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Push Notifications Studies in the Last Decade : A Bibliometric Analysis

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Abstract : *This study aims to provide a comprehensive overview of the development of research on push notifications over the past decade through a bibliometric approach. Push notifications have become a crucial feature across various digital platforms, including mobile applications, e-commerce systems, educational tools, and social communication services. However, systematic reviews that explore research trends, dominant thematic areas, and key contributing authors and institutions remain limited. Utilizing the Scopus database, this study collected and analyzed 250 scholarly publications published between 2013 and 2023. The bibliometric techniques applied include publication productivity analysis, co-authorship and co-citation mapping, as well as keyword co-occurrence analysis to identify popular topics and their evolution over time. The findings reveal a significant rise in publication volume beginning in 2017, coinciding with the rapid development of mobile technologies and machine learning applications. The most frequently discussed themes include message personalization, user engagement, data privacy, and notification-based recommendation systems. Countries such as the United States, China, and India emerged as dominant contributors in terms of publication output and research collaborations. This bibliometric analysis offers valuable insights for researchers, app developers, and policymakers interested in understanding the direction of push notification research and its practical implementations. The results also serve as a foundation for future studies in the fields of human-computer interaction, user experience design, and data-driven technologies. Additionally, this study identifies gaps in the current literature, such as ethical concerns and long-term user behavioral impacts, which warrant deeper investigation. Future research may benefit from interdisciplinary approaches combining technology, psychology, and communication studies.*

Keywords: *Bibliometric Analysis, Mobile Technology, Push Notifications, Research Trends, User Engagement.*

1. INTRODUCTION

Push notifications are an instrument of mobile marketing and can be considered an essential driver for app usage (Wohllebe & Hillmers, 2021). The practical effectiveness of push notification studies is an active area of inquiry that cuts across various disciplines, including customer behavior, engineering, content marketing, and business processes. The push notifications literature draws from and contributes to various disciplines, with clear links to marketing, psychology, engineering, management, and business. This diversity of research reflects the reality that developing push notification strategies are determined by multiple factors, with various stakeholders involved.

Despite a considerable amount of research on mobile marketing, there are few studies on understanding trends and future patterns of push notifications for business sustainability (Hussain & Aziz, 2022). Thus, this suggests that serious attention should be paid to evaluating how push notifications (as a part of mobile marketing tools) findings from across research communities might be integrated. Notably, the paper does not endorse limiting the range of

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approaches or proposing a single overarching theory on push notifications. Instead, we propose conceptual progress for each scientific topic, identifying research gaps, renewing themes, and looking for development in the study. We believe it is feasible to make cumulative intellectual progress and retain diversity, but only within a framework that eases the exchange of ideas, methods, and findings across various research streams.

This article seeks to present a quantitative and qualitative overview of research related to push notifications. Thus, this study aims to identify and explore push notifications through research conducted between 2013 and 2023. Through this new approach, we intend to contribute to the research on push notifications. Researchers conducted a bibliometric review based on two research questions.

(1) How has the development of push notifications been researched in the last decade?

(2) What theoretical and empirical contributions were made by research on the push notifications studies?

2. METHODS

We present a quantitative and qualitative overview of research related to push notifications by using bibliometric co-citation analysis. Bibliometric co-citation analysis is a type of analysis that finds and recognizes the relationship between the research articles and related topics. This type of analysis provides an understanding of the topic of the research study (Hussain & Aziz, 2022). Publications using bibliometrics have grown over the years, with an average of 1021 publications in the last decade, which can be attributed to the growth of scientific research itself (Donthu et al., 2021). Going beyond merely counting and collating citations, earlier studies have pointed out the nature and course of development of a discipline to assess which journals and authors have created value for other researchers through collaboration (Faruk et al., 2021).

The Scopus database was used to obtain the articles for this research. Scopus database was selected since we had authorized access to this database only. We began to mine the bibliometric data from the Scopus database by using the following Boolean search: "push notifications" OR "pop-up notifications" OR "Message Blast" OR "Mobile Notifications" OR "Mobile Alerts" OR "Pop-up alerts."

Push Notification is the main keyword across different papers. However, the filters of the Scopus database were only limited to 7 subject areas that refer to push notifications in mobile practice. In this work, we use 2013 to 2023 as periodically published research to ensure the research was based on the data of the last decade. The research after 2013 was also chosen

since the deployment of mobile smartphones and their usage was increasing in the 21st century. On the other hand, the limit of 7 subject areas was applied because we wanted to provide the result of this paper aligned with the digital development and business studies from which the background authors came. Hence, analysis of other prominent databases such as Web of Science or Publish Perish and the filters that are not applied can be considered in future research.

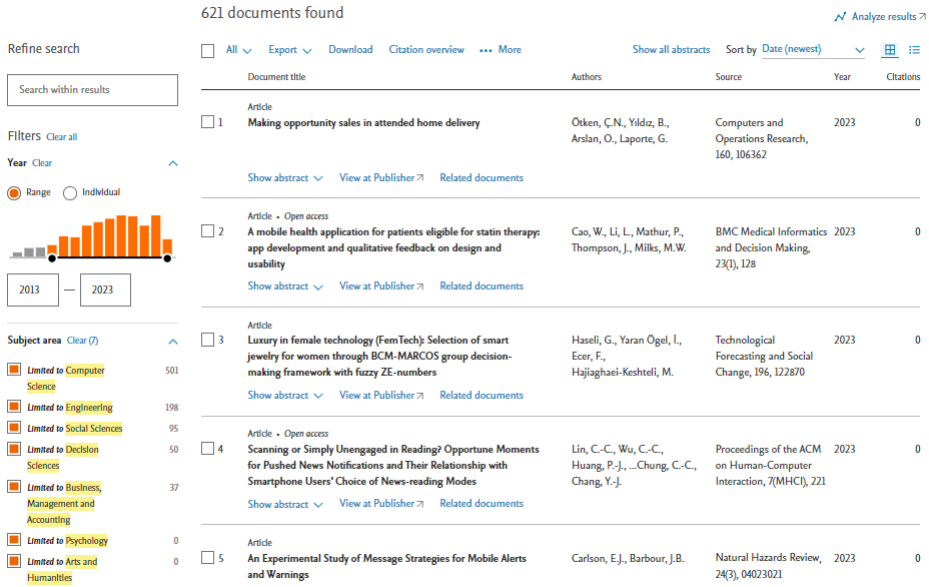

Figure 1. Filters used on the dataset

This filtration has produced 621 papers, which are to be analyzed. After retrieving the data from the Scopus database, the data were analyzed with the help of the VOS viewer. We chose VOS viewer instead of any other software because, unlike other programs that are generally used for bibliometric mapping (such as SPSS and Pajek), VOS viewer focuses on the graphic representation of bibliometric maps, presenting these in a manner that is easy to interpret (van Eck & Waltman, 2010) . Figure 2 provides a detailed schema for our analysis process in VOS viewer. Indeed, VOS viewer combines the most advanced and valid techniques for every step in the science mapping process, including (1) term extraction and selection, (2) visual mapping of relatedness, and (3) clustering of science objects. Across our maps, we use the default settings in the software, which generally represent the best practice in science mapping literature (C. I. S. G. Lee et al., 2014).

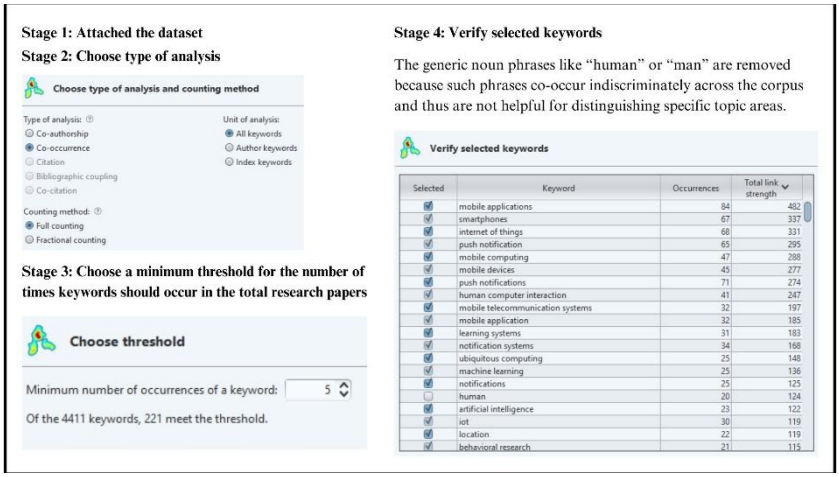

Figure 2. Workflow Process in VOS viewer

This research analyzes the networks by applying SNA tools such as clustering and network visualization. Using the network, overlay, and density visualization, we trace the evolution of the subject domain topics across years, the network of uses keywords, and identify the subject topics areas with future research scopes.

3. RESULTS AND DISCUSSION

The results of this study are presented in three parts. The first section discusses the distribution of journals publishing studies on push notifications. The second section analyzes the keywords used in the research on push notifications. The last section considers the most highly cited studies on push notifications.

The distribution of studies on Push Notification

Table 1 below shows information about the top 10 publishers published in push notification studies. The table shows that the Institute of Electrical and Electronics Engineers Inc. ranks highest in publications related to push notification with 163 publications, followed by the Association for Computing Machinery, Inc. with 68 publications. The table shows that most publishers in these studies can only publish 163 publications, which means the push notification studies between 2013 and 2023 need to be bigger and still be developed.

Table 1. Publisher and the amount of publication

Publisher	Publication
Institute of Electrical and Electronics Engineers Inc.	163
Association for Computing Machinery, Inc	68
Association for Computing Machinery	56
Springer Science and Business Media Deutschland GmbH	38
Springer Verlag	19
IEEE Computer Society	17

Springer	14
Elsevier B.V.	13
Elsevier Ltd	11
Association for Information Systems	8

Analysis of Keywords in Popular Research Areas in Push Notification Studies

This section discusses keyword co-occurrence by analyzing the distribution of keywords based on a dataset from the Scopus Database. A keyword co-occurrence map and keyword density view provide an overview of the keywords that appear in the literature and can be used to show the research hotspot areas in a field, in this case, the study of push notification (Khiste & Paithankar, 2017). Based on 621 push notification-related publications, 4411 keywords were identified; this study considered only keywords that appeared at least five times in the dataset. Figure 3 shows the keyword occurrence, as given by a VOS viewer analysis. There were six clusters divided, but two clusters had the same meaning.

Furthermore, the keywords "push notification" and "push notifications," as in one meaning, were shown to be most often used 136 times. Other keywords that occurred often included a) mobile applications, b) Internet of things, c) mobile devices, and d) smartphones. The distance between two nodes indicates the strength of their relationship; in general, a shorter distance indicates a more substantial relationship (Cicea & Marinescu, 2021).

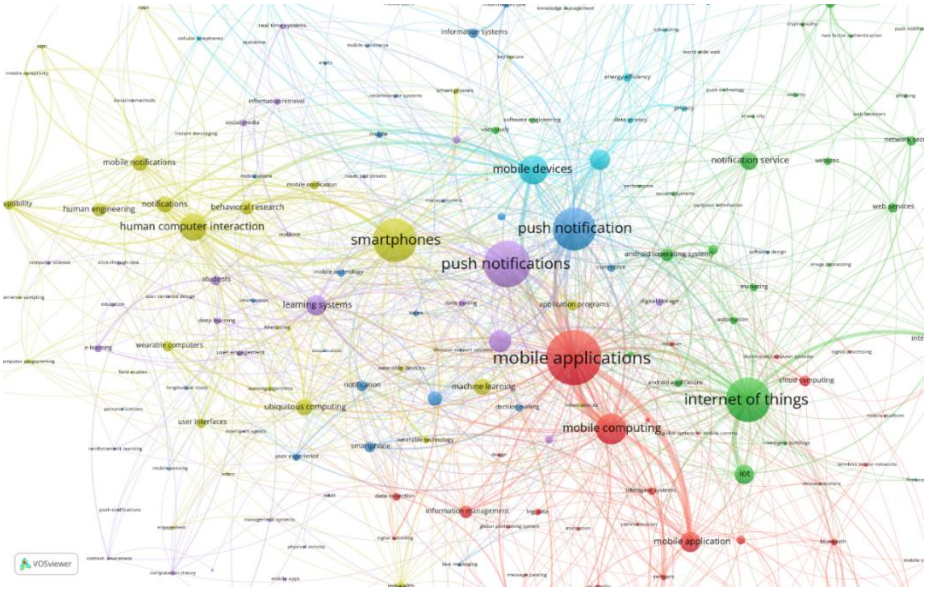

Figure 3. Network Keyword Visualization

Table 2. Top 10 most frequently used keywords in push notification related publication

Rank	Keywords	Links	Total Link Strength
1	Mobile application	142	447
2	Internet of things	116	309
3	Push notifications	128	263
4	Smartphones	127	318
5	Mobile devices	120	283
6	Push notification	113	283
7	Mobile computing	112	281
8	Computer interaction	95	241
9	Mobile telecommunication system	96	194
10	Mobile application	74	161

VOS viewer software can also visualize keyword density. Figure 4 shows the keyword density based on each node. Red indicates a higher occurrence of the word in the research than words surrounded by green. Density views provide a valuable understanding of the overall structure of mapping and drawing in visualization research (Marsh, 2020).

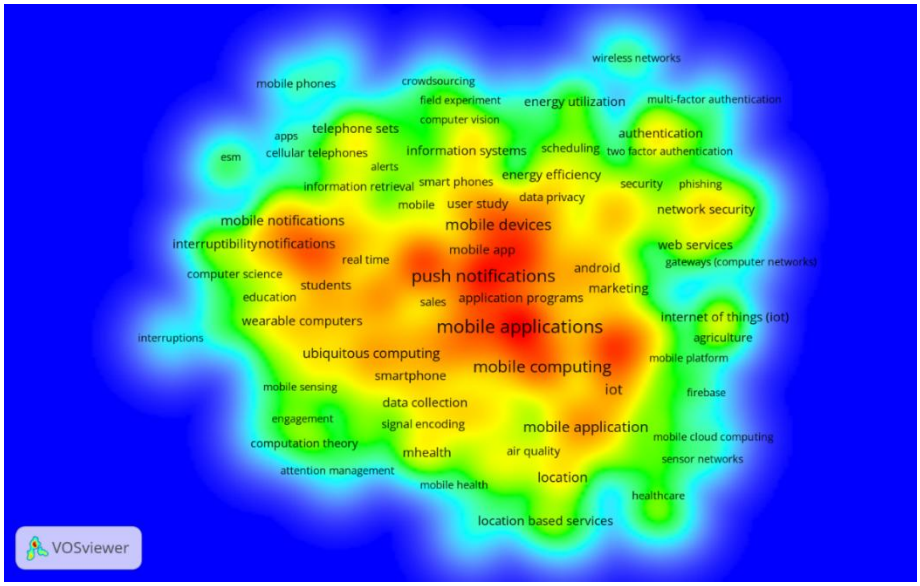

Figure 4. Heatmap density visualization on the push notification studies

Most Often Cited Push Notification-related Publications

Table 3 below shows the paper written by (Shirazi et al., 2014) titled Large-scale Assessment of Mobile Notifications receives the highest citation with 239. This paper comprehensively analyzes mobile notifications, collecting data from over 40,000 users and nearly 200 million notifications. The findings highlight differences in the importance and user

preferences for various types of notifications, offering valuable insights into the effective use of notifications on mobile devices. The paper by (Mehrotra, Pejovic, et al., 2016) explains that the notification presentation, alert type, sender-recipient relationships, task type, completion level, complexity, and even the psychological traits of individuals can significantly impact response times and the disruptions caused by notifications, even if the content is important or useful. The paper ranked third by (Anshari et al., 2019) explores integrating big data into Customer Relationship Management (CRM), highlighting its role in enhancing customer experiences through personalization and customization of services, particularly in the context of aggressive marketing strategies like smartphone push notifications.

Table 3. The top 10 highly cited publications written in push notification

Title	Journal	Authors	Year	Citation
Large-scale assessment of mobile notifications	Conference on Human Factors in Computing Systems - Proceedings	Shirazi et al.	2014	239
My phone and me: Understanding people's receptivity to mobile notifications	Conference on Human Factors in Computing Systems - Proceedings	Mehrotra, Pejovic, et al.	2016	169
Customer relationship management and big data enabled: Personalization & customization of services	Applied Computing and Informatics	Anshari et al.	2019	157
Hooked on smartphones: An exploratory study on smartphone overuse among college students	Conference on Human Factors in Computing Systems - Proceedings	U. Lee et al.	2014	151
Time will tell: The role of mobile learning analytics in self-regulated learning	Computers and Education	Tabuenca et al.,	2015	136

PrefMiner: Mining user's preferences for intelligent mobile notification management	UbiComp 2016 - Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing	Mehrotra, Hendley, et al.	2016	96
IoT-based continuous glucose monitoring system: A feasibility study	Procedia Computer Science	Gia et al.,	2017	80
Disaster Warnings in Your Pocket: How Audiences Interpret Mobile Alerts for an Unfamiliar Hazard	Journal of Contingencies and Crisis Management	Bean et al.	2016	71
The power of mobile notifications to increase wellbeing logging behavior	Conference on Human Factors in Computing Systems - Proceedings	Bentley & Tollmar	2013	70
Understanding the discontinuance behavior of mobile shoppers as a consequence of technostress: An application of the stress-coping theory	Computers in Human Behavior	Chen et al.	2019	67

Discussion of Theme Density in Push Notifications Findings.

The findings of the analysis on themes that have a high density are related to the exploration of push notifications in the topics related to mobile devices, mobile computing, user study, application programs, interruptible notifications, and Internet of Things (IoT) practices as shown in Fig.4. The high density indicates that research related to push notifications has been widely carried out.

Other results indicate that there is a theme that has a low density related to push notifications used in consumer engagement (indicated by the words engagement, attention management, and mobile sensing), related to the development of technology (indicated by the words mobile cloud computing, sensor networks, firebase, gateways, crowdsourcing, and

wireless networks); related to digital security (indicated by the keyword network security and authentication); related to the personification (indicated by location-based services); healthcare industries (indicated by the healthcare, mhealth, and mobile health); method used for research studies (indicated by ESM (experience sampling method and field experiment). The analysis shows that there is still much need to explore how push notifications affect the consumer engagement of the app; the implementation of push notifications associated with the development of technological practices, digital security orientation (e.g., privacy and authentication); push notifications research methods and its implementation in various fields (e.g., mobile health, ESM, and field experiment).

Discussion of Theoretical and Empirical Contributions to Push Notifications Studies in The Last Decade.

Qualitative analysis shows that the theoretical and empirical contributions of selected research are: First, theoretical development is carried out on the smartphone user views of push notification (Shirazi et al., 2014). The result shows the perceptions of users with push notifications came in many ways. For users, the nature of incoming notifications is to be disruptive, notifications are read in a few milliseconds, notifications are about people or events, and not all notifications are important (Shirazi et al., 2014).

Second, the empirical findings provided in the various journals included in the analysis are: mobile interaction design on push notifications can improve users' self-regulation to use the health app/ did the exercise reminder (Kunkel et al., 2023); Randomly push notifications uses in mobile marketing is effective in keeping passengers in the airport terminal shops for longer (Wu & Ma, 2022); an understanding of the user experience of push notifications and the challenge brands face in managing them effectively would consequently increase brand attachment (Gavilan & Martinez-Navarro, 2022); Push notifications can lead to more frequent checking app compared with no-push and create an endogenous impulse to check the information immediately; Mobile push messaging appears to be a very effective tool to stimulate redemption among program participants; The effect of frequency of the non-personalized push notifications increases, uninstalls increase, and the direct open rate of push notifications decreases; Among last-minute bidders, chances of winning the auction increase with their use of push notifications; Vivid push notifications can influence the click-through rate into the news app; Receiving ungrouped content via a mobile device has a greater effect on investment allocations in the presence, rather than absence, of push notifications.

There has been an increase in related to research topics during the decade. In addition to theoretical and empirical contributions, the researchers identified practical uses of push notifications in business marketing fields and customer behavior studies.

4. CONCLUSION

The aim of this study is (1) to analyze the development of push notifications research during the last decade and (2) to identify the theoretical and empirical contributions provided by push notifications research. The researcher used co-citation and co-word analysis with VOSViewer to answer the first research objective. Meanwhile, the researcher used qualitative analysis to answer the second research objective.

The results showed that the development of push notifications had been used in various fields related to the exploration of perceptions and behavior of mobile users, contents of messages, and personification communication. On the other hand, research that needs to be developed is increasing engagement through push notifications, related to the technological development of push notifications, digital security, the implementation of push notifications in healthcare industries, and the method used for push notifications research studies.

Limitations and Future Directions

The limitation of this study is the difficulty in summarizing all the studies related to this topic due to limited resources. Moreover, there is a subjective element in sorting out the appropriate documentation. This study tried to summarize the results of previous studies as much as possible to enrich the results. The existing limitations will probably be corrected in future studies.

Regarding the direction of future research, this study might be replicated in mobile marketing strategies or in technology-based companies to increase brand awareness or the number of visits to the app. This research should be used in a scientific study to determine the magnitude of the relationship between each variable in creating user interest in using push notifications on mobile devices so that a dominant variable is obtained.

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