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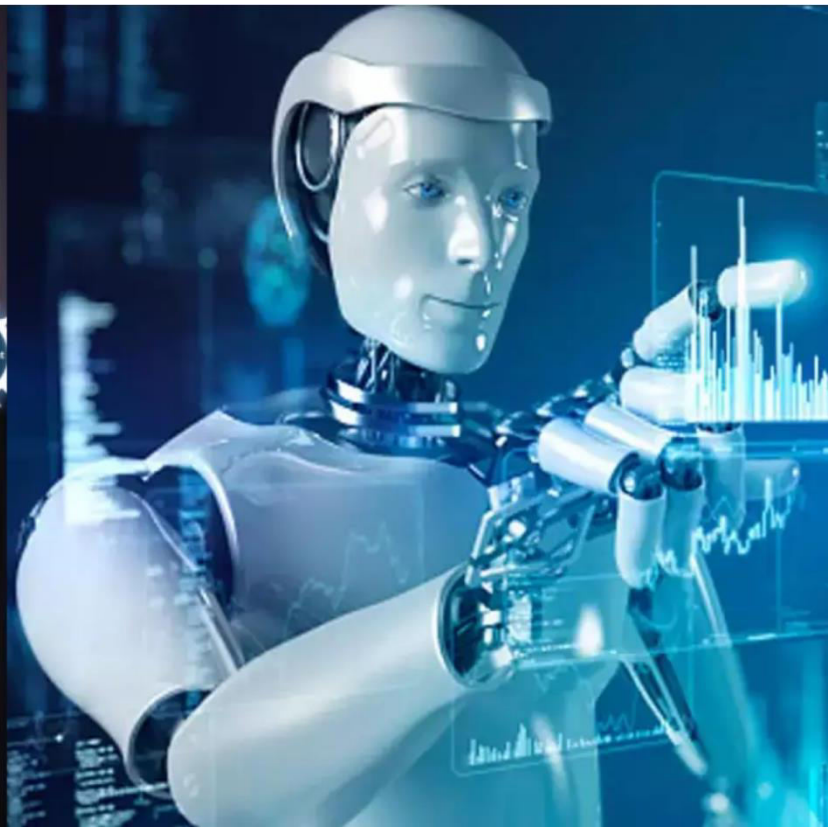
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College Chatbot and Leave Management System: Integrating an NLP Chatbot with IoT Health-Supported Leave Processing

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ABSTRACT: Colleges often distribute information and process student leave through separate channels such as notice boards, e-mail and paper forms, which causes delays and inconsistent records. This paper presents the College Chatbot and Leave Management System, an integrated web-based platform that combines a natural-language-processing (NLP) campus information chatbot with a health-aware leave-management workflow. A Raspberry Pi 4 Model B acquires body temperature (DS18B20), pulse rate and blood oxygen saturation (MAX30100) and forwards timestamped readings to a Python Flask backend. The backend coordinates authentication, information retrieval, optical character recognition (OCR) of medical certificates, rule-based evaluation, database operations and notifications. Requests are approved, rejected or routed for manual review under configurable institutional rules, and missing, unreadable or conflicting data is always escalated to a human reviewer. Sensor readings serve only as supporting administrative evidence and are not a medical diagnosis. The paper describes the architecture, hardware interfaces, software modules, exception handling, privacy safeguards and a test plan. The work is a proposed design; quantitative evaluation is left to future testing.

KEYWORDS: chatbot, Flask, Internet of Things, leave management, MAX30100, natural language processing, OCR, Raspberry Pi, smart campus.

I. INTRODUCTION

Colleges communicate with students, parents, faculty and administrators through notice boards, e-mail, websites and office visits. Because these channels are scattered, users often have to search several places or wait for staff to answer routine questions. Leave administration has a similar problem: paper or basic online forms must be checked manually, medical documents arrive in different formats, and submission, review, approval and notification are tracked in separate records.

This paper presents the College Chatbot and Leave Management System, a proposed web-based platform that treats these two needs as one service. Its first part is a chatbot that interprets natural-language questions and returns approved institutional information such as department details, faculty information, circulars, announcements and events. Its second part is a leave-management workflow in which a student submits a form and a medical certificate, and a Raspberry Pi 4–based unit contributes temperature, pulse-rate and SpO_2 readings as supporting evidence. A shared Flask backend and database keep the chatbot, document processing, sensor ingestion and leave evaluation as modular services.

The main contributions are: (i) an integrated architecture that combines conversational access and leave management; (ii) a low-cost IoT acquisition path from sensors to the backend, with explicit handling of missing data; (iii) an auditable, rule-based decision flow with a mandatory manual-review path for uncertain cases; and (iv) a privacy-aware design with a test plan. The system is an administrative support tool and not a medical diagnostic device.

The remainder of this paper is organized as follows. Section II reviews related work, Section III defines the problem and requirements, Sections IV–VII describe the architecture, hardware, software and leave workflow, Sections VIII–IX

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cover privacy, limitations and the validation plan, and Sections X–XII discuss applications, future work and conclusions.

II. RELATED WORK

Educational chatbots serve as interfaces for frequently asked questions and consistent information delivery [1], [2]. Their usefulness depends on a defined knowledge base, sound language handling and clear behavior when an answer is unknown, so a campus assistant should rely on verified content rather than fabricate answers [3]. Web-based administrative systems centralize forms, records and status tracking; a backend framework such as Flask [4] connects browser interfaces [5] with business logic and storage, and a layered design improves maintainability.

IoT prototypes connect sensors to a controller and send measurements to a server. The Raspberry Pi [6] supports GPIO, I²C and network connectivity for such demonstrations involving temperature and pulse-oximetry sensors, but accuracy depends on sensor specification, placement, calibration, skin tone and operating conditions [7]–[9]. OCR [10] can extract fields from certificate images and reduce manual re-entry, yet it can fail on low-resolution, skewed or handwritten documents, so a human review path is retained.

Rule-based decision support is explainable and routes requests consistently when rules are documented, although it becomes brittle if thresholds are poorly chosen. In this work, rules classify and route requests; they do not draw medical conclusions. Systems that store personal and health-related records also require access control, secure transport, limited retention and audit logging [11]. The present project addresses the practical gap between a campus information assistant and an administrative leave workflow by using a common backend, a shared database and a connected health-monitoring subsystem, instead of treating them as disconnected tools.

III. PROBLEM STATEMENT AND REQUIREMENTS

A. Problem Definition

The core problem is the absence of an integrated, transparent and efficient campus service that combines interactive information retrieval with structured leave management supported by documents, health data and administrative review. Existing channels are largely one-directional and do not adapt to the wording of a user's question, and manual checking of leave submissions causes delays and inconsistent record keeping.

A. Functional Requirements

The system shall support (1) sign-in with institution-approved credentials and a role; (2) natural-language questions with retrieval of approved content or a safe fallback; (3) leave submission with dates, reason and a supporting certificate where policy requires it; (4) health capture with timestamps, marking readings unavailable when a sensor fails; (5) approval, rejection or manual review by authorized staff; and (6) notifications on status changes with delivery status preserved.

B. Non-Functional Requirements and Constraints

The interface should be responsive and understandable. The backend must validate input, enforce permissions, record important actions and use secure communication in deployment. Constraints include sensor quality and placement, OCR misreads on poor images, NLP errors on ambiguous questions, network failures, and institution-specific policies and thresholds, which require a configurable rule engine.

IV. SYSTEM ARCHITECTURE

Fig. 1 shows the architecture. Users interact through a responsive web interface built with HTML, CSS and JavaScript. The interface sends requests to a Flask backend, which handles authentication, role-based permissions and API requests, and calls the NLP, OCR and rules services as needed. All persistent data are held in a central database that is accessed only through the backend, so access control and business rules are applied consistently. The Raspberry Pi submits sensor readings to the backend through an API and has no direct database access.

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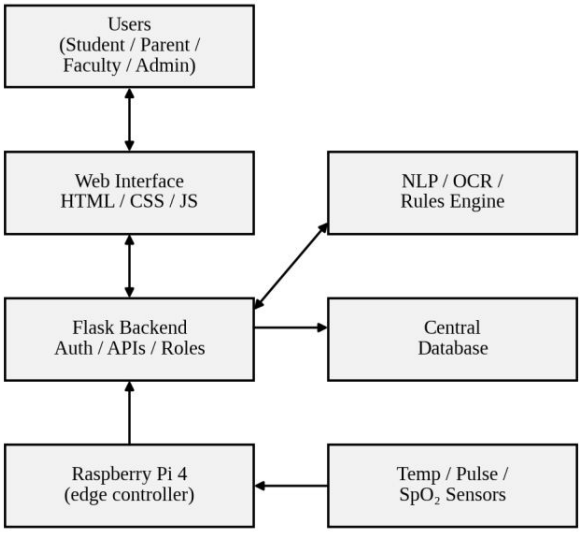


Fig.1.System architecture of the College Chatbot and Leave Management System.

Four user roles are supported. Students ask questions, submit leave applications and track progress. Parents may access permitted information and receive notifications. Faculty members view relevant requests and institutional updates. Administrators maintain records, configure rules and review exceptional cases. Each role sees only the information required for its responsibilities.

V. HARDWARE DESIGN

A. Edge Controller

A Raspberry Pi 4 Model B (4 GB) [6] is the edge controller. It provides GPIO, I²C, USB, a CSI camera connector and Wi-Fi or Ethernet connectivity, and is powered from a 5 V, 3 A USB-C supply. Python programs initialize the sensors, read measurements, attach timestamps, check for missing values and package readings for transmission, recovering from disconnections without creating duplicate or misleading records.

B. Temperature Sensor

The DS18B20 [8] is a digital thermometer on a 1-Wire bus; each device has a unique identifier. In the design, VCC connects to 3.3 V, GND to common ground and DQ to a Raspberry Pi GPIO pin with a pull-up arrangement. The source material lists an accuracy of about ±0.5°C over a specified range, which does not by itself establish suitability for clinical body-temperature measurement; packaging, contact method and calibration all affect results and must be verified.

C. Pulse and Oxygen Sensor

The MAX30100 [7] combines red and infrared LEDs with a photodetector and estimates pulse rate and SpO_2 using photoplethysmography (PPG). It communicates over I²C (SDA/SCL), and some breakout boards expose an interrupt pin. Supply voltage and logic-level compatibility depend on the breakout design and must be checked before wiring. Motion, poor contact, ambient light and perfusion degrade the signal, so software checks that readings are available and plausible.

D. Camera Module

An optional camera connects through the CSI ribbon interface, not the GPIO header, and captures an image of the medical certificate. The image is uploaded to the backend or secure storage, and OCR-extracted fields stay linked to the original image so that an authorized reviewer can verify them.

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TABLE I HARDWARE COMPONENTS AND INTERFACES

Component	Role	Interface / power
Raspberry Pi 4 Model B (4 GB)	Edge controller; runs acquisition scripts	GPIO, I²C, USB, CSI, Wi-Fi/Ethernet; 5 V, 3 A USB-C
DS18B20	Digital temperature sensing	1-Wire; 3.3 V with pull-up
MAX30100	Pulse rate and SpO_2 (PPG)	I²C; verify breakout voltage
Camera module	Certificate image capture	CSI ribbon cable

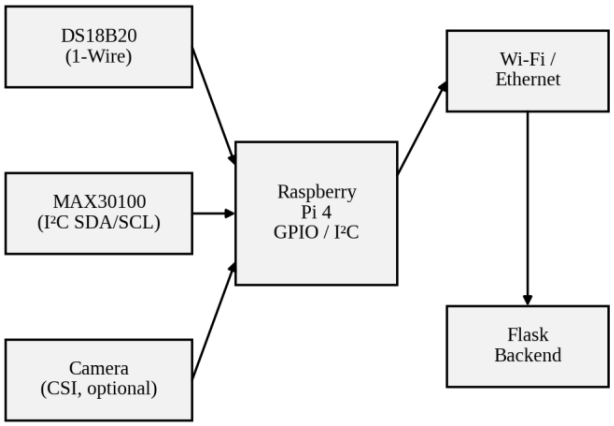


Fig.2. Simplified health-monitoring unit connection overview.

E. Data Path and Failure Handling

After acquisition, the Raspberry Pi validates a reading, attaches a timestamp and device identifier, and sends a structured message to the backend over HTTP [12] or MQTT [13] via Wi-Fi or Ethernet. The backend authenticates the device where configured, validates the payload and stores the reading against the appropriate leave record. If the network is unavailable, the device may queue a limited number of readings locally; delayed data are marked clearly and not treated as current. If a sensor is unavailable, the system records missing data rather than fabricating a value. Fig. 2 is a simplified connection overview and must be replaced by a pin-by-pin wiring diagram verified against the exact modules used.

VI. SOFTWARE DESIGN

A. Frontend and Backend

The frontend uses HTML for structure, CSS for responsive layout and JavaScript for chat interaction, client-side validation and asynchronous calls to Flask. Because browser validation can be bypassed, server-side validation is retained. Python Flask [4], [14] provides routing, login sessions, authorization checks, chatbot endpoints, leave operations and sensor-data ingestion. Decision rules are explicit, versioned and approved by the institution, and sensitive operations are logged.

B. NLP and OCR Services

The NLP component maps the wording of a question to an intent or information category (departments, faculty, circulars, announcements, events). The backend retrieves approved content and formats a concise answer; ambiguous or out-of-scope questions receive a clarification request or a safe fallback. Voice input and output can be added through speech-to-text and text-to-speech services. The OCR service extracts selected fields from certificate images. Critical fields are checked against the source image before influencing a decision, and readable text alone is never treated as proof of authenticity.

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C. Database

The database stores user roles, institutional content, leave records, certificate references, health readings, notifications and audit logs, and may hold attendance and academic-history data used by approved rules. Records carry stable identifiers and timestamps. A leave request references its applicant, certificate, readings, review status and notification history; readings are associated with a request only when appropriate and permitted. Backup, recovery and migration procedures protect backups with safeguards equivalent to live records.

VII. LEAVE WORKFLOW AND EXCEPTION HANDLING

The workflow in Fig. 3 begins when a user signs in and submits a request. The required details and a medical certificate are collected and, if the health unit is available, temperature, pulse and SpO_2 are captured. The backend validates the inputs. If mandatory information is missing, the user is asked to correct the submission; if a certificate is unreadable or information conflicts, the request is routed for manual review. A complete request proceeds to rule-based evaluation and may be approved, rejected or sent for review according to authorized rules. The system stores the decision with its time and notifies the student and the concerned faculty member. A notification failure does not erase the decision; the event is retained for retry or follow-up.

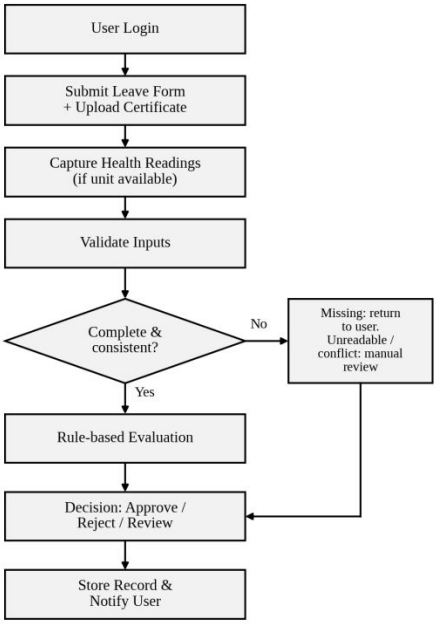


Fig.3.Leave application process flow.

Automated classification is a support function only. Institutional policy defines approval authority, and exceptional or medically uncertain cases are reviewed by an authorized person. Table II summarizes how the system handles abnormal conditions.

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TABLE II EXCEPTION HANDLING

Condition	System response
Missing certificate	Stop submission or mark incomplete per policy; tell the user what is missing.
Sensor unavailable	Mark readings unavailable or questionable; never treat missing data as evidence for or against a medical claim.
OCR uncertainty	Retain the source document and ask an authorized reviewer to confirm the details.
Conflicting records	Route to review when dates, certificate details, attendance or readings conflict; keep an audit trail of the conflict and its resolution.

VIII. PRIVACY, SECURITY AND LIMITATIONS

Health information is sensitive. The design collects only the data needed for the stated administrative purpose, enforces role-based access at every backend endpoint, protects data in transit and in storage, restricts certificates and readings to authorized reviewers, and defines retention, deletion, backup and recovery procedures. Administrative actions are logged without unnecessary sensitive content, notifications avoid medical details and direct users to the authenticated portal, and users are told what health data are collected and how they are used.

Several limitations apply. Sensor readings depend on hardware quality, placement and calibration, and are not clinically validated. OCR and NLP can misinterpret poor images or ambiguous questions. Decision thresholds vary between institutions and must be approved by the institution. A design description does not prove clinical accuracy, production reliability or institutional approval; medical judgement remains with qualified professionals, and sensor readings must not be the sole basis for refusing a request.

IX. VALIDATION PLAN

This paper describes a proposed architecture and does not claim measured performance. The following metrics are to be collected during testing rather than assumed: answer correctness on a prepared question set, time to submit and review a request, rate of incomplete submissions, success of sensor-data transmission, notification delivery and user feedback. Table III lists the planned test cases.

TABLE III PLANNED TEST CASES

ID	Test	Expected outcome
TC-01	Common campus question	Answer matches knowledge base
TC-02	Ambiguous question	Clarification or safe fallback
TC-03	Leave form with missing field	Validation error shown
TC-04	Upload clear certificate	Stored and linked to request
TC-05	Disconnect a sensor	Data reported as unavailable
TC-06	Disconnect the network	Error handled; recovery on reconnect
TC-07	Unauthorized role opens restricted record	Access denied
TC-08	Change request status	Audit and notification events recorded

X. APPLICATIONS

The platform can act as a campus help desk that answers routine questions about departments, faculty, circulars, events and services outside office hours, and as a common channel through which students and parents find approved updates. It supports digital leave submission with visible status (pending, approved, rejected or under review). Department offices can maintain faculty details, schedules and circulars, and dashboards can summarize request volumes, pending reviews and missing documentation without exposing unnecessary health details. The architecture could later be

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adapted for hostels, student-support offices and campus clinics, each requiring its own access rules and data governance. Deployment requires institutional approval, user training, privacy safeguards, sensor testing and a clear manual fallback.

XI. FUTURE WORK

The knowledge base can be extended to timetables, examination notices and student-support processes, with content owners assigned to each category. Multilingual NLP and speech services could improve accessibility, provided users can review important submitted information. Advanced document analysis could detect missing fields, duplicate submissions or mismatched dates, and should be evaluated on representative documents before deployment. Analytics dashboards and integration with attendance, timetable, examination and hostel systems could reduce duplicate entry, subject to permission and privacy review.

XII. CONCLUSION

The College Chatbot and Leave Management System combines conversational access to institutional information with a health-aware leave-management workflow in one campus platform. The proposed architecture uses an HTML/CSS/JavaScript frontend, a Python Flask backend, a central database, NLP and OCR services, and a Raspberry Pi unit for temperature, pulse and SpO_2 acquisition. Its modular structure, explicit exception handling and mandatory human-review path aim to reduce repetitive work, improve visibility of leave status and support consistent administration. Benefits depend on accurate content, reliable hardware, secure data handling and clear policies. Sensor readings cannot replace professional medical assessment, and future work will focus on implementation, testing and recorded evaluation.

XIII. ACKNOWLEDGMENT

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