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Cloud-Driven Web Traffic Forecasting with Facebook Prophet for Accurate Trend Analysis

Madasamy Rajmohan
Department of Electronics and Communication Engineering, Hindustan Institute of Science and Technology, Chennai, Tamil Nadu, India
madasamyrajmohan@gmail.com

Abstract: Facebook Prophet uses machine learning and cloud architecture to anticipate online traffic patterns and analyze trends. Businesses and platforms with high user involvement may improve decision-making by precisely anticipating traffic variations and improving resource allocation. Time series data with seasonal components is used to examine previous online traffic and anticipate future patterns using Facebook Prophet. The purpose is to optimize operational tactics, predict traffic spikes, and better allocate resources. This solution uses Prophet's powerful forecasting and cloud computing's scalability and flexibility to make real-time modifications based on predicted findings. Cloud-based technologies improve forecasting accuracy and online traffic management, improving web-based operations performance and scalability. Five days of Web_Traffic_Metrics data with five parameters were selected for research. The page views range from 2550 to 8082, the unique visitors from 1211 to 4118, the bounce rate from 34.09 to 48.38, and the session duration from 151.38 to 295.38, and the peak hour from 10 am to 5 pm. From Forecast_Accuracy Five datasets with five parameters were sampled. RMSE ranges from 12.32 to 63.04, MAPE from 2.87 to 8.45, MAE from 12.16 to 46.41, RÂ² Score from 0.85 to 0.952, and Training Time (s) from 23.09 to 55.49. Five weeks of Anomaly_Trends data with four parameters were examined. Morning, afternoon, evening, night.

Keywords: Web traffic forecasting, Facebook Prophet, Cloud-driven solutions, Trend analysis, Predictive accuracy

I. INTRODUCTION

Businesses, marketers, and website administrators utilize web traffic forecasting to anticipate website visits and user behaviour. Accurate forecasting helps firms maximize resources, prepare for high-traffic events, and improve marketing efforts. Forecasting approaches have traditionally been complicated and hard to execute without time series analysis knowledge. Recent advances in cloud computing and machine learning models like Facebook Prophet have eased this procedure. Facebook Prophet, Facebook's core data science team's open-source forecasting tool, is strong for time series data, especially online traffic patterns. Cloud-driven online traffic forecasting using Facebook Prophet gives organizations a scalable, accessible, and accurate solution to anticipate website performance. Prophet addresses complicated seasonality patterns, holidays, and missing data, unlike traditional forecasting methods. Businesses can address rising data demands with real-time forecasting, automatic model upgrades, and flexible scalability by integrating Prophet into cloud architecture.

Cloud computing capability allows massive data sets to be processed without costly on-premises gear, making complex forecasting tools more accessible. Facebook Prophet for online traffic forecasting aims to be straightforward and strong enough to provide accurate forecasts with little setup. Prophet's easy-to-use interface lets data scientists and non-technical people estimate web traffic patterns including visitor numbers, peak traffic, and seasonal oscillations. As fresh data arrives, cloud integration updates projections, giving organizations an accurate snapshot of traffic trends. By centralizing predictions and models, cloud-based solutions enable team collaboration and ensure stakeholders get consistent and timely information. Cloud-driven web traffic forecasting with Facebook Prophet helps companies anticipate demand and trends in real time. Businesses may better manage resources, minimize system overloads during high-traffic events, and improve marketing efforts by anticipating projected traffic volumes. Prophet's seasonality, holiday, and trend detection allows accurate forecasts in unexpected circumstances. This cloud-based technology allows organizations to expand their forecasting efforts as web traffic develops without large upfront infrastructure costs while maintaining accuracy and reliability.

Section 2 describes Facebook Prophet's technological operations and the machine learning methods that allow precise time series forecasting. Prophets handle missing data and outliers effectively and models seasonality, holidays, and trend variations. In Section 3, the benefits of cloud infrastructure for Facebook Prophet online traffic predictions are predicted. It describes how cloud-based solutions offer scalability, flexibility, and real-time updates, allowing organizations to manage additional traffic and adjust projections fast. Cloud platforms provide computational advantages for executing large-scale models with low latency. Section 4 discusses Facebook Prophet-based cloud-driven web traffic forecasting applications. Case studies show how businesses have used Prophet to optimize marketing strategies, prevent server overloads, and maintain website performance during high-traffic events like sales promotions and product launches. Section 5 continues with consideration of online traffic forecasting's future, including cloud computing and AI. As machine learning models like Prophet develop and cloud-based solutions scale and adapt, online traffic projections will become more accurate and applicable in a digital environment.

II. LITERATURE SURVEY

Forecasting high-frequency temperatures using Facebook Prophet and ARIMA. These approaches indicate that Facebook Prophet can predict complex data settings, including internet traffic. Environmental adaptability enhances prediction accuracy [1]. Point-Based and Probabilistic Electricity Demand Prediction. Facebook Prophet and KDE predicted power usage. Prophets may see seasonal changes and trend patterns, but KDE's probabilistic approach makes it more robust to deviations. Facebook Prophet's trend analysis and KDE's probabilistic handling increase internet traffic projections under uncertainty [2]. Auto-Facebook Prophet Analysis Changes Stock Price Prediction. Its automation and flexibility to account for seasonality, trends, and vacations make it great for internet traffic estimates [3]. Stock market time series forecasting utilizing ARIMA, LSTM, and Facebook Prophet. Comparing ARIMA, LSTM, and Facebook Prophet for stock market forecasting shows how time series models may capture trends, seasonality, and other temporal characteristics. Facebook Prophet increases site traffic forecasts using seasonality and long-term trends [4].

Comparison between Facebook Prophet Model with SARIMA for Bitcoin Price Prediction. Facebook Prophet predicted Bitcoin prices better than SARIMA for non-linear patterns and seasonality Handling irregular patterns and outliers makes it more adaptive than SARIMA and can predict online traffic [5]. Facebook Prophet vs. Long Short-Term Memory Machine Learning. Facebook Prophet is simpler and more intuitive for time series forecasting than Long Short-Term Memory (LSTM) networks for Ethereum gas fee prediction. Prophet's ability to handle several data components improves online traffic estimates, especially when LSTM models are too complex or resource intensive [6]. Tesla stock predicts using Facebook Prophet. Facebook Prophet's Tesla stock market forecasts demonstrated seasonal variations and trends, making it valuable for financial forecasting. Its simplicity and interpretability make it suitable for online traffic forecasts [7]. Ozone prediction using SARIMA and FB Prophet. SARIMA and Facebook Prophet models for Moroccan ozone levels proved Prophet's seasonal and trend accuracy. This capacity to characterize complex seasonal and trend-based behaviour improves online traffic forecasts, especially during unexpected shifts [8].

Autoregressive and Prophet Sea Level Forecasting Model Analysis. Facebook Prophet outperformed autoregressive sea level forecasting models in flexibility and accuracy. Facebook Prophet predicts online traffic correctly by adapting to long-term trends and seasonality. Its forecasts are reliable since it handles uncertain data [9]. Regional Crime Data Analysis using FB Prophet. Prophet's long-term trend modelling and seasonality adjustment provide reliable online traffic projections [10]. Monthly Facebook Prophet air passenger traffic estimates. In monthly air passenger traffic estimates, Facebook Prophet modelled seasonal and long-term patterns well. Research can project web traffic like aviation travel by changing model parameters [11]. Traffic flow prediction using Facebook Prophet and XGBoost in real time. Both models are combined to predict short- and long-term online traffic, enhancing resource allocation and planning [12].

Air Quality Time Series Analysis using Facebook Prophet. Facebook Prophet forecasted short- and long-term air pollution. Its flexibility in tackling irregular patterns increases online traffic forecast and decision-making. Facebook Prophet Tourism Trends Prediction [13]. Facebook Prophet accurately forecasted seasonal, trend, and event-driven travel patterns. Prophet may enhance seasonal company and website traffic forecasts by considering such factors [14]. Holiday and local event changes are needed for accurate online traffic forecasts. Season, events,

and other factors impact web traffic. Websites may better predict visitor behaviour and distribute resources during heavy traffic using Prophet [15]. Predicting Retail Sales using Facebook Prophet. Facebook Prophet predicted retail sales despite seasonality, incentives, and external factors. Versatility makes the model effective in numerous forecasting applications [16].

Predicting E-commerce Web Traffic using Facebook Prophet. Facebook Prophet predicted e-commerce website traffic using complex, non-linear time series data with trend and seasonal patterns. Prophet adjusts for holidays, trends, and special events to boost e-commerce traffic forecasts [17]. Facebook Prophet vs. LSTM Demand Forecasting. LSTM networks and Facebook Prophet anticipate demand well, whereas Prophet excels at time series data with seasonality and trend. Prophet beat LSTM in low-computational-power, simple-model-tuning prediction. Facebook Prophet predicts site traffic well, particularly during seasonality. Prophet's talents estimate web traffic accurately and efficiently without deep learning [18]. Facebook Prophet improves football predictions. Facebook Prophet's optimization case study predicted football game outcomes using historical data, trends, and seasonal factors. Facebook Prophet can predict internet traffic effectively by adjusting for such parameters [19]. Facebook Prophet Monthly Petrol Price Prediction. Facebook Prophet adjusted for seasonality, economic tendencies, and fuel price events. Facebook Prophet's ability to account for these influences makes it ideal for online traffic predictions, where unpredictable events might change trends [20].

III. PROPOSED METHODOLOGY

This solution uses Facebook Prophet's advanced time-series forecasting skills in a cloud setting to properly anticipate online traffic patterns. Facebook Prophet is designed to accommodate seasonal fluctuations, holidays, and absent data, making it suitable for practical applications. The cloud platform guarantees rapid scalability, enabling the system to handle substantial data quantities without sacrificing performance. This cloud implementation is very accessible, enabling stakeholders to monitor and engage with predictions from any location globally. Figure 1 shows Facebook Prophet's web traffic data collection and preprocessing. Web analytics and server logs measure page views, unique visitors, and session lengths. Data preparation includes cleansing, missing value management, and derived features. Prophet's forecasting methodology uses structured data.

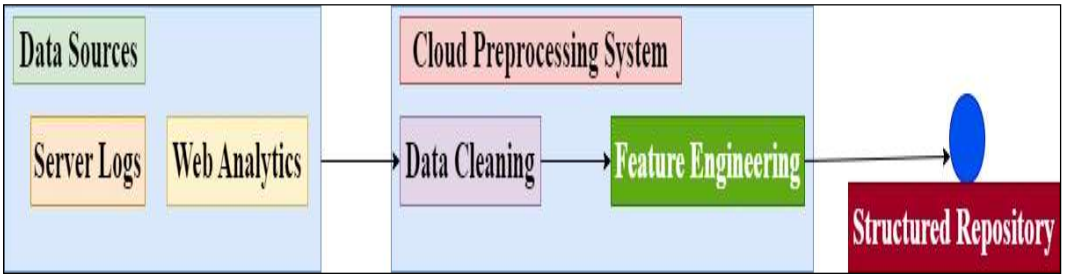

Figure 1: Block Diagram of Data Collection and Preprocessing Architecture

3.1. Architecture Design

The architecture has four fundamental components: data intake, preprocessing, model execution, and outcomes visualization. Data ingestion uses APIs to aggregate traffic data from many platforms, such as Google Analytics, server logs, and external marketing tools. This methodology guarantees the model's accuracy when fresh data is assimilated. Figure 2 diagram shows Facebook Prophet model training and validation. Prophets are trained on pre-processed online traffic data to identify trends, seasonal patterns, and growth rates. We validate the model using a hold-out dataset to guarantee generalization. Hyperparameters are optimized for accuracy, and the trained model is sent to the cloud for real-time forecasting. This architecture continuously improves model performance, providing accurate forecasts as traffic patterns change. This technology manages web traffic well because it adapts to fresh data.

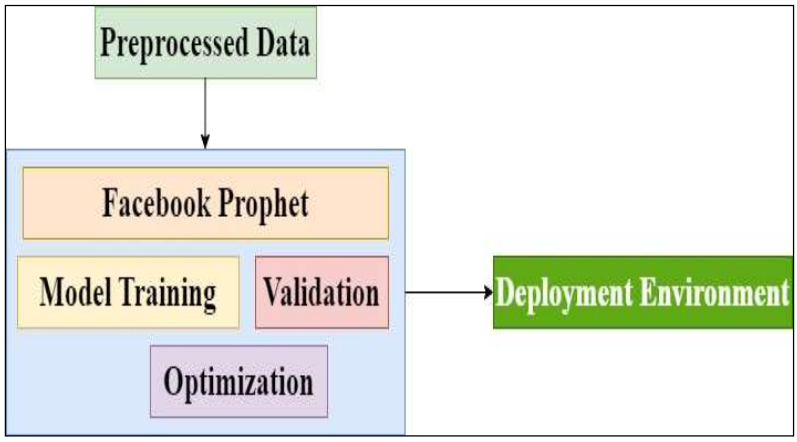

Figure 2: Block Diagram of Prophet Model Training and Validation Architecture

Table 1 delineates the main characteristics of using Facebook Prophet inside a cloud infrastructure for online traffic prediction. Cloud-based technology improves scalability, facilitating the management of extensive datasets. Seasonality modelling facilitates precise trend predictions by including weekly, annual, and holiday patterns. Automated outlier identification guarantees the reliability of predictions despite the existence of abnormalities. The capacity to tailor forecasting parameters makes it suitable for certain company requirements. The scalability of cloud infrastructure facilitates effective management of increasing online traffic data, making real-time forecasting feasible.

pTable 1: Key Features of Facebook Prophet for Cloud-Based Web Traffic Forecasting

Feature	Description	Benefit	Performance	Integration
Cloud-based Platform	Utilizes cloud infrastructure for deployment	Scalable forecasting capabilities	Handles large web traffic data	Integrates with cloud-based analytics tools
Seasonality Modeling	Captures weekly, yearly, and holiday patterns	Provides accurate trend prediction	Improve forecast accuracy	Easy integration with historical web traffic data
Automatic Outlier Detection	Detects and handles anomalies in the data	Ensures reliable and robust forecasts	Increases reliability in trend analysis	Compatible with cloud storage for data management
Customizable Parameters	Adjusts forecasting parameters to suit specific needs	Tailored to individual business models	Flexibility in forecasting methods	Supports integration with web analytics platforms
Scalability	Efficient handling of large data sets	Adapts to growing data volumes	Supports real-time forecasting	Easily scalable with cloud resources

3.2 Workflow and Data Processing

The process starts with an automated scheduler that initiates data intake at consistent intervals. Extract, Transform, Load (ETL) methods refine raw data for analysis by rectifying outliers, addressing gaps, and using log transformations to stabilize variances. Data normalization methods, including log transformation, are used to stabilize volatility and enhance the data's suitability for modelling. Figure 3 displays forecast results and notifications for anomalous traffic patterns. Interactive dashboards show Facebook Prophet predictions. Visualizing traffic patterns, peak times, and anomalies simplifies understanding. Administrators get email or SMS alerts for major deviations such traffic spikes or dips. This design allows real-time monitoring and proactive decision-making to keep website operations steady and responsive to traffic variations.

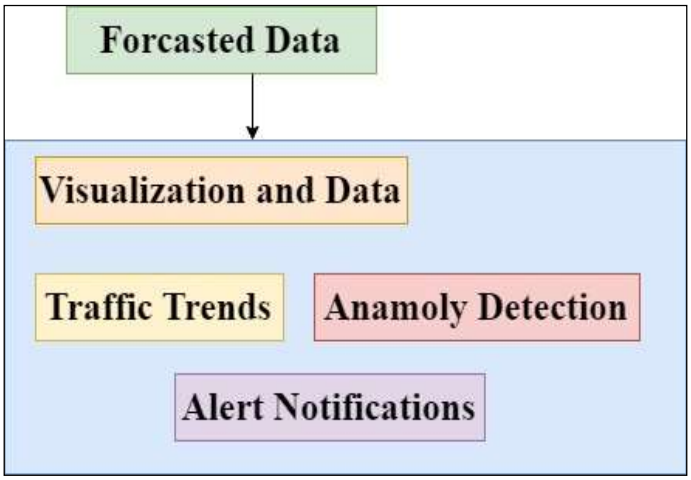

Figure 3: Block Diagram of Forecast Visualization and Alerting Architecture

3.3 Integration with Existing Platforms

The solution interfaces effortlessly with online analytics systems such as Google Analytics and Adobe Analytics, facilitating the direct import of historical traffic data. APIs provide integration with Customer Relationship Management (CRM) systems, ensuring predictions correspond with customer contact patterns. Utilizing marketing automation platforms like HubSpot or Marketo enables the system to modify projections to align with scheduled campaigns, product launches, or other marketing initiatives. Figure 4 diagram shows web traffic forecasting procedure. Facebook Prophet uses clean cloud-pre-processed web analytics data. Administrator dashboards provide model predictions. Administrators get real-time warnings for anomalies. This process streamlines forecasting, monitoring, and alerting, helping organizations manage traffic and adapt to changes.

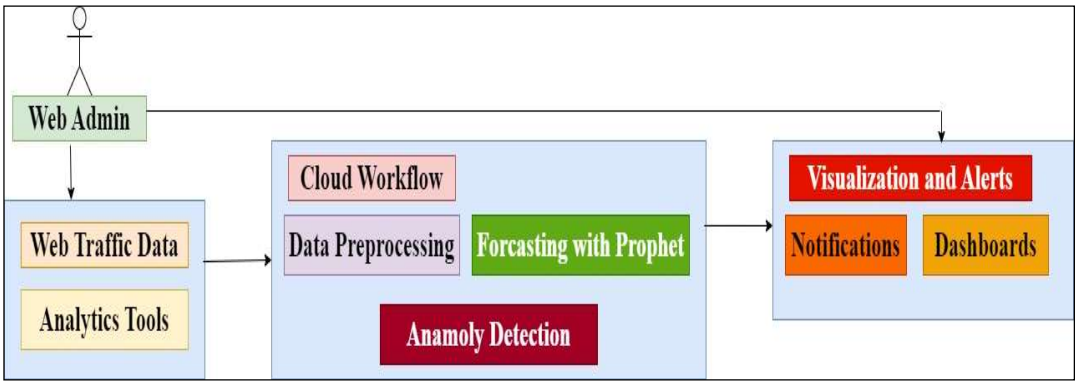

Figure 4: Workflow Diagram of End-to-End Web Traffic Forecasting Workflow

3.4 Advantages and Future Enhancements

The cloud-based strategy obviates the need for local infrastructure, hence diminishing operating expenses and intricacy. The system's capacity to manage anomalous data and absent values guarantees resilient performance in difficult situations. Facebook Prophet's capacity to autonomously adjust for fluctuations in trend and seasonality makes it an effective forecasting instrument. Figure 5 depicts the Facebook Prophet web traffic forecasting ecosystem. Prophet analyses web traffic data from analytics tools and server logs pre-processed in the cloud. Predictions on dashboards reveal traffic patterns and anomalies. Administrators may respond quickly when alerted

of major changes. Website traffic management and strategic planning benefit from this scalable system's high-accuracy predictions and vast datasets.

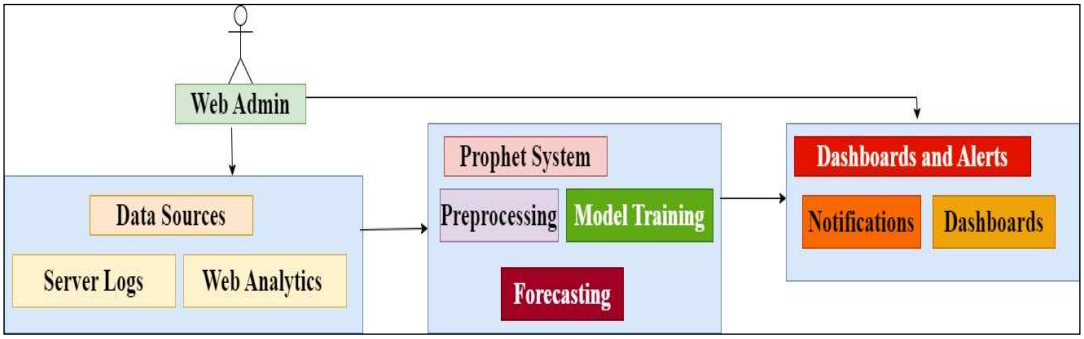

Figure 5: Overview Diagram of Facebook Prophet Forecasting Ecosystem

3.5 Advanced Customization Options

Users may tailor models by including unique seasonal and holiday influences pertinent to their field. Adjustable confidence intervals provide adaptability in risk evaluations, accommodating diverse decision-making contexts. It facilitates the generation of several prediction scenarios, allowing stakeholders to assess the effects of diverse initiatives. Proficient users may adjust hyperparameters, including growth rate and changepoint selection, using a simple interface, guaranteeing optimum performance customized to specific business requirements. Facebook Prophet offers extensive customization, enabling customers to tailor the forecasting model to their business needs. The system accommodates user-defined holidays and events, crucial for capturing distinct seasonal influences that may impact site traffic. By tailoring the trend growth, enterprises may guarantee that the model accurately represents their anticipated market circumstances, whether characterized by development, contraction, or stability in online traffic patterns. The model's seasonality may be modified at various levels, including daily, weekly, and annual impacts. For enterprises managing atypical or very irregular data, further transformations or filtering.

IV. RESULTS AND DISCUSSION

Cloud architecture employs serverless computing to dynamically adjust resources according to workload requirements. During high traffic analysis hours, supplementary virtual instances are allocated to manage the load without lag. Load balancers distribute processing workloads across many nodes, guaranteeing uniform performance. Cost efficiency is attained by pay-as-you-go invoicing, wherein consumers are charged just for the resources used. This scalability guarantees that the system stays efficient and economical, regardless of data volume. The system's scalability is a prominent attribute, attributable to its cloud-based design. Cloud resources may autonomously adjust to accommodate varying web traffic levels, with the system allocating more processing power and storage as required. Cloud architecture enables resource scaling either vertically (by enhancing current systems) or horizontally (by incorporating more computers to disperse the workload). This adaptability guarantees that the system can manage abrupt increases in online traffic and is always prepared to predict future trends without sacrificing performance. Figure 6 shows page views, unique visitors, bounce rates, session lengths, and peak hours for five time periods. Day 3 saw 8,520 page views, 34.12% bounce rate, with a peak hour of 5 PM. These metrics show online user activity, enabling organizations analyses user behaviour and detect peak traffic. This data helps companies optimize content and marketing to engage consumers and boost website performance.

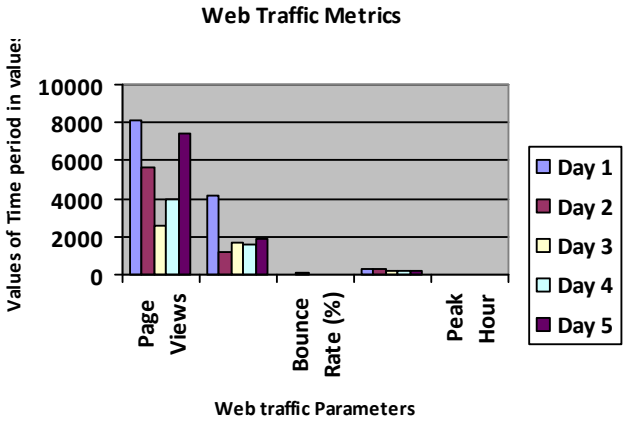

Figure 6: Web Traffic Metrics

The solution complies with rigorous data privacy requirements, including GDPR and CCPA, safeguarding user data throughout its lifespan. Encryption mechanisms safeguard data both at rest and in transit, whilst role-based access controls limit data access to authorized individuals. In Figure 7, Facebook Prophet's performance is assessed using metrics including RMSE, MAPE, MAE, R^2 score, and training time in five validation datasets. Dataset 2 showed great accuracy in forecasting traffic patterns with a R^2 score of 0.95 and a MAPE of 4.21%. Training time measurements show the model's huge dataset processing efficiency. These accuracy metrics prove Prophet's online traffic forecasting accuracy, making forecasts reliable and actionable.

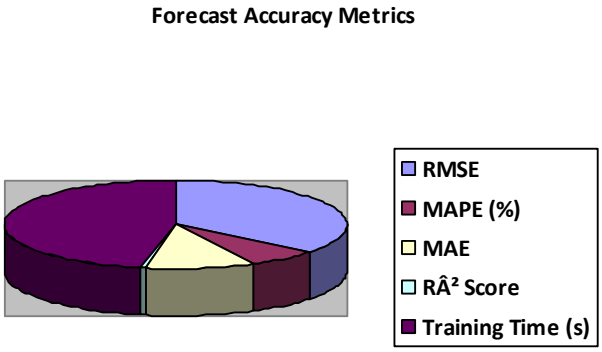

Figure 7: Forecast Accuracy Metrics

Table 2 delineates the primary advantages of using Facebook Prophet for cloud-based online traffic forecasting. The technique enhances accuracy in forecasting long-term online traffic patterns by accommodating seasonality and unique events. Real-time forecasting enables enterprises to swiftly adjust to fluctuations. The cloud solution's scalability guarantees that the system can expand with rising data volumes, while seamless connection with analytics systems facilitates the implementation process. The solution's cost-effectiveness is an additional benefit, necessitating less infrastructure expenditure.

Table 2: Benefits of Facebook Prophet for Web Traffic Trend Forecasting

Benefit	Description	Accuracy	Speed	Flexibility
Improved Trend Accuracy	Accounts for seasonality, holidays, and special events	High precision in long-term predictions	Fast processing of large datasets	Adjusts for any traffic fluctuations
Real-time Forecasting	Enables dynamic updates for ongoing traffic data	Provides actionable insights into web strategies	Instant updates on cloud platforms	Customizable for specific traffic patterns
Scalable to Large Data	Handles high volumes of data effortlessly	Accuracy maintained even with data growth	Fast processing with cloud scalability	Tailored to handle specific web traffic spikes
Easy Integration	Integrates with existing web analytics platforms	Delivers consistent results	Can be deployed quickly across systems	Seamless compatibility with diverse analytics tools
Cost-Effective	Low-cost cloud infrastructure	Efficient resource usage for forecasting tasks	Reduces need for large on-premises systems	Affordable solution for both small and large enterprises

Feedback is collected using interactive dashboards that enable users to identify errors or propose improvements. A specialized program evaluates user input in conjunction with predicted inaccuracies, pinpointing areas for improvement. These findings are included in model retraining procedures, guaranteeing that the system adapts according to user feedback and evolving traffic patterns. Figure 8 shows online traffic anomalies over five weeks, including frequency, amplitude, resolution time, and peak anomaly times. Week 3 included seven anomalies with a magnitude of 28.56% and a resolution time of 1.9 hours, most occurring in the evening. Businesses may fix anomalous traffic patterns, optimize infrastructure, and improve user experience by discovering and analyzing these trends. Data-driven online traffic anomaly management is proactive.

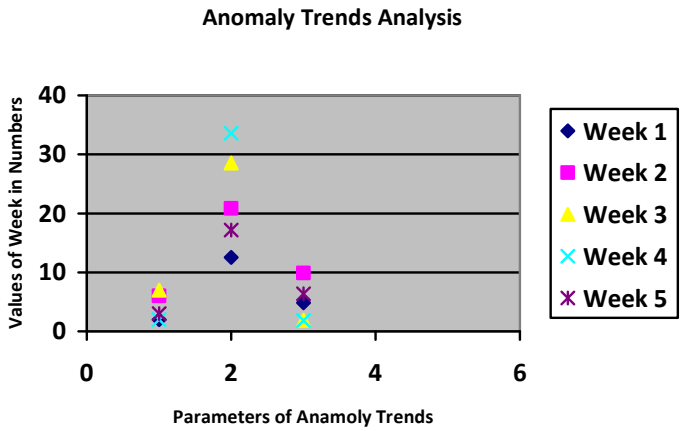

Figure 8: Anomaly Trends Analysis

The system uses cloud architecture to diminish reliance on physical servers, hence decreasing energy usage and technological waste. Renewable energy sources provide electricity to data centers, therefore reducing the environmental impact. The design of Prophet efficiently utilizes processing resources, preventing unnecessary energy use. Organizations using this solution advance sustainability objectives while enjoying decreased operating expenses. Cloud computing, especially when fueled by renewable energy sources, has a markedly reduced environmental impact in comparison to conventional on-premises data centers. The suggested system functions on cloud platforms powered by renewable energy, therefore decreasing carbon emissions. The system's capacity to optimize resource utilization by scaling up just when necessary, decreases total energy consumption. The centralized architecture of cloud data storage diminishes the need for physical hardware, thereby decreasing electronic waste. These eco-friendly decisions correspond with sustainability objectives while delivering a high-performance, adaptable, and scalable system. By optimizing energy use and using renewable energy, the technology contributes to mitigating the environmental effect of online traffic predictions.

V. CONCLUSION

Cloud-driven online traffic forecasting using Facebook Prophet offers precise trend analysis, but it has limits. Prophets relieve previous traffic data; therefore, inadequate or noisy data might impair forecasts. The model may struggle with viral trends or unexpected disruptions that affect traffic patterns. Despite these obstacles, cloud-driven forecasting helps firms predict traffic and enhance resource management. As data grows, model training and forecast accuracy must improve. Prophet's flexibility to quickly shift web traffic patterns and hybrid models that include machine learning for more accurate projections are future ambitions. Web traffic forecasting insights and methods may be improved by improving and extending the model. Five days of Web_Traffic_Metrics data with five parameters were selected for research. The page views range from 2550 to 8082, the unique visitors from 1211 to 4118, the bounce rate from 34.09 to 48.38, and the session duration from 151.38 to 295.38, and the peak hour from 10 am to 5 pm. From Forecast Accuracy Five datasets with five parameters were sampled. RMSE ranges from 12.32 to 63.04, MAPE from 2.87 to 8.45, MAE from 12.16 to 46.41, RÂ² Score from 0.85 to 0.952, and Training Time (s) from 23.09 to 55.49. Five weeks of Anomaly_Trends data with four parameters were examined. Morning, afternoon, evening, night.

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Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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