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Submission date: 23-Aug-2024 11:20AM (UTC+0530)
Submission ID: 2436565432
File name: plag_check_Internship_1.pdf (388.1K)
Word count: 4463
Character count: 27983

Summer Internship Report at PlasmIT Vector IT (April 22nd to June 21st,2024)

A Report By
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PGDM
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2023-2025

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INTRODUCTION

The PlasmIT team comprises experienced technology experts and healthcare professionals dedicated to addressing critical gaps in the existing critical care ecosystem through innovative solutions. The mission of PlasmIT is to revolutionize the way critical care is delivered, ultimately saving lives and enhancing the quality of care for both patients and healthcare providers.

Background on ICU Challenges: Intensive Care Units (ICUs) present a unique set of challenges that necessitate constant, intensive monitoring and care for critically ill patients. The high patient acuity in ICUs requires healthcare providers to manage numerous devices, medications, and interventions simultaneously. This complexity of monitoring and interventions underscores the need for real-time data, where instant access to accurate patient information is crucial for timely and effective decision-making.

Emergence of Smart ICU Solutions: In recent years, there has been a significant push towards technological integration in healthcare. The adoption of digital tools and applications aims to improve patient care by enhancing data accuracy, streamlining processes, and reducing manual tasks. PlasmIT's Care Delivery Platform, PiMed, stands at the forefront of this technological revolution. PiMed is an AI/ML-enabled next-generation platform designed to deliver trusted, connected, immersive, integrated, secure, fault-tolerant, and compliant care underpinned by blockchain technology. This platform holds the promise of delivering world-class care affordably, ensuring that even the most remote locations can benefit from advanced healthcare solutions.

Role of PiMed in ICU Efficiency: PiMed plays a crucial role in enhancing ICU efficiency. By integrating seamlessly with various medical devices connected to patients in ICUs, emergency care units, general wards, or even at home, PiMed leverages proprietary AI/ML-enabled edge devices and platforms to render care data in an intelligent manner. This real-time data access, available 24/7, enables care workers to provide point-in-time care collaboratively from anywhere, using any device. The result is improved patient outcomes through a streamlined, patient-centric approach.

Challenges Faced in ICUs: Despite advancements in technology, ICUs still face significant challenges. A considerable amount of time is lost due to manual data entry, information retrieval, and coordination among staff. Inefficient workflows, characterized by redundant steps and a lack of streamlined processes, can delay critical interventions. These challenges highlight the

pressing need for innovative solutions that can enhance efficiency and accuracy in ICUs.

Need for the Project: The need for the PiMed project is driven by the urgent requirement to address the inefficiencies and challenges in the ICU environment. By providing a platform that integrates multiple medical devices, offers real-time data access, and reduces manual tasks, PiMed aims to significantly improve the efficiency and quality of critical care. This project is not just about leveraging advanced technologies; it is about transforming the critical care landscape to ensure that patients receive the best possible care, healthcare providers can work more efficiently, and ultimately, lives are saved. In conclusion, PlasmIT's PiMed is poised to be a game-changer in the critical care ecosystem, addressing the pressing needs of ICUs through cutting-edge technology and innovative solutions.

Objectives

The study aims to:
1. Understand the core features and functionalities of PiMed.
2. Examine how PiMed integrates with existing ICU workflows.
3. Identify the challenges faced in ICUs and how PiMed addresses them.
4. Discuss the monetary implications of implementing smart ICU solutions.

The primary objective of this study is to comprehensively map the workflow of the PiMed smart ICU application and evaluate its integration into ICU operations. The study aims to achieve the following specific objectives:

1. Understand the Core Features and Functionalities of PiMed

This objective focuses on a detailed exploration of PiMed's capabilities. It involves identifying and documenting the key features of the PiMed platform, including its AI/ML-enabled functionalities, blockchain integration, real-time data rendering, and secure, fault-tolerant design. By thoroughly understanding these features, the study aims to highlight how PiMed enhances critical care delivery. This includes an examination of its user interface, ease of use, and the specific technological advancements that set it apart from traditional ICU management systems.

2. Examine How PiMed Integrates with Existing ICU Workflows

Integration is a critical factor for the successful implementation of any new technology in healthcare settings. This objective seeks to evaluate how PiMed integrates with the existing workflows in ICUs. The study will map out current

ICU workflows, identifying points where PiMed can be seamlessly incorporated. This includes assessing the interoperability of PiMed with existing medical devices, electronic health records (EHRs), and other hospital information systems. The aim is to determine the extent to which PiMed can enhance workflow efficiency, reduce manual tasks, and facilitate better coordination among healthcare providers.

3. Identify the Challenges Faced in ICUs and How PiMed Addresses Them

ICUs are faced with numerous challenges, such as high patient acuity, complex monitoring requirements, and the need for real-time data. This objective aims to identify these challenges in detail and assess how PiMed addresses them. The study will investigate issues such as time loss due to manual data entry, inefficiencies in information retrieval, and coordination difficulties among staff. By examining how PiMed's real-time data rendering, AI/ML capabilities, and integrated platform address these issues, the study will provide a clear picture of the improvements PiMed can bring to ICU operations.

4. Discuss the Monetary Implications of Implementing Smart ICU Solutions

Implementing new technology in healthcare settings has significant financial implications. This objective focuses on evaluating the cost-effectiveness of integrating PiMed into ICUs. The study will analyze the initial costs of implementation, including hardware, software, and training expenses. It will also consider the potential long-term financial benefits, such as reduced labor costs, improved patient outcomes leading to shorter ICU stays, and enhanced operational efficiency. By discussing these monetary implications, the study aims to provide a comprehensive cost-benefit analysis to justify the investment in smart ICU solutions like PiMed.

In conclusion, this study aims to provide a thorough understanding of the PiMed smart ICU application, its integration into ICU workflows, its effectiveness in addressing ICU challenges, and the financial implications of its implementation. Through these objectives, the study will offer valuable insights into how PiMed can revolutionize critical care delivery and enhance the overall efficiency and effectiveness of ICU operations.

REVIEW OF LITERATURE

1) **Integration of IoT and Fog Computing in Healthcare Based the Smart Intensive Units:** The proposed IoT-based ICU patient monitoring system aims to optimize the ICU monitoring process, thereby minimizing delayed detection and reducing the workload of ICU doctors and caregivers. This system continuously monitors critical patients by measuring various body parameters, including temperature, SpO2, heartbeat, blood pressure, ECG, glucose, and more in real-time. The collected data is processed at fog nodes to reduce latency and subsequently sent to the cloud for storage. In cases where any parameters exceed critical limits, the system promptly notifies doctors and the Emergency Care Unit (ECU), allowing for immediate intervention. Furthermore, doctors can remotely monitor patients' conditions through the cloud, enhancing response times and improving patient care efficiency. This innovative approach not only streamlines ICU operations but also significantly enhances the quality and effectiveness of patient monitoring in critical care settings.
2) **A Tablet PC based System for Ubiquitous Patient Monitoring and Smart Alert Generation in an Intensive Care Unit:** In the field of critical care, efficient monitoring and timely alert generation are paramount. Conventional ICU systems often fall short in providing the necessary real-time monitoring and smart alert mechanisms, leading to delays in critical interventions. This gap can be addressed through the implementation of a Tablet PC-based system focused on ICU workflows. Such systems facilitate seamless clinical data entry, patient monitoring, and meaningful alert generation, thereby enhancing patient care. By interfacing bedside monitors with a central server, a client-server architecture can ensure that data flows smoothly to the entire clinical team, enabling immediate access to reliable patient information. This system automates high-volume device data, lab results, and clinical documentation, thereby improving workflow efficiency. Furthermore, the proposed architecture supports remote monitoring, allowing physicians to stay informed about patient conditions regardless of their location. The system employs open-source software and hardware, with PostGreSQL for database management and JBOSS for application serving, integrated through frameworks like Hibernate and Spring. The use of tablet PCs enhances data entry flexibility and accuracy, supporting various formats such as voice recording, image capture, and file uploads. Additionally,

dynamic alert generation based on a comprehensive analysis of multiple vital signals and their interactions, as opposed to static threshold-based alerts, ensures timely and context-aware notifications. This integrated approach not only improves patient monitoring but also streamlines clinical workflows, ultimately contributing to better patient outcomes and more efficient healthcare delivery.

3) **Improving Patient Safety: Integrating Data Visualization and Communication Into Icu Workflow to Reduce Cognitive Load:**
The development of bedside information-visualization devices and clinical decision-support systems has significantly enhanced the ability of ICU clinicians to diagnose patients by providing tools that display and intelligently filter data. Despite these advancements, there remains a gap in research addressing the need for context-sensitive visualization tools that can alleviate cognitive strain during decision-making processes. To address this gap, the Medical Information Visualization Assistant (MIVA) was developed. MIVA is designed to organize patient longitudinal data contextually, employing visual-enhancing tools to facilitate easy, rapid, and accurate analysis and interpretation of real-time patient data. This EMR visualization dashboard aims to reduce cognitive load and diagnostic errors. The ongoing design phase includes communication tools to support ICU team collaboration. Two studies of MIVA indicate its potential effectiveness: quantitative findings demonstrate a significant improvement in speed and accuracy compared to paper medical charts, while qualitative outcomes suggest that MIVA may reduce cognitive load and enrich the ICU's social and informational workflow.

Methodology

Literature Review

Scope

The literature review focuses on examining existing academic journals, industry reports, and previous studies related to smart ICU solutions, workflow optimization, and healthcare technology. This comprehensive review aims to provide insights into the implementation and impact of smart ICU applications, contextualizing primary data and establishing a solid foundation for the study.

Sources

To gather relevant articles and reports, the review utilized several databases and repositories, including:

Academic Databases: PubMed, Google Scholar, and IEEE Xplore.

Industry Reports: Reports from healthcare technology companies, market analysis firms, and government health agencies.

Additional Sources: YouTube videos and institutional repositories.

Keywords

Specific keywords were employed to ensure a focused search, including:

"smart ICU app"

"workflow efficiency"

"healthcare technology"

Data Collection

Identify Relevant Studies

The review selected studies that directly relate to smart ICU solutions and their impact on workflow and patient care. The selection process involved identifying studies with clear methodologies, robust data analyses, and significant findings.

Data Analysis

Thematic Analysis

Thematic analysis was conducted to identify common themes and patterns across the selected studies. This approach highlighted improvements in workflow efficiency and patient outcomes as recurring themes.

Comparative Analysis

Comparative analysis was employed to compare findings from different studies. This step aimed to identify consistent results and highlight any discrepancies, providing a more nuanced understanding of the data.

Sources and Tools

Academic Databases

PubMed: A key resource for medical and healthcare-related research.

Google Scholar: A broad academic database covering various disciplines.

IEEE Xplore: A database specializing in technology and engineering research.

Industry Reports

Reports from healthcare technology companies, providing industry-specific insights.

Market analysis firms' reports, offering market trends and analysis.

Government health agencies' reports, ensuring credible and authoritative data.

Additional Sources: YouTube videos for practical demonstrations and additional perspectives.

Selection of Airstrip app and Epic Rover for comparison

The adoption of Airtrip and Epic Rover varies significantly by region, reflecting the diverse healthcare infrastructures and electronic health record (EHR) systems utilized around the world. Epic Rover, developed by Epic Systems, dominates the EHR market in the United States, where it is extensively used by major hospital systems and healthcare networks. This concentration of usage makes the U.S. the largest market for Epic Rover, which is particularly favored in facilities already using Epic EHR. In Canada, Epic Rover has gained traction as well, especially among hospitals and health systems that have integrated the Epic platform into their operations. Similarly, in parts of Europe such as the Netherlands, Denmark, and the United Kingdom, Epic Rover is being adopted in areas with significant Epic EHR implementations, thus expanding its geographic footprint.

On the other hand, Airtrip is a solution primarily tailored to the Japanese healthcare market, where it is specifically designed to meet the needs of local providers. Airtrip emphasizes mobility and real-time communication within hospital environments, making it a crucial tool for enhancing operational efficiency in Japanese healthcare settings. This trend of adoption is also being noticed in Southeast Asia, where there is a growing interest in mobile solutions for improved intensive care unit (ICU) management. Hospitals in this region are increasingly seeking to implement technologies like Airtrip to facilitate better patient monitoring and accelerate response times in critical care situations.

While the individual usage of Airtrip and Epic Rover is marked by distinct regional preferences, the combined usage of both platforms remains relatively limited, primarily because they address different needs within the healthcare landscape. However, large, internationally connected healthcare organizations operating in both the U.S. and Japan may opt to integrate both systems to enhance efficiency and data sharing across borders. For instance, some U.S. hospital systems that have established partnerships with Japanese institutions might utilize both platforms, allowing for seamless operations and the integration of healthcare data across various locations. Additionally, international hospital networks that maintain facilities in both regions might leverage Epic Rover in their American branches while deploying Airtrip in their facilities in Japan and other Asian countries. This dual-platform strategy helps to ensure that patient care standards are uniformly maintained through consistent data access and communication methodologies.

The integration of both Airtrip and Epic Rover globally could yield significant advantages for managing ICU workflows and improving overall patient care. Key benefits of selecting both platforms include leveraging the strengths of each system. Airtrip excels in providing mobility and real-time collaboration, enabling healthcare professionals to access patient data and communicate effectively from various locations within the hospital. Conversely, Epic Rover integrates seamlessly with existing Epic EHR systems, enhancing bedside documentation by capturing patient data accurately and without delay, thereby reducing potential errors.

Incorporating both systems can also enhance interoperability by facilitating a smooth data flow between mobile devices and bedside documentation tools. Airtrip's real-time alerts and notifications complement Epic Rover's comprehensive patient data access, fostering a holistic approach to patient management. Furthermore, as both Airtrip and Epic Rover are scalable, they can

be adapted to fit diverse healthcare environments, enabling organizations to tailor their strategies according to their specific resource levels.

Utilizing both systems simultaneously not only enhances workflow efficiency—streamlining communication and ensuring prompt responses during emergencies—but it also introduces redundancy and reliability. If one system were to face technical difficulties, the other could maintain critical operations, thereby ensuring the continuity of patient care. Security and compliance remain paramount in healthcare, and the robust protective features of both Airtrip and Epic Rover work together to safeguard patient data across varied platforms. Moreover, offering both systems accommodates different preferences among healthcare professionals, allowing staff to select tools that best suit their workflows and roles. With ongoing innovations from both platforms, healthcare organizations can future-proof their operations by accessing new features and updates that address the evolving landscape of ICU management.

Lastly, the global reach and support networks of both Airtrip and Epic Rover enhance the viability of their combined use. By establishing a comprehensive ICU management system that harnesses the unique capabilities of each application, healthcare organizations can improve patient outcomes significantly while maintaining an adaptable and responsive operational framework. In summary, while distinct regional adoption patterns exist for Airtrip and Epic Rover, their strategic integration could offer a powerful solution for healthcare systems striving for excellence in patient care and operational efficiency.

Data Analysis

COMPARISON BETWEEN PiMED, AirStrip One & Epic Rover APPLICATIONS

	PiMed APP	AirStrip ONE	Epic Rover
INTRODUCTION	➢ PiMed is an integrated care delivery platform that provides patient real-time 24×7 information in intelligent manner, from multiple sources to enable care-workers to deliver point-in-time care in a collaborative manner. ➢ Platform enables hospital care worker to connect with patients 24×7 from anywhere with any device ; finally deliver values leveraging One Global care network. ➢ Pimed only Made for Critical care /Intensive care Uint of hospitals and it mainly for time management and time lag in emergency cases.	➢ AirStrip ONE is a comprehensive mobile healthcare application that provides clinicians with real-time access to patient data from various sources, including EHRs, monitoring devices, and medical imaging systems. ➢ It enhances decision-making by delivering critical patient information anytime and anywhere, facilitating timely interventions. ➢ The app's secure, cloud-based platform ensures data privacy and compliance with healthcare regulations. ➢ AirStrip ONE supports improved patient outcomes through enhanced clinical collaboration and efficient care delivery.	➢ Epic Rover is a mobile application designed to streamline clinical workflows by allowing healthcare professionals to access and update patient information directly from their smartphones or tablets. ➢ It enhances efficiency by providing real-time access to medical records, medication administration, and clinical documentation. ➢ The app integrates seamlessly with the Epic electronic health record (EHR) system, ensuring data accuracy and consistency. ➢ With its user-friendly interface and secure access, ➢ Epic Rover supports improved patient care and workflow optimization.

FEATURES	➢ Intelligent Integrated Health Dashboard ➢ Medical device data 24x7 on mobile device ➢ Real time Health Vitals ➢ Abnormality Alerts and Insights ➢ Co-ordination & Collaboration ➢ Integrated Care Administration ➢ Diagnostics Assessments & Reports ➢ Compliant and Regulatory Adherence	➢ Easy Access: ➢ Native mobile application available on both iOS and Android. ➢ Eliminates the need for clunky VPN sign-on alternatives. ➢ Access Multiple Sites: ➢ Single login to access all hospitals in the system. ➢ Easy site selection and switching to focus on patient care. ➢ View Patient Data: ➢ View all patients on monitors. ➢ Search for patients and group by unit or bed. ➢ Filter to see patients for a specific unit. ➢ Near-real time waveforms, physiological data, and alarmed events available for each patient. ➢ See Near Real-Time Waveforms: ➢ View near real-time and historical waveforms. ➢ Scroll back in time or choose a specific date and time to see historical waveforms. ➢ Access Alarmed Events: ➢ Organized structure for viewing alarmed events. ➢ Filter alarms by type and severity. ➢ View most recent events at the top. ➢ Select a date to jump to events for that date. ➢ Digital Rhythm Strips: ➢ Eliminates the need for printing, cutting, copying, labeling, and scanning paper strips. ➢ Measure, review, acknowledge, and approve cardiac rhythm strips.	➢ BCMA (bar-coded medication administration) ➢ VS and other simple flowsheet documentation ➢ Lab collection ➢ Transport notification ➢ EVS users can take action on assigned requests ➢ Work list tasks ➢ Notifications about new Orders ➢ Blood Administration ➢ Patient and clinical image capture including Wound documentation ➢ LDA (lines, drains, airways, wounds) documentation with an avatar

		➢ **Upload digital rhythm strips to the EHR from mobile devices and the web.** ➢ **Secure Communication:** ➢ **Send messages to other clinical team members.** ➢ **Share links to live and historical waveforms for review.**	

GAPS in ICU apps/software Implementation

8

Integration of IoT and Fog Computing in Healthcare Based on Smart Intensive Units:

Interoperability Issues: While the system aims to optimize ICU monitoring, the paper may not address how the IoT devices and fog nodes integrate with existing hospital IT infrastructure and other medical devices.

Data Privacy and Security: The paper likely lacks a detailed discussion on the measures for ensuring data privacy and security when sensitive patient data is processed and stored.

Scalability: There is potentially limited information on how the system scales with the increasing number of patients and the associated data load.

User Training and Adoption: The study might not cover the challenges related to training healthcare staff to use the new system and their adoption rates.

3

A Tablet PC-Based System for Ubiquitous Patient Monitoring and Smart Alert Generation in an Intensive Care Unit:

Integration with EHR Systems: The research may not fully explore how the tablet PC system integrates with existing Electronic Health Records (EHR) systems for seamless data sharing and record-keeping.

Usability and User Experience: There might be a lack of focus on the usability and user experience of the tablet PCs, especially for less tech-savvy staff members.

Cost Analysis: The paper could be missing a comprehensive cost-benefit analysis, which is crucial for hospitals considering the implementation of such technology.

Long-Term Effectiveness: The study may not provide long-term data on the effectiveness of the system in improving patient outcomes and workflow efficiency over extended periods.

5

Improving Patient Safety: Integrating Data Visualization and Communication into ICU Workflow to Reduce Cognitive Load:

Real-World Implementation: The research might not discuss the practical challenges and barriers to implementing the Medical Information Visualization Assistant (MIVA) in real-world ICU settings.

Interdisciplinary Collaboration: There could be a gap in exploring how the tool facilitates collaboration among different types of healthcare providers (e.g., doctors, nurses, specialists).

Customization and Flexibility: The study may not address the customization of MIVA for different types of ICUs and patient conditions.

Impact on Patient Outcomes: The paper might lack detailed evidence on how MIVA directly impacts patient outcomes beyond reducing cognitive load for clinicians.

Conclusion

The integration of IoT, fog computing, tablet PC systems, and advanced data visualization tools in ICU settings significantly enhances continuous and real-time patient monitoring, facilitating immediate detection of critical changes and enabling timely interventions. These technologies streamline ICU workflows, reduce cognitive load on healthcare providers, and improve the accuracy of diagnostic processes. Remote monitoring capabilities further enhance flexibility and responsiveness in patient care. However, successful implementation requires addressing challenges such as interoperability with existing systems, data security, usability, staff training, cost, and scalability. Ensuring seamless integration, robust security measures, user-friendly interfaces, comprehensive training, and cost-effective scalability are crucial for the widespread adoption and effectiveness of these innovations in critical care environments.

All three studies emphasize the importance of continuous and real-time monitoring of critical patients. The IoT-based ICU patient monitoring system and the tablet PC-based monitoring system both facilitate immediate detection of critical changes in patient conditions. By employing these systems, healthcare providers can receive timely alerts and notifications, which are crucial for prompt interventions and potentially life-saving actions.The introduction of these technologies aims to streamline ICU workflows, thereby reducing the cognitive load on healthcare providers. For instance, the tablet PC system automates the entry and management of clinical data, lab results, and device data, which improves the efficiency of clinical workflows. Similarly, the Medical Information Visualization Assistant (MIVA) organizes and visually enhances patient data, making it easier for clinicians to analyze and interpret information quickly and accurately.Remote monitoring capabilities are a significant advantage highlighted in the studies. Both the IoT-based system and the tablet PC system allow doctors to monitor patient conditions remotely, enhancing the flexibility and responsiveness of ICU care. This ability to access patient data from any location ensures that physicians can stay informed and make timely decisions, irrespective of their physical presence in the ICU.The MIVA system specifically addresses the issue of cognitive load by providing context-sensitive visualization tools that help reduce diagnostic errors. By presenting data in a more intuitive and organized manner, MIVA enables clinicians to focus on critical information without being overwhelmed by the sheer volume of data typically encountered in ICUs.While the technologies

discussed offer significant benefits, there are common challenges that need to be addressed. Interoperability with existing hospital IT infrastructure and other medical devices remains a crucial concern. Ensuring seamless integration is essential for the widespread adoption and effectiveness of these systems.Another critical aspect is the protection of patient data. The IoT and cloud-based systems must implement robust security measures to safeguard sensitive health information from unauthorized access and breaches.The success of these systems also hinges on their usability and the adequate training of healthcare staff. Ensuring that the systems are user-friendly and that staff members are well-trained can significantly impact the adoption and effectiveness of these technologies.Considerations of cost and scalability are vital for the practical implementation of these systems in diverse healthcare settings. A thorough cost-benefit analysis and strategies for scaling the technology to handle increasing patient loads are essential for long-term sustainability."

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