens on the RCB 1st.

There are a unit 2 approaches to facilitate synchronic transmissions in an exceedingly WLAN: utilizing a reference or bearer sensing on associate degree unmoving channel [10]. These 2 techniques cause distinctive execution conditions in adjusting image times. In additional than ninety fifth of the cases, the image temporal order distinction of those 2 transmissions is below $1\mu\text{s}$, and in ninety nine cases the temporal order distinction is below $2\mu\text{s}$. To portray the greatest image time distinction once organizing with bearer sensing, we tend to utilize the concomitant technique. When the AP conveys a telecast image, one station sits tight for associate degree altered $200\mu\text{s}$ and transfer the situation PN indicator. One tends to correct holding up stretch class increasing $200\mu\text{s}$ - $220\mu\text{s}$, activity round a hundred trials for apiece charge. After break, the instant position makes bearer identifying 1st. within the event that it schools associate degree occupied channel, scratch off its broadcast attempt, also AP simply catch unique PN indicator after primary position. $9\mu\text{s}$ edge mirrors the turnaround Sora that was around $5\mu\text{s}$, also transporter identifying period of $4\mu\text{s}$ will tend to use as a neighborhood of this examination. At the purpose once the relative postponement is below $8\mu\text{s}$, the second hub faithfully schools associate degree unmoving channel and synchronic transmissions happen. The oblong focuses mark the excellence within the landing time of the 2 signs, and also the blunder bars demonstrate the negligible and greatest qualities measured. The temporal order placement directly increments with the relative postponement, obviously.

Liableness of PHY motioning

During this check, we tend to assess the unwavering quality of the PHY drooping usage. 2 hubs transmit a similar M-RTS [3] image whereas so each child carrier holds a superposition of signs communicated by 2 dispatchers. AP distinguishes info on separate subcarrier. Since one incline to acknowledge whatever accurately spread, will distinguish wrong positives and false negatives. We tend to likewise strive various things with numerous units of bit duplication on subcarriers. From a large edge, untrue positives decreasing whereas incorrect negatives increment marginally. By and enormous, however, there is much deal substantially associate degree expansive area for edge setting to convey great execution [8]. Specifically, once a trifle is duplicated on one or two of subcarriers, each false positive and negative rates area unit just about zero once α is within the extent 3–5. We tend to guess that, with a lot of synchronous transmissions, the placement need to be a lot of dependable as BAM [4] is largely vitality recognition. With a lot of transmissions superposed, the vitality is supplementary substance at the collector aspect.

8. Conclusion

In the paper, we tend to show that a satisfactory grained pathway choice system aimed at the wireless linkages which will crop the extensive performance edges below subsequent environments:

- i) Sturdy time-based damage association inside a track during which the small tenure (10-100ms) border damage rate is considerably on top of the solid formal border damage proportion
- ii) Feeble abstraction damage connection ways. Employing a assortment of practical tests of an inside 802.11n Wireless LAN, one tend to show that settings will be occurred once the receiver is set into motion. The results shows that easy and sensible fine grained path choice techniques planned during the paper will facilitate cut back damage charges deprived of overwhelming additional wireless bandwidth with the maximum amount as twenty sixth associated to a static pathway theme that practices the simplest on the market transmission path below realistic settings. The alternative of fastened formula parameters for fine grained choice might not be acceptable in atmospheres.

REFERENCES:

- [1] Tan, K., & Zhang, Y. (2010, October). Fine-grained Channel Access in Wireless LAN. Retrieved from <http://www.sigcomm.org/node/2878>
- [2] Narasimhulu, K., (2013) Retrieved from <http://www.jrcst.com/wp-content/uploads/2013/09/haseena.pdf>
- [3] Fang, J., & Zhang, Y. (2010, October 1). Fine-grained Channel Access in Wireless LAN. Retrieved from <http://research.microsoft.com/apps/pubs/default.aspx?id=132313>
- [4] Zhang, Y. (2010, October 1). Fine-grained Channel Access in Wireless LAN. Retrieved from <http://people.csail.mit.edu/lixin/files/fica.pdf>
- [5] Shi, L.(2010, October). Fine-grained Channel Access in Wireless LAN. Retrieved from <https://www.usenix.org/legacy/publications/library/proceedings/mobisys04/pdf/p203-miu.pdf>
- [6] <https://www.google.com/patents/EP2554009A2>

[7] <http://dl.acm.org/citation.cfm?id=1851202>

[8] Kenneth L. Calvert. (2006) <http://protocols.netlab.uky.edu/~calvert/classes/571/lectureslides/WiFi.pdf>

[9] http://ceng.usc.edu/~bkrishna/research/talks/WSN_Tutorial_Krishnamachari_ICISIP05.pdf

[10] http://skypilot.trilliantinc.com/pdf/wp_WhySynchronousForWireless.pdf

[11] http://www.ece.rochester.edu/projects/wcng/project_sora.html

[12] <http://h17007.www1.hp.com/us/en/networking/solutions/wlan/index.aspx?clickid=AMS|301|2016|1a88d291-ceb6-dd88-bb25-00001565da1a&jumpid=#.VTRgeSFViko>