

Feasibility Study of Internet of Things (IoT) In Construction Industry

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Abstract: As the enhancement of Internet of Things (IoT) networks and its vast use by various industry, it is one fear may arise that the construction industry may have left behind the other industry. That is why the construction industry should start the use of applications offered by IoT to ascertain the smoothness and fast progress of the construction process. At present, developing countries like India, needs fast development of infrastructure and construction, so the better solution is to use IoT applications to boost the speed of construction. This paper mainly aims to check the feasibility of IoT in the construction industry and to find out the IoT applications which are utilized for fast and quality development of construction, through a designed questionnaire survey with in the middle Gujarat state particularly in Vadodara and Anand district. After conducting a survey, the nominal analysis is to be done for the ranking of the IoT applications used in the industry. The top 3 majorly used applications and 3 least used applications are considered for ranking in this paper about the utilization of IoT applications in the construction industry, particularly for the area where the survey was conducted.

Keywords: Construction Industry, Drone, Internet of Things (IoT), Sensors, Smart construction, Nominal analysis.

I. INTRODUCTION

Internet of Things (IoT) is a human-designed technology conceptualized by intelligent virtual objects, which are capable of knowing all matter and permit the devices around themselves to interact automatically without human's control. In simple words, IoT is a network of sensors, appliances and devices competent of sending and receiving data about changes to their current physical situation and environment nearby them over the internet. The figure 1 provides the simplest understanding of the IoT, as this is superior to all type of interactions like machine to machine, machine to environment, human to human, human to machine, machine to human, machine to environment and also than a cyber-physical system.

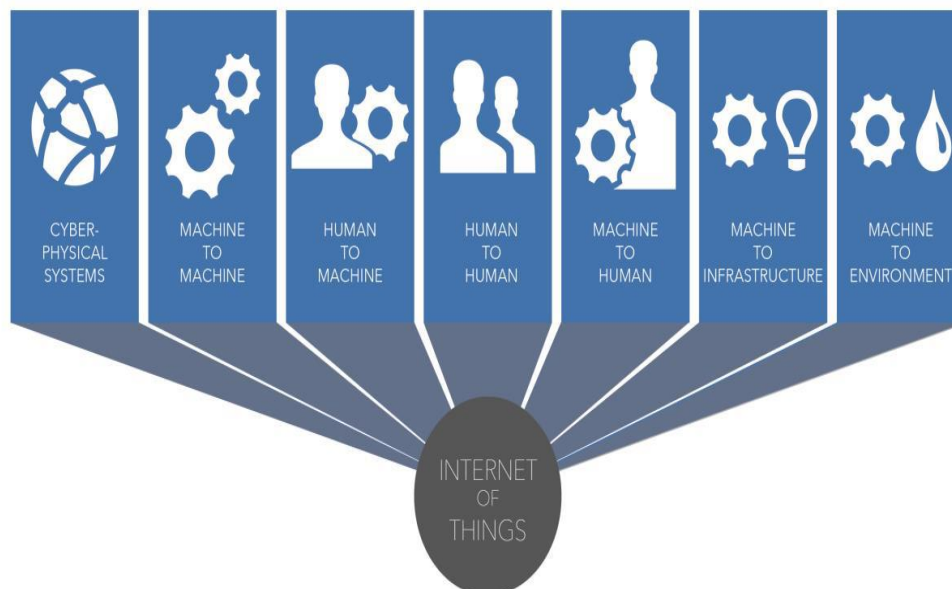


Figure 1: Internet of Things Environment [6]

According to S. Mahmud et al. (2018) the rapidity and growth of the construction industry cause construction parties to have sophisticated network communication systems to ensure the smooth delivery of information. One of the most popular examples of communication networks today is the Internet. The other industries are growing faster using these advanced technologies. The construction industry should emphasize the use of this Internet of Things applications as in the future the construction sector will become increasingly complex and complicated. If there is no application that will facilitate the work involved, the construction industry will be left behind by the improvement of other industries. [16]

This paper presents the literature review on the IoT applications utilized in construction industry. Further through the questionnaire survey, this paper presents current usage of IoT based applications in the construction industry in middle region of Gujarat state particularly in Vadodara and Anand Districts (Figure 2).

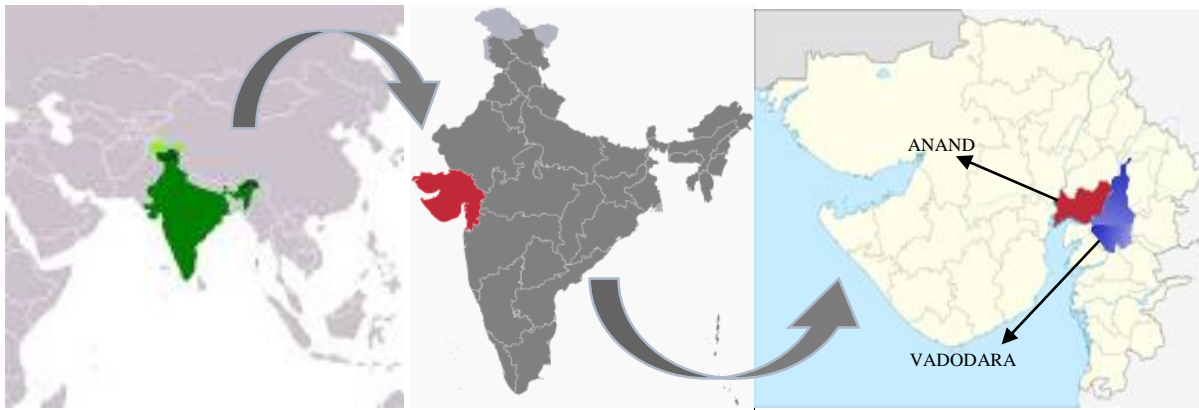


Figure 2: Physical Location of Vadodara and Anand on India map (Scope of work)

II. LITERATURE REVIEW

Following literature review is about the utilization of different IoT applications used in construction industry.

A. Medvedev et al. (2015) proposed an advanced Decision Support System (DSS) for effective waste collection in Smart Cities using IoT devices like RFID, Sensors, Wi-Fi modules and some more. [3] Bridge monitoring and self-assessment of bridge using piezo sensors and piezo generators with IoT create an effective model. [2] (A. Praba et al. 2016). According to W. Taffese et al. (2019) the intelligent data analysis using IoT can be done for corrosion monitoring and durability assessment of structures. [18]. A closed loop lifecycle management system for IoT based smart construction is introduced by J. Xu et al. (2018) using several digital technologies like 3D laser scanner, drone, building information modelling (BIM), augmented reality (AR), Auto-ID, global positioning system (GPS), wireless sensor network (WSN), robotics, mobile digital devices, and web-based applications. [10] V. Jeevana et al. (2018) provided a framework for poor site management using IoT with sensors and real time monitoring to achieve process improvement by minimization of time. [17] The questionnaire survey is conducted by the S. Mahmud et al. (2018) to identify the types of IoT applications used in construction industry of Malaysia. They have concluded by the survey that majorly used IoT applications are Social media, E-mail, GPRS and least used applications are Sensor technology, Smart Watch etc. [16] Bhavna et al. (2015) and M. Peruzzini et al. (2013) established and provide smart home automation system using several digital technologies with IoT. [12] [4] Smart sensing devices and real time monitoring devices coupled with IoT could have a very significant impact on the overall duration, quality and cost of the construction project according to A. Kumar et al (2018) [1] L. Parra et al. (2019) proposed architecture for smart city combining different systems using digital technologies and systems with IoT. [11] C. Cho et al. found out the solution for the collapsing scaffolding structure. They derived a smart prevention system using BIM, sensors, FEM analysis and IoT application to monitor and prevent the scaffolding structure collapse possibility. [5] Michael Urie stated that IoT can be helpful to overcome existing building management systems (BMS) difficulties. He also listed some of the capabilities which are, Sensors Placed in Completed Buildings and Structures, Augmented Reality (AR), Power/Fuel Saving, Remote Usage and Activity Monitoring, Enables 'Just-In-Time' Provision, Tracks Tools and Equipment etc. [13] H. Reddy et al. (2019) and J. Shah et al. (2016) both claimed that digital transformation is very ongoing challenge in construction industry and the best solution for that is IoT system. [6] [8] S. Okishiba et al. (2019) discussed about the system using tablet and Wi-Fi module to operate excavator autonomously at hazardous place. [15]

III. RESEARCH METHODOLOGY

The study aims to check the feasibility of IoT applications used by construction industry and rank their use in industry by nominal analysis after gathering data through survey. Different literatures related to this research are reviewed, and in order to see building construction practices, the following research methodology is implemented which is shown in figure 3.

There are several methods of collecting data. Important ones are: observation method, interview method, through questionnaires, through schedules. In this research, the collected data is through questionnaires. This method of data collection is quite popular, particular in case of big inquiries. In this method a questionnaire is sent to persons concern with a request to answer the question and return the questionnaires. A questionnaire consists of a number of questions printed or typed in a definite order on a form about the general information about the respondent including name, experience and other basic project details and also about the usage of different IoT applications in their construction project in Yes or No form.

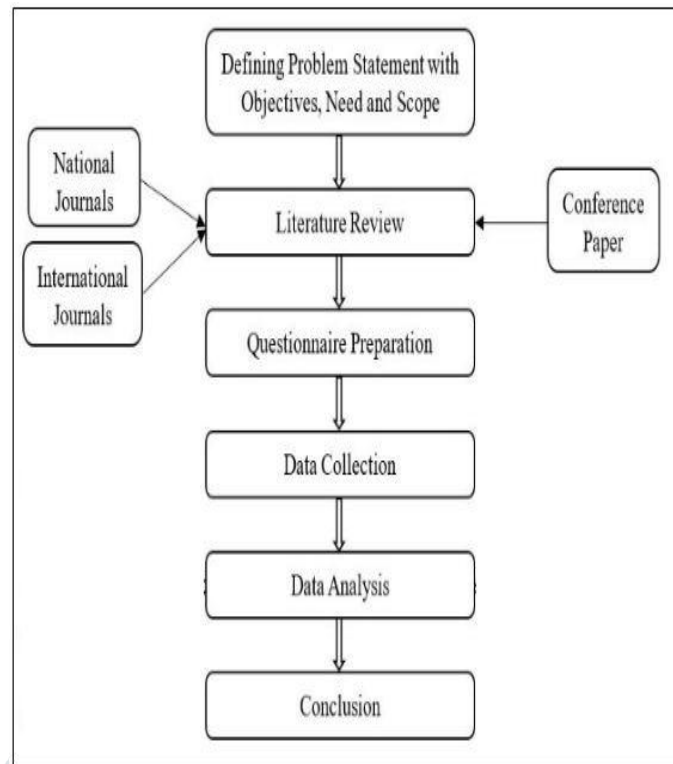


Figure 3: Methodology flow diagram

The Questionnaire consist two parts, first part includes the general information of the respondents like name, contact detail, organization name, experience in construction industry, type of profession, basic details of their current project etc. and the second part includes the main questions about the usage of different IoT applications in the different activities and phases of construction in Yes or No form.

IV. DATA ANALYSIS AND RESULT

The Questionnaire form is distributed to the different stakeholders like Contractors, Builders, Site Supervisors, Engineers and Project Engineers/Managers among the construction sites in Vadodara and Anand city. After gathering the data from all responses collected from the stakeholders, the nominal analysis is to be done in Microsoft excel. After analysis of percentage values the highest used applications and lowest used applications are ranked and top 3 majorly used and top 3 least used applications are displayed in a tabular form as shown in table 1 and table 2.

Table 1: Highest ranking and percentage of usage on types of Internet of Things applications.

Types of Internet of Things Applications	Highest Ranking	Percentage
Use of AutoCAD & other software	1	98.44
Use of Social media & Use of Email	2	92.20
Use of Net Banking	3	90.60

Based on Table 1, the use of AutoCAD & other software is an application that is majorly used by respondents with a maximum percentage of 98.44%. The use of social media and email is the second highest application used by 92.20% of respondents. The third application that many respondents use is the use of Net Banking by 90.60%.

Table 2: Lowest ranking and percentage of usage on types of Internet of Things applications.

Types of Internet of Things Applications	Lowest Ranking	Percentage
Use of Robotics	1	1.60
Use of Primavera	2	6.25
Use of Sensors for Waste management	3	7.80

Based on Table 2, the use of Robotics is an application which is less used by respondents with a percentage of only 1.60%. The use of Primavera is also the second application which is less used by respondents with a percentage of 6.25%. Then, the use of Sensors for Waste management is the lowest third application that is also less used by respondents with a percentage of 7.80%.

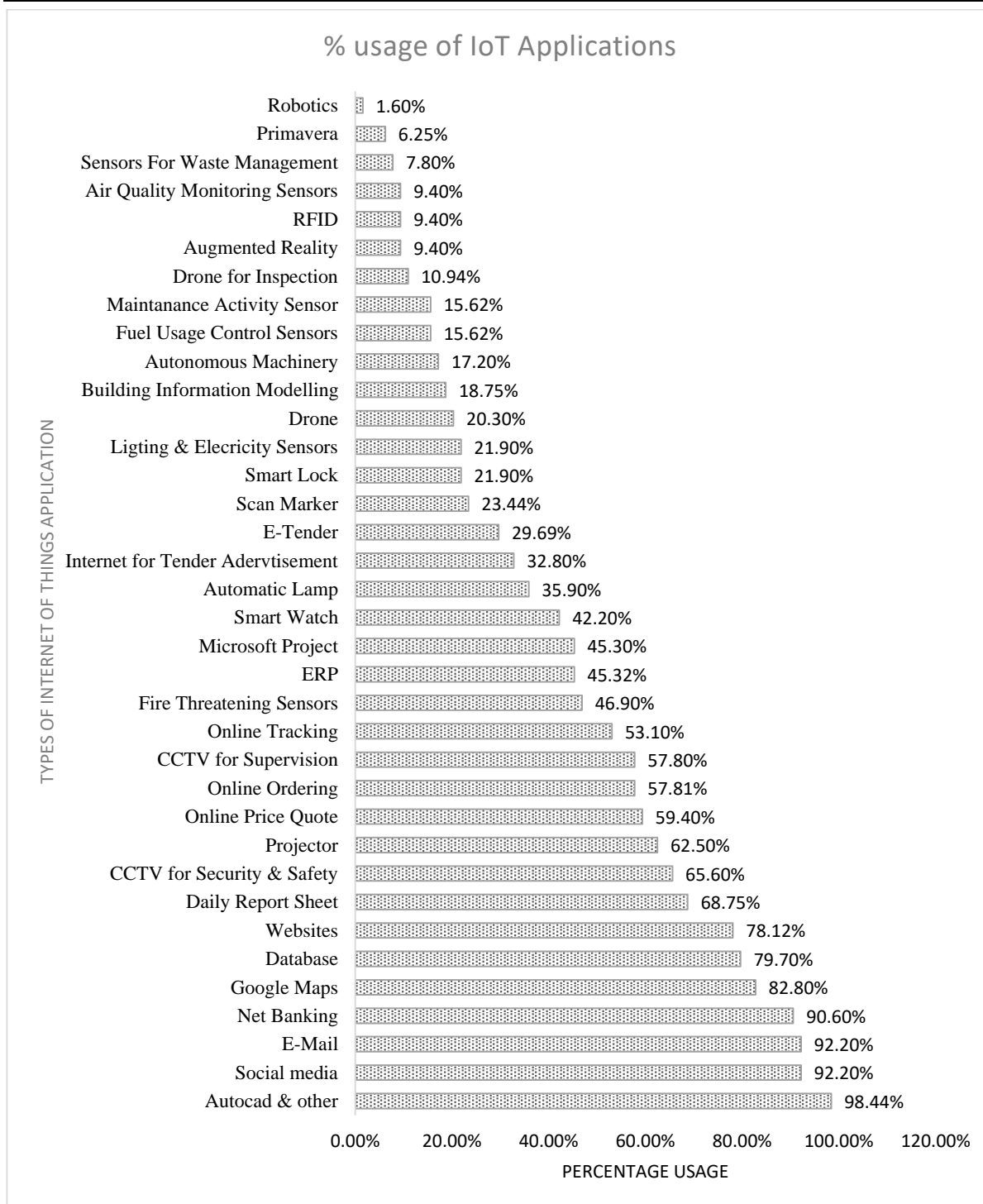


Figure 4: Summary of percentages of usage on Internet of Things application

The usage of IoT applications is analyzed in percentage values and presented graphically in tabular chart as shown in figure 4. The figure shows 36 types of Internet of Things applications that have been carried out for survey. 4 types of Internet of Things applications that get the highest percentage of users which are AutoCAD & Other software, Social media and email, Net banking which represent 98.44%, 92.20% and 90.60% respectively. A total of 10 applications also have a satisfactory rate of usage where the percentage of usage is within 50% to 90%. 3 types of Internet of Things applications that earn the lowest percentage of usage which are Robotics, Primavera and Sensor technology for waste management which account for 1.60%, 6.25% and 7.80% respectively. Next, up to 19 types of applications are also in the percentage of the lowest usage rate within 15% to 49% only.

V. CONCLUSION

Based on the results of this study some conclusions are to be found as discussed below,

- There are four types of Internet of Things applications occupy the highest percentage of usage. The use of AutoCAD and other software is the type of application which is use by many of the construction industry players for design purpose as well as analysis purpose of the structure.
- The second highest used IoT applications is social media such as WhatsApp, Telegram and Facebook Messenger. Then followed by the use of email that serves as an exchange of information between players of this industry. Both applications get the most and the same response where each respondent used it.
- The next third highest application is the use of the Net banking as the source of financial management. Any project cannot run without money; Money is one of the important pillar in the construction industry. In India, after the demonetization phase the

cashless concept is being accepted by all of the industries. That is why the Net banking is the most used IoT application for the financial activities.

- There are three types of Internet of Things applications that have the lowest usage percentage compared to other applications. The least-used application is the use of robotics in construction industry. This happens because of the complexity of project and due to that the repetition of work is less. The another reason is that, if robotics is used then the threat of job security to labors and engineers may occur.
- Second less used application is Primavera for project management purpose. This happens because of lack of knowledge about the software and the alternative software Microsoft Project is easy to use, so the Primavera is not adopted by most of the firms.
- The third application is the use of sensor technology to manage the waste. Waste management is the main thing to take care but unfortunately there is less awareness and adaptive steps are taken to look into it.
- However, the findings show that the use of Internet of Things applications is still under-utilized in the construction industry. This is because there are only 14 types of applications that are higher in usage rates than those that do not use them, and 22 applications are less used.
- The evaluation of the respondents' knowledge of the Internet of Things application found that the majority of respondents had known each type of Internet of Things application. This proves that the construction industry players are aware of the presence of this application although its usage is still less because of lack of skills to use, lack of interest in change, lack of budget to purchase and install new technologies.
- To increase the use of Internet of things application in construction industry, implementation and encouragement should be provided to each players in construction industry.

VI. FUTURE SCOPE

This paper surveyed some of the most important applications of IoT with focus on construction industry, however, future research may be conducted on implementation of the internet of things concept in building projects and the case study may be conducted to make the concept of IoT feasible.

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REFERENCES

- [1] A. Kumar and O. Shoghli 2018, "A review of IoT applications in Supply Chain Optimization of Construction Materials", 35th International Symposium on Automation and Robotics in Construction, ISARC 2018
- [2] A. Praba 2016, "IoT of Civil Infrastructures", International Journal of Research in Advanced Technology – IJORAT, 1(6): 6-9
- [3] A. Medvede, P. Fedchenk, A. Zaslavsky, T. Anagnostopoulos, S. Khoruzhnik 2015, "Waste Management as an IoT-Enabled Service in Smart Cities", Springer International Publishing Switzerland 2015, LNCS 9247: 104–115
- [4] Bhavna, Dr. N. Sharma 2018, "Smart Home Automation Using Iot", International Journal of Engineering Sciences & Research Technology, 7(5): 435-437
- [5] C. Cho; K. Kim; J. Park; and Yong K. Cho 2018, "Data-Driven Monitoring System for Preventing the Collapse of Scaffolding Structures", Journal of Construction Engineering and Management, ASCE, ISSN 0733-9364, 144(8): 1-12
- [6] H. Gopi Reddy, V. Kone 2019, "Study on Implementing Smart Construction with Various Applications Using Internet of Things Techniques", International Journal of Recent Technology and Engineering (IJRTE), 7(6): 188-192
- [7] Internet of Things Applications, AIOTI WG01 – IERC, Release 1.0, 2015
- [8] J. Shah, B. Mishra 2016, "Customized IoT enabled Wireless Sensing and Monitoring Platform for Smart Buildings", Elsevier, Procedia Technology, 23:256-263
- [9] J. Wan, M. Li, M. O'Grady, X. Gu, JinWang, N. Cao 2018, "Wearable IoT enabled real-time health monitoring system", Journal on Wireless Communications and Networking, Volume 298: 1-10
- [10] J. Xu, W. Lu 2018, "Smart Construction from Head to Toe: A Closed-Loop Lifecycle Management System Based on IoT", Construction Research Congress 2018, ASCE, 157-168
- [11] L. Parra, J. Rocher, S. Sendra and J. Lloret 2019, "An Energy-Efficient IoT Group-Based Architecture for Smart Cities", Energy Conservation for IoT Devices, Concepts, Paradigms and Solutions, ISSN 2198-4182, Springer journal, 206: 111-127
- [12] M. Peruzzini, M. Germani, A. Papetti, and A. Capitanelli 2013, "Smart Home Information Management System for Energy-Efficient Networks", International Federation for Information Processing 408: 393–401
- [13] M. Urie, The Internet Of Things In Construction, <https://www.gardiner.com/>
- [14] N. Singh, S. Kumar, B. Kanaujia, H. Choi and K. Kim 2019, "Energy-Efficient System Design for Internet of Things (IoT) devices", Energy Conservation for IoT Devices, Concepts, Paradigms and Solutions, ISSN 2198-4182, Springer journal, 206: 49-74
- [15] S. Okishiba, R. Fukui, M. Takagi, H. Azumi, S. Warisawa, R. Togashi, H. Kitaoka, T. Ooi 2019 "Tablet interface for direct vision teleoperation of an excavator for urban construction work", Elsevier, Automation in construction 102: 17-26
- [16] S. Mahmud, L. Assan, R. Islam 2018, "Potentials of Internet of Things (IoT) in Malaysian Construction Industry", Annals of Emerging Technologies in Computing (AETiC), 2(4): 44-52
- [17] V. Jeevana, S.G. Kulkarni 2018, "Internet of Things (IoT) To Prevent Delays of Construction Industry", International Journal of Pure and Applied Mathematics, 118(22): 1037-1041
- [18] W. Taffese, E. Nigussie, J. Isoaho 2019, "Internet of Things based Durability Monitoring and Assessment of Reinforced Concrete Structures", Elsevier, Procedia Computer Science 155:672-679

[19] Zeinab, K. Mohammed and S. Elmustafa 2017, "Internet of Things applications, challenges and related future technologies" World Scientific News volume 2(67): 126-148

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