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# Application of Internet of Things (Iot) Technology in Library and Information Centres – A Literature Review

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## ABSTRACT

This review examines the application of IoT technologies in libraries, focusing on how it improves services, user experiences, and operations. It analyzes existing literature, highlighting smart resource management through real-time monitoring and tracking of books and materials, leading to improve inventory management and resource utilization. Environmental monitoring ensures optimal conditions for preservation and user comfort. IoT-based smart space management optimizes seating, usage analysis, and real-time retrieval of information. Personalized services, enhanced security, and access control are achieved through IoT technologies. The review emphasizes benefits like operational efficiency, user engagement, data-driven decision-making, and innovative services. It was found that challenges of IoT include privacy, interoperability, training, costs, and governance. User perspectives address consent, data protection, and trust. Future directions include data analytics, AI integration, interoperability standards, and user-centric design. Best practices include collaboration, information sharing, and continuous evaluation. The paper concluded that a balanced approach is needed to address privacy concerns while leveraging IoT benefits in libraries. This review provides insights, identifies challenges and opportunities, and offers directions for future research and practice.

**Keywords:** Application, Internet of Things (IoT), Technology, Library and Information centres

## 1. Introduction

The term "Internet of Things" (IoT) refers to a system wherein various physical objects or "things" are equipped with sensors, software, and connectivity features. This allows them to gather and share data with each other via the internet. The objects encompass a wide range, spanning from common devices like smartphones, fitness trackers, and household appliances, to more specialized items such as industrial machinery, environmental sensors, and smart city infrastructure (Bansal, 2018). IoT is a rapidly growing technological concept that has gained significant attention in recent years. It refers to the interconnection of physical objects or "things" through the use of sensors, software, and network connectivity, enabling them to collect and exchange data (Ahmed et al., 2022). The fundamental idea behind the IoT is to make everyday objects more intelligent and interconnected, allowing them to communicate and collaborate with each other seamlessly (Osório et al., 2019)'(Brandt et al., 2014). By embedding sensors and connectivity capabilities into various devices, these objects become

capable of capturing data from their surroundings and interacting with other IoT-enabled devices or systems (Adepoju & Opele, 2021)'(Opele, 2020). Scholars such as (Tella & Ogbonna, 2023) have reasoned that the range of objects that can be part of the IoT is incredibly diverse, including smartphones, smartwatches, and home appliances, which can connect to the internet and interact with users or other devices (Opele et al., 2015). For example, a smart thermostat can adjust the temperature based on occupancy data collected from motion sensors, or a wearable fitness tracker can monitor and transmit data to a smartphone app.

However, the IoT extends beyond consumer devices (Ofuebe et al., 2022). IoT also encompasses more specialized objects and infrastructure. Industrial machinery, for instance, can be equipped with sensors to monitor performance, detect faults, and optimize maintenance schedules. Environmental sensors can be deployed to monitor air quality, weather conditions, or water levels (Hasan et al., 2022). Smart city initiatives leverage IoT technologies to enhance urban services, such as traffic management, waste management, and energy consumption optimization.

The potential applications of IoT are vast and have implications in various domains, including, transportation, agriculture, manufacturing, and energy management, among others (Ahmed et al., 2022). It promises benefits such as improved efficiency, enhanced productivity, automation, real-time monitoring, and data-driven decision-making (Ngo et al., 2019). However, the proliferation of IoT also raises concerns regarding privacy, security, and data management. As more objects become connected and share sensitive data, ensuring robust safeguards and protocols for protecting personal information and preventing unauthorized access becomes crucial (Peng et al., 2019).

Overall, the Internet of Things technologies has the potential to revolutionize the way people interact with their surroundings and how objects interact with each other, opening up new possibilities for innovation and efficiency in numerous aspects of our lives (Birkel et al., 2019). The fundamental concept behind IoT is connecting these objects to the internet and to each other, allowing them to communicate, share data, and perform tasks without the need for human intervention (Santoro et al., 2018). This network of connected devices creates an ecosystem where information can be gathered, analyzed, and acted upon in real-time, leading to increased efficiency, automation, and improved decision-making. Besides, available studies (Mahajan et al., 2022); (Santoro et al., 2018) have shown that IoT devices typically consist of many components such as:

- Sensors: IoT devices are equipped with various sensors that can detect and measure physical attributes such as temperature, humidity, motion, light, or location. These sensors capture real-world data and convert it into digital information.
- Connectivity: IoT devices utilize different communication technologies such as Wi-Fi, Bluetooth, cellular networks, or low-power wide-area networks (LPWAN) to connect to the internet and transmit data.
- Data Processing: IoT devices often have built-in processors or microcontrollers that enable them to process and analyze the data they collect. This processing can occur on the device itself or be offloaded to a cloud-based platform for more complex computations.

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- Cloud Services: IoT devices often leverage cloud-based platforms for data storage, processing, and analytics. Cloud services can provide the scalability and computing power needed to handle large volumes of data.
- User Interface: Many IoT devices have user interfaces that allow users to interact with them, either through mobile apps, web interfaces, or voice-activated assistants. These interfaces enable users to monitor device status, control functionalities, and access data insights.

## 1. The application of IoT in Library and Information Centres

Literature have shown that the applications of IoT are vast and span across various industries including education, agriculture, business and libraries (Nam et al., 2021); (Sinha & Dhanalakshmi, 2022). Smart homes use IoT devices to control lighting, thermostats, and security systems, providing convenience and energy efficiency(Hasan et al., 2022).As technology continues to advance, the Internet of Things has the potential to revolutionize industries, improve efficiency, and enhance our daily lives by creating a highly connected and intelligent world(Sinha & Dhanalakshmi, 2022); (Thamilarasu & Chawla, 2019).

IoT-enabled sensors can be installed on library shelves to track the location and availability of books. This enables librarians and patrons to quickly locate books and reduces the time spent searching for specific titles. Similarly, Radio Frequency Identification (RFID) technology can be used to tag library materials such as books, DVDs, and CDs. RFID tags can store information about the item, allowing librarians to easily track and manage their inventory. Patrons can also use self-checkout stations equipped with RFID readers to borrow and return items efficiently. Similarly, scholar have argued that IoT sensors can also be used to track patron movements within the library. This information can be analyzed to identify popular areas, optimize space utilization, and improve the layout of the library.

Book Recommendation Systems: IoT devices can collect data on patrons' reading habits, preferences, and borrowing history. This information can be used to develop personalized book recommendation systems, suggesting relevant titles based on individual interests.

Security and Access Control: IoT-enabled security systems, including cameras, motion sensors, and access control mechanisms, can enhance library security. Unauthorized access attempts can be detected, and real-time alerts can be sent to library staff.

Asset Tracking: Libraries often have mobile assets like laptops, tablets, and audiovisual equipment. IoT-based asset tracking systems can help librarians keep track of these items, locate them when needed, and prevent loss or theft.

Remote Monitoring and Maintenance: IoT sensors can monitor the condition of library equipment, such as printers, scanners, and HVAC systems. This allows librarians to proactively detect issues, schedule maintenance, and reduce downtime.

Smart Book Drop: IoT technology can be integrated into book drop systems, allowing automated check-in and sorting of returned books(Usak et al., 2020). This saves time for both patrons and library staff.These applications demonstrate how IoT can enhance various aspects of librarianship, improving operational efficiency, enhancing user experience, and providing valuable insights for better decision-making(Khadam et al., 2019);(Tang et al., 2019).

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## 2. Challenges of Integrating IoTIn Library and Information Centres

Scholars have noted that while IoT offers numerous benefits for libraries (Alzoubi et al., 2021), several challenges and drawbacks must be considered when implementing this technology (Bansal, 2018). The financial implications of implementing IoT infrastructure are significant, often requiring substantial investments in hardware, software, connectivity, and ongoing maintenance. Libraries with limited budgets may find these upfront costs a considerable barrier (Ratta et al., 2021). Furthermore, the interoperability and integration of IoT systems can present challenges. These systems often involve multiple devices and technologies from different vendors (Usak et al., 2020), and ensuring seamless integration can be complex and time-consuming. Libraries may encounter compatibility issues and face difficulties in managing a diverse IoT ecosystem.

Technical expertise is another critical area, as implementing and managing IoT infrastructure requires specialized knowledge and skills. Libraries might need to invest in staff training or hire external experts to handle the complexities of IoT systems effectively (Kassab et al., 2020). Moreover, the reliability and maintenance of IoT devices are ongoing concerns. These devices are prone to technical failures, connectivity issues, and software bugs, requiring robust maintenance and support mechanisms to address problems promptly. Downtime or disruptions in these systems can impact library operations and user experience. Ethical considerations must also be addressed, as IoT systems generate vast amounts of data about patrons' behavior and preferences. Libraries must navigate these ethical implications, ensuring transparency, consent, and responsible data usage practices. User acceptance and accessibility are also key, as not all library patrons may be comfortable or familiar with IoT technologies. Libraries need to provide adequate training and support to ensure all users can access and benefit from these services, accounting for accessibility for patrons with disabilities.

Infrastructure limitations can further complicate IoT implementation, as libraries may face challenges in retrofitting existing buildings to accommodate IoT devices and networks (Agarkar & Agrawal, 2019). Maintenance and compatibility must be taken into consideration, with IoT devices requiring regular maintenance, software updates, and compatibility checks to ensure continued functionality. Furthermore, libraries may face scalability challenges when expanding IoT systems, requiring careful planning to manage complex integration processes. Connectivity and infrastructure limitations also need to be accounted for, as IoT systems rely on stable internet connectivity that may not be available in all areas, especially in remote or underserved locations. Additionally, the energy consumption of IoT devices can lead to increased operational costs and environmental impact, necessitating the exploration of energy-efficient solutions.

User education and acceptance are also vital factors, with libraries needing to invest in user education programs to familiarize patrons with IoT-enabled services and address concerns. Ethical and legal considerations surrounding privacy, data protection, and compliance with relevant regulations also need careful attention, with libraries establishing procedures to

ensure adherence to local laws and regulations. Libraries should also invest in training to empower their staff to manage IoT devices, networks, and data analytics tools. Data privacy and security is an essential concern due to the vast amounts of data gathered about patron behavior, requiring libraries to implement safeguards to protect user privacy. Maintenance and upgrades also need to be accounted for, with libraries establishing protocols to ensure the continuous functioning and security of IoT systems. Lastly, the integration complexity of IoT devices with existing library systems needs to be managed, with libraries ensuring seamless integration through careful planning, collaboration with vendors, and robust APIs or middleware solutions. The data overload that can come from IoT systems requires that libraries have the capacity to handle and analyze that data effectively.

The rapid evolution of IoT devices and protocols presents challenges related to standardization and interoperability. Libraries must carefully select devices and technologies that adhere to widely accepted standards to ensure future-proofing their IoT infrastructure. In addition, libraries need to evaluate the compatibility of different devices and systems, often requiring middleware or integration platforms to facilitate seamless communication. Legacy system limitations pose another hurdle, as existing systems may not have been designed to accommodate IoT integration and may lack the necessary interfaces or capabilities for effective integration. Upgrades or replacements of these systems may be necessary to overcome these limitations. The massive volume of data generated by IoT devices creates the need for careful planning for data storage, processing, analysis, and lifecycle management to ensure data quality and compliance with privacy regulations.

Integrating IoT devices with existing systems significantly adds to overall system complexity. Libraries may need to invest in additional infrastructure, such as gateways, sensors, or cloud services, to support integration. Managing this complex system architecture and ensuring its stability and performance can be a challenge. The design of the user experience must carefully consider the needs of library patrons to ensure that new IoT-enabled services are easily understood and usable, incorporating user testing and feedback to iteratively improve the user experience. Furthermore, IoT devices require ongoing maintenance, updates, and technical support. Libraries must establish processes and allocate resources for this, including addressing device failures and troubleshooting issues. The energy consumption of IoT devices can lead to higher energy usage; therefore, libraries need to explore energy-efficient solutions and sustainable practices, like using renewable energy sources, to minimize their environmental impact.

Successful IoT integration requires collaboration among library staff, IT departments, vendors, and patrons. Coordinating efforts, aligning expectations, and fostering effective communication are essential for overcoming the challenges related to this collaboration. Evaluation and adaptation are continuous processes after the initial integration, with libraries gathering feedback from patrons and staff and monitoring system performance to make necessary adaptations and improvements. Cost considerations are also crucial, as libraries with limited budgets must carefully evaluate the costs involved and prioritize investments based on their expected benefits and long-term value. Libraries also need to ensure their staff receive training and development opportunities to acquire the new skills needed to manage IoT-enabled services. Change management strategies must be implemented to mitigate disruption to workflows and processes caused by the introduction of IoT devices.

Ethical considerations regarding data collection, usage, and privacy must be carefully addressed, with libraries establishing clear policies and guidelines for the responsible and ethical use of patron data. System integration complexity needs to be managed carefully due to the diversity of existing systems in libraries, with custom integrations or middleware solutions often required. Libraries must plan for long-term sustainability, considering device lifespan, vendor support, and compatibility with future technologies. Furthermore, libraries should educate patrons about the benefits, usage, and privacy implications of IoT devices and solicit their feedback to encourage user adoption. Robust data governance practices need to be implemented to manage the increased collection and use of data through IoT devices, and this includes policies defining data ownership, retention policies, and data-sharing agreements. Finally, libraries must ensure their IoT systems are reliable and plan to mitigate any issues related to system downtime.

Data integration from a range of sources needs careful planning to ensure interoperability, consistency, and seamless integration. Libraries should consider the energy usage of IoT devices and use energy-efficient solutions where possible, considering power management features and renewable energy sources. Due to the diversity of devices and platforms within the IoT landscape, libraries need to address issues of interoperability and compatibility, ensuring seamless communication between devices. Lastly, libraries must establish clear policies regarding data ownership and intellectual property rights, protecting sensitive information and ensuring compliance with relevant licensing and copyright regulations.

Libraries are increasingly focusing on environmental sustainability, and they must consider this when integrating IoT devices. Libraries should prioritize the use of recyclable materials, aim to reduce electronic waste, and implement sustainable practices throughout the lifecycle of IoT devices. They can also explore IoT applications that promote sustainability, such as energy management or waste reduction solutions. System complexity and integration testing must also be addressed, as the integration of IoT devices into existing library systems can introduce complexity, especially when multiple devices and systems need to work together. Therefore, libraries need to conduct thorough testing and quality assurance processes to minimize disruptions and ensure system stability.

Furthermore, respecting user privacy preferences is crucial when integrating IoT devices. Libraries must provide clear information about data collection practices, allow opt-in/opt-out choices, and give users control over their data (Jahmunah et al., 2021). This will help maintain trust and foster positive relationships with patrons (Latif et al., 2021). IoT devices require regular maintenance and firmware updates to ensure optimal performance and security. Libraries need to establish maintenance processes, including device monitoring and software patching. They must also consider the lifespan of these devices, planning for their replacement to avoid using outdated or unsupported technology. Libraries should also consider data storage requirements, implement data backup strategies, and adhere to data retention policies, including assessing storage capacity and implementing archiving solutions.

User experience design is a vital aspect of IoT integration, and libraries must ensure that devices are intuitive, user-friendly, and accessible. Libraries should conduct user testing, gather feedback, and iterate on the design to create seamless and engaging experiences. Collaboration and partnerships with external organizations can help libraries overcome challenges, accelerate implementation, and amplify the impact of IoT-enabled services. This can provide access to expertise, resources, and funding opportunities. Compatibility issues

can arise due to different protocols and standards used by IoT devices, and libraries may need to address issues related to seamless communication with existing systems.

Data integration and mapping are also important; the data from IoT devices needs to be properly formatted so that it can be used by existing library systems. Libraries must address discrepancies in data structures to ensure data is integrated effectively. Furthermore, reliable network connectivity is essential for IoT devices. Libraries must consider network coverage, bandwidth, and the potential for connectivity disruptions. They also need to address the additional security and privacy risks introduced by IoT devices, particularly regarding patron data. Scalability is another key consideration, as libraries need to plan for future growth and ensure that their systems can accommodate additional IoT devices seamlessly.

Libraries must invest in staff training to ensure that staff members can operate and maintain IoT devices and understand the integration process with existing systems. Budget and resource constraints may create challenges, so libraries need to prioritize their investments based on their expected benefits and long-term value. Finally, vendor management can be complex, requiring libraries to manage relationships with multiple vendors, ensure compatibility between different solutions, and hold vendors accountable for service delivery.

## 3. User Privacy Concerns with the Application of IoT In Libraries And Information Centres

Literature indicates that the application of IoT in libraries and information centers raises several privacy concerns (Ratta et al., 2021); (Alzoubi et al., 2021). To address these concerns effectively, libraries must prioritize transparent communication with users. This involves clearly explaining the procedures for data collection through IoT devices, detailing the types of data gathered, and outlining how this data will be utilized. Such transparency is crucial for building trust and empowering users to make informed decisions about their privacy (Khan et al., 2020). Furthermore, libraries should develop comprehensive privacy policies that are easily accessible to users, either physically or online. It is also essential that libraries obtain explicit consent from users before collecting any personally identifiable information or implementing IoT devices that may collect sensitive data.

To further safeguard user privacy, libraries should provide users with control over their data, including offering opt-out options for data collection and enabling them to manage their privacy preferences. Respecting user choices and ensuring that opting out does not negatively impact library services is paramount. Alongside user control, libraries should implement data minimization practices, only collecting necessary data and anonymizing or pseudonymizing personal data where possible. Data retention policies should also be in place to ensure data is not stored for longer than required. In addition, library staff should receive thorough training on data privacy, security best practices, and the proper handling of user information to understand and uphold these principles.

Regular privacy impact assessments (PIAs) should be conducted when integrating IoT devices to identify potential privacy risks and mitigate them. Libraries should thoroughly vet vendors, ensuring they have robust privacy policies and adhere to industry best practices. Libraries should also proactively educate users about IoT devices, their benefits, and associated privacy implications through various means. This includes ensuring that all privacy practices are subject to regular audits to ensure compliance and to identify areas for

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improvement (Kassab et al., 2020). Furthermore, libraries should adopt a "privacy by design" approach, integrating privacy considerations from the outset of the design and development process of IoT systems. Seeking third-party audits and certifications can further validate privacy practices and demonstrate a commitment to user protection. Libraries can also use informational materials and workshops to guide users on how to protect their personal data and control data collected via IoT devices.

Libraries must conduct privacy impact assessments specifically for their IoT projects and keep users informed about any changes in their privacy policies, seeking their feedback and promptly addressing their concerns. Forming partnerships with organizations that prioritize privacy can ensure that privacy considerations are embedded in the design and functionality of IoT devices. Libraries should offer user-configurable privacy settings whenever possible, enabling individuals to tailor their preferences. Periodic audits should also be implemented to find vulnerabilities in privacy practices, thereby guiding continuous improvements. Lastly, a governance structure with privacy officers responsible for monitoring privacy compliance is needed to ensure alignment with legal requirements and industry standards.

## 4. Strategies for Integrating IoT Devices with the Existing Library Systems

Literature (Tang et al., 2019) indicates that integrating IoT devices with existing library systems requires careful planning and implementation that may affect library services (Ngo et al., 2019); (Usak et al., 2020). The initial step involves a thorough assessment of the library's current systems and infrastructure. This assessment should identify systems that can be enhanced or optimized through IoT integration, taking into account compatibility, data requirements, and user needs (Tun et al., 2021). Following this assessment, libraries must clearly define their integration goals and objectives, outlining the specific benefits or improvements they aim to achieve through IoT adoption. This could encompass enhancements to operational efficiency, user experience, or gaining deeper insights into library usage.

Following the identification of goals, libraries should research IoT devices and solutions available in the market that align with their defined objectives. Factors to consider include compatibility with existing systems, scalability, ease of integration, and vendor support (Abdulrahman et al., 2021); (Avdhesh Yadav & Poongoodi, 2022). Therefore, it is crucial to choose solutions that offer open APIs or standards for seamless integration. Moreover, libraries should engage in active discussions with IoT device vendors and solution providers. Sharing specific integration requirements and seeking their expertise is crucial for a smooth integration process. Close collaboration with vendors ensures a successful implementation. In addition to direct vendor engagement, libraries should explore middleware solutions, which can act as intermediaries between IoT devices and existing systems, facilitating data exchange and integration.

By implementing these strategies, libraries can demonstrate a strong commitment to user privacy, foster a culture of privacy awareness, and cultivate strong relationships with patrons built on trust and transparency (Avdhesh Yadav & Poongoodi, 2022). Through these strategies, libraries can effectively prioritize user privacy, build trust with patrons, and ensure

the responsible and ethical use of IoT devices, while also providing valuable services and enhanced experiences.

## 5. Conclusion

In conclusion, the application of IoT in libraries and information centers has revolutionized the way these institutions operate and serve their patrons. IoT technology has enabled libraries to enhance their efficiency, accessibility, and overall user experience.By implementing IoT devices such as smart shelves, RFID tags, and sensors, libraries can automate various processes, including inventory management, book tracking, and security(Alam, 2021). This automation reduces manual labor, saves time, and improves accuracy, allowing library staff to focus more on assisting patrons and providing valuable services.Moreover, IoT-enabled library systems offer enhanced accessibility to users. With IoT devices, patrons can easily locate books and other resources through interactive digital maps or mobile applications. This streamlines the searching process and eliminates the frustration of trying to find specific items in large collections.

IoT also enables libraries to gather valuable data on user preferences, behavior, and resource usage(Xu et al., 2023).Hence, byanalyzing this data, libraries can gain insights into popular genres, peak usage hours, and overall trends, enabling them to make informed decisions regarding collection development, resource allocation, and service improvements.Additionally, the integration of IoT technology in libraries promotes a more interactive and engaging experience for users. Smart libraries can offer personalized recommendations based on users' interests and reading history. They can also provide interactive displays, digital signage, and virtual reality experiences, enriching the learning environment and attracting a wider audience.However, it's essential to address potential challenges associated with IoT implementation, such as data privacy and security concerns. Libraries must prioritize safeguarding user information and ensuring robust cybersecurity measures.Overall, the application of IoT in libraries and information centers has transformed these institutions into modern, tech-savvy hubs of knowledge. By embracing IoT technology, libraries can continue to evolve and adapt to the changing needs of their users, providing enhanced services and experiences in the digital age.

## 6. Recommendations

The future of IoT for library and information professionals presents exciting possibilities, with several potential directions and advancements. Libraries can evolve into more intelligent and interconnected spaces through the strategic application of IoT technology. Smart sensors, embedded throughout library environments, can monitor occupancy, temperature, lighting, and noise levels, enabling optimized environmental control and enhanced energy efficiency. This data also equips librarians with valuable insights into space utilization patterns, informing decisions regarding resource allocation and library layout.

Furthermore, IoT facilitates more efficient asset tracking and inventory management. By using RFID tags or other IoT-enabled tracking systems, libraries can gain real-time information on the availability and location of resources, including books, equipment, and media materials. This significantly streamlines inventory management and reduces the time spent searching for misplaced items. Beyond operational efficiencies, IoT holds the potential

to greatly enhance personalized user experiences within libraries. By leveraging collected data, libraries can offer personalized recommendations, customized notifications, and tailored services based on individual user preferences, interests, and usage history. Location-based recommendations within the library and notifications regarding relevant events or resources are just a few examples of the possibilities this technology can enable.

Lastly, IoT technology can transform browsing experiences by making bookshelves and collection displays more interactive. Smart bookshelves, equipped with sensors and displays, can provide real-time information about books, including summaries, reviews, and related resources. This integration of technology can greatly enhance user engagement with library collections and promote discovery.

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