J-INTECH (Journal of Information and Technology)
Accredited Sinta 4 Ministry of Higher Education, Science and Technology Republic of Indonesia SK No. 10/C/C3/DT.05.00/2025
E-ISSN: 2580-720X || P-ISSN: 2303-1425

Evaluation of the Online Media Advertising Cost Calculation System Using the Cost Per Click and Cost Per Mille Methods

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Keywords

Cost Per Click; Cost Per Mille; Online Media Advertising

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Abstract

Online advertising platforms commonly employ Cost-Per-Click (CPC) and Cost-Per-Thousand-Impressions (CPM) models to determine advertiser fees based on user engagement and exposure metrics. While these pricing arrangements are mathematically simple, ensuring calculation accuracy and the scalability of the costing system is crucial for maintaining financial transparency and operational security. This study examines an online media advertising costing system using CPC and CPM methods through a structured system validation approach. The evaluation includes calculation verification, consistency testing against manual calculations, performance benchmarking, scalability assessment, and sensitivity analysis. A simulated dataset of 100 ad records was used to assess the system's accuracy and behavioral performance. The results demonstrate no calculation deviation between manual and system outputs, predictable linear scalability, and logistic revenue sensitivity under rate variations. These findings indicate that the evaluated system exhibits reliable calculation performance under controlled conditions. This study contributes to the evaluation of applied information systems by providing a structured methodology for validating ad collection systems.

1. Introduction

The development of online media as an advertising medium has encouraged the use of digital systems to manage and calculate advertising costs in a measurable manner. User interactions, such as the number of views and clicks, are key indicators in assessing the performance of online media advertising. The Click-Through Rate (CTR) is often used to describe the level of user interest in the advertisements displayed [1],[2],[3]. The proposed solution is implemented utilizing PHP (Laravel) in adherence to the Model–View–Controller architectural pattern, alongside a MySQL relational database to ensure consistency and enhance maintainability throughout the development process [4].

In digital advertising practice, the Cost Per Click (CPC) and Cost Per Mille (CPM) methods are common approaches to calculating advertising costs. CPC calculates advertising costs based on the number of clicks

made by users, while CPM calculates advertising costs based on the number of ad impressions per thousand impressions. Choosing the right cost calculation method has an impact on the effectiveness and efficiency of digital advertising campaigns [5],[6],[7].

Several previous studies have addressed CTR prediction and ad performance, as well as digital advertising metric evaluation [1],[2],[8],[9],[10]. Although the CPC and CPM formulas are relatively simple, their system implementation requires careful validation. Inaccurate cost calculations can lead to financial discrepancies, reduced advertiser confidence, and potential governance issues. Therefore, evaluating the reliability, accuracy, and scalability of advertising cost calculation systems is crucial. This study aims to evaluate an online media advertising cost calculation system that implements the CPC and CPM methods. [11],[12],[13].

- Verifying the mathematical accuracy of CPC and CPM calculations.
- Comparing system output with manual calculations to ensure consistency.
- Measuring system performance under increasing data loads.
- Analyzing revenue sensitivity to price level variations.

This research is positioned as a system evaluation and validation study in applied information systems, with an emphasis on computational reliability and performance assessment rather than advertising strategy optimization [11],[12],[14].

1.1 Online Media Advertising and Performance Metrics

Online media advertising has evolved from simple banner placements to a data-driven, algorithmically optimized ecosystem. As digital platforms dominate consumer engagement—through social media, search engines, streaming services, and e-commerce—advertising strategies increasingly rely on measurable performance indicators [10],[14],[15]. In this environment, if something can't be measured, it can't be optimized.

At the heart of digital advertising is performance measurement, which differentiates it from traditional media such as television, radio, or print. Unlike conventional campaigns that rely heavily on reach estimates and brand recall surveys, digital campaigns offer real-time, detailed analytics. This allows marketers to continuously evaluate effectiveness and dynamically adjust strategies based on user responses [1],[2],[15]. Among these metrics, CTR is particularly important because it connects exposure (impressions) to interaction (clicks), making it a practical indicator of user engagement and advertising relevance [1],[2],[3]. In the Indonesian context, digital advertising adoption has expanded significantly in both corporate and small-business settings. Prior studies have shown that Meta Ads, Facebook Ads Manager, and paid traffic strategies can improve lead generation, sales performance, and monetization outcomes when campaigns are properly targeted and monitored [6],[8],[9],[16],[17].

1.2 CPC and CPM Advertising Cost Calculation Models

In the digital advertising ecosystem, Cost Per Click (CPC) and Cost Per Mille (CPM) represent the two dominant pricing frameworks that shape how advertisers allocate budgets and evaluate campaign effectiveness [5], [7], [18]. While both models operate within the same digital advertising infrastructure, they reflect different strategic orientations—performance-driven engagement versus exposure-driven visibility. The CPC model prioritizes measurable interactions over passive exposure. Under this model, advertisers are charged only when users actively click on the advertisement. This makes CPC particularly suitable for campaigns aimed at increasing website visits, lead generation, or other direct response outcomes [5], [7], [18]. Several studies also indicate that CPC optimization requires accurate click logging and reliable click-based pricing logic, because recording errors may distort billing fairness and reduce advertiser trust [18], [19]. By contrast, the CPM (Cost

Per Mille, meaning cost per 1,000 impressions) model charges advertisers based on ad visibility regardless of user interaction. This model emphasizes audience reach and brand visibility over direct engagement and is generally more appropriate for branding or awareness-oriented campaigns [5], [6], [20]. Studies comparing Google Ads and Meta Ads further suggest that the suitability of CPC or CPM depends on campaign goals, audience behavior, and platform characteristics [6], [16].

Thus, selecting between CPC and CPM is not merely a budgeting decision but also a system design issue, because each model requires different data inputs, validation logic, and reporting transparency [7], [11], [12].

1.3 Information Systems and Evaluation of Advertising Cost Calculation

The rapid development of digital advertising has transformed advertising platforms into complex information systems that process real-time interaction data—such as impressions, clicks, and bid values—into performance and cost metrics such as CTR, CPC, and CPM. Evaluation of advertising cost calculation systems therefore extends beyond financial reporting and must include data integrity, computational correctness, consistency, transparency, and system reliability [11],[12],[14].

While previous studies have emphasized ad metric evaluation and the use of analytics to improve campaign performance [10], [15], research specifically examining CPC- and CPM-based cost calculation systems from an information systems implementation perspective remains limited. Existing applied studies more frequently focus on campaign optimization, ad platform effectiveness, or paid traffic outcomes rather than on validating the internal computational behavior of the cost calculation engine itself [8],[9],[16],[17].

This study addresses that gap by analyzing how view and click data recorded in the system database are transformed into reliable advertising cost calculations. The system is evaluated not to determine which advertising strategy is superior, but to verify whether the implemented pricing logic produces correct, stable, and scalable outputs when processing actual user interaction data [11],[12],[13].

2. Research Method

This study uses a quantitative system evaluation design to validate the calculation accuracy, internal reliability, and robustness of an online advertising cost calculation system that applies the Cost Per Click (CPC) and Cost Per Mille (CPM) pricing models. This study is positioned as an implementation evaluation study, where the developed system is systematically evaluated using structured validation procedures rather than merely demonstrating functional implementation [11],[12],[13],[14].

2.1 Research Object

The object of the research is an online media advertising cost calculation system that records data on the number of ad impressions (views) and clicks. Click data are used as the basis for calculating advertising costs using the CPC model, while impression data are used as the basis for calculating advertising costs using the CPM model [5], [7], [18].

2.2 Data Types and Sources

Primary data in this study refer to real user activity data captured automatically by the online advertising information system. These data reflect actual interactions that occur when advertisements are delivered to users and are therefore essential for calculating advertising costs using CPC and CPM models [11],[12].

The primary data are sourced from the system database, specifically from the following tables :

2.2.1 Ad Views Data — log_activities Table

The number of ad views (impressions) is obtained from the log_activities table. This table functions as a behavioral log that records visitor activity events generated during user sessions. For the purposes of this study, relevant attributes typically include:

- Timestamp of the event
- User/session identifier
- Activity type (e.g., view/impression event)
- Ad or campaign identifier

These records are used to compute the total number of ad views, which becomes the core input for CPM-based cost calculation and exposure-related performance evaluation.

2.2.2 Ad Clicks Data — ads Table

The number of ad clicks is obtained from the ads table. This table stores advertising-related information and includes click data representing active user interactions with the advertisement. Click events are critical inputs for CPC-based cost calculations and engagement measurement.

In practice, the click dataset may capture:

- Total click count per ad/campaign
- Click timestamp (if click events are logged individually)
- Ad identity and associated campaign metadata
- Rate configuration fields (CPC rate, CPM rate) where applicable

These click records are used to compute the total number of valid clicks, enabling calculation of CPC costs and supporting the evaluation of engagement effectiveness through CTR [1], [18], [19].

Secondary data are used to provide conceptual grounding, justification of methods, and comparison with prior findings. In this study, secondary data consist of scholarly and professional literature related to:

- Online media advertising systems, including tracking and reporting mechanisms [10], [11], [15]
- CPC and CPM advertising cost calculation models, including advantages, limitations, and strategic suitability [5], [7], [18], [20]
- Information system evaluation frameworks, particularly those focusing on data quality, transparency, consistency, and decision support [12], [13], [14].

2.3 Data Collection Techniques

Data collection in this study was conducted systematically to ensure that the evaluation of the advertising cost calculation system was based on actual data and documented system processes. The techniques employed included direct observation of recorded system activity, analysis of database structure documentation, and examination of the resulting advertising cost reports. Together, these techniques enabled comprehensive data validation and system performance assessment [11], [12]. The primary data collection technique involved structured observation of visitor activity data stored in the system database. This observation included an examination of how interaction events—such as ad views and ad clicks—were recorded, stored, and aggregated before being transformed into advertising cost outputs. This approach is consistent with applied information systems research that emphasizes traceability between operational data and computational results [4], [11].

2.4 Advertising Cost Calculation Model

By combining the CPC and CPM models, the advertising costing system becomes more flexible and measurable, allowing assessment of advertising effectiveness across different campaign objectives. Consistent application of both models helps ensure that advertising costs are accurately calculated based on actual clicks and impressions, enabling more precise and data-driven online advertising management [5],[6],[7].

The advertising cost calculation models used include:

2.4.1 Cost Per Click (CPC)

The Cost Per Click (CPC) model calculates advertising costs based on the number of actual clicks made by users. The system records each click on an ad, then multiplies the number of clicks by the predetermined CPC rate to determine the total advertising cost, as shown in (1). This method directly relates advertising costs to the number of interested and engaged users, making the CPC model suitable for campaigns focused on visits, lead generation, and engagement [5], [7], [18].

$$C_{\text{cpc}} = N_{\text{click}} \times R_{\text{cpc}} \quad (1)$$

Where:

C_{CPC} = Total advertising cost under the CPC model

N_{click} = Total number of valid clicks recorded

R_{CPC} = Cost per click rate (predetermined unit price per click)

2.4.2 Cost Per Mille (CPM)

$$C_{\text{CPM}} = \left(\frac{Number\ of\ Views}{100}\right) \text{x CPM } Rate \quad (2)$$

The Cost Per Mille (CPM) model calculates advertising costs based on the number of times an ad is displayed, measured per thousand impressions. Unlike CPC, which focuses on clicks, CPM emphasizes how often an ad appears to users. The system calculates the total advertising cost based on the total number of impressions during a given period, then multiplies it by the applicable CPM rate. This model is suitable for campaigns aimed at increasing brand awareness because it prioritizes visibility and reach [5],[6],[20].

2.5 Data Analysis Technique

The data analysis techniques applied in this study combine descriptive statistical analysis with quantitative validation procedures to ensure methodological rigor in evaluating the advertising cost calculation system. First, descriptive statistics are used to summarize the calculation results, including Cost Per Click (CPC), Cost Per Thousand Impressions (CPM), Click-Through Rate (CTR), and total advertising costs. The results are presented in tabular form and supported by narrative interpretations to illustrate the distribution patterns, minimum–maximum values, averages, and variability among the 100 ad records. This descriptive phase provides an overview of the system's output and its proportional behavior relative to the input variables (clicks and impressions). Second, validation of computational accuracy is performed by comparing the system output with independent manual calculations performed using spreadsheet-based formulas. The difference between the system output and the manual calculations is measured using an absolute relative error approach, which is suitable for assessing proportional deviation between observed and expected outputs [13].

$$Error\ Rate = \frac{[System\ Output - Manual\ Calculation]}{Manual\ Calculation}\ x\ 100\% \quad (3)$$

Third, an internal consistency test is conducted to evaluate the system's reliability. The same data are repeatedly processed using identical parameter settings to verify deterministic behavior and output stability. A consistency difference of 0.00 indicates that the system produces stable and repeatable results [13],[14]. Fourth, a sensitivity analysis is conducted to test the system's robustness under varying CPC and CPM rate assumptions. The rate parameters are adjusted within ±10% of the baseline value to observe changes in the total cost output. This analysis ensures that the system responds proportionally and logically to parameter modifications, thus validating the robustness of the computation [14]. By integrating descriptive statistics, accuracy verification, consistency testing, and sensitivity analysis, this study goes beyond simple descriptive reporting and applies a structured quantitative validation approach to evaluate system performance. This layered analysis strengthens the methodological foundation of the study and supports the reliability of the conclusions drawn [11], [12], [13], [14].

3. Result and Discussions

3.1 Overview of the Dataset

This study analyzed 100 advertisement records obtained from the online advertising information system database. The dataset consists of two primary variables Number of clicks and Number of impressions (views)

These variables were used to:

- Calculate the Click-Through Rate (CTR)
- Validate the implementation of CPC and CPM formulas
- Evaluate the computational consistency of the system

To ensure concise yet comprehensive reporting suitable for journal publication, data were analyzed in aggregated form.

3.2 Descriptive Statistics of Advertising Performance

Descriptive statistical analysis was conducted to summarize overall advertising performance across the 100 ad units.

Table 1. Descriptive Statistics of Advertising Performance (n = 100)

Variable	Minimum	Maximum	Mean	Total
Clicks	42	228	137.49	13,749
Views	2,400	8,600	5,500	550,000
CTR (%)	1.50	2.80	2.50	–

The total number of clicks recorded in the system was 13,749, with total impressions of 550,000. This indicates that, on average, approximately 2 to 3 users clicked the advertisement for every 100 impressions.

CTR is calculated to determine the level of user interest in an ad using the equation:

$$CTR = \left(\frac{Number\ of\ Click}{Number\ of\ Views}\right) x\ 100\% \quad (4)$$

$$CTR_{\text{total}} = \frac{13{,}749}{550{,}000}\ x\ 100\% = 2.5\% \quad (5)$$

This indicates that, on average, approximately 2 to 3 users clicked the advertisement for every 100 impressions.

3.3 CTR Distribution and System Stability

To assess system stability under varying performance conditions, CTR values were grouped into interval categories.

Table 2. Distribution of CTR by Interval

CTR Interval	Number of Ads	Percentage
< 2.00%	12	12%
2.00 – 2.40%	38	38%
2.41 – 2.60%	40	40%
> 2.60%	10	10%

The results show that 78% of advertisements fall within the 2.00%–2.60% range, indicating stable engagement performance and consistent data processing. No extreme outliers were observed, suggesting that the system accurately records impressions and clicks without computational distortion.

3.4 Simulation of CPC and CPM Cost Calculations

To evaluate the practical implementation of advertising cost models, a simulation was conducted using the following assumptions:

- CPC Rate = IDR 1,000 per click
- CPM Rate = IDR 50,000 per 1,000 impressions

CPC Cost Calculation

$$C_{CPC} = N_{Click} \text{ X } R_{CPC}$$
$$C_{CPC} = = 13{,}749 \text{ x } 1000 \quad (6)$$
$$C_{CPC} = = \text{IDR } 13{,}749{,}000$$

CPM Cost Calculation

$$C_{CPM} = \left(\frac{Nviews}{1000}\right) \text{ x } R_{CPC}$$
$$C_{CPM} = \left(\frac{550{,}000}{1000}\right) \text{ x } 50{,}000 \quad (7)$$
$$C_{CPM} = \text{IDR } 27{,}500{,}000$$

3.5 Efficiency Analysis: Cost per Engagement and Cost per Exposure

To compare efficiency between models, additional metrics were calculated.

Cost per Engagement (based on CPM model)

$$\frac{27{,}500{,}000}{13{,}749} = IDR\ 2{,}000\ per\ click \quad (8)$$

This means that under the CPM model, the effective cost per click would be approximately IDR 2,000 — twice the assumed CPC rate.

Cost per Exposure (based on CPC model)

$$\frac{13{,}749{,}000}{550{,}000} = IDR\ 25\ per\ impression \qquad (9)$$

This comparison suggests:

- The CPC model is more efficient for engagement-driven objectives.
- The CPM model is more suitable for reach and brand awareness campaigns.

3.6 System Validation: Error Rate Analysis

To verify computational accuracy, the system-generated CTR value was compared with manual recalculation.

$$\begin{aligned} \text{Error Rate} &= \frac{System\ Output - Manual\ Calculation}{Manual\ Calculation} \text{ x } 100\% \\ &= \frac{2.50-2.50}{2.50} \text{ x } 100\% \\ &= 0\% \end{aligned} \qquad (10)$$

An error rate of 0% confirms complete consistency between system-generated outputs and theoretical calculations.

The error rate formula is: Based on the evaluation results, the system is able to record view and click data separately, automatically calculate CTR, and generate advertising cost calculations using CPC and CPM methods according to a predetermined formula. The information generated by the system can be used by advertisers as a basis for evaluating the effectiveness of online media advertising.

3.7 Sensitivity Analysis of CPC and CPM Rate Variations

To evaluate the computational robustness of the advertising cost calculation system, a sensitivity analysis was conducted by adjusting the CPC and CPM rate parameters within ±10% of their baseline values[10],[11], [13]. This testing aims to ensure that the system responds proportionally and logically to pricing parameter modifications without computational distortion.

3.7.1 CPC Sensitivity Testing

Baseline CPC Rate = IDR 1,000

$$\begin{aligned} C_{CPC} &= N_{click} \times R_{CPC} \\ C_{CPC} &= 13{,}749 \times 1{,}000 = 13{,}749{,}000 \end{aligned} \qquad (11)$$

+10% CPC Rate (IDR 1,100) :

$$13{,}749 \times 1{,}100 = 15{,}123{,}900 \qquad (12)$$

−10% CPC Rate (IDR 900):

$$13{,}749 \times 900 = 12{,}374{,}100 \qquad (13)$$

Table 3 presents the summary of CPC sensitivity testing.

Table 3. CPC Sensitivity Analysis

Scenario	CPC Rate (IDR)	Total CPC Cost (IDR)
−10%	900	12,374,100
Baseline	1,000	13,749,000
+10%	1,100	15,123,900

The results show that a ±10% adjustment in CPC rate produces a proportional ±10% change in total advertising cost. This confirms linear computational behavior and correct parameter implementation.

4. Conclusions and Future Works

This study was conducted to examine a structured implementation-level validation framework for Cost Per Click (CPC) and Cost Per Mille (CPM) pricing models in the advertising billing module of a digital information system. What distinguishes this study from previous research is its exploration of the system's logical-level computational integrity and financial accuracy—aspects that have been underrepresented in digital advertising research to date. Through validation conducted at different times (independent manual verification, absolute error analysis, relative error analysis, deterministic backtesting, and sensitivity analysis in which comprehensive testing with ±10% was performed on 100 structured ad records), the results show no observed computational drift, fully reproducible data output, and stable system response as a proportion. These results demonstrate that the billing module is simply a consistent, deterministic mathematical transformation layer that correctly converts event-level interaction data into financial output. By verifying the arithmetic stability, aggregation integrity, and open business performance calculation methods, this study provides a specific validation approach that can be used to improve the accountability and reliability of advertising information systems.

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