



Push Notification Delivery Prediction Framework

moengage

A study by MoEngage to enable mobile marketers to optimize their marketing campaigns for the highest performance by understanding what factors impact Push Notification delivery rate and predicting deliverability with maximum accuracy.

October 2020

Table of Contents

Introduction	1
The Problem	1
The Impact	2
The Data	2
About MoEngage	2
Calculating Delivery Rates The Right Way	3
The Approach	3
The Prediction Model	3
Factors That Influence Push Notification Delivery Rate	4
End-user Attributes	4
App Activity	9
Campaign Attributes	12
Conclusion	14
Appendix	16

Introduction

The Problem

Push notifications are one of the highest engaging marketing channels to reach, engage, and retain your users. However, there is a varying degree of deliverability that questions the reliability of this channel. This study is an attempt to identify the different factors that affect Push Notification deliverability and quantify the impact of each.

Most of the times, mobile marketers and mobile automation software wrongly calculate Push Notification delivery rate between the notifications that are accepted successfully by the Google Cloud Messaging (GCM)/Firebase Cloud Messaging (FCM) platform and the user to whom the notification was sent to in the selected time frame.

However, there are various cases where GCM will fail to send the notification to the end user's device, resulting in incorrect data as users who haven't received your notification will be marked as successful deliveries.

A more accurate calculation for delivery rate is:

$$\text{Delivery Rate} = \text{Impressions} / \text{Successfully Sent}$$

where 'Impressions' is the number of user devices that have received the notification measured by device confirmation, and 'Successfully Sent' is the number of Push Notifications that are accepted successfully by GCM.

The Impact

As of the date of publication of this whitepaper, no framework exists that can predict Push Notification deliverability with 80% or higher accuracy.

Our framework will enable mobile marketers to predict which user segment of theirs have a higher chance of receiving or viewing their Push Notifications.

This predictability can be used to introduce hygiene checks for each marketing campaign and to tweak them for maximum performance.

The Data

We studied 750 Push Notification campaigns on Android OS devices and considered over 70 million android users from India. We picked apps from Edtech, E-commerce, Finance, and Travel & Hospitality industries for this study.

We also consumed 52 cups of coffee during this study.

About MoEngage

MoEngage is an intelligent customer engagement platform built for the user- obsessed marketer. With AI-powered customer journey orchestration, personalization capabilities, and in-built analytics, MoEngage enables hyper-personalization at scale across mobile, email, web, SMS and messaging channels.

Fortune 500 brands and Enterprises across 35+ countries such as Deutsche Telekom, Samsung, Ally Financial, Vodafone and McAfee along with internet-first brands such as Flipkart, Ola, OYO, Bigbasket, and Tokopedia use MoEngage to orchestrate their cross-channel campaigns and engage efficiently with their customers.

Calculating Delivery Rates The Right Way

The Approach

To test the impact of the different factors that impact Push Notification delivery, we studied various traits of users of Edtech, E-commerce, Finance, and Travel & Hospitality apps. The varying nature of user activity across apps in these verticals ensures that anomalies in data, if any, are normalized.

We started by capturing the delivery data for a period of seven days and tracking user app activity for a period of thirty days before a Push Notification was sent. We then split user app activity into different weeks leading up to the push delivery. This data gave us a deeper understanding of the user traits (hereafter referred to as factors) that impact deliverability.

We were able to successfully identify 14 factors and the degree to which they impact Push Notification delivery rate.

The Prediction Model

Once we finalized these factors and created a single view, we leveraged multiple machine learning (ML) techniques like Logistic Regression, SVM, RFM, and XGboost to train and calculate the accuracy of different prediction models.

Among all models, we observed that the Random Forest Classification model successfully predicted delivery rates with an accuracy score of 80%, a precision score of 81% and a recall score of 90%.

We then used Feature Importance Calculation techniques to analyze the importance assigned to each feature in predicting the model accurately. Although all tested techniques showed similar values, we considered the Permutation Importance Calculation as it does not devalue categorical variables. The numeric value of feature importance shows the degree of impact of each factor in creating the prediction model and not the measure/coefficient score, as the model hides the actual values.

We also calculated the Spearman's Correlation Coefficient between deliverability rates and each of the factors to understand the directional relationship of each factor on Push Notification delivery rate. This serves as a validation of the feature importance of factors provided by the Prediction model.

Factors That Influence Push Notification Delivery Rate

Our study identified the following 14 factors impact deliverability on mobile phones. We've divided these into three categories, namely, App Activity, End-user Attributes, and Campaign Attributes.

End-user Attributes

According to the earlier studies conducted by MoEngage, about 30% of notifications are not delivered because of Original Equipment Manufacturer (OEM) related reasons. We have observed that many new device manufacturers that use a custom Operating System have built stricter battery optimization algorithms to force stop mobile apps or disrupt the background processes. This disruption, in turn, cuts off the Google Cloud Messaging (GCM)/Firebase Cloud Messaging (FCM) notification delivery service, which results in delayed or no delivery of notifications to those mobile devices.

Since it is necessary for a mobile user to be connected to the internet to receive the notification, a device's network also impacts Push Notification Delivery. While real-time tracking of device networks is outside the scope of this study, the user's location is a strong indicator of the network quality.

These are all the end-user attributes that impact Push Notification delivery rate:

City Tier	User's location categorized by different tiers (Tier 1, Tier 2 and Others)
Original Equipment Manufacturer (OEMs)	Device's model and manufacturer
OS Version	Android OS version API
Device Longevity	Number of days since the app was installed on the device by the user
Devices Linked	Number of devices linked to the user

Before you read on, note the following

- 1 We've broken down each factor below into three metrics vis-à-vis, Share, which represents the relative size of the factor we have considered for the study, Importance, which shows the degree of impact of each factor, and Correlation, which establishes a direct or inverse relationship between the factor and delivery rate.
- 2 If Correlation is negative, there is an inverse relationship between the delivery rate and the corresponding factor.

1. City Tier

The data shows that Push Notifications sent to devices in Tier 1 cities have a higher delivery rate than Tier 2 and other cities.

City Tier	Share	Importance	Correlation
Tier 1	39%	0.031	0.002
Tier 2	36%	0.026	-0.03
Other Cities	24%	0.027	0.02



We believe this is because of the relatively larger size of mobile devices, improved network connectivity, and ease of internet access in Tier 1 cities.

As the infrastructure in Tier 2 and lower cities gets better, we can expect Push Notification delivery rates to improve accordingly. Similarly, as the affordability of smartphones and internet plans improves, delivery rates will increase as well.

2. Original Equipment Manufacturer

We noticed a very distributed impact of OEMs on Push Notification delivery rates from the data. Samsung and OnePlus have a positive effect on delivery rates, while Huawei, Oppo and Vivo have a significant negative impact. It is evident that the few Chinese OEM devices which hold a prominent share in India, drastically affect Push Notification deliverability.

We attribute this trend to the way Chinese OEM devices handle background processes to optimize the performance of the mobile phone's battery, as stated earlier.

OEM	Share	Importance	Correlation
Xiaomi	27%	0.03	0.04
Samsung	20%	0.04	0.11
Vivo	9%	0.04	-0.12
OnePlus	9%	0.03	0.10
OPPO	8%	0.03	-0.11
Realme	5%	0.01	0.02
Huawei	4%	0.02	-0.10

An interesting observation here is that Xiaomi is the only Chinese OEM with a slightly positive correlation to delivery rate. This trend is primarily because of Push Amp Plus, a proprietary MoEngage offering that is custom built to improve deliverability on Xiaomi devices only (at the time of this analysis).



MoEngage was the first to build Push Amplification technology, which has since then been widely adopted by most mobile automation platforms. Push Amp Plus is a newer, more efficient technology to improve Push Notification delivery rates and remains unique to MoEngage till date.

[You can know more about Push Amp Plus here.](#)

3. Mobile Operating System (OS) Version

By looking at the Correlation to understand the directional relation between OS version and delivery rate, we can see that older app versions reduce delivery rate. Over time, as more and more users upgrade their mobile devices to the latest OS versions, the share of older devices will gradually decrease.

OS and API Version	Share	Importance	Correlation
Android 11, API 30	0.00%	0.00	0.00
Android 10, API 29	18%	0.07	0.13
Android 9, API 28	44%	0.05	0.01
Android 8, API 27	16%	0.01	-0.04
Android 8, API 26	4%	0.00	0.00
Android 7, API 25	5%	0.01	-0.07
Android 7, API 24	5%	0.01	-0.07
Android 6, API 23	6%	0.00	-0.05
Android 5, API 22	2%	0.00	-0.06
Android 5, API 21	0%	0.00	-0.01
Android 4, API 19	0%	0.00	-0.01
Android 4, API 18	0%	0.00	0.00
Android 4, API 17	0%	0.00	0.00

Most of the devices considered in our study (62%) have an OS API version 28 and higher, and we observed the highest delivery rate in Android 10 with the OS API version 29.

We observed a fascinating trend that most mobile marketers and developers have debated since 2018. And, we have data to put that debate to rest.



Starting with Android Version 9, all mobile apps adhere to App Standby Buckets. This means that even if specific notifications are set to high priority by the mobile marketer, it's delivery will be determined by the score of the application before it exits Standby Mode.

The Android OS decides this criterion. Mobile marketers and developers all over the world pondered whether this change impacts delivery rate negatively or not. Our data proves that App Standby Buckets do not harm the delivery rate.

4. Device Longevity

Our study shows that an increase in the number of days since a user has installed the mobile app results in a positive impact on Push Notification delivery rates. From this data, we can safely assume that increased app activity in older users positively impacts deliverability.



Mobile marketers take note, this means that increasing user app activity in the few initial days of installation is crucial.

5. Devices Linked

We observed that as the number of devices linked to a single user decreases, the delivery rate for each device belonging to that user decreases correspondingly.

App Activity

A user's activity on an app is a strong indicator of their interest in the app and how they interact with its notifications. Long periods of inactivity indicates that the user isn't interested or has uninstalled the app.

The latest Android OS version (starting from Android P) also scores the app based on how many times and how recently a user has interacted with the mobile app. It accordingly either decreases the priority or stops running background services for low activity apps, thereby impacting Push Notification delivery. Android P also recommends blocking an app's Push Notifications if a user has dismissed them too many times.

Tracking the volumes and recency of a user's activity like app launches, successful transactions, and the notification clicks leading up to the campaign's delivery gives accurate insights into how delivery rate varies.

Here are all the factors around app activity that impact Push Notification delivery rate:

Factor	Description	Importance	Correlation
Notification Count	Number of Push Notifications sent to the user in the last 30 days	0.13	0.04
Session Recency	Number of days since the last session by the user	0.12	-0.22
Click Recency	Number of days since the last time the user clicked on a Push Notification	0.11	-0.22
Click Count	Number of Push Notifications clicked by the user in the previous 30 days	0.10	0.17
Session Count	Number of sessions in the previous 30 days	0.05	0.10
Total Transactions	Lifetime total of the number of transactions by the user	0.04	0.05

Note: In the table above, Importance shows the degree of impact of each factor and Correlation establishes a direct or inverse relationship between the factor and the delivery rate. If Correlation is negative, there is an inverse relationship between the delivery rate and the corresponding factor.

6. Notification Count

Our study shows that an increase in the number of Push Notification campaigns sent has a positive impact on the delivery rate.

The Prediction model assigns a high feature importance score to the notification count due to the increased availability of data, which can be verified by the fact that the correlation value, even though positive, is not relatively lower than the other factors.

7 & 8. Session Recency and Session

We observed that as the time duration between the two recent user sessions decreases, Push Notification delivery increases correspondingly. As seen from the table above, this is one of the primary factors our model predicted and has a high positive correlation with deliverability.



The data also shows that an increase in the number of sessions improves Push Notification delivery rate.

If you're a mobile marketer from the Travel & Hospitality, you must know that the session recency and count, on an average, for your app is much lower compared to apps from other verticals like Media & Entertainment or Edtech. Similarly, given the nature of E-commerce apps, consumers tend to use them less frequently.

The best way to incentivize users to visit your app often is by providing them value apart from your core app's offerings. And the lowest-hanging fruit is content. Travel & Hospitality marketers can invest time in creating short listicle videos of holiday destinations, or even give virtual tours. E-commerce marketers can put up DIY or how-to articles on the app that users can refer to when they want to build something by themselves. Not only will the increased app activity improve Push Notification delivery rates, but your brand's affinity will also improve this way.

9 & 10. Click Recency & Count

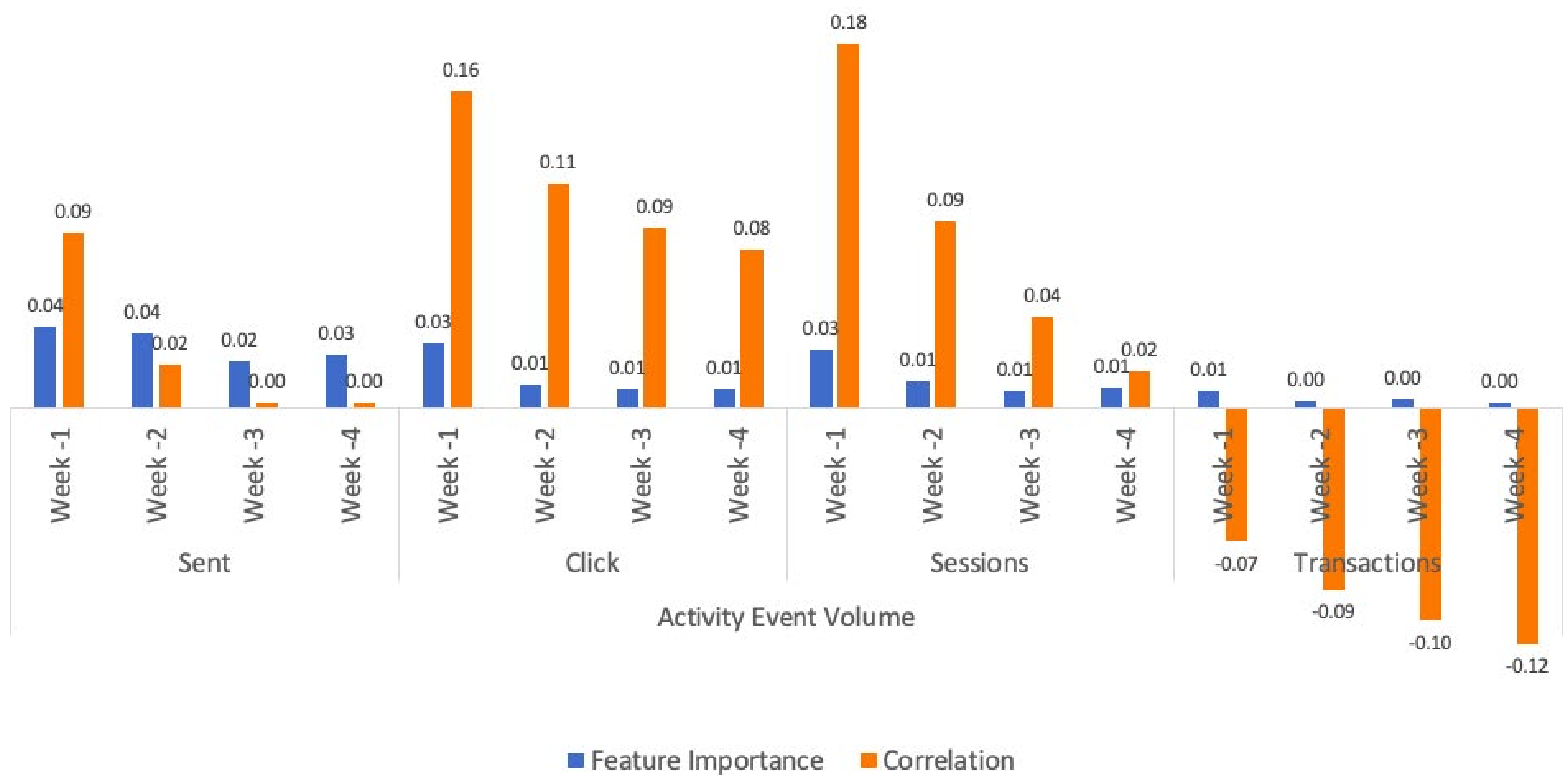
For this study, we considered users' historical interactions with Push Notifications. After observing the user's notification click behavior for the thirty days leading up to a campaign, we observed that click recency and the number of clicks impact the deliverability.



If the previous notification click is recent, the chance of successful delivery of the next notification increases. We also observed that an increase in the number of historic clicks has a positive impact on Push Notification delivery rate.

11. Total Transactions

To get a deeper understanding of how user activity impacts deliverability, we tracked user actions and split them by weeks. In the chart below, Week-1 represents the previous week, Week-2 is two weeks, Week-3 is three weeks, and Week-4 is four weeks before the date on which the Push Notification was sent.



Looking at the image above, it becomes evident that recent app activity has a higher positive impact on the delivery rate. The feature importance and correlation are highest for Sent, Clicks, Sessions, and Transactions in the first week, and the effect on delivery rate gradually decreases as the time increases (Weeks 2, 3, and 4).



Our study shows that an increase in the number of lifetime transactions of a user increases the Push Notification delivery rate for that user. We hypothesise that since a mobile user interacts multiple times with the app before making a transaction on the app, it increases app activity, which results in a higher delivery rate for Push Notifications.

Campaign Attributes

Our study shows that three campaign attributes impact Push Notification deliverability:

12. Hour Of The Day

Since app activity and network availability varies by the time of day, the hour of the day in which a Push Notification is sent also impacts its delivery rate.

The data below will help mobile marketers understand the correlation between Push Notifications sent at an hourly basis and the delivery rate. Optimizing for this is a low-hanging fruit for mobile marketers to improve Push Notification performance.

Hour in GMT	Hour in IST	Share	Correlation
4	9.5	16%	0.06
9	14.5	3%	0.05
3	8.5	7%	0.04
15	20.5	6%	0.04
13	18.5	5%	0.03
8	13.5	4%	0.02
10	15.5	3%	0.01
16	21.5	4%	0.01
17	22.5	2%	0.01
19	0.5	0%	0
23	4.5	0%	0
1	6.5	2%	0
5	10.5	5%	0
6	11.5	5%	0
0	5.5	1%	-0.01
2	7.5	4%	-0.01
7	12.5	7%	-0.03
14	19.5	8%	-0.03
18	23.5	0%	-0.03
11	16.5	7%	-0.05
12	17.5	10%	-0.1



We observed that Push Notification delivery is highest in the mornings between 8 AM and 10 AM, and the afternoons from 1 PM to 4 PM. Notifications sent in the evening (between 4 PM and 9 PM) have an inverse relationship with deliverability.

Interestingly, only 5% of all the notifications are sent between 9:30 PM and 6:30 AM.

13. Day Of The Week

Similar to the campaign sent time, we observed that the day of the week on which the Push Notification is sent also affects deliverability.

Day of Week	Share	Correlation with DR
Sun	13%	0.08
Sat	13%	0.01
Thu	14%	0.00
Fri	19%	-0.02
Wed	13%	-0.02
Tue	16%	-0.02
Mon	13%	-0.03



It is interesting to note that the delivery rate is higher towards the end of the week and on Weekends. This could be due to the increased device usage by users on these days.

14. Message's Time To Live (TTL)

Higher message TTL allows Google Cloud Messaging (GCM)/Firebase Cloud Messaging (FCM) to try delivery more frequently and for a longer duration, during which the chance of maximum users coming online and receiving the notification increases. We observed that higher TTL results in better Push Notification delivery rates.

Conclusion

Our study predicts the delivery rate of Push Notification for Android devices in India and lists the various factors impacting the delivery rate. These include end-user attributes (like OEM and city tier), app activity (like the number of sessions and click recency), and a few campaign attributes (like the hour of the day and the day of the week).

Once mobile marketers are aware of the primary drives of Push Notification delivery, they can easily predict the performance of their campaigns and make tweaks to ensure a high delivery rate. Although this analysis takes into account apps across different industries, it is still a generalized analysis. Therefore, it is essential to study each app's unique properties and use these learnings to predict the delivery rate.



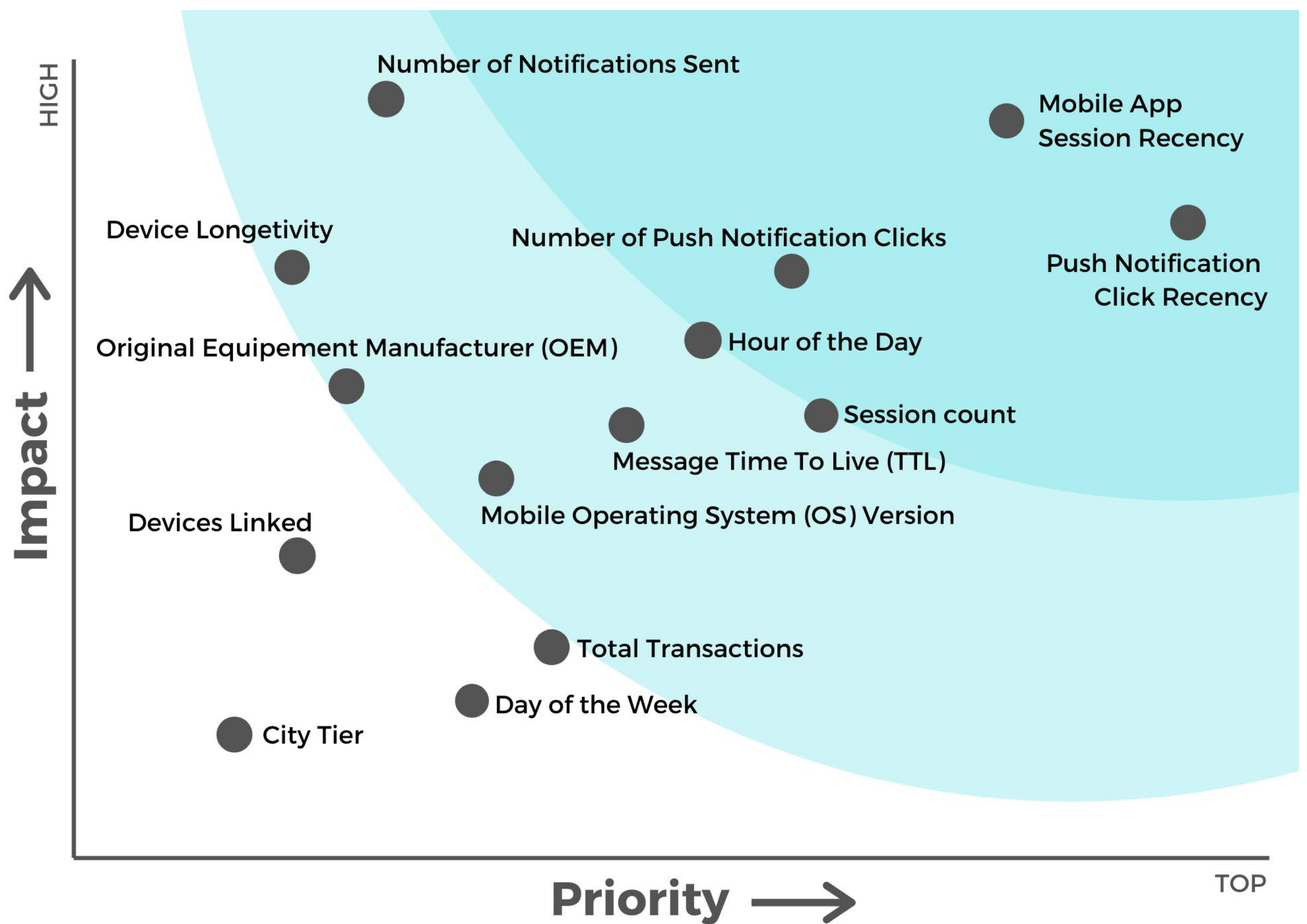
The primary takeaway for mobile marketers from this study is to improve the app activity of your users. You can do this by identifying the right user segment, knowing the best time to send the Push Notification, and picking the best message to send to each user.

MoEngage features like Smart-triggers and Flows target users based on a specific action and automatically send them a Push Notification. Geo-fencing, another MoEngage feature, allows marketers to send notifications base on a user's geo-location. All of these ensure that Push Notification delivery remains in the highest percentile.

Mobile marketers can also boost user engagement by optimizing Push Notifications for maximum click performance. You can achieve this by using rich content, implementing personalization, and running dynamic multivariate tests. More clicks on your Push Notifications ensure that your messages are prioritised through Google Cloud Messaging (GCM). The Android OS, in turn, improves the delivery rate of all future Push Notifications from your mobile app.

Our study identified 14 factors that impact deliverability on mobile phones. The top 5 factors are based on App Activity. Apart from this specific OEMs, OS Versions and sent time of campaign also impact the deliverability of Push Notifications.

Here is the framework you can refer to whenever you're launching a marketing campaign that uses Push Notifications:



Appendix

Why Push Notification?

Push Notification is a marketing channel that has gained massive popularity over more conventional channels like SMS and email in recent years. Let's break down what Push Notifications are to understand the reason behind their popularity:

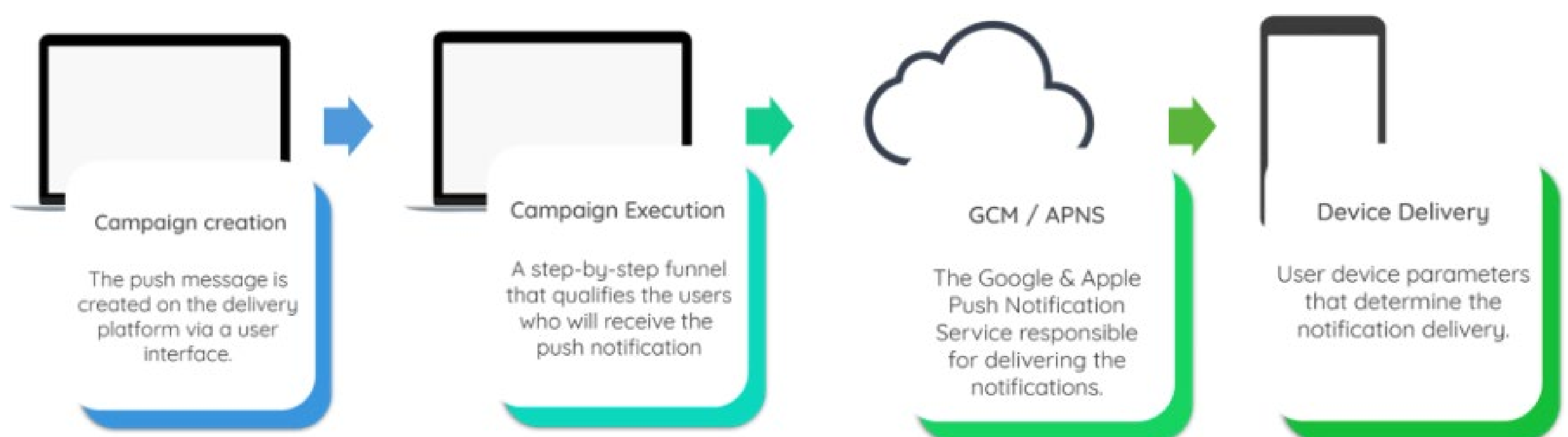
- Push notifications are pop-up-like messages that can be sent to the user's mobile device after a user installs a mobile app. It works on a permission-based marketing model.
- Mobile Marketers send alerts and messages to their user in real-time at no cost.
- It provides more control over the content, which can contain rich media content, and also can be personalized to drive the desired action from the user.

Push notifications are easily trackable, helping mobile marketers understand the impact on apps better. A study conducted by MoEngage shows the following:

- E-commerce customers found a direct revenue impact as Push Notifications drove 10% to 15% of the transactions.
- The Click-through rate (CTR) of personalized notifications was four times more than broadcast messages, reaching up to 45%.
- Push notifications influence over 20% of all mobile app opens.

How To Measure Delivery Rate Correctly?

Let's understand how a Push Notification is created and delivered to the end-user. We will also look at how to calculate delivery rates accurately.



Campaign Creation

The marketer creates a campaign in a marketing automation platform like MoEngage. At this stage, the marketer specifies the following for each campaign:

- **Target audience:** This can be all users or a specific set of customers based on the campaign
- **Message:** The user specifies the content of the campaign, including rich content, personalization locales, and variations which would help improve engagement of the message
- **Sent Time:** The marketer also needs to specify if the campaign is sent immediately, at a specific scheduled time or if it is periodic

Campaign Execution

Once the campaign is executed, MoEngage will identify reachable users from segmented customers. This is done through active push tokens which is a unique identifier set by cloud messaging platforms that helps marketers to communicate with the end-users of the app. After identifying the reachable users, MoEngage identifies the eligible users after frequency capping (which determines the number of messages that a user will receive during a specific time frame) and creates a target list of users that will receive the notification.

Cloud Network Delivery

Cloud messaging platforms like Google Cloud Messaging (GCM)/Firebase Cloud Messaging (FCM) for android, and Apple Push Notification service (APNS) for iOS receive the target list and push campaign and handle the delivery process from this stage.

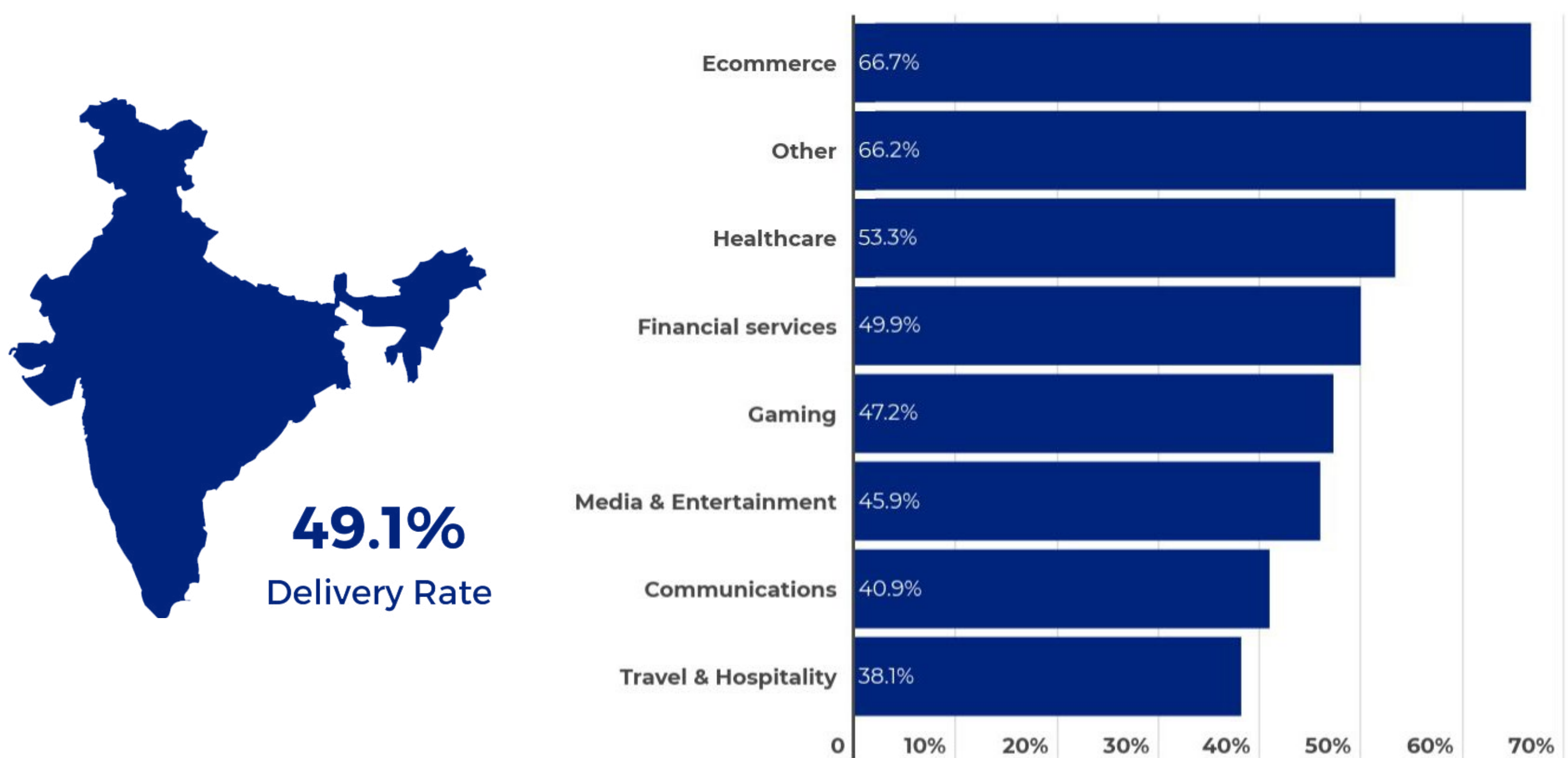
Device Delivery

The GCM/FCM/APNS sends the message from the marketing platform to the end user's device. Once the user receives the notification, the MoEngage's Software Developer's Kit (SDK) informs the server about it and tracks it as an Impression.

Average Delivery Rate In India And Industry-Split

The average delivery rate of Push Notifications on Android devices in India is 38%. The image shows the delivery rate split across verticals with FinTech having the highest at 62%, and Travel having the lowest (28%) delivery rate.

This huge variation in delivery rate across verticals can be primarily attributed to the nature of the app and the way users interact with it.



About The Authors

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Jansher is the go-to data guy at MoEngage. With over 5 years of analytics experience in user engagement, he takes cues from data to improve the way marketers connect with consumers. He is always excited about understanding why things happen through data and sharing those stories.

Pulkit Jain Content Marketing, Global

Pulkit drives growth through content at MoEngage. His experience as a marketer comes fueled with a passion for user-centricity, affinity for data, and a love for technology.

Together, Pulkit and Jansher have co-authored several data-driven reports for MoEngage and have identified engagement and retention trends for various mobile-first consumer-facing verticals like E-commerce, Travel, Media & Entertainment, and more.

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