Multi-Criteria Methodology for Selecting Communication Protocols in M2M Environments

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***Abstract*—The continuous expansion of Machine-to-Machine (M2M) communication and Internet of Things (IoT) ecosystems has significantly increased the complexity of selecting appropriate communication protocols and data flow management systems. Contemporary M2M deployments operate across heterogeneous functional domains, including sensor networks, transactional systems, and real-time streaming environments, each imposing distinct and often conflicting non-functional requirements such as latency, reliability, scalability, and resource efficiency. This study proposes a domain-oriented multi-criteria decision-making methodology for structured protocol selection in M2M environments. The framework integrates the Analytic Hierarchy Process (AHP) for context-dependent weighting of evaluation criteria with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for quantitative ranking of alternative technologies. A structured domain taxonomy is introduced to dynamically align evaluation priorities with functional deployment characteristics, and 99th percentile latency (L_{p99}) is incorporated as a primary performance indicator to capture tail-behavior effects critical for M2M reliability. Beyond ranking computation, the methodology formalizes a reproducible analytical workflow linking empirical measurements to domain-specific decision outcomes and incorporates a sensitivity-analysis perspective to assess ranking robustness under variations in criterion weights. The proposed framework establishes a transparent and adaptable decision-theoretic foundation for context-aware communication protocol selection in heterogeneous M2M scenarios.**

Keywords*—*Machine-to-Machine communication; Internet of Things; multi-criteria decision making; AHP; TOPSIS; communication protocol selection; non-functional requirements

I. Introduction

Machine-to-Machine (M2M) communication has evolved from a specialized industrial paradigm into a foundational architectural component of modern cyber-physical systems, smart infrastructures, and large-scale Internet of Things (IoT) deployments. The rapid growth of connected devices, heterogeneous hardware platforms, and distributed data-processing architectures has significantly increased the complexity of communication design decisions. Contemporary M2M environments operate under diverse functional constraints, including energy efficiency, transactional consistency, ultra-low latency, and high-throughput streaming, each imposing distinct non-functional requirements.

The proliferation of communication technologies-ranging from request–response protocols such as HTTP/1.1 and HTTP/2 [1] to broker-oriented systems such as MQTT and AMQP, and high-throughput distributed streaming platforms such as Apache Kafka-has transformed protocol selection into a multi-dimensional engineering problem. Each protocol is optimized for specific design assumptions, transport-layer characteristics, and performance objectives. However, when deployed outside their intended operational domain, these technologies may exhibit significant degradation in latency, reliability, or scalability [2].

The protocol selection problem is further complicated by the conflicting nature of non-functional requirements (NFRs). Minimizing latency may increase resource consumption; maximizing reliability may reduce throughput; and optimizing scalability may introduce architectural complexity. In practice, many M2M deployments rely on protocol benchmarking studies that compare isolated performance metrics without embedding them into a unified analytical framework [3]. As a result, architectural decisions are frequently driven by ad hoc evaluations rather than systematic, reproducible methodologies.

This study addresses this gap by proposing a structured, domain-oriented decision-making methodology grounded in Multiple-Criteria Decision-Making (MCDM) theory. The proposed framework integrates the Analytic Hierarchy Process (AHP) [4] for domain-specific weighting of evaluation criteria with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) [5] for quantitative ranking of alternative technologies.

The present work formalizes a reproducible methodological workflow that can be systematically applied across heterogeneous M2M scenarios. Its primary contribution lies in the definition of a consistent analytical framework in which heterogeneous communication protocols can be evaluated, compared, and ranked according to domain-specific priorities.

While the current study focuses on the conceptual structure, mathematical formulation, and decision-theoretic foundations of the model, its empirical application to concrete deployment scenarios constitutes a complementary line of research that extends the methodology toward domain-specific validation.

The objective is not to identify a universally optimal protocol, but rather to determine the most suitable communication solution for a given functional context. By explicitly linking domain taxonomy, measurable evaluation criteria, and structured multi-criteria analysis, this study provides a reproducible foundation for systematic protocol selection in M2M environments.

The remainder of this study is organized as follows: Section II reviews related work and identifies the main research gaps. Section III introduces the conceptual architecture and the domain taxonomy. Section IV formalizes the evaluation criteria and details the integrated AHP–TOPSIS workflow. Section V discusses the implications of the methodology, including a sensitivity perspective. Finally, Section VI concludes the study and outlines directions for future research.

The main contributions of this study can be summarized as follows:

- Domain-Oriented Formalization: A structured taxonomy of three representative M2M domains (Sensor Networks, Transactional Systems, and Real-Time Streaming) is defined, explicitly linking functional requirements to measurable non-functional criteria.
- Integrated AHP–TOPSIS Methodology: A reproducible multi-stage computational framework is developed, combining domain-aware subjective weighting (AHP) with objective distance-based ranking (TOPSIS).
- Tail-Latency-Centric Evaluation: The explicit inclusion of 99th percentile latency (L_{p99}) as a primary evaluation criterion addresses a critical yet frequently underrepresented performance dimension in M2M systems.
- Hybrid-Architecture Compatibility: The methodology supports evaluation of both standalone and hybrid communication architectures, reflecting contemporary deployment practices.
- Sensitivity-Aware Decision Framework: A structured sensitivity-analysis perspective is incorporated, enabling evaluation of ranking stability under variations in domain-specific weight configurations.
- Reproducible Analytical Model: The proposed framework establishes a transparent mathematical workflow linking empirical performance metrics to domain-specific decision outcomes.

II. Literature Review and Related Work

The scientific discourse regarding communication protocols in M2M and IoT environments has historically been divided into two separate silos: empirical performance evaluation and theoretical decision science. This section explores the convergence of these fields and identifies the prevailing research gaps.

A. Comparative Analysis of Communication Protocols

Extensive surveys have established a baseline for understanding protocol behavior. Al-Fuqaha et al. [2] provided one of the most comprehensive classifications of IoT technologies, mapping protocols to the OSI model and highlighting the trade-offs between RESTful architectures and broker-based systems. Their work emphasized that the choice of protocol is tightly coupled with the transport layer (TCP vs. UDP), which dictates the underlying reliability and congestion control mechanisms.

Empirical studies, such as those by Thangavel et al. [6], have utilized specialized testbeds to compare MQTT and CoAP. Their findings demonstrated that MQTT's TCP-based nature provides superior reliability in stable networks, whereas CoAP's UDP-based approach offers lower overhead in constrained environments. However, these studies typically focus on a narrow set of criteria, such as latency or throughput, often ignoring the "tail latency" (L_{p99}) or the impact of message ordering violations on transactional integrity.

More recent experimental studies extend these comparisons by incorporating security mechanisms and realistic deployment constraints. Seoane et al. [7] evaluate the performance impact of security layers on CoAP and MQTT in IoT environments, highlighting non-negligible latency overhead under encryption. Similarly, Wytrebowicz et al. [8] provide a pragmatic comparison of messaging protocols that considers not only raw performance metrics but also implementation complexity and deployment characteristics.

B. Architectural Middleware and Data Flow Management

The role of Message-Oriented Middleware (MOM) has been critically examined by Curry [3], who identified persistence, delivery guarantees, and asynchronous decoupling as the three pillars of modern M2M communication. As systems scale, the focus shifts from individual device connectivity to the management of large-scale data streams. Platforms like Apache Kafka have introduced a paradigm shift towards "log-based" communication, which offers high durability but introduces significant complexity in terms of client-side resource consumption.

The literature highlights a clear trade-off: lightweight protocols (MQTT, CoAP) lack the robust data management features of heavy-duty streaming platforms (Kafka, Pulsar). Yet, performance-oriented studies rarely provide a mechanism for translating these qualitative architectural benefits into a structured decision-making framework.

C. Multi-Criteria Decision-Making (MCDM) in IoT

The application of MCDM methods to solve complex engineering trade-offs has gained significant traction. The Analytic Hierarchy Process (AHP), developed by Thomas Saaty, has been used to determine information priorities in resource allocation [4]. In the IoT context, AHP has been successfully applied to select routing protocols and cloud service providers. However, AHP alone is often criticized for its susceptibility to human subjectivity and the "rank reversal" phenomenon when many alternatives are added.

To address these limitations, researchers have explored hybrid models. The integration of AHP with TOPSIS [5] has been identified as a robust solution. Sharifian et al. [9] applied this combination to evaluate reactive routing protocols, while Durão et al. [10] used it for process selection in industrial IoT. These frameworks demonstrate that while AHP captures expert knowledge, TOPSIS provides a mathematically stable ranking based on the Euclidean distance to an "ideal solution" [11].

Recent literature reviews further demonstrate the growing adoption of MADM methodologies in Industry 4.0 decision problems. Zayat et al. [12] synthesize contemporary applications of MADM techniques across industrial systems, confirming their relevance for complex multi-criteria technological selection scenarios similar to M2M communication environments.

Table I summarizes representative studies across protocol surveys, empirical evaluations, and MCDM-based selection approaches, highlighting the absence of dynamic domain weighting and hybrid support in most prior work.

TABLE I. COMPACT SUMMARY OF RELATED WORK CHARACTERISTICS

Reference	Type	Domain Weights	Hybrid
Al-Fuqaha et al. [2]	Survey	No	No
Thangavel et al. [6]	Empirical	No	No
Seoane et al. [7]	Empirical	No	No
Wytrebowicz et al. [8]	Empirical	No	No
Sharifian et al. [9]	MCDM	Partial	No
Durão et al. [10]	MCDM	Static	No
Zayat et al. [12]	Review	N/A	No
Proposed work	MCDM	Yes (Dynamic)	Yes

D. Discussion and Identification of Research Gaps

Despite the richness of the existing literature, two major structural limitations can be identified. First, most MCDM-based approaches in IoT assume static criterion importance, implicitly treating evaluation weights as context-independent. Such an assumption neglects the fact that distinct M2M domains, such as sensor networks and real-time streaming systems, impose fundamentally different non-functional priorities. Second, existing studies typically evaluate communication protocols as mutually exclusive alternatives, without systematically considering hybrid architectural configurations.

The proposed methodology addresses these limitations by introducing a domain-oriented formalization of the decision space. Criterion weights are dynamically derived through AHP in accordance with functional context, thereby embedding domain specificity directly into the ranking process. Furthermore, the integration of tail latency (L_{p99}) as a primary evaluation parameter extends traditional benchmarking approaches that rely predominantly on average metrics. Finally, the formalized AHP–TOPSIS workflow establishes a reproducible mathematical bridge between empirical measurements and domain-aware decision outcomes.

III. DEFINING THE METHODOLOGICAL ARCHITECTURE

Selecting a communication protocol in an M2M environment is inherently a multi-criteria problem. It involves balancing throughput, latency, reliability, scalability, and resource efficiency [5]. The proposed architecture integrates domain-oriented reasoning with quantitative evaluation.

A. Three-Layer Decision-Making Process

The framework in Fig. 1 defines an iterative, three-layer process.

- The Contextual Layer (Domain & Criteria Definition): The process begins by identifying the functional domain and the specific non-functional requirements. This layer defines the “Goal” and the “Criteria” of the AHP hierarchy.
- The Analytical Layer (Evaluation via AHP-TOPSIS): At this stage, weights are calculated using AHP [4] to reflect domain priorities. These weights are then applied to normalized empirical data within the TOPSIS model [9].
- The Strategic Layer (Selection & Hybridization): The output is a closeness coefficient C_i. This value is used to rank technologies or to identify complementary protocols for a hybrid solution.

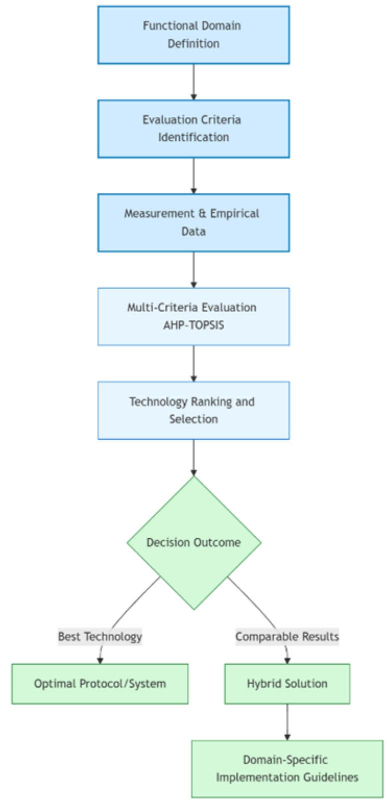

Fig. 1. Conceptual framework for selecting communication protocols and data flow management systems in M2M environments.

B. Core Design Principles

The methodology is guided by four fundamental principles:

- Domain Orientation: Priorities are not fixed but derived from the functional needs of the domain (e.g., Sensor vs. Real-Time).
- Quantitative Measurability: Every criterion must be expressed in a measurable unit (ms, msg/s, $\%$ loss).
- Mathematical Consistency: The use of the Consistency Ratio (CR) in AHP ensures that expert judgments are logical [4].
- Euclidean Distance Optimization: TOPSIS ensures that the chosen technology is not just ”the best” in one category, but the closest to the multidimensional “Ideal Solution” [11].

C. Taxonomy of M2M Domains

To enable dynamic weighting, we classify M2M environments into three domains:

- Sensor Networks: Focus on energy efficiency and aggregate reliability. Latency is secondary.
- Transactional Systems: Focus on strict message ordering, idempotency, and low tail latency to ensure system consistency.

- Real-Time Streaming: Focus on high throughput and minimal L_{p99} latency. Minimal loss is acceptable to maintain "freshness".

IV. Evaluation Criteria and Integrated Methodology

A. Formalization of Evaluation Criteria

A critical aspect of this methodology is the rigorous definition of criteria [13]. The selection process relies on multiple empirically measurable criteria, grouped into two main categories, as in Table II:

TABLE II. Formalized Evaluation Criteria for Protocol Selection.

Criterion	Description	Unit	Type
L_{avg}	Average message transmission latency	ms	Cost
L_{p99}	Latency at 99th percentile	ms	Cost
$Loss$	Share of lost messages	%	Cost
$Ordering$	Message ordering violations	%	Cost
$Reliability$	Successfully delivered messages	%	Benefit
$Throughput$	Channel throughput	msg/s	Benefit
$Scalability$	Behavior with increasing client count	-	Benefit
$Efficiency$	Efficiency in network and computational resource usage	-	Benefit

The relationship between domain and criteria is non-uniform: for instance, in sensor networks L_{avg} and $Reliability$ are prioritized, while in real-time systems L_{p99} and $Tput$ carry higher weights. This dependency is modeled via AHP-derived weights.

We categorize criteria into "Cost" (to be minimized) and "Benefit" (to be maximized), as given in Table III.

TABLE III. Mathematical Definitions of Selection Criteria

Criterion	Mathematical Definition	Type
L_{avg}	$\frac{1}{N}\sum_{i=1}^{N}(t_{recv,i} - t_{send,i})$	Cost
L_{p99}	$P(L \leq x) = 0.99$	Cost
$Loss$	$(1 - \frac{N_{recv}}{N_{sent}}) \times 100$	Cost
$Ordering$	$\frac{N_{out\_of\_order}}{N_{recv}} \times 100$	Cost
$Reliability$	$\frac{N_{ack}}{N_{sent}} \times 100$	Benefit
$Throughput$	$\frac{Total\_Bytes}{Total\_Time}$	Benefit
$Scalability$	$\frac{Perf_{N\_clients}}{Perf_{1\_client}}$	Benefit
$Efficiency$	$\frac{Payload\_Size}{Total\_Packet\_Size}$	Benefit

This categorization ensures that during the normalization phase of TOPSIS, the mathematical direction of each variable is correctly handled [5].

B. The Integrated AHP-TOPSIS Computational Workflow

The core of the proposed methodology lies in the synergy between the subjective prioritization of AHP and the objective, distance-based ranking of TOPSIS. The synergy between AHP and TOPSIS is illustrated in Fig. 2. This dual-layered approach mitigates the inherent weaknesses of using either method in isolation. While AHP can be prone to inconsistencies in human judgment, TOPSIS provides a stable mathematical anchor. Conversely, while TOPSIS requires predefined weights, AHP provides a rigorous mechanism for deriving them based on domain-specific expertise.

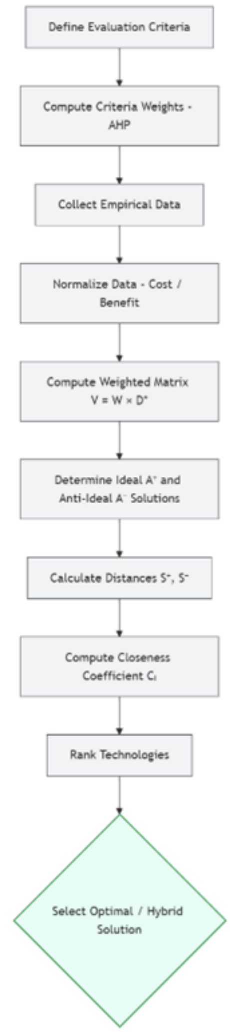

Fig. 2. Integrated AHP–TOPSIS evaluation process for technology selection.

1) Weight determination via the Analytic Hierarchy Process (AHP): The AHP phase begins with the decomposition of the decision problem into a hierarchy. At the summit is the objective (optimal protocol selection), followed by the criteria (latency, throughput, etc.), and finally the alternatives (HTTP/2, Kafka, MQTT).

The fundamental tool of AHP is the pairwise comparison matrix A. For a set of n criteria, the matrix $A = [a_{ij}]$ is a square $n \times n$ matrix where each element represents the relative importance of criterion i compared to criterion j based on the Saaty Fundamental Scale (ranging from 1 to 9) [4]. The matrix is reciprocal, such that $a_{ji} = 1/a_{ij}$ and $a_{ii} = 1$.

To derive the weight vector W, we solve the eigenvalue problem:

$$A \cdot w = \lambda_{max} \cdot w \quad (1)$$

where, λ_{max} is the principal eigenvalue. In practice, the geometric mean method is often used to approximate the weight vector:

$$w_j = \frac{\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}} \quad (2)$$

A critical requirement for the validity of AHP is the consistency check [4]. Since human judgment is stochastic and potentially contradictory (e.g., if $A > B$ and $B > C$, a human might mistakenly say $C > A$), we must calculate the Consistency Index (CI):

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

The final validation is the consistency ratio ($CR = CI/RI$), where RI is the Random Index for a matrix of size n. If $CR \leq 0.1$, the weights are considered robust and logically consistent [4]. If not, the pairwise comparisons must be re-evaluated. This rigor is essential in M2M systems where a misaligned weight (e.g., underestimating the importance of tail latency in a transactional domain) could lead to catastrophic system failure.

2) Normalization and the construction of the decision space: Once the weights $W = (w_1, w_2, \ldots, w_n)$ are established, we move to the empirical evaluation of technologies. Let D be the decision matrix containing the raw performance data for m alternatives and n criteria. Because the criteria are measured in heterogeneous units (milliseconds, percentages, messages per second), they cannot be compared directly.

Non-linear normalization is employed [5] to transform all values into a dimensionless space $[0, 1]$. Unlike simple linear scaling, this approach preserves the relative significance of extreme values, which is vital for capturing the performance gaps between protocols like Kafka and HTTP/2.

For benefit criteria (e.g., Throughput, Reliability):

$$r_{ij} = \frac{x_{ij}}{\max_i(x_{ij})} \quad (4)$$

For cost criteria (e.g., Latency, Loss):

$$r_{ij} = \frac{\min_i(x_{ij})}{x_{ij}} \quad (5)$$

This transformation ensures that for all r_{ij}, a value closer to 1 always represents superior performance, regardless of whether the original metric was a "cost" or a "benefit".

3) The TOPSIS ranking algorithm: The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is based on the geometric principle that the chosen alternative should have the shortest Euclidean distance from the positive ideal solution (A^+) and the farthest distance from the negative ideal solution (A^-) [11].

First, we construct the weighted normalized decision matrix V:

$$v_{ij} = w_j \cdot r_{ij} \quad (6)$$

Next, we identify the ideal coordinates:

- Positive Ideal Solution (A^+): $A^+ = (v_1^+, v_2^+, \ldots, v_n^+)$, where $v_j^+ = \max_i(v_{ij})$.
- Negative Ideal Solution (A^-): $A^- = (v_1^-, v_2^-, \ldots, v_n^-)$, where $v_j^- = \min_i(v_{ij})$.

The separation measures for each alternative i are calculated using the n-dimensional Euclidean distance:

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^+)^2}, \quad S_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \quad (7)$$

Finally, we compute the closeness coefficient (C_i):

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad (8)$$

The value C_i serves as a universal performance index [5]. An alternative with $C_i = 1$ would represent a hypothetical "perfect" protocol, while $C_i = 0$ would represent the worst possible performer across all criteria.

C. Methodology Summary

For clarity and reproducibility, the complete methodological workflow can be summarized in the following sequential stages:

- Definition of functional domain.
- Identification of measurable evaluation criteria.
- Construction of AHP pairwise comparison matrix.
- Consistency validation of weight configuration.
- Normalization of empirical performance metrics.
- Computation of TOPSIS separation measures.
- Ranking via closeness coefficient C_i.

D. Illustrative Example

To demonstrate the operational logic of the proposed framework, consider a simplified scenario involving three communication alternatives: HTTP/2, MQTT, and Apache Kafka. Let the evaluation criteria be latency (L_{p99}), throughput, and reliability.

Assume that the AHP phase produces the following domain-specific weights:

$$W = (0.4, 0.35, 0.25)$$

After normalization and TOPSIS computation, assume the resulting closeness coefficients are:

$$C_{HTTP/2} = 0.62, \quad C_{MQTT} = 0.71, \quad C_{Kafka} = 0.84$$

In this illustrative scenario, Apache Kafka ranks first due to its superior throughput and reliability characteristics under the assigned domain priorities.

This example does not represent empirical validation, but serves to clarify the computational mechanics of the integrated AHP–TOPSIS workflow.

V. Discussion and Sensitivity Analysis

The results generated by the integrated AHP-TOPSIS methodology provide more than just a simple ranking; they offer a profound insight into the architectural trade-offs inherent in M2M communication. This section delves into the interpretation of the closeness coefficient and the stability of the model.

A. Conceptual Sensitivity Analysis

In multi-criteria decision-making frameworks, ranking stability is inherently dependent on the configuration of criterion weights. Since the AHP phase introduces domain-specific weighting derived from expert judgment, it is necessary to examine the structural robustness of the resulting ranking with respect to controlled perturbations of the weight vector.

Let w_k denote the weight of criterion k. A perturbation Δw_k modifies the weighted normalized matrix V, and consequently affects the separation measures S_i^+ and S_i^-. The perturbed closeness coefficient can be expressed as:

$$C_i' = \frac{S_i^-(\Delta w_k)}{S_i^+(\Delta w_k) + S_i^-(\Delta w_k)}.$$

Conceptually, three stability regimes may be distinguished:

- Dominant-Criterion Regime: Small perturbations in w_k induce ranking shifts, indicating high sensitivity to specific criteria.
- Balanced Regime: Moderate perturbations lead to proportional changes in C_i without rank reversal.
- Robust Regime: The ranking remains invariant under admissible perturbations, demonstrating structural stability of the decision space.

The explicit incorporation of a sensitivity-analysis perspective enhances the methodological credibility of the framework and provides decision-makers with insight into ranking resilience under evolving domain priorities.

B. Architectural Implications of the Closeness Coefficient

A high C_i value suggests that a protocol occupies a "sweet spot" in the multi-criteria space for a specific domain. For instance, in the real-time streaming domain, a protocol like Apache Kafka might achieve a high C_i not necessarily because it has the lowest latency, but because its superior throughput and scalability outweigh its latency costs when weighted through the AHP process.

Conversely, the model often reveals the limitations of "general-purpose" protocols. HTTP/2, while highly efficient for request-response cycles, frequently shows a declining C_i as the number of concurrent M2M connections increases, due to the overhead of its frame-management and the Head-of-Line (HoL) blocking issues at the application layer.

C. The Role of Hybridization in M2M Systems

One of the most significant findings of our methodology is that no single protocol is universally optimal. This supports the move towards hybrid communication architectures. By analyzing the distances S_i^+ and S_i^-, architects can identify protocols that are "specialists". If Protocol A has the best S^+ for reliability and Protocol B has the best S^+ for latency, a hybrid system can be designed where Protocol A handles control signaling and Protocol B handles the raw data payload.

D. Sensitivity Analysis: Testing Model Robustness

In any MCDM model, the final ranking is sensitive to the weights assigned in the AHP phase. To assess robustness, an OAT sensitivity-analysis procedure can be applied by varying the weight of a single criterion (e.g., Latency) by $\pm 20\%$ and examining the resulting changes in the C_i ranking [5]. This procedure can be used to identify stability zones in which the ranking remains invariant and regimes in which rank reversal occurs.

Conceptually, the methodology implies that: 1) Dominant Criteria: In the Transactional domain, the ranking is highly sensitive to the $Ordering$ and $Reliability$ weights. Even a small reduction in these weights can shift the preference from Kafka to a more traditional RDBMS-backed broker. 2) Resilient Criteria: $Throughput$ weights tend to have a more linear and less volatile impact on the final ranking, suggesting that most modern protocols are sufficiently optimized for volume, making other NFRs the true differentiators.

E. Practical Implementation Challenges

Implementing this methodology in a real-world industrial environment requires addressing the stochastic nature of empirical data. Network latency is rarely a constant; it is affected by "micro-bursts", background traffic, and hardware-level interrupts. Therefore, the input data for the decision matrix D should be derived from statistical distributions (e.g., 99th percentile values) rather than simple arithmetic means. Furthermore, the computational overhead of the AHP-TOPSIS process itself is negligible, meaning it can be integrated into "self-adaptive" M2M systems that dynamically switch protocols as network conditions change.

VI. Conclusion and Future Research Directions

This study has presented a domain-oriented, multi-criteria methodology for structured communication protocol selection in Machine-to-Machine (M2M) environments. By integrating the Analytic Hierarchy Process (AHP) with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), the proposed framework establishes a transparent and reproducible analytical workflow linking domain requirements to measurable performance criteria.

The primary contribution of this study is methodological. Rather than focusing on isolated protocol benchmarks, the framework defines a consistent decision-theoretic space in which heterogeneous communication technologies can be evaluated according to domain-specific priorities. The explicit incorporation of functional taxonomy, measurable non-functional criteria, and tail-latency–centric evaluation enhances the rigor and interpretability of protocol selection decisions.

The proposed approach is not intended to identify a universally optimal communication protocol. Instead, it formalizes a structured mechanism for determining context-dependent suitability. By supporting dynamic weighting of criteria and accommodating hybrid architectures, the model reflects the practical realities of contemporary M2M deployments.

Limitations: The current study focuses on the conceptual and methodological formalization of the decision workflow. The empirical population of the decision matrix with domain-specific measurements, and the evaluation of ranking outcomes against deployment objectives, are treated as complementary research activities and will be reported separately.

Future research will focus on large-scale empirical validation of the framework across representative deployment scenarios and on extending the methodology toward adaptive decision models capable of responding to dynamic environmental conditions. The integration of uncertainty-aware extensions, such as Fuzzy-AHP and stochastic sensitivity modeling, constitutes a promising direction for further methodological refinement.

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