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Wireless Communications Technologies for Implementation of Fintech Solutions

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Abstract

Reliable and effective wireless communication solutions are in more demand due to the fast expansion of financial technology or fintech. This work aims to analyze and rank different wireless communication technologies according to how suitable they are for fintech applications. Relevant wireless technologies and their characteristics are identified in a literature survey and the important evaluation criteria for financial deployment. The paper analyzed and ranked the alternatives using the multi-criteria decision-making framework- Entropy-weighted Combinative Distance-based Assessment (CODAS). The findings enable software developers and service providers to make well-informed decisions by offering information on the appropriateness of each technology for fintech solutions. The study highlights the trade-offs and strengths of different wireless technologies, enabling the selection of appropriate communication solutions tailored to the specific requirements of fintech applications.

Keywords

Fintech, communication technologies, CODAS, mobile banking, digital payments,

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Introduction

The rapid digitization of financial services and the growing need for practical, safe, and effective financial solutions have propelled the financial technology (fintech) sector to amazing development in recent years (Arner et al., 2015; Gomber et al., 2017). Among the many uses for fintech include mobile banking, digital payments, peer-to-peer lending, cryptocurrencies, and investment management (Schueffel, 2016). Fintech is still developing, hence strong and dependable wireless communication technologies are more and more important (Gai et al., 2018). Real-time financial transactions are made possible, smooth and secure data transfer is made possible, and user experiences in fintech apps are improved by the pivotal role of wireless communication technology (Astanakulov & Balbaa, 2022). The delivery and use of financial services has been transformed by technologies like Near Field Communication (NFC), Bluetooth, Wi-Fi, cellular networks (4G/5G), Radio Frequency Identification (RFID), and Wireless Sensor Networks (WSNs) (Larios-Hernández, 2017; Ranjan et al., 2022). In addition to offering ubiquitous connection, these technologies help fintech solutions be more scalable, secure, and reasonably priced (Allen et al., 2021; Gai et al., 2018).

This work aims to assess and rank wireless communication technologies for their applicability in fintech software development by means of a thorough multi-criteria decision-making (MCDM) study. In particular, the research seeks to: (1) identify the pertinent wireless communication technologies and their features in the context of fintech applications; (2) identify the important evaluation criteria for choosing appropriate wireless technologies based on fintech requirements; (3) use MCDM techniques to analyze and rank the found alternatives based on the defined criteria; and (4) offer fintech software developers and service providers insights and recommendations regarding the choice and integration of wireless communication technologies. In this work, security, data transfer rates, range, scalability, and user experience are all considered while assessing wireless communication technologies for their suitability in fintech software deployment. To support fintech industry decision-making processes, the research intends to offer a thorough analysis and rating of options. It should be remembered, although, that the particular needs and limitations of different fintech applications might differ, hence the results should be evaluated and modified appropriately (Arner et al., 2015; Gai et al., 2018; Gomber et al., 2017; Larios-Hernández, 2017; Schueffel, 2016).

Literature Review

The term "fintech" (financial technology) refers to the integration of financial services and innovative technology solutions, disrupting traditional financial systems and business models (Chiu, 2016). Fintech has emerged as a rapidly evolving industry, driven by the increasing demand for efficient, accessible, and personalized financial services, leveraging cutting-edge technologies such as mobile computing, big data analytics, artificial intelligence, and blockchain (Kayode, 2023). Fintech applications span a wide range of domains, including:

Mobile banking and digital payments

Mobile banking and digital payments involve enabling secure financial transactions, money transfers, and payment processing through mobile devices and digital wallets, utilizing technologies like near-field communication (NFC) and biometric authentication (Ahmed et al., 2021; Raina et al., 2012).

Peer-to-peer (P2P) lending and crowdfunding

Peer-to-peer (P2P) lending and crowdfunding involves facilitating direct lending and investment opportunities between individuals or businesses, bypassing traditional financial intermediaries, enabled by online platforms and distributed ledger technologies (Cai, 2018; Jenik et al., 2017).

Cryptocurrency and blockchain

Cryptocurrency and blockchain *a*pplication include decentralized digital currencies and distributed ledger technologies that enable secure, transparent, and immutable financial transactions, challenging traditional payment systems and financial intermediaries (Javaid et al., 2022; Suprayitno et al., 2024).

Robo-advisors and automated investment management

Robo-advisors and automated investment management are Algorithmic platforms that provide automated financial advice, portfolio management, and investment recommendations based on customer profiles and market data analysis (Phoon & Koh, 2018; Shanmuganathan, 2020).

InsurTech

InsurTech involves the *a*pplication of technology to streamline insurance processes, improve risk assessment, and enhance customer experience through digital platforms, telematics, and data analytics (Ali Albasheir, 2023; Volosovych et al., 2021).

Regulatory technology (RegTech)

Regulatory technology involves leveraging technology solutions to facilitate regulatory compliance, risk management, and reporting in the financial services industry (Arner et al., 2016; Olawale et al., 2024).

Wireless Communication Technologies in Fintech

Among the various wireless communication technologies, several have shown promise in enabling fintech applications and facilitating secure, reliable, and efficient data transfer. These technologies are discussed in this section.

Bluetooth

The latest version of Bluetooth technology offers improved data rates, range, and energy efficiency compared to previous iterations (Tosi et al., 2017). Bluetooth 5.2 supports a maximum data rate of 3 Mbps and a range of up to 200 meters, making it suitable for secure device pairing, data exchange, and peripheral connectivity in fintech applications (M. A. Khan, 2022). Its low power consumption and compatibility with Bluetooth Low Energy (BLE) make it an attractive option for mobile payments and financial applications on battery-powered devices (Headquarters, 2013).

Wi-Fi 6 (802.11ax)

As the latest generation of Wi-Fi technology, Wi-Fi 6 offers significant improvements in data rates, efficiency, and performance (Oughton et al., 2021). With a maximum data rate of 9.6 Gbps and support for wider channel bandwidths (up to 160 MHz), Wi-Fi 6 can provide reliable and high-speed internet connectivity for mobile banking, trading platforms, and other financial applications (Kassab & Darabkh, 2020). Its advanced security protocols, such as WPA3, further enhance the security of wireless financial transactions and data transfers (Al-Mejibli & Alharbe, 2020).

4G LTE:

As the predominant cellular network technology, 4G LTE offers ubiquitous connectivity and high-speed mobile broadband for fintech services (Lehr, 2019). With a maximum data rate of up to 1 Gbps and advanced security protocols, 4G LTE enables real-time financial data access, mobile transactions, and location-based services (Garcia et al., 2020). Its widespread deployment and compatibility with various devices make it a viable option for enabling mobile fintech applications (Iman, 2018).

Sigfox

Designed for low-power, long-range applications, Sigfox is a proprietary wireless technology that operates in the unlicensed industrial, scientific, and medical (ISM) radio bands (Pérez et al., 2022). With a maximum data rate of 0.1 Mbps and a range of up to 50 km, Sigfox is suitable for applications that require infrequent data transmissions, such as asset tracking and monitoring in the financial sector (Buurman et al., 2020). However, its limited data rate and proprietary nature may pose challenges for more demanding fintech applications (Islam et al., 2024).

Radio Frequency Identification (RFID) UHF

RFID technology, particularly in the ultra-high frequency (UHF) band, has found applications in fintech for secure authentication, asset tracking, and inventory management (Saeed et al., 2022). UHF RFID supports data rates ranging from 64 Kbps to 640 Kbps and a typical range of 1 to 12 meters (Dobkin, 2012). Its ability to uniquely identify and track assets and financial instruments makes it a valuable technology for supply chain management and security in financial institutions (N. Khan & Valverde, 2014).

These wireless technologies offer various capabilities and trade-offs in terms of data rates, range, power consumption, and security features, making them suitable for different fintech applications and use cases (Whig et al., 2024). The selection and integration of these technologies into fintech software solutions should be based on a careful evaluation of the specific requirements, such as data throughput needs, security considerations, and deployment scenarios (Allioui & Mourdi, 2023).

Table 1. Wireless communication technologies and their features

Technology	Power Consumption (dBm)	Channel Bandwidth (MHz)	Maximum Data Rate (Mbps)	Data Protection (bits-CRC)	Maximum Throughput (Mbps)	Latency (ms)
Bluetooth 5.2	0 to 20	2	300	24	300	< 10
Wi-Fi 6 (802.11ax)	15 to 25	20, 40, 80, 160	960	32	960	< 10
4G LTE	23	20	1000	24	300 - 1000	50 - 100
Sigfox	14 - 22	0.1	0.1	16	0.1	1000 - 10000
RFID (UHF)	0 - 30 (readers), -20 to 0 (tags)	0.5	0.64	16	0.064 - 0.64	< 10

Features of wireless communications for Power Consumption (dBm):
Power consumption is a critical factor in wireless communication technologies, especially for battery-powered devices and energy-efficient applications (Pentikousis, 2010). It is typically measured in decibel-milliwatts (dBm), which represents the power level relative to one milliwatt (Mokhtari et al., 2018). Lower power consumption values in dBm indicate more energy-efficient operation, enabling longer battery life and reduced environmental impact (Mahmoud & Mohamad, 2016).

Channel Bandwidth (MHz): Channel bandwidth refers to the range of frequencies or the amount of spectrum allocated for data transmission in a wireless communication system (Flikkema, 1997). It is measured in megahertz (MHz) and determines the maximum achievable data rate, as well as the potential for interference and coexistence with other wireless technologies (Wang et al., 2014). Wider channel bandwidths generally allow for higher data rates but may also require more complex signal processing and greater power consumption (Ghosh et al., 2014).

Maximum Data Rate (Mbps): The maximum data rate, measured in megabits per second (Mbps), represents the theoretical highest rate at which data can be transmitted over a wireless communication channel (Esmailian, 2003). It is determined by factors such as channel bandwidth, modulation scheme, coding techniques, and signal-to-noise ratio (Catreux et al., 2002). Higher data rates enable faster data transfer and support bandwidth-intensive applications but may also require more complex hardware and signal processing (Pane & Joe, 2005).

Data Protection (bits-CRC): Data protection mechanisms, such as Cyclic Redundancy Check (CRC), are employed in wireless communication systems to ensure data integrity and detect transmission errors (Koopman et al., 2015). The CRC is a mathematical algorithm that generates a specific number of check bits based on the data being transmitted (Tsimbalo et al., 2016). The number of bits used for the CRC (e.g., 16-bit CRC, 24-bit CRC) determines the level of error detection capability, with longer CRC lengths providing better protection against errors (Georgakakis et al., 2011).

Maximum Throughput (Mbps): Maximum throughput refers to the actual data rate or effective data transfer rate that can be achieved in a wireless communication system under typical operating conditions(Ju & Zhang, 2013). It is often lower than the maximum data rate due to factors such as overhead, protocol inefficiencies, and environmental conditions (Awerbuch et al., 2004). Maximum throughput provides a more realistic representation of the achievable data rates in practical scenarios (Oestges & Clerckx, 2010).

Latency (ms): Latency, measured in milliseconds (ms), represents the delay or time it takes for data to be transmitted from the source to the destination in a wireless communication system (De Vito et al., 2008). Low latency is crucial for real-time applications, such as voice and video communication, online gaming, and time-sensitive financial transactions (Shukla et al., 2021). Higher latency can lead to noticeable delays, degrading the user experience and potentially impacting the performance of time-critical applications (Jiang et al., 2018).

Methodology

The study uses Entropy-weighted Combinative Distance-based Assessment (CODAS) multi-criteria framework to evaluate and rank the wireless communication alternatives identified for implementing fintech technologies. This section discusses the Entropy method for weighing of the alternatives and the CODAS for raking the wireless technologies.

Entropy Method

To determine the weights of the criteria using the entropy method, follow these steps:

1. Normalize the decision matrix:

Normalize the data to ensure all criteria are comparable. This can be done using the expression:

$$X_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{1}$$

Where X_{ij} is the normalized value, x_{ij} is the original value, and m m is the number of alternatives (5 in this case).

2. Calculate the entropy for each criterion:
   Entropy E_j for each criterion j is calculated using:

$$E_j = -k \sum_{i=1}^{m} \left(X_{ij} . \ln\left(X_{ij} \right) \right) \tag{2}$$

Where $k = \frac{1}{\ln(m)}$

3. Calculate the degree of diversification d_j:

$$d_j = 1 - E_j \tag{3}$$

4. Determine the weights for each criterion:

$$w_j = \frac{d_j}{\sum_{i=1}^{n} d_j} \tag{4}$$

where n is the number of criteria (6 in this case)

Combinative Distance-based Assessment (CODAS)

Eight (8) fundamental steps can be used to implement CODAS (Keshavarz Ghorabaee et al., 2016). These steps are as follows:

Stage 1: Aggregation of the communication technologies (known as alternatives) and the selected metrics (known as criteria) to form a decision-making matrix. This takes the form of the expression presented in Equation 5.

$$Y = \left[y_{ij} \right]_{q \times p} = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1p} \\ y_{21} & y_{22} & \cdots & y_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ y_{q1} & y_{q2} & \cdots & y_{qp} \end{bmatrix} \tag{5}$$

$$0 \le y_{ij}$$

$$i \in \{1,2, \ldots q\} \text{ and } j \in \{1,2, \ldots p\}$$

Stage 2: Estimation of the normalized decision matrix using linearization of the performance values

$$q_{ij} = \begin{cases} \dfrac{y_{ij}}{\max\limits_{i} y_{ij}} & if\ j \in Q_b \\ \dfrac{\min\limits_{i} y_{ij}}{y_{ij}} & if\ j \in Q_c \end{cases} \tag{6}$$

Q_c and Q_b are the non-beneficial and beneficial criteria, respectively.

Stage 3: Estimating the weight (w_j) of the criteria and multiplying it with the normalized decision matrix to obtain the weighted decision matrix. It takes the form of Equation 7.

$$r_{ij} = w_j q_{ij} \tag{7}$$

$$1 > w_j > 0$$

The weight w_j is usually greater than 0 and does not exceed 1; also, the sum of the weights of the criteria must be equal to 1. In this study, Entropy method was used in estimating the weights of the criteria

Stage 4: The negative ideal point is determined as:

$$ns = \left[ns_j\right]_{1\times p} \tag{8}$$

$$ns = \min_i r_{ij} \tag{9}$$

Stage 5: The Taxicab (T_i) and Euclidean (E_i) distances of the communication technologies from the negative ideal solution are obtained as:

$$T_i = \sum_{j=1}^{p} \left|r_{ij} - ns_j\right| \tag{10}$$

$$E_i = \sum_{j=1}^{p} (r_{ij} - ns_j)^2 \tag{11}$$

Stage 6: The relative assessment matrix using the expression in Equation 12.

$$R_a = [(E_i - E_k) + (\varphi((E_i - E_k) \times (T_i - T_k))] \tag{12}$$

$$\varphi(y)\ (\begin{cases} 1 & if\ |y| \ \geq \tau \\ 0 & if\ |y| < \tau \end{cases} \tag{13}$$

Where φ and $k \in \{1,2,\dots q\}$ represent a threshold function to recognize the equality of the Euclidean distances of two alternatives, τ denotes the threshold parameter.

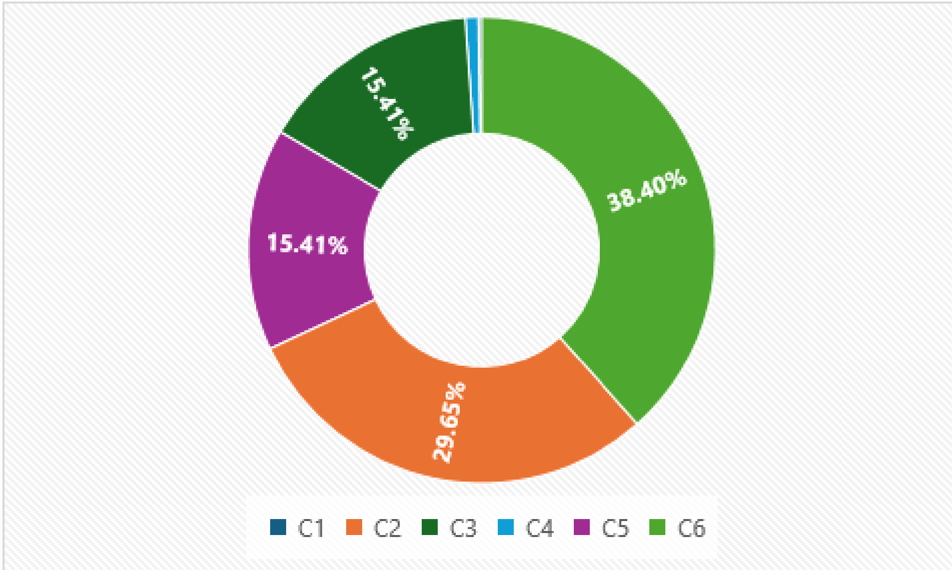
Stage 7: The assessment score for each choice of communication technology is obtained using Equation 14. The values of the assessment score are used to rank the alternatives.

$$H_i = \sum_{k=1}^{q} h_{ik} \tag{14}$$

Stage 8: Alternatives are ranked based on decreasing values of the assessment.

Results

The weights for every criterion were determined as follows using the entropy method: 0.0025 is the power consumption; 0.2965 is the channel bandwidth; 0.1541 is the maximum data rate; 0.0089 is the data protection; 0.1541 is the maximum throughput; and 0.3840 is the latency. These weights were determined by normalizing the data, calculating the entropy for each criterion, deriving the degree of diversification, and finally normalizing these values to obtain the weights. The findings show that, with the greatest weights of 0.3840 and 0.2965, respectively, Latency (C6) and Channel Bandwidth (C2) are the most important factors and have the biggest influence on the decision-making procedure. By contrast, with weights of 0.0025 and 0.0089, respectively, Power Consumption (C1) and Data Protection (C4) have the least effect. The weights for Maximum Data Rate (C3) and Maximum Throughput (C5) are equal at 0.1541, indicating a moderate level of importance. There is a moderate degree of significance shown by the equal weights of Maximum Data Rate (C3) and Maximum Throughput (C5) at 0.1541. Since the total of these weights equals 1, the overall weight distribution is precise and well-balanced.



Multi-criteria decision-making requires normalization to provide direct comparison of criteria with various units and scales. The result of the normalization of the original data from table 1 is given in Table 2. This phase produced a normalized matrix in which each criterion value was changed to range between 0 and 1, allowing for direct comparisons. For example, Sigfox's channel bandwidth (a benefit criterion) was significantly lower than others, resulting in a very low normalized score, indicating its inadequacy in this aspect.

Table 2. Normalized decision matrix

Technology	C1 (Power Consumption)	C2 (Channel Bandwidth)	C3 (Maximum Data Rate)	C4 (Data Protection)	C5 (Maximum Throughput)	C6 (Latency)
Bluetooth 5.2	0.3303	0.0125	0.2929	0.5475	0.2929	0.5
Wi-Fi 6	0.4129	0.998	0.9372	0.73	0.9372	0.5
4G LTE	0.3803	0.1248	0.9765	0.5475	0.9765	0.005
Sigfox	0.3635	0.0006	0.0001	0.365	0.0001	0
RFID (UHF)	0.4954	0.0031	0.0006	0.365	0.0006	0.5

Every criterion receives a weight after normalization (Table 3). The relative significance of every criterion in the decision-making process is reflected in the weights. the weight was obtained by the entropy approach. For example, out of all the criteria examined, latency (C6) got the highest weight (0.38402). These weights are included into the normalized decision matrix, which increases the significance of the normalized values. In this study, Wi-Fi had high values in channel bandwidth and maximum data rate, but the high weight of latency could offset its benefits due to its less significant improvements in latency compared to Sigfox and 4G LTE.

Table 3. Weighted Normalized Decision Matrix

Technology	C1 (Power Consumption)	C2 (Channel Bandwidth)	C3 (Maximum Data Rate)	C4 (Data Protection)	C5 (Maximum Throughput)	C6 (Latency)
Bluetooth 5.2	0.0008	0.0037	0.0451	0.0049	0.0451	0.192
Wi-Fi 6	0.001	0.2959	0.1444	0.0065	0.1444	0.192
4G LTE	0.0009	0.037	0.1503	0.0049	0.1503	0.0019
Sigfox	0.0009	0.0002	0	0.0032	0	0
RFID (UHF)	0.0012	0.0009	0.0001	0.0032	0.0001	0.192

Each criterion's Euclidean and taxicab distances from the negative ideal solution were computed, as Table 4 illustrates. The poorest performance results for every criterion are represented by the negative ideal solution. These distances measure the distance, for every criterion, between each option and the worst-case scenario. For instance, Sigfox's relatively low results for both distances suggest that it is close to the optimal performance across the most important parameters.

Table 4. Euclidean and Taxicab Distances from the Negative Ideal Solution

Technology	Euclidean Distance	Taxicab Distance
Bluetooth 5.2	0.2259	0.2916
Wi-Fi 6	0.3963	0.7266
4G LTE	0.1594	0.2774
Sigfox	0.0003	0.0003
RFID (UHF)	0.2211	0.222

The assessment score for each alternative is given in Figure 2. The assessment score for each alternative is the sum of its Euclidean and Taxicab distances. This score provides a single metric to rank the alternatives. Lower scores indicate better performance relative to the negative ideal solution. Given all criteria and their weights, Sigfox is the best choice because it received the lowest assessment score (0.0006). This low score is mostly due to its little power usage and latency. Wi-Fi is the least desirable choice in this situation because, although having great bandwidth and throughput performance, its higher power consumption and less effect on latency result in the highest assessment score (1.1229).

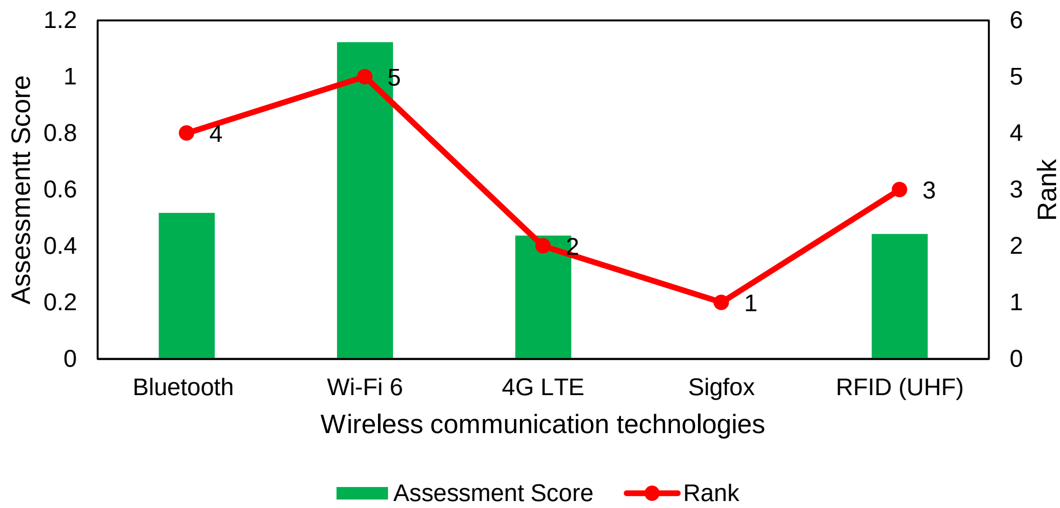


Figure 2. Assessment Score and Rank of the communication technologies

The last stage ranks the alternatives according to the assessment scores; the alternative with the lowest score is the one that is the most preferred. Because it uses the least amount of power, requires the least amount of bandwidth, and has the best latency, Sigfox is rated top for wireless communications. 4G LTE is ranked in second place, balancing high data rates and throughput with acceptable power consumption and latency. RFID (UHF) comes third, showing moderate performance across criteria but excelling in low latency. Bluetooth 5.2 is ranked fourth, offering balanced performance but not excelling in any criterion. Finally, Wi-Fi 6 is ranked last due to its high-power consumption, despite its excellent bandwidth and throughput.

Conclusion

This study employed a multi-criteria decision analysis approach to evaluate and rank wireless communication technologies for their applicability in fintech software development. The Entropy-weighted CODAS method was utilized, considering critical criteria such as power consumption, channel bandwidth, data rates, data protection, throughput, and latency. The analysis revealed that Sigfox, a low-power wide-area network technology, emerged as the top-ranked alternative due to its low power consumption, acceptable latency, and suitability for applications requiring infrequent data transmissions. 4G LTE and RFID (UHF) followed closely, offering a balance between high data rates, throughput, and moderate power consumption, making them suitable for mobile banking, asset tracking, and secure authentication.

Bluetooth 5.2 and Wi-Fi 6 were ranked lower due to their higher power consumption, despite their advantages in data rates and throughput. However, these technologies may still be suitable for specific fintech applications with less stringent power requirements or where high data transfer rates are prioritized. It is crucial to note that the ranking and suitability of wireless technologies may vary depending on the specific requirements and constraints of individual fintech applications. The findings of this study provide a comprehensive evaluation framework and insights for fintech software developers and service providers to make informed decisions regarding the selection and integration of wireless communication technologies in their solutions.

References

Ahmed, W., Rasool, A., Javed, A. R., Kumar, N., Gadekallu, T. R., Jalil, Z., & Kryvinska, N. (2021). Security in next generation mobile payment systems: A comprehensive survey. *IEEE Access*, *9*, 115932–115950.

Al-Mejibli, I. S., & Alharbe, N. R. (2020). Analyzing and evaluating the security standards in wireless network: A review study. *Iraqi Journal for Computers and Informatics*, *46*(1), 32–39.

Ali Albasheir, K. A. M. (2023). The Impact of IT on Insurance of the Technological Industry. *Journal of Advanced Zoology*, *44*.

Allen, F., Gu, X., & Jagtiani, J. (2021). A survey of fintech research and policy discussion. *Review of Corporate Finance*, *1*, 259–339.

Allioui, H., & Mourdi, Y. (2023). Exploring the full potentials of IoT for better financial growth and stability: A comprehensive survey. *Sensors*, *23*(19), 8015.

Arner, D. W., Barberis, J., & Buckey, R. P. (2016). FinTech, RegTech, and the reconceptualization of financial regulation. *Nw. J. Int'l L. & Bus.*, *37*, 371.

Arner, D. W., Barberis, J., & Buckley, R. P. (2015). The evolution of Fintech: A new post-crisis paradigm. *Geo. J. Int'l L.*, *47*, 1271.

Astanakulov, O., & Balbaa, M. E. (2022). The Use of the Internet of Things to Ensure the Smooth Operation of Network Functions in Fintech. *International Conference on Next Generation Wired/Wireless Networking*, 452–461.

Awerbuch, B., Holmer, D., & Rubens, H. (2004). High throughput route selection in multi-rate ad hoc wireless networks. *IFIP Working Conference on Wireless On-Demand Network Systems*, 253–270.

Buurman, B., Kamruzzaman, J., Karmakar, G., & Islam, S. (2020). Low-power wide-area networks: Design goals, architecture, suitability to use cases and research challenges. *IEEE Access*, *8*, 17179–17220.

Cai, C. W. (2018). Disruption of financial intermediation by FinTech: a review on crowdfunding and blockchain. *Accounting & Finance*, *58*(4), 965–992.

Catreux, S., Erceg, V., Gesbert, D., & Heath, R. W. (2002). Adaptive modulation and MIMO coding for broadband wireless data networks. *IEEE Communications Magazine*, *40*(6), 108–115.

Chiu, I. H. Y. (2016). Fintech and disruptive business models in financial products, intermediation and markets-policy implications for financial regulators. *J. Tech. L. & Pol'y*, *21*, 55.

De Vito, L., Rapuano, S., & Tomaciello, L. (2008). One-way delay measurement: State of the art. *IEEE Transactions on Instrumentation and Measurement*, *57*(12), 2742–2750.

Dobkin, D. (2012). *The rf in RFID: uhf RFID in practice*. Newnes.

Esmailian, T. (2003). *Multi mega bit per second data transmission over in-building power lines*.

Flikkema, P. G. (1997). Spread-spectrum techniques for wireless communication. *IEEE*

Signal Processing Magazine, *14*(3), 26–36.

Gai, K., Qiu, M., & Sun, X. (2018). A survey on FinTech. *Journal of Network and Computer Applications*, *103*, 262–273.

Garcia, A. C., Maier, S., & Phillips, A. (2020). *Location-based services in cellular networks: from GSM to 5G NR*. Artech House.

Georgakakis, E., Nikolidakis, S. A., Vergados, D. D., & Douligeris, C. (2011). An analysis of bluetooth, zigbee and bluetooth low energy and their use in wbans. *Wireless Mobile Communication and Healthcare: Second International ICST Conference, MobiHealth 2010, Ayia Napa, Cyprus, October 18-20, 2010. Revised Selected Papers 1*, 168–175.

Ghosh, A., Thomas, T. A., Cudak, M. C., Ratasuk, R., Moorut, P., Vook, F. W., Rappaport, T. S., MacCartney, G. R., Sun, S., & Nie, S. (2014). Millimeter-wave enhanced local area systems: A high-data-rate approach for future wireless networks. *IEEE Journal on Selected Areas in Communications*, *32*(6), 1152–1163.

Gomber, P., Koch, J.-A., & Siering, M. (2017). Digital Finance and FinTech: current research and future research directions. *Journal of Business Economics*, *87*, 537–580.

Headquarters, V. (2013). *Bluetooth Low Energy, Beacons and Retail*.

Iman, N. (2018). Is mobile payment still relevant in the fintech era? *Electronic Commerce Research and Applications*, *30*, 72–82.

Islam, M., Jamil, H. M. M., Pranto, S. A., Das, R. K., Amin, A., & Khan, A. (2024). Future Industrial Applications: Exploring LPWAN-Driven IoT Protocols. *Sensors*, *24*(8), 2509.

Javaid, M., Haleem, A., Singh, R. P., Suman, R., & Khan, S. (2022). A review of Blockchain Technology applications for financial services. *BenchCouncil Transactions on Benchmarks, Standards and Evaluations*, *2*(3), 100073.

Jenik, I., Lyman, T., & Nava, A. (2017). Crowdfunding and financial inclusion. *CGAP (Consultative Group to Assist the Poor) Working Paper*, *41*.

Jiang, X., Shokri-Ghadikolaei, H., Fodor, G., Modiano, E., Pang, Z., Zorzi, M., & Fischione, C. (2018). Low-latency networking: Where latency lurks and how to tame it. *Proceedings of the IEEE*, *107*(2), 280–306.

Ju, H., & Zhang, R. (2013). Throughput maximization in wireless powered communication networks. *IEEE Transactions on Wireless Communications*, *13*(1), 418–428.

Kassab, W., & Darabkh, K. A. (2020). A--Z survey of Internet of Things: Architectures, protocols, applications, recent advances, future directions and recommendations. *Journal of Network and Computer Applications*, *163*, 102663.

Kayode, S. (2023). *Revolutionizing Financial Landscapes: The Role of Emerging Technologies in Fintech Transformation*.

Keshavarz Ghorabaee, M., Zavadskas, E. K., Turskis, Z., & Antucheviciene, J. (2016). A new combinative distance-based assessment (CODAS) method for multi-criteria decision-making. *Economic Computation \& Economic Cybernetics Studies \& Research*, *50*(3).

Khan, M. A. (2022). *Internet of Things: A Hardware Development Perspective*. CRC Press.

Khan, N., & Valverde, R. (2014). The use of RFID based supply chain systems in data centers for the improvement of the performance of financial institutions. *Engineering Management Research*, *3*(1), 24.

Koopman, P., Driscoll, K., & Hall, B. (2015). *Selection of cyclic redundancy code and checksum algorithms to ensure critical data integrity*.

Larios-Hernández, G. J. (2017). Blockchain entrepreneurship opportunity in the practices of the unbanked. *Business Horizons*, *60*(6), 865–874.

Lehr, W. (2019). 5G and the Future of Broadband. *The Future of the Internet*, 109–150.

Mahmoud, M. S., & Mohamad, A. A. H. (2016). *A study of efficient power consumption wireless communication techniques/modules for internet of things (IoT) applications*.

Mokhtari, G., Anvari-Moghaddam, A., Zhang, Q., & Karunanithi, M. (2018). Multi-residential activity labelling in smart homes with wearable tags using BLE technology. *Sensors*, *18*(3), 908.

Oestges, C., & Clerckx, B. (2010). *MIMO wireless communications: from real-world propagation to space-time code design*. Academic Press.

Olawale, O., Ajayi, F. A., Udeh, C. A., & Odejide, O. A. (2024). RegTech innovations streamlining compliance, reducing costs in the financial sector. *GSC Advanced Research and Reviews*, *19*(1), 114–131.

Oughton, E. J., Lehr, W., Katsaros, K., Selinis, I., Bubley, D., & Kusuma, J. (2021). Revisiting wireless internet connectivity: 5G vs Wi-Fi 6. *Telecommunications Policy*, *45*(5), 102127.

Pane, J. F., & Joe, L. (2005). *Making Better Use of Bandwidth: Data Compression and Network Management Technologies*. RAND.

Pentikousis, K. (2010). In search of energy-efficient mobile networking. *IEEE Communications Magazine*, *48*(1), 95–103.

Pérez, M., Sierra-Sánchez, F. E., Chaparro, F., Chaves, D. M., Paez-Rueda, C.-I., Galindo, G. P., & Fajardo, A. (2022). Coverage and energy-efficiency experimental test performance for a comparative evaluation of unlicensed lpwan: Lorawan and sigfox. *IEEE Access*, *10*, 97183–97196.

Phoon, K. F., & Koh, C. C. F. (2018). Robo-advisors and wealth management. *Journal of Alternative Investments*, *20*(3), 79.

Raina, V. K., Pandey, U. S., & Makkad, M. (2012). A user friendly transaction model of mobile payment with reference to mobile banking in India. *International Journal of Information Technology*, *18*(2), 1–6.

Ranjan, P., Rao, R. S., Kumar, K., & Sharma, P. (2022). *Wireless communication: Advancements and challenges*. CRC Press.

Saeed, G., Kohler, J. C., Cuomo, R. E., & Mackey, T. K. (2022). A systematic review of digital technology and innovation and its potential to address anti-corruption, transparency, and accountability in the pharmaceutical supply chain. *Expert Opinion on Drug Safety*, *21*(8), 1061–1088.

Schueffel, P. (2016). Taming the beast: A scientific definition of fintech. *Journal of Innovation Management*, *4*(4), 32–54.

Shanmuganathan, M. (2020). Behavioural finance in an era of artificial intelligence:

Longitudinal case study of robo-advisors in investment decisions. *Journal of Behavioral and Experimental Finance*, *27*, 100297.

Shukla, S., Hassan, M. F., Tran, D. C., Akbar, R., Paputungan, I. V., & Khan, M. K. (2021). Improving latency in Internet-of-Things and cloud computing for real-time data transmission: a systematic literature review (SLR). *Cluster Computing*, 1–24.

Suprayitno, D., Sari, A. L., Judijanto, L., Amalia, D., & Sukomardojo, T. (2024). Blockchain And Cryptocurrency: Revolutionizing Digital Payment Systems And Their Implications On The Digital Economy. *Migration Letters*, *21*(S6), 932–944.

Tosi, J., Taffoni, F., Santacatterina, M., Sannino, R., & Formica, D. (2017). Performance evaluation of bluetooth low energy: A systematic review. *Sensors*, *17*(12), 2898.

Tsimbalo, E., Fafoutis, X., & Piechocki, R. J. (2016). CRC error correction in IoT applications. *IEEE Transactions on Industrial Informatics*, *13*(1), 361–369.

Volosovych, S., Zelenitsa, I., Kondratenko, D., Szymla, W., & Mamchur, R. (2021). Transformation of insurance technologies in the context of a pandemic. *Insurance Markets and Companies*, *12*(1), 1–13.

Wang, Y., Li, J., Huang, L., Jing, Y., Georgakopoulos, A., & Demestichas, P. (2014). 5G mobile: Spectrum broadening to higher-frequency bands to support high data rates. *IEEE Vehicular Technology Magazine*, *9*(3), 39–46.

Whig, P., Kouser, S., Bhatia, A. B., Nadikattu, R. R., & Alkali, Y. J. (2024). IoT Industrial Application Using Wireless Technologies. In *Wireless Communication Technologies* (pp. 101–121). CRC Press.