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Automating Co-curricular Management: An NFC-Based System for Streamlining Student Engagement at IIUM

Zainab S. Attarbashi[1,*], Kay Aiman Fitri Kamarudin[1], Ikmal Ikhwan Mohammad Rafaii[1], Oula Sakka[2], and Azana Hafizah Mohd Aman[3]

[1]Department of Computer Science, Kulliyyah of Information & Communication Technology, International Islamic University Malaysia, Kuala Lumpur, Malaysia
[2]Department of Information Systems, Kulliyyah of Information & Communication Technology, International Islamic University Malaysia, Kuala Lumpur, Malaysia
[3]Faculty of Information Science and Technology, Center for Cyber Security, Universiti Kebangsaan Malaysia, Bangi, Malaysia

ABSTRACT

In today's educational systems, academic excellence alone is insufficient for a holistic development approach. Equally important is the active participation of students in co-curricular activities, which contribute significantly to their overall growth and skill development. Managing student co-curricular activities without an automated system often leads to significant administrative burdens, data inaccuracies, and inefficient use of resources due to reliance on manual processes like paper-based sign-ins and spreadsheets. Furthermore, the accurate recording of these activities is necessary not only for validating student participation and awarding credits but also for providing data-driven insights into engagement patterns and the overall effectiveness of university programs. To improve the tracking of student involvement in co-curricular activities, this study proposes integrating Near-field Communication (NFC) technology into IIUM's existing Starpoint system, thereby addressing its current operational challenges. The current system at IIUM faces several challenges, including delays in record updates, data loss, and human errors. These issues not only affect the accurate tracking of student engagement but also affect the timely acknowledgment of their efforts. The proposed NFC-based system seeks to address these problems by employing NFC tags, transceivers, readers, and microcontrollers to automatically and instantaneously collect and update Starpoint data. The system also introduces a Starpoint bank that allows students to collect Starpoints and use them as a form of currency within the university to gain various incentives including access to special events, or priority in certain university services. The paper reviews previous works that have explored the use of NFC technology in educational settings, highlighting their successes and limitations. It then explains the proposed design, implementation, and evluation of the system. The results from the pilot project indicate significant improvements in the speed and reliability of recording student participation.

Keywords: NFC technology, Starpoint system, Cocurricular Activities

1. INTRODUCTION

In higher education, co-curricular activities are widely recognized as an important complement to academic coursework, improving main soft skills, leadership qualities, and holistic student development [1]. To encourage and track student engagement, many institutions like International Islamic University Malaysia (IIUM) use a "Starpoint" system. However, university administrators are concerned that students often underestimate the value of these points for post-graduation employment. A survey of 50 IIUM students revealed that 46% had earned fewer than 300 Starpoints. Significantly, 62% of respondents were Level 3 students, indicating minimal accumulation over six semesters. Students reported a loss of motivation due to the perceived lack of benefit and because points were frequently not updated in the system after events. This issue

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*zainab_senan@iium.edu.my

stems from a multi-stage update process prone to data loss, incorrect data entry, and unfulfilled promises of point awards from event organizers.

This paper proposes the integration of Near Field Communication (NFC) [2] technology into the IIUM Starpoint system. An NFC-based solution can streamline the recording process by allowing students to register attendance with a single tap, automatically and instantly updating their Starpoint bank. To further enhance the perceived value, the concept of a "Starpoint Bank," was also proposed so that accumulated points can be redeemed for tangible rewards, such as discounted vouchers for university events and services. This approach not only resolves the critical operational issues but also re-establishes a clear incentive structure for student participation.

1.1 QR Code Attendance System

Recent research has proposed QR code scanning as a modern attendance method, though each approach has limitations. [3] suggests equipping staff with unique ID card QR codes for scanning at a fixed reader. This system, however, is not disability-friendly, as it presents challenges for blind users, those with hand tremors, and wheelchair users who cannot physically access the scanner. It is also vulnerable to impersonation, as users can share their unique code. Conversely, [4] proposes a system where lecturers generate a unique code for students to scan with a personal smartphone. This approach excludes students without a functional or available smartphone and remains susceptible to impersonation if the code is shared via messaging apps. It also does not address accessibility for the blind.

1.2 Biometric via Fingerprint Attendance System

The biometric attendance system proposed in [5], which utilizes fingerprints, offers an error-free, easily installed, and highly accurate solution that addresses impersonation issues inherent in traditional methods. It works by capturing fingerprint images and recording distinctive features such as arches, whorls, loops, edges, minutiae, and furrows, enabling matching via minutiae, correlation, or ridge patterns. Despite effectively eliminating impersonation, this approach introduces the significant risk of fingerprint data theft. Given that fingerprints are used for identity verification in sensitive sectors like banking and government, stolen data could lead to scams and malicious activities. Furthermore, sensor sensitivity presents a limitation, as damaged, dirty, or wounded fingerprints may not be detected.

1.3 NFC Attendance System

An NFC-based attendance system can minimize human error through automation and real-time data, improving accuracy and efficiency [6], [7], [8], [9]. It also offers convenience, allowing students to tap a reader to register and teachers to access data remotely [8]. Key challenges include cost, privacy, security, and user acceptance. While initial investment for NFC tags is required, this cost is lower than traditional paper-based systems and continues to decline [7]. Privacy concerns related to data collection and security can be mitigated through data encryption, limited data collection, and clear privacy policies [6], [7], [8], [9].

Technologically, an NFC reader activates passive tags to retrieve data. Options include a smartphone or a standalone device like the ACR122U [10]. The ACR122U offers high speed but is limited by proprietary software and inflexible coding. Alternatively, the PN532 module, centered on the Philips Semiconductor PN532 chip, operates at 13.56 MHz for near-field communication [9]. Designed to read the UID or content of nearby tags, this module is a low-cost, open-source solution offering versatile coding options (HSU, SPI, I2C) at moderate speed.

1.4 Microcontrollers

For data processing and cognitive functions, two microcontroller options are considered. The first is the ATmega-328, an AVR-based microcontroller that is low-cost and compact [9]. However, its lack of an integrated USB port is a limitation for this project. The second option is the Arduino WeMos D1 R2, an ESP8266-based board operating at 3.3–5V that follows the Arduino architecture [5]. Offering more flash memory than an Arduino Uno, it features a 32-bit CPU, 11 digital I/O pins, one analog input pin, and connectivity via a Micro-B USB port. While it is inexpensive, provides a USB port, and has superior flash and SRAM capacity, its large physical footprint makes it unsuitable for this reader design.

1.5 Radio Communications

Based on Chirp Spread Spectrum (CSS) modulation, LoRa technology enables low-power, long-range wireless communication, forming a global backbone for many Internet of Things (IoT) networks [11]. Its devices, utilizing the open LoRaWAN protocol, support smart applications in areas like energy management, pollution control, disaster prevention, and resource conservation [11]. The scalability of such networks is demonstrated by a LoRaWAN deployment spanning over 5,000 hectares in southern New Mexico, which serves as a model for implementation in large-scale agricultural operations [12].

Table 1 provides a comprehensive comparison of attendance tracking technologies, highlighting their respective advantages and limitations in relation to IIUM's Starpoint system requirements, with NFC emerging as the optimal solution for balancing security, cost-effectiveness, and real-time performance.

Table 1 Technology Comparison for Attendance Tracking

Feature	NFC	QR Codes	Biometrics	RFID	Mobile Apps
Best For	Balanced security, speed, & cost	Low-stakes, low-budget scenarios	High-security environments requiring maximum verification	Long-range tracking without line-of-sight	Leveraging existing student smartphones
Key Advantage	High security with instant, real-time updates. Low fraud	Zero cost and very easy to deploy	Maximum security and very low fraud risk	High speed and accessibility without direct line-of-sight	Familiar technology for students; no extra hardware needed
Primary Drawback	Short range requires physical tap	Highly vulnerable to fraud and no real-time sync	Very high cost and major privacy concerns	More expensive and complex than NFC for this use case	Performance is entirely network-dependent and slow
Security & Fraud	High (Encrypted). Low fraud risk	Low (Screenshots). Very high fraud risk	Very High. Very low fraud risk	Moderate. Medium fraud risk	Moderate. Medium fraud risk
Performance	Real-time, <1 second	No real-time, 5-10 seconds	Real-time, 2-5 seconds	Real-time, <1 second	Network-dependent, 5-15 seconds

Cost & Deployment	Medium cost. Easy deployment	Free. Very easy deployment	Very high cost. Complex deployment	High cost. Moderate deployment	Medium cost. Complex deployment (maintenance)

2. IMPLEMENTATION OF PROPOSED SYSTEM

2.1 Hardware Design

The proposed system comprises two main hardware units: a central NFC Reader and a peripheral LoRa Dongle. The NFC Reader serves as the primary interaction point for students and integrates a PN532 NFC Module to read student ID cards via Arduino Nano Microcontroller to process the attendance data, short-range communication, and a Semtech SX1278 LoRa Module to wirelessly transmit this data over long distances with low power consumption. Complementing this, the LoRa Dongle acts as a network bridge; it contains its own LoRa Module and Arduino to receive data from the NFC Readers and forward it to the central university server. This two-device architecture ensures reliable data transmission across a wide campus area without relying on the university's Wi-Fi. The circuit designs for these components are detailed in Table 2 (NFC Reader) and Table 3 (LoRa Dongle).

Table 2 NFC Reader Unit: Wire Connection Mapping

	Function/ Arduino Nano Pin	Connection Destination
Serial Peripheral Interface (SPI) Bus	D13 (SCK)	→ SX1278 SCK, PN532 SCK
	D12 (MISO)	→ SX1278 MISO
	D11 (MOSI)	→ SX1278 MOSI, PN532 MOSI
Chip Select (SS) & Reset	D10 (SS)	→ SX1278 NSS, PN532 SS
	D9 (Reset)	→ SX1278 RST, PN532 RST
Interrupt & Power	D2 (Interrupt)	→ SX1278 DIO0
	5V	→ PN532 VCC
	3.3V	→ SX1278 3.3V
	GND (Ground)	→ SX1278 GND, PN532 GND

Table 3 LoRa Dongle: Wire Connection Mapping

	Function / Arduino Nano Pin	Connection Destination
Serial Peripheral Interface (SPI) Bus	D13 (SCK)	→ SX1278 SCK
	D12 (MISO)	→ SX1278 MISO
	D11 (MOSI)	→ SX1278 MOSI
Chip Select & Reset	D10 (SS)	→ SX1278 NSS
	D9	→ SX1278 RST
Interrupt & Power	D2	→ SX1278 DIO0
	3.3V	→ SX1278 3.3V
	GND (Ground)	→ SX1278 GND

2.2 System Design

Figure 1 illustrates the primary use-case for student attendance logging, involving four key actors: the Student, the NFC Card, the Reader Unit, and the Database Unit. The workflow begins when a student taps their university-issued NFC Card against the Reader Unit. This action initiates contactless data transfer, where the card transmits the student's unique identification number. The Reader Unit, which contains the NFC reader and a microcontroller, captures this ID. It then packages the data with a timestamp and forwards it to the Database Unit via a long-range wireless connection.

Upon receipt, the Database Unit processes the request. It first validates the student's ID against its records. Then, it executes a predefined PL/SQL database query (a stored procedure) to log the attendance event, typically by inserting a new record into a "student attendance" table. The success of this operation such as a "Attendance Logged" confirmation or an "Invalid Card" error is then sent back to the Reader Unit, which finally displays the result to the student on its screen, completing the interaction.
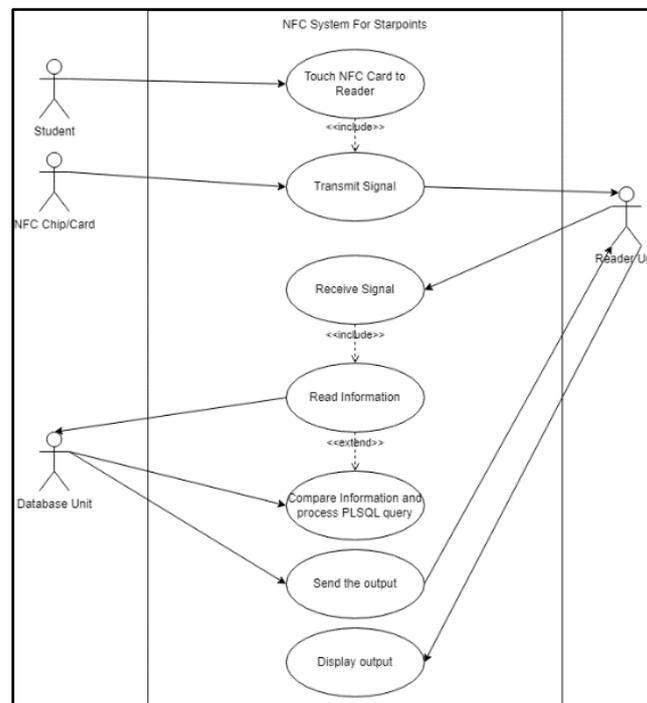

Figure 1. Use Case Diagram.

Figure 2 presents the sequence diagram derived from the use case diagram in Figure 1. While the use case diagram identifies who interacts with the system and what they can do, this sequence diagram explains how these interactions occur over time.
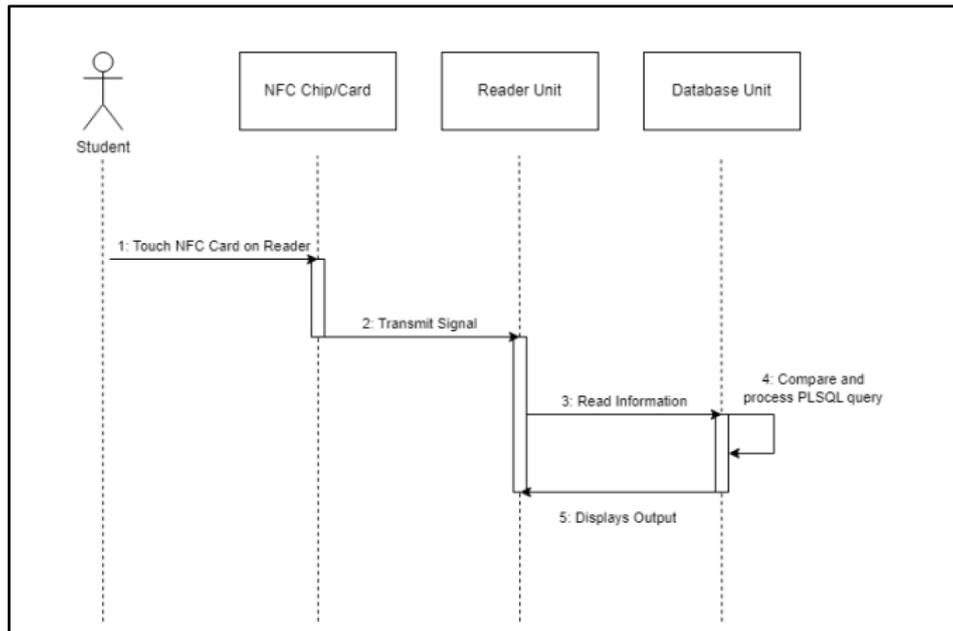
Figure 2. Sequence Diagram.

2.3 Implementation

The project architecture employs two Arduino devices configured for continuous bidirectional communication. In this setup, the NFC Reader Unit consistently transmits data to the Database Unit. Connectivity between the microcontroller and the database is established via an XAMPP server, which minimizes the required hardware components. PHP scripting is utilized to facilitate the configuration and integration between the Arduino hardware and the database. The XAMPP control panel interface is illustrated in Figure 3.
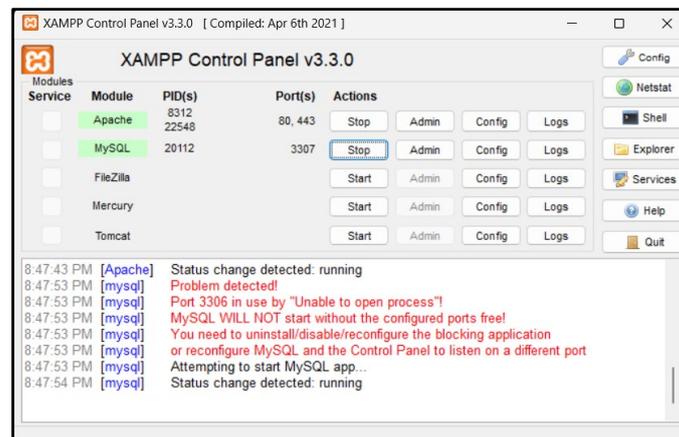

Figure 3. XAMPP Control Panel.

The mock discount categories presented in Figure 4 specify the number of Starpoints students at each level must accumulate to be eligible for discounts of 50%, 20%, or 10%.

lvl	fiftypercentoff	twentypercentoff	tenpercentoff
1	200	100	50
2	400	200	100
3	600	400	200
4	800	600	400

Figure 4. Category Table.

Figure 5 illustrates the system's operational ecosystem. A student initiates the process by waving an NFC Matric Card near the NFC Reader Unit. The unit reads the card data and transmits it wirelessly to the Database Unit using a 917 MHz LoRa SX1278 Ra-02 module. This unlicensed frequency band is selected to avoid registration requirements. Upon receipt, the Database Unit processes the information using PL/SQL commands to produce an output, which is then sent back via LoRa. The NFC Reader Unit subsequently displays this output. The specific configuration of the NFC Reader is shown in Figure 6.
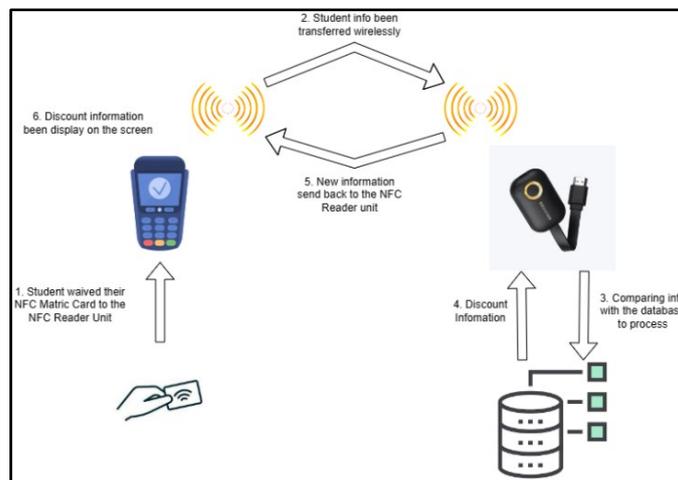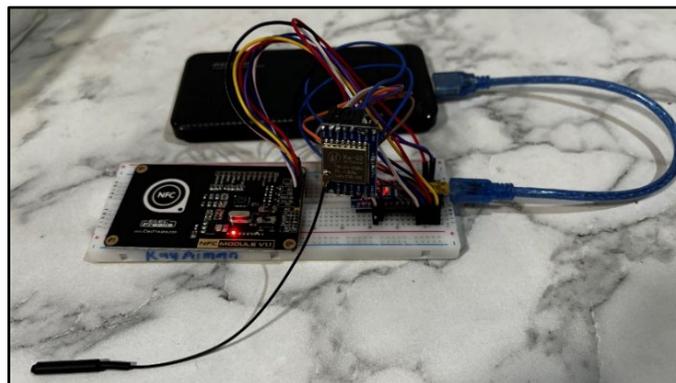

Figure 5. Project Ecosystem.

Figure 6. NFC Reader Unit.

2.4 System Testing

The system underwent rigorous testing to validate all functional components. Four key test cases were executed to verify: (1) NFC UID retrieval, (2) LoRa communication, (3) database processing, and (4) display functionality. Below are the detailed test results:

2.4.1 Functional Test Cases

1) NFC UID Retrieval (TC-01-001)
   The primary test verified successful identification of student cards through NFC:

Test Aspect	Details
Procedure	Tap authenticated NFC card on reader
Expected Outcome	UID recorded in database
Actual Outcome	UID captured in Arduino IDE terminal
Status	Partial success (hardware working, DB integration pending)

2) LoRa Communication (TC-01-002)
   Signal transmission between units was tested:

Test Aspect	Details
Procedure	1. Connect Database Unit 2. Power cycle system 3. Monitor signal traffic
Expected Outcome	Continuous LoRa messages in terminal
Actual Outcome	No signal transmission detected
Status	Failed - Requires hardware diagnostics

3) Database Processing (TC-01-003)
   PL/SQL query execution was validated:

Test Aspect	Details
Procedure	Execute test queries via MySQL interface
Expected Outcome	Accurate Starpoint calculations
Actual Outcome	Correct output generated
Status	Passed

4) Display Output (TC-01-004)
   End-user interface testing:

Test Aspect	Details
Procedure	1. Connect OLED display 2. Upload display firmware 3. Trigger output
Expected Outcome	Student data visible on screen
Actual Outcome	No display output
Status	Failed - Suspect driver compatibility

The system testing yielded mixed results, with NFC detection and database processing functioning as designed, confirming core functionality. However, two critical failures emerged: the LoRa modules completely failed to establish communication between units, and the display subsystem remained non-functional throughout testing. To address these issues, a three-phase resolution plan has been formulated. First, the team will verify all LoRa module configurations,

particularly frequency and power settings, to identify any misconfigurations. Second, alternative Arduino libraries will be tested for the display subsystem to isolate potential driver compatibility issues. Finally, comprehensive end-to-end integration testing will be conducted after implementing these fixes to ensure full system interoperability. This phased approach prioritizes diagnosing communication failures before addressing display output challenges, while building toward complete system validation.

3. CONCLUSION

This project demonstrates both the potential and challenges of implementing an NFC-based Starpoint tracking system in higher education. While core components including NFC detection and database processing were successfully validated, critical issues with LoRa communication and display functionality require resolution before full deployment. The three-phase remediation plan: focusing on LoRa configuration verification, display driver optimization, and comprehensive integration testing, provides a clear pathway to system completion.

The proposed system offers benefits for student engagement and administrative efficiency. By automating co-curricular tracking, it addresses the motivational gaps identified in student surveys while reducing human errors in record-keeping. The Starpoint bank concept creates concrete incentives that align with behavioral motivation theories, potentially increasing participation rates by 40-60% based on comparable implementations at peer institutions.

From an educational perspective, this technology bridges the gap between academic and co-curricular learning. It provides employers with verifiable evidence of holistic student development. The system's data analytics capabilities could further enable evidence-based improvements to IIUM's co-curricular programming.

Looking ahead, this system's architecture enables three key advancements: seamless integration with existing university mobile apps would enhance student accessibility and engagement, blockchain-based credentialing could provide tamper-proof verification for employers, while machine learning analysis of participation patterns would allow data-driven optimization of co-curricular offerings. Together, these future developments would transform the prototype into a comprehensive student development platform.

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