

PureCare Air Purifier

Jimmy MacDonald
dept. of Computer Science
Hanyang University
Seoul, South Korea
james.macdonald.1@slu.edu

Soobeen Yim
dept. of Information System
Hanyang University
Seoul, South Korea
s00been@hanyang.ac.kr

Minjin Kim
dept. of Information System
Hanyang University
Seoul, South Korea
idid02@hanyang.ac.kr

Yeonwoo Kim
dept. of Computer Science
Hanyang University
Seoul, South Korea
bbongvong@hanyang.ac.kr

Abstract—Air purifiers have become more and more common in people’s houses, but as houses gain more technology, it seems that air purifiers haven’t had any major improvements. We propose a smart air purifier which learns and adapts how it runs based on it’s users. Specifically, by monitoring and recognizing when users are sick, gaining insights about air quality outside as well as seasonal allergies, and smart scheduling on when to run the air purifier to minimize electricity usage. We are going to implement 3 models-cough detection, sniff detection, machine control. Respiratory diseases are air-sensitive, which means complicated factors, such as air quality-include dust, viruses, temperature, and humidity affect users. Our expanded goal is to implement total air care control.

Index Terms—Smart Air Purifier, AQI

TABLE I
ROLE ASSIGNMENTS

Roles	Name	Task description and etc.
User	Yim Soobin	Identifies user needs and improves product usability. Thinks of ideas, designs functions, and suggests practical ways to implement features that address real-world problems.
Customer	Jimmy MacDonald	Conducts competitive analysis and plans differentiation strategy. Examines competitor services, identifies market gaps, and designs UI elements that attract customers.
Software developer	Kim Yeonwoo	Converts requirements into functional software. Writes code, implements features, debugs programs, monitors performance, and ensures all components execute properly.
Development Manager	Kim Minjin	Manages overall development process and team coordination. Creates plans, assigns roles, monitors progress, manages schedules, and ensures smooth communication among team members.

I. INTRODUCTION

A. Motivation

As the world continues to industrialize, air quality has declined as a direct consequence. As harmful particulate matter such as PM_{2.5}, PM₁₀, and other volatile organic matter enter the atmosphere, residents find difficulty in breathing under these conditions. The World Health Organization (WHO), estimates that 99% of the global population breathes air that exceeds guidelines, leading to millions of premature deaths annually from various diseases [1].

Despite living in a technology-driven age, air purifiers have seemed to lack any significant advances, remaining more reactive than proactive. Modern air purifiers activate only once particles have been detected in the air, leaving users exposed to a harmful environment until the device responds. While this reactive approach provides some benefit, the delay between exposure and activation can lead to numerous audible health symptoms, such as sneezing or coughing, potentially interrupting important moments such as presentations or meeting. Furthermore, current air purifiers require human configuration and continue to run continuously regardless if anyone is home resulting in a waste of electricity.

We propose PureCare, a truly intelligent air purification system that acts as a proactive health assistant rather than a passive appliance. PureCare distinguishes itself through several key innovations: Audible Health Symptom Recognition technology that detects sneezing, coughing, and snoring to automatically adjust purification settings; geofencing capabilities that optimize operation based on occupancy; API integration with local air quality data to prepare for poor outdoor conditions; personalized care recommendations that learn individual sensitivities over time; and sleep mode optimization for nighttime respiratory issues. Unlike traditional purifiers that simply filter air, PureCare anticipates needs, provides gentle human-like notifications, and creates safer environments before problems arise.

B. Similar Products

A. LG PuriCare Objet Collection AI+ 360° Air Purifier

- Detects harmful gas and fumes from three major sick-building substances-formaldehyde ammonia, and volatile organic compounds (VOCs)-and automatically purifies the air according to gas type and pollution level.
- Detects ammonia, the main source of pet waste odors.
- Detects contaminants such as cooking fumes.
- "AI Customized Operation" learns and analyzes indoor air quality every hour. Using accumulated data, it identifies times when the air is clean, stops the purifier's fan, and dims the display to save energy.
- By autonomously analyzing air quality and adjusting operating intensity, it can reduce power consumption by up to 50 percent or more compared with the conventional AI mode, helping lower electricity costs.

B. SAMSUNG BESPOKE Cube Air Infinite Line

- Provides an AI-powered integrated personalized cleaning solution.
- "Customized Clean AI+" compares and learns indoor and outdoor air quality, and pre-cleans when deterioration is predicted.
- "AI Saving Mode" automatically adjusts airflow or stops the fan when indoor air improves, cutting energy use by up to 45
- "Customized Clean AI+" is certified with "AI+ Certification" by the Korea Standards Association.

C. SK Wellness Robot

- The Wellness Robot by SK Namoothix's brand, NAMUHX, removes harmful substances that enter during ventilation to maintain air quality. It also offers performance equivalent to six air purifiers. All of its air solution functions are controlled entirely by voice without touch, and through the AI control system, device monitoring and remote support for maintenance are provided, greatly enhancing user convenience.

II. REQUIREMENT ANALYSIS

A. App Installation and First Launch

1) FR-001: Application and First Launch:

A. Platform Availability

- 1) iOS Platform: Available on App Store for iOS 12.0+ (iPhone 6S and newer)
- 2) Android Platform: Available on Google Play Store for Android 10+ (Armv7 and ARM64 architectures)

B. First Launch Experience

- 1) Splash Screen: Displays application logo and version number for 1-2 seconds
- 2) Permission Requests: Camera (for QR scanning), Notifications (for device alerts), and optional Location (for weather recommendations)

B. Login/Sign Up

1) FR-002: User Authentication:

A. Welcome Screen

Displays after splash screen with application logo, tagline, and two buttons: "Login" and "Sign Up"

B. Login Screen

Contains email and password fields, "Remember me" checkbox, "Forgot Password?" link, and "Don't have an Account? Sign Up" link

C. Sign-up Flow

- 1) Page 1: Basic account information (Full Name, Email, Password, Confirm Password, Terms Agreement)
- 2) Page 2: Optional profile information (Phone, Profile Picture, DOB, Country)

C. Product Setup via QR Code

1) FR-003: Product Registration: Note: Only accessible after successful login/sign up

A. Access Points

- 1) Automatically shown to new users after login (if no devices registered)
- 2) "Add Device" button on Home Page
- 3) "+" button in navigation bar

B. Initial Screen for New Users

If user has zero registered devices, shows empty state with title "Connect your first device", description "Scan the QR code on your device to get started", "Scan QR Code" button, and "Enter serial number manually" link

C. QR Code Scanning Process

- 1) Camera Activation: Checks auth token validity. If invalid, redirects to login with message "Please login to register devices"
- 2) QR Detection and Validation: Scans QR code, validates against database, checks if device already registered. Error shown: "This device is registered to another account"
- 3) Device Linking: Links device to user account, stores User ID, Device Serial Number, Device Model, and Registration Timestamp

D. Product Information Confirmation

Displays product image, model name, serial number, and user's name with prompt "Register this device to {Name}'s account?" with confirm/cancel buttons

E. Registration Complete

Shows success message "Device registered successfully", sends email notification, offers "Go home" or "Add another device" options, then navigates to Home Page

D. Home Page

1) *FR-004: Home Page: Note: Only accessible after successful login/sign up*

A. Home Page Access

Displayed after successful login, device registration (first-time), or tapping "home" tab. Checks authentication on load—expired tokens redirect to Login

B. Home Page Layout

- 1) Header: User greeting "Welcome back {user}", current AQI conditions, notification bell, settings gear
- 2) Device List: Shows all registered devices or "No devices yet..." if empty. Each card displays Device Name, Model, Status, Last Active time, and Quick Action button. Includes "add device" floating action button

C. Device Status Synchronization

Loads device list from database, queries IoT server status, updates UI with real-time data, auto-refreshes every 30 seconds

D. Navigation Bar

The Home Page must include the bottom navigation bar as specified in FR-005, with the "Home" tab highlighted/active

E. Navigation Bar

1) *FR-005: Navigation Bar:*

A. Bottom Navigation Structure

Persistent across all main screens with three tabs arranged from left to right: Automation (clock icon), Home (house icon), Settings (Gear icon). When logged out, tapping any tab redirects to login

F. Automation Page

1) *FR-006: Automation: Note: Only accessible after successful login/sign up*

A. Routine Screen Sections

1) Screen Header

- i) *FR-RTS-1.0:* The screen must display a static title "Routines"
- ii) *FR-RTS-1.1:* Below the title must display a static helper text "Automate your Air Purifier by building Routines. For each Routine, schedule events with a start time and action for your selected devices."
- iii) *FR-RTS-1.2:* The header must contain an "Add" icon button (a + symbol) in the top-right corner.

2) Routine List

- i) *FR-RTS-2.0:* The system must fetch and display the user's routines
- ii) *FR-RTS-2.1:* If the list of routines exceeds the vertical viewport, the list must be vertically scrollable.
- iii) *FR-RTS-2.2:* Each routine in the list must be displayed as a distinct "Routine Card" (see FR-RTS-3.0).

3) Routine Card

- i) *FR-RTS-3.0:* Each Routine Card must display the user-defined name of the routine (e.g., "My Routine").
- ii) *FR-RTS-3.1:* The card must contain a visual summary of the routine's logic.
- iii) *FR-RTS-3.2:* The visual summary must display a chronological list of triggers (clock icons) aligned vertically.
- iv) *FR-RTS-3.3:* The visual summary must display a corresponding list of device actions (e.g., Air Purifier, Thermostat) to the right of the triggers.
- v) *FR-RTS-3.4:* A vertical connector line must visually link the triggers and actions, with nodes indicating each time/action pair.
- vi) *FR-RTS-3.5:* Device icons in the summary must visually represent their target state:
 - A) On/Active: Icon is illuminated (e.g., glowing, in color).
 - B) Off/Inactive: Icon is dim (e.g., greyed out).

4) Navigation

- i) *FR-ITS-4.0:* Tapping the "Add" icon (FR-RTS-1.2) must navigate the user to the "Create Routine" screen.
- ii) *FR-ITS-4.1:* Tapping on any existing "Routine Card" (FR-RTS-3.0) must navigate the user to the "Edit Routine" screen, pre-populated with that routine's data.
- iii) *FR-ITS-4.2:* The screen must display a "New Routine" card-style button below the list of existing routines.
- iv) *FR-ITS-4.3:* The "New Routine" button must display the text "New Routine" and an "Add" icon (+).
- v) *FR-ITS-4.4:* Tapping the "New Routine" button (FR-RTS-4.2) must navigate the user to the "Create Routine" screen (same action as FR-RTS-4.0).

5) Navigation Bar

- i) *FR-RTS-5.0:* The Automation Page must include the bottom navigation bar as specified in FR-005, with the "Automation" tab high-

lighted/active

G. Add Routine Screen

1) *FR-007: Add Routine Screen:*

A. Screen Header

- 1) *FR-RTA-1.0:* The screen must display a title "Custom Routine" centered at the top
- 2) *FR-RTA-1.1:* The header must contain a "Back" icon button (← arrow) in the top-left corner. When clicked, if the user has unsaved changes, a dialog must warn the user about unsaved changes with options to "Discard" or "Keep Editing"
- 3) *FR-RTA-1.2:* The header must contain a "Delete" icon button (trash bin icon) in the top-right corner. When clicked, a confirmation dialog must appear with "Delete Routine?" message and "Cancel"/"Delete" options

B. Routine Name Section

- 1) *FR-RTA-2.0:* Below the header, the screen must display an editable routine name field with default text "[Time] Routine" (e.g., "10:49 AM Routine")
- 2) *FR-RTA-2.1:* An edit icon (pencil) must appear next to the routine name to indicate editability
- 3) *FR-RTA-2.2:* Tapping the routine name or edit icon must open an inline text input or modal for editing
- 4) *FR-RTA-2.3:* A toggle switch must appear on the right side of the routine name to enable/disable the entire routine
- 5) *FR-RTA-2.4:* The toggle switch must be green when enabled and gray when disabled

C. Day Selection Section

- 1) *FR-RTA-3.0:* A "When" label must be displayed above the day selection buttons
- 2) *FR-RTA-3.1:* Seven day buttons must be displayed in a horizontal row: S, M, T, W, TH, F, SA
- 3) *FR-RTA-3.2:* Each day button must be a rounded square with uniform size and spacing
- 4) *FR-RTA-3.3:* Selected days must have white background; unselected days must have dark/transparent background
- 5) *FR-RTA-3.4:* Multiple days can be selected simultaneously
- 6) *FR-RTA-3.5:* At least one day must be selected for the routine to be valid
- 7) *FR-RTA-3.6:* Tapping a selected day must deselect it; tapping an unselected day must select it

D. Events Section

- 1) *FR-RTA-4.0:* An "Events" label must be displayed as a section header

- 2) *FR-RTA-4.1:* A copy/duplicate icon must appear in the top-right corner of the Events section to duplicate the entire routine
- 3) *FR-RTA-4.2:* The section must display a scrollable list of event cards
- 4) *FR-RTA-4.3:* Each event must be contained in a distinct card with rounded corners and dark background

E. Event Card Structure

- 1) *FR-RTA-5.0:* Each event card must display a colored gradient icon on the left (unique color per event)
- 2) *FR-RTA-5.1:* The icon must contain a clock symbol to indicate time-based triggering
- 3) *FR-RTA-5.2:* Event cards must display the event name (e.g., "Untitled Event 65011")
- 4) *FR-RTA-5.3:* The second line must show the action state (ON/OFF), time in 24-hour format, and action type (e.g., "Set Scene")
- 5) *FR-RTA-5.4:* Format must be: "[STATE], [TIME], [ACTION]" (e.g., "ON, 18:00, Set Scene")
- 6) *FR-RTA-5.5:* A chevron (>) must appear on the right side of each card to indicate it's tappable
- 7) *FR-RTA-5.6:* Tapping an event card must navigate to the event detail/edit screen
- 8) *FR-RTA-5.7:* Event cards must support swipe gestures for quick delete actions

F. New Event Button

- 1) *FR-RTA-6.0:* A "New Event" button must appear at the bottom of the events list
- 2) *FR-RTA-6.1:* The button must have a "+" icon on the right side
- 3) *FR-RTA-6.2:* Tapping "New Event" must navigate to the event creation screen
- 4) *FR-RTA-6.3:* The button must maintain consistent styling with other UI elements (dark background, light text)

G. Event Ordering and Management

- 1) *FR-RTA-7.0:* Events must be automatically sorted chronologically by their trigger time
- 2) *FR-RTA-7.1:* Users must be able to reorder events via drag-and-drop (long-press and drag)
- 3) *FR-RTA-7.2:* A maximum of 20 events per routine must be enforced
- 4) *FR-RTA-7.3:* If a user attempts to add more than 20 events, an error message must display: "Maximum 20 events per routine"

H. Save and Validation

- 1) *FR-RTA-8.0*: Changes must auto-save after 2 seconds of inactivity
- 2) *FR-RTA-8.1*: A routine is valid only if: at least one day is selected and at least one event exists
- 3) *FR-RTA-8.2*: If validation fails, the back button must show the unsaved changes warning
- 4) *FR-RTA-8.3*: Upon successful save, a toast notification must display: "Routine saved"

H. Control Page

1) *FR-008: Device Control Page*:

A. Access Control

- 1) *FR-CTL-1.0*: Accessible only after successful device pairing (FR-003)
- 2) *FR-CTL-1.1*: Must verify device connectivity before displaying controls
- 3) *FR-CTL-1.2*: If device is offline, display "Device Offline" message with retry button

B. Power Control

- 1) *FR-CTL-2.0*: Display prominent ON/OFF toggle button at the top of control interface
- 2) *FR-CTL-2.1*: Toggle must show current device state with visual feedback (colored indicator)
- 3) *FR-CTL-2.2*: Power state changes must be reflected on device within 2 seconds
- 4) *FR-CTL-2.3*: When device is OFF, all other controls must be visually disabled/grayed out

C. Fan Speed Control

- 1) *FR-CTL-3.0*: Display horizontal percentage slider for fan speed control (0-100%)
- 2) *FR-CTL-3.1*: Slider must show current fan speed percentage as text above or beside slider
- 3) *FR-CTL-3.2*: Fan speed adjustments must be sent to device in real-time during slider movement
- 4) *FR-CTL-3.3*: Slider must be disabled when device is in Timer Mode or Auto Mode

D. Timer Mode

- 1) *FR-CTL-4.0*: Provide timer mode selection with options: OFF, 4hr, 6hr, 8hr
- 2) *FR-CTL-4.1*: Display timer as segmented control or dropdown menu
- 3) *FR-CTL-4.2*: When timer is active, display countdown showing remaining time
- 4) *FR-CTL-4.3*: Device must automatically turn OFF when timer expires
- 5) *FR-CTL-4.4*: User must receive push notification when timer completes: "Air purifier timer finished"
- 6) *FR-CTL-4.5*: Timer mode overrides Auto Mode when activated

E. Child Lock

- 1) *FR-CTL-5.0*: Display Child Lock toggle switch with lock icon
- 2) *FR-CTL-5.1*: When enabled, all physical controls on device must be disabled
- 3) *FR-CTL-5.2*: Child Lock state must persist until manually disabled via app
- 4) *FR-CTL-5.3*: Lock status must be visually indicated on device (LED indicator or display message)
- 5) *FR-CTL-5.4*: App controls remain functional regardless of Child Lock state

F. Operation Modes

- 1) *FR-CTL-6.0*: Provide mode selection between "Manual Mode" and "Auto Mode"
- 2) *FR-CTL-6.1*: Display current active mode prominently with visual distinction
- 3) *FR-CTL-6.2*: Mode changes must be confirmed with user before applying

G. Manual Mode Controls

- 1) *FR-CTL-7.0*: In Manual Mode, enable direct fan speed control via percentage slider
- 2) *FR-CTL-7.1*: Manual controls must override any automatic adjustments
- 3) *FR-CTL-7.2*: Display "Manual Mode" indicator when active
- 4) *FR-CTL-7.3*: User must manually adjust all settings (fan speed, timer, etc.)
- 5) *FR-CTL-7.4*: Manual Mode remains active until user switches to Auto Mode or device power cycle

H. Auto Mode Operation

- 1) *FR-CTL-8.0*: In Auto Mode, device must take sensor readings every 15 minutes
- 2) *FR-CTL-8.1*: Fan speed must automatically adjust based on environmental sensor data
- 3) *FR-CTL-8.2*: Display "Auto Mode" indicator and show "Next sensor reading in: X minutes"
- 4) *FR-CTL-8.3*: Auto Mode adjustments must consider: air quality, temperature, humidity, and detected health symptoms
- 5) *FR-CTL-8.4*: Fan speed slider must be disabled/read-only in Auto Mode, showing current automatic setting
- 6) *FR-CTL-8.5*: User must be able to view sensor reading history and auto-adjustment reasoning
- 7) *FR-CTL-8.6*: Auto Mode must respect Child Lock and Timer Mode settings when active

I. Control Interface Layout

- 1) *FR-CTL-9.0*: All controls must be organized in

- logical sections with clear visual separation
- 2) *FR-CTL-9.1*: Emergency/priority controls (Power, Child Lock) must be easily accessible
- 3) *FR-CTL-9.2*: Current device status must be displayed at top: power state, mode, timer status
- 4) *FR-CTL-9.3*: Interface must update in real-time to reflect device state changes
- 5) *FR-CTL-9.4*: Loading states must be shown during control command transmission

I. Settings Page

1) *FR-009: Settings Page (Main Menu)*: Note: Only accessible after successful login/sign up

A. Settings Page Access

- 1) *FR-SET-1.0*: The Settings Page is accessed by tapping the "Settings" tab in the bottom navigation bar (FR-005)
- 2) *FR-SET-1.1*: The page must check authentication on load—expired tokens redirect to Login
- 3) *FR-SET-1.2*: The Settings Page must include the bottom navigation bar with the "Settings" tab highlighted/active

B. Screen Header

- 1) *FR-SET-2.0*: The screen must display "Settings" as the page title at the top-left
- 2) *FR-SET-2.1*: An optional icon (such as a palette or settings gear) may appear in the top-right corner

C. Settings Menu List

- 1) *FR-SET-3.0*: The screen must display a vertically scrollable list of settings options
- 2) *FR-SET-3.1*: Each menu item must have an icon on the left, title text in the center, and a chevron (>) on the right
- 3) *FR-SET-3.2*: The following options must be displayed in order:
 - Account (with user/profile icon)
 - My Devices (with device icon)
 - Location (with location/pin icon)
 - Privacy (with shield/lock icon)
- 4) *FR-SET-3.3*: Tapping any menu item must navigate to its respective detail screen
- 5) *FR-SET-3.4*: Menu items must have sufficient touch target size (minimum 44pt height)

2) *FR-010: Account Screen*:

A. Screen Structure

- 1) *FR-ACC-1.0*: Display "Account" or user's account name as the title
- 2) *FR-ACC-1.1*: Include a back button (<) in the top-left corner to return to Settings menu

- 3) *FR-ACC-1.2*: Display a section header "Account Settings"

B. Account Options

- 1) *FR-ACC-2.0*: Display "Edit Account" option with a chevron (>)
- 2) *FR-ACC-2.1*: Tapping "Edit Account" navigates to account editing screen
- 3) *FR-ACC-2.2*: Display "Log Out" option without a chevron
- 4) *FR-ACC-2.3*: Tapping "Log Out" must show confirmation dialog: "Are you sure you want to log out?"
- 5) *FR-ACC-2.4*: Upon logout confirmation, clear authentication token and redirect to Login screen

C. Edit Account Screen

- 1) *FR-ACC-3.0*: The Edit Account screen must allow users to edit their account name/display name
- 2) *FR-ACC-3.1*: Display current account name in an editable text field
- 3) *FR-ACC-3.2*: Include a "Save" button to save changes
- 4) *FR-ACC-3.3*: Include a "Cancel" button or back button to discard changes
- 5) *FR-ACC-3.4*: Show success message "Account updated" after successful save
- 6) *FR-ACC-3.5*: Validate that account name is not empty and is between 2-50 characters

3) *FR-011: My Devices Screen*:

A. Screen Structure

- 1) *FR-DEV-1.0*: Display "My Devices" as the screen title
- 2) *FR-DEV-1.1*: Include a back button (<) in the top-left corner
- 3) *FR-DEV-1.2*: Include a "+" button in the top-right corner to add new devices
- 4) *FR-DEV-1.3*: Tapping the "+" button must trigger the device registration flow (FR-003)

B. Device List Display

- 1) *FR-DEV-2.0*: Display all registered devices in a scrollable vertical list
- 2) *FR-DEV-2.1*: If no devices are registered, show empty state: "No devices registered" with "Add Device" button
- 3) *FR-DEV-2.2*: Each device must be displayed in a card with the following information:
 - Device icon (left side)
 - Device name with optional status indicator icon
 - Room/location name (below device name)

- Device version or model number (below location)
 - Three-dot menu button (...) on the right side
- 4) *FR-DEV-2.3*: Device cards must have rounded corners and appropriate padding/spacing
 - 5) *FR-DEV-2.4*: Cards should maintain consistent styling with other UI elements (dark background for dark mode)

C. Device Options Menu

- 1) *FR-DEV-3.0*: Tapping the three-dot (...) button must display a context menu/modal overlay
- 2) *FR-DEV-3.1*: The menu must appear as a popup/modal centered or near the device card
- 3) *FR-DEV-3.2*: The menu must have a light background with rounded corners (iOS-style)
- 4) *FR-DEV-3.3*: The menu must include the following options in order:
 - "Rename" (with edit/pencil icon)
 - "Identify" (with location/search icon)
 - "Settings" (with gear icon)
 - "Delete" (with trash/minus icon, displayed in red/warning color)
- 5) *FR-DEV-3.4*: Tapping outside the menu must close it without taking action
- 6) *FR-DEV-3.5*: Each menu option must have an icon on the right side

D. Rename Device

- 1) *FR-DEV-4.0*: Tapping "Rename" must open a dialog/modal with a text input field
- 2) *FR-DEV-4.1*: The dialog must display current device name as default value
- 3) *FR-DEV-4.2*: Include "Cancel" and "Save" buttons
- 4) *FR-DEV-4.3*: Device name must be 1-50 characters
- 5) *FR-DEV-4.4*: Show success message "Device renamed" after save

E. Identify Device

- 1) *FR-DEV-5.0*: Tapping "Identify" must send a command to the physical device to identify itself
- 2) *FR-DEV-5.1*: The device should flash its LED, beep, or otherwise indicate which device it is
- 3) *FR-DEV-5.2*: Show message "Identifying device..." while command is being sent
- 4) *FR-DEV-5.3*: Show success message "Device should now be blinking/beeping"

F. Device Settings

- 1) *FR-DEV-6.0*: Tapping "Settings" must navigate to device-specific settings screen
- 2) *FR-DEV-6.1*: Device settings may include:

firmware version, WiFi connection, update options, etc.

G. Delete Device

- 1) *FR-DEV-7.0*: Tapping "Delete" must show confirmation dialog: "Remove [Device Name]? This device will be removed from your account."
- 2) *FR-DEV-7.1*: Dialog must have "Cancel" and "Remove" buttons
- 3) *FR-DEV-7.2*: "Remove" button must be in red/warning color
- 4) *FR-DEV-7.3*: Upon confirmation, remove device from user account
- 5) *FR-DEV-7.4*: Show success message "Device removed"
- 6) *FR-DEV-7.5*: Update the device list to remove the deleted device

4) *FR-012: Location Screen:*

A. Screen Structure

- 1) *FR-LOC-1.0*: Display "Location" as the screen title (centered)
- 2) *FR-LOC-1.1*: Include a back button (<) in the top-left corner
- 3) *FR-LOC-1.2*: Include a "Save" button in the top-right corner

B. Location Search

- 1) *FR-LOC-2.0*: Display a search bar below the header with placeholder text "Search"
- 2) *FR-LOC-2.1*: Include a magnifying glass icon on the left side of the search bar
- 3) *FR-LOC-2.2*: Include a location/GPS icon button on the right side of the search bar
- 4) *FR-LOC-2.3*: Tapping the GPS icon must request device location and auto-populate nearest city
- 5) *FR-LOC-2.4*: As user types, show autocomplete suggestions for cities/locations
- 6) *FR-LOC-2.5*: User can select a location from search results or autocomplete suggestions

C. Location Selection

- 1) *FR-LOC-3.0*: Selected location must be saved to the user's profile in the database
- 2) *FR-LOC-3.1*: Tapping "Save" must save the location and return to Settings menu
- 3) *FR-LOC-3.2*: Show success message "Location saved"
- 4) *FR-LOC-3.3*: If user taps back button without saving, show warning: "Discard changes?"
- 5) *FR-LOC-3.4*: Location data should include: city name, country, latitude, longitude (optional)

D. Location Usage

- 1) *FR-LOC-4.0*: Saved location will be used for external AQI (Air Quality Index) API integration
- 2) *FR-LOC-4.1*: Location will be used for weather-based automation recommendations

5) *FR-013: Privacy Screen*:

A. Screen Structure

- 1) *FR-PRIV-1.0*: Display "Privacy" as the screen title
- 2) *FR-PRIV-1.1*: Include a back button (<) in the top-left corner

B. Privacy Content

- 1) *FR-PRIV-2.0*: Display privacy policy statement or summary
- 2) *FR-PRIV-2.1*: Include link to full privacy policy document: "Read Full Privacy Policy"
- 3) *FR-PRIV-2.2*: Optionally include toggles for:
 - Data collection consent
 - Audio processing (for cough/sneeze detection)
 - Location services
- 4) *FR-PRIV-2.3*: Include explanation text for each privacy setting
- 5) *FR-PRIV-2.4*: Include "Download My Data" option
- 6) *FR-PRIV-2.5*: Include "Delete My Account" option at bottom in red text

6) *FR-014: Empathetic Intelligence Notifications*:

A. Notification Permissions

- 1) *FR-NOTIF-1.0*: During app setup (FR-001), request push notification permissions with explanation: "Allow notifications to receive caring health insights and device updates"
- 2) *FR-NOTIF-1.1*: If permissions denied initially, provide in-app prompt in Settings to enable notifications
- 3) *FR-NOTIF-1.2*: User must be able to customize notification types and frequency in Settings menu
- 4) *FR-NOTIF-1.3*: Notifications must respect device "Do Not Disturb" and quiet hours settings

B. Notification Design Principles

- 1) *FR-NOTIF-2.0*: All notifications must use empathetic, human-like language that demonstrates care and understanding
- 2) *FR-NOTIF-2.1*: Notifications must be actionable, providing clear next steps or automatic solutions
- 3) *FR-NOTIF-2.2*: Tone must be supportive and non-alarming, avoiding medical terminology or urgent language
- 4) *FR-NOTIF-2.3*: Messages must personalize to individual users when multiple users detected
- 5) *FR-NOTIF-2.4*: Include gentle emoji or icons

where appropriate to enhance emotional connection

C. Responsive Notifications

- 1) *FR-NOTIF-3.0*: Monitor cough/sneeze detection events and trigger notifications when threshold exceeded
- 2) *FR-NOTIF-3.1*: Threshold definition: 5+ cough events or 8+ sneeze events within 30-minute window
- 3) *FR-NOTIF-3.2*: Example responsive notification: "We've noticed you have been coughing quite a bit lately, I've turned on Pollen Protection Mode to help out "
- 4) *FR-NOTIF-3.3*: Automatic action must be taken simultaneously with notification (e.g., activate protection mode)
- 5) *FR-NOTIF-3.4*: Follow-up notification after 2 hours: "How are you feeling? The air should be much cleaner now"
- 6) *FR-NOTIF-3.5*: Avoid sending duplicate responsive notifications within 4-hour window for same symptom type

D. Predictive Notifications

- 1) *FR-NOTIF-4.0*: Integrate external AQI data with user health sensitivity profiles to predict issues
- 2) *FR-NOTIF-4.1*: Learn individual user sensitivities over time (Person A reacts to pollen, Person B to dust, etc.)
- 3) *FR-NOTIF-4.2*: Multi-user household example: "Pollen levels in the area are rising and [Person A] might have some struggles, we recommend moving the purifier to [Person A]'s room "
- 4) *FR-NOTIF-4.3*: Location-specific example: "The ultrafine dust level in [Location] is high this afternoon, and I've detected some sneezing. I've activated 'Pollution Defense' mode to create a safe zone for you at home. Please remember to keep the windows closed! "
- 5) *FR-NOTIF-4.4*: Predictive notifications must be sent 1-2 hours before predicted air quality deterioration
- 6) *FR-NOTIF-4.5*: Include specific recommendations: window closure, room changes, device repositioning
- 7) *FR-NOTIF-4.6*: Track prediction accuracy and adjust sensitivity thresholds based on user feedback

E. Maintenance Notifications

- 1) *FR-NOTIF-5.0*: Monitor filter life and send proactive replacement notifications
- 2) *FR-NOTIF-5.1*: Filter warning at 90% capacity: "Your filter is running low! Replace it soon to avoid

air quality issues "

- 3) *FR-NOTIF-5.2*: Critical filter notification at 100% capacity: "Time for a fresh filter! I've reduced fan speed to protect the motor until you can replace it"
- 4) *FR-NOTIF-5.3*: Include direct link to purchase replacement filters or schedule maintenance
- 5) *FR-NOTIF-5.4*: Send reminder notifications every 3 days after initial filter warning
- 6) *FR-NOTIF-5.5*: Other maintenance notifications: cleaning reminders, sensor calibration, software updates

F. Notification Timing and Frequency

- 1) *FR-NOTIF-6.0*: Respect user's local time zone and avoid notifications between 10 PM - 7 AM unless critical
- 2) *FR-NOTIF-6.1*: Maximum 3 notifications per day per device to avoid notification fatigue
- 3) *FR-NOTIF-6.2*: Priority system: Critical (filter/safety) > Predictive > Responsive > General updates
- 4) *FR-NOTIF-6.3*: User must be able to snooze non-critical notifications for 1hr, 4hr, or until tomorrow
- 5) *FR-NOTIF-6.4*: Smart batching: combine multiple low-priority notifications into daily summary

G. Notification Customization

- 1) *FR-NOTIF-7.0*: Settings menu must include notification preferences with toggles for each notification type
- 2) *FR-NOTIF-7.1*: Allow users to set "empathy level": Minimal, Standard, Caring, Very Caring
- 3) *FR-NOTIF-7.2*: Empathy level affects message tone, frequency, and personalization depth
- 4) *FR-NOTIF-7.3*: Quick notification response options: "Thanks!", "Not helpful", "Remind me later"
- 5) *FR-NOTIF-7.4*: Learn from user responses to improve future notification relevance and timing

H. Emergency and Safety Notifications

- 1) *FR-NOTIF-8.0*: Override quiet hours for safety-critical notifications (device malfunction, air quality emergency)
- 2) *FR-NOTIF-8.1*: Emergency example: "Air purifier has stopped working! Please check the device and ensure proper ventilation"
- 3) *FR-NOTIF-8.2*: Severe air quality example: "Air quality in your area is hazardous. Please stay indoors and run the purifier on maximum"
- 4) *FR-NOTIF-8.3*: Safety notifications must be persistent until acknowledged by user
- 5) *FR-NOTIF-8.4*: Include emergency contact infor-

mation or support links when appropriate

III. DEVELOPMENT ENVIRONMENT

A. Choice of Software Development Platform

- **Host OS**: Windows 11 Build 26200.6899/7019
- **Language**: Python 3.11.9/3.12.5 for rapid prototyping, strong audio and ML ecosystem
- **Target Edge**: Ideal LG Purifier Hardware (for convenience).

B. Software in Use

- **ML**: PyTorch, Scipy, librosa, MLlib(optional).
- **Streaming/Backend**: Django(essential), Firebase, Heroku. Apache Kafka (events), Apache Spark (Structured Streaming + batch ETL); optional.
- **DevOps**: VS Code, Git/GitHub, Git Projects

TABLE II
TASK DISTRIBUTION

Jobs	Name	Description
Frontend	Kim Soobin, Kim Yeonwoo	In charge of the planning, development and rollout of the PWA onto mobile devices.
Backend	Kim Yeonwoo	In charge of database and API creation, management, and maintainment
ML/AI	Jimmy MacDon-ald, Kim Minjin, et Al	In charge of collecting data, planning and creating an AI model to achieve the task at hand
Project Manager	Kim Minjin	Keeps track of documentation, assigns tasks, and make sure deadlines are met on time

IV. SPECIFICATION

A. Requirement 2

1) Features:

A. Device Enrollment

- 1) Permission Requests: Camera (for QR scanning), Notifications (for device alerts), and optional Location (for weather recommendations)
- 2) Method: QR-based local AP or BLE provisioning (LG ThinQ-like flow)
- 3) Maximum Number of Device per User: 6

B. Logs

- 1) On-device: last 7 days of inference summaries (timestamp, event type).
- 2) Server: event features and environment snapshots; **no raw audio**.
- 3) Retention: event/features 30 days (default)

C. Login and Sign-up

- 1) Login Screen
Contains email and password fields, "Remember me" checkbox, "Forgot Password?" link, and "Don't have an Account? Sign Up" link
- 2) Sign-up Flow
 - i) Page 1: Basic account information (Full Name, Email, Password, Confirm Password, Terms Agreement)
 - ii) Page 2: Optional profile information (Phone, Profile Picture, DOB, Country)

D. Selecting and Entering Information

- 1) Splash: app logo + version for 1–2 s.
- 2) Profile (optional): respiratory sensitivities, quiet hours, preferred temperature/humidity bands.
- 3) Units: Celsius only; humidity in %RH.

E. Information Screen

- 1) Display: current air quality, temperature (°C), humidity (%RH), device state, event timeline.
- 2) Refresh: 1 s UI update; 5 s sensor polling; status colors by thresholds.

F. Hardware API/DB

- 1) Serves as the stand in for the actual hardware device for each production model.
- 2) Characteristics
 - `userId` (ref: User, required: True)
 - `name` (type: String, required: true, trim: true)
 - `deviceId` (type: String, required: true, unique: true)
 - `location` (name: String, city: String, latitude: Number, longitude: Number, lastUpdated: Date)
 - `settings` (autoMode type: Boolean, default: true, fanSpeed type: Number, default: 1, sensitivity sensitivity: type: Number, default: 2)
 - `status` (online: type: Boolean, default: false, lastSeen: Date)
- 3) Posts
 - i) Update database with the characteristics of the device
- 4) Gets
 - i) Every 24 hours, the API will send a request to the database to get an updated AQI prediction for the day as well as surrounding conditions from the DB

G. Firebase API/DB: Acts as the main database for user data, air quality metrics, and device information. Cannot make external API requests. **Collections:**

- **Cities** - Stores unique city info to consolidate and

cache data from regular updates

- **Devices** - Links registered air purifiers to users, storing device ID, name, timezone, and geolocation coordinates
- **AirQuality** - Caches air quality data including AQI, pollutant levels (CO, NO2, O3, PM2.5, PM10, SO2), location coordinates, and timestamps
- **masterDeviceList** - Keeps track of all products manufactured
- **timezones** - Keeps track of all active timezones so that we only query for timezones that we have products active in
- **Users** - Stores user authentication (username, email, password) and profile data (phone number, respiratory services, quiet hours, device count)

REFERENCES

- [1] World Health Organization, "Billions of people still breathe unhealthy air: new WHO data," WHO News, 04-Apr-2022. [Online]. Available: <https://www.who.int/news/item/04-04-2022-billions-of-people-still-breathe-unhealthy-air-new-who-data> (Accessed: 01-Oct-2025).