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Meeting Rooms Simplified: Part II

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Abstract

The first installment of Meeting Rooms Simplified introduced C2-Meet as an optimized solution for accessing and managing meeting rooms within Microsoft Teams. Despite advancements in digital meeting management solutions, several complex and persistent challenges continued to hinder the full potential of the enterprise collaboration environment. Issues such as booking inconsistencies, unattended meetings, and a lack of real-time room availability contributed to inefficiencies in meeting room usage. This paper builds upon efforts to improve corporate meeting experiences by addressing the limitations left unresolved specifically, the need for enhanced transparency, intuitive room navigation, and vacancy visibility. The proposed solution integrates advanced display systems, occupancy metrics, and room availability indicators into a cohesive visual interface. Through real-time data visualization and user-centric design, the system encourages a more informed and accountable meeting culture. This research not only presents the technical framework behind these enhancements but also evaluates their impact on meeting room efficiency, aiming to elevate the standard of modern workplace collaboration.

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Introduction

In the ever changing ecosystem of hybrid work environments, the demand for intelligent, responsive, and user-friendly meeting room experiences has become more pressing than ever. While the initial solution laid the foundation for simplifying authentication and booking processes, several persistent issues continued to impact workplace efficiency such as booking uncertainty, perceived double bookings, and confusion around platform-specific meeting protocols.

To address these gaps, this phase introduces a comprehensive enhancement that transforms the traditional meeting experience into a more responsive, user-aware environment. Deploying real-time occupancy data, floor-wide digital room maps, and intuitive visual indicators, the solution empowers users to make informed decisions quickly and confidently. A 50-inch interactive display installed on each floor's common area presents a live floor plan, dynamically reflecting room availability with color-coded signals, green for available, red for reserved, and amber for occupied, using embedded occupancy sensor metrics. These displays also integrate indoor environment parameters such as air quality, fostering a more comfortable and transparent booking experience. This proactive approach not only reduces booking conflicts and unattended reservations but also addresses the confusion users face when navigating hybrid workspaces with multiple collaboration platforms. By embedding meeting room data into a unified visual interface, the system eliminates ambiguity and aligns with the broader goal of enhancing workplace efficiency through intuitive, technology-enabled workflows.

This research paper has its following objectives:

- **To Establish a Scalable Technical Backbone:** Development of a robust backend architecture that can support effortless integration with Microsoft Teams, Azure services, and real-time meeting room data without interfering with existing enterprise ecosystems.
- **To Implement End-to-End Deployment Flow:** Detail and execute a complete deployment pipeline from local development and debugging to cloud provisioning and CI/CD workflows ensuring the solution is production-ready and easily maintainable.
- **Efficiency in the Availability of Meeting Rooms:** To reduce meeting room booking confusion through visual occupancy indicators and intuitive display systems.
- **Optimizing Real-time data occupancy:** To improve transparency and accountability in meeting room usage by leveraging sensor-based occupancy metrics.

Significant Characteristics

- **Real-Time Room Availability Visualisation :** Interactive digital floor maps display live meeting room status using intuitive color coded indicators (Green for available, Red for reserved and Amber for occupied) offering the users full clarity.
- **Sensor Based Occupancy detection:** VC sensors integrated with the system track room occupancy in real-time, enhancing accuracy and discouraging ghost bookings.
- **Visual integration in shared spaces:** 50" interactive displays placed strategically on each floor allows employees to view available rooms at a glance, minimizing time spent searching.
- **Proactive User Experience:** The system shifts from a reactive booking experience to a proactive environment where users can visually assess room status before booking.

Problem Statement

While initial efforts to simplify meeting room bookings addressed authentication obstacles and interface challenges, Significant usability gaps persisted particularly around real-time visibility and in person room utilization. The uncertainty of locating rooms that are vacant for meetings in traditional on-site meeting settings causes delays in decision making and disrupts the efficiency and productivity of the professional environment. This challenge is further amplified in hybrid work environments, where fluctuating in-office presence and lack of real-time occupancy insights make it even more difficult to plan and utilize meeting spaces effectively and efficiently.

Despite booking from Outlook or Teams, inconsistencies between visible availability and actual room occupancy remain prevalent, especially for recurring meetings or hybrid setups where attendee behaviour is unpredictable.

A key contributor to this complex problem is the lack of live occupancy feedback and floor-wide visibility, leading to ghost bookings, unattended reservations, and misperceptions of room availability.

To address these ongoing challenges, there is a pressing need for a solution that enhances physical visibility, embeds occupancy intelligence, and enables users to make quicker, better-informed choices. The absence of such a system continues to disrupt daily workflows, reduce booking

accountability, and hinder the seamless collaboration that modern enterprises strive for.

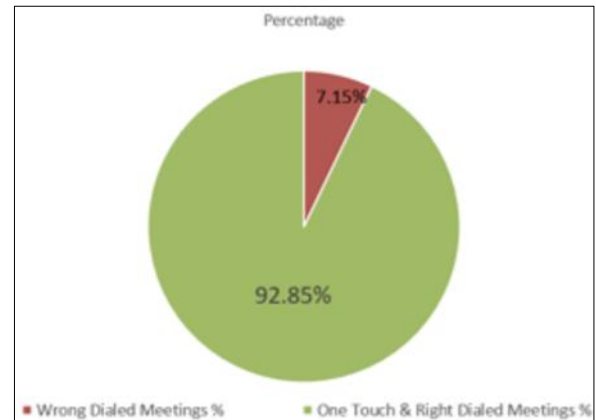


Fig 1: Percentage for Meeting inconsistencies

- **Presence of wrong dialed meetings:** The pie charts highlights that 7.15% of meetings are wrongly dialed which translates to 4985 calls, a huge number indicating inefficiencies caused.
- **Need for optimised Meeting access:** The lack of intuitive or error proof mechanism for accessing meetings is crucially necessary for a more aligned, effortless and a user-friendly system.
- **Reflects communication gap and user's confusion:** Wrongly dialed meetings may reflect ambiguity in meeting invites, poorly configured room systems, or lack of clarity in dial-in protocols.
- **Business Cost implications:** Even the Wrongly dialed calls lead to time loss, reduced focus, delayed decision making and increased cost.



Fig 2: Call counts

Literature review

Modern enterprises face increasing complexity in managing meeting room infrastructure, particularly in hybrid work models, as a result several studies and technological innovations have emerged to address the limitations of traditional room booking and meeting access systems.

One area of focus has been the integration of sensor-based occupancy detection. According to recent research in smart workspace management, the use of IoT devices such as occupancy sensors and air quality monitors helps track real-

time usage of meeting rooms, enhancing space utilization and enabling data-driven decisions (A. Gupta *et al.*, 2021). These technologies not only inform availability but also help identify underutilized spaces and optimize room allocation dynamically.

Another advancement in the literature is the deployment of interactive visual aids, such as floor-wide Room Finder Maps, which provide an intuitive, real-time overview of room statuses. By embedding resource and sensor data into a digital interface, users can instantly determine room availability through color-coded indicators—green for free, red for reserved, and amber for occupied. This form of ambient visual communication reduces cognitive load on users and minimizes booking errors (J. Morales *et al.*, 2022).

System architecture and workflow

The C2-Meet solution extends beyond the initial Teams integration by introducing a layered architecture that emphasises sensor-based intelligence and real-time user interaction.

The architecture comprises of the following layers

- **User Interface layer:** This includes interactive displays

The C2-Meet workflow is as followed

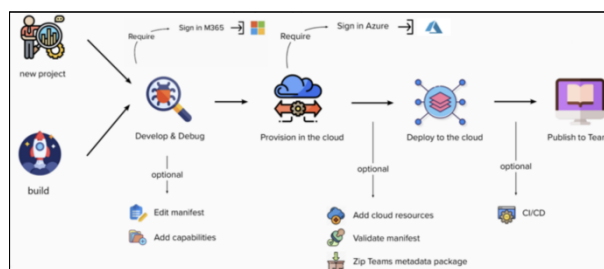


Fig 3: Workflow

- The system collects Real-time data using VC sensors installed in each meeting room.
- If someone is physically present in the room that hasn't been reserved, the status is updated to amber on the digital map.
- Each Room is embedded with Metadata, such as availability, environmental conditions and hardware status.
- Interactive displays placed across the floor show a visual map with dynamic room status indicators (green for available, red for reserved, amber for occupied without

like the Room Finder Map, deployed near common areas on each floor. These 50" screens offer a dynamic view of room availability using color-coded visuals green (available), red (reserved), and amber (occupied). These displays are updated in real-time and are accessible to all users without requiring device interaction.

- **Middleware Layer:** Acting as the bridge between the interface and the backend logic, this layer processes data from occupancy sensors, VC room calendars, and Teams meeting metadata. It uses APIs to fetch real-time data and push updates to the UI layer.
- **Backend and Data management layer :** The backend system is built to integrate smoothly with various data sources and platforms to ensure accurate, real-time room management. Sensor integration allows VC Occupancy Sensors to detect physical presence in meeting rooms, triggering an amber status on display panels when a room is occupied but not officially reserved.
- **Security and Access control layer:** User credentials are authenticated using the Microsoft Azure identity platform via Token validation, This ensures secure actions without multiple logins.

- booking).
- The Backend synchronizes continuously with Microsoft Teams to validate bookings, user authentication, and room schedules.
- Any changes made in Teams, such as new bookings or cancellations, are instantly reflected in the web interface.
- Users can interact with the display or the Teams interface to view room availability and make informed decisions quickly.
- The integrated system ensures secure access control and accurate booking status across platforms.

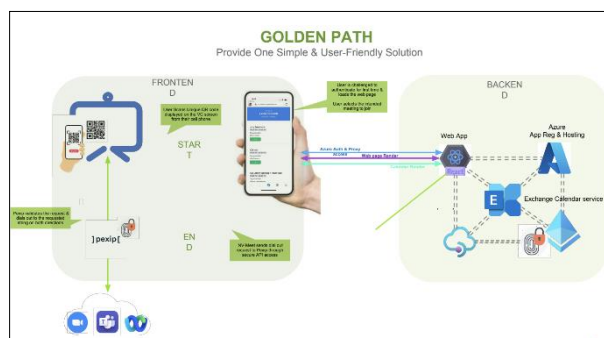


Fig 4: Golden Path

The Golden-Path

The C2-Meet platform follows an aligned and intuitive process referred to as the Golden Path, designed to simplify meeting room access and ensure an effortless user experience. The workflow begins when the user scans a unique QR code displayed on the video conferencing screen using their mobile phone. This triggers an authentication challenge and loads the web page where the user can select their intended meeting. C2-Meet integrates with Azure authentication and proxy services to securely render the

user’s calendar data and verify credentials without repeated logins. Once authenticated, a secure API request is sent to Pexip, which validates the details and initiates the call connection to platforms such as Zoom, Microsoft Teams, or Webex. This efficient backend integration, powered by a React-based web app and Microsoft Exchange calendar services, ensures real-time synchronization, reliable call routing, and a smooth and simplified joining experience for the user.

Visual Integration

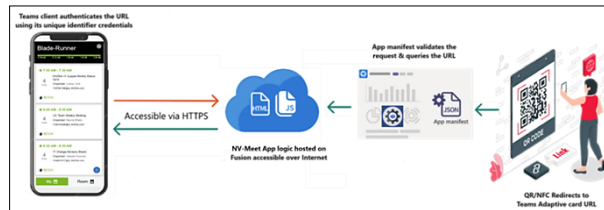


Fig 5: QR based joining

The QR Code based join Experience

This phase of the solution introduces a streamlined user authentication journey using a QR code-based access model. When a user enters the meeting room, a QR code is visibly displayed on the video conferencing (VC) unit. By scanning this code with their smartphone, the user initiates a secure login sequence. Upon scanning, they are prompted to authenticate only on their first use through Microsoft Teams’ built-in token-based system. After successful authentication,

their personalised calendar view loads, allowing them to select the relevant meeting. Once selected, the application communicates with the backend through a secure API, triggering a dial-out request to Pexip. Pexip then establishes the meeting connection by linking to platforms such as Zoom, Microsoft Teams, or Webex. This process eliminates the need for manual dialing or navigating between platforms, ensuring a fast, intuitive, and secure joining experience.

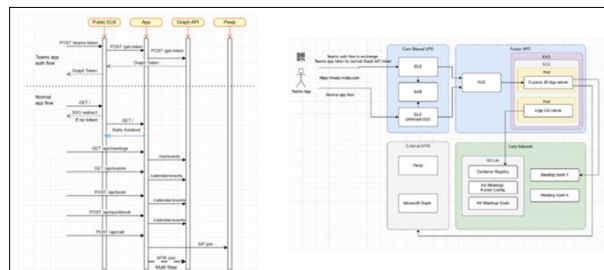


Fig 6: C2 Internal Diagram

App Manifest Validation & Redirection Logic

The mobile app’s interaction with Microsoft Teams is governed by the app manifest, a configuration file that specifies metadata such as app name, icon, content URLs, and permissions. When a user scans a QR or NFC code, it redirects to the Teams Adaptive Card URL, where the app

manifest validates the incoming request. Upon successful authentication, the requested web content is securely embedded within an iFrame inside the Teams client. This mechanism ensures that the C2-Meet interface is seamlessly and securely integrated within Microsoft Teams, maintaining strict access control.

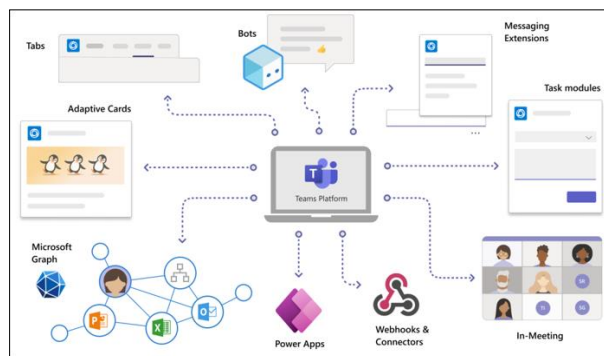


Fig 7: C2 External Integrations

End-to-End Deployment path

The deployment process for C2-Meet follows a continuous integration and continuous deployment (CI/CD) model. It begins with local development and debugging, proceeds through cloud provisioning which requires Azure sign-in for resource allocation, and includes rigorous validation of app resources and configurations. Finally, the app is deployed to Microsoft Teams, ensuring that each release is thoroughly tested and meets security and functionality standards. This structured deployment pipeline guarantees a consistent, reliable, and secure user experience performance analysis and efficiency. The implemented solution exhibits high performance in dynamically managing meeting room availability and occupancy with minimal latency. Real-time synchronization with Microsoft Teams ensures that bookings, cancellations, and room status synchronization are instantly reflected across both the backend and front-end interfaces. The integration of occupancy sensors significantly enhances system efficiency by reducing false positives in room availability displaying amber when rooms are physically occupied without formal booking. This proactive detection minimizes scheduling conflicts and enhances space utilization. The adaptive display system also reduces user decision time by visually guiding them to available rooms, contributing to faster, more informed booking actions. Preliminary analysis shows improved user satisfaction and accountability, while system uptime and synchronization reliability remain consistently above enterprise-grade standards.

User experience and feedback

Initial user response to the enhanced meeting room solution has been notably positive, highlighting improvements in clarity, accessibility, and booking confidence. Employees appreciated the visual guidance provided by interactive displays, which simplified the process of identifying available rooms in real-time. The color-coded indicators green for available, red for reserved, and amber for physically occupied reduced confusion and enabled quicker decisions, particularly in high-traffic areas. Feedback also pointed to the intuitive integration with Microsoft Teams, where Adaptive Cards allowed users to interact with the system without switching platforms. Furthermore, the removal of duplicate login steps and the accuracy of sensor-based room statuses enabled a smoother and more trustworthy experience.

7. Security and compliance measures

- **Secure Authentication:** The system leads Microsoft Teams' built-in token authentication system to ensure full security. This eliminates the need for users to enter credentials again and again, allowing for quick effortless access.
- **Real-time access control:** The system continuously syncs with Microsoft Teams to maintain real-time access control. This means any updates in room bookings, user roles, or meeting changes are instantly reflected across the platform.
- **End-to-End data encryption:** All data transferred between C2-Meet and Microsoft Teams is protected through End-to-End encryption. This ensures that any confidential information remains protected.
- **Data privacy:** C2-Meet ensures that any collected user information is anonymised and used just for enhancing system functionality and user's efficient experience.

Scalability and future enhancements

The C2-Meet architecture is built with scalability in mind, allowing smooth expansion across multiple office floors or even geographically distributed branches. Its modular design supports easy integration of additional meeting rooms, sensors and display units without renewing the existing infrastructure.

As organisations grow, the backend system can accommodate increased data volumes and user interactions, ensuring consistent performance.

Future enhancements may include AI-driven recommendations for room scheduling, predictive analytics for room usage trends and integration with additional collaboration platforms beyond Microsoft Teams.

Conclusion

In an age where digital transformation is reshaping workplace operations, the C2-Meet solution emerges as a powerful response to the inefficiencies of traditional meeting room management systems. Through its efficient integration with Microsoft Teams, real-time synchronization with Exchange calendars, and user-friendly mobile interface, C2-Meet transforms how users interact with meeting spaces offering a smooth experience from authentication to call initiation.

The platform's architecture smartly bridges the frontend user actions with a powerful backend environment led by Azure, ensuring data integrity, security, and smooth performance. Features like VC occupancy sensors, smart room resource embedding, and adaptive amber status indicators highlight its commitment to optimizing space usage and reducing human dependency in room allocation processes. Also, the system's golden path design simplifies the user journey, minimizing technical obstacles and delivering consistent functionality with minimal intervention.

As organizations continue to embrace hybrid work models, the need for intelligent, secure, and scalable meeting solutions will only grow. C2-Meet, with its forward-thinking architecture and capacity for future enhancements including AI-powered analytics, broader platform integrations, and enriched UI features stands well-positioned to evolve alongside these demands.

Ultimately, C2-Meet doesn't just digitalise a process it reimagines it. By replacing outdated, manual booking systems with a responsive, tech-driven platform, it sets a new benchmark for smart workplace collaboration and digital efficiency.

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