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Performance Investigations By Using X2B Ayes Approach In LTE Networks

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Abstract

Long Term Evolution (LTE) is a wireless communications standard defined by the 4th Generation Project (4G). The new standard provides low latency, high throughput packet data communication. The network uses the vital handover mechanism to facilitate efficient User Equipment (UE) movement across eNodeB (eNB) stations, forming an LTE system. Nevertheless, the handover scheme comprises disconnection when moving across cells because of traffic congestion in the LTE network; hence, in-progress calls might be interrupted for a short duration as the equipment moves from one cell to another, leading to potential packet loss and transmission latency challenges. Many researches had been investigated which aimed to control the traffic of cellular networks by assign a priority for handover calls. These priorities will be used to locate bandwidth for a call based on the bandwidth performance metric. This paper proposes new method called X2Bayes. This approach that facilitates the LTE system to prioritize calls based on levels. High-level calls (e.g., video calls), low-level calls (e.g., voice calls), and lastly, lowest-level calls (e.g., messages and emails) are prioritized, in this order when the bandwidth is insufficient based on fairness bandwidth that can provide high QoS, decrease call dropping in cellular networks. That helps to enhance the handover speed and handover latency by applying class call priorities during handover technique. This approach helps reduce denote call count corresponding to the handover process. The initial user equipment (UE) location is identified to determine the closest eNB station using GPS. Subsequently, the X2Bayes technique is employed to determine ToS for incoming calls. Next, the E-UTRAN NodeB (eNB) is identified for handover. Prior knowledge concerning the resource of the destination eNB allows for a prudent node selection decision, facilitating better network transmission quality.

Key word : Investigations, ,Handover Scheme, X2Bayes Approach, LTE Networks

1. Introduction

The 4th Generation (4G) proposed the UMTS Terrestrial Radio Access Network (UTRAN) Long Term Evolution (LTE) roadmap to fulfill the rising wireless data requirements [1]. LTE networks can offer enhanced downlink and uplink communication speed; moreover, the objective is to reduce network complexity but provide better capacity at reduced installation and maintenance expenditure [2]. The LTE architecture employs two distinct radio access schemes, orthogonal frequency-division multiple access (OFDMA) and single-carrier frequency-division multiple access (SC-FDMA) for downlink and uplink, respectively [3]. The OFDMA approach offers high spectral efficiency and is resistant to interference. Moreover, it facilitates a reduction in computational needs for high-bandwidth terminals [4]. The SC-FDMA scheme's peak to average power ratio (PAPR) regulation facilitates better battery life and enhanced network coverage [5]. Additionally, the LTE architecture is versatile because it provides the advantage of backward compatibility with legacy the Wideband Code Division Multiple Access (WCDMA) scheme when an LTE user equipment (UE) exits the LTE coverage area [6].

This paper proposes an augmented version of the X2Bayes technique to facilitate prudent resource distribution to improves the handover process. The algorithm considers stack protocols, UE movement characteristics, and the Naïve Bayes classifier to fulfill maximum handovers, reducing delay and missed handovers.

This paper is structured as described: Section 2 discusses associated studies concerning existing research works regarding handover process enhancement for LTE systems. Section 3 provides a brief of the LTE Architecture and Handover Mechanism. Section 4 presents the suggested X2Bayes approach, followed by an architecture explanation in Section 5. Section 6 presents the simulation outcomes presented as Functional Experiments. Finally, the Conclusion sums up this paper.

1. Related works

Researchers J. Moysen and L. Giupponi [17] formulated automatic parameter conflict coordination concerning the Markov decision-making scheme's D-SON approach. The study facilitates SON expression and conflict modelling when implemented concurrently. Moreover, the researchers used the Markov decision process (MDP) theory to describe auto-coordination aspects concerning numerous actions implemented by distinct SON functions.

This study has indicated that an MDP can model the global SON challenge; moreover, it can be split into more minor subproblems to improve scalability and subMDP modelling [17]. Hana Jouini [18] suggested LTE radio resource regulation: load balancing in heterogeneous cellular networks; this study experiments on MLB techniques using adaption FHO to regulate the adaptive HO hysteresis limit for every adjacent cell. The load balancing scheme is based on the Poisson point approach, where an overloaded cell is assessed based on actual load data. The MLB scheme improves the overall throughput for numerous network cells, specifically for simulations comprising extensive network traffic.

As examined, UE density significantly regulates the effects of MLB on network performance. Therefore, low UE density, like [10−5, 5×10−5], leads to a minor improvement in network characteristics because such density values might not load the network extensively during simulations. Likely, the MLB approach will not be enabled [18].

Researchers M. D. Abrignani, L. Giupponi, A. Lodi, and R. Verdone [19] researched M2M LTE packet uplink scheduling for dense networks built using small cells. The problem was formulated as multiple objective optimizations for enhancing network throughput, reducing extensive ICI created because of the repeated spatial small cell reuse, and optimize radio resources. The proposed solution is feasible for practical networks. The paper recommended an implementable and effective heuristic technique that addresses the NP-hard challenge. It was demonstrated that the greedy algorithm reaches within 10% of the theoretically feasible optimal solution in 90% of the situations.

Moreover, nondedicated hardware-based execution time was below 1ms, adhering to the conventional scheduling requirements. The greedy approach was implemented using a standard-compliant LTE simulation (NS3 LTE module). This implementation comprised the comprehensive set of LTE protocols implemented with high fidelity [19].

The algorithm proposed by Jamal Fathi [20] reduces time requirements by preventing the use of wholly loaded eNBs, stations misaligned with the mobile station (i.e., deprioritizing stations having angles other than the stored angles). This approach reduces handover latency better than other techniques, implying that the user equipment avoids misaligned eNBs, higher separation, fully or extensively loaded stations [20].

Academicians M. A. Khan, X. T. Dang, T. Dörsch, and S. Peters [21] worked to enhance the scalability concerning SNDized implementations and control scheme delegation for handling user equipment mobility. Specific experiments were used for a Huawei implementation called iMoveFAN. The objective is to build upon the existing work to handle additional network-based scenarios like link adaptation, radio resource regulation, and access control systems [21].

2. LTE Architecture and Handover Techniques Overview

- LTE Architecture

An LTE network implementation comprises evolved NodeBs (eNBs), system architecture evolution gateways (S-GW), routers, and mobility management entity (MME) [4]. The S1 interface is used to link the nodes and the MME/S-GW; interconnection is handled using the X2 interface. Handover is a critical LTE network aspect that facilitates UE movement within the signal range of an eNB. The X2 interface facilitates the nodes to interchange handover data. The LTE architecture uses the hard handover approach to reduce the need for radio resources [7]. The hard handover mechanism is more significantly affected by failed radio links than the soft handover approach; hence, handover regulation is required corresponding to a communication channel to facilitate the required quality of service (QoS) [8].

The LTE system requires the UQ to use reference symbols (RS) to conduct numerous measurements concerning the downlink radio channel for the active and neighbouring cells [8]. Network performance is determined using these measurements. A handover may be triggered primarily due to a dissatisfactory QoS level or inappropriate cell coverage. The reference signal received power (RSRP) is processed to determine the coverage metrics from the serving and neighbouring cells. Concurrently, the reference symbol received quality (RSRQ) is used with several other metrics to determine QoS level [6], [9].

The user equipment determines the RSRQ and RSRP metrics during a specific measurement period. For coverage-specific handover scenarios, the handover process is initiated if a neighbouring cell provides better RSRP than the serving cell and a particular hysteresis magnitude equal to or exceeding the time-to-trigger duration [10], [11]. After the handover trigger conditions are fulfilled, the UE reports the measurement data to the serving eNB, informing about the trigger event and the destination cell providing optimal RSRP levels compared to the serving cell. The serving station receives the metrics and initiates handover preparation based on the report.

- Handover in LTE

The handover process requires the eNB and UE to connect and send data, requiring additional time and incurring transmission overhead [12] to retain the data connection. Considering the inevitable handover latency [13], it is infeasible to maintain interrupt-free communication, considerably comprising the effectiveness of real-time use cases. Additionally, the handover process might fail, causing the radio link to fail [14], [15]. Deferred handover implementation risks increasing radio link failure. The problems are compounded because of improper handover request prioritization, adversely impacting system behaviour [16]. We recommend using an enhanced handover scheme using call service-type based prioritization, location estimation, and incoming UE type. UE location can be mapped using GPS; ToS helps with call types, facilitating the Naive Bayes function to ascertain the destination eNB corresponding to a UE handover. Candidate eNBs are monitored for free resources, and a destination serving cell is identified for handover. Handover delay could be reduced using precise destination cell identification, reducing packet delay and loss rates.

3. Description of the X2Bayes Technique

Cellular devices are essential for daily human activity; they serve several requirements and are considered inevitable by some. The classification mechanisms propose predictor independence to reduce handovers, enhance cellular connectivity, facilitate reduced delay, increase throughput and speed, and enhance packet delivery rate (PDR).

Three vital processes comprise the X2Bayes method, as depicted in Figure 1:

1. X2 Application Protocol;
2. Mobility;
3. Naïve Bayes Algorithm.

1. X2 Application Protocol (X2AP)

It should be noted that the X2Bayes network implementations comprise 60 UE and 20 eNodeB stations. The eNB stations must communicate to facilitate applications like interference coordination and handover, which are being actively studied through research works. The X2 interface allows eNBs to communicate; the interface is simulated using SimuLTE (belonging to the OMNeT++ workspaces). In the context of an eNB, the LteX2App implements communications with a peer eNB and works using the Stream Control Transmission Protocol (SCTP) for data transport; moreover, TCP and UDP burst protocols are used, as depicted in Figure 2.

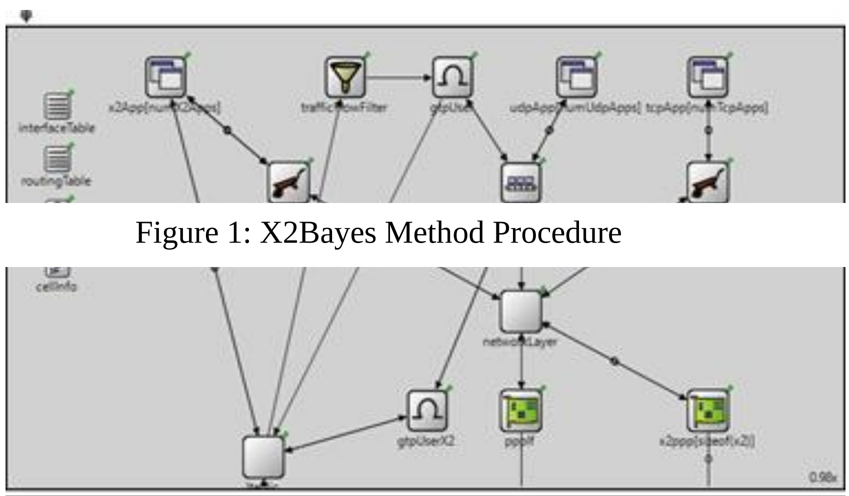

Figure 1: X2Bayes Method Procedure

Figure 2: eNodeB Structure for X2Bayes Network in OMNeT++ Simulation

Probable inter-cell disturbance mitigation requires adjacent eNBs to interchange scheduling data using the X2 system to eliminate duplicate RB allocation. Table 1 present the handover code concerning the X2Bayes approach.

Table 1: X2App Missions Code

Parameters Code	missions
x2Enabled = ${x2=true}	Enable X2Ap connections
eNodeB*.x2App[*].server.localPort = 5000 + ancestorIndex(1)	Server Port

eNodeB.numX2Apps	Number of connections by X2Ap with eNodeB
eNodeB1.x2App[0]. client.connectAddress = "eNodeB2%x2ppp0"	Connection between eNodeB1 with eNodeB2

2. UE Mobility

Modelling wireless equipment mobility is crucial for simulating wireless network systems. Inter-node separation regulates channel occupancy and received signal strength. The choice of the mobility approach can profoundly affect simulation outcomes (e.g., PDR).

A mobility model uses 3D Euclidean coordinates to map UE orientation and position with time. The primary objective is to indicate position, speed, and acceleration, in addition to angular position, speed, and acceleration in the form of 3D metrics at a specified simulation time.

The INET mobility framework typically comprises an OMNeT++ module that uses C++ to implement the motion algorithm. Several frameworks allow geo-positioning to allow straightforward map-based configuration use cases. Mobility can be simulated using single or multiple models. Single mobility allows entities to move independently of the others. On the other hand, group mobility comprises interdependent motion. LTE cellular systems recognize several mobility types like linear, random, circular, rectangular, and others. The X2Bayes technique considers a stationary cellular system comprising linear movement along the horizontal and vertical directions.

3. Naïve Bayes algorithm

This study emphasizes classification using the likelihood of calls being rejected or accepted. The classification system requires knowledge identification concerning the calls, referred to as the Naive Bayes Theorem. Hence, the class identified for assessment depends on incoming call priority and the likelihood of call acceptance; metrics like user movement speed, traffic, and overall network users are used for class determination.

Implementing the Naive Bayes Theorem requires classifier instantiation where a classifier instance defines different call categories. The technique is used for model training and testing. The system also comprises private vectors for retaining model data.

The next step requires defining the functions for the call categories and create the NaiveFit() function. The subsequent section describes the fit-and-predict approach corresponding to the Naive Bayes Theorem.

NaiveFit and NaivePredict Methods:

Required for implementing the Fit method corresponding to the Naive Bayes technique. The probability value is expressed as follows [22], [23]:

P(class=0|X1,X2) = P(X1|class=0) * P(X2|class=0) * P(class=0)

Here, X1 and X2 denote calls; P is the probability of getting a specified call class. Specifically, if an eNB has a three-call handover request, this expression determines the likelihood of the call belonging to the video (CBR), audio (VBR), or message (UBR) classes. The values can be computed by multiplying the probability value of X1 (assuming Class 0) and the probability value of X2 (assuming class 0) and Class 0 probability.

The Predict Method employs the test set to compute the probability values of incoming data belonging to different categories; the index corresponding to the maximum likelihood is obtained. The calls are subsequently classified using the feature index.

4. X2Bayes Method Architecture

This research work considers an LTE cellular system comprising a single cell coexisting with twenty eNodeB stations. The distance between two adjacent sites is 500 m. The entire network comprising sixty UE is in coverage. The system comprises one router, one packet gateway (PGW), and a single server. The network has a 5 MHz bandwidth over a 2.4 GHz carrier frequency. The bandwidth is divided to provide a 5 MHz band for every eNodeB. Standard transmit power values are UE Tx = 25 and eNodeB Tx = 45. The linear movement scenario comprising random velocity and direction (including horizontal and vertical) is considered, as depicted in Figure 3 and Table 2.

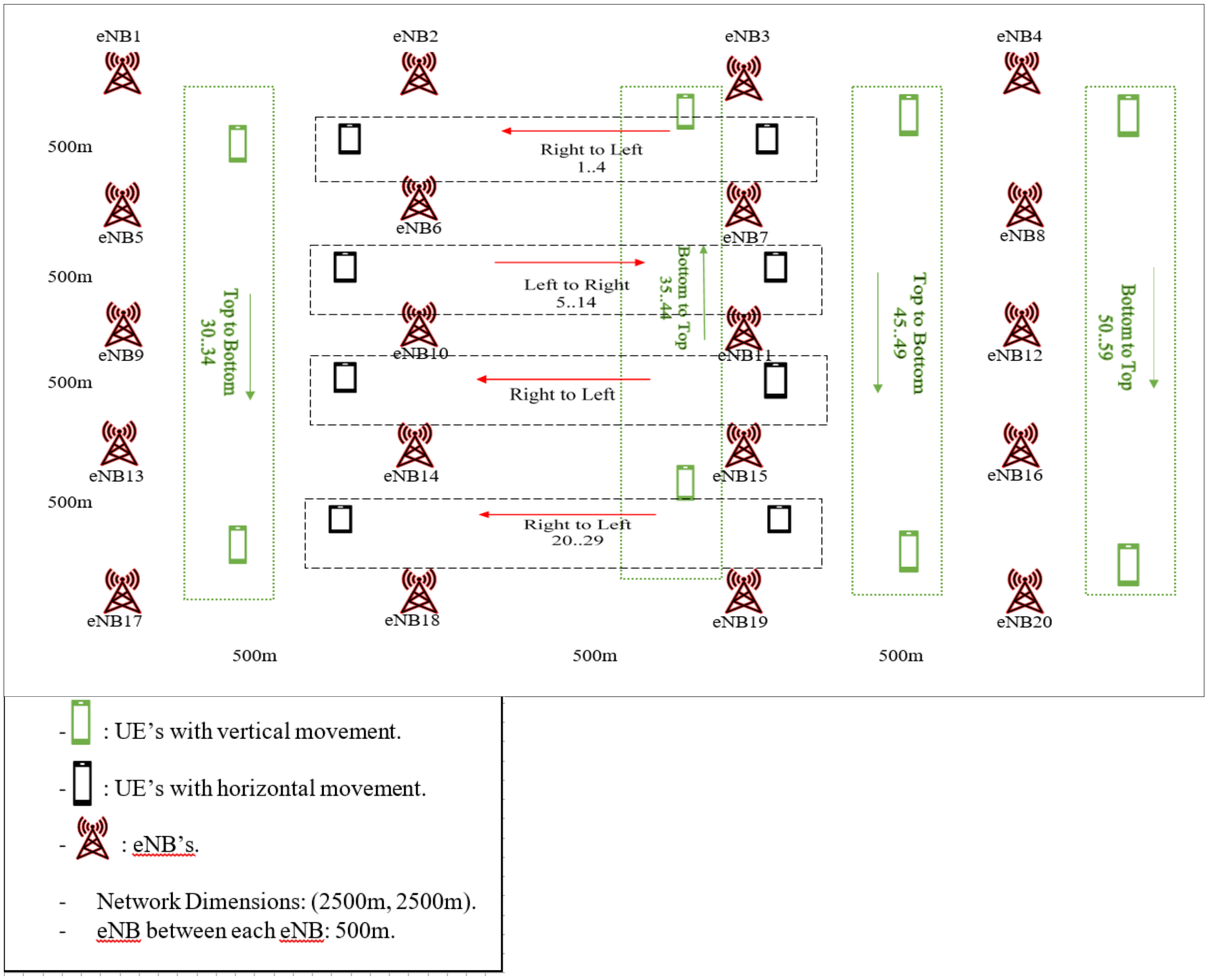

Figure 3: X2Bayes Network Design

Table 2: X2Bayes Network Parameters

Simulation System Parameters	Value
Network Dimensions	X= 2500 m
	Y= 2500 m
Number of cells	1
Number of UEs	60
Number of eNBs	20
Network	Long Term Evolution (LTE-4G)
Server	1

Mobility Management Entity (MME)	1	
Pgw	1	
Cell Radius	500 m	
Carrier Frequency	2.4 GHz	
System Bandwidth	5 MHz	
Threshold Value	5 MHz	
Direction Movement of UEs (Mobility Model)	Linear Mobility	Horizontal
		Vertical
Handover Protocol	X2Ap	
Transport Protocol	UDP	
eNodeB Tx Power	46 dBm	
Ue Tx Power	26 dBm	
Simulation Time	Start Time= 10 sec	
	Stop Time= 200 sec	

Such resource allocation enhances network handover performance to provide effective outcomes with reduced user drops. Handover acceptance is performed based on the priority determined using the X2Bayes method.

Realistic X2Bayes network simulation requires downlink and uplink communication at the application scope. A server is an ideal device for implementing such a network. A StandardHost server specified by the INET is used for the network; it supports communication at the transport and application layers (TCP and UDP protocol stack).

When an X2Bayes-based LTE implementation for 60 eNodeBs is completed, the next step is to facilitate communication between the nodes using the X2 interface. It is critical to set distinct port numbers for different X2 applications, as indicated in Table 4.1.

The X2 application comprises the client-server system for receiving and sending messages. X2 applications are deployed on top using SCTP transport rules.

The source node has several handover requests; hence, the node begins the process for an X2 handover using the Radio Resource Control (RRC) characteristics reported by the UE. The downlink signal characteristics provided by the UE and the uplink characteristics from the station are used for decision-making.

X2 handover is started if one Mobility Management Entity (MME) works for both source and target eNodeB stations. The message comprises contextual data concerning the UE for determining the UE at the S1AP level. The message also encapsulates data concerning the radio bearers. Radio Accesses Bearer (RAB) data is specific to every bearer and comprises GTP Tunnel Information, QoS characteristics, and RRC context data.

The destination eNodeB implements admission control when it receives the Handover Request. The destination station provides confirmation using X2AP Handover Request Acknowledge. The message comprises data concerning the implemented RABs. RAB-specific data concerning downlink and uplink GTP tunnel is transmitted. Tunnel allocations are conducted at the destination to move traffic when the handover is implemented. A transparent container moves the Handover Command message from the source station to the UE.

It is the responsibility of the source eNodeB to transmit UE location data and the class instance (video, audio, or message and emails) for a UE handover.

The implementation requires defining the call classes. The NaiveX2Bayes.h is the file containing information concerning call classes. The NaiveX2Bayes class is defined with two public functions, NaiveX2BayesFit() and NaiveX2BayesPredict() for training and testing. These functions help train and test the system using the incident calls. The functions also comprise several private vectors for recording model data. The data stored in these vectors is discussed ahead.

Subsequently, the call class functions are created. The X2BayesFit method computes the likelihood of the calling class and determines its location based on the training set. The systematic assessment indicates that the generic ToS IP header (Type of Service) uses the label vector corresponding to an incoming call and identifies label information. Several iterations are employed to use the GPS to determine UE and eNB position.

GPS is a satellite-based navigation facility that offers a precise position, speed, standard time, and other information across the globe. Device position can be easily determined and communicated since most modern smartphones are GPS enabled. The eNB node positions can also be determined using GPS because network implementers plan and develop the stations. Hence, GPS facilitates individual tracking of UE and eNB. Subsequently, the mean and standard deviation metrics are computed for every call at the feature level. The class summary is encapsulated in a 2D vector comprising feature-level information like mean and standard deviation, classes, and location likelihood. Hence, the calculate class summary method helps transfer data to the private vectors of the X2Bayes class for each entity in the X2BayerFit method. The objective is to use the provided information to compute the class probability, as specified above.

The prediction phase constitutes using the X2Bayes function that solves the equation to compute the class probability and belongingness. Figure 4 depicts the flowchart for the X2Bayes technique to augment the LTE handover mechanism.

Once the source eNodeB serving a UE determines a destination based on available resources, the X2Ap (UE context release) is used to send a message after the destination node completes handover radio signalling and path transition. The request to change the tracking area (by NAS) is transmitted if a successful handover required an update in the tracking area. The area update request is accepted, an acknowledgement is sent when the handover is successful.

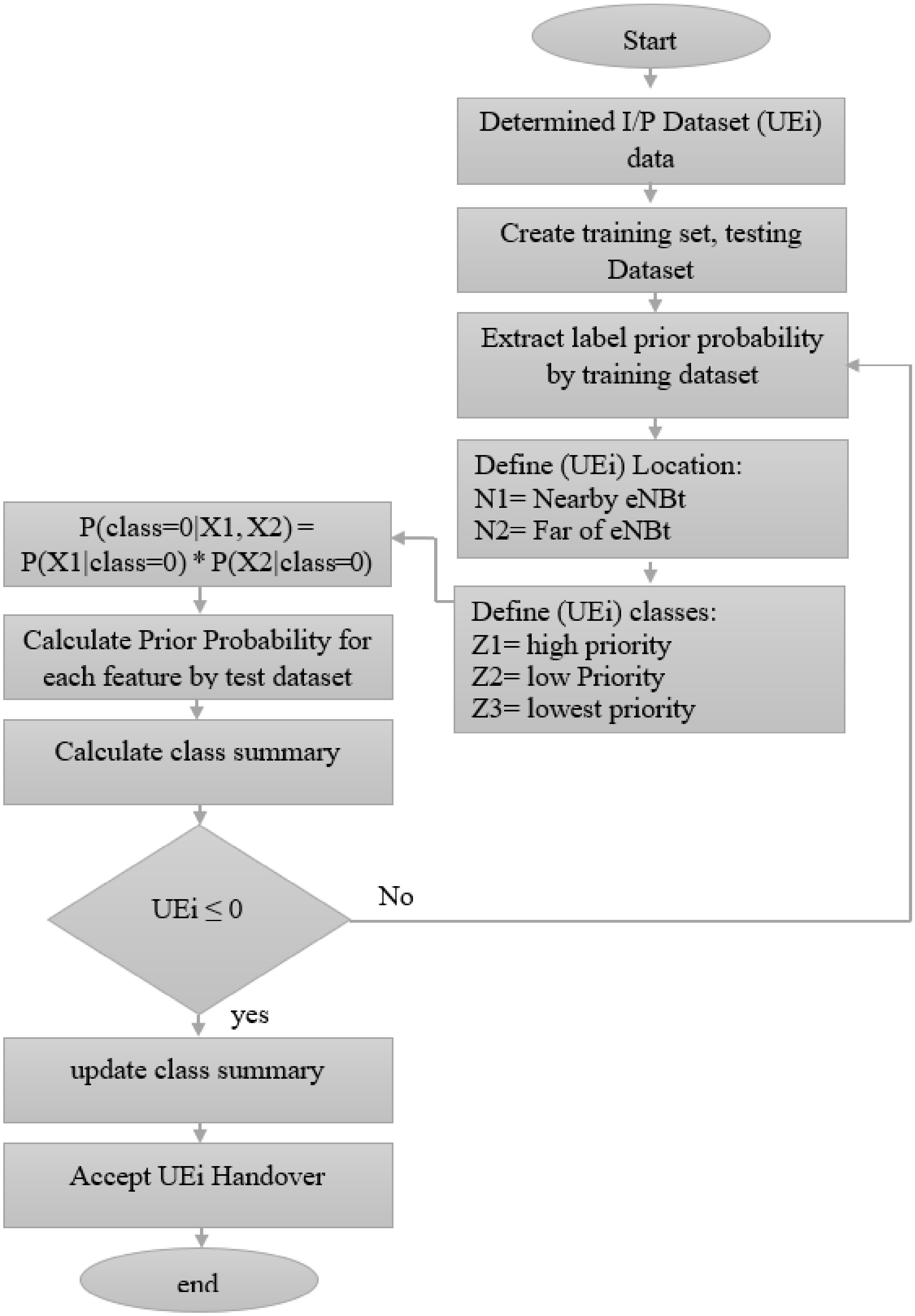

Figure 4: X2Bayes Method Flow Chart

5. Functional Experiments

The present work analyses the results of the X2Bayes approach to validate proper handover transition. Subsequently, the outcomes of the X2Bayes approach are contrasted with previous research results.

- User Equipment Movement Speed (UE MS)

  This thesis produces the outcomes of the X2Bayes approach. Validating precise UE movement requires formulating experimental systems to contrast the results of this study with the Markov Decision Process (MDP) technique.

  - Experimental Setup 1: eNodeB location is static; UE can traverse in two directions, measured in meters per section (mps).
  - Objective: Assessing UE movement at different velocities
  - Description: The experiment demonstrates the delay value of the proposed X2Bayes method and contrasts it against the corresponding Markov Decision Process (MDP) based value from previous studies. The experiment considers the UE moving at different velocities in specified directions; moreover, user count, eNodeB and UE Tx power, and traffic levels are maintained static. The X2Bayes approach comprises speed increments in mps; Table 3 specifies the MS (mps) experiment characteristics.

Table 3: MS in (mps) Experiment Specifications

UE's Movements (Mobility Speed) in (mps)	Directions	Traffic Generation	Number of Users	Number of Towers	UE Tx Power	eNodeB Tx Power
8mps	V/H	150 KB/sec	60	20	26	46
10mps	V/H	150 KB/sec	60	20	26	46
12mps	V/H	150 KB/sec	60	20	26	46
14mps	V/H	150 KB/sec	60	20	26	46
16mps	V/H	150 KB/sec	60	20	26	46

  - Expectation: When the target starts moving away from the source station, it moves closer to the destination station. This phenomenon leads to a likelihood of better throughput, delay values, and PDR for the destination node signal transmitted to the UE during handover.

- Result: The three plots below determine the outcomes of the X2Bayes approach and contrast them against Markov Decision Process (MDP) outcomes; the outcomes satisfy the expectations listed above. The UE moves away from the source eNodeB station during experiment initiation as it transitions closer to the destination. Consequently, the delay value peaks at 12 mps UE speed considering a unique scenario concerning changes to demand. Proximal traffic flow is substantially different from the "typical" observations.
- Unusual occurrences might lead to traffic demand surges that cause system overload; subsequently, at 14 mps UE mobility speed, delay deterioration begins and lasts till the experiment is concluded. The details are depicted in Figure 5.

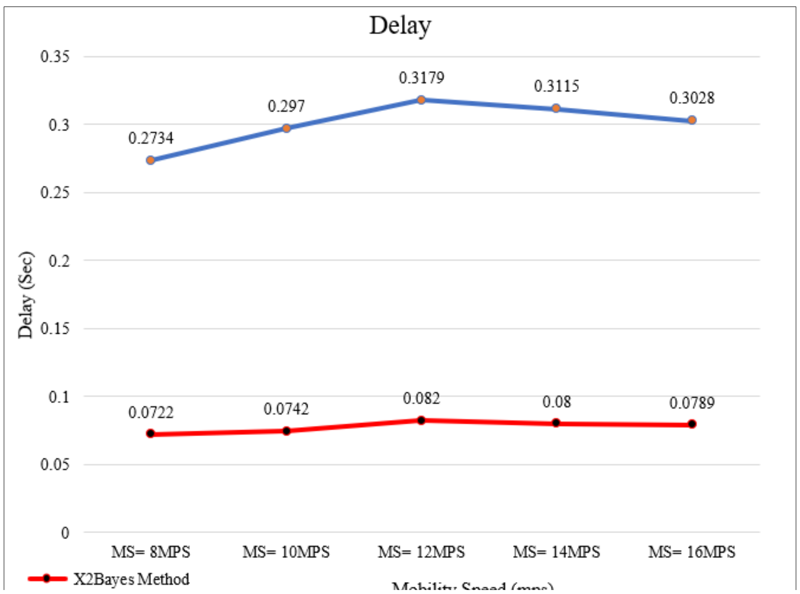

Figure 5: Delay Vs UE' s Mobility Speed Movement in (mps)

- Experimental Setup 2: eNodeB location is static; UE can traverse in two directions, measured in kilometre per hour (kmph).

- Objective: Assessing UE movement at different velocities.
- Description: The experiment assesses PDR, throughput, and determining delay corresponding to the proposed X2Bayes approach and contrasts against previous studies' Markov Decision Process (MDR) outcomes. Assessed metrics include several UE speed magnitudes, user count, traffic levels, and eNodeB and UE Tx

power levels. The X2Bayes technique considers movement increments in kmph. Table 4 lists the experiment characteristics (based on kmph).

Table 4: MS Experiment Specifications

UE's Movements (Mobility Speed) in (kmph)	Directions	Traffic Generation	NOU	Number of Towers	UE Tx Power	eNodeB Tx Power
3Kmph	V/H	150 KB/sec	60	20	26	46
30Kmph	V/H	150 KB/sec	60	20	26	46
120Kmph	V/H	150 KB/sec	60	20	26	46
150Kmph	V/H	150 KB/sec	60	20	26	46

- Result: The three plots below indicate the outcomes for the proposed X2Bayer technique and contrast against the outcomes of the Markov Decision Process (MDP); the outcomes satisfy the expectations specified previously. The UE moves away from the source eNodeB station during experiment initiation as it transitions closer to the destination. Consequently, the delay value peaks at 3 kmph UE speed, which reduces delay, as depicted in Figure 6.
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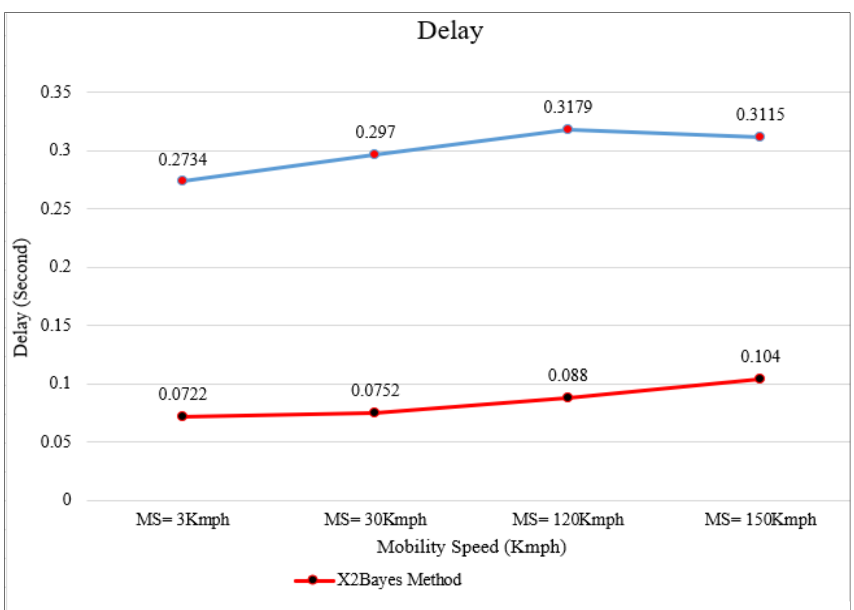

Figure 6: Delay Vs UE's Mobility Speed Movement in (Kmph)

➢ Number of Users (NOU)

The objective of the simulation is to test the framework proposed in the study by detracting about 10% of network users.

- Description: The initial setup comprises 60 UE, which are gradually reduced by 10% until the final count of 36 UE is achieved. The final network conditions comprise a specified movement speed and direction. The NOU experiment characteristics are specified in Table 5.

Table 5: NOU Experiment Specifications

Number of Users	Directions	Traffic Generation	Mobility Speed	Number of Towers	UE Tx Power	eNodeB Tx Power
60	V/H	150 KB/sec	10mps	20	26	46
54	V/H	150 KB/sec	10mps	20	26	46
48	V/H	150 KB/sec	10mps	20	26	46
42	V/H	150 KB/sec	10mps	20	26	46
36	V/H	150 KB/sec	10mps	20	26	46

- Results: The three plots indicate that delay value dropped for 54 users and peaked for 48 network users. This phenomenon is a unique demand fluctuation scenario comprising proximal network traffic. It begins to drop and resumes for NOU values of 42 and 36, as mention in Figure7.

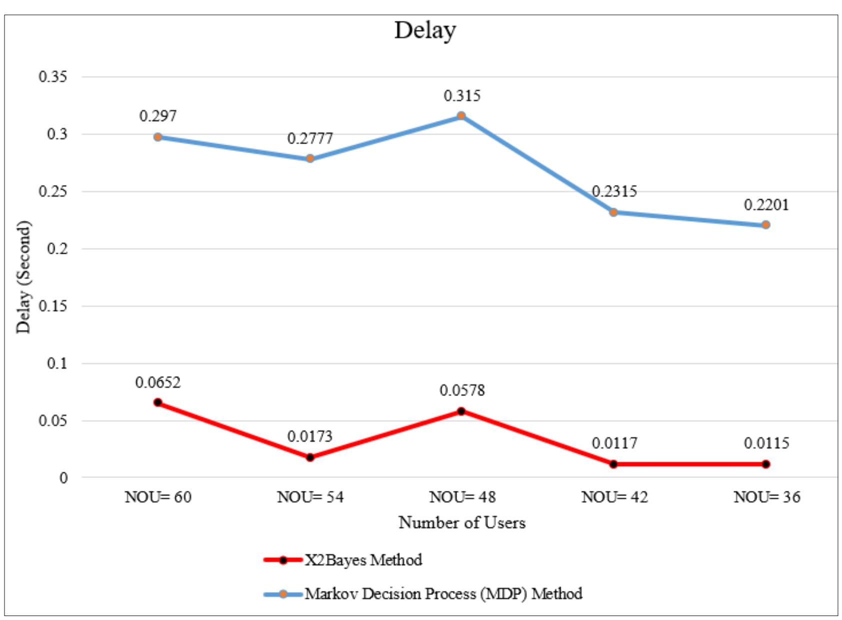

Figure 7: Delay Vs Number of Users

- Packet Size (PS)

The third experimental setup was used to contrast X2Bayes approach performance against previous studies by using a packet size increment of 200 bytes for every test conducted for handover assessment.

- Description: This test comprises a 200-byte increase in packet size for testing the handover phenomenon. Other test characteristics comprise fixed movement speed, direction, eNodeB and UE transmitted power, and user count. Experiment characteristics (using bytes) are specified in Table 6.

Table 6: PS Experiment Specifications

Packet Size	Directions	MS	No of Users	No of Towers	UE Tx Power	eNodeB Tx Power
624B	V/H	10mps	60	20	26	46
824B	V/H	10mps	60	20	26	46
1024B	V/H	10mps	60	20	26	46
1224B	V/H	10mps	60	20	26	46
1424B	V/H	10mps	60	20	26	46

- Results: This segment describes the increasing delay for sending the higher sized packets during handover. Figure 8 depicts that a 1424-byte packet causes peak delay, indicating higher delays for larger packet sizes.

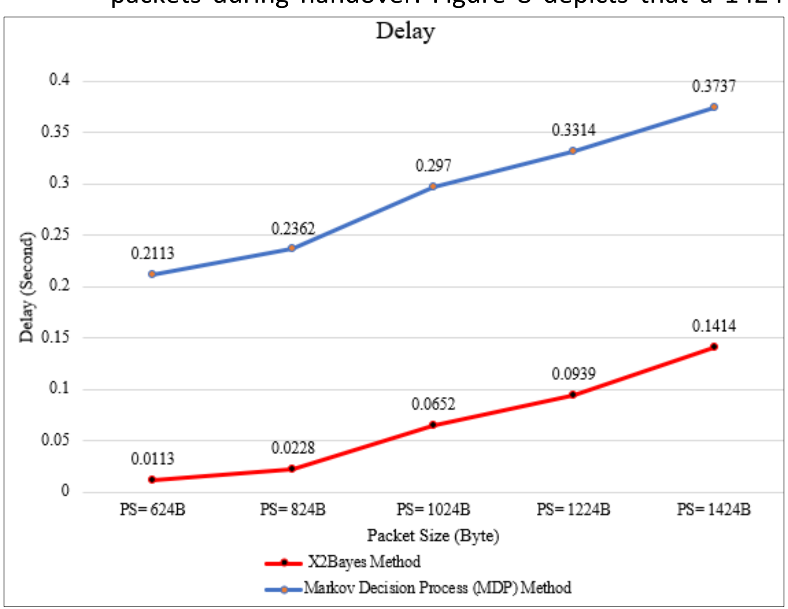

Figure 8: Delay Vs Packets Size

- Traffic Generation (TG)

The following setup was used to verify the X2Bayes approach and its ability to handle additional network traffic. Application-level traffic creation happens according to a specified packet count per unit time.

- Description: This test comprises a 50 KB/sec network traffic increment while the handover is in progress. Other characteristics comprise fixed movement direction, speed, eNodeB and UE transmitted power, user count, and packet size. Experiment characteristics (using KB/sec) are specified in Table 7.

Table 7: TG Experiment Specifications

Traffic Generation	Directions	Mobility Speed	Packet Size	No of Users	No of Towers	(UE/ eNodeB) Tx Power
100KB/sec	V/H	10mps	1024B	60	20	26/46
150 KB/sec	V/H	10mps	1024B	60	20	26/46
200 KB/sec	V/H	10mps	1024B	60	20	26/46
250 KB/sec	V/H	10mps	1024B	60	20	26/46
300 KB/sec	V/H	10mps	1024B	60	20	26/46

- Results: Figure 9 depicts the delay values corresponding to the X2Bayes approach. The curve indicates that the delay effect of traffic increase peaks at TG = 250 KB/sec and begins reducing when the generation reaches 300 KB/sec. In contrast, the previous approach has a sustained increase in delay with increasing network traffic.

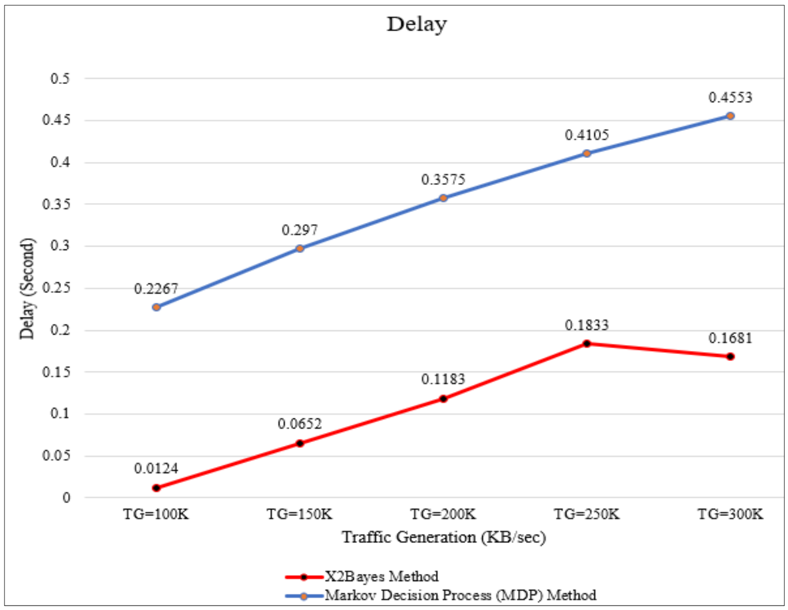

Figure 9: Delay Vs Traffic Generation

6. Comparison of the X2Bayes Approach

The experiments used for this study aimed to contrast the performance of the X2Bayes approach against the Markov Decision Process (MDP). The proposed technique uses the Naive Bayes algorithm and implements handover using the X2 Application Protocol. This technique suggests using a simulator to optimize the handover process. Additionally, the optimal outcomes are consumed by the Naïve Bayes approach to facilitate machine learning in combination with the X2Ap stack protocol.

The comparison of the described network situations is based on previous studies, as specified in Section 2. The comparison comprises four metrics: packet size, traffic creation, user count, and movement speed). The impact of these factors on delay is monitored.

- Delay Comparison

This section describes the delay as a network characteristic for the X2Bayes and Markov Decision Process (MDP) approaches using packet size, user count, movement speed, and several traffic-generation scenarios. The X2Bayes approach has a lesser delay than the MDP approach.

The delay value peaks at 0.082025 sec for a 12 mps mobility speed and subsequent levels with higher movement speed (mps); the two aspects are positively correlated. The X2Bayes approach presents a 0.0774984-sec average delay; in contrast, the corresponding value for the Markov Decision Process (MDP) is 0.3005626 sec. Hence, in terms of user mobility, the X2Bayes approach provides a delay improvement of -74.21555443 %.

When movement speed (kmph) causes a higher delay with increasing UE speed, the peak delay value stands at 0.104067 sec for 150 kmph speed. The X2Bayes technique has an average delay duration of 0.08489275 sec against 0.2999925 sec for the Markov Decision Process (MDP). The proposed approach reduces delay by 71.70170921% compared to the MDP when speed is measured in kilometres per hour.

A sustained random reduction of 10% of connected users is associated with lesser delay values. However, when there are 48 users on the network, the delay rises because of demand changes in proximity of the UE and its network distribution. The X2Bayes approach corresponds to a 0.032735-sec average delay, corresponding to a -87.80001491% change. Nevertheless, this technique corresponds to a 0.26832-sec average outage probability.

The packet size metric is used for assessing X2Bayes performance. Delay rises as packet size increases; it is expected because packet size is directly correlated with delay. 624-byte packet size is associated with the slightest delay of 0.01136 sec. Delay gradually increases packet size and reaches its peak value of 0.14147 sec for 1424-byte packet size.

The X2Bayes approach provides an average delay of 0.066975 sec, compared to 0.2899548 sec for the Markov Decision Process (MDP), corresponding to an improvement of -76.90157225%.

Lastly, the X2Bayes approach was tested by different magnitudes of traffic generation. Traffic increase causes increasing delay; the peak delay was 0.18327 sec, corresponding to a 250 KB/sec TG rate. Delay started levelling after this rate. The X2Bayes approach provides an average delay of 0.1095 sec, compared to 0.3494524 sec for the Markov Decision Process (MDP). The delay metric of the proposed approach provides an improvement of about -68.66526028%.

Figures 10 and 11 depict all experiments described above.

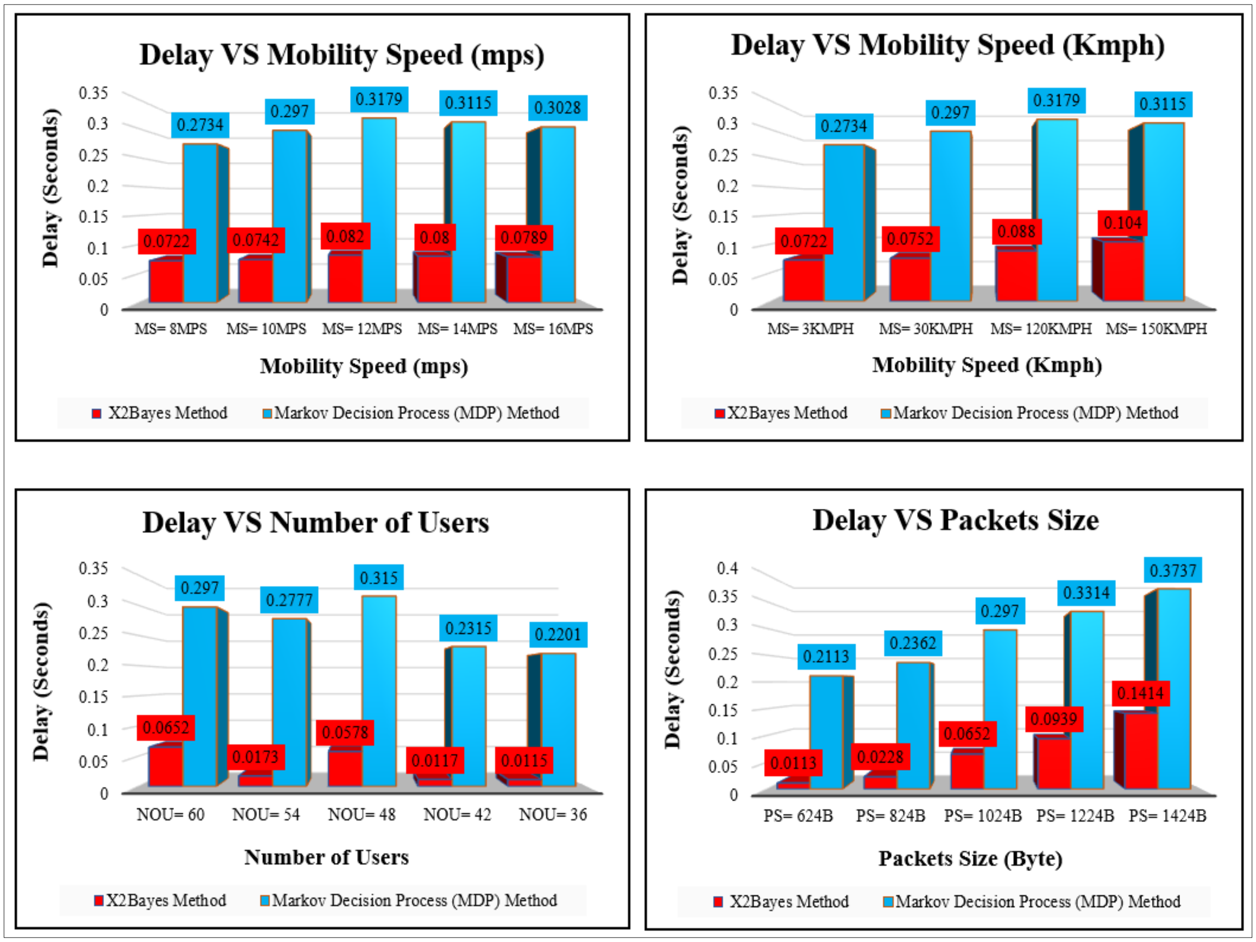

Figure 10: Delay Comparison Between X2Bayes Method and Markov Decision Process (MDP) with Different Performance Metrics

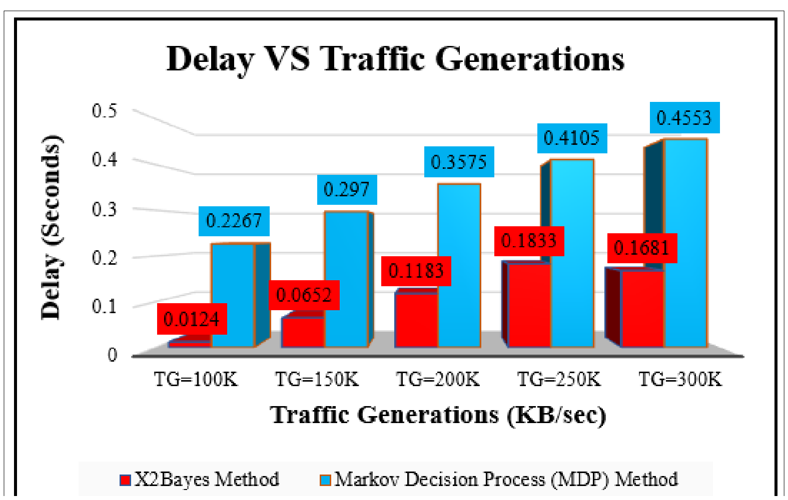

Figure 11: Delay Comparison Between X2Bayes Method and Markov Decision Process (MDP) with Traffic Generations Performance Metric

7. Conclusion

This paper achieved to use a priority prediction scheme for LTE transmission so that eNB resources can be allocated prudently. The proposed approach comprises a location estimation technique using the Naïve Bayes function to determine the type of UE call considered for the handover process. Subsequently, a destination eNB is identified since UE call handovers require a resource. Simulation outcomes indicate that several UE speed setting and the suggested handover approach is superior to the conventional method for implementing UE handover. The proposed approach scores better based on transmission delay and packet loss.

The X2Bayes technique demonstrates superior simulation outcomes. The proposed approach reduces average simulation handover delay by 74.21% using an mps-based speed measurement; for the kmph measurement scenario, the improvement is 71.70%. Moreover, the technique provides 87.80% improvement when the user count is reduced by 10%. Also, increasing packet size proves that the proposed approach provides a 76.90% improvement than other approaches. Finally, in the traffic generation case, the X2Bayes approach improves delay by 68.66526028%, compared to the conventional MDP scheme.

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