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ANALYSIS OF SIGNAL QUALITY MEASUREMENT AND MEASUREMENT REPORT MECHANISM IN 5G NR SYSTEM

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Abstract. This paper presents a systematic analysis of the signal quality measurement mechanism and the operation principles of the measurement report system in fifth-generation (5G) New Radio (NR) mobile communication systems. The physical meaning, measurement methods, and practical application of the indicators defined in the 3GPP TS 38.215 standard — RSRP (Reference Signal Received Power), SINR (Signal-to-Interference-plus-Noise Ratio), and RSRQ (Reference Signal Received Quality) — are described in detail. The signal monitoring requirements of various service types — enhanced Mobile Broadband (eMBB), Ultra-Reliable Low-Latency Communication (URLLC), and massive Machine-Type Communication (mMTC) — are comparatively analyzed. The Non-Standalone (NSA) and Standalone (SA) variants of the 5G NR network architecture, as well as the RedCap (Reduced Capability) devices introduced in Release 17, are examined in the context of signal measurement. The discrete values of the ReportInterval parameter defined in the 3GPP standard are analyzed, and the inefficiencies caused by the current static assignment practice for low-mobility IoT devices — including energy consumption, signaling overhead, and radio resource waste — are demonstrated. The difference in signal stability between stationary and mobile devices is quantitatively assessed based on RSRP and SINR variance. The analysis results substantiate the necessity of developing an adaptive ReportInterval management mechanism.

Keywords: *5G NR, RSRP, SINR, RSRQ, measurement report, ReportInterval, signal quality, IoT, RedCap, 3GPP, radio resource management.*

1. Introduction

The fifth-generation mobile communication system (5G NR) has been standardized by 3GPP starting from Release 15 and is being deployed globally. By 2024, the number of 5G subscriptions reached 2.3 billion, and this figure is expected to grow to 6.3 billion by 2030 [1]. The system supports three main service types: enhanced Mobile Broadband (eMBB), Ultra-Reliable Low-Latency Communication (URLLC), and massive Machine-Type Communication (mMTC) [2]. The radio resource requirements of each service type differ significantly, which increases the complexity of network resource management algorithms.

The central element of the Radio Resource Management (RRM) mechanism in the 5G NR system is the measurement report periodically sent by the User Equipment (UE) to the base station (gNB) [3]. Based on these reports, the gNB performs cell selection, handover decisions, modulation level adaptation, and other RRM functions. The quality and frequency of the reports directly affect network performance. In particular, timely and accurate reports increase the handover success rate and reduce connection interruptions.

At the same time, an increasing share of 5G connections is being formed by stationary or low-mobility devices — IoT sensors, smart meters, industrial monitors, and RedCap terminals introduced in Release 17 [1, 4]. The signal characteristics of these devices fundamentally differ from those of traditional terminals moving at high speed. For stationary devices, signal indicators remain relatively stable over time, and rapid handover decisions are not required.

In recent years, the issue of energy efficiency in 5G networks has received particular attention [11, 12]. Extending the battery life of IoT devices and rational utilization of network resources have become pressing issues [13]. Furthermore, it has been established that signal propagation characteristics differ significantly across frequency ranges in 5G NR — sub-6 GHz and mmWave [14, 15], which imposes additional requirements on the signal monitoring mechanism. In the mmWave range, issues such as rapid signal attenuation and inability to penetrate obstacles exist, while in sub-6 GHz the coverage is wider but the throughput is lower.

Within the 3GPP standards, UE energy saving mechanisms — C-DRX (Connected Mode Discontinuous Reception), RRC Inactive state, and others — have been extensively studied [9]. However, these mechanisms do not fully eliminate the measurement report obligation. A device in RRC_CONNECTED state is forced to send reports according to the assigned ReportInterval regardless of signal conditions.

This paper systematically analyzes the signal quality indicators and measurement report mechanism in the 5G NR system, identifying the problems arising in the context of low-mobility devices. The main objective of the paper is to demonstrate the inefficiencies of the current static ReportInterval assignment practice for low-mobility IoT devices and to substantiate the necessity of adaptive management.

2. Literature Review

Research on signal measurement and reporting mechanisms in 5G NR systems has been conducted extensively. Holma et al. [11] provided a detailed description of NR physical layer measurements, calculation methods for SS-RSRP and CSI-RSRP indicators, and the relationship between the measurement report system and RRM in their work dedicated to 5G technology. The authors specifically analyzed the behavior of SSB and CSI-RS signals across different frequency ranges, demonstrating the differences between sub-6 GHz and mmWave. They emphasized that beam management and signal measurement processes in the mmWave range are considerably more complex and require additional resources.

Baek et al. [7] analyzed the updates introduced in 3GPP Release 16 for 5G IoT, discussing the problems of energy consumption and signaling overhead for devices in RRC_CONNECTED state. The study showed that the existing measurement report mechanism for IoT devices was designed for high-mobility terminals and has not been optimized for stationary scenarios. The authors demonstrated that IoT devices are characterized mostly by low data rates and long-duration connections, which exacerbates the inefficiency of existing RRM mechanisms.

Lauridsen et al. [8] investigated connection mobility during the transition from LTE to 5G, empirically analyzing how signal indicators change across different speed regimes — pedestrian (0–3 km/h), vehicular (30–120 km/h), and high-speed (120–500 km/h). Their results quantitatively confirm the difference in RSRP variance between stationary and mobile devices. Specifically, it was noted that RSRP variation in stationary conditions was around 2–3 dB, while at high speed this indicator increased to 15–20 dB.

Huang et al. [12] conducted a deep analysis of the relationship between energy consumption and performance indicators in mobile networks. They demonstrated that the energy consumption of the radio interface in active state is hundreds of times higher than in deep sleep mode. This finding provides an important basis for understanding the negative impact of excessive measurement reports on battery life. The study also quantitatively assessed the impact of radio chain activation and deactivation cycles on device batteries.

Rodriguez et al. [13] measured indoor propagation loss across frequency ranges from 800 MHz to 18 GHz. They showed that signal levels for indoor devices remain relatively stable, but attenuation increases with frequency. These results support the signal stability hypothesis for stationary devices. In particular, it was found that indoor RSRP variation in the 800 MHz and 2100 MHz ranges remained stable at around 3–5 dB.

Narayanan et al. [14] were the first to measure the real performance indicators of commercial 5G networks on a large scale. The study demonstrated how signal quality indicators differ across various environments — indoor, outdoor, and in motion — based on empirical data. The findings regarding the stability of RSRP and SINR in stationary conditions provide an important context for this research.

The 3GPP TR 38.840 document [9] provided a detailed analysis of UE energy saving mechanisms, including C-DRX. The power consumption model presented in the document — 255.5 mW in active mode and 0.7 mW in deep sleep — serves as the primary source for estimating the energy cost of measurement reports. The C-DRX mechanism allows the UE to save energy by turning off the receiver chain during the DRX cycle, but it does not eliminate the obligation to send measurement reports.

Lin et al. [17] investigated the possibilities of applying machine learning methods for handover optimization in 5G networks. They demonstrated that making handover decisions based on prediction of signal indicators improves efficiency. This approach is directly related to the idea of detecting signal stability for stationary devices and adapting measurement report frequency.

The analysis of the above literature shows that signal measurement indicators and RRM mechanisms have been widely studied in existing research. However, the issue of adaptive ReportInterval management based on device type and signal stability has not been sufficiently investigated. This paper is aimed at filling precisely this gap.

3. 5G NR Architecture and Device Categories

Network architecture. 5G NR has been deployed in two types of architecture [2]. In the Non-Standalone (NSA) architecture, the 5G radio network operates in conjunction with the existing 4G LTE core network (EPC) — this is convenient for rapid deployment but limits the utilization of all 5G capabilities. In the NSA architecture, gNB operates with the LTE eNodeB through dual connectivity, and control signaling is handled by the LTE side. In the Standalone (SA) architecture, a fully independent 5G core network (5GC) is used, which enables full support for network slicing, URLLC, and other advanced functions. In both cases, the base station — gNB — plays a central role. Structurally, gNB consists of a CU (Central Unit) and one or more DUs (Distributed Units), where the CU handles RRC signaling and PDCP functions, while the DU manages the MAC and PHY layers [2]. The CU-DU split architecture increases network flexibility and supports various deployment scenarios.

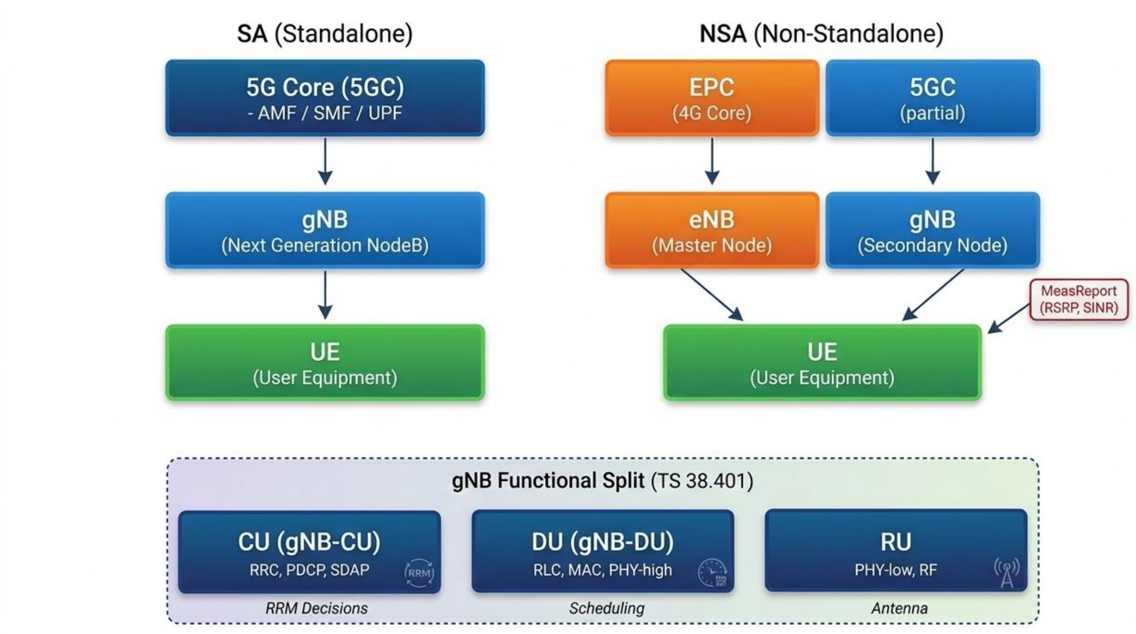

Figure 1. NSA and SA architectures of the 5G NR network: CU/DU structural composition of gNB

The gNB requires periodic measurement reports from UEs to continuously monitor signal quality. These reports are mandatory for all devices in RRC_CONNECTED state, and their frequency is controlled through the ReportInterval parameter [3]. Based on the received reports, the gNB compares the signal indicators of the serving cell and neighbor cells to assess the need for handover. In the SA architecture, measurement reports are delivered directly to the gNB CU, while in NSA the processing procedure through the LTE eNodeB may be more complex.

Service types and their signal monitoring requirements. The three service types standardized during 3GPP Releases 15–18 differ significantly from the signal monitoring perspective. Table 1 presents the main parameters for eMBB, URLLC, and mMTC service types:

Table 1. 5G NR service types and their main characteristics

Parameter	eMBB	URLLC	mMTC / RedCap	Measurement frequency requirement	Measurement report overhead
Purpose	High-speed enhanced mobile broadband	Ultra-reliable low-latency communication	Massive machine-type communication (IoT)	High	High
Data rate	Up to 20 Gbit/s (downlink)	Up to 1 Gbit/s	Up to 1 Mbit/s	High — changes rapidly at high speed	High — frequent reports needed
Latency requirement	4 ms (eMBB)	1 ms (URLLC)	Up to 10 s (relaxed)	Medium — important for handover	Medium
Connection density	10^4 devices/km²	10^4 devices/km²	10^6 devices/km²	Not directly related	Not directly related
Mobility	Up to 500 km/h	Up to 500 km/h	Stationary or	Key factor — frequency	Proportional

			0–3 km/h	increases with speed	to speed
Battery life	1–2 days (smartphone)	1–2 days	5–15 years (sensor)	Less critical (smartphone)	Less critical (smartphone)
RSRP range (typical)	–44 ... –100 dBm (wide)	–60 ... –100 dBm	–75 ... –95 dBm (narrow, stable)	Wide range requires frequent measurement	Wide range = more reports
SINR range (typical)	–5 ... +30 dB (wide)	5 ... 25 dB	10 ... 25 dB (stable)	Wide range requires frequent measurement	Wide range = more reports
Measurement frequency req.	High — signal changes rapidly	Medium — reliability is critical	Low — signal is stable	High → Low	—
Measurement report overhead	High — frequent reports necessary	Medium — regular reports	Excessive — due to static interval	—	High → Excessive

An important difference is evident from Table 1: mMTC/IoT devices are mostly stationary and have a narrow and stable signal range. According to the Ericsson Mobility Report [1], users spend approximately 90% of their time indoors, and 70–80% of mobile traffic is generated in indoor environments. This means that the majority of devices in RRC_CONNECTED state are stationary or in low-mobility conditions at any given time. According to ITU-R M.2083 recommendation, the target connection density for the mMTC scenario is 10^6 devices/km^2 [15], which makes the signaling overhead issue even more pressing.

The RedCap (Reduced Capability) devices introduced in Release 17 deserve special attention [4]. They are limited to 1–2 receive antennas, 20 MHz bandwidth, and 1 HARQ process, and are designed for industrial sensors, wearable devices, and video surveillance cameras. Their limited computing resources and the requirement for 5–15 years of battery life increase the significance of every additional computing operation and signal transmission. Special energy saving mechanisms have also been introduced for RedCap devices in 3GPP Release 17, but the measurement report burden remains a significant problem. In Release 18, the eRedCap (enhanced RedCap) concept is being developed, which is expected to provide additional energy saving capabilities.

4. Signal Quality Indicators

Definitions of RSRP, SINR, and RSRQ. Three main indicators are defined in the 3GPP TS 38.215 standard for evaluating signal quality in the 5G NR system [5]. These indicators are measured by the UE and delivered to the gNB as part of the measurement report. Each indicator has its own specific physical meaning and application area.

RSRP (Reference Signal Received Power) is the power of the reference signal received from the base station, measured in dBm. Its values range from −44 dBm (best) to −140 dBm (worst) [6]. RSRP serves as the primary metric for cell selection, handover between cells, and radio channel quality assessment. Its physical meaning represents how strong a signal the UE is receiving from the base station. The RSRP value mainly depends on the distance from the UE to the gNB, the number of obstacles, and antenna characteristics. According to the 3GPP TS 38.133 standard [6], RSRP measurement accuracy must be ensured within ±6 dB.

SINR (Signal-to-Interference-plus-Noise Ratio) is the ratio of the useful signal to interference and noise, measured in dB. Unlike RSRP, SINR reflects not only signal strength but also the quality of the communication environment — that is, it takes into account the impact of interference from neighboring cells and thermal noise [5]. Its values typically range from −10 dB to +30 dB. SINR is used in CQI (Channel Quality Indicator) calculation, adaptive modulation and coding scheme (MCS) selection, and link adaptation decisions. At high SINR values, 256QAM modulation can be used and data rates reach maximum levels, while at low SINR it is reduced to QPSK and the rate decreases significantly.

RSRQ (Reference Signal Received Quality) is a relative indicator of signal quality based on RSRP and total received power. It is calculated using the formula RSRQ = N × RSRP / RSSI, where N is the measurement bandwidth (number of resource blocks) and RSSI is the Received Signal Strength Indicator [5]. RSRQ provides a more accurate assessment than RSRP especially in high-interference conditions, as it accounts for total received power. RSRQ values range from −3 dB (best) to −19.5 dB (worst).

Among these three indicators, the combination of RSRP and SINR provides the most complete picture of the signal: RSRP shows signal strength while SINR shows signal quality (against an interference background). For example, a device located at the center of a cell may exhibit RSRP = −75 dBm (high power) and SINR = 25 dB (high quality), whereas a device at the cell edge may show RSRP = −110 dBm (low power) and SINR = 3 dB (low quality). Therefore, monitoring both indicators simultaneously is essential for making correct RRM decisions.

Measurement methods. In 5G NR, RSRP and SINR are measured based on two reference signals [5, 6]. SS-RSRP is based on PSS (Primary Synchronization Signal) and SSS (Secondary Synchronization Signal) within the Synchronization Signal Block (SSB) and is used for cell selection and handover decisions. The SSB is transmitted periodically and its periodicity can be configured from 5 ms to 160 ms. CSI-RSRP is calculated based on CSI-RS (Channel State Information Reference Signal) and serves for detailed channel state evaluation. CSI-RS can be configured in semi-static or aperiodic manner and is used for MIMO channel estimation. Similarly, SS-SINR and CSI-SINR indicators are defined for SINR. SS-SINR is expressed by the following formula:

$$SS-SINR=\frac{SS-RSRP}{\left(SS-RSIP+N_0\right)} \tag{1}$$

where: SS-RSRP is the reference signal power based on SSB (mW); SS-RSIP is the interference power within the SSB measurement bandwidth (mW); N_0 is the thermal noise power (mW). The interference power depends on the signal strength of neighboring cells and reaches its maximum level at the cell edge.

For low-mobility devices, the time-averaged values and variances of these indicators serve as reliable measures of signal stability:

$$\mu_{RSRP}=\left(\frac{1}{N}\right)\sum_{i=1}^{N}RSRP_i\,,$$

$$\sigma_{RSRP}^2=\left(\frac{1}{N-1}\right)\sum_{i=1}^{N}\left(RSRP_i-\mu_{RSRP}\right)^2 \tag{2}$$

$$\mu_{SINR}=\left(\frac{1}{N}\right)\sum_{i=1}^{N}SINR_i\,,$$

$$\sigma_{SINR}^2=\left(\frac{1}{N-1}\right)\sum_{i=1}^{N}\left(SINR_i-\mu_{SINR}\right)^2 \tag{3}$$

As indicated in the literature [7, 8], in stationary devices σ_{RSRP}^2 remains stable at around 4–9 dB² and σ_{SINR}^2 at around 2–6 dB², while in devices moving at high speed these indicators increase to 25–50 dB² and 15–30 dB², respectively. This difference demonstrates the necessity of accounting for the device's mobility level when assessing signal conditions. Low variance indicates signal stability, while high variance indicates rapidly changing channel conditions.

Layer 3 filtering mechanism. Before the UE sends measurement results to the gNB, Layer 3 (L3) filtering is applied [3]. This filtering is performed using the exponential averaging method and is expressed by the following formula:

$$F_n = (1 - a) \cdot F_N^{-1} + a \cdot M_n \qquad (4)$$

where: F_n is the filtered value, F_{n−1} is the previous filtered value, M_n is the new measurement result, and α is the filtering coefficient. When the α value is small, filtering is strong — it responds slowly to signal changes; when α is large, filtering is weak — it is sensitive to rapid changes. A small α value is appropriate for stationary devices, while a larger α is required for mobile devices [3].

Signal level classification. Signal quality can be classified into five levels based on RSRP and SINR ranges:

Table 2. Signal quality classification by RSRP and SINR ranges

Level	**RSRP (dBm)**	**SINR (dB)**	**Signal quality**	**Report interval possibility**
1 — Excellent	–44 ... –80	> 20	Excellent — stable	Significant extension possible
2 — Good	–80 ... –90	10 ... 20	Good — reliable	Moderate extension possible
3 — Fair	–90 ... –100	0 ... 10	Fair — average	Cautious extension
4 — Poor	–100 ... –110	–5 ... 0	Poor — risky	Standard or short interval
5 — Very poor	–110 ... –140	< –5	Very poor	Accelerated monitoring

As can be seen from Table 2, stationary IoT devices mostly operate stably at levels 1–2 (RSRP > −90 dBm, SINR > 10 dB), as they are located indoors or at a fixed position. Mobile devices, on the other hand, can rapidly change between levels 3–5, especially at cell edges and during fast movement. This difference imposes different requirements on measurement report frequency: mobile devices need to send reports frequently, while for stationary devices this need is evidently lower.

5. Measurement Report Mechanism and the ReportInterval Problem

Operating principles of the measurement report system. In 5G NR, the measurement report system operates according to the 3GPP TS 38.331 standard [3]. The gNB sends the measurement configuration to the UE through RRCReconfiguration signaling. This configuration specifies which indicators (RSRP, SINR, RSRQ) to measure, which cells to monitor, and the report submission frequency (ReportInterval). The configuration also includes Layer 3 filtering parameters and report triggering conditions (event-triggered or periodic).

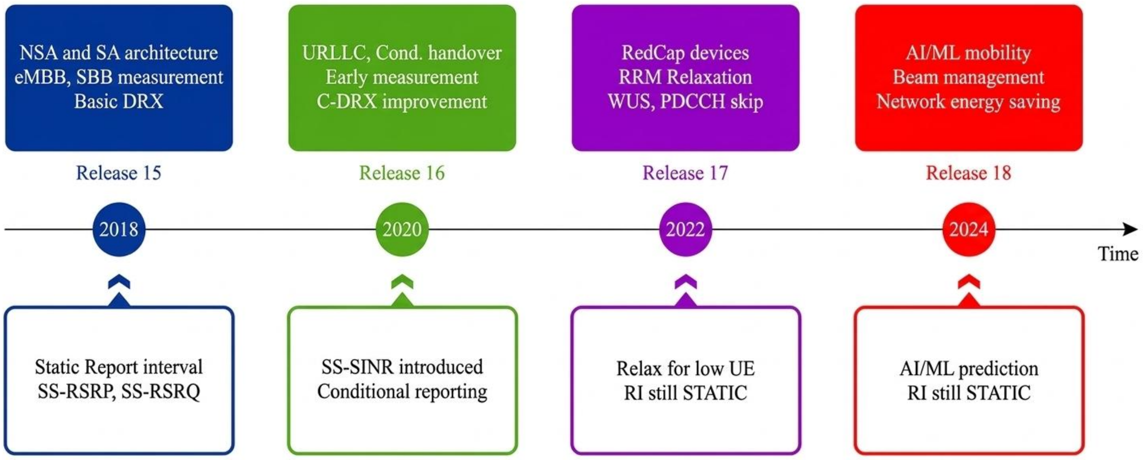

Figure 2. Evolution of signal monitoring and measurement report mechanism across 3GPP releases

The measurement report can operate in two modes: periodic and event-triggered. In periodic mode, the UE sends regular reports according to the assigned ReportInterval. In event-triggered mode, a report is sent only when a specific condition is met — for example, when the neighbor cell signal becomes stronger than the serving cell (Event A3) [3]. However, in practice, most operators use the periodic mode as it provides consistent monitoring.

The process of sending each measurement report involves the following steps: in the first step, the UE activates the receiver chain and measures SSB or CSI-RS signals; in the second step, Layer 3 filtering is performed — this filtering smooths signal indicators by accounting for previous measurement results; in the third step, the results are formatted as a MeasurementReport message; in the fourth step, the message is transmitted to the gNB via PUSCH (Physical Uplink Shared Channel) [3].

According to 3GPP TR 38.840 [9], the UE's power consumption in active mode during this process is 255.5 mW, while in Deep Sleep mode this indicator is only 0.7 mW — a 365-fold difference. This means that each additional measurement report consumes a certain portion of the device's battery. In particular, activating the receiver chain, measuring the signal, processing the data, and transmitting via PUSCH — each of these four steps requires separate energy.

As specified in 3GPP TS 38.304 [16], the cell reselection mechanism operates differently in the UE's RRC_{IDLE} and $RRC_{INACTIVE}$ states, and measurement reports are not required. In these states, the UE independently measures SSB signals and transitions to the best cell. However, all devices in $RRC_{CONNECTED}$ state — including stationary IoT sensors — are obligated to send periodic reports [3].

ReportInterval parameter. ReportInterval is the time interval between two consecutive measurement reports, assigned by the gNB. The following discrete values are defined in 3GPP TS 38.331 [3]:

Table 3. ReportInterval values defined in 3GPP TS 38.331

Report Interval (ms)	Reports per second (MR/s)	Typical application scenario
120	8.33	When fast handover is required
240	4.17	Standard (default in most cases)
480	2.08	Medium mobility

640	1.56	Reduced monitoring
1024	0.98	Low-variability environment
2048	0.49	Stable signal conditions
5120	0.20	Stationary devices
10240	0.10	Long-term stationary

As can be seen from Table 3, a wide range — from 120 ms to 10240 ms — is available in the standard. However, in practice, the decision of when and how to change these values has been left to the operator, and in most networks a conservative value of 240 ms is uniformly assigned to all devices.

The static assignment problem. In current practice, the gNB assigns the same ReportInterval value to all $RRC_{CONNECTED}$ devices — typically 240 ms [3]. This approach is simple to implement but leads to significant inefficiency.

The first problem is energy consumption. Even though the signal condition of a stationary IoT sensor barely changes, it is forced to activate the receiver chain, conduct measurements, and send reports every 240 ms. Each such cycle consumes 255.5 mW of power [9]. For devices that need to have a battery life of 5–15 years, this excessive load is significant. The C-DRX mechanism [9] provides some degree of power saving but does not cancel the measurement report obligation.

The second problem is signaling overhead. A single gNB can serve 500–2000 UEs [2]. If each of 1000 UEs sends a report at 240 ms intervals, the gNB must process 4167 measurement reports per second. The majority of these reports — those coming from stationary devices — repeat the same data that does not differ from the previous report. Since the gNB's processor resources are limited, this excessive load negatively affects overall network performance.

The third problem is radio resource waste. Each measurement report occupies a certain amount of resources (50–100 bytes) on the PUSCH channel. Excessive reports wastefully consume uplink resources that could be used for IoT data. This issue becomes even more critical in achieving the connection density target of 10^6 devices/km^2 defined in 3GPP TR 38.913 [15].

The essence of the problem is that the 3GPP standard has not provided an adaptive mechanism for assigning ReportInterval based on device type or signal stability. The values exist in the standard (see Table 3), but when and how to change them has been left to the operator. As a result, a conservative static value (240 ms) is used in most networks.

6. Comparative Analysis of Static and Adaptive ReportInterval Approaches

To quantitatively assess the problem of static ReportInterval assignment, consider the following scenario. Assume that there are 1000 $RRC_{CONNECTED}$ devices in a single gNB's service area, of which 600 are stationary IoT sensors (60%), 250 are low-mobility devices — pedestrian users (25%), and 150 are high-speed devices — vehicles (15%). This distribution is consistent with the data from the Ericsson Mobility Report [1] and 3GPP TR 38.913 [15].

Under the current static approach, when ReportInterval = 240 ms is assigned to all 1000 devices, the number of measurement reports received by the gNB per second is calculated as follows:

$$MR_{static} = \frac{N_{total}}{RI} = \frac{1000}{0.24} = 4167\ \frac{reports}{s} \tag{5}$$

If an adaptive approach is applied, assigning different ReportIntervals based on device category — RI = 5120 ms for stationary devices, RI = 1024 ms for low-mobility devices, and RI = 240 ms for

high-mobility devices — the total number of measurement reports would be:

$$MR_{adaptive} = \frac{600}{5.12} + \frac{250}{1.024} + \frac{150}{0.24} = 117 + 244 + 625 = 986\ \frac{reports}{s} \quad (6)$$

Thus, the adaptive approach reduces signaling overhead from 4167 to 986 — a 4.2-fold reduction. This result significantly frees up the gNB's processor resources and increases uplink channel capacity by approximately 76%. The numerical results of these formulas are summarized in Table 4:

Table 4. Comparative indicators of static and adaptive ReportInterval approaches

Indicator	Static approach (RI = 240 ms for all)	Adaptive approach	Improvement
Device category	All 1000 devices: same RI = 240 ms	600 stationary: RI = 5120 ms 250 low-mobility: RI = 1024 ms 150 high-mobility: RI = 240 ms	—
MR per second (gNB load)	4167 MR/s	986 MR/s	**4.2× reduction**
Daily MR count (stationary IoT)	360,000 reports/day	16,875 reports/day	**21.3× reduction**
Daily active mode time (stationary)	720 s/day	33.75 s/day	**21.3× reduction**
Power consumption per MR cycle	255.5 mW (same for all)	255.5 mW (but less frequent)	**Same per cycle, but total energy 21× less**
Uplink resource usage	100% baseline	~24% of baseline	**76% freed**
Handover risk	Minimal (frequent reports)	Low for mobile, needs monitoring for stationary	**Acceptable with dispersion-based monitoring**

The benefit from an energy saving perspective is also clearly evident. For a stationary IoT sensor, the daily number of measurement reports at the current 240 ms interval is: 1/(0.24) × 86400 = 360,000 reports/day. If the interval is changed to 5120 ms: 1/(5.12) × 86400 = 16,875 reports/day — a 21.3-fold reduction. According to the power consumption model in 3GPP TR 38.840 [9], each measurement report cycle lasts approximately 2–5 ms in active mode. Accordingly, daily active mode time drops from 720 seconds to 33.75 seconds — significantly extending battery life.

At the same time, the potential risk of the adaptive approach must also be considered. If a device classified as stationary suddenly begins to move, the long ReportInterval may cause handover delay. For example, with RI = 5120 ms, information about handover could be delayed by up to 5 seconds, which may lead to a temporary decrease in connection quality. Therefore, the adaptive mechanism must have the capability to monitor signal variance in real time and rapidly readjust the ReportInterval when stability is disrupted.

Another important aspect is the complexity and implementation cost of the adaptive mechanism. Such a mechanism requires additional computing resources on the gNB side: monitoring the signal variance of each device, determining its category, and dynamically changing the ReportInterval. However, the above analysis results show that this additional cost is small compared to the benefits gained from signaling overhead and energy savings.

Conclusion

This paper presented a systematic analysis of signal quality indicators and the measurement report mechanism in the 5G NR system. It was shown that RSRP reflects signal strength, SINR reflects signal quality (against an interference background), and RSRQ reflects relative quality in interference conditions. Together, these three indicators provide a complete picture of the channel.

A fundamental difference was identified in the signal monitoring requirements of 5G NR service types: mMTC/IoT devices operate in a narrow and stable signal range (σ²_RSRP = 4–9 dB²), while eMBB devices have a wide and variable range (σ^2_{RSRP} = 25–50 dB²). Despite this difference, in current practice the same ReportInterval (240 ms) is assigned to all devices.

Quantitative analysis results show that the adaptive ReportInterval approach can reduce signaling overhead by 4.2 times and save energy for stationary devices by 21 times. These results are particularly relevant for IoT sensors and RedCap devices that require battery life of 5–15 years.

This analysis demonstrates the necessity of developing an adaptive ReportInterval management mechanism based on RSRP and SINR statistical indicators — particularly variance values. Such a mechanism should flexibly manage report frequency based on the signal stability and mobility level of the device. Layer 3 filtering parameters should also be adapted according to device category.

In future research, the mathematical model of this adaptive mechanism, simulation results, and testing results under real network conditions are planned to be presented. Additionally, the possibilities of applying machine learning methods to automatically classify device mobility and optimize ReportInterval in real time will be investigated.

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