POLITECNICO DI TORINO

Master's Degree in Cinema and Digital Media Engineering



Master's Degree Thesis

Design and Evaluation of an Innovative User Interface for an Integrated Smart Home System

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Abstract

The rapid expansion of Internet of Things (IoT) technologies has fundamentally transformed domestic environments. However, despite the widespread adoption of connected devices, many smart home ecosystems remain fragmented and are plagued by high cognitive friction. This redesign addresses these usability challenges by comprehensively rethinking the mobile user interface for Smartotum, an Italian smart home platform built around privacy. The original application functioned merely as a technical prototype, suffering from severe cognitive overload, a lack of visual hierarchy, and inadequate system feedback.

Applying the human centered Design Thinking methodology, this research transformed the baseline application into an intuitive, highly accessible control hub. The process encompassed contextual market research, competitor benchmarking, and the definition of targeted user personas to establish strict heuristic requirements. The resulting detailed Figma prototype [1] introduces a visual system that utilises semantic status indicators and progressive disclosure to manage complex domestic tasks.

To validate the proposed design, a formative usability evaluation based on practical tasks was conducted with target users. The redesigned prototype achieved a System Usability Scale (SUS) score of 83.0. Qualitative feedback indicated that the spatial mapping, immediate visual feedback, and simplified automation logic substantially reduced the cognitive friction observed in the baseline application.

[1] High-fidelity can be accessed at: `https://www.figma.com/proto/p9BMoPEJDz3QJfWBJiMGsd/Smartotum?node-id=7-332&t=6d0mHKnHDA6unO3D-1`

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Introduction

In recent years, the integration of IoT technologies into domestic environments has transformed the traditional house into a smart home. This sector has undergone significant growth, reflecting an increasing consumer interest in digital solutions aimed at improving domestic comfort, security, and energy efficiency.

However, despite the widespread diffusion of unified platforms such as Google Home or Amazon Alexa, many households still rely on multiple applications from different brands. In this context, the mobile application acts as the primary bridge between the user and their physical environment. Consequently, the success and adoption of smart home technologies no longer depend solely on hardware capabilities, but decisively on the quality of the User Interface (UI) and User Experience (UX). A well-designed interface must combine simplicity, reliability, and clear feedback to prevent cognitive overload and foster user trust.

1.1 The Italian Smart Home Market Landscape

To contextualize the design requirements for a modern smart home application, it is essential to examine the specific market dynamics and consumer behaviors of the target demographic. In recent years, the smart home sector in Italy has undergone significant and sustained growth. This expansion reflects the country's increasing cultural interest in digital technologies aimed at improving domestic comfort, physical security, and energy efficiency.

According to the latest joint research conducted by the Internet of Things Observatory of the Politecnico di Milano and BVA Doxa, the penetration of smart technologies in Italian households has reached a critical mass.[1;2] Approximately six out of ten Italians now own at least one smart device in their homes.[2] Specifically, 59% of consumers report owning connected products. General awareness of the "smart home" concept has expanded considerably; currently, 69% of Italians claim familiarity with the term, representing an increase of nearly ten percentage points compared to 2023.[2]

However, only about 41% of Italian users with smart devices have successfully configured them to function as part of a unified home network. In many cases, households rely on multiple

applications from different brands rather than a single unified control platform. This fragmentation, as documented in academic studies from institutions such as IUAV University, poses severe usability challenges, resulting in high cognitive load for users who must continuously switch context between disparate apps to perform basic household routines.[3]

Despite these fragmentation issues, mobile applications have decisively established themselves as the primary interface between users and their smart environments. Approximately 72% of users control their smart home devices through dedicated smartphone apps. The frequency of use is also notable: 87% of these individuals engage with their smart home apps at least once or twice per week, and 72% report using them daily. Consequently, users place a high premium on ease of use, with a majority evaluating their current apps positively but continuously demanding a more seamless experience.

Market data from the Internet of Things Observatory and Fantini Cosmi highlights that the Italian smart home market is primarily driven by four distinct functional segments: home security systems (24%), smart appliances (19%), climate control devices such as connected thermostats and air conditioning units (18%), and smart speakers or voice assistants (16%).[1;4] In addition, energy-related solutions remain highly relevant. Despite the reduction of national fiscal incentives for energy upgrades, 17% of Italian consumers explicitly associate smart home technologies with energy management, and 24% consider real-time energy monitoring to be among the most valuable future functions they expect from these systems.

Economically, the sector is entering a dynamic phase of expansion. The Internet of Things Observatory estimates that the Italian smart home market reached approximately €900 million in 2024, marking an 11% increase from the previous year.[1] In the broader IoT ecosystem, Italy counted around 155 million connected devices in 2024, an average of 2.6 per inhabitant. International forecasts corroborate this domestic growth trajectory. Reports by NextMSC valued the Italian smart home market at approximately USD 3.39 billion in 2023, projecting expansion to USD 12.58 billion by 2030, which represents a Compound Annual Growth Rate (CAGR) of approximately 20.6%.[5] Similarly, Mordor Intelligence provides a conservative but robust estimate, forecasting growth from USD 2.54 billion in 2025 to USD 4.14 billion by 2030 (a CAGR of 9.8%).[6]

These findings indicate that the typical Italian smart home user is driven by four core objectives: improving domestic security, simplifying daily tasks through automation, enhancing comfort via environmental control, and reducing energy consumption. A smart home application must therefore address these four pillars through its user interface, consolidating fragmented devices into a single, highly usable and accessible system.

1.2 The Smartotum Application



Figure 1.1: Smartotum company logo.

This redesign focuses on the mobile application for **Smartotum**, an Italian smart home platform that integrates home automation, energy management, and security functionalities into a single unified system. Conceived to make home automation accessible, its core philosophy is built upon three main principles: *one app for all functions, no structural renovation required, and guaranteed local privacy*.

Unlike many major competitors that rely heavily on cloud infrastructures, Smartotum emphasizes a local-first approach, ensuring that user data remains within the home network. It allows users to manage lighting, motorized blinds, electrical sockets, climate control, and security systems, while also providing energy monitoring in real time. The platform positions itself as an innovative, privacy-oriented, and human-centered system that adapts to the home environment rather than forcing domestic habits to adapt to technology.

1.3 Problem Statement

Although Smartotum provides a robust and privacy-oriented technical infrastructure, its original mobile application existed primarily as an initial functional prototype. A baseline review of this initial design reveals a significant lack of attention to user experience and interface aesthetics.

While the application successfully demonstrated core technological features, it suffered from critical usability flaws:

- **Cognitive Overload:** Navigation relied heavily on unlabeled icons and flat structures, forcing users to guess functionalities and increasing the learning curve.
- **Lack of Visual Hierarchy:** The interface utilized uniform containers and colors, making it difficult for users to distinguish between primary actions and secondary information.

- **Inadequate System Feedback:** User interactions lacked immediate visual confirmation, creating uncertainty about whether a command was successfully executed.
- **Brand Misalignment:** The absence of a cohesive visual identity resulted in an interface that felt purely technical.

In response to these baseline flaws, an initial structural study was carried out by Ghorbani in 2025, which introduced a five-tab global navigation structure and established baseline task pathways to reduce the navigational confusion of the original prototype.[7]

However, moving from preliminary wireframes to an ergonomic, fully realized user interface requires addressing several critical interaction challenges. The interface must provide an ergonomic visual system to prevent eye strain during low-light domestic use, gestural administrative decluttering, progressive disclosure logic for complex automations, contextual error prevention dialogs, and localized energy tracking workflows. Therefore, while adopting the five-tab structure established by Ghorbani as a foundational skeleton, this thesis provides the original contribution of designing a comprehensive visual design system, detailing internal page hierarchies, developing advanced interaction paradigms (gated filtering, gesture-based actions, and semantic status indicators), and evaluating the interactive prototype with target users.[7]

1.4 Research Objectives

The primary objective of this work is to apply a user-centered design methodology to redesign the UI and UX of the Smartotum mobile application. The goal is to transform the functional prototype into an intuitive, efficient, and visually coherent interface that aligns with user needs and brand identity.

Specifically, the research aims to:

1. Investigate the needs, expectations, and behavioral patterns of smart home users to inform design decisions.
2. Analyze the usability of the existing Smartotum app and define clear, actionable design requirements.
3. Refine and detail the Information Architecture (IA) by structuring page hierarchies, spatial containment models, and interaction logic that minimize cognitive effort.
4. Create a detailed interactive prototype featuring a modern, accessible, and scalable visual design system.

5. Evaluate the redesigned interface through usability testing to measure task efficiency, clarity, and perceived user satisfaction.

1.5 Competitor Benchmarking and State of the Art

To translate theoretical UX principles into practical design strategies, a heuristic desk review was conducted on widely used smart home applications. The applications selected for this benchmarking, Amazon Alexa, Google Home, Apple Home, Philips Hue, and Eve, were chosen for their high market relevance and their ability to integrate multi-device ecosystems. The evaluation followed an expert-review approach grounded in Nielsen's usability heuristics and Norman's core interaction design principles.

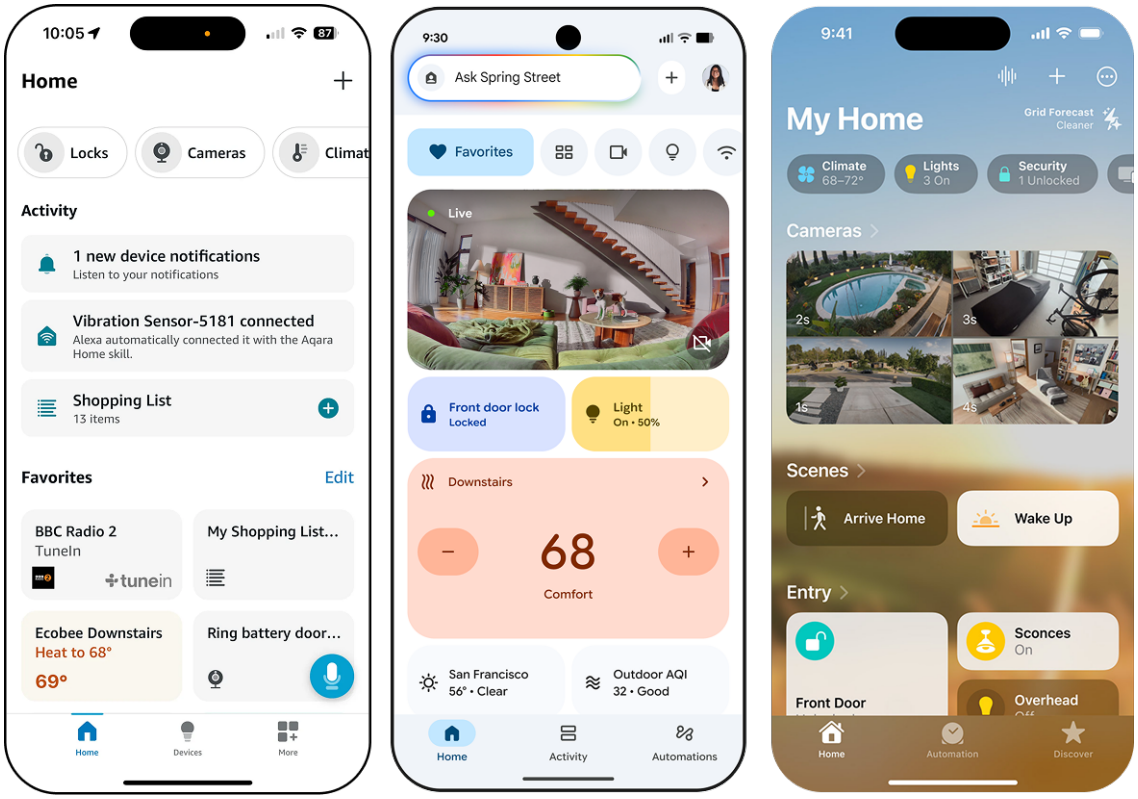


Figure 1.2: Amazon Alexa, Google Home, and Apple Home apps

The objective of this comparative analysis is to identify prevailing industry standards, highlight common usability pitfalls, and define the baseline expectations of modern smart home users. Table 1.1 summarizes the presence and execution quality of core smart home capabilities across these platforms.

Capability	Alexa	Google Home	Apple Home	Hue	Eve
Room-centric dashboard	✓	✓	✓	∼	∼
Quick global actions (e.g., All Off)	∼	∼	✓	×	∼
Guided routine/scene setup	∼	∼	✓	×	∼
Schedules (lighting/heating)	∼	✓	✓	✓	✓
State feedback & confirmations	∼	✓	✓	✓	∼

Table 1.1: Summary of common capabilities (✓ Clearly present/Easy; ∼ Partially present/Hard to find; × Missing).

1.5.1 Comparative Usability Analysis

The evaluation assessed the applications across four primary dimensions: Navigation, Device Control and Feedback, Automation Management, and Visual Design.

1. Ease of Navigation

Navigation structures vary significantly among the leading platforms. *Apple Home* and *Google Home* successfully prioritize a spatial, room-centric mental model. Their dashboards immediately present the home's structure, allowing users to locate devices based on their physical placement. Apple Home, in particular, uses minimalist iOS native patterns, making navigation highly intuitive. Conversely, *Amazon Alexa* relies on a heavily menu-driven architecture. Users must navigate through disparate tabs (e.g., Devices, Routines, Skills), which creates a fragmented experience and increases cognitive load, especially for first-time users. *Philips Hue* and *Eve* offer clear groupings for specific device types (like lighting), but their navigation often breaks down when attempting to integrate third-party devices.

2. Device Control and Feedback

Immediate visual feedback is critical for establishing user trust. *Google Home* and *Apple Home* excel in this area, providing real-time, unambiguous visual state changes (such as card color shifts or icon animations) whenever a device is toggled. *Amazon Alexa*, originally designed as a voice-first interface, often treats the mobile screen as a secondary touchpoint. Consequently, its visual feedback mechanisms are occasionally delayed or less prominent, making it difficult for users to confirm actions performed silently via the app.

3. Automation and Scenario Management

Automation remains one of the most valued yet complex features to design. *Amazon Alexa* supports highly complex conditional routines across a vast array of third-party devices; however, the creation process is nested deep within menus and lacks visual guidance, making it inaccessible to non-technical users. *Google Home* enhances this process slightly with straightforward con-

ditional triggers (e.g., time of day or device state). *Apple Home* stands out by offering a highly visual, step-by-step guided setup for scenes and automations, significantly lowering the technical barrier to entry and allowing users to combine multiple devices effortlessly.

4. Visual Design and Aesthetics

The aesthetic coherence of these platforms deeply impacts their perceived usability. *Amazon Alexa*'s interface is functionally robust but visually dense, prioritizing information quantity over aesthetic balance. In contrast, *Google Home* utilizes a clean, card-style layout with consistent typography and color coding, enhancing readability. *Apple Home* embraces extreme minimalism, utilizing generous whitespace and highly legible, standardized iconography to reduce visual noise.

1.5.2 Insights for the Redesign

This benchmarking exercise provides clear empirical directives for the redesign of the Smartotum application. The new interface must adopt the proven interaction patterns identified across industry benchmarks: prioritizing a clear, room-based or task-based dashboard, ensuring immediate and explicit visual feedback for all actions, and implementing a visually guided, step-by-step approach to automation setup. It must also avoid fragmented navigation, deeply nested menus, and excessive visual density. By synthesizing these industry insights, the Smartotum redesign seeks to establish a balanced interaction model combining technical capabilities with intuitive domestic control.

Methodology, Baseline Analysis, and Requirements

To achieve these objectives, this project adopts the **Design Thinking** methodology. This human-centered, iterative approach is uniquely suited for solving complex UX problems. The process is structured around five sequential phases:

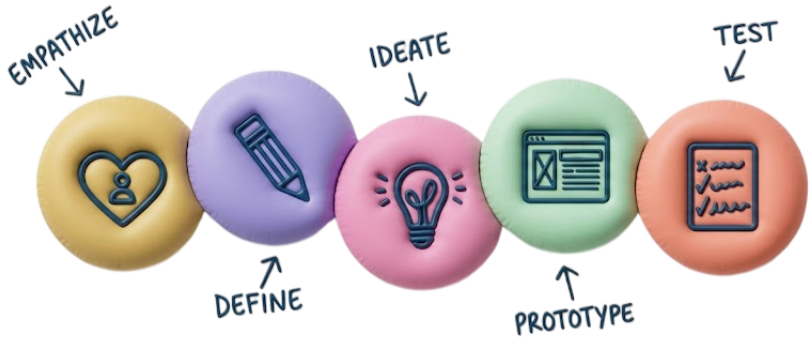


Figure 2.1: Design Thinking Methodology

- **Empathize:** Understanding the market context, analyzing competitors, and identifying the pain points of the current application.
- **Define:** Synthesizing research into User Personas, scenarios, and functional requirements.
- **Ideate:** Exploring structural solutions through Information Architecture, user flows, and simple wireframes.
- **Prototype:** Translating structural concepts into a polished, detailed visual interface.
- **Test:** Validating the proposed design with real users to ensure it meets usability standards.

2.1 Human Computer Interaction in Smart Environments

While market data illustrates the rapid physical adoption of connected devices, academic research in Human Computer Interaction (HCI) reveals that the true bottleneck for smart home

success lies in the user interface. The literature emphasizes that a smart home should not merely be defined as a residence equipped with networked technologies, but rather as an environment that provides personalized, context-aware services to its users. From this perspective, technological advancement alone does not guarantee adoption. Instead, the extent to which users feel in control of their systems, mediated entirely through the UI, is the primary factor influencing long-term engagement and satisfaction.

2.1.1 Cognitive Load and Small-Scale Interface Design

Managing a smart home requires users to mentally map physical spaces to digital controls, a process that can easily induce cognitive overload if the interface is poorly designed. Recent empirical studies on smart home dashboards highlight that even small-scale UI decisions have a profound impact on user performance. For instance, research by Yu et al. demonstrated that specific interface characteristics, such as the orientation of horizontal sliders and the implementation of larger touch targets, significantly improve task completion times and reduce cognitive strain.[8] These findings prove that in a smart home context, where users frequently perform repetitive and rapid actions (e.g., adjusting thermostats or dimming lights), minimalist and well-structured UI components are not just aesthetic choices, but functional necessities.

2.1.2 Accessibility and Inclusive Design

Accessibility and inclusivity have also emerged as central themes in smart home interface literature. The demographic of smart home users is broadening, encompassing individuals with varying levels of digital literacy, motor skills, and visual acuity. According to research by Fakhimi et al., older adults often encounter significant barriers when interacting with smart home applications.[9] These challenges primarily stem from interface complexity, abstract iconography, inconsistent system feedback, and deep navigational hierarchies. The literature advocates for inclusive design strategies that mitigate these barriers by offering clear visual hierarchies, explicit text labels rather than relying solely on icons, and multimodal interaction options (such as combining touch interfaces with voice commands). A good smart home application must therefore be highly adaptable, providing an inclusive experience that does not alienate non-technical users.

2.1.3 User Values

Beyond functional usability, smart home interface design must align deeply with user values and psychological needs. A smart home system permeates the most intimate space of an individual's life, their residence. Consequently, the interface must foster a sense of security and trust. A

2024 study by Samancıoğlu examined the relationship between technology attributes and user preferences, concluding that adoption heavily depends on interfaces that express transparency, simplicity, and a profound respect for privacy.[10]

Users evaluate smart home systems through the lens of perceived autonomy. If an application executes automated routines without providing clear notifications, or if the logic behind a scheduled action is buried within confusing menus, the user experiences a loss of control. Conversely, an interface that clearly visualizes system states, offers straightforward customization, and transparently handles user data cultivates trust. In this sense, the UI acts as the visual manifestation of the system's reliability. The literature firmly positions user interface design as a strategic factor that dictates whether a smart technology feels like an intrusive surveillance tool or a helpful, empowering domestic assistant.

2.2 Core UX/UI Principles in Smart Home Design

User Experience (UX) design in smart home systems extends far beyond visual aesthetics. Interfaces must bridge complex, multilayer device ecosystems and present them in meaningful, comprehensible ways. As highlighted by foundational Human-Computer Interaction literature[11;12] and Ben Shneiderman's Eight Golden Rules of Interface Design[13], good design is fundamentally about creating understandable, predictable, and usable systems rather than simply attractive ones. In the context of IoT, this means translating complex network commands into natural, human-centered interactions.

To achieve this, the design of a smart home application must adhere to a specific set of core UX principles tailored to domestic automation, synthesized in Figure 2.2:

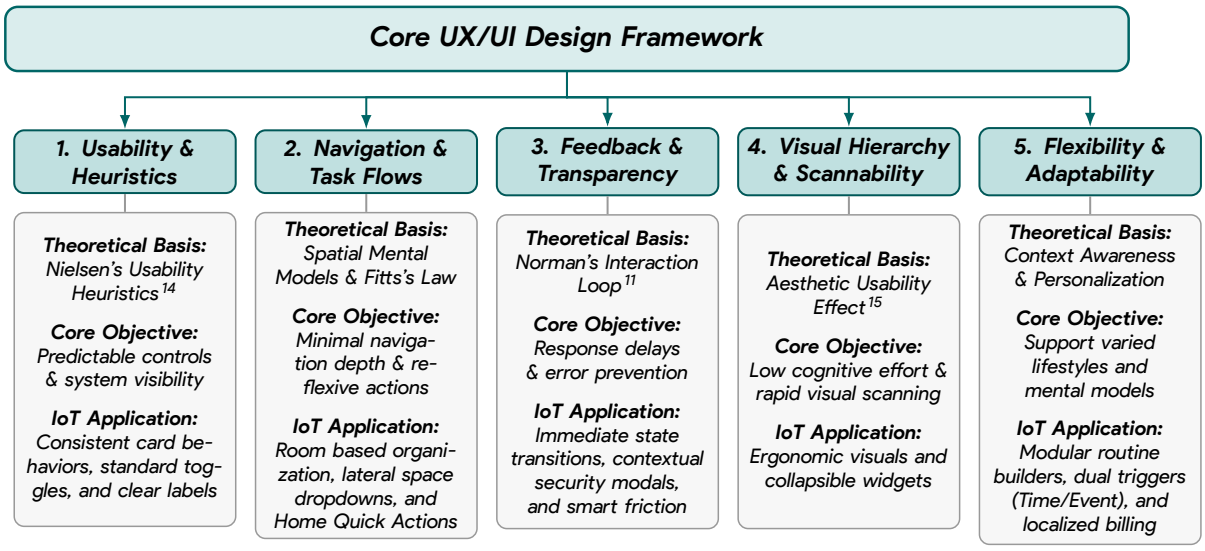


Figure 2.2: The core UX/UI pillars for domestic IoT control

2.2.1 Heuristic Standards

The foundational pillar of any interface is its usability, which comprises learnability, efficiency, memorability, error tolerance, and satisfaction. These attributes are especially critical in smart home applications where users manage dozens of distinct devices, from security cameras to smart plugs, through a single interface. Jakob Nielsen's classic usability heuristics provide a practical foundation for evaluating and designing these systems.[14] Two heuristics are particularly vital for IoT: *Visibility of system status* and *Consistency and standards*. Users must always be informed about what the system is doing, and interface elements (such as toggle switches or slider bars) must behave predictably across all rooms and device categories.

2.2.2 Navigation Clarity and Task Optimization

Smart home applications are highly task-oriented. Users frequently open these apps to perform quick, specific actions, such as turning off all lights before leaving the house, scheduling a heating routine, or checking the status of an alarm. Consequently, navigation must be clear, and task flows must be optimized. Interfaces that bury everyday functions beneath nested menus or require excessive taps cause high user frustration. A good smart home UI minimizes navigational depth, grouping related functions spatially (by room or by activity) to support rapid task execution.

2.2.3 System Feedback

Feedback is arguably the most critical component in remote environmental control. When a user issues a command (activating a "Good Night" scene or adjusting a thermostat), the physical device may have a latency period before responding. During this gap, the digital system must provide clear, immediate acknowledgement that the action succeeded, failed, or is pending. Inconsistent or missing feedback severely degrades user trust in the automation. Effective smart home interfaces utilize robust feedback loops, incorporating visual state changes (such as color shifts), haptic responses, or toast notifications, to maintain system transparency and reassure the user that they remain in control.

2.2.4 Visual Hierarchy and Minimal Cognitive Load

Because smart home dashboards frequently display a dense amount of data, ranging from indoor temperatures to energy consumption metrics and device statuses, managing cognitive load is a must. Visual hierarchy dictates the arrangement of elements in a way that implies importance, guiding the user's eye to the most critical information first (such as an active security breach or

an enabled alarm). Minimizing visual clutter by utilizing correct spacing, clear typography, and universally recognized iconography allows users to scan the interface effortlessly. This approach is reinforced by the aesthetic usability effect, an HCI principle suggesting that users inherently perceive visually appealing and well-organized interfaces as easier to use.[15]

2.2.5 Adaptability

A smart home interface must acknowledge that domestic routines are deeply personal and highly variable, interfaces must therefore be flexible and adaptable, allowing users to customize their dashboards, favorite devices, and custom automation triggers without being constrained by rigid software architectures. Providing this level of adaptability ensures that the technology serves the user's unique lifestyle, rather than forcing the user to conform to the system's logic.

Together, these principles establish a theoretical and highly actionable framework for designing a smart home app interface. They ensure the final product is intuitive, efficient, and perfectly aligned with the fast-paced, task-oriented nature of modern domestic environments.

2.3 Usability Flaws of the Original Prototype

The first iteration of the software served primarily as a functional proof of concept (see Figures 2.3 and 2.4). From a backend engineering perspective, it effectively executed core smart home functions. However, a heuristic evaluation revealed critical usability bottlenecks:



Figure 2.3: The original Smartotum application interface, highlighting the seven-icon navigation bar and a flat card layout.

- **Cognitive Overload and Navigational Friction:** Navigation was handled via a bottom tab bar containing seven unlabeled icons (visible in Figure 2.3). This directly violated the heuristic of *Recognition rather than Recall*, forcing users to rely on trial and error to discover destinations like Settings, Analytics, or Routines.
- **Absence of Visual Hierarchy:** The layout employed rigid, uniform dark blue and light blue panels, failing to visually distinguish between primary actionable buttons and passive data displays.
- **Inadequate System Feedback:** The prototype relied heavily on static navigation and binary toggles, offering minimal changes of state or confirmation messages, leaving users

uncertain about task completion.

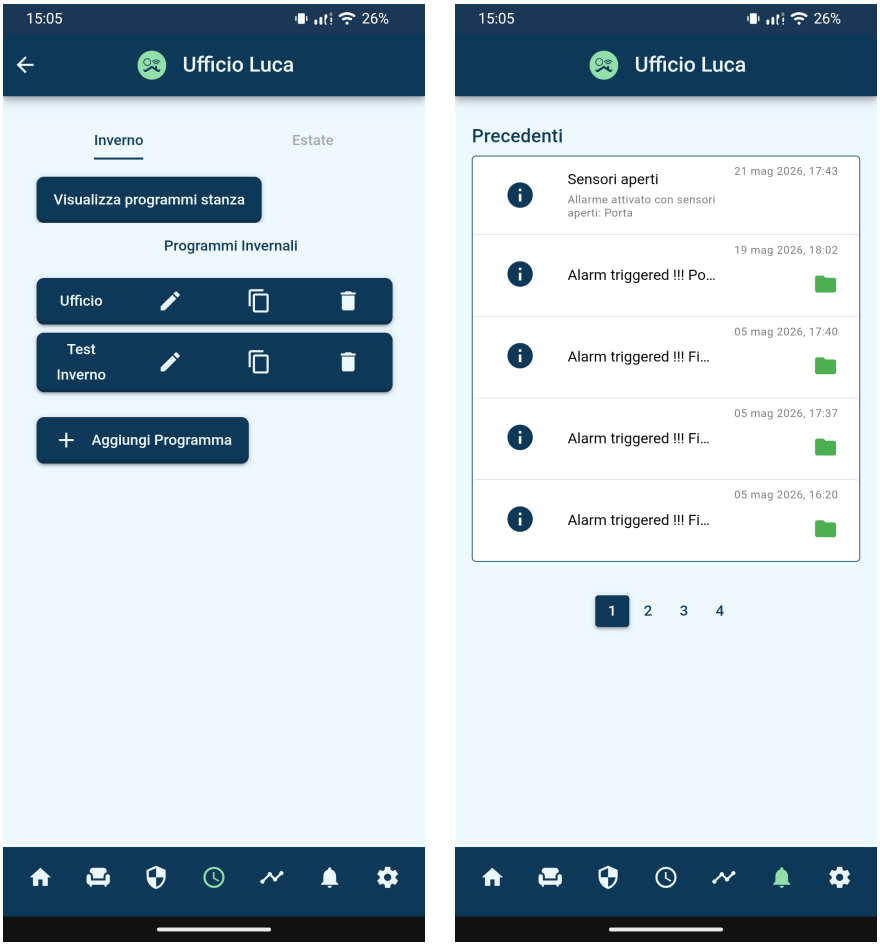


Figure 2.4: Examples of the original prototype's complex scheduling forms and unstructured event logs with dense text.

Furthermore, advanced options such as configuring automation schedules or reviewing system logs (Figure 2.4) suffered from low discoverability and high cognitive load. Schedules were buried within static layouts that provided no step-by-step guidance, while security events were presented as unstructured text feeds rather than scannable, actionable insights.

2.3.1 The 2025 Structural Redesign

To address the foundational flaws of the original engineering prototype, Ghorbani proposed a redesign focused on restructuring the Information Architecture (IA) and standardizing user flows[7]. As shown in Figure 2.5, she simplified the navigation from seven unlabeled icons to a clear five-tab bar (Home, Devices, Security, Routines, Analytics) supported by explicit text labels.

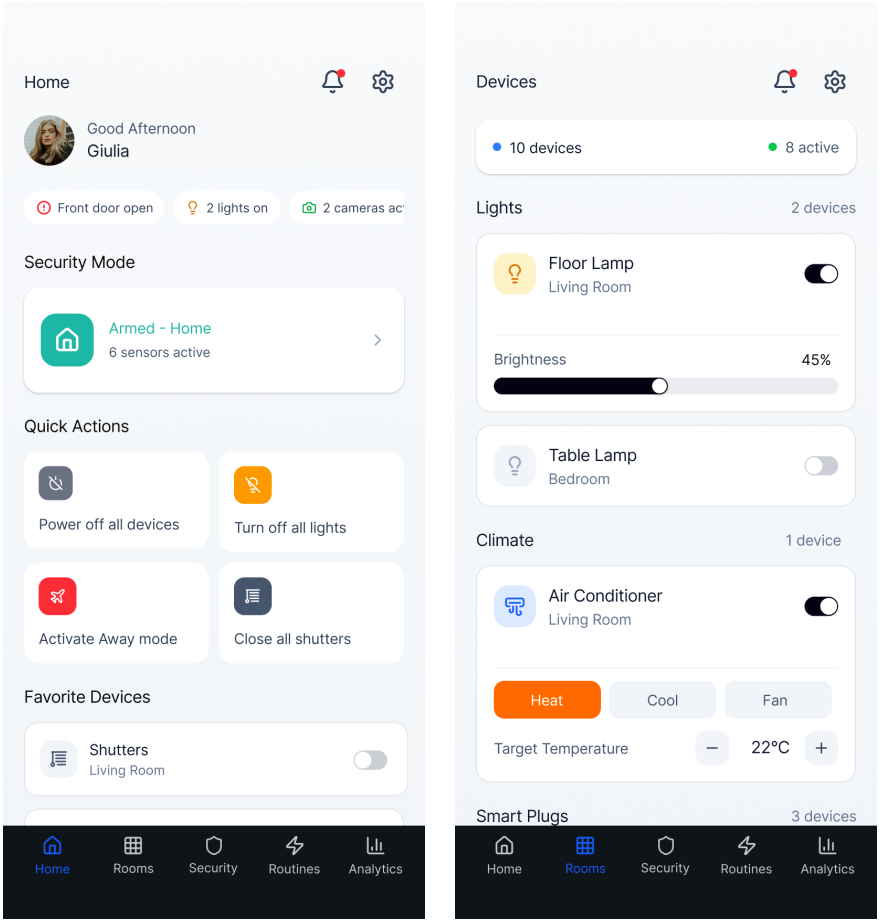


Figure 2.5: The 2025 structural redesign by Ghorbani, introducing a light theme and a simplified five-tab navbar.

This redesign introduced a clean, light theme with a card layout that significantly improved the visual hierarchy. By grouping elements into logical containers, the 2025 iteration established the essential flows for navigating room spaces and managing basic domestic routines.

2.3.2 Elevating the Design

While Ghorbani's 2025 redesign established the overall structure and basic logical flow of the application, there remained significant opportunities to elevate the application from a flat interface to an ergonomic, polished, and brand-aligned system. A critical review of this intermediary design (referencing Figures 2.5 and 2.8) identified the following areas for advanced refinement:

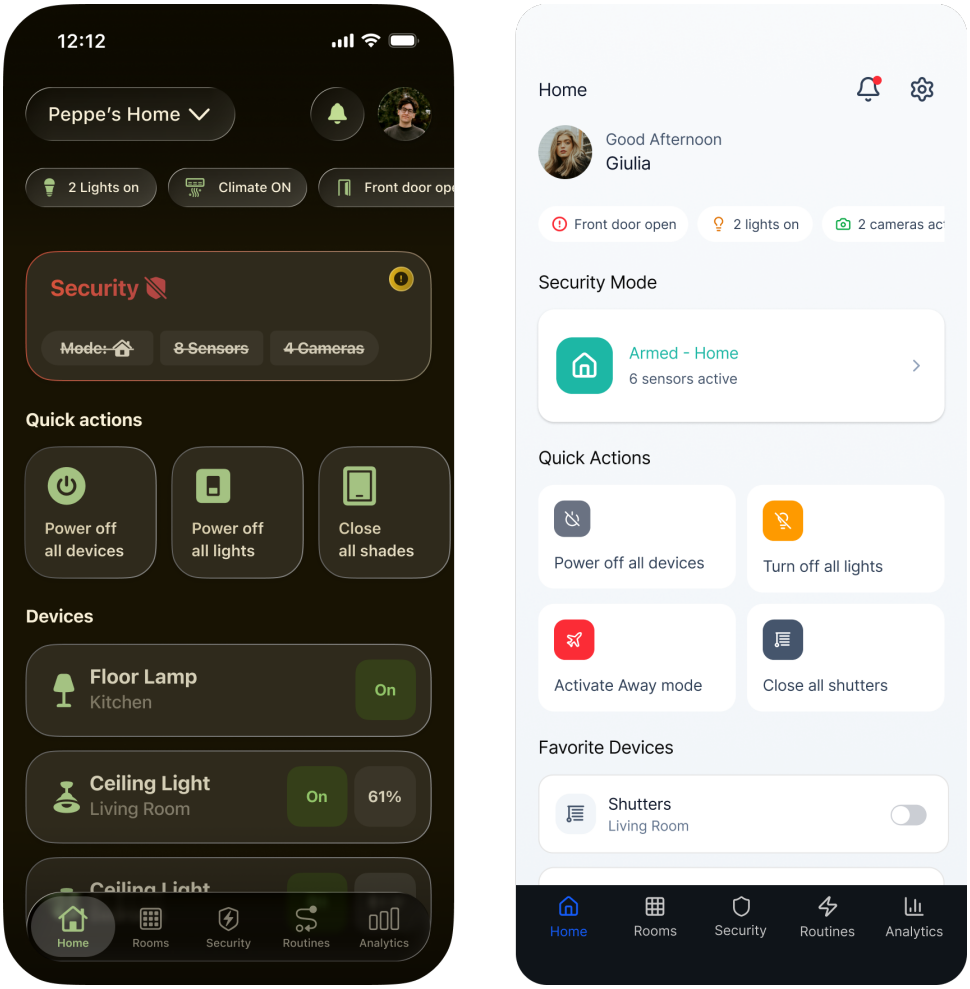


Figure 2.6: Visual comparison between the 2025 light-themed baseline (left) and the proposed ergonomic dark theme (right).

- **Aesthetic Evolution and Eye Strain:** As seen in Figure 2.5, the entirely light-themed interface did not account for the specific environmental context of smart home usage, which is often accessed first thing in the morning or late at night from a dark bedroom. Transitioning to an ergonomic, warm-dark theme (Figure 2.6) is necessary to reduce visual fatigue[16] and project a cohesive, privacy-oriented brand identity.

- **Interface Decluttering via Gestural Interaction:** The 2025 redesign lacked modern, intuitive gestural interactions (such as long presses), which hide secondary administrative actions (like editing or deleting routines) until needed, maintaining a clean visual environment (Figure 2.7).

- **Progressive Disclosure and Gated Logic:** While the scheduling forms (Figure 2.8) were structurally correct, they presented all inputs (devices, modes, temperatures, and times) simultaneously. This can induce cognitive overload for non-technical users. The interface requires *Progressive Disclosure*[17] and gated logic, where subsequent options only appear

after a primary selection (such as the target room) is made.

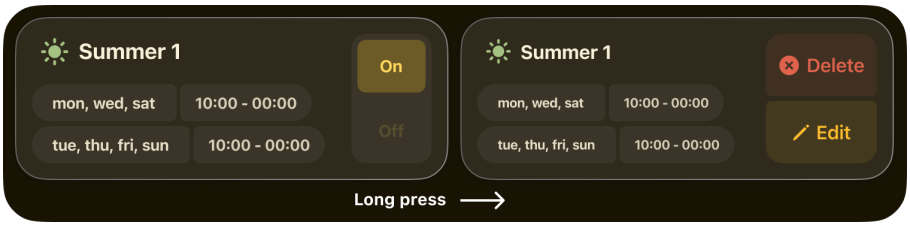


Figure 2.7: Gestural interaction: long-pressing an item (such as an automation routine) reveals contextual edit and delete controls without cluttering the persistent UI.

By adopting Ghorbani's five-tab navigation and core user flows as a starting point, this redesign focuses on these advanced interaction paradigms, delivering detailed page hierarchies, contextual overlays, and an ergonomic visual design system.

Furthermore, Ghorbani's work attempted to clarify the notoriously complex process of creating automated routines and schedules based on time (Figure 2.8). By separating "Schedules" and "Automations" into distinct views, the redesign provided a useful separation of mental models, utilizing a guided form-based approach to configuration that was completely absent in the original engineering prototype.

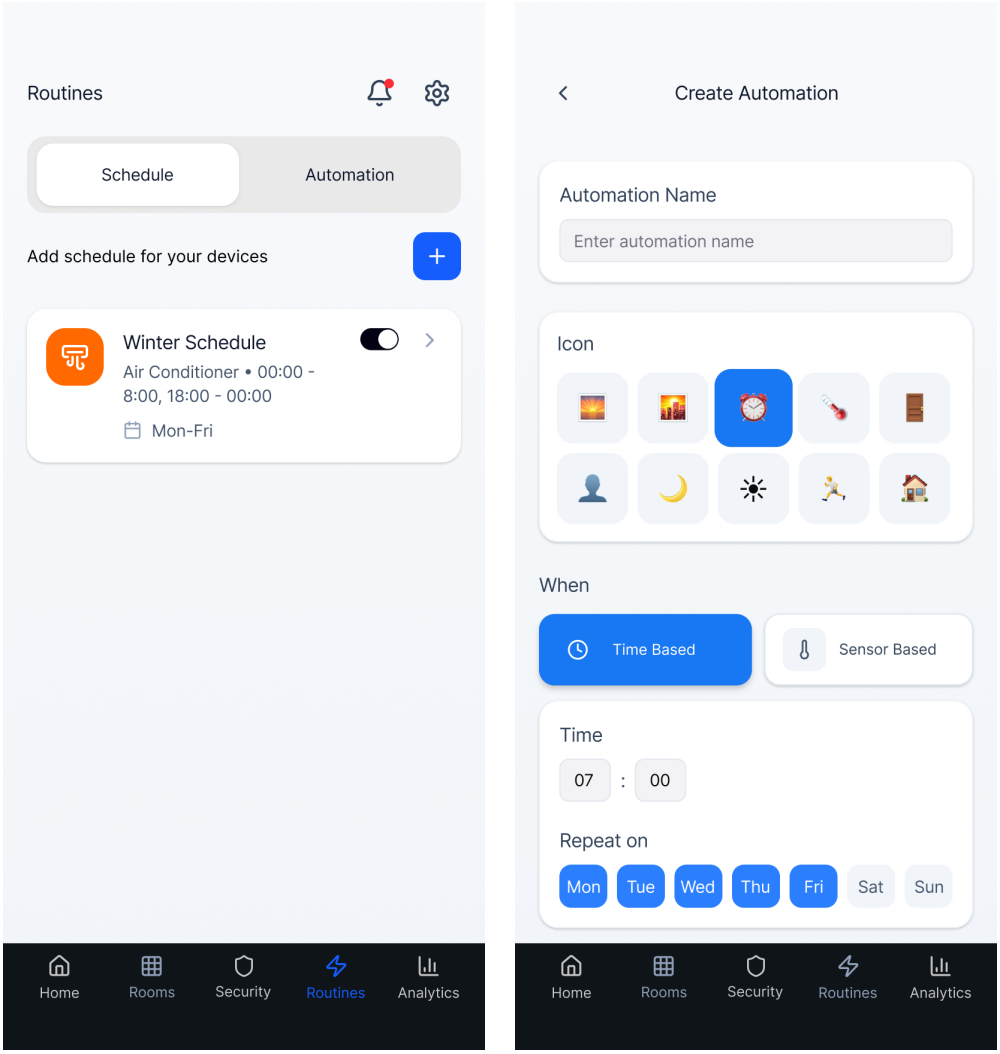


Figure 2.8: Ghorbani's 2025 approach to automation, utilizing separate views and structured form-based input screens.

2.4 Target Audience and User Personas

Having investigated the market context, established UX heuristics, and critiqued the baseline application, now it is time to define exactly who the target users are and what they are trying to achieve. This section establishes the strict behavioral and functional parameters that will guide the subsequent ideation and prototyping of the new Smartotum interface.

To contextualize the usability challenges identified in the baseline review and to ensure that the new interface remains deeply aligned with human needs, two distinct User Personas were developed. These, derived from market demographics and user behavior research, represent the archetypal Italian smart home users. They capture complementary usage patterns, varying levels of technological proficiency, and differing psychological expectations regarding automation.

Persona 1: The Efficiency-Driven Professional

Giulia Colosseo is a 34-year-old Data Analyst living in Turin. She represents the primary, highly tech-proficient user profile. As an analytical professional with a busy lifestyle, Giulia views the smart home as a tool for ultimate efficiency, optimization, and remote management.

- **Goals:** Giulia wants to control and monitor all her devices from one unified application, eliminating the frustration of switching between multiple apps from different brands. She is highly interested in tracking and reducing her household energy consumption. She relies heavily on automated routines (such as a "Leave Home" scene) to handle repetitive tasks quickly.
- **Frustrations:** She is easily frustrated by interfaces that are overly complex, visually cluttered, or require too many steps to perform simple actions. She dislikes the lack of clear visual hierarchy in her current apps, which prevents her from checking the status of her home at a glance.
- **Design Implication:** For Giulia, the interface must prioritize speed, efficiency, and data visualization. Quick actions must be instantly accessible from the home dashboard, and energy analytics must be presented in a clean, legible format.

Persona 2: The Comfort-Oriented User

Marco Lombardelli is a 51-year-old high school teacher. He represents the secondary user profile: a family-oriented individual with medium technological proficiency. Marco is not interested in complex technology for its own sake; rather, he values comfort, reliability, and security.

- **Goals:** Marco wants things to work smoothly without having to spend time figuring them out. His primary use cases involve controlling the heating schedule, adjusting lighting for comfort, and ensuring the physical security of his home at night. He wants to feel confident that the system is armed and running as expected.
- **Frustrations:** Marco is intimidated by complicated interfaces and unclear technical terminology. His biggest pain point is uncertainty, when he performs an action, he becomes anxious if the system does not explicitly confirm that the action was completed.
- **Design Implication:** For Marco, the interface must prioritize clarity, reassurance, and straightforward control. Important actions, like security modes, must be large, clearly labeled, and

accompanied by immediate, unambiguous visual feedback (such as color shifts and confirmation text).

These two personas establish a dual mandate for the redesign: the new Smartotum application must be advanced enough to satisfy Giulia's need for efficiency and analytics, yet accessible and reassuring enough to provide Marco with a calm sense of control.

2.5 User Scenarios in Context

While User Personas define *who* the users are, User Scenarios define *how* they interact with the system in realistic, everyday situations. By mapping these contextual narratives, we can identify specific interaction friction points and directly extract functional and design requirements. The following scenarios illustrate how Giulia and Marco interact with the Smartotum ecosystem.

Scenario 1: Giulia's Quick Departure and System Control

Before leaving for work in a rush, Giulia opens the Smartotum application to ensure her home is secure and energy efficient. Instead of navigating through individual rooms to check devices, she utilizes the **Quick Actions grid** (Figure 3.9) on the main dashboard, simply tapping the "Power off all lights" command. This single action immediately updates the system. She then briefly navigates to the Security tab to activate the "Away" mode. The system presents a brief confirmation popup to ensure no one is left inside, which she approves, leaving her feeling reassured and in control.

Design Implication: The interface must provide a clear overview dashboard with prominent global commands (Quick Actions) to perform tasks almost instantly, minimizing navigation depth and interaction cost.

Scenario 2: Giulia Analyzes Her Energy Consumption

During the weekend, Giulia wants to understand her recent electricity costs to optimize her usage. She navigates to the newly integrated **Analytics tab**. Instead of raw, contextless wattage data, she is guided through a brief onboarding wizard where she selects her specific Italian energy billing plan (e.g., a plan with several F1/F2/F3 rates). The application then presents a clear, color-coded stacked bar chart summarizing her actual estimated costs in Euros.

Design Implication: Complex data must be localized and translated into tangible, human-readable financial insights, utilizing progressive disclosure (wizards) to prevent onboarding fatigue.

Scenario 3: Marco Automates His Morning Comfort

Marco wants his bedroom shades to open automatically when he wakes up. He navigates to the **Routines hub** and switches to the **Automations** tab. Rather than dealing with complex, developer-oriented "If this happens, then do that" logic, he simply locates the "Morning shades up" automation card, which is logically grouped under the "Bedroom" room. He taps the large, tactile toggle to activate it.

Design Implication: Conditional logic should be grouped spatially (by room) and utilize explicit, conversational data tags and immediate visual feedback to make automation accessible to non-technical users.

Scenario 4: Marco Configures a Cooling Schedule

On a warm Saturday morning, Marco decides to configure a new cooling schedule for the living room. He navigates to the **Schedules** tab and taps "New Schedule." The interface uses gated logic, prompting him to "Select room first" before choosing a device. This prevents him from accidentally selecting the bedroom air conditioner. He then uses the intuitive temporal stacking buttons to set the cooling times for the weekend and saves the schedule.

Design Implication: Complex configuration tasks must employ error prevention (such as gated dropdowns) and direct manipulation to minimize cognitive effort and choice paralysis.

2.6 Core Design Principles

Based on the theoretical UX principles discussed in Section 2.2, the baseline analysis, the personas, and the user scenarios, six project-specific design principles were established. These principles translate the research findings into concrete guidelines for the Smartotum redesign and guide the subsequent *Ideate* and *Prototype* phases.

1. **Simplicity and Cognitive Ease:** Smartotum must present the most important information and actions first. The Home dashboard should provide a clear overview, while secondary controls should remain available without competing with the user's main task.

2. **Visual Hierarchy and Readability:** The interface must distinguish clearly between primary actions, system status, and supporting information through typography, spacing, and color. Security state and urgent feedback must be immediately visible on the relevant screen.

3. **Consistency and Predictability:** Repeated components must behave consistently across Home, Rooms, Security, Routines, and Analytics. Terminology, navigation patterns, tog-

gles, cards, and confirmation states must follow the same interaction logic throughout the application.

4. **Feedback and System Transparency:** Each important action must provide a visible response that confirms the result or explains what remains to be done. Existing confirmation overlays for security actions must be retained, while status changes and system events must remain easy to interpret.

5. **Accessibility and Inclusiveness:** The interface must support both the efficiency-driven user and the comfort-oriented user. Labels, touch targets, contrast, and terminology should remain understandable for users with different levels of technical familiarity and visual acuity.

6. **Aesthetic Coherence and Brand Alignment:** The visual system must express Smartotum's identity through a cohesive dark theme built upon deep gold surfaces, clear typographic hierarchy with bold section headers and titles, greenish functional icons and active state indicators, warm golden accents, and balanced spacing. These choices support glanceability, visual comfort, and user trust rather than functioning as superficial decoration.

2.7 Functional and Non-Functional Requirements

The user scenarios and design principles must be translated into explicit system requirements. These requirements act as the definitive checklist against which the final Smartotum prototype will be evaluated.

Functional Requirements (FR)

Functional requirements define the specific tasks, operations, and interactions that the application must enable users to perform. They are directly derived from the needs of the user personas and the core capabilities of the Smartotum hardware ecosystem.

Non-Functional Requirements (NFR)

Non-functional requirements define *how* the system must behave, ensuring that its usability, performance, and aesthetic quality support an optimal and reassuring user experience.

ID	Requirement	Description	Rationale
FR-01	Dashboard Overview	The user shall view the status of connected devices, climate, and security modes on a single unified dashboard.	Giulia's need for a quick morning overview without deep navigation.
FR-02	Scene Activation	The user shall be able to activate predefined scenes (e.g., Leave Home, Night) with a maximum of two taps.	Supports rapid, reflexive actions for both personas.
FR-03	Device Control	The user shall be able to control individual devices (on/off, brightness, temperature) from dedicated room views.	Marco's requirement for granular, straightforward environmental control.
FR-04	Scheduling & Automation	The system shall allow visual creation, modification, and deletion of schedules and conditional triggers.	Simplifies complex automation for nontechnical users.
FR-05	Analytics Visualization	The user shall access graphical representations of energy consumption over selected timeframes.	Addresses Giulia's goal of optimizing household energy efficiency.

Table 2.1: Core Functional Requirements for the Smartotum Redesign.

ID	Requirement	Description	Design Principle
NFR-01	Usability	The interface must be intuitive, requiring minimal learning effort for first-time users.	Simplicity and Cognitive Ease.
NFR-02	Feedback Responsiveness	The interface design shall incorporate immediate visual state feedback, targeting an interaction response within 1 second of user input (to be formally validated upon production implementation).	Feedback and System Transparency.
NFR-03	Accessibility	Component colors, typography, and contrast pairings are designed referencing WCAG 2.1 AA standards[18] for readability (with full automated audit required on live code).	Accessibility and Inclusiveness.
NFR-04	Visual Coherence	The UI must maintain consistent spacing, bold typographic hierarchy, and iconography across all screens.	Consistency and Brand Alignment.

Table 2.2: Core Non-Functional Requirements for the Smartotum Redesign.

System Design and High-Fidelity Prototype

Having clearly defined the problem and established requirements in the previous chapter, this phase explores how the Smartotum application can be structurally reorganized to deliver clarity, reliability, and simplicity in daily use.

The primary goal of this phase is not to design the final visual aesthetics, but rather to establish the functional skeleton of the application. Visualizing these early structural concepts helps bridge abstract requirements with tangible interaction logic, enabling the validation of navigational hierarchies before committing to a detailed implementation.

3.1 Concept Development and Affinity Mapping

To synthesize user needs, pain points, and functional requirements into a cohesive design direction, an affinity mapping exercise was conducted. The redesigned application largely retains the information architecture and main interaction structure introduced by Ghorbani in 2025. The affinity mapping therefore focused on identifying targeted refinements rather than replacing that structure.[7] The mapping highlighted four key themes that guided the visual and interaction refinements:

1. **Aesthetic Evolution:** The bright, light-themed UI causes eye strain in typical smart home use cases (e.g., early morning or late night). The interface must adopt an ergonomic dark theme with deep gold backgrounds and warm golden accents to align with the Smartotum brand and ensure visual comfort.

2. **Interface Decluttering:** The five-tab navigation and main screen structure from Ghorbani's redesign are retained. The principal interaction change is the implementation of contextual gestures, such as long presses, for administrative actions that were previously accessed through the standard interaction flow.

3. **Step-by-Step Logic:** Configuration forms that present all inputs simultaneously cause cog-

nitive overload. Automation creation must be redesigned using a step-by-step process, such as requiring room selection before device selection.

4. **Enhanced Analytics Setup Process:** Energy insights must go beyond raw consumption graphs. The Analytics module must be enhanced with a guided onboarding wizard, enhancing the transparency of energy consumption data.

3.2 The Information Architecture

To address the cognitive overload caused by the original engineering prototype's seven-item navigation bar, Ghorbani (2025) introduced a five-tab navigation system organized into five primary sections.[7] This thesis adopts Ghorbani's five-tab system as a functional starting point, but significantly extends and details the underlying sub-page hierarchies, spatial mapping, and contextual modal layers, as summarized in the five core destinations:



Figure 3.1: The five-tab global navigation bar proposed by Ghorbani (2025).

- **Home:** The central dashboard featuring important modules: Security Overview, Quick Actions, Climate summary, and Room overviews.
- **Rooms:** A view for each room, featuring all devices in that space, including climate controls.
- **Security:** A dedicated main hub for safety, housing Modes, Sensors, and Camera feeds.
- **Routines:** A dedicated environment for automation, divided into triggers based on time (Schedules) and conditions (Automations).
- **Analytics:** An interactive space for energy consumption tracking and localized tariff calculations.

Across the primary dashboard views, the global application header retains and refines the *Notifications* bell and *Profile/Settings* button, ensuring quick access to asynchronous alerts and account preferences without cluttering primary task flows or consuming bottom navigation space. Specialized environments, such as the Analytics hub onboarding, intentionally omit these utility controls to maintain single-task focus.

Figure 3.2 visualizes the complete redesigned Information Architecture (IA), illustrating the structural hierarchy, primary functional modules, contextual modal layers, and guided configuration flows across all five core destinations.

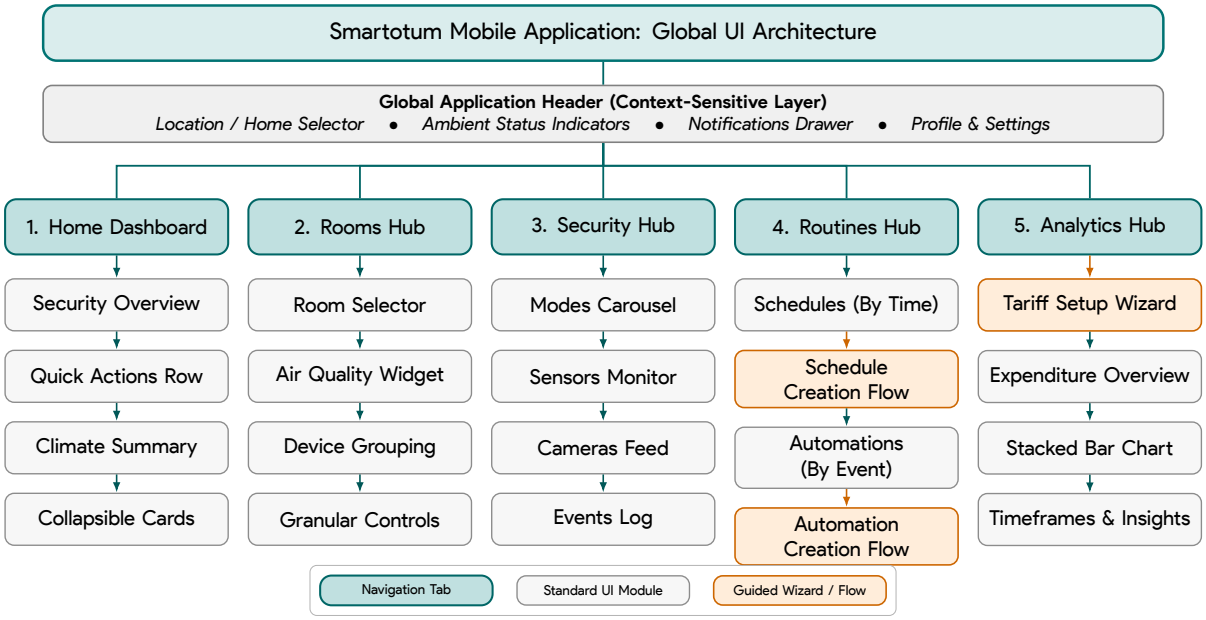


Figure 3.2: Information Architecture of the redesigned Smartotum application, detailing the five primary functional destinations, second-tier UI modules, and contextual configuration flows.

3.3 User Flows and Advanced Interaction Logic

To ensure the application logically supports daily domestic routines, this redesign adopts the baseline behavioral pathways originally explored by Ghorbani (2025). These flows establish foundational pathways for recurring domestic tasks.[7]

However, the *interaction logic* within these flows has been substantially enhanced. The revised flows integrate advanced UI paradigms, specifically gestural management, progressive disclosure, and error prevention precautions:

Flow 1: **Executing a Global Command ("Power off all lights").** This flow models Giulia's rapid departure sequence. The flow prioritizes the "Quick Actions" grid directly on the Home dashboard rather than burying controls within room specific menus. The interaction is executed with a single tap on the command card, which immediately updates its visual state, providing clear visual feedback with minimal interaction cost.

Flow 2: **Activating "Away" Security Mode.** This flow models securing the domestic perimeter. Starting from the Home dashboard, the user navigates to the Security hub and selects "Away" mode. Instead of instantly arming the system, this flow introduces a contextual

confirmation modal. The dialog explicitly confirms perimeter status ("Make sure no one is still inside") and lists the sensors to be armed, providing error prevention and psychological reassurance before arming.

Flow 3: **Enabling an Automation for One Room.** Illustrating automated domestic comfort, this flow maps the journey to enable the "Morning shades up" routine. The user navigates to Routines → Automations. Relying on spatial mental models, the user locates the "Bedroom" container and taps the tactile toggle next to the routine card, receiving immediate visual state confirmation.

Flow 4: **Creating a New Cooling Schedule.** This flow addresses complex automation configuration. Marco accesses Schedules → "New schedule." The redesigned flow introduces *Gated Device Selection and Temporal Stacking*, guiding the user through a progressive UI that requires selecting the physical room ("Living Room") before the device dropdown unlocks. This eliminates choice paralysis and prevents assigning cooling rules to devices in the wrong room.

Figure 3.3 illustrates the complete decision logic and feedback stages of Flow 4, detailing how gated selection and temporal stacking prevent configuration errors.

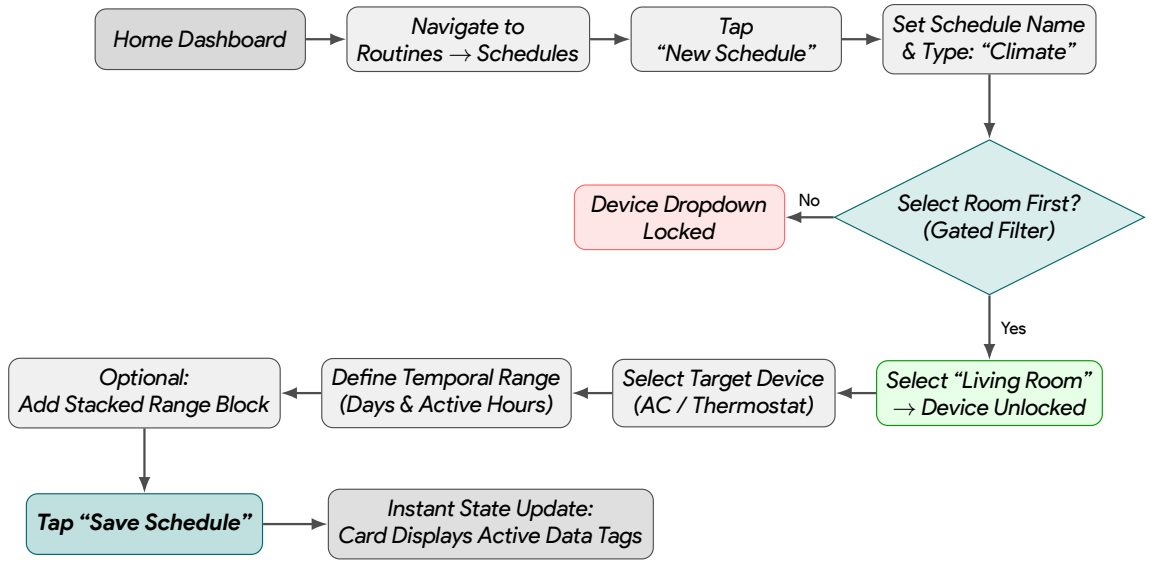


Figure 3.3: User flow for configuring a complex cooling schedule (Flow 4), demonstrating gated spatial filtering, error prevention, and stacked temporal logic.

3.3.1 Gestural Interaction and Decluttering

A key interaction design decision in this detailed prototype is the removal of persistent administrative buttons across dashboard cards. In previous iterations, administrative buttons cluttered

card headers, increasing visual noise and distracting from primary monitoring and control tasks.

To achieve a higher level of *Aesthetic and Minimalist Design*, the interface relies on a globally applied **long press gesture**. Whenever a user wishes to edit, reorder, or delete an element (such as a security mode, a routine, or a device), performing a long press on the relevant card surfaces contextual actions. This approach leverages established mobile OS mental models, keeping the interface visually clean during everyday monitoring while preserving full user control when adjustments are required.

3.4 Visual Design System and High Fidelity Prototype

A significant evolution in this iteration of the interface is the transition to an ergonomic and brand-aligned visual design system. Moving away from generic flat interfaces, the UI establishes a cohesive aesthetic foundation built on deep gold surfaces, structured typography, and deliberate accent colors (Figure 3.4). This specific palette substantially reduces eye strain in low-light environments, such as during morning or late-night domestic check-ins, while projecting a modern, trustworthy visual identity.[16]

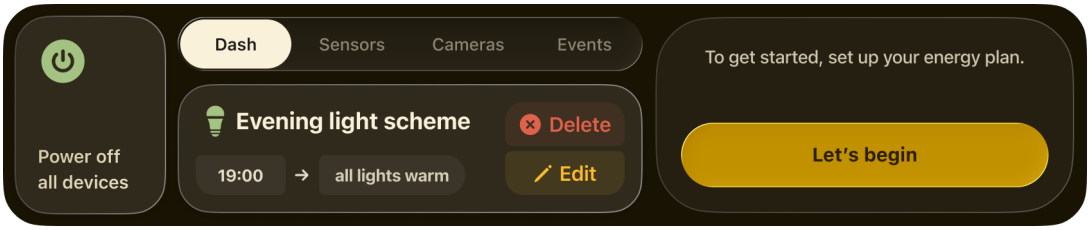


Figure 3.4: The visual design system showing color palette, typography hierarchy, and UI component styling.

3.4.1 Color Palette and Chromatic Hierarchy

- **Deep Gold Foundational Surfaces:** The app canvas utilizes a deep, warm dark gold background with darker gradients on top and bottom sides, complemented by cards with subtle translucent borders. This avoids the harshness of pure white/black interfaces, creating an ambient domestic warmth.

- **Greenish Functional Accents:** To make the redesign coherent with the Smartotum branding, a distinctive greenish hue serves as the primary functional accent across the interface. Rather than being purely decorative, this is systematically applied to actionable iconography (such as the quick action triggers and lighting fixtures), active state indicators (such as the illuminated "On" button pills), key environmental telemetry figures, and the active nav-

igation tab. This provides an organic, positive visual cue that immediately guides the user's attention toward operable controls and positive system states.

- **Warm Golden Highlights and Steppers:** Refined golden accents are employed for secondary interactions, card framing, segmented tab indicators, and tactile adjustment controls (such as the climate temperature stepper).
- **High-Contrast Semantic Alert Colors:** Critical alerts are strictly demarcated from routine operations: red is reserved for security warnings and alert headings, while amber yellow is applied to exclamation badges indicating sensor anomalies or conditions to be checked.

3.4.2 Typographic Hierarchy and Information Density

To minimize cognitive friction, typography is structured into explicit weight layers that support easy scanning:

- **Bold Headers and Icons:** All major section headings (e.g., *Quick actions*, *Devices*, *Climate*, *Lights*, *Others*) and individual card titles (e.g., *Floor Lamp*, *Ceiling Light*, *Thermostat*, *Humidity*, *Air quality*) are rendered in bold typography. This creates immediate visual landmarks, allowing users to scan the screens effortlessly.
- **Regular-Weight Metadata for Hardware Transparency:** Secondary technical metadata, such as hardware manufacturers (*Xiaomi Yeelight*, *Philips Hue*, *Vimar GSM*) and spatial room tags (*Kitchen*, *Living Room*), is rendered directly beneath the primary label in regular font weight and muted tones. This ensures that technical details are easily accessible for hardware verification without cluttering the primary cognitive flow.
- **Oversized Bold Telemetry Display:** Key environmental measurements employ an oversized, bold typographic scale in the signature greenish tone (e.g., the prominent **46** for humidity and **345** for air quality), paired with smaller unit labels (% RH, ppm). This high-contrast typographic treatment adheres to the principle of glanceability, enabling users to verify ambient indoor comfort from a distance with zero interaction cost.

3.4.3 The Home Dashboard

The Home screen serves as the primary control hub and the user's first point of contact with the Smartotum ecosystem. In the original prototype, this screen functioned merely as a repository of raw functional data. The redesigned Home dashboard restructures this paradigm, transforming

the screen into a contextual, priority-driven interface that adheres to the UX heuristics of *Flexibility and Efficiency of Use* (Figure 3.5).

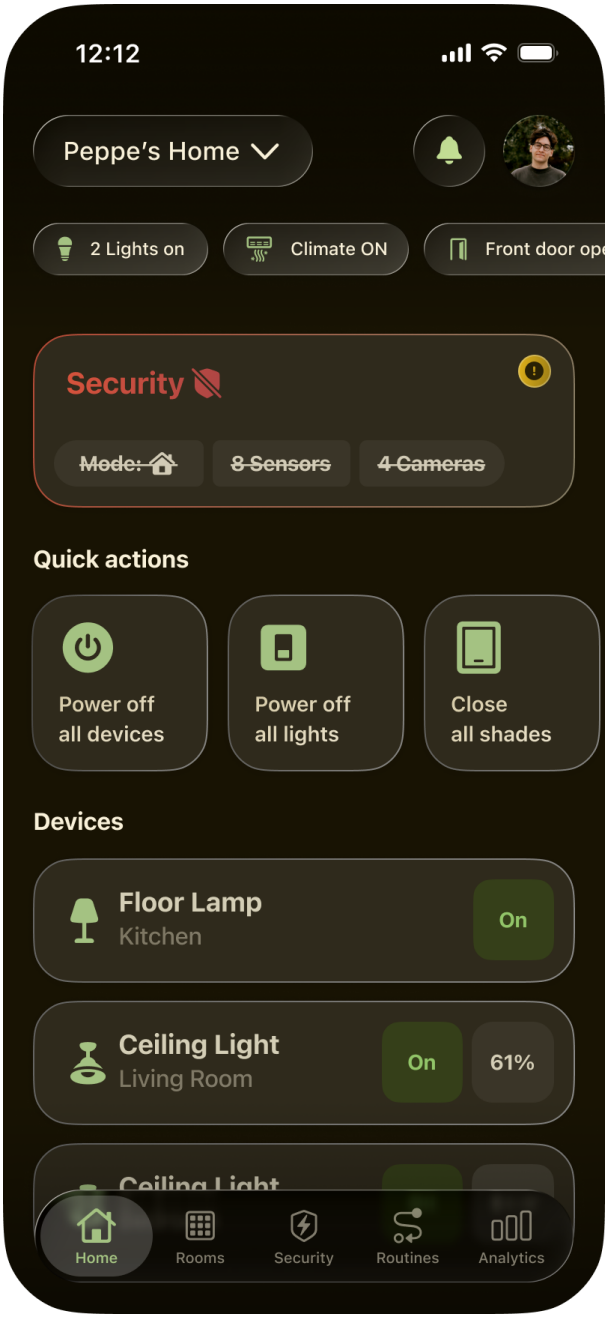


Figure 3.5: The redesigned Home dashboard control hub.

By prioritizing high-frequency actions and safety summaries, the dashboard delivers an immediate overview of active devices, domestic comfort levels, and perimeter status. Users can verify domestic conditions at a glance or trigger immediate whole-home actions without navigating through secondary hierarchies.

3.4.4 The Global Header

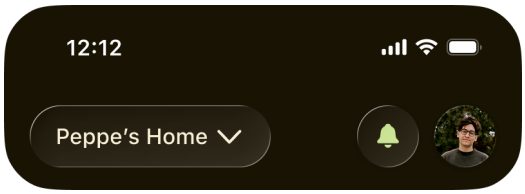


Figure 3.6: Global application header.

Directly above the status pills sits the redesigned global application header. In the baseline prototype, "Notifications" and "Settings" were positioned in the bottom navigation bar, cluttering ergonomic space with infrequent administrative actions.

To resolve this, utility touch targets were relocated to the top of the interface across primary hubs (Home, Rooms, Security, and Routines). The header pairs a translucent property dropdown with two familiar touch targets: the **Notification Bell** for alerts and the **User Profile** for account settings, adhering to *Jakob's Law*.[19] Notably, this top bar is not universally persistent: focused environments such as the Analytics hub and configuration wizards omit it to eliminate distraction and preserve single-task focus.

3.4.5 System Status Overview



Figure 3.7: The redesigned system status bar.

At the top of the interface, beneath the header, a horizontally scrollable row of Status Pills (e.g., "2 Lights on", "Climate ON", "Front door open") provides an ambient environmental overview. Each pill integrates a distinctive greenish icon (such as a light bulb or air conditioner) with clear text, encased in a frosted-glass container.

3.4.6 The Security Summary Module

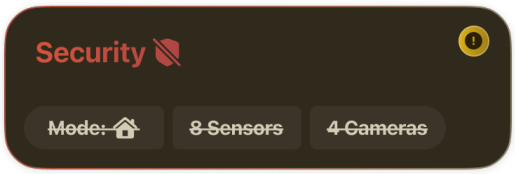


Figure 3.8: Security summary module, in error status.

Following the insights gathered during the contextual analysis, the Security module (presented here in a “error“ status) remains elevated at the top of the visual hierarchy. The card features a bold header paired with a disarmed/armed status icon, alongside an status-dependent amber alert badge for immediate issue recognition. Dark pills provide a concise breakdown of system active mode, number of sensors and cameras currently active. As the 2025 redesign, this layout elevates the Smartotum’s security-first approach.

3.4.7 Quick Actions Row

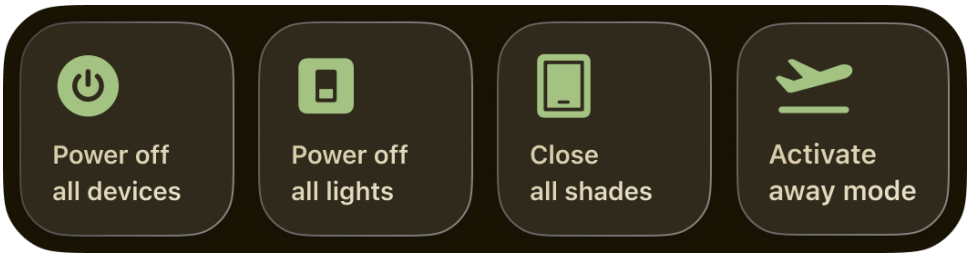


Figure 3.9: Customizable quick-actions row for rapid execution of macro commands.

Beneath the Security module lies the **Quick Actions** section, composed of rounded squared cards dedicated to customizable macro-commands, (such as “Power off all devices”, “Close all shades”). Each card features a greenish icon, to visualize the action, set above action text. By grouping these global triggers into an easily accessible, scrollable single row, the interface acts as an operational shortcut, reducing the interaction cost required to secure the home before leaving or retiring for the night.

3.4.8 Dashboard Collapsible Widgets

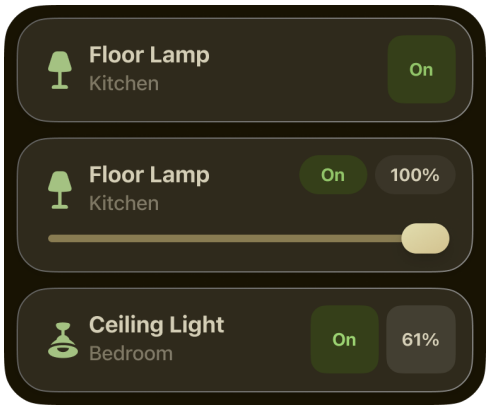


Figure 3.10: Collapsible device cards.

The Home dashboard presents **Collapsible Device Widgets**. To prevent cognitive overload,

the design employs the HCI principle of *Progressive Disclosure*. Each device card pairs a distinctive greenish fixture icon related to the device type, with a bold, customizable device title (e.g., “Floor Lamp”, “Ceiling Light”). Beneath the bold name, the specific domestic space (e.g., “Kitchen”, “Living Room”) is displayed in muted typography for immediate context.

On the right side, big primary operational controls are illuminated in red or green, based on the “On/Off” status, alongside real-time dimming percentages (e.g., “61%”). Tapping the card smoothly expands the widget to reveal granular controls, including the brightness slider and color picker (opening to system color picker), without requiring navigation to a dedicated sub-screen.

3.4.9 Redesigned Global Navigation

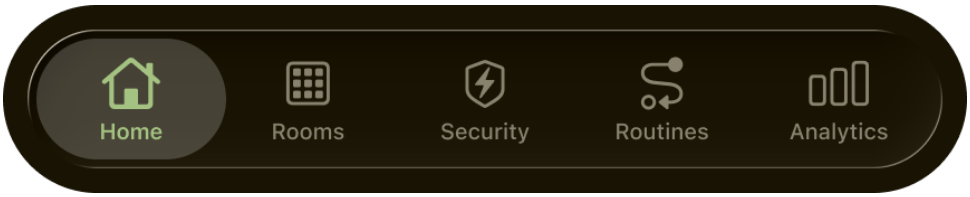


Figure 3.11: Redesigned five-tab global navigation bar.

The navigation bar was redesigned to modernize the interface and anchor the information architecture with a contemporary layout. The bar keeps the previous five core destinations: *Home, Rooms, Security, Routines, Analytics*. Explicit text labels accompany recognizable icons. The active tab is highlighted by a greenish icon and label on a lighter pill-shaped background, while other tabs are rendered in a muted tone.

This redesign substantially reduces cognitive friction and enhances interaction ergonomics, compared to the previous design’s low-contrast dark blue on dark background.

3.5 The Room Overview

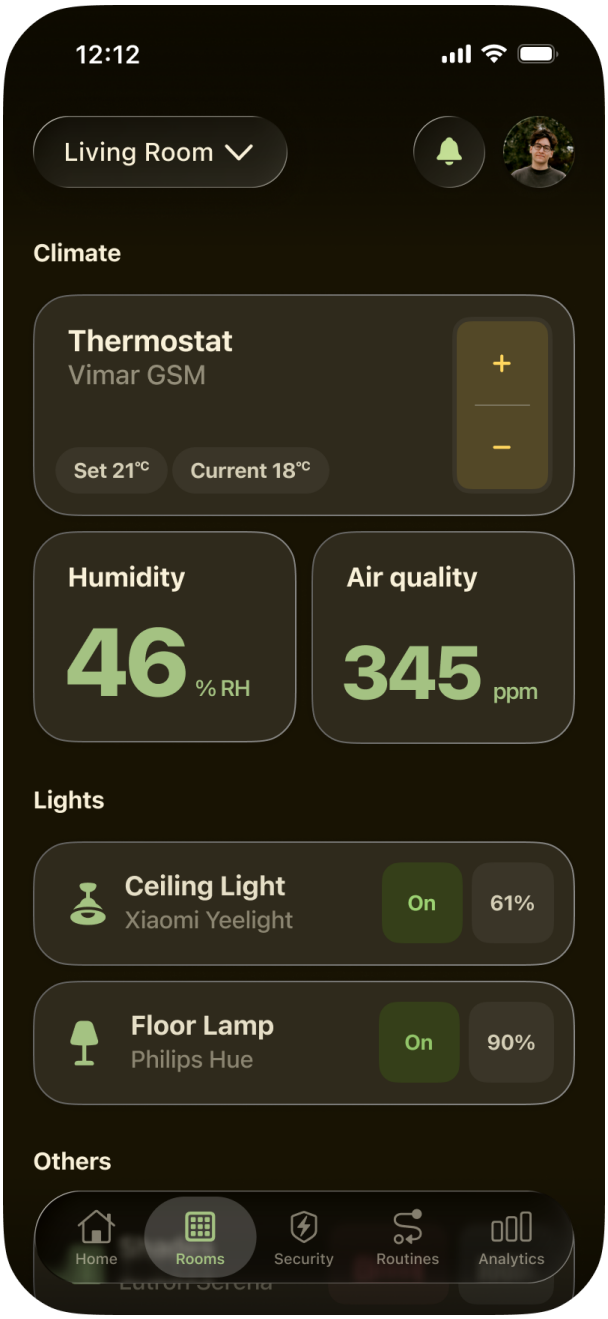


Figure 3.12: Room overview organized by physical domestic spaces.

While the Home dashboard provides a macro-level overview of the entire home, the Room page provides granular control over devices within a specific physical space. The redesigned interface anchors navigation to a spatial mental model, adhering to the HCI heuristic of a *Match Between the System and the Real World*.

While the previous redesign displayed all devices in a single view with room tags, the new approach introduces a dedicated room selector in the header (Figure 3.13), ensuring each view

exclusively displays room-specific devices.

Ghorbani's "active devices" summary bar was removed, as it cluttered the interface with secondary information.

3.5.1 Rooms Navigation Header

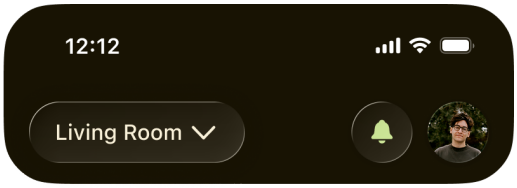


Figure 3.13: Contextual room header with interactive dropdown for easy room navigation.

To ensure consistency, the header's transparent selector adapts into a room switcher while preserving the notification and settings buttons. The dropdown allows for immediate navigation between spaces. This reduces interaction cost and supports the heuristic of *Flexibility and Efficiency of Use*.

The rooms list dynamically changes, based on the specific property selected in the home header.

3.5.2 Climate and Air Information

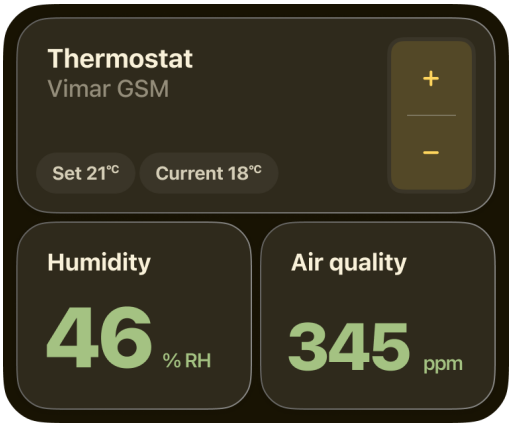


Figure 3.14: Climate control stepper and ambient environmental telemetry cards.

The uppermost module within the room view is dedicated to climate and environmental health, establishing a clear hierarchy of physiological comfort:

Thermostat Control: The Thermostat card pairs a bold title with hardware brand subtitle. Explicit frosted status pills distinguish between the target setting ("Set 21°C") and current reading ("Current 18°C"). Temperature adjustments are executed via a large vertical stepper block on the right side, containing tactile controls in a golden container.

Passive Data Cards: Directly beneath the thermostat, environmental metrics are presented in two dedicated cards labeled with bold headers (*Humidity* and *Air quality*), displaying environmental readings using bold numerals in a greenish accent for immediate and clear visibility.

3.5.3 Device Management and Native Integrations



Figure 3.15: Room-level device management with contextual controls and status indicators.

The lower section of the screen organizes specific hardware under distinct bold category headers (e.g., **Lights**). It adopts the identical collapsible card pattern introduced on the Home, ensuring *Consistency and Standards* across the application:

Default State: The card highlights the fixture with a distinctive greenish icon with a bold customizable title (such as a pendant lamp or floor lamp), followed by a bold device name (e.g., "Ceiling Light", "Floor Lamp"). A secondary subtitle in regular weight displays the exact hardware model (e.g., "Xiaomi Yeelight", "Philips Hue"). Active states are immediately visible via the green "On" button and real-time brightness percentage tag (e.g., "61%", "90%").

Expanded State: Tapping the card expands the container, revealing granular controls such as the continuous brightness slider and light color picker.

3.5.4 Hardware Transparency and Ecosystem Trust

Being in a specific room, device hardware model name is explicitly displayed under the custom title (such as "Xiaomi Yeelight" or "Philips Hue") bridging the gap between the Smartotum platform and third-party hardware. This reduces perceived fragmentation and builds ecosystem trust, assuring users that disparate smart devices operate cohesively under a unified visual language.

3.6 The Security Hub

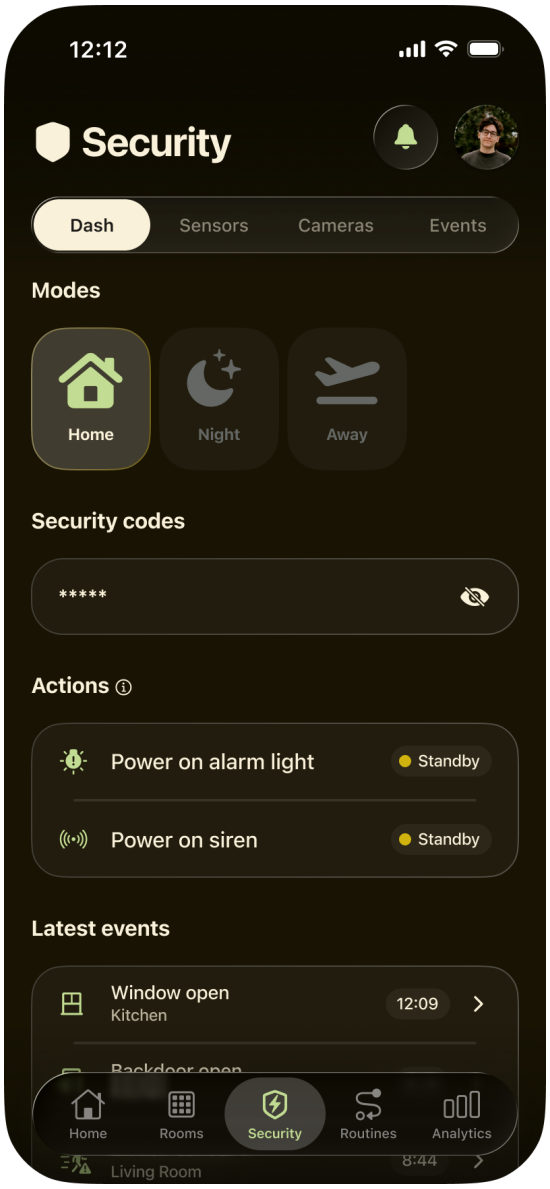


Figure 3.16: Security hub dashboard overview.

The baseline analysis of the original Smartotum application revealed a profound misalignment between user priorities and interface architecture. Domestic security is arguably the most psychologically sensitive aspect of smart home management; users require immediate reassurance and absolute clarity. The old application relegated security features to fragmented, deep-level menus, presenting alarms and sensors as plain, unstructured lists indistinguishable from basic lighting controls. Ghorbani's redesign established an organized foundational structure, which this work further refines and reorganizes.

3.6.1 Dash and Modes

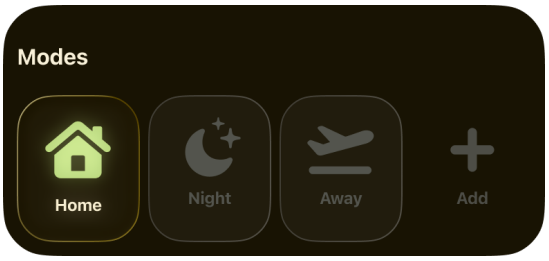


Figure 3.17: Modes selector.

The ”Dash” view acts as the macro control centre for the home’s security. It is specifically designed to accommodate the comfort-oriented persona (Marco), who requires straightforward interactions.

At the top of the Security hub, a pill-shaped segmented control divides the ecosystem into four distinct sub-views (Dash, Sensors, Cameras, Events). The active ”Dash” tab is highlighted using a warm white tone.

The Modes Module and Contextual Overlays

The redesigned mode cards are arranged in a horizontal carousel rather than a rigid grid, ensuring a cleaner interface. When active, the selected mode (e.g., Home) illuminates with a golden border accent and greenish icon, providing an immediate, high-contrast visual cue. By using large touch targets paired with universally recognised iconography, the interface leverages Fitts’s Law, reducing the physical effort required to engage the system.[20]

Crucially, the interaction flow for activating these modes introduces a layer of **Error Prevention**. Tapping a mode triggers a contextual modal overlay rather than instantly arming the system, preventing accidental false alarms[21]:

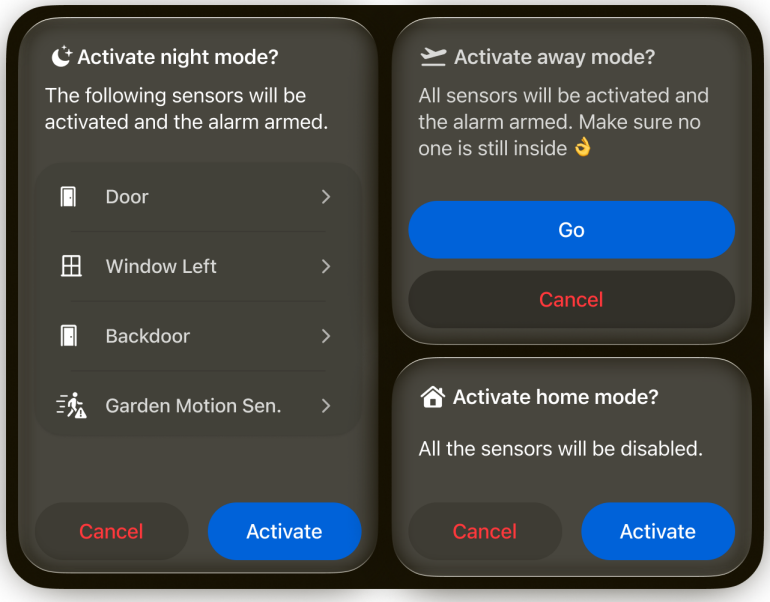


Figure 3.18: Mode confirmation overlays.

- **Granular Transparency:** When activating "Home" or "Night" mode, the overlay explicitly lists the specific endpoints that will be armed (e.g., "Door", "Window Left"). This provides system transparency.
- **Human-Centric Warnings:** When activating "Away" mode, the interface provides a conversational warning: *"All sensors will be activated... Make sure no one is still inside."*

Following the global design system rules, administrative management of these modes is entirely gesture-based; a long press on any mode card surfaces the underlying edit and creation controls.

Inline Contextual Actions and Gestural Management

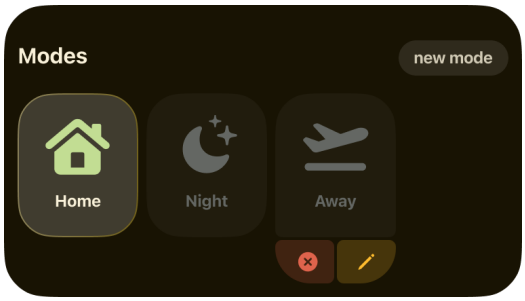


Figure 3.19: Inline contextual actions revealed via a long press.

When a user executes a long press on a specific security mode card, the interface employs an **inline contextual reveal**. The bottom edge of the mode card dynamically expands to unveil a dual action pill containing two tactile buttons:

Destructive Action (×): A crimson red “delete” icon for immediate removal.

Modification Action (Pencil): A golden-yellow “edit” icon to configure the mode (Figure 3.20).

By revealing the actions directly attached to the original card, the interface maintains strict spatial proximity. The interactive targets appear immediately beneath the user’s finger, reducing travel time and adhering to Fitts’s Law, while the semantic colour coding ensures the user can distinguish between modification and deletion pre-attentively.[20]

Inclusion vs. Exclusion Logic

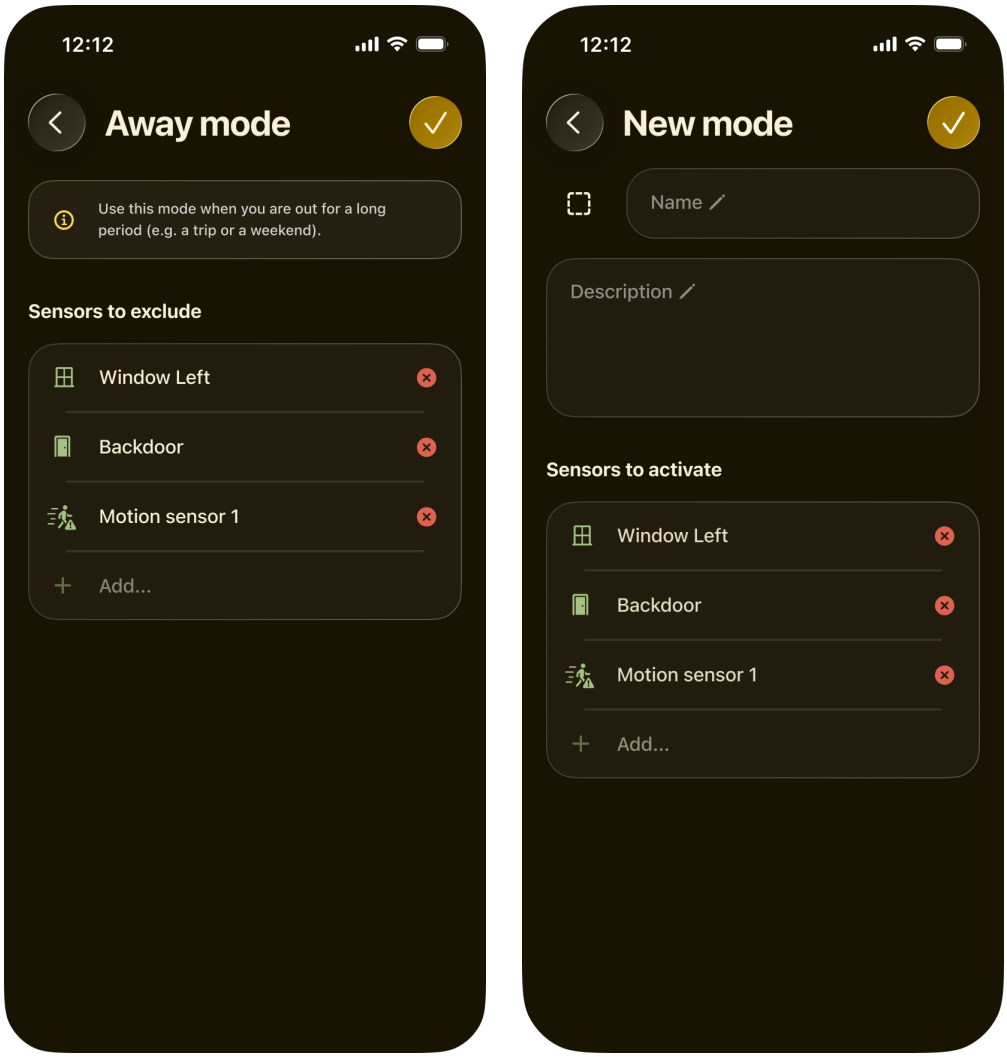


Figure 3.20: Comparison of security mode configuration using inclusion and exception logic.

When the user enters the configuration screen for a specific mode, the interface adapts its logical framework to minimize user effort. This is illustrated by comparing the creation of a ”New mode” instead of editing the pre-existing ”Away mode.”

- **Inclusion Logic (New Mode):** When creating a custom mode from scratch, the interface

presents a blank slate, asking the user to define "Sensors to activate". The user explicitly selects which device should trigger the alarm. This additive approach is logical for highly specific, localised perimeters.

- **Exception-Based Logic (Away Mode):** Conversely, the "Away" mode inherently implies a global perimeter, typically, the user wants every sensor in the house armed. Rather than forcing the user to manually select fifty individual sensors, the interface flips the paradigm, presenting a "Sensors to exclude" list. This allows the user to arm the entire house with the exception of a specific endpoint (e.g., excluding the "Backdoor" so a pet can go into the garden). This application of *Exception-Based Logic* drastically reduces cognitive load and interaction time.

Security Codes and Deterrent Actions

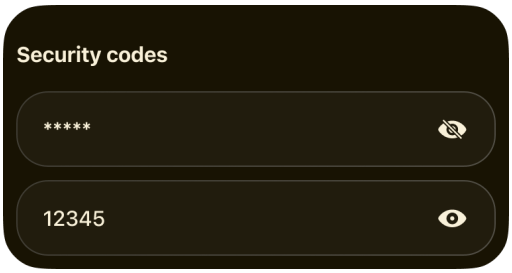


Figure 3.21: Security PIN code management widget with masked entry.

Below the modes, the **Security codes** section allows users to audit and configure their alarm PINs. Adhering to standard digital security heuristics and preventing shoulder-surfing in shared domestic environments, the interface masks the numeric sequence by default while featuring an intuitive "reveal" eye icon. This design ensures that Marco or other household members can verify or adjust access credentials rapidly without exposing sensitive security codes to casual onlookers.

Beneath the modes on the main dashboard lies the **Actions** section, which dictates the system's physical response to a triggered alarm. To ensure *System Transparency*, the section header includes a subtle information (*i*) icon. Tapping this reveals a simple dialog box: *"Actions are events triggered during alarm,"* providing in-context documentation and clarifying system behaviour for non-expert users. 3.22

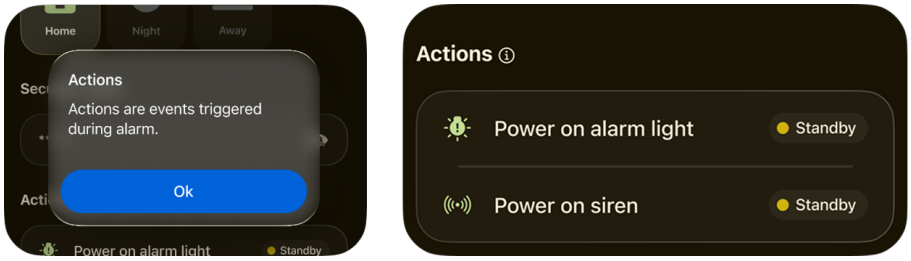


Figure 3.22: Alarm action configuration modal for automated deterrence responses.

If a user wishes to modify these responses, the flow triggers a dedicated “Actions” modal. Here, users can easily select from available hardware to edit the current actions configuration.

3.6.2 Sensors Status

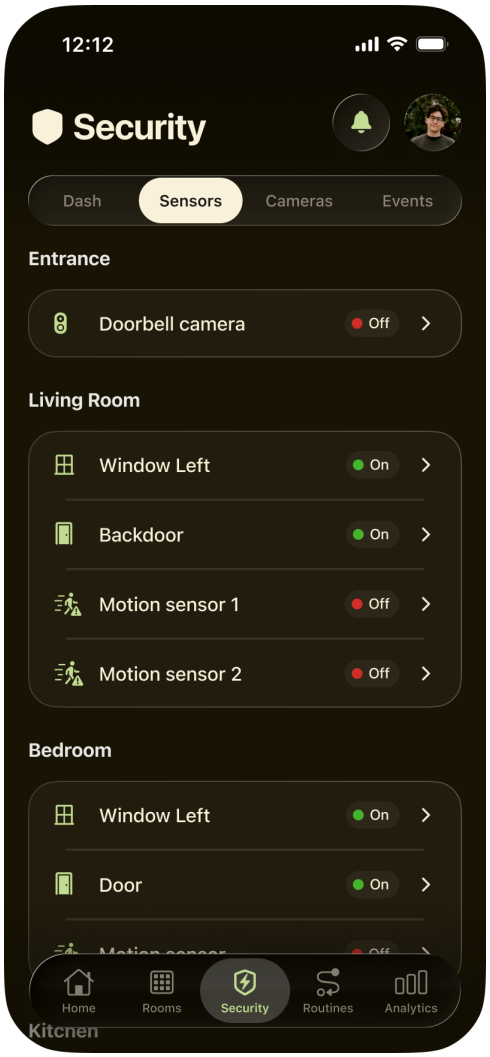


Figure 3.23: Security sensors tab organized by room.

The ”Sensors” tab acts as the detailed level monitoring environment for the home’s security perimeter. In the baseline application, sensors were presented as a continuous, unstructured list of tech-

nical names; the 2025 redesigned interface[7] rectifies this by introducing a structured architecture that significantly reduces cognitive load, aligning with the application's ergonomic design language and spatial organization.

Spatial Organisation and Mental Models

Addressing the previous lack of visual hierarchy, the redesigned interface groups sensors strictly by their physical location (e.g., Entrance, Living Room, Bedroom). This spatial grouping maps to the user's real-world mental model. Rather than forcing the user to look through a long list and manually search for a specific window, they can now intuitively scroll to the specific room container to verify its status.

Feedback via Semantic Pills

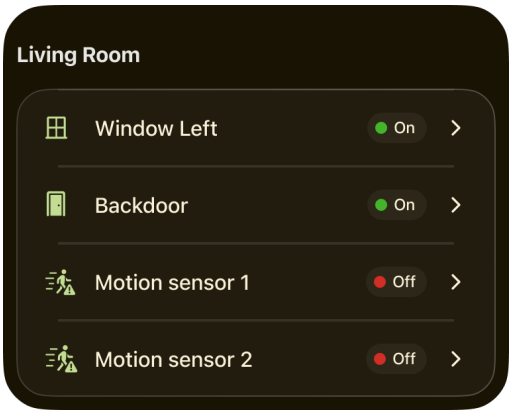


Figure 3.24: Sensor status list displaying clear semantic indicators.

System feedback in this tab is highly scannable. Each listed device is paired with a semantic status pill that utilizes a combination of a coloured status dot and explicit text: a greenish dot indicating "On" (armed/active) and a red dot indicating "Off" (disarmed/inactive).

A user like Giulia can scan a list of all sensors in a room in a fraction of a second, drastically reducing interaction time compared to the unstructured lists of the original prototype.

Minimalism and Progressive Disclosure

The design systematically incorporates chevron icons (>) on the right edge of every sensor row. This implementation adheres to the principle of *Progressive Disclosure*. The top-level view provides just enough information for a quick status check. The chevron serves as a clear affordance; tapping the row will reveal sensor-specific details such as battery life, device-specific settings, and event logs, without cluttering the primary dashboard.

3.6.3 Camera Feeds

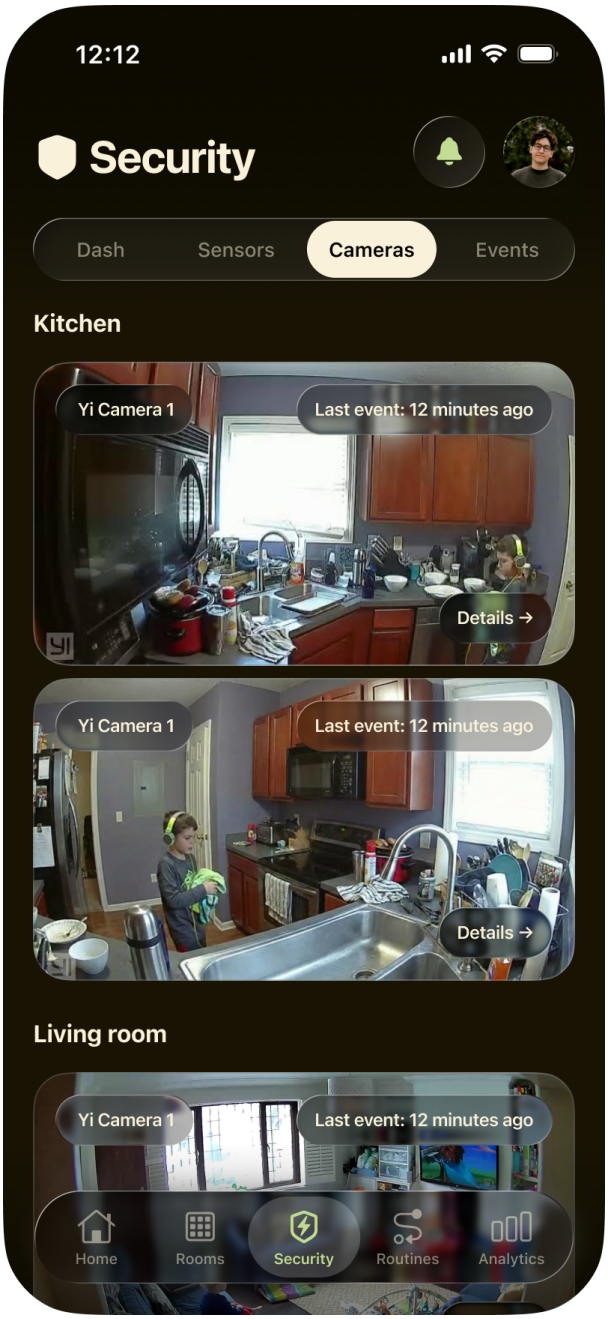


Figure 3.25: Camera feed stream cards displaying location grouping, timestamps, and explicit detail affordances.

The cameras feeds sub-tab was improved and modernized. It improves the experience by grouping the cameras based on their locations (e.g., *Kitchen, Living room*), consistent with the architectural logic of other sections of the app.

This persistent spatial mapping ensures that users do not have to shift their mental models when moving between different security tabs. The design maximises screen real estate, allowing users to rapidly scan multiple areas of their home without needing to load separate livestream

pages.

Contextual Metadata The new prototype solves this by employing dark overlays placed at the edges of the camera feeds. The top left overlay clearly identifies the device, while the top right overlay provides contextual feedback in real time (e.g., "Last event: 12 minutes ago").

Explicit Affordances To ensure absolute interaction clarity without sacrificing visual purity, the interface introduces an explicit **"Details →"** button situated in the bottom right corner of the video feed.

While some modern mobile applications treat entire media cards as hidden touch targets, this can cause interaction ambiguity for users with lower technical proficiency (such as the Marco persona). Introducing this specific button provides an unambiguous affordance, while Giulia will naturally tap on the card itself. It explicitly signals that deeper functionalities, such as a full-screen live feed, two-way audio controls, or a timeline of recorded events, are available.

3.6.4 System Events and Logging

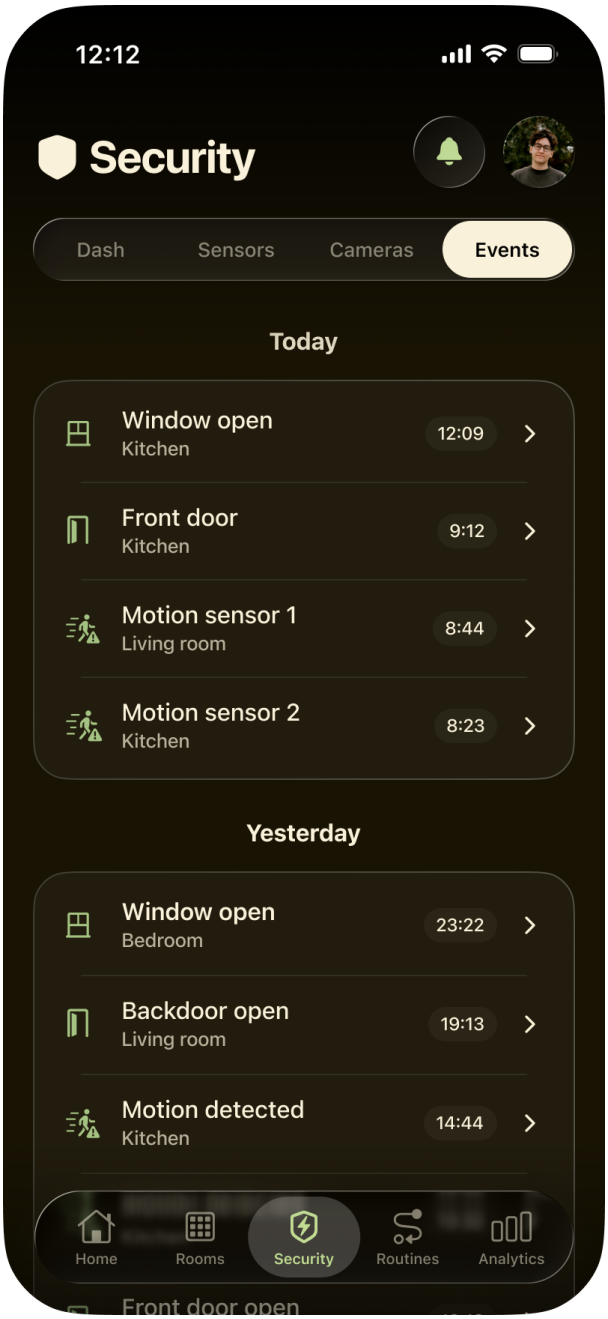


Figure 3.26: Chronological security event history with temporal grouping and icons for each device type.

If a system takes an action, triggers an alarm, or registers an environmental anomaly, the user must be able to trace exactly what happened and when.

The last sub-tab has been renamed from ”Preferences” to ”Events”, leaving other preferences, as Activation Delay and user settings to the global menu. In the baseline application, system notifications and events were presented as an unstructured feed of text, previous redesign was still cluttered with those other settings. The redesigned ”Events” sub-tab rectifies this by

leaving it dedicated to events only and providing an easily scannable and chronological log of all security triggers.

The chronological categorisation reduces the cognitive load associated with parsing long lists of data (e.g., Today, Yesterday). This design choice aligns with the HCI heuristic of a *Match Between the System and the Real World*.

Visually, these temporal groups are housed within rounded containment cards. This chunking prevents the logs from feeling like an endless wall of text, dividing the user's history into digestible daily blocks.[22]

The design of the individual event rows is structured to prioritise the most critical information, guiding the user's eye from left to right:

- **Iconography:** A clear icon allows for rapid visual filtering; a user can scroll down the list and spot all motion events just by looking at the icon, bypassing the need to read every line of text.
- **Location:** The primary information (e.g., "Window open") is displayed on top of the location of the device itself.
- **Timestamp Pills:** The exact time of the event is encapsulated within a pill on the right side of the row.

Tapping an event allows the user to drill down into the specifics of that trigger, for example, viewing a recorded video clip of the motion event from the associated camera.

3.7 The Routines Hub

Automation is simultaneously the most powerful and the most complex feature of any smart home ecosystem. In the baseline Smartotum application, as well as in many competitor platforms, creating and managing routines required users to navigate through complex logic. The redesigned Routines Hub simplifies this process by employing a visual, segmented interface that takes advantage of data chunking and custom components.

3.7.1 Segmented Architecture: Schedules vs. Automations

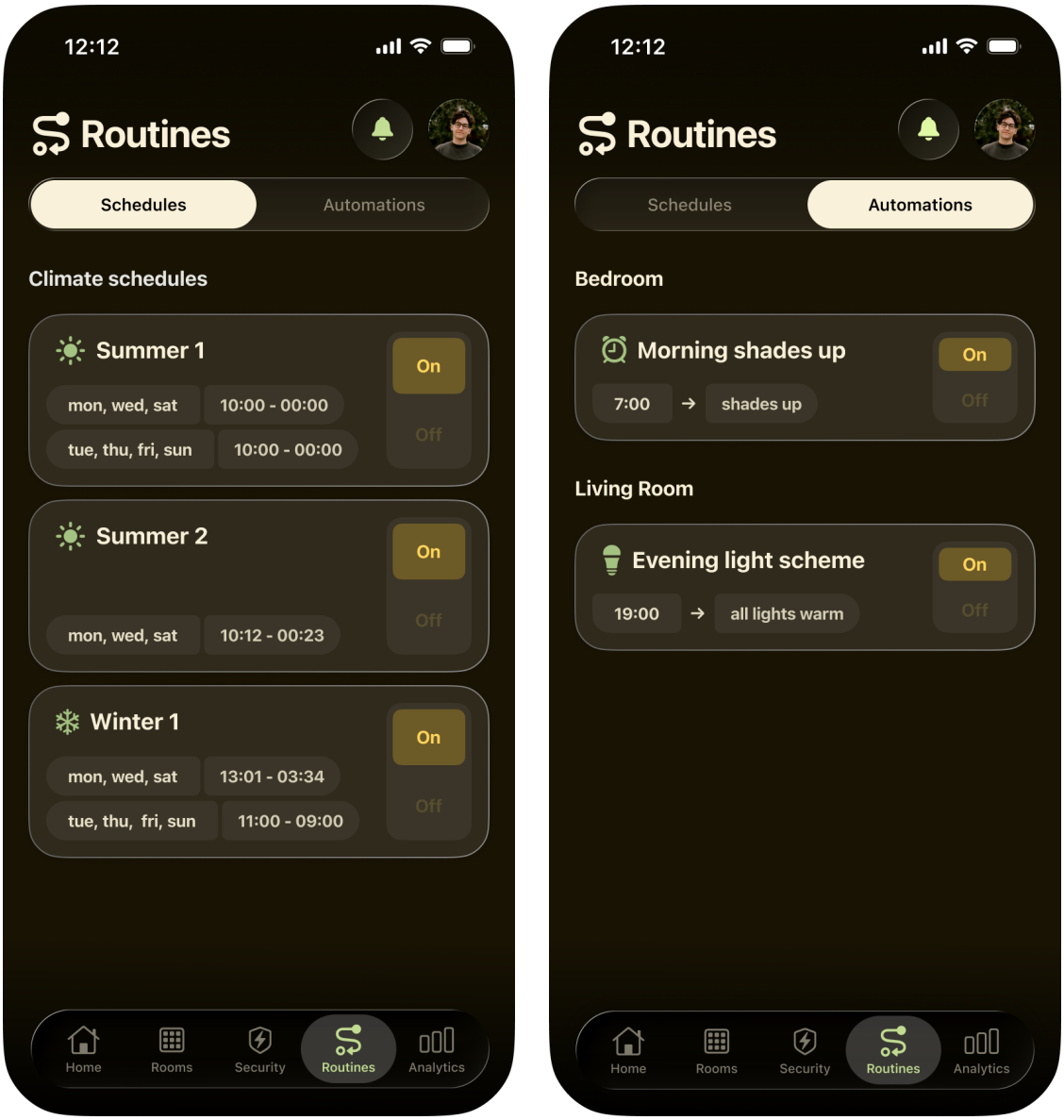


Figure 3.27: Schedules and automations views in the routines hub.

The Routines Hub adopts the segmented layout proposed in 2025, but is enhanced to reduce cognitive overload by employing a clear segmented control that simplifies schedules and automations creation and edit logic.

3.7.2 Schedules: Programming by Time

The "Schedules" sub-tab is dedicated entirely to temporal routines, such as climate control programs (e.g., "Summer 1", "Winter 1"). The redesign of these schedule cards introduces several critical UX enhancements aimed at improving scannability and interaction efficiency.

Data Tags

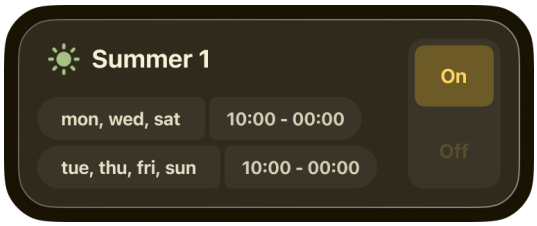


Figure 3.28: Schedule data tags summarizing active days and time ranges directly on the card surface.

In traditional smart home applications, users must tap into a schedule to view its underlying parameters, increasing interaction cost. The new Smartotum design resolves this by introducing **Data Tags** (pills) directly on the surface of the card. These translucent dark pills explicitly summarise active days and specific time ranges. If a schedule contains multiple distinct time blocks, they are stacked neatly side-by-side. This *Recognition rather than Recall* allows users to understand the exact behaviour of a complex heating schedule with a single glance, without getting into further pages.

Custom Toggles

To manage the active state of these schedules, the interface introduces a custom, block-style "On/Off" switch embedded on the right side of the card. This component replaces the standard, diminutive mobile OS toggle with a much larger, tactile touch target that provides immediate state confirmation, effectively leveraging Fitts's Law.[20]

Gestural Edit States

The Schedules tab relies on a long press gesture to enter the administrative edit state, triggering a state change:

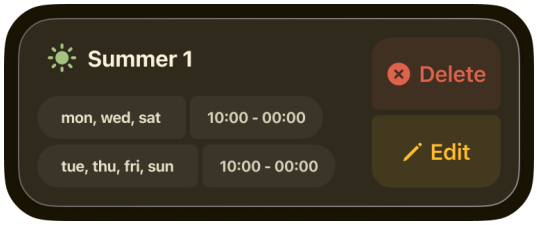


Figure 3.29: Schedule card in gestural edit state displaying deletion and modification affordances.

Action Reveal: The custom On/Off toggle is seamlessly replaced by two distinct action buttons: a red ”Delete” and a golden ” Edit” button.

Global Save: A green ”save” button appears at the category header, whilst a ”New schedule” button dynamically appears at the bottom of the list.

Schedule Creation Flow

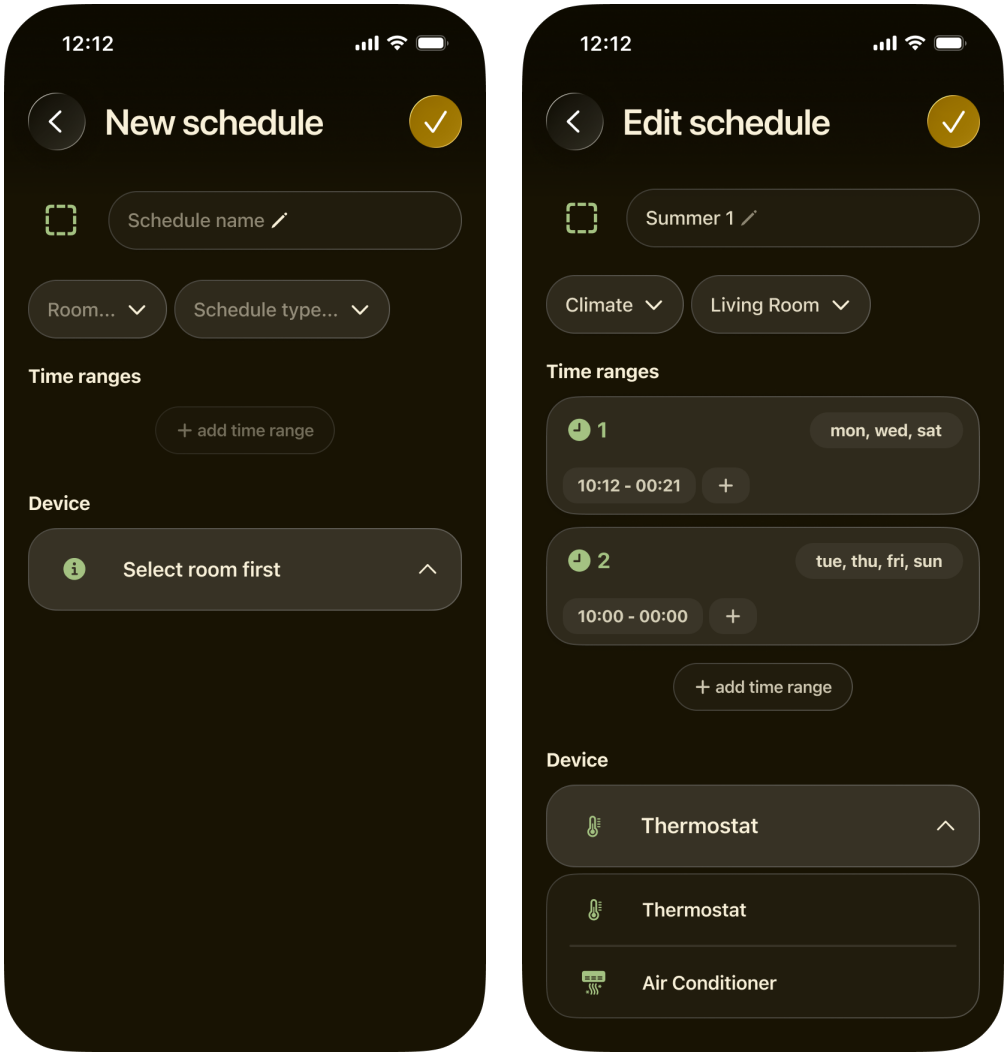


Figure 3.30: Schedule creation and edit flows with guided configuration in several steps.

The redesigned "New Schedule" (and "Edit Schedule") guides the user by consolidating configuration into a visually guided, linear interface.[17]

Contextual Device Filtering and Temporal Stacking

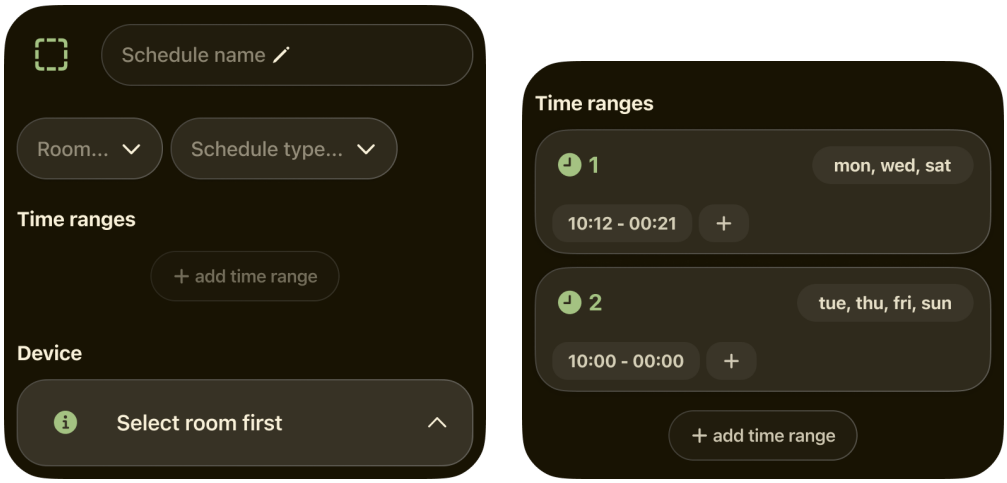


Figure 3.31: Schedule configuration details: gated room and category selection filters (left) and nested stackable time ranges (right).

The most significant structural improvement in this flow is the implementation of gated interaction logic for device selection. At the top of the screen, beneath the naming input, the user is presented with two pill-shaped dropdown filters: "Room" and "Schedule type".

Until the user defines the physical space, the "Device" dropdown remains locked, displaying a clear instructional prompt: *"Select room first"*.

Forcing the user to select the room first and the type (e.g., "Climate"), the system filters the device dropdown to show only the relevant hardware. This substantially reduces interaction friction and prevents configuration errors.

The central portion of the screen is dedicated entirely to temporal logic. The interface introduces a dual-layered approach to temporal stacking, facilitated by modular buttons:

- **Nested Stackable Logic:** In the baseline application, if a user wanted heating on in the morning and again in the evening, they were forced to create entirely separate schedules. The redesigned interface, based on 2025 concept, resolves this by supporting multi-level stacking. First, users can create distinct macro-blocks for different days (e.g., Block 1 for Mon/Wed/Sat, and Block 2 for Tue/Thu/Fri/Sun) using the global "add time range" button. Second, within each day block, an inline "+" button allows appending multiple intra-day time periods. This nested logic consolidates complex routines into a single, unified schedule.

- **Native OS Integration:** When users input time boundaries, the application triggers the na-

tive system time picker of the mobile operating system. This adherence to the heuristic of *Consistency and Standards* capitalises on existing muscle memory, providing a faster and more reliable input method than custom scrolling wheels.

3.7.3 Automations: Conditional Logic and Spatially Grouped Rules

While the Schedules tab handles predictable, time-bound events, the "Automations" tab manages the conditional, trigger-based intelligence of the smart home (Figure 3.27).

Spatial Categorisation

A key architectural distinction between the two views is how routines are grouped. While schedules are grouped by functional domains (e.g., *Climate schedules*), the Automations tab organizes rules spatially by room (e.g., *Bedroom, Living Room*). Because automations frequently involve interconnected hardware within a specific physical space, such as turning on a lamp when a door opens, this spatial grouping aligns with the user's real-world mental model, enabling rapid diagnosis of automated behaviours.

Visualising Events

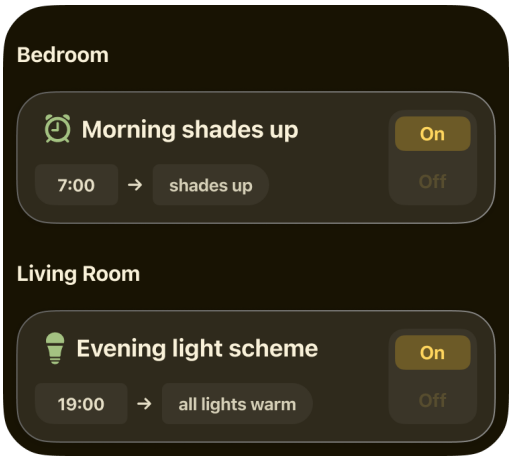


Figure 3.32: Automation cards displaying conditional logic pills and tactile toggles.

A key UX solution within the Automations tab is the method used to display conditional logic. Rather than hiding rules written as "If this happens, then do that" (IFTTT) behind a tap, the interface shows them directly on the card surface.

For example, a card titled "Evening light scheme" features a pill reading `19:00 → all lights warm`. Another card titled "Morning shades up" displays `7:00 → shades up`. This execution translates abstract machine logic into a conversational syntax. It satisfies the heuristic of *Visi-*

bility of System Status, enabling users to comprehend both trigger and resulting action at a single glance.

Global Consistency

Adhering strictly to the heuristic of *Consistency and Standards*, the Automations tab inherits the identical interactive components and gestural behaviours established in the Schedules tab:
Tactile Status Toggles: Cards utilize the identical, custom block-style "On/Off" switch, allowing users to temporarily bypass an automation with a single tap.
Gestural Edit States: The interface remains free of administrative clutter until the user initiates a long-press, revealing edit options directly on the automation card, replacing the toggle with colored buttons, revealing the "New automation" CTA at the bottom.

3.7.4 Automation Creation Flow

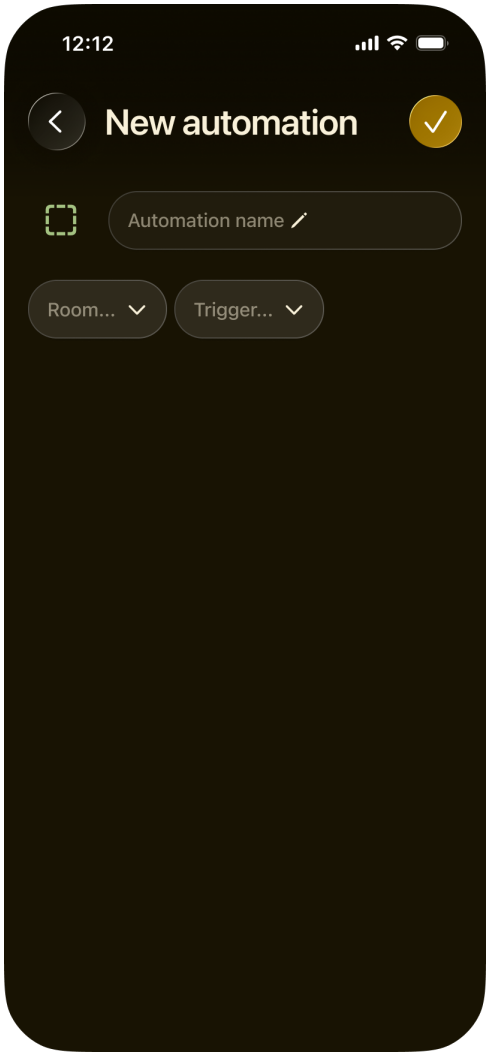


Figure 3.33: Initial step of the automation creation flow featuring gated room and trigger filters.

In the baseline design, creating customized automation flows was not supported, as routines were limited strictly to time-based events. Ghorbani's redesign addressed this by introducing an "if this then that" structure. In this thesis, the automation creation flow has been further refined, mitigating complexity and preventing errors through structured *Progressive Disclosure*, dynamically expanding the interface as the user defines logical parameters one step at a time.

Upon entering the creation screen, the interface is intentionally minimal. Beneath the naming input, the user is presented with only two mandatory, gated filters: **"Room"** and **"Trigger"**.

Until these foundational parameters are defined, the rest of the screen remains blank. This reduction of UI elements adheres to *Hick's Law*, minimizing decision time and effort.[23] The user must first define the spatial context (e.g., "Bedroom") and then select the logical trigger event: **By Time** or **By Event**.

Automation by Event or by Time

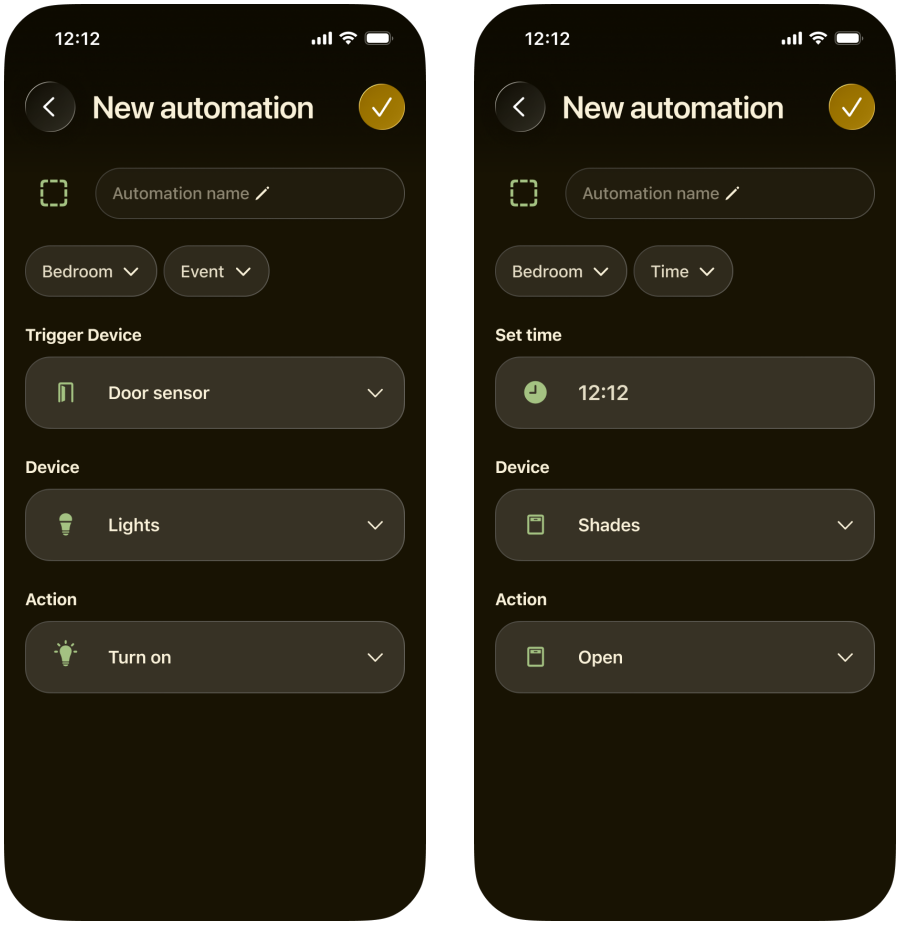


Figure 3.34: Gated automation creation logic: trigger sequence based on an event (left) and trigger structure based on time (right).

If the user selects an ”Event” trigger (Figure 3.34, left), the interface initiates a cascading sequence of contextual dropdowns, translating machine logic into conversational syntax:

1. The “If” Condition: Once the “Event” trigger is selected, a “Trigger Device” dropdown animates onto the screen, filtered to show only relevant sensors (e.g., “Door sensor”) based on the pre-selected room.

2. The “Then” Target: Once established, the “Device” dropdown appears to select the responding hardware (e.g., “Lights”).

3. The “Action” Execution: Finally, the “Action” dropdown allows defining the target behaviour (e.g., “Turn on”).

This sequential revelation ensures that the user is never overwhelmed, guiding them through creating a causal relationship one logical step at a time and lowering the technical barrier for non-expert personas like Marco.

If the user selects the ”Time” trigger (Figure 3.34, right), the interface dynamically adapts its structure: a ”Set time” module appears to capture the temporal input. Once defined, the system proceeds to ask for the target device and action, presenting only fields relevant to the chosen automation intent and preventing input errors.

3.8 The Analytics Hub

Market research established during the contextual analysis revealed that energy management is a primary driver for smart home adoption in Italy. However, raw energy data often lacks actionable context for typical users.

The redesigned "Analytics" tab bridges the gap between raw hardware telemetry and financial impact. To achieve accurate cost tracking, the system guides users through inputting data from their electricity bill using a structured configuration process.

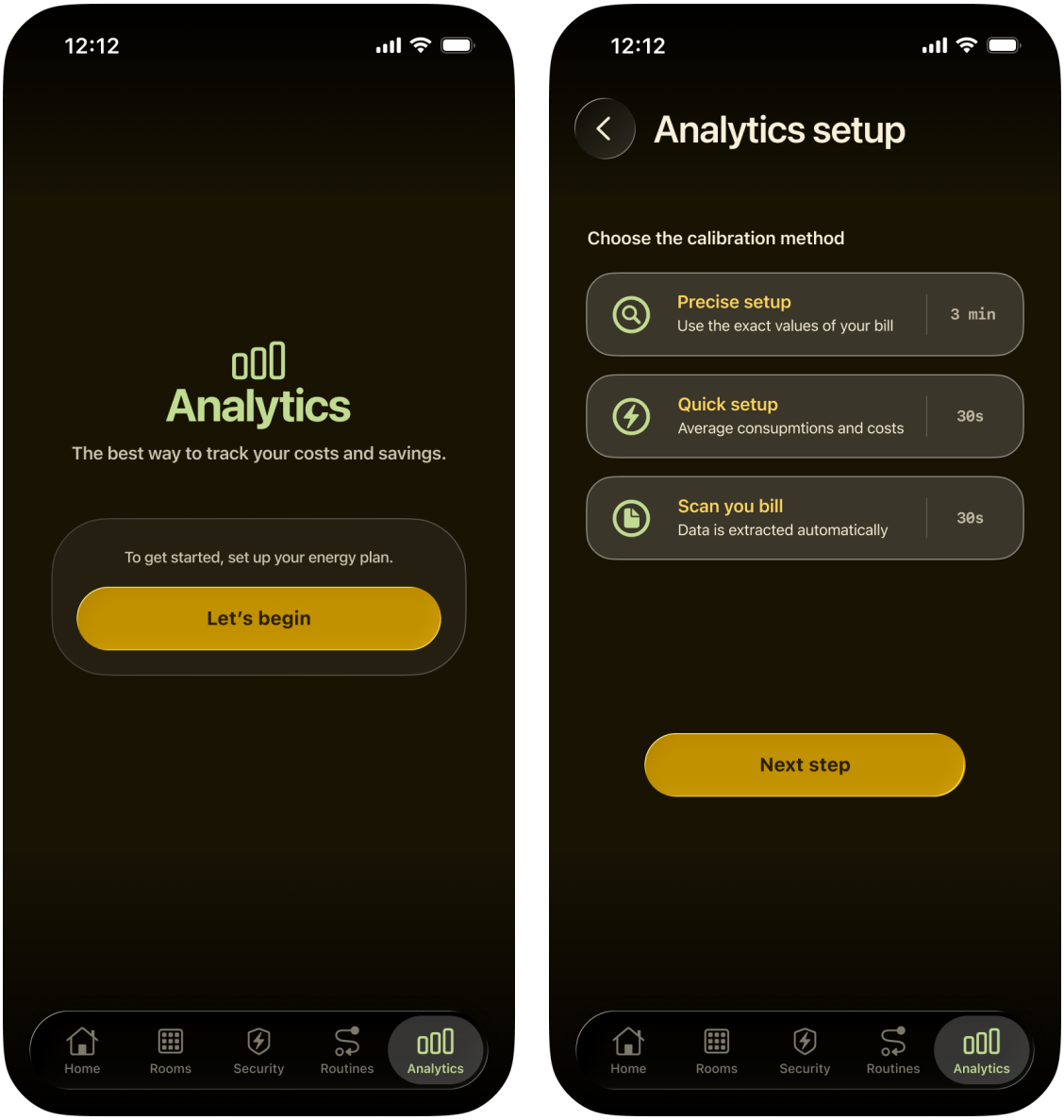


Figure 3.35: Analytics module: main consumption overview dashboard (left) and guided energy onboarding calibration method selection (right).

3.8.1 Guided Configuration and Calibration Wizard

When a user accesses the Analytics tab for the first time, they are greeted by a welcome state presenting a clear value proposition: *"The best way to track your costs and savings,"* followed by a prominent call-to-action to start the guided configuration.

Upon beginning the setup, the interface addresses user hesitation by offering three distinct calibration paths: *Precise setup, Quick setup,* and *Scan your bill*. Each option displays an estimated completion time. By managing expectations upfront, the system reduces abandonment rates, adhering to the HCI principle of respecting user time and cognitive bandwidth.

3.8.2 Contextual Assistance and Billing Verification

Users opting for "Precise setup" are guided through a multi-step wizard. To mitigate the frustration of deciphering utility bills, the UI employs contextual assistance. At the top of each screen, an information banner directs the user where to locate specific figures on their physical document. This serves as an in-context help system, satisfying Nielsen's heuristic of *Help and Documentation* precisely at the moment of need.

To structure data input, the flow utilizes a step indicator ("1/4", "2/4") in the top right corner. This grounds the user within the navigation flow, providing *Visibility of System Status* and assuring them that the process is finite.

3.8.3 Localized Settings

Instead of forcing users to manually type out plan details, the interface utilizes segmented controls for parameters such as Client type (*Residential/Non-Residential*), Power tiers (*1.5 kW, 3 kW, 6 kW*), and specific billing schemes (*Monoraria, Bioraria, Trioraria*).

When defining Energy Prices (Step 2/4), the interface breaks down costs by the standard Italian time bands (*F1, F2, F3*).

3.8.4 Dynamic Feedback and Visual Calibration

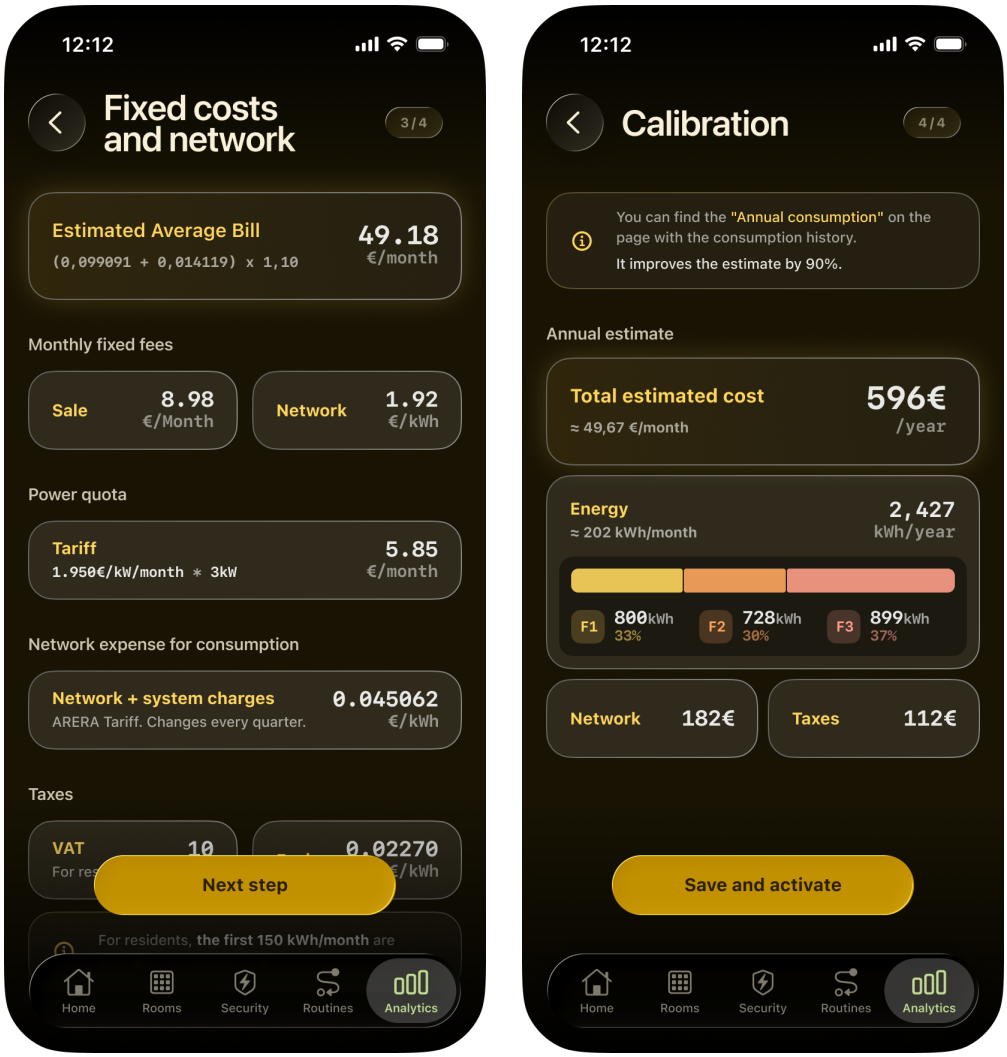


Figure 3.36: Dynamic energy cost preview and final calibration summary for the analytics setup flow.

As the user inputs fixed and variable costs (Steps 3/4), the interface displays a real-time ”Cost preview” formula dynamically calculating raw material costs. Exposing the underlying calculation logic fosters user trust through system transparency.

In the final step (Step 4/4: Calibration), the wizard synthesizes all inputs to generate an ”Annual estimate” of total cost and energy distribution. A color-coded stacked bar chart breaks down estimated usage across the F1, F2, and F3 time bands.

Usability Evaluation

This phase focuses on evaluating the interactive high-fidelity prototype developed in Figma. Following the structural and visual overhaul detailed in the previous chapter, it was necessary to observe how representative users interact with the redesigned interface. The primary objective was not to validate backend hardware communication, but rather to evaluate whether the new theme, the gestural interactions, and the restructured navigation hierarchy effectively mitigate the cognitive friction identified in the baseline design.

This chapter details the testing objectives, methodological framework, participant demographics, apparatus, and testing procedures. The subsequent quantitative metrics and qualitative observations provide empirical validation of whether the redesigned system effectively supports the mental models of smart home users.

4.1 Testing Objectives

The usability evaluation was structured around four specific operational goals. Rather than soliciting general aesthetic opinions, the sessions measured user task performance and cognitive responses across specific interaction paradigms:

1. **Efficiency of global commands:** Determine if users naturally locate and utilize the new Quick Actions row on the Home dashboard for rapid operations.
2. **Efficacy of intentional "smart friction":** Observe user reactions to contextual security overlays. Assess whether the confirmation dialogs provide reassurance or introduce unwanted friction.
3. **Intuitiveness of gestural administrative management:** Verify whether replacing explicit "Edit" buttons with a contextual gesture on cards hindered task completion or caused cognitive hesitation.
4. **Comprehension of gated configuration logic:** Assess if users could navigate gated dropdowns and progressive disclosure steps when configuring a new schedule.

The evaluation deliberately prioritized these high-frequency operational controls, security arming flows, and routine creation sequences. Secondary informational areas, such as energy consumption graphs in the Analytics hub, were set aside for subsequent summative evaluation cycles in order to maintain a focused testing duration and prevent participant cognitive fatigue.

4.2 Methodology

The evaluation employed a task-based usability testing protocol supplemented by the standardized System Usability Scale (SUS) questionnaire to gather post-test quantitative usability metrics.[24] The sessions were conducted individually. Participants followed a concurrent think-aloud protocol, verbalizing their expectations, thought processes, and any moments of hesitation while navigating the prototype.

4.2.1 Participants

Five participants were recruited for this formative evaluation. According to standard usability methodology established by Nielsen, a sample size of five users is sufficient to uncover approximately 80% of core usability issues in an iterative, qualitative design cycle.[25]

The participants were aged between 23 and 34. All participants owned and regularly operated at least one smart home device (ranging from smart speakers to connected lighting and thermostat setups), placing their prior domain familiarity in the moderate-to-high range. While these users mirror the characteristics of the efficiency-driven persona (Giulia) and provided a reliable baseline for testing advanced routing and scheduling features, the comfort-oriented persona, Marco (51 years old, lower digital familiarity), was not directly represented in this initial testing cycle. Evaluating the interface with older and less technically experienced users remains an essential objective for subsequent validation phases. All sessions adhered to ethical research standards, and no personally identifiable data was recorded.

4.2.2 Testing Apparatus and Remote Procedure

To balance ecological validity with practical testing constraints, the evaluation utilized two distinct testing modalities:

- **In-Person Testing (2 sessions):** Participants interacted directly with the prototype on a mobile smartphone display. This setup allowed the moderator to observe natural touch gestures, thumb reachability, and physical hesitations directly.

- **Remote Testing (3 sessions):** Conducted via remote session with real-time screen sharing. Participants interacted with the prototype hosted in the Figma environment.

A critical technical consideration in the testing apparatus involves the implementation of the contextual administrative gesture. Within the Figma prototyping engine, standard mobile long-press gestures cannot be emulated natively. Consequently, the interaction logic was specifically implemented using a hold-and-drag trigger on the interactive components. To surface the administrative edit state (replacing toggles with edit and delete controls), participants were required to hold and execute a deliberate slight drag on the specific card or component.

4.2.3 Evaluation Tasks

Participants were asked to execute four realistic domestic scenarios without preliminary coaching:

- **Task 1: Global control.** "You are leaving the house in a hurry. Turn off all the lights."
  Target Flow: Home dashboard → Quick Actions row → Tap "Power off all lights".
- **Task 2: Security activation.** "You are going away for the weekend. Arm the house accordingly."
  Target Flow: Security Hub → Away Mode → Acknowledge confirmation popup → Arm system.
- **Task 3: Routine modification and gestural management.** "You want to adjust the trigger settings of an existing morning routine. Modify the bedroom shades routine."
  Target Flow: Routines Hub → Automations tab → Long press (hold and drag) the "Morning shades up" card → Tap golden "Edit" button.
- **Task 4: Complex configuration.** "Create a new cooling schedule for the living room."
  Target Flow: Routines Hub → Schedules tab → New Schedule → Gated room selection ("Living Room") → Gated device selection → Define time range.

4.3 Evaluation Metrics

Performance was logged using binary and scaled metrics. A **Success** was recorded if the user completed the task without intervention. A **Partial Success** was noted if the user reached the goal but required a hint, took a highly inefficient route, or hesitated significantly. A **Failure** meant the user gave up. Following the tasks, the standardized SUS questionnaire provided a score between 0 and 100 to measure perceived usability.[24]

4.4 Results

Overall task performance demonstrated high interaction fluency across the redesigned interface. Participants completed the majority of tasks quickly and without external guidance. Table 4.1 provides a detailed summary of task outcomes across the five testing sessions.

Task Scenario	Success	Partial	Failure	Completion Rate
1. Turn off all lights (Quick Actions)	5	0	0	100%
2. Activate "Away" security mode	5	0	0	100%
3. Modify morning automation settings	4	1	0	100% (80% direct)
4. Create new cooling schedule	5	0	0	100%

Table 4.1: Task completion summary across the five evaluation sessions.

4.4.1 Task Performance Analysis

The observational data revealed clear trends regarding interaction patterns and cognitive load:

- **Rapid Global Control (Task 1):** All five participants completed Task 1 within seconds; users immediately recognized the dedicated Quick Actions row and tapped the macro command directly. This confirmed that elevating macro triggers to the primary dashboard effectively minimizes operational cost, consistent with earlier exploratory findings.
- **Reassuring Security Arming (Task 2):** Navigation to the elevated Security hub was instantaneous. When the confirmation modal appeared displaying the warning message ("Make sure no one is still inside"), all participants paused briefly before tapping "Proceed".
- **Gestural Interaction and Feedback (Task 3):** Task 3 accounted for the only instance of partial success. Four participants completed the edit trigger smoothly. However, Participant 4 initially hesitated, actively searching for a visible pencil or settings icon. After several seconds of searching the card perimeter, the moderator offered a minimal neutral prompt: "Try interacting directly with the card surface." The participant then executed the long-press(hold-and-drag) interaction, which successfully revealed the hidden edit controls and allowed task completion.
- **Gated Schedule Setup (Task 4):** All participants navigated the schedule creation flow smoothly. The gated constraint requiring users to select a room before unlocking device options was understood immediately and prevented unnecessary cognitive load.

4.4.2 System Usability Scale (SUS) Quantitative Ratings

Post-test subjective usability was quantified using Brooke's standard scoring method, where individual item contributions $s_i \in [0, 4]$ are scaled to compute a composite score ($Score = 2.5 \times \sum_{i=1}^{10} s_i$).[24] Table 4.2 presents the individual participant scores alongside descriptive statistics.

Participant ID	SUS Score
P1	95.0
P2	80.0
P3	97.5
P4	70.0
P5	72.5
Mean Score	**83.0**
Median Score	**80.0**
Standard Deviation	**12.7**

Table 4.2: Individual and aggregate System Usability Scale (SUS) scores.

The evaluation yielded a mean SUS score of **83.0** ($SD = 12.7$, $Median = 80.0$). In empirical usability research, a score of 68.0 represents the historical industry benchmark for average usability. According to the rating scale established by Bangor, Kortum, and Miller,[26] an average score of 83.0 places the redesigned Smartotum interface within the **"Excellent"** category. Participant 4 assigned the lowest rating (70.0), which correlates directly with their initial hesitation during the gestural editing task. Even with this variation, all individual scores remained at or above the acceptable threshold, demonstrating overall satisfaction.

4.4.3 Qualitative Findings and User Feedback

Qualitative data collected through the think-aloud protocol provided nuanced insights into specific design decisions:

Visual Ergonomics

Participants unanimously praised the visual transition from flat interface styles to the deep gold foundational canvas (`#181303` to `#2f2a1c`). The deep gold background felt calm, warm, and significantly less straining on the eyes than sterile white layouts.

Security Overlays and Reassuring Friction

An interesting psychological observation emerged during Task 2. In modern interface design, confirmation dialogs are often viewed as friction points that slow users down. However, when the security modal dialog appeared stating *"All sensors will be activated... Make sure no one is still inside,"* participants visibly nodded in approval. Participants remarked that arming a physical domestic security system carries emotional weight; introducing an intentional moment of smart friction provided reassurance that the system was acting deliberately and prevented accidental false alarms.

Progressive Disclosure

During the schedule creation scenario (Task 4), the gated interaction logic proved highly successful. In baseline smart home applications, users are frequently confronted with an exhaustive, unfiltered list of every peripheral in the residence. Structuring the screen into collapsible chunks and progressive filters eliminated choice paralysis, confirming the practical value of Hick's Law in domestic control configurations.

Gestural Discoverability and Prototype Dynamics

The primary interaction friction observed during the evaluation involved the discovery of administrative editing controls. In an effort to achieve an aesthetic, minimalist interface free of visual clutter, explicit "Edit" buttons were removed from routine cards in favor of a contextual gesture.

While four participants discovered and executed the emulated long-press gesture without prompting, Participant 4 struggled initially because their mental model was conditioned to look for static icon affordance. Once Participant 4 understood the gesture, they adopted it effortlessly for subsequent interactions. This finding demonstrates that while contextual gestures effectively declutter the UI for everyday use, they benefit from subtle initial affordance hints to bridge the gap for users accustomed to static buttons.

4.5 Discussion and Design Implications

The quantitative results (83.0 mean SUS score, 100% overall task completion) confirm that the interface bridges complex IoT functionality with intuitive human-centered interaction. Crucially, the qualitative observations validate three central design principles:

1. **Contextual Glanceability:** High-contrast greenish telemetry numerals and bold headings

against deep gold surfaces allow users to assess domestic status in under two seconds without navigating secondary menus.

2. **Intentional Friction as Reassurance:** In high-consequence domains such as domestic security, conversational confirmation modals reinforce trust and user autonomy rather than impeding efficiency.

3. **Progressive Disclosure over Exhaustive Menus:** Gating complex multi-parameter inputs reduces decision time and interaction errors.

The insights gained regarding gestural discoverability directly inform the final design recommendations: while the gesture-based card architecture will be preserved to maintain visual clarity, production releases should incorporate lightweight introductory tooltips. This ensures that efficiency-oriented users (such as Giulia) enjoy a clean, fast interface, while comfort-oriented users (such as Marco) are provided with explicit guidance.

Conclusions and Future Work

This research set out to investigate and address a prevalent challenge within the modern Internet of Things (IoT) landscape. By applying a human-centered Design Thinking methodology, the project redesigned the Smartotum mobile application from a fragmented baseline designed for developers into an intuitive prototype organized around user tasks.[7]

The initial contextual analysis and baseline review identified notable usability bottlenecks in the original prototype, primarily cognitive overload, an absence of visual hierarchy, and a lack of system status transparency. Through iterative ideation, and detailed prototyping, these bottlenecks were systematically addressed and reduced.

The final Figma prototype was designed to align with the behavioural needs of the market, addressing key requirements from both the efficiency-driven persona (Giulia) and the comfort-oriented persona (Marco). Key UX and UI interventions included:

- **Progressive Disclosure and Spatial Mapping:** By anchoring the application to a spatial mental model (Rooms) and introducing collapsible device widgets, the interface provides comprehensive control without visual clutter. Users are presented with primary controls first, accessing granular configurations only on demand.
- **Gestural Decluttering:** Transitioning explicit administrative edit buttons into a contextual gesture yielded a cleaner, simpler interface while retaining secondary configuration capabilities.
- **Error Prevention:** The introduction of contextual overlays, such as gated dropdowns in the scheduling flow ("Select room first") and explicit confirmation popups for security arming, translates system constraints into clear user flows that prevent errors.
- **Market Localisation:** The Analytics hub addresses local user context by mapping energy data and translating raw metrics into tangible financial and consumption transparency.

The transition to an ergonomic deep gold visual system built upon warm foundational surfaces (`#181303` to `#2f2a1c`), clear bold typographic hierarchy, and greenish functional accents (`#a4c282`) created an easily scannable, visually comfortable interface that minimizes eye strain.

The positive findings from the formative evaluation (mean SUS score of 83.0, representing "Excellent" usability[26]) confirm that the redesigned prototype effectively bridges the gap between technological complexity and everyday domestic interaction.

5.1 Limitations

While the formative usability evaluation provides positive indicators for the proposed design, several limitations must be acknowledged:

- **Demographic Focus:** The participant sample was limited to five individuals aged between 23 and 34, all possessing moderate-to-high smart device familiarity. While this sample size aligns with established usability heuristics for uncovering the majority of qualitative usability flaws during an iterative cycle[25], it exclusively reflected characteristics of the efficiency-driven persona (Giulia). The comfort-oriented persona, Marco (51 years old, lower digital familiarity), was not directly represented in this initial testing.
- **Prototype Fidelity and Environmental Constraints:** The evaluation was conducted using a Figma prototype rather than deployed software connected to physical hardware. While detailed interactive prototyping enables realistic simulation of user flows, it cannot fully replicate physical system latency, such as the delay between triggering a command and receiving physical device actuation. Furthermore, the prototype could not evaluate user responses to intermittent connectivity, sensor dropouts, or hardware offline states, which represent common friction points in IoT environments.
- **Interaction Simulation in Remote Modalities:** Within the Figma prototyping engine, mobile long-press gestures were emulated via a hold-and-drag interaction, which contributed to minor initial hesitation during tasks.

5.2 Future Work

Building upon the structural and visual foundation established in this redesign, several concrete directions are planned for future research and engineering development:

- **Internationalisation and Multi-Country Energy Tariff Adaptation:** While the current Analytics hub localises energy costs to the Italian regulatory framework (F1/F2/F3 time-of-use tariffs and ARERA/PUN market rates), international deployment requires a modular, multi-country tariff engine. Future iterations should expand the configuration wizard to support:

1. *Dynamic Spot-Pricing Tariffs:* Integrating real-time market APIs (such as Nord Pool in Northern Europe, EPEX SPOT, or Agile Octopus in the UK) where electricity prices fluctuate hourly or every 15 minutes, including alerts for negative pricing events.
2. *Solar Power and Metering:* Incorporating bidirectional telemetry for residential photovoltaic (PV) arrays and battery storage systems, tracking self-consumption versus grid tariffs.
3. *Automated Cost Savings Routines:* Enabling the Routines Hub to communicate directly with the energy engine, automatically delaying energy-intensive appliances (heat pumps, EV chargers, washing machines) to the cheapest forecasted hours.

- **Multi-User Roles and Household Awareness:** Domestic spaces are shared by multiple occupants with diverging technological needs. Future work should implement role-based access control (RBAC), offering guest modes, child locks for climate and security settings, and privacy masking for specific camera feeds. Furthermore, multi-occupant geofencing will ensure that whole-home automation flows (such as "Away" arming) trigger only when all household members have left.

- **Production Implementation and Field Testing:** The next engineering phase involves translating the Figma design system into a production cross-platform mobile application connected to the Smartotum local server. This will facilitate longitudinal in-home field studies to evaluate real-world system latency, battery consumption, and ambient daylight legibility.

- **First-Use Onboarding and Inclusive Accessibility:** To resolve the discoverability friction observed during gestural interactions, a lightweight, non-intrusive onboarding walkthrough will be implemented for first-time users. Additionally, code-level accessibility will be expanded to achieve comprehensive WCAG 2.1 AA compliance[18], including full screen reader semantic trees, dynamic font scaling, and multimodal voice interaction.

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