

# A Survey on Physical Random Access Channel Performance Evaluation and Preamble Detection in 5G Systems

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**Abstract** From the past few years, the networking technology is been emerged in a very high speed and have been currently research been existing on 5G technology and above. The Physical Random Access Channel (PRACH) playing a major role in improvising and modernizing the Wireless technology. This importance of PRACH makes as a necessary criteria to evaluate the performance of the PRACH based on various performance evaluation techniques with the modern networking models. Moreover, there are various challenges existing in environment of random access networks, that allows the unlicensed secondary users to use the channels and not allowing the primary licensed users to use the maximum channel bandwidth. In this research topic, we aim at focusing on the various PRACH techniques applied which aim at the evaluation of the performance of the channel. Initially, the paper focuses on the explanation of the various terminologies used for the system. Later, we focus on the major fine tuning methodologies been used to improvise the performance and the evaluation parameters been used by each researchers. In this article, we have considered various emerging technologies the researchers have developed to overcome the performance issues of the PRACH. Initially we explain the parameters included in the performance evaluation, and in the later part we will discuss about the improvements in the technology to have better performance. Finally, we concluded with positive outcomes and the drawback of all the discussed major technologies and the algorithms.

**Keywords** — Physical Random Access Channel, 5G, LTE

## I. INTRODUCTION

A huge revolution is been created from the past decade by the device to device communication systems. Owing towards its approach the low-cost solution, the provision remains to be mostly reinforced by the present Long-Term Evolution (LTE) cellular admission skill that consumes mature in footings of attention also manufacturing price. Yet, the LTE expertise is formerly intended aimed at human-centric communications as well as might not manage fine by the enormous expedient populace of the massive Machine Type Communication (mMTC) provision. Lessons after the 3GPP also works consume certainly exposed that once tens of thousands of Mobile telephony system D (MTDs) awaken conscious then try to admittance an LTE cell hip an extremely coordinated way, the cell's Physical Random Access Channel (PRACH) might remain sternly loaded, which consequences vogueish an important ration of the MTDs not actuality capable to get admittance privileges beforehand beyond the extreme quantity of allowable efforts.

The 3GPP consumes elevated the essential to reenter the enterprise of following peers of cellular nets in command to

style them proficient also well-organized to offer Machine-to-Machine (M2M) facilities. Unique of the crucial contests that partakes been known is the essential to improve the process of the chance admission frequency of LTE also LTE-Advance (LTE-A). The existing device to petition admittance towards the system is recognized to agonize after mobbing besides congestion in the incidence of a vast amount of strategies. Aimed at this aim, dissimilar investigation collections about the ball are employed to the enterprise of supplementary effective conducts of handling the admittance towards these nets in such situations. A inclusive conversation of the dissimilar replacements is providing, classifying fortes besides indistinctness of all unique of them, though sketch upcoming tendencies to coxswain the exertions done the similar salvo streak. In adding, though current works consumes stood absorbed taking place the recital in rappsorts of interruption, the vigor competence of the admission apparatus of LTE willpower piece a crucial part in the placement of M2M grids. Aimed at this aim, a inclusive presentation assessment of the vigor competence of the haphazard entree appliance of LTE is providing cutting-edge this broadside. The intention of this computer-based pretend revision remains to usual a point of

departure exhibition upon which novel also supplementary energy-efficient strategies canister be intended cutting-edge the nearby forthcoming.

To content the community necessities of many IoT devices, numerous wireless methods stayed advanced also specific industrialized values remained recognized. In specific, founded scheduled the variety of IoT nets, these methods canister be alienated hooked on two groups: solitary is short-range communiqué expertise, such by way of Z-Wave Zigbee as well as WirelessHART, Bluetooth Low Energy (BLE), a;6LoWPAN. The former is low power wide area network (LPWAN), such by way of ECGSM besides LTE-M working in approved orchestras, also LoRa as well as SigFox operating in uninhibited bands. Cutting-edge September 2015, narrow band Internet of Things (NB-IoT) remained originally presented by the (3GPP) by way of a novel LPWAN resolution also was consequently quantified in Proclamation 13. NB-IoT is well-matched by numerous IoT requests besides resolves the problematic of disintegration too inadequate attention of old-style skills, therefore with any luck hastening the applications of IoT nets.

## II. MAJOR TERMINOLOGIES

In order to give a complete idea about the methodologies and the researches in this we section we give a brief idea about the major scientific terminologies used in these chosen survey papers.

### A. Physical-Random-Access-Channel:

The random-access channel (RACH) stands a communal station rummage-sale thru wireless depots to admittance the mobile net (TDMA/ FDMA, also CDMA based network) aimed at plea set-up also bursty information broadcast. When itinerant needs to sort an MO (Mobile Originating) plea it agendas the RACH. RACH remains transport-layer station; the consistent physical-layer station is PRACH.

Alike towards LTE, NR(New Radio) PRACH remains rummage-sale to carry chance admission introduction after User Equipment (UE) to gNodeB(gNB) also it assistances gNB to regulate uplink controls of the UE. The chief difference amid LTE RACH also NR RACH would remain the provision aimed at beam establishing which would remain reinforced by evasion in mm Surge in NR. While NR UE remains functioning voguish beam founding method, it will sense besides choice a finest beam aimed at NR RACH procedure. While a appropriate beam couple hip one of the broadcast guidelines is resolute, the similar couple canister then be castoff likewise in the conflicting broadcast route in the opinion of beam communication.

### B. 5G

In communications, 5G is the fifth cohort expertise typical for broadband cellular systems, which cellular telephone businesses instigated organizing universal in 2019, besides

is the deliberate heir towards the 4G nets which deliver connectivity towards greatest existing cellphones. 5G nets are prophesied to consume supplementary than 1.7 billion subscribers universal through 2025, rendering toward the Global System for Mobile Communication(GSM) Connotation. Similar its precursors, 5G nets remain cellular nets, cutting-edge which the provision expanse is alienated hooked on trivial physical parts baptized cells. Altogether 5G wireless expedients hip a cell remain associated toward the Internet also phone net thru radio surfs finished a native feeler hip the cell. The key benefit of the novel nets is that they determination consume better bandwidth, generous advanced transfer rapidity, finally awake to 10 gigabits for every second (Gbit/s). Owing towards the augmented bandwidth, the aforementioned is probable the nets determination progressively remain castoff as over-all internet provision breadwinners meant at laptops also desktop processors, rival by current Internet Service Provider (ISPs) such by way of shackle internet, besides likewise fortitude variety plausible novel solicitations hip internet of things besides mechanism to appliance extents. 4G cellphones remain not competent to usage the novel nets, which need 5G allowed wireless strategies.

The amplified rapidity is attained partially by means of extra higher-frequency receiver influences in adding towards the squat also average band incidences castoff in preceding cellular nets. Though, higher-frequency receiver surfs consume a littler beneficial corporeal assortment, needful slighter physical cells. Aimed at extensive provision, 5G nets function taking place up towards three rate of recurrence crews – low, medium, also high. A 5G net determination be tranquil of nets containing of up and about near three dissimilar kinds of cells, every requiring precise protuberance enterprises by way of thriving as provided that a dissimilar compromise of transfer rapidity to expanse also provision zone. 5G cellphones also wireless strategies attach to the net over the uppermost rapidity projection inside variety by their locality.

## III. BIBLIOGRAPHIC REVIEW

We present an overview of all the existing modern research trends been performed to evaluate the performance of PRACH in the 5G and other model below.

Quiming et al [1] propose an optimum action recognition structure is initially intended thru by the Neyman-Pearson standard. Formerly, a low-complexity iterative exploration procedure is advanced aimed at the combined estimate of residual-carrier-frequency-offset (RCFO) besides timing-advanced (TA), evading the consequence of stage vagueness. Lastly, imitation consequences cooperate the efficiency as well as competence of the imminent receiver.

Anh-Tuan et al [2] suggest to spiritedly refrain together the excepting influence also the callous excepting period by a strengthening erudition method recognized by

way of the Conflicting Deep Q-Network. Processor simulations demonstration that assumed a convinced broad-mindedness near on admittance interruption also energy ingestion, our enterprise canister attain a suggestively advanced glassy of vigor gratification though upholding a analogous equal of interruption gratification likened to arrangements that solitary emphasis on alteration the excepting aspect.

Houcine et al [3] suggest receiver approaches aimed at the recognition of the novel waveform must content the necessities scheduled the effective operator revealing as thriving as the effectiveness management accurateness. This remains not a inconsequential chore, particularly hip the incidence of radio deficiencies alike carrier-frequency-offset (CFO) which establishes one of the chief transistor deficiencies also the sound. In directive to wrestle this problematic, we suggest a novel receiver technique aimed at NB-IoT Physical-Random -Access-Channel (NPRACH). The technique is intended to remove flawlessly the CFO deprived of any supplementary computational intricacy besides provisions all NPRACH preface arrangements. The related recital partakes remained assessed underneath 3GPP circumstances.

Yuan et al [4], suggest a combined manipulator action trailing also information recognition process grounded on the influence chart outline, which depend on a erudite mixture of expectation maximization (EM) also amalgam communication transitory systems. The intricacy of the system supported solitary upsurges linearly by the amount of lively operators. Our simulated consequences demonstration that the projected system is actual in pursuing operator action also noticing data cyphers in lively arbitrary admittance systems.

Miuccio et al [5], recommend a novel outline, modified for huge MTC facilities, that comprises a combined regulator of the vibrant source distribution amid the PRACH also the Physical Uplink Shared Channel(PUSCH), besides a novel arbitrary admittance process grounded off an adaptive Access-Class-Barring (ACB) system that suitably banquets arbitrary admittance re-attempts hip interval. In tally, to supplementary upsurge the broadcast competence, we espouse the Sparse-Code-Multiple-Access (SCMA) system for PUSCH possessions, since SCMA fallouts by way of the utmost auspicious Non-Orthogonal-Multiple-Access (NOMA) method to provision massive MTC connectivity by small-size statistics. Simulated consequences demonstration that the projected regulator outline ominously recovers the amount of prospered communications in contrast by the further suggestions obtainable in fiction. Also, an energy ingesting classical is presented to demonstration the substantial vitality redeemable attained thru the MTC maneuvers which espouse our combined regulator structure.

Aleixandre et al [6], projected supersets besides the

novel 5G PRACH set-ups, hundred-times additional lockups deprived of order re-claim canister be reinforced likened to ZC orders for a abstemiously superior inter-cell association than intra-cell association. Simulated consequences indorse that by the anticipated supersets in its place of re-claiming orders in the net can expressively progress recognition recital.

Pham et al [7], projected technique usages an improved algorithm by multi-detection phases to castoff efficiently untrue unease crests in line for to sound besides station complaint as multipath declining, Doppler-shift, occurrence counterpoise also effectiveness equipoise. Virtual reality consequences display that the projected technique with augmented recognition verges placates the necessities of system around recognition prospect also untruthful alarm prospect underneath a definite Signal-to-Noise-Ratio(SNR) level besides proliferation malady.

Orim et al [8], recommend a precedence grounded spatial combination process to adequately uphold a stable trade-off amid the influence spent thru MTCs formerly their quality-of -service (QoS) necessities. The projected scheme stretches importance toward Ultra-reliable Low-Latency Communication (uRLLC) strategies (UMTCs) over power ramping voguish the physical-random-access-channel (PRACH). The presentation events demonstration a reduction hip the regular power disbursed thru UMTCs through uplink huge admittance besides a substantial decrease hip their dormancy deprived of excepting admittance towards non-delay profound MTCs.

Jayashree et al [9], steered a complete presentation assessment of dissimilar random access (RA) improvements aimed at uRLLC above 5G wireless nets. Our recital assessment is grounded off a genuine system-level simulant. The essential improvements deliberated hip this exertion comprise early-data-transmission (EDT), earmarked introductions also the usage of lithe physical (PHY) film numerology. We likewise recommend three novel RA improvements aimed at uRLLC. Recital assessment proves that the projected RA improvements canister achieve the 3GPP regulator plane aim of lesser than 10 ms expectancy by 99.99% consistency hip factory surroundings.

Gwondo et al [10], approved out secure fact connection equal simulated to understand the applied presentation in scheming modem piece for UE then gNB. In the secure theme simulated, we presumed the sample frequency of 61.44 Msps, 30 kHz subcarrier space, 3.7 GHz norm incidence, also 40 MHz method bandwidth. To decrease the difficulty hip the receiver, we working the alpha do well plus beta min procedure, which stays a high rapidity estimate of the square-root of the amount of two-squares. We mentions towards the presentation necessities defined hip 3GPP TS38.104, which defines the indorsed presentation necessities for corporeal chance admittance station for novel radio.

Harwahu1 et al [11], attempt to optimally skill additional time-diversity improvement in introduction broadcast acquired from ‘retransmission’ to decrease the ‘repetition’ obligation in NB-IoT. The desired areas aimed at untainted ‘repetition’ also ‘retransmission’ structures dispersal the similar quantity of NPRACH source below numerous obtainable loads also channel situations remain

first examined. The optimum quantity of NPRACH source, ‘repetition’ assessment, also ‘retransmission’ assessment remain before got matter to a objective efficacious possibility. The consequences demonstration that the entrenched retransmission fauna of NPRACH canister efficiently decrease the amount of recurrences.

Algorithms		Reference	Metrics			Validation			Traffic		Number of devices**
Method	Sub-Method		Energy	Delay	Throughput	Test bed	Simulation	Theory	M2M	H2H	
MAC Optimization	Pre-coded Preamble	[3]	✓				✓				-
	Data in Message	[2]	✓	✓			✓				-
schemes for Class Barring	ACB Scaling Individual	[7]	✓	✓			✓			✓	-
	Access Barring Extended	[4]	✓				✓		✓		35000
		[5]	✓					✓	✓	✓	37496
	Access Barring Dynamic *	[6]	✓						✓		37296
	ACB Cooperative	[8]	✓	✓			✓	✓	✓	✓	55000
RA Resources Separation	occasions for Split PRACH	[1]	✓								-
	Preambles for Split	[10]	✓				✓	✓	✓		35000
		[12]	✓	✓				✓		✓	110 per min
	Allocation of Virtual Resource *	[14]	✓						✓	✓	37496
Other Methods	RACH Resources Dynamic Allocation	[9]	✓				✓				32000
	Schemes for Back off Adjustment	[16]	✓				✓		✓		32000
		[13]	✓	✓			✓				-
	Slotted access	[17]	✓				✓				-
	Access with Prioritized Random	[18]	✓				✓		✓	✓	38396
	Control with Self-Optimizing Overload	[20]	✓	✓					✓		-
	Code RA	[11]	✓				✓				1300

Table 1 Survey Comparison

Mukherjee et al [12], recommend to usage the huge antenna collection at the huge multiple contribution multiple production BS to together collection RA needs after dissimilar operators by means of the similar RA preface. We formerly beam procedure the communal Random Access Response (RAR) of every perceived operator cluster on the similar incidence reserve, hip such a method that utmost manipulators hip the collection canister consistently decipher the RAR. The projected RAR beam creating consequently routinely resolutions the problematic of impact amid manifold RA requirements scheduled the similar preface, which lessens the RA dormancy suggestively as associated to LTE. Examination also mockups as well divulge that meant at a secure predicted sign to intrusion besides sound proportion of the established RAR, together the obligatory per-user preface broadcast

power also the entire RAR beam creating power canister be reduced coarsely by 1.5 dB by each replication in the amount of Base-Station(BS) tentacles.

Schreiber et al [13], projected enterprise is actual vigorous alongside incidence qualms inventing after wireless station proliferation also indigenous oscillator inadequacies. Replication consequences show that the proposed *m*- sequence based preambles bring decent recital smooth below exacting broadcast circumstances, though ZC grounded prefaces fail. Supplementary compensations of accepting *m*-sequence grounded prefaces in 5G NR comprise random-access-channel (RACH) volume improvement, provision aimed at low-power strategies besides squat intricacy execution.

Pitaval et al [14], suggest a explanation grounded scheduled an leeway of the LTE PRACH order set. Cell-

specific arrangements remain resultant after solitary origin Zadoff-Chu (ZC) orders by a zero association region, also if essential, diverse m-sequence concealments in its place of manifold origins by way of in LTE. Though this edifice is revealed to sanctuary a like low-correlation region by way of thru the LTE intention, the aforementioned ensures not devour the extra ZC roots which canister formerly be castoff to sustenance additional cells. The projected PRACH intention is assessed by 5G link-level imitations to prove the predictable decent discovery recital also squat PAPR.

Xiong et al [14], projected Orthogonal Frequency Division Multiplexing (OFDM) baseband indication cohort aimed at PRACH, the indication is located in amid of the information stations as intermediate by way of conceivable hip instruction to ease the probable intrusion after adjoining subcarriers. Likewise, the projected etiquette initiative receipts the impression of multi-beam competence hooked on interpretation. The intention of solitary Msg.1 by multi-beam process also tender of numerous Msg.1 remain together deliberate. The simulated fallouts are obtainable to exemplify the presentation of our projected arbitrary admittance resolutions.

Neng et al [15], enthused thru the perception of conservative NOMA. In NOMA, one corporeal reserve expanse is kept also alienated hooked on orthogonal resource-units (RU), wherever every operator is allowable to persuade-randomly convey the similar pack on every one RU rendering to enhanced prospect. By the receiver, inter also intra-RU Successive-Interference -Cancellation (SIC) remains practical aimed at multi-user getting. A edge construction remnants likewise envisioned to permit NOMA, anywhere gesturing overhead on apprising every UE with allotted possessions is abridged. Simulated fallouts spectacle, the planned technique is vigorous also is able to attain expressively improved recital than original accidental admittance technique, i.e. uneven recurrence positioned aloha, wherever its admittance gradation delivery stands enhanced in lieu of binary expurgation station.

Jang et al [17], recommend an initial preamble-collision-detection (e-PACD) structure on the chief stage of RA process grounded off marked prefaces, which entail of together PA also label Zadoff-Chu classifications by dissimilar root statistics, correspondingly. The projected e-PACD structure allows faster PA crash recognition also notice, likened by the conservative RA system. So, it canister decrease the RA interruption also also eliminate reserve wilds which arise by the third phase of the conservative RA process. The abridged RA interruption attained thru the projected e-PACD structure canister give to an ultralow dormancy obligation hip 5G cellular nets. In adding, the anticipated e-PACD outline allows the eNodeB to display the amount of RA-attempting bulges (RA load) scheduled every physical-random-access-channel (PRACH) slot.

Cassiau et al [18], yet demonstration that it remains likely to intention a FBMC structure by fairly robust time restraints. The defy remained to contrivance a Long-Term-Evolution (LTE) similar Physical-Random-Access-Channel (PRACH) grounded on FilterBank Multi Carrier (FBMC). Incidence Dispersal execution of FBMC remains rummage-sale also a PRACH is intended by equal or improved time also incidence localizations than the LTE traditional PRACH.

Lai et al [19], recommend a tactic to evade the crucial error frequency presentation forfeiture triggered by via codebooks that remain intended by our process. The projected higher inevitable abetted codebook project chaos canister inferior comparatively good codebooks by low difficulty. By uniting Sparse Code Multiple Access(SCMA) codebook intention also safe communiqué, our structure make sure preserve for gigantic extents of operators by low encoded also decrypted intricacy by the price of broadcast rate also likely inaccuracy rate recital forfeiture. Furthermore, the projected arrangement canister attain heftiness in contradiction of station valuation mistakes. Examines also Monte Carlo replications indorse the efficiency of our structure.

Park et al [20], recommended technique is associated by LTE Time Division Duplex(TDD) PRACH structure technique over theoretic examination. It demonstrations that the projected technique delivers improved reserve exploitation for PRACH also corporeal uplink collective station possessions (PUSCH), permits lithe source exploitation hip uplink preparation, also is instinctive also operative hip cell disposition by arbitrary admittance station optimization vogueish rapports of arbitrary admittance source outline.

Wunder et al [21], follow-up off current perceptions uniting progressive MAC etiquettes by Compressed-Sensing (CS) grounded multiuser recognition. Precisely, we present a perception for scant cooperative bustle, station also information recognition hip the milieu of the Oblique ALOHA (FDMA) etiquette. We drive contend that a guileless scant commotion also data revealing remains not adequate (as numerous papers do) since regulator capitals remain hip the directive of the information. In adding, we drive rally off the presentation of such conventions now rapports of the deterioration of assets obligatory aimed at the operator bustle, station approximation also information recognition. We determination precisely examine the structure consequently besides deliver lexes aimed at the detention prospects of the basic meager multiuser finder.

#### IV. CONCLUSION

Based on the bibliographic review of different research articles and on the parameters considered the following conclusions can be drawn. As per different researchers working in the field of 5G technology and the organization

responsible for 5G, the RA channel of LTE and 5G is prone to collision when the number of PRACH devices simultaneously attempting to access the system is very high.

An ample analysis and contrast of the existing research work has been presented in this article. Prevailing solutions have been categorized depending on various approaches to solve the congestion problem. The executive summaries for congestion problem solutions are

- a) 5G layer optimizations.
- b) Assigning separate resources for 5G and PRACH traffic.
- c) Arrival request distribution along time adopt to random counters.

Some researchers have come up with the idea of hybrid approach where all the solutions mentioned above are used. Yet, state of the art method to this problem need to be found to improve the random access channel utilization and to reduce the congestion.

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