Journal of Science Engineering Technology and Management Science *ISSN:3049-0952*
Volume03, Issue04(1), April 2026 *www.jsetms.com*

A SURVEY ON DATA ACQUISITION AND LOGGING MECHANISMS IN IN-FLIGHT ENTERTAINMENT (IFE) SYSTEMS

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To Cite this Article
Mr. Sachin Manekar, "A Survey On Data Acquisition And Logging Mechanisms In In-Flight Entertainment (IFE) Systems", Journal of Science Engineering Technology and Management Science, Vol. 03, Issue 04(1), April 2026,pp: 124-130, DOI: http://doi.org/10.64771/jsetms.2026.v03.i04(1).pp124-130
Submitted: 10-03-2026 *Accepted: 18-04-2026* *Published: 25-04-2026*

***Abstract*—The In-Flight Entertainment (IFE) systems have now become a multi-dimensional and data-driven system, which not only improves passenger experience, but also supports the airline operations, creating and analyzing data in real-time. This survey provides a comprehensive description of data acquisition and logging systems incorporated in current IFE systems, their architecture, techniques and concerns. It explores the primary data sources, such as passenger contacts, system sensors, and network traffic, and focuses on how embedded software agents, monitoring tools, and middleware contribute to efficient data collection. The paper also examines communication protocols used, such as TCP/IP and HTTP/HTTPS, and lightweight messaging systems that help ensure the correct transmission of data in both onboard and air-to-ground environments with limited resources. The paper also examines centralized and distributed logging architectures, as well as real-time and batch logging designs, to effectively manage data. Such critical issues as limited bandwidth, data heterogeneity, hardware limitations, and security issues are also addressed. Recent literature is also surveyed to identify gaps in research, particularly in integrated and scalable frameworks. Overall, this work provides insights into improving data-handling strategies for next-generation intelligent IFE systems.**

Keywords—In-Flight Entertainment (IFE), Data Acquisition, Data Logging, Aircraft Connectivity, Passenger Experience, Network Protocols.

I. INTRODUCTION

The aviation industry has undergone a significant digital transformation, which began in previous ten years, because of rapid technology progress in information and communication systems [1]. Modern aircraft now come equipped with advanced digital systems that enable aircraft connectivity and operational automation and provide intelligent system capabilities. In-Flight Entertainment (IFE) systems have developed from their original function as basic audio and video playback devices into complete digital systems that enable users to create interactive, networked and customized experiences [2]. The aviation industry has shifted toward data-driven operational systems, which connect onboard systems to ground-based services for real-time information exchange. The transformation process exists because organizations now recognize that passenger experience improvement acts as the main factor which drives their activities [3]. Airlines have expanded their competition base to include both pricing and scheduling, and the standard of their in-flight customer experiences. IFE systems provide passengers with access to various multimedia content, including live updates, internet access and tailored content, through their built-in displays and personal devices. The combination of streaming services, e-commerce features, and interactive applications has transformed how passengers expect to interact with digital systems, which now plays a vital role in determining their satisfaction levels. IFE systems have become essential components that determine how people experience their entire travel journey [4] .

The operational efficiency of IFE operations depends on data, which is a critical component of their operational capabilities. Large amounts of data from many sources are constantly generated and processed by modern IFE systems, which include passenger interactions, system performance metrics and network activity. The data can give valuable information that can be used to deliver personalized content and monitor the health of the system, optimize operations and develop a predictive maintenance strategy[5][6]. Data-driven insights enable airlines to better understand their customers, tailor content delivery to their preferences, and enhance service quality. This necessitates well-developed data acquisition and logging systems, as these systems the key elements in the performance of the IFE systems and in the case of smart systems. The systems of IFE have various technical issues, which pose a challenge to their data collection and recording processes. The onboard environment is constrained in operations by three key factors: limited bandwidth, intermittent connectivity and limited computational resources. IFE systems must be able to handle various data of diverse system elements, such as hardware sensors, user interfaces and network modules. It is harder to collect reliable data since the system has to transmit data effectively, whilst not reducing the ability to meet future data storage needs. Managing passenger information must be highly secure due to its sensitive nature, as it should be safeguarded to uphold regulatory requirements. The challenges present should be systematically researched and analyzed to develop appropriate procedures to data acquisition and a logging framework within the IFE systems.

A. Structure of the paper

The paper is organized into several sections: Section II provides a general description of IFE systems, their architecture and types, and the role of data. Section III explains the data acquisition mechanisms, data sources, data techniques, protocols and challenges. Section IV is dedicated to data logging structures, methods and management. Section V discusses the current literature and outlines the gaps in research, and Section VI conclusion of the paper and proposes the future direction of the research.

II. OVERVIEW OF IN-FLIGHT ENTERTAINMENT (IFE) SYSTEMS

In-Flight Entertainment (IFE) has become a multifaceted and data-driven digital ecosystem, which not only improves passenger experience but also helps airlines gather important operational and behavioural data. The current IFE systems have not only ceased to provide only passive media delivery but have also incorporated connectivity, personalization, and real-time analytics.

A. Architecture and Components of IFE Systems

The architecture of IFE systems is designed to have three key layers: hardware, software, and network infrastructure. Hardware layer comprises of seatback displays, control units, onboard servers and cabin network devices. The software layer consists of operating systems, content management systems, middleware and user interfaces. Additionally, the network infrastructure connects onboard components via either wireless (Wi-Fi access points) or conventional (Ethernet-based) communication[7]. Multimedia content is stored in central servers (also known as Media Servers or Content Distribution Units). They are linked to seat electronics boxes (SEBs) or wireless access points, which provide passenger devices with content. Also, satellite communication can be installed to connect the aircraft to the internet, enabling real-time communication between ground systems and the aircraft (as shown in Fig. 1).

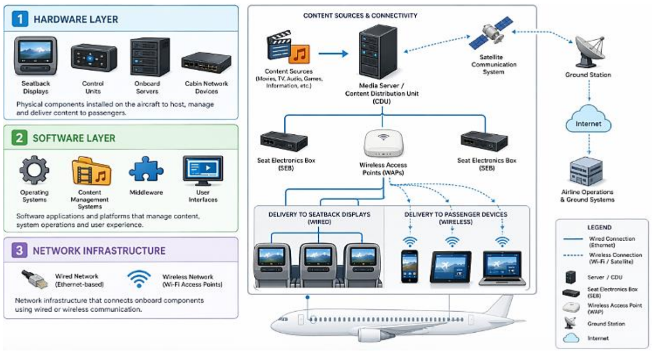

Fig. 1. Architecture of IFE system

B. Types of IFE Systems (Embedded, Wireless, BYOD)

The purpose of IFE systems is to provide travelers with multimedia services and content in the flight, contributing to their overall flight experience.

- **Embedded IFE Systems:** These systems are directly fitted on aircraft seats, with dedicated screens and controls. They are very reliable and offer uniform user experience but are costlier in terms of installation and maintenance.
- **Wireless IFE Systems:** These technologies feed entertainment straight to passenger devices via onboard Wi-Fi networks. They lower the weight and maintenance of hardware and are flexible.
- **Bring Your Own Device (BYOD):** BYOD systems are based on the use of devices owned by the passengers, i.e., smartphones, tablets, or laptops. Onboard portals or applications are provided by airlines, making them a cost-effective and scalable solution.

C. Role of Data in IFE Operations

Data is crucial in enhancing functionality and the passenger experience of the In-Flight Entertainment (IFE) systems. Using data gathered during passenger interactions and system operations, airlines able to improve service quality, make sure that systems are reliable, and make informed and data-driven decisions.

- **Personalization:** The data of passenger interaction, including viewing history and preferences, allow airlines to make personalized content suggestions that result in increased engagement and satisfaction.
- **System Monitoring:** Real-time data on operations is available, such as bandwidth utilization and the performance metrics of the system, which can assist in real-time monitoring of system and rapid resolution of technical problems.
- **Predictive Maintenance:** The performance of the system and logs of historical systems are analyzed to identify any possible faults even before they take place to minimize downtimes and costs of maintenance.
- **Content Optimization:** The passenger behaviour provides insights that airlines can use to modify and create better content according to their population, preference of the route and popularity to increase the overall service delivery.

III. DATA ACQUISITION MECHANISMS IN IFE SYSTEMS

Data acquisition serves as a key element of IFE systems, as it provides a platform to constantly gather various data streams needed to monitor the system, optimize its performance, and make informed decisions[8][9]. The collection of data on various onboard sources allows the airlines to have a comprehensive view of behaviour of passengers and conditions of the technical system.

A. Sources of the Data

IFE systems gather a variety of important sources of data, which provide individual insights:

- **Passenger Interaction Data:** This contains details like content selection, history views, browsing behaviour, time per session and user commentary. This data analysis helps airlines to learn more about their passengers, make them more individual and engage them more effectively in general.
- **System Sensor Data:** Physical devices on the board generate this data and this data comprises of temperature, power usage, device health and hardware health indicators[10]. It is important in stability monitoring of the system, safety and in support of predictive maintenance strategies.
- **Network Traffic Data:** This logs information such as bandwidth consumption, signal strength, latency, packet loss and total data traffic in the onboard network. It assists in ensuring effective connectivity, in maximizing the streaming quality and in detecting network related issues.

The signalization of these data sources gives a holistic and unified perspective of IFE system performance and user behaviour to allow airlines to deliver captivating, effective and passenger-centric services.

B. Data Collection Techniques and Tools

The data gathering of the IFE systems is carried out in a mixture of software-based data collection instruments with the system-level data collection mechanisms to guarantee ongoing and precise data collection. These steps give a chance to gather information about the interaction with passengers and operation indicators of passenger's flow with ease and make efficient decisions basing on the information and guarantee the management of the system. The key methods and equipment employed in the process are enumerated below:

- **Embedded Software Agents:** They are incorporated into IFE applications as a form of capturing user interventions like the content selection, navigation pattern and activity in the session[11] automatically, which can include all the information on the interaction between the passengers.
- **Monitoring Tools:** System-level hardware performance monitors (e.g. device healthy, temperature and power consumption) are monitored to guarantee stability and reliability of the system.
- **Logging Frameworks:** They are employed to document system events, system errors and operational logs in a methodical way which are important in troubleshooting, auditing and performance analysis.
- **APIs and Middleware:** APIs and middleware facilitate systematized data-collection and seamless integration of different IFE components enabling subsystems to share the data efficiently.
- **Edge Data Processing:** Advanced IFE systems employ onboard edge processing techniques to pre-process and filter data before it is sent to ground systems and thus conserve bandwidth and improve efficiency.

C. Communication Protocols and Data Transmission

In-Flight Entertainment (IFE) systems are based on strong communication standards and effective data delivery systems to provide seamless connectivity and effective service delivery[12]. These standards facilitate easy communication with onboard devices, servers, and external networks to enable passenger services and a system to operate. The commonly used protocols in IFE systems include:

- **TCP/IP (Transmission Control Protocol/Internet Protocol):** The basis of majority of onboard network communications and provides a reliable and structured flow of data between system components.
- **HTTP/HTTPS:** Widely used web-based services, including streaming content, accessing onboard portals, and providing secure exchange of data via encryption (HTTPS).
- **MQTT / AMQP:** Lightweight messaging systems that are optimized to support effective communication in bandwidth-restricted networks, commonly employed in real-time data transfer and monitoring of systems.

The transmission of data in IFE systems is done using onboard networks between different elements like seatback screens, servers, and wireless access points[13]. In case of outside connectivity, the data are sent through satellite links or air-to-ground communication networks. The bandwidth and high transmission cost mean that the data is usually compressed, sent on a priority basis based on its importance and only sent selectively in order to maximize performance and provide a pleasant experience to the passengers.

D. Challenges in Data Acquisition

The acquisition of data used in IFE systems can be complicated because of peculiarities of aviation environment. The efficiency and reliability of data collection can be influenced by factors like limited connectivity, various sources of data, and other hardware constraints. The most crucial issues at hand are as follows:

- **Limited Bandwidth and Intermittent Connectivity:** IFE systems depend on satellite or air-to-ground connections, which can be limited in bandwidth and prone to interruptions, impacting real-time data transmission.

- **Data Heterogeneity:** It has a number of sources of data such as passenger interactions, sensors and network systems that lead to variation of formats, structure and types and hence it becomes difficult to integrate and analyze the data.
- **Latency in Real-Time Transmission:** Reduced transmission speed of data can impact on real-time monitoring and responsiveness, especially time-sensitive applications.
- **Hardware Constraints:** The onboard systems are not as robust in their computation, storage, and energy, which restricts the capability to do large scale data processing and storage.
- **Ensuring Data Integrity and Reliability:** It may lose data, corrupt or have transmission errors and thus data accuracy, consistency and security is hard to maintain in the collection and transmission process.

These barriers are the foundation of the utility of good data management processes, smooth communication processes as well as good system design to facilitate the reliable and efficient data intake in the IFE systems.

IV. DATA LOGGING MECHANISMS AND MANAGEMENT

The logging of data is a major consideration of In-Flight Entertainment (IFE) systems as it allows observing the operations of the system in real-time, troubleshooting the failures, and basing the analysis and decision-making process on performance[14]. Good logging systems help airlines to monitor the health of a system and detect anomalies and improve overall efficiency.

A. Architectures of the Logging systems

Data logging constitutes a significant component of the In-Flight Entertainment (IFE) systems since it enables a consistent monitoring of the system behaviour, diagnosis of issues, and sophisticated analytics. As IFE environments are distributed such as the provision of seatback screens, onboard servers and connectivity modules, a suitable logging architecture needs to be chosen to make the system efficient and reliable. The IFE systems mostly embrace distributed or centralized logging and all with their advantages and disadvantages.

1) Centralized Logging Architecture

It involves collecting log information of different sections of the system and sending it to a single, central server. This approach simplifies the administration of logs since all data is gathered and computed at one location hence easier to perform real time monitoring, debugging and analytics. Further, centralized systems can be incorporated with visualization and alerting systems. However, this architecture can cause performance bottlenecks especially when it is handling a lot of log data. It is also characterized by one point of failure that can affect the resilience of system unless addressed adequately using redundancy mechanisms.

2) Distributed Logging Architecture

Conversely, there are stores and processes which store data in the system in a huge number of nodes. All the components or subsystems have their own logs, either locally available or in a distributed format[15]. It is scalable and fault tolerant because the system is not dependent on a single central server. Specifically, it is sensitive to the already deployed highly distributed IFE systems having many endpoints. Nevertheless, distributed logging requires more complex coordination, such as time coordination, aggregation of logs rules and standardized format to permit every node to analyze the logs suitably. The IFE systems have centralized and distributed logging architectures as shown in the figure 2 which are major trade-offs in the scales of scalability, performance and fault tolerance.

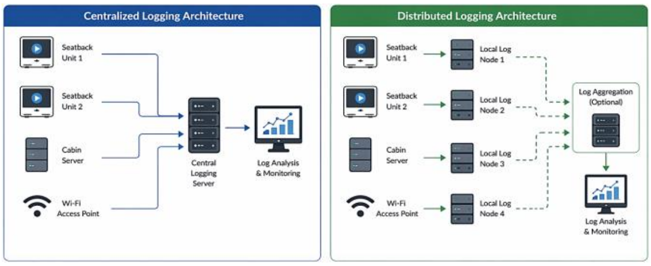

Fig. 2. Logging Architectures in IFE Systems: Centralized vs Distributed

B. Real-Time and Batch Logging Approaches

The logging methods employed on IFE systems should be in a position to balance the immediacy and efficiency depending on the requirements of the operations. There are two major methods of it: real-time logging and batch logging.

- **Real-Time Logging** is a real-time process of capturing and processing log data as they happen. It also allows operators to continuously monitor the system to identify anomalies, diagnose and react to system failures in near real time. It may be especially useful with major elements of the system that need real-time feedback to ensure the quality of the provided services and passenger experience[16]. Nonetheless, real-time logging can be more computationally intensive and consume additional network bandwidth.
- **Batch Logging**, conversely, gathers data and, at a specified frequency, handles the data. This is especially true when dealing with large volumes of data and is more suitable for offline analysis, reporting and long-term trend analysis. Even though the batch processing lowers the overhead and utilization of resources, it is not real-time, as required to detect and respond to problems in time.

C. Storage, Processing, and Data Management

In-Flight Entertainment (IFE) systems have a strong dependence on the data storage, processing, and management to ensure efficient operation and enable data-driven insights. The data storage is typically in a two-tier format with onboard storage as a temporary store of logs, user interactions and system data during flights especially in areas with limited connectivity. This data is then moved to the on-ground cloud systems or data centers to archive and analyze the data in the long term[17][18]. Data processing pipelines refer to the transformation of raw data into useful information through stages of filtering, aggregation, and transformation. The processes enable quality, consistency and analytics-enabling data. Distributed databases, data lakes, and stream processing systems are examples of modern technologies that are gaining traction to handle the massive amounts of data produced by IFE systems. These technologies are more scalable, support real-time and batch processing, and can handle both structured and unstructured data.

D. Security, Privacy, and Compliance Considerations

Security and privacy are essential component in proper management of data in IFE systems, since most of systems handle sensitive information of passengers including their preferences and usage patterns and their connection information. A high degree of protection and compliance with regulations and ethical data management are essential to secure the user data and retain the trust of passengers.

- **Data Protection Measures:** Strict security protocols, like an end-to-end encryption, secure transport protocols and role-based access control are implemented to prevent unwanted access and guarantee integrity and security of data.
- **Privacy Preservation:** Anonymization, pseudonymization, and masking of data protect the personal identifiable information (PII) and decrease the likelihood of misuse or data disclosure.
- **Regulatory Compliance:** The IFE systems should also be aligned to international data protection rules and standards to ensure that the data collection, storage and processing practices are not illegal in various jurisdictions.
- **Transparency and Ethical Practices:** Airlines should accept the task of clarifying to the passengers how their information is gathered, saved and utilized, advancing spirit of openness and ensuring that personal and behavioural facts are applied in a morally and ethically proper way.
- **Risk Management and Monitoring:** Periodic audits, vulnerability tests, and ongoing security checks can help to identify potential threats, reduce risks, and enhance the overall system resilience to cyberattacks[19].

V. LITERATURE OF REVIEW

Recent research has outlined the progress in IFE systems in performance, security, user experience and communication technologies, but has found very limited research done into integrated data acquisition and logging systems.

S. Moghadas Nian and H. Nafisi (2026) is a mixed-method, which applies a quantitative analysis of data regarding usage and engagement with systems and qualitative passenger and crew feedback. As a part of this overall assessment, the research outlines some of the key KPIs, like the content variety, platform utilization, system accessibility, and customer satisfaction, which are directly related to the efficacy of IFE offerings. The findings indicate that dynamic approach to content strategy, customized engagement activities, and focus on technical reliability is the key to enhancing the overall passenger experience. Moreover, the research suggests the importance of a strategic and data-oriented attitude to IFE management that enables the airlines to align their services more with the needs of passengers and technological advances. This paper add valuable insights to the current discussion on improving in-flight services in a competitive market environment by pinpointing actionable insights and providing recommendations on strategic IFE optimization[20].

A. Al Ishtiaq *et al.* (2025) present the first comprehensive investigation utilizing network tomography of the design and security guidelines of in-flight Wi-Fi paywall systems. They find that attackers can build covert channels and hide data packets within certain "always-allowed" traffic for free Internet access by taking use of the inherent architectural flaws of aerial networks. Additionally, these systems' flawed device authentication procedures provide limitless free Internet access. Lastly, unsecured ARP regulations enable hackers to steal bandwidth from paying subscribers in order to gain even quicker access to the free Internet. to verify these problems using common protocols, such as UDP and DNS, across two significant in-flight Wi-Fi providers. Additionally, they discover that several design decisions made in these systems' architectures are the primary drivers of these problems, and they suggest fixes to fix these defects and stop similar attacks[21].

M. H. Heo and Y. J. Park (2025) analyzes the structural impact relationship between the quality of wireless in-flight entertainment, variables derived from the extended technology acceptance model, and passengers' intention to use it. An online survey was conducted with 180 Korean passengers who had experience using the wireless entertainment system on Full-Service Carrier (FSC) aircraft. The PLS-SEM approach was implemented to estimate the measurement and structural model. The results show that perceived ease of use, perceived utility, and reported enjoyment are all strongly influenced by the quality of wireless IFE. Furthermore, the intention to use was influenced by perceived utility, perceived enjoyment, and self-efficacy. In the moderation effect analysis, gender influenced the relationship between wireless in-flight entertainment quality and perceived enjoyment, while age moderated the relationship between quality and perceived ease of use [22].

T. White, A. Fonnegra, and O. Hazbon (2024) presents the development and testing of a telemetry system designed for a small Unmanned Aerial System (UAS) to facilitate a comprehensive flight test analysis. The system integrates off the shelf sensors and a microcontroller unit (MCU) to accurately estimate critical flight parameters such as position, speed, attitude, control surface deflection, engine thrust, and RPMs, providing a reliable source of the aircraft's state estimation. The telemetry system employs a suite of sensors including a 9-Degrees of Freedom (DOF) Orientation Inertial Measurement Unit (IMU) Fusion

Breakout, a Precision Barometric Pressure and Altimeter Breakout, an MTK3333 GPS chipset, and an MS4525 PCB-mounted pressure transducer. These components are interfaced via I2C with an MCU board, allowing for centralized data acquisition and processing [23].

J. B. Rosolem *et al. (*2024) explains an optical fiber (PoF)-based video and power transmission technology for use in IFE systems. Present a summary of the advantages and drawbacks of this application and conduct two practical tests to show the effectiveness of the form. One 15-Watt semiconductor laser operating at 808 nm was one of the commercially available equipment utilized in the research. Gaas video displays, photovoltaic converters, and optical transmitters and receivers. Two 50-meter-long multimode fibers were used to send the power and video signals. Furthermore, the two types of energy transformation units (ETUs) that were presented and tested are in charge of providing electrical energy to the optical fiber receiver and the IFE visual display[24].

B. Mafakheri *et al.* (2023) provide a proof-of-concept for an in-flight edge network through an experimental demonstration of an AI-based edge-computing platform created as part of the cloud-enabled Aircraft Network and Artificial Intelligence-based data Analysis (CANARIA) project. In addition to enhancing the in-flight experience for passengers and cabin staff, the CANARIA edge-computing platform provides a range of AI-based and containerized apps that support the cabin's digital transformation and boost connection system security and safety[25].

The table I highlight notable studies, with special attention to areas of focus, findings, challenges, and limitations, with gaps in unified data acquisition, logging mechanisms, and real-time analytics in IFE systems.

TABLE I. Summary Of Recent Studies In Ife Data Acquisition And Logging Systems

Authors	**Focus**	**Key Findings**	**Challenges**	**Limitations**	**Future Work**
S. MoghadasNian and H. Nafisi (2026)	Evaluation of IFE performance using mixed-methods (KPIs & user feedback)	Identified KPIs: content diversity, engagement, reliability, and customer satisfaction; emphasized data-driven IFE optimization	Integration of qualitative and quantitative data; maintaining consistent engagement	Limited emphasis on technical aspects of data acquisition and logging	Develop automated, real-time data-driven IFE optimization frameworks
A. Al Ishtiaq *et al.* (2025)	In-flight Wi-Fi paywall system security analysis	Identified vulnerabilities such as covert channels, weak authentication, and ARP exploits	Ensuring secure communication in airborne network environments	Focus limited to security; lacks discussion on full data acquisition and logging pipeline	Design secure architectures integrating data acquisition and logging mechanisms
M. H. Heo and Y. J. Park (2025)	Wireless IFE quality and user acceptance (TAM-based analysis)	Perceived utility, usability, enjoyment, and user intention are all strongly impacted by IFE quality.	Capturing subjective user behavior and perception metrics	Does not address system-level data acquisition or logging techniques	Integrate behavioral analytics with real-time data logging for personalization
T. White, A. Fonnegra, and O. Hazbon (2024)	Telemetry-based data acquisition system for UAS	Demonstrated accurate acquisition of multi-sensor flight data using MCU and integrated sensors	Real-time synchronization and processing of multi-source data	Focus on UAS rather than IFE systems	Adapt telemetry-based acquisition models for IFE systems
J. B. Rosolem *et al.* (2024)	Optical fiber-based video and power transmission for IFE	Demonstrated efficient and reliable data transmission using Power-over-Fiber	Hardware integration and system complexity in aircraft environment	Limited discussion on data logging and analytics	Extend system with integrated logging and monitoring mechanisms
B. Mafakheri *et al.* (2023)	AI-based edge computing platform (CANARIA) for aircraft systems	Improved passenger experience and system efficiency using AI and edge computing	Deployment complexity and resource constraints in edge environments	Lacks focus on standardized logging and acquisition frameworks	Develop AI-driven integrated data acquisition and logging systems

VI. Conclusion And Future Work

The functionality, reliability and intelligence of the modern In-Flight Entertainment (IFE) systems cannot be achieved without effective data-gathering and recording systems. With the increased and very fast growth of digital aviation technologies, IFE systems have become more data-intensive, grounded on the unremitting data-gathering and processing to enhance the passenger experience and ensure the maximum efficiency in the operations. Despite the noticeable enhancements in system architecture, communication protocols and data processing schemes, several challenges exist, which inhibit optimal performance. They are limited onboard computing, intermittent connectivity, high data heterogeneity and increasing data volumes. Moreover, most of the solutions in the market are skewed to one specific functionality such as security, user interaction or network optimization, and not an end-to-end, integrated data management framework. The strain on real time analytics, scalable logging systems and capability to manipulate sensitive passenger data in a secure manner further increases the necessity to possess stronger systems. Future research should focus on developing integrated and adaptive frameworks comprising of edge computing, artificial intelligence, and cloud-based analytics to help manage the data efficiently and intelligently. Digital twin technology can also be used in a large-scale adoption to improve real-time monitoring and predictive maintenance in IFE systems. Moreover, attempts must be made to normalize data formats, enhance security and privacy measures, and develop lightweight communication systems that can be used in constrained systems. The solutions to these problems will result in the next-generation IFE systems, which are more scalable, resilient, secure, and can offer passengers a highly personalized experience.

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