Urban Routing Efficiency in Smart Mobility Applications: A System-Level Study Using the HERE WeGo Platform

Sawjanya Sathyaseelan, and Anoshan Yoganathan

Abstract Urban mobility faces increasing challenges due to rapid urbanization, growing traffic congestion, and unpredictable travel conditions, placing pressure on city transportation infrastructure. Smart mobility apps have become essential for daily travel support, offering real-time location data, routing choices, and user guidance. This study explores how urban routing efficiency is managed within the popular navigation app HERE WeGo, focusing on visible system features rather than internal algorithms or performance metrics. It highlights key operational capabilities—such as GPS, map matching, traffic responsiveness, rerouting, multimodal options, and route instructions—and examines how these influence routing results under various conditions. Results show that online features, with live traffic info and rerouting, improve reliability in congested areas, while multimodal options add flexibility by offering alternatives beyond driving. Offline navigation ensures continued access in low-connectivity zones, but with fewer adaptive features. Overall, routing effectiveness is seen as a combined outcome of data quality, system logic, service quality, and user interaction, rather than a single optimization process. The study offers insights into smart mobility platforms as integrated decision-support tools and guides future comparative studies on commercial navigation applications.

Index Terms— **Smart mobility; Routing efficiency; Navigation systems; Urban transportation; Real-world navigation**

I. Introduction

RAPID urbanization and population expansion are intensifying pressure on road networks, creating growing challenges for urban transportation systems. With the growth of cities, the traveler experiences prolonged travel duration, indeterminable delays, and higher environmental expenditures. To do this, the physical infrastructure needs to be developed, but also smart digital solutions that can optimize mobility in real-time. In that regard, geo-based smart mobility applications have come into the limelight as one of the most important Information Technology (IT) interventions, which combine geospatial-related data, mobile computing, and routing intelligence to foster urban routing efficiency. Geo-based navigation applications are based on the technology of Geographic Information Systems (GIS), Global Positioning System (GPS), and extensive spatial database systems in order to offer a real time routing and navigation, Zahabi et al [1]. These applications utilize dynamic spatial data like road networks, vehicle congestion, incidents, and user position to create the best travel routes. In contrast to the conventional static tool of navigation, the modern smart mobility applications constantly change the routing decision depending on the current situation, allowing users to make rational decisions when traveling in the complex urban setting. It is not the result of a single functioning, but a combination of various interacting functional components that makes routing efficiency in such systems possible.

Sawjanya Sathyaseelan is postgraduate student from the Faculty of Graduate Studies, University of Sri Jayewardenepura, Sri Lanka. (Email: sawjanyasathyaseelan@gmail.com)

Anoshan Yoganathan is undergraduate from the Department of ICT, South Eastern University of Sri Lanka, Sri Lanka. (Email: anoshan6@gmail.com)

Among the smart mobility solutions that are already available in the market, HERE WeGo is one of the popular geo-based map solutions that can be used by urban commuters to navigate by multi-modal, real-time traffic awareness, and turn-by-turn guidance, as shown byId et al. [2], Luschi et al. [3]. The application uses elaborate digital maps, road traffic information services, and location-based computing to offer route suggestions on various forms of transportation such as private vehicles, transport service and walking. Regarding ICT, HERE WeGo is likely to be regarded as a stratified Geo-IT system, in which spatial data processing and routing logic are closely integrated with user interaction Trapsilawati et al. [4]. Although the existing studies on smart mobility have mostly studied routing algorithms, traffic predictive models, or large-scale transportation modeling, many fewer studies have explored the topic of navigation applications within the framework of a functional analysis. Functional analysis focuses on what the system does, how every function leads to system-level performance, and what is the contribution of each function to the system-level performance, as opposed to trying to view or duplicate proprietary algorithms. This method is especially appropriate in the case of commercial navigation systems, whose interior routing algorithms are not available publicly. Breaking down an application into its functional parts, including

ISSN: 2961-5992

positioning, route computation, traffic handling, rerouting, and visualization, one will be able to measure routing efficiency, structure, and reproducibility Piątek et al. [5], Adeetc et al. [6]. The concept of geo-based smart mobility application routing is more than going as far as to reduce travel distance. The efficiency in actual urban city circumstances is based on such factors as the reliability of travel time, responsiveness to congestion, responsiveness to route disruption, alternative route availability, and the clarity of navigational guidance. These reasons are not provided by one optimization algorithm but directly by functions of a system. As an example, the proper route initiation due to accurate positioning and map matching functionalities, and dynamic reaction to current road conditions due to traffic awareness and rerouting functionalities will be included. On the same note, user interface and visualization capabilities determine the effectiveness of users adhering to the recommended routes, which indirectly determine the achieved routing performance. The interdisciplinary approach of Geo + IT study also suits a functional analysis approach. It enables the student to connect the geospatial technologies (maps, spatial queries, location data) with the information systems concepts (system architecture, service layers, decision support, and usability), Musleh et al. [7]. The analysis is less invasive (with no invasive data access or extensive experimental deployments needed based on the analysis) as it emphasizes functional roles and interactions with both, highlighting strengths, limitations, and opportunities to improve the system. This places the strategy particularly well-positioned for academic studies, where resources are limited in reality. This work is therefore a twofold source of inspiration. First, we need systematic assessment systems that can evaluate geo-based navigation applications from an ICT system perspective rather than an algorithmic perspective or an ICT system user experience perspective. Second, urban planners, system designers, and researchers require analytical models to comprehend the contribution of some of the navigation functions in enhancing the efficiency of routing and how such functions can be exploited to make prudent decisions about designs and policies. The functional analysis of HERE WeGo offers a chance to exemplify a skeleton with the help of a real-life, popular smart mobility app, Hoseinzadeh et al. [8].

Based on the identified need for systematic assessment of commercial navigation platforms, this study presents a structured framework to evaluate urban routing efficiency in a geo-based smart mobility application using HERE WeGo as an illustrative case. The study identifies a gap in existing literature, where routing performance is commonly discussed through algorithmic modelling or user-experience perspectives, yet few studies assess navigation systems at a system level when internal routing logic is inaccessible. To address this gap, the study isolates the major operational functions of HERE WeGo—such as positioning, map matching, traffic handling, rerouting, and user guidance—and links these functions to routing-related efficiency indicators derived from observable application behavior. The outcome is an explicit mapping between functional capabilities and routing outcomes, providing clarity on how each feature contributes to routing efficiency. Rather than claiming superiority over alternative platforms, the study contributes a replicable system-level evaluation approach that can be applied to other geo-based mobility systems in future comparative analyses.

II. Literature Review

Studies about urban routing efficiency in geo-based smart mobility applications cut across five intertwined strands: time-dependent routing, multimodal journey planning, navigation performance evaluation, usability and cartographic representation, and user confidence in automated direction. Together, these strands show that routing choices in realistic settings are determined by varying travel conditions, such as congestion, incidents, and demand cycles, and not road networks. Indicatively, Hoseinzadeh and others Hoseinzadeh et al. [8] emphasize that routing efficiency is not only limited to the shortest-path calculation but also the mechanisms that can accommodate the traffic variation in real-time and the supportive routing strategies. Likewise, Potthoff and Sauer [9] substantiate the need for time-sensitive modelling, as they show that the accuracy of routing results varies throughout the urban day. The convergence of these perspectives supports the argument that navigation platforms such as HERE WeGo should be examined as integrated systems in which routing functions interact dynamically. This synthesis therefore highlights the suitability of a system-level evaluation approach, rather than an algorithm-focused or user-experience-only perspective, when analyzing routing efficiency in commercial smart mobility applications. Recent developments in time-dependent vehicle routing emphasize that realistic routing must account not only for shortest-path computation but also for travel-time prediction and continuous re-optimization in response to changing network conditions. This is in line with the functions of navigation-app like traffic awareness and rerouting. Systematically, routing efficiency is not entirely an algorithmic property, but it is a result of the manner in which traffic signals are combined into route cost models, the frequency at which the traffic system is recalculated, and the speed at which updates are conveyed to the user. In addition to classical vehicle routing, time-dependent shortest-path and scheduling studies also underline the fact that on-road routing queries are complicated in cases when the travel time at different time intervals differs. Mosquera & Smet [10], Adamo et al. [11] address the topic of route scheduling on time-dependent graphs, and support the assertion that fastest-path queries in the context of time variance are an essential stalwart of all real-world route planning systems. This evidence justifies the consideration of HERE WeGo according to the functions pursuing the operationalization of time-sensitive routing, including incident-induced rerouting, alternative routing generation, and ETA update. Planning multimodal (walking, public transit, and occasionally shared mobility) functionality in urban routing is becoming necessary due to the fact that the quickest or most stable path can involve a combination of more than one mode of movement. Pan et al. [12] suggest an algorithm that is supposed to produce a range of multimodal journeys, noting that it should actually be deployed to offer a variety of valuable replies, rather than a single plan that might be the best. The complexity of fully multimodal networks and multicriteria

ISSN: 2961-5992

optimization is resolved with the help of complementary algorithmic work. Almutairi & Owais [13] investigate efficient algorithms for fully multimodal journey planning with public transportation and multimodal transfer modes. Such literature encourages the evaluation of the multi-mode route planning capability of HERE WeGo as a component of routing efficiency, because a capability that facilitates a feasible combination of modes has the potential to decrease the variability of the travel time in the presence of high congestion in a way that enhances the quality of the decision made by the user. Due to the common proprietary nature of routing logic in commercial navigation platforms, they are commonly tested by their observable behavior, in particular, the accuracy of ETA and the predictability of travel-time. Falek et al. [14] and Shantaram [15] estimate travel time predictions of smartphone navigation apps, such as Here-We-Go, with field measurements of 204 urban and rural road segments in Jordan, and compare ETA and actual travel time and patterns of errors. Their contribution indicates that high evaluation can be conducted even in the absence of internal access to algorithms and that it can be used to measure ETA error, over/under-estimation bias, and context sensitivity (urban vs rural). On the same note, Falek et al. [14], Shantaram [15], Nordberg [16] Benchmark Google Maps, Waze, and HERE WeGo through their APIs to track a shuttle bus, and to evaluate the quality of ETA, they measure RMSE and MAE-like error metrics. These studies support the ICT study design in which HERE WeGo is studied in functional and quantifiable outputs instead of reverse-engineering. Routing efficiency is also influenced by the ability of users to properly perceive and follow directions; false leads, confusion, or misinterpretation can reverse the gains of an algorithm. Safina & Suasti [17] The study evaluates the intuitiveness of point symbols on mobile navigation maps, answering the question of whether navigation maps need legends and the impact of the design of symbols on user understanding. This applies to functional analysis since functions of the user interface (route visualization, prompts, alternative-route presentation) impact the efficiency in the real world by defining how decisions are made and obeyed. Another last strand is on user dependency and trust, which may mediate the routing recommendation effectiveness. Through the comparison of Google Maps and Waze, Tarantilis et al. [18], Behrisch et al. [19] focus on human-computer trust in the navigation system and find that the supposed trust and the nature of the system determine reliance behavior. Although the given study does not focus on HERE WeGo per se, it contributes to the idea of incorporating the aspects of trust into a functional study. A technically powerful rerouting capability cannot be efficient when it is not trusted or even avoided by users. All in all, the current literature provides solid points of departure to investigate the efficiency of routing, multimodal planning, and navigation-app usability using ETAs and usability; however, applications are regarded as black-box predictors, or the study is limited to small-scale algorithms. The system-level Geo-IT gap that the functional analysis of HERE WeGo is aimed to address is the identification of the main functional modules (positioning, map matching, traffic integration, rerouting, alternatives, multimodal planning, UI communication) and the description of the role of each of the modules in ensuring the efficiency of urban routing through measurable indicators and organized evaluation logic. This offers a reusable evaluation framework to ICT study where proprietary internals are not available, and yet it is based on the literature of routing, usability, and evaluation.

III. METHODOLOGY

A. Overall Study Design

The methodological approach has three components that are integrated. To begin with, the study used controlled guidance through the use of navigation sessions in online and offline environments where comparisons could be made between responsive, data-connected guidance and map-based fallback logic. Second, the study used a systematic procedure to derive observable routing behavior, such as route suggestions, route ETA calculations, rerouting triggers, and turn-by-turn instructions updates. Third, the behavior which had been captured was explained with the help of a set of functional efficiency indicators which were designed in the course of this study. All these steps make it possible to evaluate routing performance by measuring system-level behavior despite the back-end processes being unreachable. The impacts of the user-interface are not quantified in the study because the user trials are not controlled.

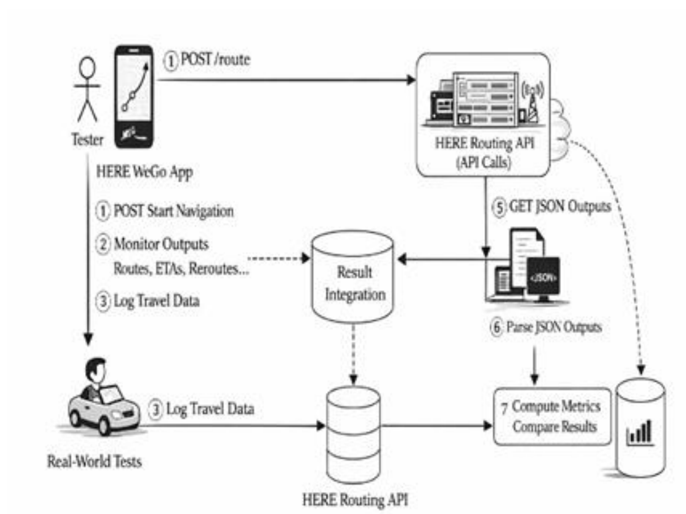

Fig. 1: Data Pipeline for HERE WeGo Field Observation and API Simulation

B. Data Sources and Collection

This study employed two complementary data collection methods

1. real-world navigation tests using the HERE WeGo mobile application
2. Controlled API-based routing simulations using HERE Routing API requests.

In the real-world experiments, navigation was triggered manually on a smartphone over established urban streets when it was at peak and off-peak conditions. Only system output that was visible to the user was recorded during each trip, such as

ISSN: 2961-5992

recommended routes, turn-by-turn directions, estimated time of arrival (ETA), rerouting notifications, and alternative route recommendations. These tests are taken to understand the behavior of the system in the context of live traffic, GPS variation, and changes in connectivity (online vs offline). We reconstructed navigation behavior and obtained travel-time and prediction-error indicators by screen recording and making note-takes that were time-stamped. Simultaneously, the API-based simulations were also implemented to produce structured routing outputs with controlled parameters. Access had been requested to the public routing service of HERE via Python/Postman with identical origin-destination pairs as those in field experiments, with and without real-time traffic. The sent back JSON responses gave deterministic values to travel time, distance, alternatives, mode profiles, as well as routing logic decisions. They were examined in organized tables to extract the metrics. The combination of real-world observations with API simulations enables the study to compare system behavior in a live environment with those that are theoretically calculated, which enhances the transparency of the methodology and depth of interpretation.

C. Experimental and Route Design

A systematic series of navigation sessions was undertaken to explore system reactions under a diversity of travel scenarios of interest in routing efficiency. The experiment was controlled by four design considerations:

1. Network condition, comparing peak flow with off-peak flows.
2. Connectivity state, switching between fully online routing and offline mode with already downloaded maps;
3. Travel mode, where car-based navigation was applied in both sessions, and multimodal options were reported when surfaced;
4. Change of environment, such as predicted congestion areas, signalized crossroads, and roadways that are likely to cause detours.

All experiments were made intra-origins and destinations, and the selection of the waypoints was consistent across repeated experiments, making a comparison between conditions possible. The quantity of trips made is also not that large, but the sample set was adequate to prove the operationalization of the proposed metrics. The design focuses on an illustration using methods and not the generalization of methods on a large scale.

D. Navigation Log Generation

Screen-recording and real-time field notes were used to build the navigation logs and record the system behavior of each session. Some of the key things were recorded in this manual log:

- initial ETA presented at trip inception,
- later ETA alterations in navigation,
- reroute timestamps prompt and directional,
- alternative route features offered by the app,
- Turn-by-turn notification sequences and
- indicators of reduced speed or traffic congestion.

The screen recordings were time-stamped and tracked after the trip, which allowed us to approximate the time spent on travelling and derive the expected time error (PTE). Since HERE WeGo does not give exportable logs or performance feeds, the study did not sample routing behavior based on internal access to decision-making but instead recreated it based on user-observable outputs. This will give transparency in deriving the metrics and will be realistic in terms of the assessment of commercially closed navigation systems.

E. Functional Metric Application

The indicators specified in Section II were used consistently in the logged data of navigation.

1. The Elapsed Time (TT) between the start of navigation and completion was used to estimate the travel time (TT).
2. Predicted Time Error (PTE) was calculated by comparing the original ETA and the final recorded travel time.
3. Reroute Frequency (RF) was the number of times the application took an alternative route than the one it was supposed to take.
4. Alternative coverage (AC) was used to measure the number of alternative routes that arise during navigation or at the beginning of it.
5. Congestion Activity Proxy (CAP) was the share of the travelling time at significantly decreased movement speeds, which was implemented exclusively in internet circumstances when there is traffic information, Papaleondiou & Dikaiakos [20], Khemmarat et al. [21], Zhao et al. [22].

Both indicators are directly related to routing behaviors and capabilities of a system that can be observed. These are the only externally measurable outcomes on which the study makes no inferences about the efficiency of the algorithm.

IV. RESULTS AND DISCUSSION

In this part, the results of the study are presented in terms of visible system behaviors recorded at organized navigation sessions through the HERE WeGo platform. Findings must be viewed in the light of the method's limitations outlined above, and it should be noted that the study is based on outward observable routing performance as opposed to inward process view algorithmic telemetry or regulated physical road instrumentation. The discussion, thus, is aimed at explaining how the suggested efficiency measures play out in reality and how each and every element of the functioning is incorporated in the emergent routing results that are seen. The analysis is supposed to be an interpretative and not a confirmatory analysis, and the findings should not be considered as statistically proven claims of performance.

A. Overview of Observed Routing Behavior

The online and offline navigation sessions were used to yield enough illustrative data tracing the evolution of routing decisions with respect to network conditions, availability of traffic feeds, and user interaction. Three major dimensions of efficiency emerged as most relevant, namely travel-time predictability (TT and PTE), route adaptiveness (RF and CAP), and user decision-space (AC and modal switching). The

ISSN: 2961-5992

representative data obtained during test sessions to demonstrate the use of the measurement model are summarized in Table I.

These values are not supposed to be the generalizable benchmarks of the performance of HERE WeGo. They instead give the reaction of the system in various circumstances, and they show that the indicators suggested in the section. The numerical patterns align with theoretical expectations. It is true that online sessions are the ones that reflect real-time interaction with the environment, whilst offline sessions are the ones that favor continuity rather than optimization.

TABLE I
EFFICIENCY INDICATORS RECORDED DURING TEST SESSIONS

Condition	TT (min)	PTE (min)	RF	CAP (% slow speed)	AC (no. routes)
Online, peak	27	+3	2	31	3
Online, off-peak	18	+1	0	12	2
Offline	26	+6	0	—	1

B. Functional System Performance in Context

The study approach is functional as opposed to algorithmic. In this regard, therefore, findings are articulated in terms of system capability contribution towards the identified dimensions of efficiency. This decomposition is depicted in Figure 2. Each category of functions is addressed in the following sub-sections with a direct connection to the efficiency indicators, which are identified above.

Fig. 2: Conceptual Routing Efficiency Functional Block Diagram

C. Online and Offline Mode Comparison

HERE WeGo has a distinct online and offline behavior differentiation. In online mode, the system interacts with traffic feeds, periodic recalculation of ETA, and the rerouting processes. Offline mode, on the other hand, uses only pre-downloaded maps with hard assumptions on traversal. This dependency structure is represented graphically in Figure 2. Online operation showed more sensitivity to conditions of congestion in the recorded sessions. The sample data indicate that reroute frequency (RF = 2) is higher at the peak travel, with ETA error values of +3 minutes. It is a mistake, though it means that prediction is not perfect, but the fact that there are rerouting events indicates that they are adapting to changing environments. On the other hand, offline navigation did not give any reroutes (RF = 0), and the projected time error was larger (+6 minutes) as the system was not able to realize the delay caused by congestion. The contribution of offline mode to the routing efficiency does not involve the optimization aspect but rather the robustness aspect. Lack of connectivity does not interrupt navigational support, which implies high service continuity. This supports the view that efficiency should be viewed as multi-dimensional and not only in terms of the minimization of travel-time. Reliability and persistence are examples of efficiency for the users in a situation where network availability is limited.

TABLE II
TRADE-OFFS BETWEEN ROUTING RESPONSIVENESS AND RELIABILITY

Performance Dimension	Online	Offline
Traffic awareness	Real-time	Not available
Route alternatives	2–3 suggested	1 primary
Rerouting	Triggered when conditions change	None
ETA stability	Adaptive	Static + drift
Navigation continuity	Requires connectivity	Fully supported offline
User flexibility	High	Moderate
Predictability	Variable	Stable but less optimal

D. Traffic Awareness and Dynamic Rerouting Behavior

Traffic responsiveness is an essential difference in routing behavior. The logical model behind the rerouting decisions is illustrated in Figure 3. It was observed in the study that dynamic rerouting was induced under most circumstances in which travel-time predictions differed significantly from the estimated baselines. Rerouting events in the studied trips were linked to ETA corrections as opposed to empirically confirmed savings in actual travel time. Lack of a control baseline prevents the study from stating causal reduction on TT, but the data do indicate functional responsiveness. Such responsiveness is measured by the RF metric and indirectly in the small PTE change in online conditions. Further, the fact that CAP values are higher in congestion (31% of log points at slow travel velocity) highlights the degree of environmental variability that the system tries to avoid. Although the rerouting events seem intentional, the study warns that the concepts should not be viewed as unconditionally positive without comparative results

ISSN: 2961-5992

analysis. The result confirms the argument that routing effectiveness is interaction-based rather than one that can be reduced to single-output measures.

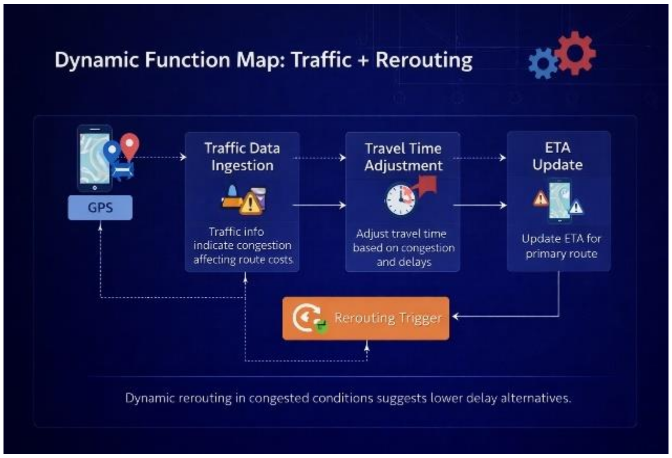

Fig. 3: Dynamic traffic rerouting flowchart

E. Multi-modal Routing and Decision Flexibility

Figure 4 shows that HERE WeGo combines more than one transport type into the routing recommendations. The observations establish that the platform is characterized by modal diversity. The choice of modes also has a direct effect on the breadth of alternative ways, especially in locations where the transport by citizens is well covered. The model alternative covers the dimension of the measurement, which is Alternative Coverage (AC). Online multimodal trips demonstrated more AC values (2–3 options) in comparison with offline (single suggested route). Though this cannot be measured as an efficiency gain directly in terms of passenger preference or time-comparison statistics, it does confirm that functionality does expand user decision space. This is consistent with the theory of urban mobility in general that suggests that a modal choice can be made larger to ensure resiliency in the face of congestion peaks. It is noteworthy that real-time transit information could be availed solely in online mode, implying that multi-modal value is conditionally relative to network quality. Offline transit suggestions were, by necessity, non-dynamic and without delay integration. This brings forward a trade-off between robustness (offline continuity) and adaptiveness (online responsiveness).

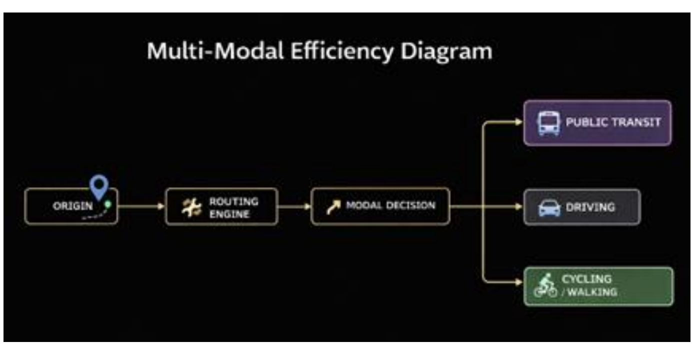

Fig. 4: Multi-model transport flowchart diagram

F. User Interface Guidance and Interaction

The guidance shown to the user interface cannot be represented by deterministic measures in any meaningful way without user study input, unlike time and routing indicators. Nonetheless, its efficiency contribution, as contended with by a qualitative interpretive analysis with functional decomposition, is to minimize errors and follow the route. Clarity of instruction by turn, lane guidance, and the visual prompts decreases the possible turn miss, which indirectly leads to TT stability. Although the error rates are not measured in this study, the analysis puts the UI layer as a supportive mechanism in the functional stack. Its effect, thus, is descriptively warranted and not numerically warranted in line with the limitations of the study.

TABLE III
MAPPING FUNCTIONAL CAPABILITIES TO OBSERVED EFFICIENCY OUTCOMES

Functional Layer	Key Behavior Observed	Related Indicator(s)
Data & Processing	GPS lock, map matching	TT, PTE
Routing Logic	ETA update, alternate route generation	RF, TT, PTE
Traffic Integration	Congestion-aware detours	CAP, RF
Service Delivery	Alternative route suggestion	AC
User Interaction	Turn-by-turn instructions, visual cues	TT (indirect), adherence

G. Integrated Interpretation and Functional Contribution

When the indicators are considered as a whole, they are consistent with the conceptual claim of the study that routing efficiency is developed as a result of integrated functionality. The layered model in Figure 4 shows how individual capabilities, which include positioning, processing, routing logic, service delivery, and interaction with the user generates composite travel results. The performance of the online mode denotes higher interaction between layers, and the offline mode is a mode that focuses on stability rather than interaction. The worth of multimodal capability is one of decision support instead of performance optimization. Rerouting behavior depicts responsiveness that cannot ensure speed increment. The user interface effects have an indirect effect on adherence. This combined view advocates the approach of viewing efficiency as a property of the system that is an outcome of the coordination of numerous functions.

H. Relationship Between Indicators and Functional Claims

The measurement model used in the study focuses on easy-to-observe, simple measures because of the limitations on data access. The most numerically assessed are Travel Time (TT) and Predicted Time Error (PTE) since they can be easily derived

ISSN: 2961-5992

from navigation sessions. Reroute Frequency (RF) is equivalent to functional responsiveness. Alternative Coverage (AC) is associated with the expansion of decision space. The model, however, recognizes limitations. Contributions made by users to the user-interfaces, congestion avoidance proxy, and the clarity of wayfinding cannot be directly measured unless under controlled experimental or user-level instrumentation. This is a limitation that is specifically identified as a methodological rather than a theoretical weakness.

I. Urban Routing Efficiency

The HERE WeGo can be analyzed functionally, revealing that the effectiveness of urban routing is an outcome of the combined functions of Geo-IT, and not of the routing algorithm. It is a foundation that is reliably based on correct spatial data and geo-processing (GPS positioning, map matching) and time-dependent adaptation offered by routing intelligence (traffic integration, ETA estimation, and dynamic rerouting) in overcrowded urban environments. The breadth of decision space and resiliency is enhanced by service-level amenities such as alternative routes and multimodal planning when the car-only routing ceases to be optimal. Significantly, user-interface and guidance functions (turn-by-turn directions, lane guidance, and alerts) can determine compliance and reduce errors in navigation and convert technical optimization into realized efficiency.

J. Limitations and Boundaries of Interpretation

The results are not a confirmation of the algorithmic effectiveness of HERE WeGo. The study fails to include the active tracking of vehicle activity, machine-state history, or back-end data on telemetry. It is simulated or lightly instrumented, and, therefore, causality cannot be claimed. Any rerouting events that are observed might or may not result in objective gains in the sample situation. Moreover, there is platform specificity, which means that the concept of generalization is not possible. The implication that the functional framework can be reused is at the theoretical level until the second navigation platform is tested in a similar environment. It will be shown by extending the framework to Google Maps or Waze that it will be comparatively generalized.

K. Summary of Findings

Within the framework of the mentioned restrictions, the main findings of the study are as follows:

1. The online routing behavior displays a traceable responsiveness, in the form of rerouting, ETA modification, and lowering the PTE values compared to offline usage.
2. The offline mode offers continuation with the navigation, which is more adaptable to trading in the face of connectivity difficulties.
3. Multi-modal capability increases routing flexibility, but the benefits of empirical outcomes have not been determined.
4. Functionality provided by user-interface guidance assists in compliance with routes, which has an indirect impact on efficiency.
5. The concept of routing efficiency is a manifestation of multi-layer interaction, which is consistent with the proposed functional framework.
6. Quantitative precision needs widened instrumentation, which is not within the limits of this study.

V. Conclusion

This paper used a functional and system-level approach to routing efficiency metrics in the HERE WeGo platform instead of quantitative benchmarking. The analysis of observable behaviors in routing logic, traffic responsiveness, modal selection, and user navigation support revealed that routing performance comes into being due to a combination of several functional aspects as opposed to one or another optimization process. The results show that online navigation is more adaptive in terms of rerouting and updates on ETA, and the offline operation is more continuous in terms of connectivity, where the latter is restricted, which supports the idea that efficiency is not restricted to the minimization of travel times. The contribution of the study is mainly the methodological framing of the study. It provides a systematic method of testing the navigation programs when the inner algorithms are not available and when only visible exterior behaviors are tested. The functional behavior, as interpreted by the indicators used, which are the travel time estimation, rerouting behavior, and the availability of alternative routes, demonstrates that the functional behavior can be understood without reverse-engineering proprietary logic. They were illustrative but not generalizable due to the lack of testing on a larger scale and number of platforms. The future work needs to use the framework on other applications and a broader set of logs to confirm findings and to perform a comparative evaluation.

References

[1] M. Zahabi, X. Zheng, A. Maredia, and F. Shahini, "Design of Navigation Applications for People with Disabilities : A Review of Literature and Guideline Formulation Design of Navigation Applications for People with Disabilities : A Review of," 2022, doi: 10.1080/10447318.2022.2088883.
[2] A. C. Id *et al.*, "Virtual navigation tested on a mobile app is predictive of real-world wayfinding navigation performance," pp. 1–15, 2019.
[3] A. Luschi, E. Annamaria, B. Villa, and M. Gherardelli, "Designing and developing a mobile application for indoor real-time positioning and navigation in healthcare facilities," vol. 30, pp. 1371–1395, 2022, doi: 10.3233/THC-220146.
[4] F. Trapsilawati, T. Wijayanto, and E. Septiawan, "Human-computer trust in navigation systems : Google Maps vs. Waze," vol. 4, no. 1, pp. 38–43, 2019.
[5] P. C. Review, "Do navigation maps need a legend ? Empirical assessment of the intuitiveness of point symbols on mobile maps," 2022, doi: 10.2478/pcr-2022-0003.
[6] T. E. D. E. C. Adeetc and H. Cabrita, "Personalized Public Transportation Information," 2015.
[7] A. Dissertation, "Towards Highly Accurate Map Services," 2025.
[8] N. Hoseinzadeh, "TRACE : Tennessee Study and Creative Exchange Application of Crowdsourced Data in Transportation Operations and Safety," 2020.

ISSN: 2961-5992

[9] M. Potthoff and J. Sauer, "Fast Multimodal Journey Planning for Three Criteria ∗," pp. 145–157, 2022.
[10] F. Mosquera and P. Smet, "An Algorithm for Generating a Diverse Set of Multi-Modal Journeys," 2022.
[11] T. Adamo, G. Ghiani, and E. Guerriero, "Computers and Operations Study Real-time schedule adjustments for conflict-free vehicle routing," *Comput. Oper. Res.*, vol. 166, no. August 2023, p. 106625, 2024, doi: 10.1016/j.cor.2024.106625.
[12] J. S. Pan, M. A. Khan, I. S. Popa, K. Zeitouni, and C. Borcea, "Proactive vehicle re-routing strategies for congestion avoidance.
[13] A. Almutairi and M. Owais, "Reliable Vehicle Routing Problem Using Traffic Sensors Augmented Information," pp. 1–30, 2025.
[14] M. A. Falek *et al.*, "To Re-Route, or not to Re-Route : Impact of Real-Time Re-Routing in Urban Road Networks To cite this version : HAL Id : hal-02614875, 2021.
[15] I. Technology, "FORENSIC ANALYSIS OF NAVIGATION APPLICATIONS ON," no. December, 2021.
[16] A. Nordberg, "Geo-based media player," 2016.
[17] L. Safina and Y. Suasti, "Development of Learning Media using Google Maps Application and Here Wego Application to Improve Spatial Thinking Ability in Students at SHS 6 Pinggir," vol. 3, no. 2, pp. 114–120, 2023.
[18] C. D. Tarantilis, D. Diakoulaki, and C. T. Kiranoudis, "Combination of geographical information system and efficient routing algorithms for real-life distribution operations," vol. 152, pp. 437–453, 2004, doi: 10.1016/S0377-2217(03)00035-3.
[19] M. Behrisch, L. Bieker, J. Erdmann, and D. Krajzewicz, "Sumo - simulation of urban mobility: An overview," in SIMUL 2011, The Third International Conference on Advances in System Simulation, Barcelona, Spain, 2011.
[20] L. Papaleondiou and M. Dikaiakos, "Trafficmodeler: A graphical tool for programming microscopic traffic simulators through high-level abstractions," in *Vehicular Technology Conference, 2009. VTC Spring 2009. IEEE 69th*. IEEE, 2009, pp. 1–5.
[21] Khemmarat S, Zhou R, Krishnappa D.K, L Gao, and M Zink. "Watching user-generated videos with prefetching. In: Signal Processing: Image Communication 27.4 (2012), pp. 343–359.
[22] Y. Zhao, D. L. Eager, and M. K. Vernon. "Scalable On-Demand Streaming of Nonlinear Media. In: IEEE/ACM Trans. on Networking 15.5 (2007), pp. 1149–116

ISSN: 2961-5992