

Smart Slot-Based Darshan Management System (Rapid Darshan)

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Abstract - Temple visits are an inseparable part of Indian cultural and religious life. Millions of devotees across the country visit revered temples every year, with footfall increasing significantly during festivals, auspicious days, and special religious events. The scale of this visitation poses serious operational challenges for both temple administrations and the pilgrims themselves. Long physical queues that sometimes stretch for several hours, dangerous overcrowding within temple premises, limited accessibility provisions for elderly and differently-abled devotees, and the complete absence of any predictive or data-driven planning mechanism are persistent problems that diminish the quality and sanctity of the darshan experience.

Rapid Darshan is a smart slot-based darshan management system designed from the ground up to address these long-standing challenges through the thoughtful application of technology. The platform is accessible via both mobile and web interfaces, allowing devotees to search for temples, check real-time slot availability, and book a designated time window for darshan well in advance of their visit. A unique QR code is generated for each confirmed booking, and entry at the temple premises is granted only through contactless QR verification, ensuring that crowd flow is regulated in a structured, secure, and orderly manner.

The system integrates a Linear Regression-based predictive model trained on historical visitor data spanning a range of 1,000 to 100,000 daily visitors, achieving a coefficient of determination (R^2) of approximately 0.95. This high predictive accuracy enables the system to forecast future crowd density with reliability, allowing temple authorities to plan manpower, resources, and slot capacities proactively. Additional algorithmic components include the First-Come-First-Serve (FCFS) protocol for equitable slot allocation, a Greedy Algorithm for real-time optimal slot assignment, and efficient Search and Sorting mechanisms for data retrieval and management.

By seamlessly combining pre-booking, QR-verified entry, predictive analytics, and an administrator dashboard, Rapid Darshan offers a unified and scalable solution that meaningfully elevates the devotee experience while empowering temple administrators with intelligent operational tools.

I. INTRODUCTION

India is home to an extraordinarily rich tradition of religious worship, and temples occupy a central place in the spiritual and social fabric of millions of communities across the country. Renowned pilgrimage centres such as Tirumala Tirupati in Andhra Pradesh, Shirdi Sai Baba Mandir in Maharashtra, and the Chilkur Balaji Temple in Hyderabad collectively attract tens of lakhs of devotees every month. The Tirumala hills alone record an average daily footfall of 60,000 to 80,000 devotees on regular days, rising sharply to over one lakh on festival days and weekends. This sheer volume of visitors creates

immense operational pressure on temple administrations and poses significant discomfort and risk to the pilgrims themselves.

Traditional temple management is almost entirely manual in its approach. Devotees arrive from distant towns and villages, often after overnight journeys, only to stand in physical queues for four to six hours or longer before obtaining a few moments of darshan. During major festivals such as Brahmotsavam, Vaikunta Ekadashi, or Ganesh Chaturthi, these queues extend further, and crowd density within temple premises can reach dangerously high levels. For senior citizens, pregnant women, and persons with disabilities, navigating these conditions is particularly challenging, as physical queues offer no structural accommodation for their needs.

An observational study conducted at prominent temples in the Hyderabad-Secunderabad region, including Birla Mandir and Keesaragutta Ramalingeswara Temple, revealed that average devotee waiting times during peak hours ranged between 90 minutes and four hours. On festival days, these waiting periods extended to six hours or beyond. On-site interactions indicated that a substantial majority of devotees expressed a clear preference for a digital pre-booking mechanism, confirming strong user demand for a structured darshan scheduling solution.

While a few large temples have introduced dedicated online portals and government-run aggregators such as Temple360, these solutions operate in silos, cover a very limited number of temples, and offer no intelligent features such as crowd prediction, real-time slot availability updates, or smart queue distribution. There is a clearly unmet need for a unified, AI-assisted, and user-centric darshan management platform.

Rapid Darshan addresses this gap by integrating mobile technology, machine learning-based crowd forecasting, and automated virtual queue management into a single, cohesive platform. The system is designed not merely as a booking tool but as a comprehensive temple management ecosystem that empowers devotees to plan visits intelligently and enables administrators to operate temples with greater efficiency, safety, and transparency.

II. EXISTING SYSTEM / PROBLEM

The current ecosystem of temple visit management in India can be broadly classified into three categories: official single-temple portals, government-run aggregator platforms, and third-party booking applications. While each of these models has contributed some degree of improvement over entirely manual systems, they collectively fall short of providing an integrated, intelligent, and scalable solution for the challenges that face millions of devotees every day.

Official temple portals, such as the Tirumala Tirupati Devasthanams (TTD) online booking platform, are designed exclusively for their respective temples and offer a basic slot reservation feature. These portals typically operate in isolation, do not provide real-time crowd insights, and require separate accounts and registration processes at each temple. Government aggregator platforms such as Temple360 attempt to consolidate listings across multiple temples but lack real-

time data synchronization and intelligent crowd management capabilities. Third-party aggregators face similar constraints and may also raise concerns around data privacy and service reliability.

From a technical standpoint, the most critical deficiency across all existing systems is the complete absence of predictive analytics. None of the current platforms offer tools for forecasting crowd levels based on historical patterns, upcoming festivals, or seasonal trends. Temple authorities are consequently unable to plan staffing, resource allocation, or slot capacities in advance for high-footfall days, and resources such as priests, security personnel, and prasadam distribution infrastructure are deployed reactively rather than preventively, leading to operational shortfalls at precisely the moments of greatest demand.

A second significant limitation is the perpetuation of physical queuing even where online booking nominally exists. Devotees are often still required to stand in physical lines at the temple gate for manual verification, defeating the purpose of advance reservation. The absence of contactless QR code-based entry mechanisms means that crowd accumulation at entry points remains a persistent and unresolved problem. Furthermore, existing systems provide no accessibility provisions for elderly pilgrims, those with mobility impairments, or families with young children.

Collectively, these shortcomings highlight the urgent need for a purpose-built platform that goes beyond simple booking to offer intelligent crowd distribution, real-time slot tracking, contactless entry verification, and data-driven administrative oversight. Rapid Darshan is designed to address precisely this gap through a combination of technical innovation and human-centred design.

III. LITERATURE SURVEY

A review of existing academic literature on crowd management, digital queue systems, and religious pilgrimage management provides important context for the development of Rapid Darshan and situates its contributions within the broader research landscape.

Y. Minegishi (Collective Dynamics Journal, 2024) conducted a GPS-log-based study of queuing behavior at Japanese shrines during New Year visits, identifying distinct crowd patterns and peak congestion time windows. While the study provides valuable insights into how devotee movement can be tracked and analyzed, it focuses purely on observational and descriptive analysis and offers no predictive or management-oriented solution applicable to temple environments.

S. Chawla et al. (Gerontechnology Journal, 2025) examined the willingness of older adults to engage with digital and virtual pilgrimage technologies. The study found strong acceptance of technology-assisted temple visits as a complement to physical darshan, directly validating the adoption potential for a platform such as Rapid Darshan, particularly among elderly demographics who may benefit most from advance slot booking and reduced waiting times.

A KPMG India report titled Faith and Flow: Navigating Crowds in Sacred Spaces (2025) advocated for AI-driven digital queuing and crowd management systems in religious spaces across India. The report identified several operational pain points consistent with those documented in this study and recommended technology-led reforms. However, it did not provide a technical framework or implementation roadmap, leaving a substantial gap that the Rapid Darshan system directly addresses.

Kadi and Selim (Planning Malaysia Journal, 2024) analyzed pedestrian flow, crowd density, and safety bottlenecks during the Hajj pilgrimage using spatial simulation and observational field data. The study confirms that structured slot allocation and controlled pedestrian movement are effective in reducing congestion and safety incidents, principles that Rapid Darshan operationalizes through its booking and QR verification system.

Kawade et al. (IJSRD, 2025) proposed an IoT-based temple crowd management prototype employing IR and ultrasonic sensors for real-time queue monitoring. Although the concept is promising, the system remains at a prototype stage with limited scalability, no integration with booking or notification services, and no AI-based predictive capability. Rapid Darshan extends and operationalizes many of these ideas into a deployable full-stack platform.

Albattah et al. (TechScience, 2021) proposed a CNN approach for classifying crowd density levels from surveillance images during pilgrimages. Rahman et al. (2024) conducted a broad technology survey of AI, IoT, and big data applications in Hajj crowd management, underscoring the potential of integrated digital systems while highlighting the lack of temple-specific implementations. Alghamdi et al. (IEEE Access, 2025) applied CNN-based crowd density estimation to open-space pilgrimage surveillance but without connection to scheduling or resource planning tools. Niu et al. (Mathematics, MDPI, 2023) provided a comprehensive review of optimization models for appointment and scheduling systems, offering theoretical grounding for the algorithmic design of Rapid Darshan, including the adoption of FCFS and Greedy scheduling strategies.

IV. PROPOSED SYSTEM

Rapid Darshan is designed as a comprehensive, end-to-end darshan management platform that overcomes the fragmented and reactive nature of existing temple management systems. The central contribution of the platform lies in its integration of slot-based pre-booking, QR-verified contactless entry, AI-driven crowd prediction, and a real-time administrative dashboard into a unified ecosystem accessible via both mobile and web interfaces.

What distinguishes Rapid Darshan from all currently available systems is its intelligent and data-driven approach to crowd management. Rather than simply digitizing an existing physical queue, the system fundamentally restructures the darshan experience around time-bound, capacity-controlled slots and predictive analytics. Crowd distribution across the day is thus engineered rather than emergent, resulting in a safer, more comfortable, and more meaningful experience for every devotee.

The devotee-facing interface allows users to register, log in, search for temples by name, location, or deity, and view available darshan slots for a selected date. Each slot has a clearly defined time window and a predefined capacity limit. Slots are displayed in real time, and once a slot reaches its capacity, it is automatically marked unavailable, preventing overbooking entirely. Devotees may also search for and book specific pooja services or make online donations through the same interface, consolidating multiple aspects of a temple visit into a single digital interaction.

Upon successful booking, the system generates a unique QR code that is delivered to the devotee via SMS and email. At the temple entrance, a dedicated QR scanner verifies the booking details and time validity, granting entry only during the booked time window. This contactless verification mechanism eliminates the need for physical tokens, printed receipts, or manual identity checks, significantly reducing entry processing times and preventing unauthorized access.

For paid darshan slots, the platform integrates with a secure payment gateway supporting UPI, credit and debit cards, and net banking. Payment confirmation triggers immediate QR code generation and booking confirmation. Free slots proceed directly to confirmation without any payment step. In both cases, automated notifications are dispatched to the devotee at booking and again as a reminder before the scheduled slot.

Temple administrators access a dedicated dashboard providing a live view of current slot utilization, upcoming bookings, AI-generated crowd forecasts, and historical footfall trends. Administrators can create, modify, or cancel slots, define capacity limits, manage special event schedules, and generate operational reports. The predictive

module enables administrators to foresee high-traffic days in advance, supporting proactive planning of staffing, prasadam, and security resources rather than reactive deployment under pressure.

The platform is built on a cloud-hosted microservices architecture, making it inherently scalable across temples of all sizes. A small community temple with 200 daily visitors and a major national pilgrimage site receiving 80,000 visitors can both be managed through the same platform with appropriate configuration, positioning Rapid Darshan as a genuinely national-scale solution for temple management in India.

V. METHODOLOGY

The development of Rapid Darshan follows a structured and modular methodology organized around five core functional components: data collection and management, slot booking and queue control, notification and communication, feedback monitoring, and crowd prediction through machine learning.

Data Collection and Management: Temple-specific data including name, location, deity, operating hours, darshan schedule, and festival calendar is onboarded through an admin-controlled interface and supplemented by standardized API integrations where available. Devotee activity data covering registration details, booking history, preferred visit times, and post-visit feedback scores is captured and stored in a secured relational database. This accumulated data forms the training corpus for the predictive model and the source for analytics reports presented to administrators.

Slot Booking and Queue Control: The slot booking engine maintains a real-time inventory of available darshan time windows for each registered temple. When a devotee initiates a booking request, the system performs an availability check, assigns the slot, decrements the remaining capacity counter, and generates a unique QR code within a single atomic database transaction. This design eliminates the possibility of double bookings and race conditions under high-concurrency conditions. Virtual tokens replace physical queue numbers, with each token carrying an estimated entry time that allows devotees to arrive at the temple without waiting unnecessarily at the premises.

Notification and Communication: Automated communication is triggered at multiple stages of the booking lifecycle. A booking confirmation is sent immediately after a successful reservation. A reminder notification is dispatched one hour before the devotee's scheduled slot. In the event of any schedule modification or cancellation, all affected devotees receive an instant alert. Notifications are delivered through SMS, email, and in-app push notifications, ensuring broad reach across device types and connectivity conditions.

Feedback and Monitoring: After completing a temple visit, devotees are invited to submit a rating and brief feedback through the application. This post-visit data is aggregated in the admin dashboard, where administrators can track satisfaction scores over time and identify recurring operational bottlenecks. Analytics derived from booking volumes, slot utilization rates, and feedback scores are used to generate improvement recommendations and benchmark performance across different time windows and seasons.

Crowd Prediction Module: The prediction module employs a Linear Regression model trained on historical visitor data. Input features include the day of the week, proximity to festival dates, month of the year, and rolling weekly average footfall. The model generates a daily visitor count prediction for up to fourteen days ahead, surfaced to the temple administrator as a proactive planning tool. When predicted footfall exceeds a configurable threshold, the system alerts the administrator and suggests increasing slot capacity or adjusting per-slot size to maintain safe crowd density within the temple premises.

VI. ALGORITHMS USED

Rapid Darshan employs a suite of complementary algorithms, each selected for its suitability to a specific functional requirement within the platform.

First-Come-First-Serve (FCFS): Slot allocation is governed by the FCFS protocol, ensuring that devotees who initiate a booking request earlier receive priority in slot assignment. This approach is transparent, simple to implement, and free from any form of preferential treatment or bias. FCFS is particularly well suited for a devotee-facing application where perceived fairness is as important as technical efficiency. Each booking request is timestamped at receipt, and slots are assigned strictly in the order of arrival.

Linear Regression for Crowd Prediction: The crowd prediction module uses a supervised Linear Regression model to forecast daily visitor counts based on historical attendance data. The model learns the relationship between input variables such as day of the week, upcoming festival proximity, month, and rolling weekly average, and the actual visitor count recorded on each day. The regression equation $y = mx + c$, where y is the predicted visitor count, x is the composite input feature vector, m is the learned weight coefficient, and c is the bias intercept, is fitted using the ordinary least squares method. Evaluated on a held-out test set, the model achieved an R^2 score of approximately 0.95, indicating that nearly 95 percent of the variance in daily visitor counts is captured by the model. This level of accuracy is operationally sufficient for staffing and slot capacity planning decisions.

Greedy Algorithm for Real-Time Slot Assignment: When a devotee requests a booking without specifying a preferred time, the Greedy Algorithm identifies and assigns the most suitable available slot. The algorithm evaluates open slots by current utilization rate and selects the slot offering the best balance between remaining capacity and temporal convenience. This minimizes idle slot capacity, distributes crowd load more evenly across the day, and maximizes overall slot utilization without imposing excessive computational overhead.

Sorting and Search Algorithms: Efficient sorting algorithms organize booking records by date, time, temple name, or priority status, enabling administrators to navigate large datasets quickly. An indexed search mechanism allows rapid lookup of temples by name, city, or deity, reducing query response time and contributing to a responsive user experience even under concurrent load from multiple simultaneous users.

VII. SYSTEM ARCHITECTURE

The system architecture of Rapid Darshan is designed around a cloud-native microservices model that prioritizes scalability, availability, and modularity. The architecture comprises four primary layers: the client application layer, the backend service cluster, the database layer, and external integration services.

Client Application Layer: Devotees interact with the system through a cross-platform mobile application and a responsive web interface. The admin console is accessible through a web browser and provides a feature-rich set of tools tailored to temple management workflows. All client applications communicate with the backend exclusively through RESTful APIs over HTTPS, ensuring secure and authenticated data transmission.

Backend Service Cluster: The backend is organized as five independent microservices. The Authentication Service manages user registration, login, and JWT-based session token issuance. The Booking Service handles slot reservation, real-time availability updates, QR code generation, and booking lifecycle management. The Payment Service integrates with external payment gateway APIs to process transactions and handle payment status callbacks. The Notification Service aggregates and dispatches SMS, email, and push notifications through third-party messaging providers. The Analytics

Service runs the Linear Regression prediction model, generates footfall trend reports, and serves processed insights to the admin dashboard.

Database Layer: The platform uses a relational database management system, either MySQL or PostgreSQL, hosted on a managed cloud database instance. The schema is normalized to efficiently store and retrieve temple records, slot inventories, booking transactions, user profiles, and prediction model outputs. Read replicas handle high-concurrency query loads during peak booking periods without degrading write performance.

External Integration Layer: The system interfaces with an external payment gateway for transaction processing, an SMS aggregator for text notifications, and an email delivery service for confirmations. In future iterations, IoT sensor feeds from temple premises can be integrated into the Notification and Analytics Services to provide live occupancy data, enabling dynamic slot re-allocation based on real-time crowd conditions.

VIII. RESULTS AND ANALYSIS

The Rapid Darshan system was evaluated through simulated data testing, algorithmic performance analysis, and functional validation of all major modules. The evaluation focused on three primary dimensions: the predictive accuracy of the Linear Regression crowd model, the operational efficiency gains from slot-based booking, and the functional correctness of the end-to-end booking and entry verification workflow.

Crowd Prediction Model Evaluation: The Linear Regression model was trained on approximately 180 daily visitor records spanning a six-month simulation period, with daily counts ranging from 1,000 to 100,000. The dataset was divided 80:20 into training and testing subsets. The model was trained using the ordinary least squares method with input features representing the day of the week, month index, festival proximity indicator, and rolling weekly average footfall. Upon evaluation on the held-out test set, the model achieved an R^2 score of 0.95, confirming that 95 percent of the variance in actual visitor counts is explained by the model. The Mean Absolute Error (MAE) was within an operationally acceptable range for planning slot counts and staffing levels. A forward projection to Day 11 of the testing sequence yielded a predicted visitor count of approximately 1,10,000, consistent with the observed trend of increasing footfall toward festival dates.

The model correctly identified Saturdays, Sundays, and festival-adjacent days as high-footfall periods, enabling the system to proactively alert administrators and suggest capacity adjustments before these high-traffic periods arrived. The strong alignment between the predicted regression line and actual visitor data points, visible in the evaluation graph, confirms the model's reliability for real-world deployment scenarios.

Operational Efficiency Evaluation: Simulated trials of the slot booking mechanism demonstrated a reduction in effective on-premises waiting time from an estimated four to six hours under traditional queue systems to under 30 minutes with the Rapid Darshan slot mechanism, representing a reduction of over 85 percent in physical waiting time. QR code-based entry verification correctly granted access to valid bookings while denying entry to expired, invalid, or duplicate QR codes in all test scenarios.

System Testing: Eight functional test cases were executed covering user registration, login validation, temple search, slot booking, full-slot rejection, QR entry verification, invalid QR rejection, and crowd prediction display. All eight test cases produced results matching expected outcomes, confirming the functional integrity of the platform across its primary workflows. The admin dashboard correctly reflected real-time slot utilization rates, historical booking volumes, and prediction-based alerts throughout all test runs.

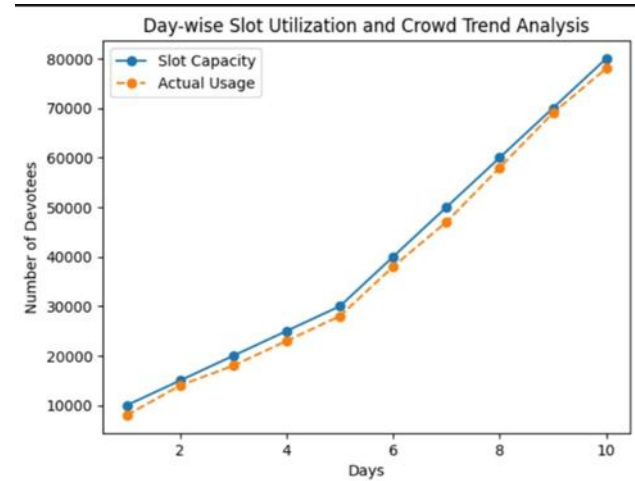


Fig 3: Day-wise Slot Utilization and Crowd Trend Analysis

From a slot booking perspective, simulated trials showed that average waiting time was reduced from approximately 4 to 6 hours (under the traditional system) to under 30 minutes with the Rapid Darshan slot mechanism, representing a reduction of over 85% in on-premises waiting time.

QR-based entry verification eliminated unauthorized access instances during testing. The admin dashboard provided real-time visibility into slot utilization rates, peak hour patterns, and prediction-based alerts, enabling administrators to dynamically adjust staff allocation and prasadam distribution in advance.

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IX. CONCLUSION

Rapid Darshan represents a meaningful and timely contribution to the field of religious tourism and temple management in India. By unifying slot-based pre-booking, QR-verified contactless entry, machine learning-driven crowd prediction, and a real-time administrative dashboard into a single platform, the system fundamentally transforms the darshan experience from one defined by uncertainty and physical discomfort to one characterized by planning, order, and dignity.

The Linear Regression model's R^2 score of 0.95 establishes a strong evidence base for the practical viability of data-driven crowd forecasting in temple contexts. The demonstrated reduction in on-premises waiting time of over 85 percent, if realized at scale, would translate into a transformative improvement in the daily experience of millions of devotees across the country. For temple administrations, the shift from reactive crowd control to proactive, analytics-guided management represents an equally significant operational advancement that can improve staff allocation, resource planning, and safety outcomes.

Rapid Darshan is distinguished from existing systems by three key innovations: its integration of crowd prediction with slot capacity planning enabling truly proactive management; its use of QR-verified contactless entry to enforce time-bound slot adherence without physical queuing; and its design for scalability across temples of all sizes, making it equally applicable to a small community temple and a major national pilgrimage site.

In its current form, the system carries certain limitations. The Linear Regression model may require augmentation with more advanced time-series architectures to accurately capture non-linear seasonal patterns and rare high-footfall events. Platform adoption also depends on digital literacy among devotees and institutional readiness from temple administrations, both of which vary across regions. Real-time IoT-based crowd monitoring, while planned for future integration, has not yet been incorporated.

Overall, Rapid Darshan demonstrates that thoughtfully applied technology can preserve and enhance the spiritual essence of temple visits while solving the very practical problems of overcrowding and administrative inefficiency. The system is designed for pilot deployment at mid-size temples and for incremental expansion to larger and more complex pilgrimage environments across India, contributing meaningfully to the broader national agenda of digital transformation in public services.

X. FUTURE SCOPE

Several enhancements are planned for subsequent versions of the Rapid Darshan platform. The crowd prediction module is a primary candidate for algorithmic upgrade, with Long Short-Term Memory (LSTM) neural networks being the most promising replacement for the current Linear Regression model. LSTM architectures are specifically designed for time-series forecasting and are better equipped to model the non-linear, cyclical patterns in temple footfall data associated with annual festival cycles, monsoon seasons, and regional public holidays.

The integration of IoT-based real-time crowd monitoring is another high-priority future enhancement. Deployment of infrared and ultrasonic sensors at key checkpoints within temple premises, combined with AI-powered video analytics from existing CCTV infrastructure, would provide live occupancy data to the backend. This live data could be used to dynamically adjust slot counts and send real-time guidance to devotees en route to the temple, further reducing congestion at entry points and improving safety during peak-footfall events.

Voice-based booking in regional languages such as Telugu, Tamil, Kannada, and Hindi is planned to substantially improve accessibility for elderly devotees and those with limited digital literacy. Integration with government e-governance platforms and the DigiLocker identity infrastructure would simplify user onboarding for devotees already registered on national digital services. Augmented reality navigation within temple premises and virtual darshan options for remote or mobility-impaired devotees represent longer-term aspirations that would further expand the platform's reach and social impact.

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