

## Original Article

# The Impact of Real-Time App Activity Signals on Ad Effectiveness in Auction-Based Digital Ad Platforms

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**Abstract:** Real-time app activity signals, such as user browsing behavior, product interactions, and transactional events, enable advertisers to personalize and optimize ad delivery in auction-based digital advertising platforms. By incorporating these signals into real-time bidding (RTB) algorithms, advertisers can improve key performance indicators (KPIs) such as click-through rate (CTR), conversion rate, and return on ad spend (ROAS). This paper introduces a formal framework to evaluate the impact of real-time signals, performs quantitative analysis on ad campaigns, and presents actionable insights for advertisers.

**Keywords:** Real Time Bidding, Auction Based Ad Platforms, Digital Advertisin.

## I. INTRODUCTION

Auction-based digital ad platforms such as Google Ads, Meta Ads Manager, and Amazon Advertising rely on real-time bidding (RTB) systems. These systems enable advertisers to bid dynamically on ad placements, using available user data to maximize performance metrics. Among the most impactful data sources are real-time app activity signals—up-to-the-minute insights derived from users' current interactions within apps.

Real-time signals, such as viewing specific product categories, initiating checkout processes, or time spent on high-interest app screens, provide a window into immediate user intent. By integrating these signals with historical data, advertisers can refine audience targeting and adjust bids in milliseconds, optimizing ad performance.

This paper aims to:

- Quantify the contribution of real-time app activity signals to KPIs.
- Provide a formal model to incorporate real-time signals in RTB frameworks.
- Offer technical recommendations for advertisers to effectively leverage these signals.

## II. THEORETICAL FRAMEWORK

### A. Real-Time Signals in Ad Personalization

The inclusion of real-time signals in RTB systems enhances:

- Bid Prioritization: Higher bids for users with high purchasing intent.
- Ad Creative Selection: Adjusting content based on immediate interests.
- Audience Segmentation: Dynamic updating of audience clusters.

### B. Mathematical Modeling

Let  $S$  denote the signal set used in bidding, composed of historical signals ( $S_h$ ) and real-time signals ( $S_r$ ):

$$S = S_h + S_r$$

The bid value  $B$ , determined by the RTB system, can be expressed as:

$$B = \alpha \cdot U_h + \beta \cdot U_r$$

Real-time signals improve  $P_i$  by refining the prediction of user intent:

$$P_i = \sigma(\theta_h \cdot S_h + \theta_r \cdot S_r + \varepsilon)$$

Where  $\sigma$  is a logistic function mapping signal inputs to probabilities, and  $\varepsilon$  represents noise.

Where:

- $U_h$ : Utility derived from historical signals.
- $U_r$ : Utility derived from real-time signals.
- $\alpha, \beta$ : Weight parameters representing the relative importance of each signal type.

The advertiser's goal is to maximize the expected return  $R$  from the bid:



$$R = \sum_{i=1}^N (V_i \cdot P_i) - C_i$$

Where:

- $V_i$ : Value of the conversion for impression  $i$ .
- $P_i$ : Probability of conversion, a function of  $S$ .
- $C_i$ : Cost of the bid.

### III. METHODOLOGY

#### A. Data Sources

Data was collected from 30 ad campaigns across industries including retail, travel, and gaming. Key data points included:

- Real-Time Signals: Product views, cart additions, checkout initiations, session duration.
- Historical Signals: Past purchases, demographic data, and app usage frequency.
- KPIs: CTR, conversion rates, and ROAS.

#### B. Experimental Setup

Controlled experiments compared two approaches:

- Baseline Group: Bids based on historical signals only ( $Sh$ ).
- Test Group: Bids based on both historical and real-time signals ( $Sh + Sr$ ).

#### C. Statistical Analysis

To evaluate the impact of real-time signals, we employed:

- Regression Analysis: Estimating the contribution of  $Sr$  to KPIs.
- Lift Analysis: Quantifying percentage improvement in CTR, conversion rates, and ROAS.
- The regression model used is:

$$Y = \beta_0 + \beta_h Sh + \beta_r Sr + \epsilon$$

Where:

- $Y$ : KPI (CTR, conversion rate, or ROAS)
- $\beta_h, \beta_r$ : Coefficients indicating the impact of  $Sh$  and  $Sr$ , respectively.

### IV. RESULTS

#### A. Key Findings

Incorporating real-time signals led to significant improvements across KPIs:

- CTR: Increased by 20%, driven by dynamic relevance.
- Conversion Rate: Increased by 27%, highlighting the precision of real-time intent signals.
- ROAS: Improved by 23%, with a marked impact on time-sensitive campaigns.

#### B. Incremental Value of Real-Time Signals

The regression analysis revealed:

- $\beta_r$  (real-time signals) was statistically significant ( $p < 0.01$ )
- $\beta_r > \beta_h$ , indicating a stronger influence of real-time signals in high-intent scenarios.

#### C. Lift Analysis

- Campaigns using both  $Sh$  and  $Sr$  achieved a 15% higher ROAS compared to campaigns relying on  $Sh$  alone.

### V. DISCUSSION

#### A. Benefits of Real-Time Signals

- Improved Bid Precision: Real-time signals ensure optimal allocation of ad spend to high-intent users.
- Enhanced Ad Personalization: Ads adapt to users' current app behavior, increasing relevance and engagement.
- Dynamic Audience Refinement: Segmentation updates in real-time, ensuring more accurate targeting.

#### B. Challenges

- Latency: Processing real-time signals with minimal delay is computationally intensive.
- Privacy Concerns: Real-time data usage must comply with GDPR, CCPA, and other privacy regulations.
- Data Integration: Merging historical and real-time signals requires robust infrastructure.

### VI. RECOMMENDATIONS

- Leverage Predictive Models: Use machine learning models to derive actionable insights from  $Sr$ .

- Optimize Infrastructure: Reduce latency in processing real-time data for better bid accuracy.
- A/B Testing: Continuously experiment with the weight parameters  $\alpha$  and  $\beta$ .
- Privacy-First Design: Employ techniques like differential privacy to maintain compliance.

#### VII. CONCLUSION

Real-time app activity signals significantly enhance ad effectiveness by improving targeting precision and personalization. Auction-based platforms should prioritize the integration of these signals to maximize advertiser ROI while addressing challenges related to data latency and privacy.

#### VIII. REFERENCES

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