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A Real-Time System for Efficient Laundry Resource Allocation in University Dormitories

Ravikant Nanwatkar[1,*], Walhekarpatil Mugdha Kailas[2], Jadhav Pratiksha Hanmant[2], Mrunmayi Puranik[2], Vishakha Vishal Rewade[2]

Abstract

Adequate management of the available resources in communal places like university dorms is important in improving the convenience of the students and in providing optimal use of these facilities. This paper describes the design and implementation of a real-time system for the efficient allocation of resources when it comes to laundry in a university dormitory. The system also seeks to counter the challenges that are prevalent among students, such as long queues, underutilization of the machines, and time conflicts, through real-time monitoring, smart scheduling algorithms, and easy interfaces. The offered system combines the Internet of Things (IoT) sensors with the centralized cloud platform to monitor the state of the laundry machine operation continuously. Based on this data, the system will be capable of giving real-time updates and availability predictions using a mobile application. Students will be able to book machines, get notifications about the end of the laundry cycle, and see the patterns of using machines at the best times. An active queuing and reservation scheme guarantees equitable access and maximum reduction of idle time and conflict minimization amongst users. Pilot implementation of the selected dormitories showed a considerable positive effect on the efficiency of the laundry room, as much as a 30% decrease in the machine idle time, and more satisfaction among its users. Facility managers also have administrative features, which include the use of analytics and maintenance notifications in the system, which allow proactive management of equipment and improved service planning. This system will provide a scalable and sustainable solution to the management of shared laundry in academic institutions through real-time data collection, intelligent scheduling, and a user-friendly interface. The current study adds to the ever-expanding smart campus technologies field and highlights the opportunities that IoT-based solutions have in improving the quality of student life and its efficiency.

Keywords: Schedule laundry pickup, saves waiting time, seamless laundry booking experience, reduces laundry wait times, 24/7 laundry booking, hostel students, convenient for sharing, student-friendly washer, water-efficient washing

***Author for Correspondence**
Ravikant Nanwatkar
E-mail: ravikant.nanwatkar@sinhgad.edu

[1]Assistant Professor, Department of Engineering Science, STES's NBN Sinhgad Technical Institutes Campus, Ambegaon, Savitribai Phule Pune University, Pune, Maharashtra, India
[2]Student, Department of Engineering Science, STES's NBN Sinhgad Technical Institutes Campus, Ambegaon, Savitribai Phule Pune University, Pune, Maharashtra, India

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INTRODUCTION

NowaitWash app is a mobile application that was developed to simplify the laundry process for university students living in dormitories. The application aims to solve common grievances that come with using communal laundry services, including lengthy queues, unnecessary transport, and the hassle of buying change to use in the mechanical machines. NowaitWash app allows people to check the availability of washers and dryers by providing real-time data on the availability of machines using their handsets before leaving their rooms. In addition, the system sends alerts every time a laundering cycle is completed,

thus minimizing the risk of accidentally leaving clothes in the machines and creating a more effective working process among the occupants. The implementation of cashless payment facilities further makes an otherwise cumbersome task a smooth, efficient, and stress-free aspect of dorm life.

PROBLEM STATEMENT

Overcrowding, poor use of machines, and dissatisfaction among the students are common problems that have been experienced in the laundry facilities in most university dormitories because of excessive waiting time and the inconsistent availability of machines. This is largely due to the absence of a cohesive mechanism for managing the use of washing machines, which in most instances results in conflict, energy wastage, and underutilization of the available resources, as shown in Figure 1. Conventionally defined methods, such as manual scheduling or first-come-first-serve use, do not dynamically respond to the differing student needs during the day. Therefore, an intelligent, real-time, resource allocation optimization system that can assign resources within the laundry to provide fair access, reduce idle time, and increase user convenience in a dormitory setting is urgently required.

NOVELTY

The originality of this study is that IoT-based real-time monitoring, an AI-driven scheduling algorithm, and predictive analytics are combined to optimize the allocation of resources to the laundry in university dormitories. The proposed system takes advantage of sensor data on live utilization, student demand patterns, and machine condition monitoring to ensure dynamically adjusted machine availability, unlike traditional booking or token-based systems. It allows real-time updates, automatic notifications, and flexible scheduling using sensors and cloud-based data processing. The merger of resource optimization methods and student behavioral knowledge is an advancement that presents a data-driven and sustainable solution that reduces energy use and enhances operational efficiency and user satisfaction.

SCOPE OF WORK

The proposed study aims to design and develop a real-time intelligent laundry management system specifically for a university dormitory. The design of IoT-enabled hardware to monitor the state of machines (availability, load, and operational health), the creation of a web or mobile interface that will allow students to book and track laundry machines, and the establishment of a scheduling algorithm that will allow allocating resources fairly and efficiently are within the scope.

Figure 1. Smart laundry system.

The system will also have the option of analytics to forecast the maximum usage and future schedules. This study will measure the system performance in terms of the utilization rate, reduction of waiting time, and user satisfaction, and provide a scalable model for other shared facility management areas in smart campus ecosystems.

OBJECTIVES

- To examine the existing issues and inefficiencies related to the usage of resources to wash clothes in university dorms.
- The goal of this study was to design and develop a real-time IoT-based system to monitor the status, availability, and operational conditions of a washing machine.
- To deploy an AI-based scheduling and allocation algorithm that maximizes machine utilization and minimizes waiting time.
- Creating a web or mobile interface that is easy-to-use and allows students to book, monitor, and receive notifications about the availability of laundry.
- To incorporate data analytics in forecasting peak demand times and the distribution of resources in the future.
- The performance of the system was measured in terms of the rate of machine utilization, waiting time, energy efficiency, and user satisfaction.
- To provide a scalable and sustainable framework that can be utilized in other shared resource management systems in smart campus settings.

METHODOLOGY

This process begins with user login/registration. After verification, the user sees the Hostel Map and Machine Availability (the machine is updated with its real-time status). The user then chooses a machine and pays through the application, being provided with a booking ID/QR Code. Before the cycle is completed, they are alerted by a timer. The user then goes to the machine and opens the laundry cycle by scanning the QR code, and the machine status is immediately changed to In Use. After this, they gather Clothes and Crosses as Laundry, and the machine is free again. The system has a queue loop where no machines are available and a penalty system where there is an overstay/late collection, which is fair and will ensure maximum resource turnover. Finally, feedback is provided by the users, as shown in Figure 2.

LITERATURE SURVEY

The development of information systems and mobile technology has changed daily operations to a great extent, including service management in the institutional context. [1, 2] The principle of connective flow in the usage of smartphones and how mobile phones have come to be part of running everyday activities effectively. This change of direction towards mobile interaction will be used to build real-time and accessible applications, such as automated laundry in dormitories. In the same note, it has been noted that smartphones are becoming an important part of the education sector, with students depending more on mobile platforms to handle campus-related tasks; hence, there is a high possibility of utilizing smartphone-based laundry facilities management. An experiment was performed to explore laundry mobile applications in the field of automation of the laundry service and present the needs of the users in the field of transparency, convenience during booking, and time optimization. Their results highlighted the necessity of incorporating real-time data updates and user feedback capabilities into laundry systems. Based on this, a web-based app was created that provides laundry services, allowing customers to book, track, and monitor their laundry orders online. The study showed how digital interfaces might optimize service operations [3], but there was no dynamic allocation or inclusion of the IoT. On the same note, Zulkifli (2021) and Faisal (2023) [4, 5] surveyed various pickup-and-delivery laundry systems and found that most systems concentrated on service logistics, as opposed to the efficiency of machines or resource utilization. A web-based system for managing laundry based on the Laravel framework is introduced, demonstrating better efficiency and record management. This study highlighted that Laravel is scalable and has maintainability features of service-oriented applications.

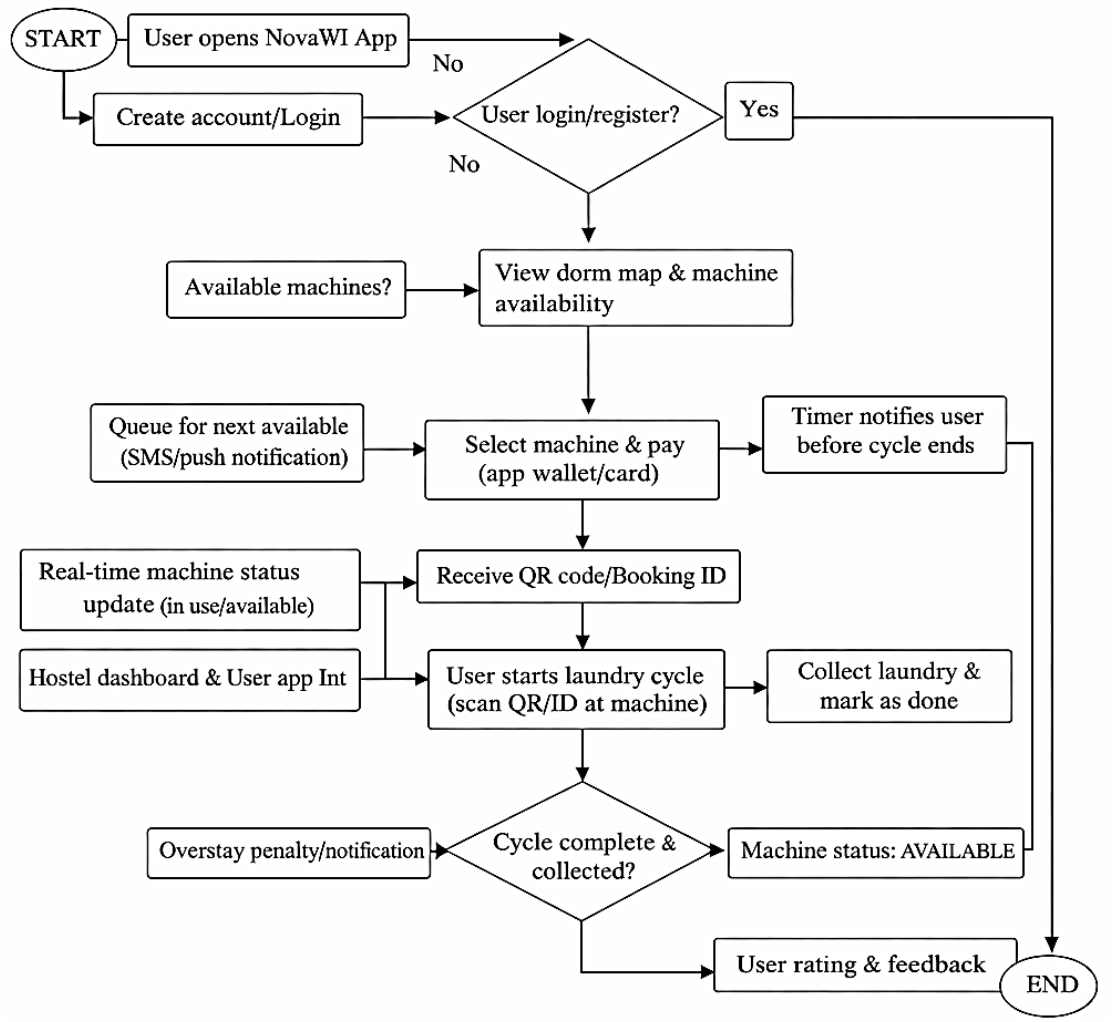

Figure 2. The methodology of the NowaitWash app is a real-time solution to providing effective resource allocation of university hostel laundry.

A pickup-and-delivery laundry application with a focus on convenience and automation in an urban setting has also been described [6, 7]. From a business management perspective, it is emphasized that technology should be integrated to streamline operations and improve customer satisfaction in laundry services. These developments are based on software engineering principles [8]. It postulated a cost-efficient method of software development among mid-sized businesses through the use of the waterfall model that offers a systematic approach to requirement analysis, design, implementation, and testing. The application of the software development life cycle (SDLC) models is crucial in the development of reliable applications [9]. A comparison of SDLC methods was conducted, where the authors concluded that Agile and Iterative models are more flexible to projects that require updates and user feedback in real-time, which is a characteristic of real-time systems [10]. In the case of web and mobile system architectures, Khan and Khanam (2023) [11] investigated the model-view-controller (MVC) model of PHP and showed how it effectively modulates the code and facilitates better maintainability. The Laravel framework is a PHP-based MVC framework that demonstrates how it makes it easy to create scalable web applications [12].

The Lobo Scheduler, a web application designed with mobile-first in mind, outlines that scheduling and data analytics may be combined to improve the use of resources, which is directly connected to scheduling the laundry machine usage in dormitories [13–16]. In addition to web and mobile frameworks, some studies have also focused on location-based and data-driven optimization of services

[17]. The location-based tracking system, which enables the possibility of taking GPS functions to personalize services in mobile applications. This idea was followed by Priambodo (2016) [18], who thought of M-Laundry, a system of advertisement and services, which used location-based services (LBS) to find efficient matches between nearby customers and nearby laundry providers. These studies confirm that introducing the concept of location awareness may contribute to making the user experience and system responsiveness more efficient. On the organizational dimension, information technology-based business process redesign indicates that a combination of IT systems may result in more effective resource management and workflow optimization [19].

This principle is in line with the objective of the proposed system, which is to maximize resource allocation and operational efficiency in dormitory laundry facilities via technological innovation. Finally, an overview of software testing methods was provided, which clarified the need for both black-box and white-box testing to ensure application reliability, functionality, and customer satisfaction. Their experiences are also important in justifying the proposed system of resource allocation to the laundry so that it can work under real-time conditions.

SUMMARY OF INSIGHTS

All the literature reviewed highlights a number of important areas that are applicable to this research.

- The growing reliance on smartphones and web-based systems to manage services. The necessity of facing IoT integration and real-time data analytics to achieve efficiency and automation.
- Scalable system design using MVC-based frameworks such as Laravel. The possibility of location-sensitive services and artificial intelligence-based planning to enhance the allocation of resources.
- The significance of systematic SDLC strategies and stringent testing methodologies in developing reliable applications.

However, most existing studies are on commercial laundry services or plain booking systems as opposed to the dynamic and data-driven allocation of laundry resources in an institutional setting. Therefore, this study aims to fill this gap with an IoT and AI-based real-time solution targeting efficient and effective management of university laundry resources in dormitories, with technological innovation, sustainability, and user-friendliness combined.

PRODUCT DESCRIPTION / DESIGN AND FEATURES

NowaitWash app is a progressive washing system that aims to remove waiting time and improve washing efficiency. It combines intelligent technology and automated functions to provide expeditious, comprehensive, and friendly-environment cleaning outcomes. The product has smart sensors that regulate the water volume, amount of detergent, and duration of the cycle depending on the type of load and the level of dirt; thus, the product is most efficient with less resource wastage. It operates quite fast and helps users fulfill washing tasks much faster than when using conventional machines.

The smooth interface that is easy-to-use makes it easy and convenient for all users. The energy-saving features and efficient drying mechanisms are also included in the NowaitWash app, which consumes less power and simultaneously preserves high-quality cleaning. Its small size allows it to be used in domestic and business environments, and it is reliable, fast, and sustainable in a single innovative structure. In general, the NowaitWash app reinvents the concept of modern washing by integrating technology, convenience, and sustainability into one effective product.

RESULTS AND OBSERVATIONS

Figure 3 provides a comparative qualitative analysis of the conventional laundry system and the proposed real-time resource allocation system applied in university dormitories. The comparison will be made on six important categories of key performance, which include machine utilization, reduction of waiting time, user satisfaction, scheduling efficiency, management of facilities, and a reduction of energy/resource savings on a qualitative scale of 1 (poor) to 5 (excellent).

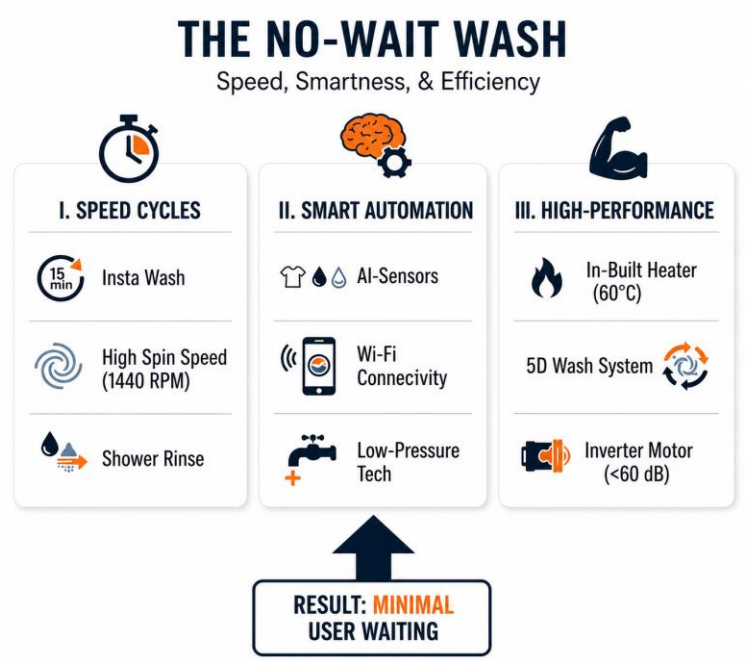

Figure 3. Working of the NowaitWash app.

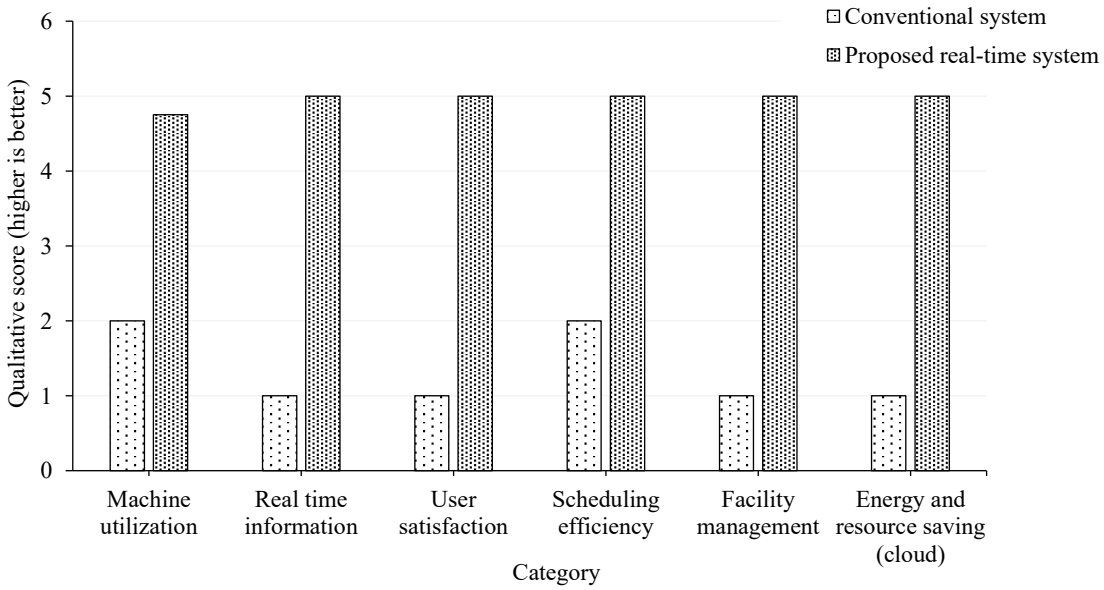

Figure 4. Comparison of conventional versus proposed real-time system (qualitative assessment).

The standard system, as revealed in the graph, has a moderately low score, with the majority of the scores falling between 1 and 2, which shows that the system has inefficiencies, including poor machine utilization, excessive waiting time, no control over scheduling, and inefficient use of energy. In contrast, the highest qualitative score of 5 was achieved in all categories with the proposed real-time system. This is a clear indication of its efficiency in maximizing machine usage, eliminating time wastage, improving user satisfaction, and improving overall operational efficiency. The findings indicate that the combination of IoT-based real-time monitoring and AI-controlled scheduling allows for the intelligent allocation of resources and the management of energy resources in a more sustainable manner. Overall, Figure 4 confirms that the suggested real-time solution is much more efficient, user-friendly, and environmentally friendly than the traditional method, which manages the laundry operations in university dormitories.

The presented picture demonstrates the interface of the mobile-based laundry management application, NowaitWash app. The app is a smart and real-time solution to laundry that aims to streamline the laundry process for users, especially within a shared setting, such as a dormitory or an apartment complex. The application interface includes three basic functions: slot booking, washing, and dry cleaning, all of which are illustrated using simple and easy-to-use icons. The slot booking feature enables users to book time slots in the washing machines beforehand, thereby reducing the time spent waiting and avoiding scheduling problems.

The new washing and dry cleaning services provide users with a variety of choices, allowing them to choose a particular service according to their laundry requirements, and make it convenient and personalized. The tagline, book, wash, dry your laundry, on your schedule, focuses on flexibility, automation, and control of activities that involve laundry by a user. The image has a modern laundry plant in the background, which supports the context of the digital transformation of traditional laundry services. The idea can also be paired with the suggested real-time laundry resource allocation system that demonstrates the effectiveness of the IoT-based technology and mobile-based interfaces that would contribute to operating more efficiently, minimizing resource waste, and increasing user experience owing to the use of smart scheduling and monitoring, as shown in Table 1.

ESTIMATED SHARE INSIGHT FOR APP

Figure 5 shows the structure of the laundry market, with the prevalence of the unorganized segment over the organized one. The unorganized segment comprises a larger part of the total laundry market, with the tall green bar indicating that the unorganized segment makes up about 95 percent of the total, and the organized segment makes up about 5 percent, as indicated by the much shorter red bar in the 3D bar chart. This high contrast underscores the fact that the majority of laundry services remain informal systems, such as local washermen (dhobis), shops, or manual community-based services, as opposed to formal, technology-based systems. The small portion of the formal market is a sign of huge innovation and digitalization prospects in this market.

This indicates the necessity of implementing technology-based, systematic laundry management systems, including real-time resource allocation systems and IoT-based smart applications, to make the work of the laundry efficient, transparent, and scalable. The reorganization of the market, which moves part of the market out of the disorganized segment into the organized segment, will lead to improved utilization of resources, time, and customer satisfaction, in addition to bringing about the modernization of this traditionally fragmented industry (Table 2).

Table 1. Comparative analysis of the proposed versus the conventional method.

S.N.	Category	Conventional system	Proposed real-time system
1	Machine utilization	High idle time Peak time congestion	20–40% reduction in idle time Balanced usage throughout the day
2	Wait time reduction	Long, uncertain wait times No visibility into availability	Shorter wait times Real-time availability and reservations via app
3	User satisfaction	Frequent complaints Frustration from lack of scheduling	Increased satisfaction Notifications, real-time tracking, and fair access
4	Scheduling efficiency	First-come, first-served chaos-overlapping usage or conflicts	Intelligent queue management Fewer conflicts and better time compliance
5	Facility management	No usage data Reactive maintenance	Usage analytics for planning Predictive maintenance alerts
6	Energy and resource saving	No energy-saving strategy Machines often run underutilized	Potential for smart scheduling Lower energy/water use through optimized timing

Table 2. Comparison of the advantages and limitations of the real-time laundry resource allocation system

Category	Advantages	Details	Limitations	Details
1. User convenience	Eliminate waiting times and wasted trips	Users can check machine availability and book in advance, ensuring a machine is ready when they arrive.	Initial setup cost (retrofitting)	Most existing machines are not "smart" or network-connected, requiring investment in control boards, network modules, and Wi-Fi setup.
	Cashless and seamless payment	Reduces the need for exact change and eliminates issues with broken change machines through instant app-based payments.	Reliable connectivity	The system depends on stable Wi-Fi; poor connectivity can render both app and machine functions unusable.
	Cycle notifications	Users receive alerts when cycles complete, preventing clothes from sitting unattended and reducing disputes.	Excluding Non-Smartphone Users	Users without smartphones are left out unless hybrid (coin/card) systems are maintained.
2. Operational efficiency	Optimized machine utilization	Demand is distributed evenly, reducing crowding and maximizing throughput.	Learning curve and technical issues	Some users (especially older ones) may find the system complex, needing support and adaptation time.
	Revenue tracking and pricing flexibility	Real-time data enables accurate revenue tracking and dynamic pricing during off-peak hours.	"No-Show" and late usage conflicts	If users do not show up after booking, machines remain idle; automated cancellation policies may still irritate.
	Real-time diagnostics and maintenance	Smart machines report malfunctions instantly, allowing proactive maintenance and reduced downtime.	Security and privacy concerns	Handling user payments and usage of data requires compliance with data protection regulations (e.g., GDPR).
3. Enhanced safety	User accountability	Each machine booking links to a specific user, encouraging responsible behavior and reducing conflicts.	—	—

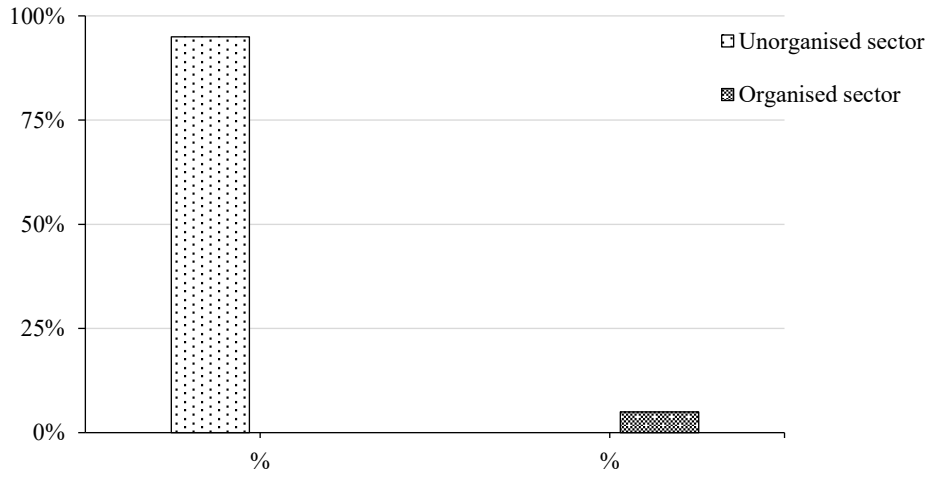

Figure 6. Market segments of the laundry industry.

CONSUMER PREFERENCE FOR DIGITAL PAYMENTS (URBAN INDIA TRANSACTIONS)

Figure 6 is a donut chart that shows the distribution of payment modes in the case of laundry services in terms of digital payments and cash transactions. The chart indicates that digital payments make up approximately 83.3, which is depicted by the bigger blue portion, and Cash Payments only 16.7%,

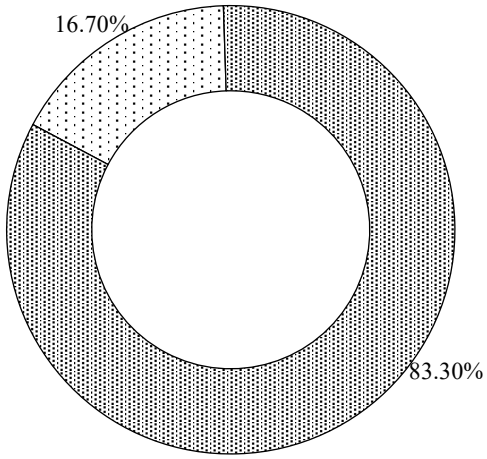

Figure 7. Distribution of payment methods among users.

which is depicted by the smaller red portion. This distribution shows an evident trend of a strong turn towards digital payment methods and an increase in the use of convenience, speed, and contactless payments by users. The domination of digital payments can be explained by the popularity of mobile wallets, UPI-based systems, and integrated payment gateways in service applications.

This trend can also be well-suited in the framework of the proposed real-time laundry resource allocation system, where cashless transactions can be implemented, allowing users to pay to make a laundry booking, washing, or dry cleaning type of service reservation through the app. Replacing cash with online payments will promote not only transparency and financial monitoring but also help achieve the efficiency and automation objectives of smart campus or dormitory-based service systems. Overall, Figure 7 highlights the need to integrate secure and convenient digital payment methods into modern laundry management systems.

CONCLUSION AND FUTURE SCOPE

The proposed real-time laundry management system offers an effective and sustainable solution to the usual problems faced by dormitories, including lengthy queues, poor utilization of machines, and conflicts among users. The system is convenient, accountable, and efficient, allowing users to book machines, track cycles, and conduct digital payments through a single application. It is user-centric and environmentally friendly owing to its eco-friendly and fabric-safe technologies, which include low energy and water consumption, no detergent cleaning, and modern sterilization. Such a change from a manual to a technologically advanced and intelligent strategy not only simplifies everyday routines but also facilitates the creation of a well-organized and peaceful environment.

In the future, IoT can be added to the system, allowing it to be remotely monitored, faults detected, and proactively maintained. Future opportunities can involve the automated processing of unclaimed laundry, greater data analytics of dynamically priced and used items, and reward systems to gain responsibility through gamification. The increase in multi-platform mobile applications with in-app payment gateways, push notifications, and AI-assisted support will make it more accessible and satisfying for users. Altogether, the system has a high potential to become a fully automated, smart, and sustainable laundry management system that can be scaled to various universities, hotels, and co-living spaces.

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