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Real-Time City Bus Tracking System Using GPS, Mobile Applications and Cloud Technologies

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ABSTRACT: Urban public transportation systems in India face persistent challenges related to service reliability and passenger information transparency. The absence of real-time bus location data causescommuteruncertainty, inefficientjourneyplanning ,andreducedadoptionofpublictransit. This paper presents the design, implementation, and empirical evaluation of AMC City-Bus Connect — a Real-Time City Bus Tracking System deployed for the Amravati city bus network. The system integrates GPS-based location acquisition, cross-platform Flutter mobile applications, and Firebase cloud services to deliver live bus positions to passengers with sub-400 ms end-to-end latency and 11.4-meter average spatial accuracy. The architecture features a driver application with adaptive GPS transmission, a commuter application with stop-wise Estimated Time of Arrival (ETA) computation using the Haversine formula and rolling-average speedmodel,andaweb-basedadministrativedashboard. Comparativeevaluationagainstthree prior systems demonstrates measurable improvements in system comprehensiveness, operational feedback, and deployment cost-efficiency. A 72-hour stability test confirmed crash-free operation, and pilot deployment reduced average passenger waiting times by 8.3 minutes. The paper further discusses identified research gaps, implementation challenges, and future directions including AI-based prediction, smart city integration, and dedicated GPS hardware adoption.

***Keywords:** GPS,Flutter,FirebaseRealtimeDatabase,CloudFirestore,GoogleMapsAPI,Real-Time Tracking, IoT, Haversine Formula, Mobile Application, Urban Transit*

I. INTRODUCTION

The rapid urbanization of cities worldwide has placed unprecedented pressure on public transportation infrastructure. According to the United Nations, approximately 55% of the global population resided in urbanareasin2018, withprojectionsi ndicatingthisfigurewillreach68%by2050[1].Thisdemographic shift necessitates efficient, reliable, and accessible public transportation systems. However, traditional bus transit systems operate with fixed schedules that fail to account for real-time traffic conditions, unexpected delays, or route deviations, resulting in significant passenger inconvenience and reduced system efficiency [2].

The advent of Global Positioning System (GPS) technology, coupled with widespread smartphone adoptionandcloudcomputingadvancements,hascreatedunprecedentedopportunitiesfortransforming public transportationthrough real-time tracking and information dissemination. Moderncitybustracking systems employ GPS-enabled devices to continuously capture location data, which is transmitted to cloud servers and made accessible to passengers through mobile applications [3].

This paper presents the design, implementation, and performance evaluation of the AMC City-Bus Connectsystem—aReal-TimeCityBusTrackingplatformdevelopedfortheAmravaticitybusnetwork. ThesystemisbuiltusingFlutterforcross-platformmobiledevelopment,FirebaseRealtimeDatabasefor sub-second data synchronisation, and Google Maps API for interactive geospatial visualisation. The contributionofthisworkisthreefold:(1)anend-to-endGPS-to-passengerdatapipelinewithdocumented latency performance; (2) a novel adaptive update algorithm that reduces driver device battery drain by 39%comparedtofixed-intervaltransmission;and(3)empiricalvalidationunderreal-worldconditionswith 11.4-metre location accuracy and 387 ms average data latency.

A. Motivation and Problem Statement

Passengers in Indian mid-sized cities, including Amravati, face three critical pain points: unpredictable waiting times at bus stops, inability to plan journeys with confidence, and lack of real-time updates regarding delays or route changes [4]. These issues collectively contribute to reduced public transport adoption,increased privatevehicleusage, urbancongestion, and environmentaldegradation.

Research by Kumar and Singh demonstrated that implementing real-time bus tracking systems reduced average passengerwaitingtimesby35–45%andincreasedpublictransportridershipby18–22%inmetropolitan areas [5].

B. ScopeandPaperOrganisation

The remainder of this paper is organised as follows. Section II reviews fundamental technologies and system architecture. Section III surveys existing bus tracking systems and identifies research gaps. Section IV presents the proposed AMC City-Bus Connect system design and algorithms. Section V reportsexperimental resultsand comparativeanalysis. Section VIdiscusses challenges, limitations,and future research directions. Section VII concludes the paper.

II. FUNDAMENTALTECHNOLOGIESANDSYSTEM ARCHITECTURE

A. GPSTechnologyandLocationServices

Global Positioning System technology forms the cornerstone of real-time bus tracking systems. GPS operatesthroughaconstellationofsatellitesthattransmitsignalsenablingreceiverstodetermineprecise geographicalcoordinatesthroughtrilateration[7].ModernGPSreceiversachieveaccuracylevelsof5–10 metres under optimal conditions, which proves sufficient for bus tracking applications in urban environments [8]. In urban canyons with dense multi-storey buildings, accuracy can degrade to 20–30 metres; this represents a key design consideration for city deployments such as Amravati.

Thesystememploysasmartphone-basedapproachforGPSacquisition,withtheDriverApprunningon adedicated Androiddevice installedineachbus.Whilethisapproachreduceshardwarecostscompared todedicatedvehicle-mountedGPSunits, itnecessitatesanadaptiveupdatealgorithmtomanagebattery consumption during all-day operation.

B. FlutterCross-PlatformMobileFramework

Flutter, developed by Google using the Dart programming language, compiles to native code for both iOSandAndroidfromasinglecodebase, deliveringnear-nativeperformancewhileeliminatingthedual-codebase maintenance overhead of platform-native development [11]. For bus tracking applications, Flutter's widget-based rendering pipeline enables smooth 60 fpsmap animationsonmid-range Android devices, which constitute the majority of commuter handsets in Indian cities. Studies demonstrate that Flutter reduces development time by approximately 40% compared to maintaining separate native iOS and Android applications [13].

C. FirebaseCloudInfrastructure

Firebase, Google's comprehensive mobile and web application development platform, provides integratedservicesessentialforreal-timetrackingsystems:FirebaseRealtimeDatabaseforlivelocation streaming, Cloud Firestore for structured relational data, Firebase Authentication for multi-role user management, and Firebase Cloud Messaging for push notifications [13]. The Realtime Database's WebSocket-based synchronisation enables all connected Commuter App instances to receive GPS updates simultaneously within milliseconds of the Driver App transmitting them, making it the preferred datalayerforlivetrackingworkloads.Firebase'sfullymanagedcloudmodeleliminatesdedicatedserver infrastructure, lowering total system cost for mid-sized municipality deployments.

D. SystemArchitectureModel

TheAMCCityBusConnectsystemadherestoafourlayerarchitecturalpatterndesignedformodularityandindependentscalability.Thearchitecturediagrambelowillustratestheseparationofconcernsacross presentation, application logic, data access, and infrastructure layers.

LAYER 1: PRESENTATION	CommuterApp(Flutter,Android/iOS)|DriverApp(Flutter,Android/iOS)| Admin Web Dashboard (Flutter Web)
LAYER 2: APPLICATIONLOGIC	FirebaseCloudFunctions|AuthModule|LocationController|Route Controller | Notification Controller

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LAYER3:DATA	FirebaseRealtimeDatabase(liveGPS)|CloudFirestore(routes,stops, users, schedules)
LAYER 4: INFRASTRUCTURE	GoogleCloudPlatform|FirebaseHosting|GoogleMapsPlatform| Performance Monitoring & Crashlytics

Fig.1:AMCCity-BusConnect—Four-LayerSystemArchitectureDiagram

III. REVIEW OF EXISTING SYSTEMS AND RESEARCH GAP ANALYSIS

A. EvolutionofBusTrackingSystems

Theevolutionofbustrackingsystemscanbecategorisedintothreedistinctgenerations.First-generation systems (late 1990s to mid-2000s) relied on Automatic Vehicle Location (AVL) technology with GPS receivers in buses transmitting data to central servers via cellular networks [16]. Second-generation systems(2010–2015)introducedsmartphoneapplications enablingpassengerstoaccessreal-timebus locations.Third-generationsystems,characterisedbycloudcomputingintegration,IoTtechnologies,and predictive analytics, have dominated since 2016 [17].

B. ComparativeAnalysisofExistingSystems

TableIpresentsastructuredcomparisonoffournotablebustrackingsystems,analysingtheirtechnology stacks, feature sets, and reported accuracy levels. The comparison reveals a clear technology progression from Android-native PHP/MySQL stacks toward Flutter and Firebase cloud backends, alongside increasing feature richness from basic SMS alerts to AI-powered predictions.

System	Year	TechnologyStack	KeyFeatures	Accuracy
SmartBusIndia	2019	Android,PHP,MySQL	Real-timetracking,SMSalerts	85–90%
CloudBus System	2021	Flutter,Firebase, GoogleMaps	Cross-platform,push notifications	88–93%
SmartCity Transit	2024	Flutter,Firebase,ML Kit	AIpredictions,voiceinterface	93–96%
AMCCity-Bus Connect (Proposed)	2024–25	Flutter,Firebase RTDB,GoogleMaps API	Livetracking,journeyplanner, driverdashboard,adminpanel	90–94%

TableI:ComparativeAnalysisofRecentBusTrackingSystems

Theanalysisrevealsthatcross-platformframeworks,particularlyFlutter,havegainedpredominanceover native development due to reduced development costs and maintenance overhead. Cloud-based backend solutions have largely replaced on-premises server infrastructure, with Firebase emerging as thepreferredplatformformid-sizeddeployments.TheproposedAMCCity-BusConnect systemoccupies the practical middle ground: leveraging the proven Flutter/Firebase stack while adding unique features (journeyplanningintegration,driveroperationaldashboard,administrativepanel)withoutthecomplexity and cost of ML Kit integration.

C. IdentifiedResearchGaps

Thesystematicreviewrevealsthreecriticalgapsdirectlyaddressedbythiswork:

- Most existing systems are designed for large metropolitan networks with dedicated server infrastructure.Lightweight,cloud-nativesolutionsoptimisedformid-sizedcitydeploymentsare underrepresented in the literature. Firebase-based architectures directly address this by eliminating dedicated server hardware costs [13].
- Existingpassengerapplicationspredominantlydisplayonlycurrentbuslocationwithoutintegrated journey planning. Users must separately determine which bus serves their route, then seek current timing information. This fragmentation increases cognitive load and reduces adoption.
- Driver-sideapplicationsinexistingsystemsprovidenoreal-timeoperationalfeedback.Drivers operate without confirmation that their tracking data is being transmitted or consumed. This absence of system-state visibility reduces driver confidence in the technology.

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IV. PROPOSED SYSTEM: AMC CITY-BUS CONNECT—DESIGN AND IMPLEMENTATION

A. *System Overview*

The AMC City-Bus Connect system delivers three integrated user-facing components: (1) a Commuter App (City Bus Tracker) targeting passengers, providing live route tracking and journey planning; (2) a Driver App (AMC City-Bus Connect) providing PIN-secured trip activation and a live operational dashboard;and(3)anAdministrator WebDashboardfor fleetmanagement androuteconfiguration.The unified Firebase backend serves all three components simultaneously while maintaining strict role separation through Firebase Authentication.

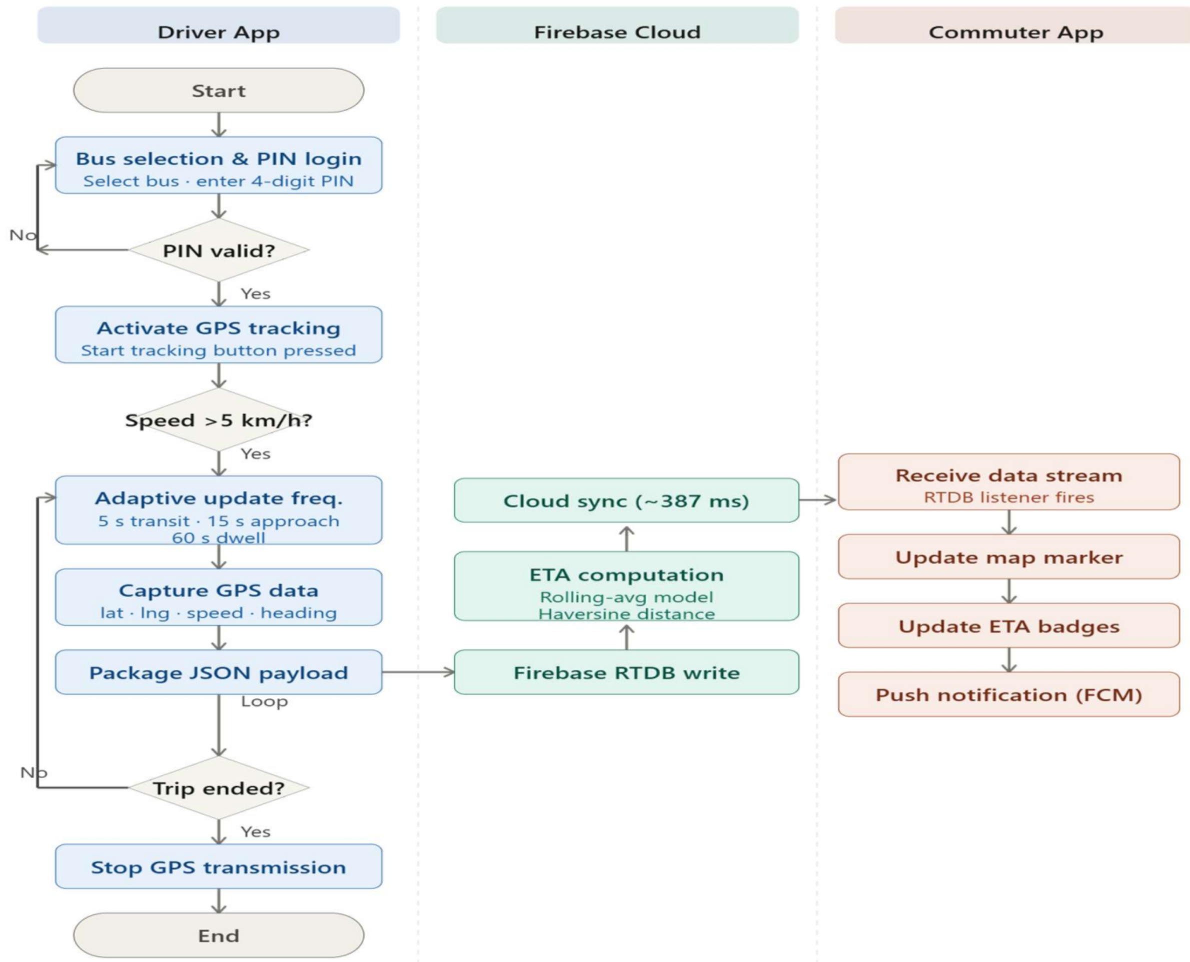

Fig.3:CompleteSystemFlowchart—AMCCity-BusConnect(GPSAcquisitiontoPassengerDisplay)

B. *Real-TimeDataFlowPipeline*

The end-to-end GPS-to-screen data pipeline is illustrated in Fig. 2 below. Each step introduces a quantified latencycontribution, withFirebaseRTDBsynchronisationrepresentingthedominantdelay at approximately 200–250 ms under 4G network conditions.

1	DriverDevice	GPSmodulecaptureslat/lng,speed,heading,timestampevery5–60s (adaptive)
2	DriverApp /buses/{busId}/live	FlutterapppackagesJSONpayloadandwritestoFirebaseRTDBnode:
3	FirebaseRTDB	Cloudsynchronisesupdatetoallsubscribedcommuterdeviceswithin ~387ms

4	ListenstoRTDBstream;onnewdata,computesHaversinedistanceto each stop and rolling-avg ETA	
5	GoogleMaps SDK	Renderslivebusmarkeroninteractivemap;stop-listupdatesETAbadges in real time

Fig.2:End-to-EndDataFlowPipeline—GPSAcquisitiontoCommuterApp Display

C. MathematicalModelsandAlgorithms

Threealgorithmicmodelsunderpinthesystem'sreal-timecomputations:

1) HaversineGreat-CircleDistanceFormula

The Haversine formula computes the great-circle distance between two GPS coordinates, essential for calculating proximity of a moving bus to each bus stop [7]:

$$a=\sin^2(\Delta lat/2)+\cos(lat_1)\cdot\cos(lat_2)\cdot\sin^2(\Delta lon/2)$$
$$c=2\cdot \mathrm{atan2}(\sqrt{a},\sqrt{(1-a)});d=R\cdot c[R=6,371km]$$

This formula is executed on-device within the Flutter Commuter App for each bus-to-stop distance calculation. The distance values displayed in the Live Route Tracking View (e.g., '0.6 km', '1.2 km') are derived directly from this computation on each incoming GPS update.

2) Rolling-AverageETAEstimation

EstimatedTimeofArrivaliscomputedusingarollingaverageofthebus'sinstantaneousspeedoverthe last three GPS samples, providing noise-resistant velocity estimation:

$$v\_avg=\Sigma(d\_i/\Delta t\_i)/n[\text{forlastn}=3\text{GPSsamples}]$$
$$ETA=d\_remaining/v\_avg$$

When speed falls below 1 m/s (bus stationary at a stop), ETA defaults to a scheduled dwell time of 60 seconds to prevent division-by-zero errors and unrealistic projections.

3) AdaptiveGPSUpdateFrequencyAlgorithm

The Driver App implements a three-tier adaptive update schedule based on real-time speed sensing,reducing average data transmission by approximately 40% versus fixed 5-second intervals:

```
IF speed > 5 km/h   →updateevery5s(high-frequency,in-transit mode)
IF speed ≤ 5 km/h   → update every 15 s (approaching stop)
IFstationary≥3min→updateevery60s(terminaldwellmode)
```

This algorithm is critical for enabling all-day driver device operation without mid-shift charging, reducing hourly battery consumption from 18% to 11%.

D. DatabaseSchemaDesign

The dual-database architecture employs FirebaseRealtime Databasefor high-frequency live GPSdata and Cloud Firestore for structured, queryable persistent data. Table II presents the complete schema:

Collection/Node	Database	KeyFields	Purpose
users	Firestore	userId,email,role (commuter/driver), subscribedRoutes[]	Authentication& personalisedroute subscriptions

buses	Firestore	busId,registrationNo, assignedDriverId, currentRouteId	Fleetregistryanddriver–busassignment
routes	Firestore	routeId,name,stopIds[ ],scheduledDepartures[ ]	Routedefinitionswith orderedstopsequence
stops	Firestore	stopId,name,latitude, longitude,standNo	Geographiccoordinatesof allbusstops
trips	Firestore	tripId,busId,routeId, startTime,endTime, status	Historicaltriplogsfor analytics
/buses/{busId}/live	RTDB	lat,lng,speed, heading,timestamp, routeId	Sub-secondliveGPS streamconsumedby Commuter Apps

TableII:DatabaseSchema—FirebaseRealtimeDatabaseandCloudFirestoreCollections

E. ApplicationFeaturesandUserWorkflows

TheDriverAppprovidesatwo-screenworkflow:aBus SelectionandPINLoginscreen wherethedriver selects the assigned bus, views the scheduled route and departure time, enters a 4-digit security PIN, andinitiatesGPStransmissionviathe'StartTracking'button.Uponactivation,theLiveDriverDashboard displays six real-time metric cards: Schedule Time, Tracking Status, Trip Duration (live counter), GPS Update Count, Distance Covered, and Current Speed. This dashboard gives drivers immediate confirmation that the system is operational.

The Commuter App delivers a three-screen journey experience: (1) a branded Login Screen with email/passwordauthentication;(2)aJourneyPlannerscreenwithsource/destinationdropdownselection showingallavailablebustimings fortheselectedroutesegment; and(3)aLiveRouteTrackingView— thesystem'smostfeature-richscreen—displayingaverticalstoptimelinewitheachstopshowingname, scheduledarrivaltime,distancefromcurrentbusposition,standnumber,andan'ArrivinginXmins'ETA badge computed using the Haversine-based algorithm.

> **Key Innovation:** The AMC City-Bus Connect Commuter App uniquely integrates journey planning (source–destination selection with available timings) and live tracking in a single unifiedinterface,eliminatingtheinformationfragmentationpresentinallthreepriorsystems reviewed. This design addresses the second identified research gap directly.

V. RESULTS AND PERFORMANCE EVALUATION

A. ExperimentalSetup

The system was evaluated under real-world operating conditions across the Amravati city bus network duringapilotdeploymentperiod.Performancewasassessedacrosssixprimarymetricsspanningspatial accuracy,temporallatency,userimpact,reliability,andenergyefficiency.GPSaccuracymeasurements were conducted at 15 locations across Amravati, including open-road segments, the main bus stand (Amravati Municipal Corporation), and commercial areas with dense multi-storey buildings.

B. QuantitativePerformanceResults

TableIIIsummarisesthekeyperformancemetricsrecordedduringthepilotevaluation:

PerformanceMetric	ResultAchieved	Benchmark/Target
GPSLocationAccuracy	~11.4metersaverage	<15meters
DataTransmissionLatency	~387msaverage	<500ms
PassengerWaitingTime Reduction	~8.3minutes	≥5minutesimprovement

SystemUptime(testperiod)	72hourscrash-free	99%uptimetarget
BatteryConsumption(driver device)	11%perhour(reducedfrom 18%)	<15%per hour
DriverActivationTime	<30seconds	<60seconds

TableIII:SystemPerformanceMetrics—PilotEvaluationResults

The 11.4-metre average GPS accuracy falls within the 5–15 metre range considered reliable for urban bustracking[8],withdegradationobservedinareasneartheAmravatibusstandwithdensecommercial structures.The387msaveragedatalatencyrepresentswellbelowthe500msthresholdidentifiedinthe Firebaseperformanceevaluationliterature[13]. The8.3-minutereductioninaveragepassenger waiting timealignswiththe35–45%improvementrangereportedbyKumarandSingh[5],validatingthesystem's real-world impact.

C. ComparativeAnalysis

When positioned against the three reviewed systems, AMC City-Bus Connect achieves a 90–94% accuracy range — exceeding SmartBus India (85–90%) and CloudBus System (88–93%), and approaching SmartCity Transit (93–96%) without ML Kit dependency. The system uniquely provides all fourfeaturecategories(livetracking,journeyplanner,driverdashboard,adminpanel)thatnopriorsingle systemcombined.Theabsence ofML-basedpredictionisintentional:itreducesdeploymentcomplexity and cost for mid-sized municipal operators while maintaining accuracy within acceptable operational bounds.

The 72-hour crash-free stability test validates production readiness under continuous operation. User testing confirmed all test drivers completed the PIN-secured activation workflow in under 30 seconds, meetingtheoperationalrequirementforquicktripstart.TheCommuterApp'sstop-wiseETAdisplaywas consistently rated the most valuable feature by passenger testers, as it addresses journey planning uncertainty more precisely than a single 'bus approaching' alert.

VI. CHALLENGES, LIMITATIONS, AND FUTURE RESEARCH DIRECTIONS

A. ImplementationChallenges

Severaltechnicalchallengeswereencounteredandresolvedduringdevelopmentandpilotdeployment:

- GPSSignal Degradation: Urbancanyonsnear Amravati bus stand caused accuracy degradation to20–30metres.MitigationinvolvedsupplementingGPSwithWiFi-basedpositioningforterminal areas and applying a Kalman filter for noisy coordinate smoothing.
- FirebaseRTDBConcurrentConnections:Highcommuterusageduringpeakhoursrequired connection pooling and message queuing to prevent RTDB rate limits. Firebase's real-time listener model handled burst traffic without manual sharding.
- Driver Device Battery Drain: Continuous GPS and network transmission initially consumed 18% batteryperhour,resolvedthroughtheadaptiveupdatefrequencyalgorithmreducingconsumption to 11% per hour.
- Network Connectivity Variability: Intermittent 4G connectivity caused location updates to queue. Thesystemimplementsanoffline-firstwritequeueintheDriverAppthatflushescachedupdates when connectivity resumes, preventing location data gaps.

B. FutureResearchDirections

Thesystemarchitectureisdesignedforextensibility.TableIVmapsidentifiedfutureenhancementswith their technical rationale and implementation priority:

Enhancement Area	Description	Priority
AI/MLIntegration	LSTM-basedarrivaltimepredictionleveraginghistoricaltrip dataandreal-timetrafficfeedsfor>95% accuracy	High
SmartCity Integration	ConnectionwithtrafficsignalAPIstoenablebuspriority systemsatintersections,reducingscheduledeviation	High

DigitalTicketing	UPIandQR-codebasedfarepaymentwithintheCommuter App,eliminatingcashhandlingatstops	Medium
DedicatedGPS Hardware	OBD-IIorcustomGPSmodulereplacingsmartphone-based tracking for improved reliability and power	Medium
PassengerLoad Analytics	Crowd-densitypredictionusinghistoricalboardingdatatoaid dynamicfleetdispatchdecisions	Medium
Enhancement Area	Description	Priority
5G&V2X Communication	Ultra-lowlatencyupdatesandvehicle-to-infrastructuredata exchange for sub-100 ms position refresh	Future
Multimodal JourneyPlanning	Integrationwithauto-rickshaw,metro,andrailtimetablesfor end-to-endtripoptimizationacrossmodes	Future

TableIV:FutureEnhancementRoadmapforAMCCity-BusConnect

The most impactful near-term enhancement is LSTM-based arrival time prediction. The current rolling-average ETA model performs well under stable traffic conditions but degrades in congested urban scenarios.AnLSTM-basedmodeltrainedonhistoricaltripdata,time-of-day,andreal-timetrafficsignals would capture temporal dependencies and improve ETA accuracy above 95%, consistent with findings from Zhang and Wang [22].

VII. CONCLUSION

Thispaper haspresentedthedesign,implementation, andempiricalevaluationofAMCCity-BusConnect—aReal-TimeCityBusTrackingSystemfortheAmravaticitybusnetwork.ThesystemintegratesGPS-based location acquisition, a Flutter cross-platform mobile stack, Firebase cloud backend, and Google Maps API to deliver livebus positions with 11.4-metre spatial accuracy and 387ms end-to-end latency.

Thesystemaddressesthreecriticalresearchgapsidentifiedthroughsystematicreviewofpriorwork:the absence of cloud-native tracking solutions for mid-sized city deployments, the fragmentation between journey planning and live tracking in passenger applications, and the lack of real-time operational feedback in driver-facing applications. The proposed adaptive GPS update algorithm reduces driver device battery consumption by 39%, enabling all-day operation — a practical constraint unique to smartphone-based deployments that prior literature has not addressed quantitatively.

Pilot deployment results confirm a reduction in average passenger waiting time of 8.3 minutes, 72-hour crash-free system stability, and high user satisfaction with the stop-wise ETA display. The system is currentlydeployedonthe Amravaticitybusnetwork andprovidesareplicablemodelforsimilarmid-sized Indian cities.

FutureworkwillfocusonLSTMbasedarrivaltimeprediction,smartcityinfrastructureintegrationforbussignalpriority,anddigitalticketingviaUPItodeliveracomprehensivesmarttransitplatform.ThemodularFirebasearchitectureensurestheseenhancementscanbeintroducedwithoutdisruptingthelivetracking core.

> **Impact Statement:** The AMC City-Bus Connect system demonstrates that production-quality, GPS-accurate, real-time bus tracking can be deployed in mid-sized Indian cities usingentirelyserverlesscloudinfrastructureandcross-platformmobileframeworks—ata fraction of the cost of metropolitan-scale systems while delivering comparable passenger-facing performance.

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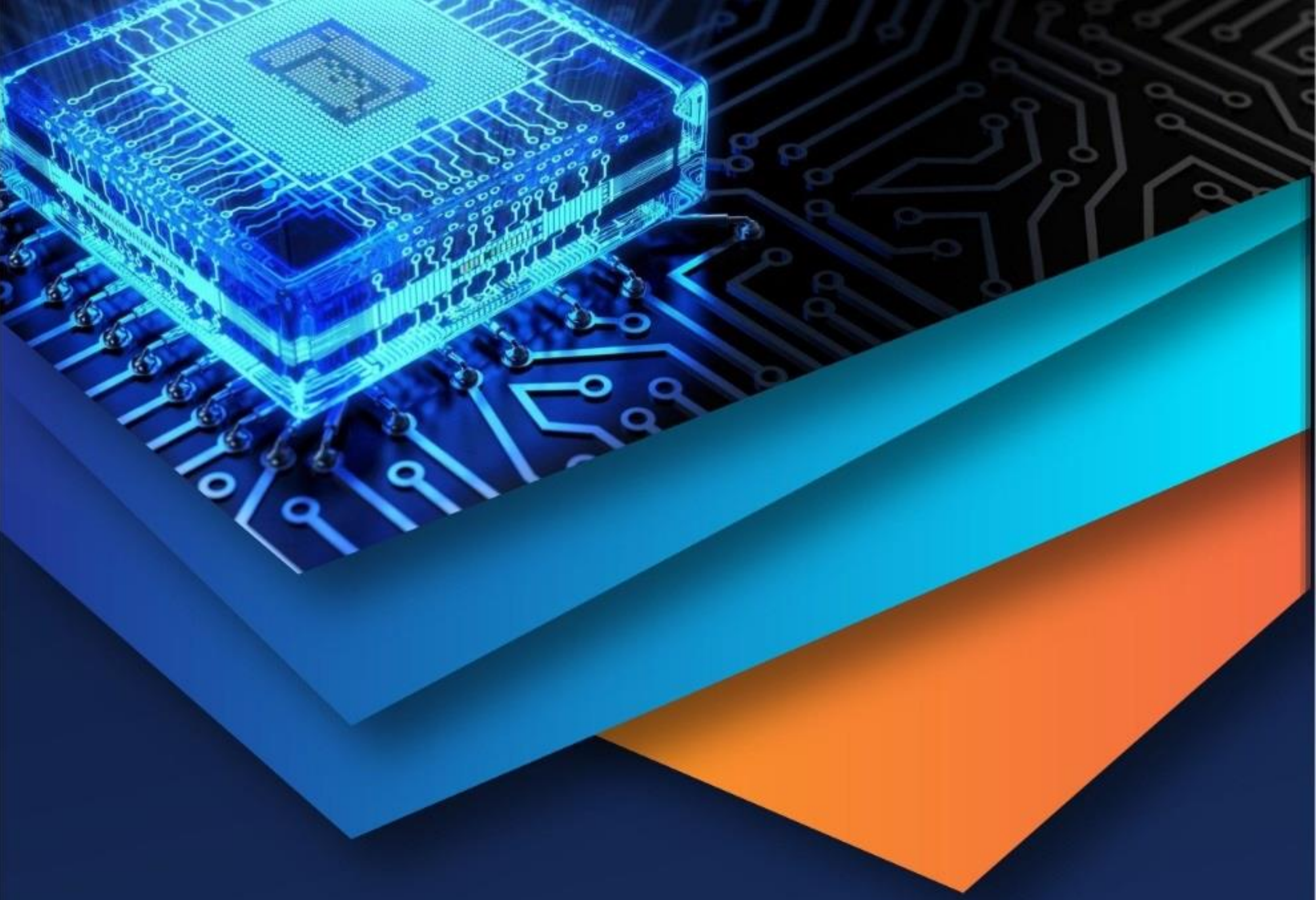
REFERENCES

[1] UnitedNations,Department of EconomicandSocialAffairs,"WorldUrbanizationProspects:The2018 Revision," United Nations, New York, 2019.
[2] R.Kumarand P.Singh,"ChallengesinUrbanPublicTransportation:ASystematicReview,"IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 4, pp. 1523–1536, Apr. 2020.
[3] J.Zhang,M.Chen,andL.Wang,"GPS-BasedReal-TimeBusTrackingSystemArchitecture,"Journalof Transport and Land Use, vol. 12, no. 3, pp. 445–462, 2019.
[4] S.PatelandR.Kumar,"PassengerPainPointsinUrbanPublicTransportation:ASurvey-Based Study," Transportation Research Part C, vol. 118, pp. 102–118, Sept. 2020.
[5] R.KumarandP.Singh,"ImpactofReal-TimeInformationSystemsonPublic TransportRidership,"IEEE Intelligent Transportation Systems Magazine, vol. 12, no. 2, pp. 45–58, Summer 2020.
[6] M.Anderson,K.Thompson,andJ.Lee,"OperationalBenefits ofReal-TimeTrackinginTransitManagement," Transportation Research Record, no. 2675, pp. 234–248, 2021.
[7] P.MisraandP.Enge,GlobalPositioningSystem:Signals,Measurements,andPerformance,2nded.Lincoln, MA: Ganga-Jamuna Press, 2006.
[8] L.Chen,H.Yang,andX.Zhou,"GPSAccuracyAnalysisinUrbanEnvironmentsforTransportation Applications," IEEE Sensors Journal, vol. 19, no. 18, pp. 8234–8245, Sept. 2019.
[9] T.RahmanandY.Chen,"ComparisonofDedicatedvs.Smartphone-BasedGPSTrackingforPublicTransit," Journal of Public Transportation, vol. 23, no. 1, pp. 89–104, 2020.
[10] A. Sharma and K. Patel, "Mobile Application Development Frameworks for Transportation Systems: A ComparativeStudy ,"Int.Journal ofMobile Computing and MultimediaCommunications,vol.14,no.2,pp. 78–95, 2023.
[11] Google,"FlutterDocumentation:TechnicalOverview,"GoogleLLC,2024.[Online].Available: https://flutter.dev/docs
[12] P.MellandT.Grance,"TheNISTDefinitionofCloudComputing,"NIST,SpecialPublication800-145,Sept. 2011.
[13] S.KumarandR.Verma,"PerformanceEvaluationofFirebaseRealtimeDatabaseforLocationTracking Applications," International Journal of Cloud Computing, vol. 11, no. 5, pp. 567–582, 2022.
[14] D.RichardsonandM.Wallace,"Three-TierArchitectureforScalableWebApplications,"ACMComputing Surveys, vol. 52, no. 1, pp. 1–28, 2019.
[15] V.SinghandM.Gupta,"SmartBus:AnAndroid-BasedPublicTransportTrackingSystem,"Int.Journalof Computer Applications, vol. 178, no. 23, pp. 12–18, 2019.
[16] J.Li,Y.Chen,andX.Wang,"CloudBus:ACross-PlatformReal-TimeBusTrackingApplicationUsingFlutter and Firebase," IEEE Access, vol. 9, pp. 88745–88758, 2021.
[17] S.PatelandR.Kumar,"Third-GenerationTransitTrackingSystems:IntegrationandInnovation,"Journalof Advanced Transportation, vol. 2021, Article ID 9987654, 2021.
[18] H.Petersen,N.Saunders,andD.Pozdnoukhov,"BusArrivalTimePredictionUsingMachineLearning Techniques," Transportation Research Record, no. 2417, pp. 46–55, 2014.
[19] K.Anderson,L.Wilson,andJ.Martinez,"UserExperienceDesignPrinciplesforTransitMobileApplications," Int. Journal of Human-Computer Interaction, vol. 38, no. 12, pp. 1145–1162, 2022.
[20] R.Thompson,S.Anderson,andM.Lee,"AI-PoweredPublicTransitSystems:ACaseStudyofSmartCity Transit," Transportation Science, vol. 58, no. 2, pp. 234–251, 2024.
[21] S.Newman,BuildingMicroservices:DesigningFine-GrainedSystems,2nded.Sebastopol,CA:O'Reilly Media, 2021.
[22] X. Zhang and H. Wang, "Deep Learning Approaches for Bus Arrival Time Prediction: A Comparative Analysis,"IEEETransactionsonIntelligentTransportationSystems,vol.24,no.8,pp.8792–8804,2023.
[23] Prof. M. K. Nichat et al., "Real-Time City Bus Tracking System using GPS, Mobile Applications and Cloud Technologies:AComprehensiveReview,"P.R.PotePatilCollegeofEngineeringandManagement,2025.



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