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Strong Signal, Slow Data: Explaining the Throughput Paradox of a 4G LTE Network in a Vegetated Highland Tourist Area

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Abstract
Users commonly equate a full signal-strength indicator with fast internet, yet the two are governed by different physical mechanisms and can diverge sharply. This study documents and explains that divergence, the throughput paradox, in the 4G LTE network at Cimory Dairyland, a hillside tourist area in Gowa Regency, South Sulawesi, using a walk test conducted with Tems Pocket and Nemo Handy and analysed against RSRP, RSRQ, SINR, RSSI, and throughput. The measurements show that received signal strength was uniformly excellent, with RSSI above the strong-signal threshold across 82.14 to 100 per cent of the routes, while the useful reference signal was weak, with up to 80.34 per cent of the Telkomsel route in the poor RSRP classes and SINR confined to the moderate band for both operators. Downlink throughput consequently varied, reaching 61.18 to more than 74 per cent of area above the high-speed threshold but leaving substantial low-speed pockets. The novelty of this study is a mechanistic explanation of the paradox: because throughput is governed by signal quality (SINR and RSRQ) rather than by aggregate received power (RSSI), a strong signal indicator can coexist with slow data whenever the wanted signal is attenuated relative to interference and noise, a condition produced here by terrain and vegetation.

Keywords: 4G LTE, Throughput, SINR, RSSI, Signal Quality

INTRODUCTION

A near-universal assumption among mobile users is that a full bars indicator guarantees fast internet. The assumption is intuitive but physically unsound, because the bars typically reflect received signal strength while data rate is governed by signal quality, and the two need not move together. In 4G Long Term Evolution (LTE) networks this distinction is formalised in a suite of key performance indicators: Reference Signal Received Power (RSRP) and Received Signal Strength Indicator (RSSI) express strength, while Reference Signal Received Quality (RSRQ) and Signal to Interference plus

Noise Ratio (SINR) express quality, and throughput expresses the delivered data rate that depends chiefly on quality (Krasniqi et al., 2015; Herina, 2022).

Field studies of LTE performance in Indonesia have measured these indicators across many environments (Efriyendro & Rahayu, 2017; Fauzan & Fery, 2018; Sukiswo & Zahra, 2018; Mursid et al., 2019; Tamtama, 2017), and studies of highland and vegetated terrain have documented the propagation losses that such environments impose (Rahmania, 2020; Karo et al., 2019). What these studies rarely make their explicit focus, however, is the relationship between the strength indicators and the throughput a user actually obtains. When strength and throughput are reported side by side but not related to one another, the reader is left unable to explain the common and frustrating experience of a strong signal that nonetheless delivers slow data.

This study takes that relationship as its central object. Using walk test measurements at Cimory Dairyland, a hillside tourist area whose terrain and vegetation make it an ideal natural laboratory, it documents a clear throughput paradox, an abundance of received power coexisting with weak useful signal and variable data rates, and explains it mechanistically. The novelty pursued is not a new measurement but a diagnostic account: a demonstration that throughput at this site tracks the quality indicators SINR and RSRQ rather than the strength indicator RSSI, so that the paradox dissolves once the correct governing variable is identified. The account has direct value for both users, who misread the signal indicator, and operators, who must target the right parameter to improve service.

Strength versus Quality: Two Families of Indicators

The five LTE indicators fall into two families that must not be conflated. The strength family comprises RSRP, the average power of the useful reference signal from the serving cell, and RSSI, the total received power in the band including serving cell, neighbouring cells, and noise. The quality family comprises RSRQ, which relates RSRP to total received power, and SINR, which relates the useful signal to interference plus noise. Throughput, the delivered data rate, is governed principally by the quality family, because the modulation and coding scheme a link can sustain is set by SINR rather than by raw power (Krasniqi et al., 2015; Herina, 2022). This is the theoretical root of the paradox: RSSI can be high while SINR is low, and in that case a strong signal indicator will coexist with modest throughput.

The Site as a Natural Laboratory and the Walk Test Method

Such a condition arises whenever the wanted signal is attenuated relative to the ambient and neighbouring-cell energy that also enters the band. Highland, vegetated terrain produces exactly this situation: diffraction and shadowing from undulating ground and absorption and scattering by foliage weaken the useful reference signal from the serving cell along the ray path, while total received power remains high because energy from multiple sources still reaches the receiver (Rahmania, 2020; Karo et al., 2019). Cimory Dairyland, sitting on a vegetated hillside, therefore functions as a natural laboratory in which the divergence between strength and quality can be observed directly. This study measures the site by walk test, logging all five indicators continuously along the pedestrian routes and classifying each sample into standard quality categories, with two independent chains, Tems Pocket and Nemo Handy, used for corroboration (Kurniawan & Prasetyo, 2020; Herina, 2022; Dewa et al., 2016).

RESEARCH METHOD

Design, Site, and Instruments

This study uses a quantitative descriptive design based on walk test field measurement, oriented specifically toward the relationship between signal indicators and throughput. Measurements were taken at Cimory Dairyland, Bontoparang, Parangloe District, Gowa Regency, a hillside site enclosed by dense vegetation, along pedestrian visitor routes running from the main building cluster to the southern and southwestern margins, between February and July 2025. The networks of Telkomsel and XL Axiata were measured along an identical route. Two independent chains operated over the same path: Tems Pocket with logfiles processed in TEMS Investigation, and Nemo Handy processed in Nemo Analyze, with MapInfo used for route preparation. Each chain logged RSRP, RSRQ, SINR, RSSI, and uplink and downlink throughput continuously, with samples geo-referenced along the walked path.

Analysis: Relating Strength, Quality, and Throughput

The analysis was designed to expose the strength-quality-throughput relationship rather than to report each parameter in isolation. Every sample was first classified into a quality category using standard value ranges and the percentage of samples per category computed. The strength indicators (RSRP, RSSI) and the quality indicators (RSRQ, SINR) were then examined jointly at the same locations, and both were related to the co-located throughput classification. Particular attention was paid to locations where RSSI was strong but throughput was not, since these are the locus of the paradox, and to whether the throughput distribution tracks the quality indicators or the strength indicators. The spatial maps were used to confirm that the divergence concentrates where terrain and vegetation are most obstructive.

RESULTS AND DISCUSSION

The Paradox Documented: Strong RSSI, Weak Useful Signal

The measurements document the paradox unambiguously, as summarised in Table 1. On the strength side, received power was abundant: RSSI registered strong signal above the threshold across 100 per cent of the Telkomsel route on Tems Pocket and 91 per cent on Nemo Analyze, and 82.14 per cent for XL Axiata, with no weak locations identified for either operator. A user reading the signal indicator anywhere on the route would have seen a strong, reassuring signal. On the useful-signal side, however, the picture was quite different: RSRP placed up to 80.34 per cent of the Telkomsel route in the poor to very poor classes, and SINR was confined to the moderate band for both operators, 61.20 per cent of the Telkomsel route between 10 and 20 dB and 63.90 per cent of the XL Axiata route between 0 and 10 dB, with no area exceeding 20 dB.

Table 1. The Throughput Paradox: Strength, Quality, and Delivered Data Rate

Indicator Family	Parameter	Telkomsel	XL Axiata	Role in the Paradox
Strength	RSSI	100% strong (Tems); 91% (Nemo)	82.14% strong	High everywhere; misread as fast internet
Strength	RSRP	80.34% poor (Tems)	49.52% poor (Tems)	Useful signal actually weak
Quality	RSRQ	Mostly moderate	54.43% yellow-orange (Nemo)	Depressed by attenuation
Quality	SINR	61.20% at 10-20 dB	63.90% at 0-10 dB	Governs achievable data rate
Outcome	Downlink	61.18% high-speed; 29.55% low	More than 74% high-speed	Tracks quality, not strength

Throughput Tracks Quality, Not Strength

The decisive observation is that throughput followed the quality indicators, not the strength indicator. Despite RSSI being near-uniformly strong, downlink throughput varied substantially, from 61.18 per cent of the Telkomsel area above 11,000 Kbps with 29.55 per cent below 1,500 Kbps, to more than 74 per cent of the XL Axiata area above 7,200 Kbps. Had throughput been governed by received strength, it would have been uniformly high wherever RSSI was strong, which was almost everywhere; instead it tracked the moderate and variable SINR, falling precisely where signal quality, not signal strength, deteriorated. This is the empirical resolution of the paradox: the strength indicator and the data rate are governed by different variables, and it is the quality variable that determines throughput.

The spatial maps confirm the mechanism. The locations where throughput dropped into the low-speed classes coincided with the southern and southwestern sectors of the park, the areas most distant from the serving cell and most heavily screened by canopy and terrain. In exactly those locations RSSI remained strong because ambient and neighbouring-cell energy still reached the receiver, while the useful reference signal from the serving cell had been attenuated by foliage and diffraction, depressing SINR and RSRQ and with them the achievable data rate. The co-location of strong RSSI, weak SINR, and low throughput at the same obstructed points is the signature that ties the paradox to its physical cause.

Spatial Confirmation of the Mechanism

It is notable that the paradox appeared for both operators despite their different network configurations, which shows that it is not an artefact of one operator but a general consequence of the propagation environment. This also explains why increasing transmitted power alone, which would raise RSSI further, would not resolve the problem: the limiting quantity is the quality of the wanted signal relative to interference and noise, not the absolute power in the band, and only interventions that improve that ratio, such as bringing the serving cell closer or reducing the obstruction, will lift throughput.

Synthesis: Resolving the Paradox

Bringing the observations together resolves the paradox completely. A strong signal indicator reflects abundant received power (RSSI), but the data rate a user obtains is set by signal quality (SINR and RSRQ); when terrain and vegetation attenuate the useful signal relative to the ambient energy, the two diverge, and a strong indicator coexists with slow data. The user is not mistaken about the signal being strong; the user is mistaken about what the strong signal implies. Once throughput is understood to track quality rather than strength, the paradox is not a contradiction but the expected behaviour of an LTE link in an obstructed environment.

Discussion: Implications for Users and Operators

For users, the practical lesson is that the signal-strength indicator is an unreliable predictor of data speed in obstructed environments. A full indicator confirms that the phone is receiving ample power, but it says little about whether that power carries a clean, usable signal from the serving cell. At a site like Cimory Dairyland, users experiencing slow uploads or buffering despite strong bars are encountering the paradox directly, and the correct interpretation is not that the phone is faulty but that the wanted signal is degraded relative to interference and noise. This reframing is valuable in itself, because it redirects user expectations from an indicator that misleads to the quality mechanism that actually matters.

Table 2. The Paradox Explained and the Interventions It Implies

Observation	Governing Variable	Why the Indicator Misleads	Effective Intervention
Strong RSSI everywhere	Total received power	Reflects ambient energy, not usable signal	Not a target; raising power does not help
Weak RSRP and SINR	Useful signal vs noise	Determines the achievable data rate	Bring serving cell closer; reduce obstruction
Variable throughput	Signal quality (SINR, RSRQ)	Tracks quality, not the strength indicator	Improve quality via siting and antenna tuning
Degradation in the southwest	Terrain and vegetation	Attenuates wanted signal while RSSI stays high	Densify coverage with repeaters or small cells

For operators, the mechanistic account identifies the correct lever. Because throughput is limited by quality rather than strength, interventions that merely raise received power, such as increasing transmit power, would improve the indicator without improving the data rate. The effective interventions are those that improve the ratio of wanted signal to interference and noise: siting a cell or repeater closer to the obstructed southwestern sector so the useful signal arrives less attenuated, adjusting antenna tilt and azimuth to illuminate the screened areas, and managing inter-cell interference. The finding that the paradox appears identically for both operators confirms that this is an environmental rather than an operator-specific problem, and therefore a shared target for network planning. The methodological caution from the two measurement chains still applies: because absolute RSRP classification differed between chains while the spatial pattern agreed, the diagnosis rests on the corroborated pattern rather than on single-chain figures (Herina, 2022; Dewa et al., 2016). Table 2 summarises the paradox and the interventions it implies.

CONCLUSION

This study documented and explained the throughput paradox in the 4G LTE network at Cimory Dairyland, a vegetated highland tourist area in Gowa Regency, through walk test measurements of Telkomsel and XL Axiata across five key performance indicators. The measurements showed that received signal strength was uniformly excellent, with RSSI above the strong-signal threshold across 82.14 to 100 per cent of the routes, while the useful reference signal was weak, up to 80.34 per cent of the Telkomsel route in the poor RSRP classes and SINR confined to the moderate band for both operators, and downlink throughput consequently varied from 61.18 to more than 74 per cent of high-speed area with substantial low-speed pockets. Critically, throughput tracked the quality indicators SINR and RSRQ rather than the strength indicator RSSI, and the low-throughput pockets coincided spatially with the terrain- and vegetation-obstructed southwestern sector. The paradox is therefore resolved mechanistically: a strong signal indicator reflects abundant received power, but the delivered data rate is set by signal quality, so the two diverge whenever the wanted signal is attenuated relative to interference and noise. For users this means the signal indicator is an unreliable predictor of speed in obstructed environments; for operators it means the effective lever is signal quality, not transmitted power. Future research should quantify the throughput-SINR relationship across more sites to generalise the account, and pair the measurements with active data-rate tests under controlled load so that the quality-throughput mapping can be calibrated precisely.

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CONFLICTS OF INTEREST

The author declares no conflict of interest.

REFERENCES

Dewa, I. G. A., Sudiarta, P. K., & Diafari, I. G. A. (2016). Analisis parameter jaringan HSDPA kondisi indoor dengan Tems Pocket Investigation dan G-NetTrack Pro. Jurnal Teknologi Elektro, 15(2), 45-52.

Efriyendro, R., & Rahayu, Y. (2017). Analisa perbandingan kuat sinyal 4G LTE antara operator Telkomsel dan XL Axiata berdasarkan parameter drive test menggunakan software G-NetTrack Pro. Jurnal Online Mahasiswa Fakultas Teknik Universitas Riau, 4(2), 1-9.

Fauzan, M., & Fery, A. (2018). Analisis performansi jaringan outdoor 4G LTE di kampus UMY antara provider Indosat dan Three. Jurnal Teknik Elektro Universitas Muhammadiyah Yogyakarta, 6(1), 33-42.

Herina, H. N. (2022). Analisis pengukuran kinerja jaringan 4G LTE berdasarkan hasil drive test. Politeknik Negeri Ujung Pandang.

Karo, F., Hikmaturokhman, A., & Danisya, A. R. (2019). Analisis hasil pengukuran performansi jaringan 4G LTE 1800 MHz di area Sokaraja Tengah Kota Purwokerto. Jurnal Infotel, 11(2), 55-63.

Krasniqi, F., Maraj, A., & Blaka, E. (2015). Performance analysis of mobile 4G/LTE networks. Proceedings of the South East European Conference on Telecommunications, 1-4.

Kurniawan, D., & Prasetyo, Y. (2020). Pengukuran kualitas sinyal jaringan LTE menggunakan walk test. Jurnal Telekomunikasi dan Jaringan, 8(1), 45-52.

Mursid, A. R., Hendrawan, H., & Sari, R. F. (2019). Analisis performansi dan optimisasi jaringan 4G LTE pada kawasan Telkom University. Jurnal Elektro dan Telekomunikasi Terapan, 6(1), 780-789.

Rahmania, R. (2020). Analisis cakupan area jaringan Long Term Evolution. Vertex Elektro, 12(10), 21-30.

Sukiswo, S., & Zahra, A. A. (2018). Analisis quality of service (QoS) jaringan 4G dengan metode drive test pada kondisi outdoor. Jurnal Ilmiah Teknik Elektro, 7(2), 408-415.

Tamtama, B. (2017). Analisis kinerja kualitas jaringan 4G Long Term Evolution di kawasan Perumahan Singgalang, Kota Padang. Jurnal Teknik Elektro Universitas Negeri Padang, 5(2), 112-120.