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E-commerce payment systems: A review and comparison

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Abstract
Payment systems in the e-commerce industry have undergone substantial changes to cater to the needs of businesses and consumers in the ever-changing world of online commerce. This abstract examines the complex dynamics of e-commerce payment systems, which involve several technologies and processes that aim to enable secure, efficient, and user-friendly transactions on the internet. The emergence of digital wallets, cryptocurrencies, and sophisticated fraud protection techniques underscores the ongoing innovation in this domain. An essential aspect of this transformation is the focus on improving the speed of transactions, minimizing expenses, and guaranteeing the security of data. Payment systems must also manage intricate legal frameworks and cater to diverse consumer preferences across different geographical areas. The growth of e-commerce necessitates payment systems with strong adaptability and integration capabilities. These systems must provide smooth user experiences, adhere to international standards, and effectively manage new cybersecurity concerns. The continuous progress in payment technology demonstrates a wider movement towards increased accessibility and convenience, highlighting the crucial role these systems play in the digital economy.

Keywords: E-commerce, payment systems, businesses and consumers

Introduction

By changing traditional transactions that take place in brick-and-mortar stores into dynamic online exchanges, e-commerce has completely transformed the way in which businesses and customers interact with one another. Mobile commerce and digital services are only two examples of the many activities that fall under its umbrella. Online shopping and electronic marketplaces are also included [2]. There are a number of variables that are driving the expansion of e-commerce. These factors include the growing prevalence of mobile devices and the internet, the convenience of purchasing online, and the opportunity to access a global market. When it comes to e-commerce, one of the most important aspects is the payment system, which acts as the foundation for the processing of transactions and ensures that there is a seamless flow of funds between buyers and sellers [3]. Customer trust and satisfaction can be increased by the provision of different payment choices, such as credit cards, digital wallets, and bank transfers, which are all provided by effective payment systems. These systems not only make transactions more safe and efficient, but they also facilitate transactions. The prevention of fraud, the guarantee of data security, and the fulfillment of regulatory requirements are all very important functions that these systems provide [5, 6]. In light of the ongoing development of e-commerce, the incorporation of cutting-edge payment technologies, such as block chain and cryptocurrencies, further emphasizes the need of dependable payment systems in facilitating the expansion and continued viability of online enterprises [7]. Since the introduction of online shopping in the middle of the 1990s, there has been a substantial amount of development in the payment systems used in e-commerce. In the beginning, the most common way to make a payment was through the use of credit cards. This was made possible by the secure socket layer (SSL) encryption technology, which offered a safe way to send payment information over the internet. During this time period, businesses such as Amazon and eBay were among the original pioneers in the establishment of trust in online transactions [8, 9]. Electronic payment systems came into being as a result of the growing demand for payment methods that were both more convenient and more varied as e-commerce continued to expand [10]. Beginning in the late 1990s and continuing into the early 2000s, services such as PayPal came into existence. These services provided an additional layer of convenience and security by acting as intermediates between customers and retailers. The emergence of digital wallets, such as Google Wallet and Apple Pay, further revolutionized the scene by enabling mobile payments and contactless transactions [11]. This was a direct result of the growing popularity of using smartphones and other mobile devices for online shopping. The proliferation of cryptocurrencies such as Bitcoin led to the development of decentralized payment mechanisms that offered anonymity and lessened the fees associated with transactions. In addition, the integration of payment gateways with e-commerce platforms has become more smooth, which has made it easier for businesses to provide customers with a variety of payment choices [12]. Consumers now have more options to choose from thanks to innovations such as buy-now-pay-later services and peer-to-peer payment systems. These innovations have also made online shopping more accessible and comfortable for customers. Throughout this history, the focus has consistently been on improving security, convenience, and user experience [13]. This has been driven by technology advancements as well as shifting preferences among consumers.

Table 1: Brief history of E commerce payments [14, 15]

Year	Event/Development	Description
1994	First Online Transaction	The first secure online transaction took place on the NetMarket website, marking the beginning of e-commerce.
1995	Launch of Amazon and eBay	Amazon and eBay were launched, becoming pioneers in online retail and auction sites, respectively.
1998	Introduction of PayPal	PayPal was founded, offering a convenient and secure way to make payments online.
1999	Development of SSL Encryption	SSL (Secure Sockets Layer) encryption was widely adopted, providing a secure channel for online transactions.
2000s	Growth of Credit Card Payments	Credit card payments became the dominant method for online purchases, with Visa and MasterCard leading the way.
2004	Introduction of 3D Secure	Visa introduced 3D Secure (Verified by Visa) to enhance online transaction security through authentication.
2008	Emergence of Mobile Payments	The introduction of smartphones led to the rise of mobile payment solutions like Apple Pay and Google Wallet.
2010s	Rise of Digital Wallets	Digital wallets such as PayPal, Venmo, and Alipay gained popularity for their convenience and security.
2014	Launch of Apple Pay	Apple introduced Apple Pay, enabling contactless payments using NFC technology on iPhones.
2015	Blockchain and Cryptocurrencies	Bitcoin and other cryptocurrencies began to gain traction as alternative payment methods.
2017	PSD2 and Open Banking	The EU's Payment Services Directive 2 (PSD2) promoted open banking, enhancing competition and innovation in payments.
2020s	Growth of Buy Now, Pay Later (BNPL)	Services like Afterpay and Klarna gained popularity, allowing consumers to pay for purchases in installments.
2022	Expansion of Digital Currencies	Central Bank Digital Currencies (CBDCs) and stablecoins began to be explored by various countries as new forms of payment.

1. Types of E-commerce payment systems

Consumers and businesses are able to electronically exchange money thanks to the infrastructure that is provided by e-commerce payment systems, which are the backbone of online transactions. Over the course of the years, these systems have undergone tremendous development in order to meet the ever-increasing need for online payment methods that are not only safe and efficient but also user-friendly [16]. In their most fundamental form, e-commerce payment systems are designed to facilitate the movement of funds from buyers to sellers using a range of different mechanisms. These mechanisms include the processing of credit and debit cards, electronic wallets, and bank transfers [17]. Payments made with credit and debit cards continue to be among the most widely used methods, and payment gateways and processors continue to help ensure the safety and effectiveness of financial transactions. Users are able to store payment information and make transactions with only a few clicks or taps using electronic wallets such as PayPal, Apple Pay, and Google Wallet [18]. These wallets have gained popularity due to the ease and enhanced security features that they offer. Another dependable way is bank transfers, which include transactions conducted through the Automated Clearing House (ACH) [19]. This approach is particularly useful for larger transactions or payments that are made on a regular basis. Additionally, the advent of cryptocurrencies such as Bitcoin has brought about a new dimension to the payment systems used in online business. These cryptocurrencies offer choices for transactions that are both decentralized and safe. Every single one of these methods comes with its own individual set of benefits and difficulties, which may include concerns regarding safety, velocity, expense, and accessibility on a global scale. It is anticipated that e-commerce payment systems will continue to innovate as technology continues to grow. These systems will use artificial intelligence, blockchain, and biometric authentication in order to improve the user experience and the safety of online transactions [20].

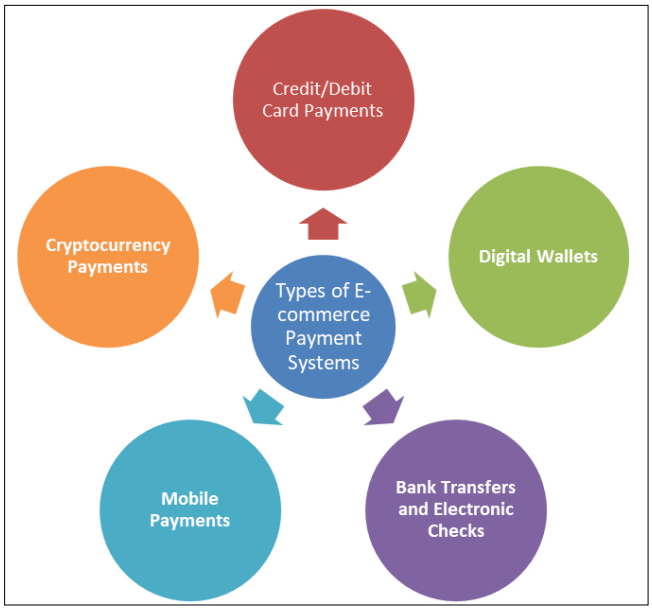

Fig 1: Types of Ecommerce payments

1.1. Credit/Debit card payments

Because of the continuously changing nature of the e-commerce scene, payments made with credit and debit cards have become an essential component of digital transactions [21]. This has been a driving force behind the expansion and accessibility of online shopping all over the world. Customers have the ability to make purchases from the comforts of their own homes or while they are on the move thanks to the unprecedented simplicity and safety offered by these payment options. The simplicity of use of credit and debit cards in online commerce is a major factor that has contributed to their broad adoption [22]. Customers just need to enter their card data in order to complete transactions, which normally takes only a few seconds [23]. This simplicity is complimented by sophisticated security features, including as encryption and two-factor authentication, which safeguard sensitive information and

create confidence between customers and merchants. These methods are designed to secure sensitive information [23]. In addition, credit and debit cards make it possible to conduct international transactions without any complications, which helps to promote a worldwide marketplace that allows for the uncomplicated management of currency conversions and purchases made across international borders [23]. Payment systems for credit and debit cards are also evolving as a result of the ongoing transformation of the e-commerce scene brought about by technology improvements. These payment systems are combining with digital wallets and mobile payment solutions in order to provide even greater flexibility and speed [23]. These advancements guarantee that payments made using credit and debit cards will continue to be an essential part of online commerce, thereby facilitating the growth of this industry and improving the shopping experience for millions of customers all over the world [23].

Table 2: Credit card payments

Company	Market Share	Unique Features	Key Partnerships
Visa	~50%	Global acceptance, secure tokenization technology	PayPal, Stripe, Square
Mastercard	~30%	Advanced fraud detection, loyalty programs	Amazon, Shopify, Apple Pay
American Express	~10%	Premium cardholder benefits, robust rewards programs	Expedia, Uber, Airbnb
Discover	~5%	No annual fee, cash back rewards	PayPal, Apple Pay, Amazon
JCB	~2%	Strong presence in Asia, tailored travel benefits	UnionPay, Alipay, Rakuten
UnionPay	~3%	Extensive network in China, local currency support	Alipay, WeChat Pay, JD.com

1.2. Digital Wallet

The introduction of digital wallets has brought about a sea change in the payment landscape of e-commerce by offering a technique that is not only secure but also streamlined and effective for making transactions online[28]. It is becoming increasingly crucial to have payment options that are both flexible and user-friendly as the worldwide market for digital commerce continues to increase. The adoption of digital wallets, which enable users to store payment information and ease transactions with only a few clicks or taps, has become an increasingly popular choice among consumers as well as among businesses [23]. They provide a variety of advantages, including as increased safety made possible by encryption and tokenisation, convenience brought about by the elimination of the have to repeatedly enter card details, and speed brought about by the streamlining of the checkout process. In addition, digital wallets frequently interact with a variety of financial services, which enables users to handle numerous currencies, keep track of their spending, and gain access to loyalty programs and discounts. The implementation of digital wallets can result in better consumer satisfaction, less cart abandonment, and higher conversion rates for businesses that offer online shopping [23]. To add insult to injury, the proliferation of mobile commerce has made digital wallets even more indispensable. These wallets allow users to make payments directly through their smartphones and wearable devices, thereby satisfying the growing demand for solutions that are optimized for mobile use. In general, digital wallets are causing a transformation in the payment systems used for online shopping since they provide a more flexible and effective alternative to the conventional means of payment. This is in line with the changing expectations of modern consumers [24].

Payment systems are extremely important in the fast developing environment of e-commerce since they play a crucial role in creating the experience of customers and ensuring the safety of financial transactions. PayPal, Apple Pay, and Google Wallet are three of the most popular payment methods and each of these options offers a unique set of features that are designed to meet the varied requirements of online buyers. PayPal, a pioneer in the field of digital payments, offers its consumers a reliable platform for sending and receiving money all over the world. It also boasts comprehensive security measures and buyer protection policies [25]. Apple Pay, which is seamlessly integrated with Apple products, provides a convenient and safe means for completing transactions through the use of NFC technology. This approach enables customers to make purchases with only a touch or glance. Google Wallet, which is now a component of Google Pay, combines the ease of saving payment information with the capability of making rapid payments in addition to the ability to make purchases both online and in physical stores [27]. These payment methods not only makes the process of checking out more streamlined, but they also improve security by utilizing cutting-edge technology such as tokenization and biometric verification. As a result, they contribute to an environment that is both more efficient and secure for online shopping [28]. These platforms continue to evolve, which is driving the future of digital commerce. Consumers are increasingly looking for speed, security, and convenience in an online shopping experience [28].

Table 3: Features of digital wallet

Feature	PayPal	Apple Pay	Google Wallet
Ease of Use	Simple setup, widely accepted	Easy for iOS users, integrated with Apple devices	Easy for Android users, integrated with Google ecosystem
Security	Strong security measures, buyer protection	High security with biometric authentication (Face ID, Touch ID)	High security with biometric authentication (Fingerprint, Face ID)
Transaction Fees	Fees for merchants (2.9% + $0.30 per transaction)	Low to no fees for users; fees for merchants	Low to no fees for users; fees for merchants
Compatibility	Compatible with most e-commerce platforms	Limited to Apple devices	Limited to Android devices
User Base	Over 300 million active users	Over 500 million users	Over 150 million users
Global Reach	Available in over 200 countries	Available in over 60 countries	Available in over 30 countries

Refund Process	Buyer protection and easy refund process	Depends on merchant's refund policy	Depends on merchant's refund policy
Payment Methods	Credit/debit cards, bank accounts, PayPal balance	Credit/debit cards, Apple Cash, Apple Card	Credit/debit cards, bank accounts, Google Pay balance
Merchant Integration	Easy to integrate with various platforms	Seamless integration with Apple products	Easy integration with Google services
Mobile Experience	Strong mobile app	Integrated into iOS and watchOS	Integrated into Android and Wear OS
Customer Support	Extensive support options	Limited support compared to PayPal	Limited support compared to PayPal
Merchant Fees	Fees for transactions, currency conversions	Lower fees, but limited to Apple devices	Lower fees, but limited to Google devices

1.3. Bank transfers and electronic checks

Payment systems have become essential in the dynamic realm of e-commerce, serving as the foundation for secure and smooth transactions between buyers and sellers. Bank transfers and computerized checks are prominent payment options. Bank transfers provide a straightforward and dependable way to move payments from a customer's bank account to a merchant's account, ensuring a strong level of security and traceability. This approach is especially popular in areas with well-developed banking systems, where customers value the security of conducting financial transactions directly without any intermediaries. However, electronic checks, often known as e-checks, utilize the conventional check processing system in a digital form, providing the same familiarity as paper checks but with the added ease and efficiency of electronic processing [29]. E-checks generally require customers to provide their bank account information and authorization, following which monies are electronically deducted from their account. Both approaches are essential for diversifying payment alternatives, meeting various customer preferences, and enabling e-commerce platforms to support a wide range of financial transactions. Integrating these payment methods not only improves the user experience by providing flexibility, but also instills trust through their well-established security and fraud prevention mechanisms [29]. In the era of digital transactions, the need of secure and efficient payment methods such as bank transfers and electronic checks cannot be emphasized enough. These payment systems serve as the foundation for financial transactions in the expanding global e-commerce industry [30].

- **EChecks and ACH transfers**

Within the domain of e-commerce payment systems, eChecks and ACH (Automated Clearing House) transfers are crucial means for enabling secure and efficient transactions. EChecks, also known as electronic checks, are digital counterparts of conventional paper checks that utilize the functionalities of internet banking to authorize payments straight from a customer's bank account to the merchant's account [31]. This technology not only simplifies the payment procedure but also decreases the likelihood of errors and fraud that are typically connected with manual cheque handling. ACH transfers are a type of electronic payment that occurs between banks, facilitated by the ACH network, which is overseen by NACHA (National Automated Clearing House Association). These transfers are commonly used for direct deposits, bill payments, and business-to-business transactions since they are cost-effective, reliable, and capable of handling large numbers of transactions with minimum processing expenses [32].

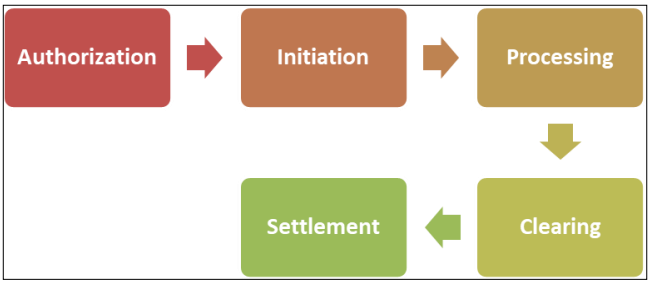

Fig 2: Process of eCheques

Both eChecks and ACH transfers are essential components of contemporary e-commerce, providing consumers and businesses with a safe, automated, and efficient option for making payments. This improves the overall user experience and operational efficiency compared to previous payment methods. The increasing expansion of the digital economy is anticipated to drive the growth of electronic payment solutions. This growth will be fuelled by developments in financial technology and the rising consumer desire for online transactions that are both secure and seamless [34].

Fig 3: Process of ACH

1.4. Mobile payments

Within the dynamic realm of e-commerce, mobile payment applications such as Venmo and Cash App have emerged as influential entities, fundamentally transforming the manner in which transactions are carried out [55]. These platforms provide efficient and easy-to-use solutions that meet the demands of contemporary consumers who priorities quickness and convenience. Venmo, renowned for its interface resembling social networking, enables users to easily transfer dollars to acquaintances and relatives, while also seamlessly connecting with diverse businesses for uncomplicated payments [36]. Similarly, Cash App offers a diverse range of services, including peer-to-peer transactions, direct deposits, and investment options, making it a handy tool for both personal and professional purposes. Integrating these mobile payment options into e-commerce platforms streamlines the checkout process, decreases cart abandonment rates, and improves the overall customer experience [37]. With the rising popularity of digital wallets, they are not only promoting greater financial inclusivity but also accelerating the transition to a society where currency is no longer used [38]. This change is characterized by the implementation of advanced security measures, including encryption and two-factor authentication, which guarantee not only the speed and

convenience of transactions but also their safety. The extensive utilization of mobile payment applications in electronic commerce highlights their crucial significance in the future of digital transactions, serving as a means to connect customers and merchants in an increasingly interconnected world [39].

NFC technology is transforming e-commerce by offering a rapid, safe, and touch less payment solution that caters to the needs of contemporary consumers [40]. With the continuous development of infrastructure and increasing consumer awareness, NFC is on track to become a widely accepted standard in the payment industry [41]. This technology brings substantial advantages to both consumers and companies. Adopting this technology can result in improved client satisfaction, heightened transaction efficiency, and a competitive advantage in the ever-changing realm of online commerce [42]. Near Field Communication (NFC) is a type of wireless communication that enables the exchange of data between devices within a limited range of 4 centimetres (1.6 inches) [43]. NFC functions based on the theory of electromagnetic induction, allowing two devices such as a smartphone and a payment terminal, to establish contact by being brought into close proximity [44].

1.5. Cryptocurrency Payments

Cryptocurrency refers to a form of currency that exists only in digital or virtual form and relies on encryption to ensure its security [45]. Cryptocurrencies, unlike government-issued fiat currencies, function on decentralized networks that rely on blockchain technology. This technology utilizes a distributed ledger to record all transactions on a network of computers. The utilization of cryptocurrency payments in the e-commerce sector offers a potentially advantageous although intricate prospect. They provide numerous benefits, such as reduced fees, expedited transactions, and enhanced security [46]. Nevertheless, in order to fully use their capabilities, it is imperative to confront obstacles like as unpredictability, regulatory complications, and technological limitations. As technology and regulations change, cryptocurrencies could become a more essential component of the worldwide e-commerce system [47]. Bitcoin, the initial and most renowned cryptocurrency, was launched in 2009 by an unidentified individual named Satoshi Nakamoto. Subsequently, a multitude of alternative cryptocurrencies, sometimes referred to as altcoins, have been created, each possessing distinct characteristics and applications. Notable examples encompass Ethereum, Ripple (XRP), Litecoin, and Bitcoin Cash. Cryptocurrencies utilize blockchain technology to achieve decentralization, transparency, and immutability. Network nodes use cryptography to verify transactions and store them in a publicly accessible distributed ledger known as a blockchain. Every transaction is safeguarded by intricate algorithms, rendering it very difficult to modify after it is appended to the blockchain [47].

Bitcoin, which was introduced in 2009 by an unidentified individual named Satoshi Nakamoto, has fundamentally transformed our understanding and involvement in financial transactions. Bitcoin, being a decentralised digital currency, functions on a peer-to-peer network, hence eliminating the requirement for intermediaries such as banks and financial institutions [48]. This attribute renders it especially attractive for e-commerce, since it offers significant benefits in terms of decreasing transaction fees and enhancing payment speed [48]. The blockchain technology that underlies Bitcoin guarantees safe, transparent, and irreversible transactions, thereby bolstering confidence between buyers and sellers. Moreover, the global character of Bitcoin enables seamless transactions across borders, thereby promoting international trade and broadening the market reach of e-commerce enterprises [48]. Integrating Bitcoin into e-commerce platforms can give businesses a competitive advantage, attract a wider range of customers, and create a smooth shopping experience as consumers become more knowledgeable about technology and look for more ways to make payments. Nevertheless, businesses must effectively address the hurdles posed by the fluctuating value of Bitcoin, regulatory ambiguities, and the requirement for strong cyber security measures in order to fully exploit its potential within the e-commerce ecosystem [48].

2. Key features of e-commerce payment systems

E-commerce payment systems are vital elements of the digital marketplace, serving as the fundamental infrastructure for online transactions between consumers and sellers. Essentially, these technologies are created to enable safe, effective, and smooth financial transactions online. E-commerce payment systems possess essential attributes, such as strong security measures like encryption and fraud detection algorithms, that safeguard sensitive payment information from unauthorized access and cyber threats [48]. These systems provide several payment methods, such as credit and debit cards, digital wallets, bank transfers, and other payment choices, providing flexibility to cater to a wide range of customer preferences. Another crucial advantage is the integration with several e-commerce platforms, which guarantees the smooth incorporation of payment solutions into online stores and marketplaces. In addition, e-commerce payment systems frequently offer real-time transaction processing and fast confirmation, which improves the customer experience by enabling instant order fulfillment and minimizing transaction-related delays. Implementing user authentication and authorization processes provides an additional layer of protection. Additionally, utilizing extensive reporting and analytics solutions allows organizations to gain significant insights into transaction patterns and customer behavior. The success of e-commerce payment systems depends on its capacity to harmonies security, convenience, and integration, guaranteeing a seamless and dependable payment experience for merchants and consumers alike [49].

Table 4

Feature	Description
Security	Measures like SSL encryption, tokenization, and PCI-DSS compliance to protect payment information.
Payment Methods	Support for various payment methods, including credit/debit cards, digital wallets, bank transfers, etc.
User Experience	Easy and intuitive checkout process, including options for guest checkout and minimal form fields.
Fraud Prevention	Tools and systems to detect and prevent fraudulent transactions, such as AVS and CVV checks.
Mobile Compatibility	Optimization for mobile devices and responsive design for a seamless payment experience on smartphones.
Multi-Currency Support	Ability to handle transactions in multiple currencies and provide real-time currency conversion.
Integration Capabilities	Compatibility with various e-commerce platforms and shopping carts, as well as other business tools.

Payment Gateway	The service that processes payments, including authorization and settlement of transactions.
Transaction Fees	Information on costs associated with each transaction, including processing fees and any additional charges.
Reporting and Analytics	Tools to track and analyze transaction data, sales performance, and customer payment behaviors.
Chargeback Management	Systems to handle disputes and chargebacks, including tools for resolution and reporting.
Customer Support	Availability of support for resolving payment-related issues and assisting with technical problems.
Compliance	Adherence to legal and regulatory requirements, including data protection laws and financial regulations.

3. Comparison of Popular E-commerce Payment Systems

When evaluating popular e-commerce payment systems, various crucial elements are considered, such as security, user-friendliness, transaction fees, and integration possibilities [50]. PayPal is widely recognized for its extensive acceptance and user-friendly interface, providing personal and commercial accounts with robust fraud prevention features [51]. Nevertheless, its fees may be comparatively expensive, particularly for international transactions, when compared to alternative choices. Stripe is notable for its APIs that are easy for developers to use and its smooth interaction with many platforms, which makes it a favored option for tech-savvy firms. In addition, it provides affordable pricing and additional functionalities such as subscription payment and custom reports. However, the setup process may be more intricate. Square is a well-liked option that is recognized for its clear and transparent pricing structure and its integrated point-of-sale (POS) systems. This may be particularly beneficial for businesses that operate both online and brick-and-mortar stores. While it offers a user-friendly interface, it may have less extensive global assistance in comparison to PayPal or Stripe. Apple Pay and Google Pay are becoming increasingly popular choices because of their user-friendly interface on mobile devices and their robust security measures, which utilize tokenization to safeguard payment data. Nevertheless, their adoption is steadily increasing, and they may not enjoy the same level of widespread acceptance as PayPal. The optimal payment system for a firm will ultimately be determined by its unique requirements, such as transaction volume, target market, and technological specifications [51].

Table 5: Comparison of different payment platforms

Payment System	Transaction Fees	Supported Currencies	Notable Features	Security Features
PayPal	2.9% + $0.30 per transaction (domestic); 4.4% + fixed fee based on currency (international)	Over 100 currencies	Easy integration, buyer and seller protection, PayPal Credit	Fraud detection, encryption, 2FA
Stripe	2.9% + $0.30 per transaction (domestic); 3.9% + 1% for international cards	135+ currencies	Developer-friendly, subscription billing, invoicing	Encryption, fraud prevention, 2FA
Square	2.6% + $0.10 per transaction (domestic); 3.5% + $0.15 for international cards	USD (other countries available with varying fees)	Point of sale (POS) solutions, inventory management, no monthly fees	Encryption, fraud detection
Authorize.Net	2.9% + $0.30 per transaction (domestic); 3.9% + $0.30 for international cards	USD, CAD, EUR, AUD, GBP	Advanced fraud detection, recurring billing, virtual terminal	Encryption, fraud prevention, 2FA
Amazon Pay	2.9% + $0.30 per transaction (domestic); 3.9% + $0.30 for international	20+ currencies	Leverages Amazon's customer base, voice payments, Alexa integration	Encryption, fraud protection
Apple Pay	No fees for transactions	26+ currencies	Contactless payments, integration with Apple devices, easy setup	Encryption, biometric authentication
Google Pay	No fees for transactions	30+ currencies	Contactless payments, integration with Google services, easy setup	Encryption, biometric authentication

4. Trends and Innovations in E-commerce Payments

The field of e-commerce payments is undergoing tremendous evolution, propelled by technological improvements and shifting consumer expectations. An important trend is the increasing popularity of digital wallets and mobile payments, which provide ease and improved security through technologies such as tokenization and biometric authentication [52]. Crypto currencies are increasingly becoming popular, offering an alternative to conventional fiat currencies and facilitating international transactions with reduced fees and quicker processing times. Furthermore, the incorporation of artificial intelligence and machine learning into payment systems is improving the identification of fraudulent activities and tailoring customer experiences to individual preferences. Buy-now-pay-later (BNPL) options are revolutionizing payment systems by providing consumers with flexible financing alternatives at the time of purchase [90]. Furthermore, the expansion of omnichannel retailing requires payment solutions that are smooth and efficient, functioning seamlessly on many platforms and devices. With the ongoing growth of e-commerce, advancements like blockchain technology for transparent transactions and the Internet of Things (IoT) for intelligent payment connections are poised to revolutionize the industry. These developments will enhance payment security, efficiency, and customization to better suit individual preferences [53].

4.1. Adoption of AI and machine learning for fraud detection

The integration of AI and machine learning in e-commerce payment systems is a substantial progress in enhancing the security of online transactions by detecting and preventing fraud. These systems utilize advanced algorithms and extensive transaction data to detect patterns and irregularities that could suggest fraudulent behavior [54]. AI systems can accurately identify and prevent fraudulent transactions by utilizing advanced methods such as supervised learning, unsupervised learning, and anomaly detection. Machine learning models are taught using past data to identify established fraud tendencies and adjust to new risks, so enhancing their efficiency as time progresses

[55, 56]. Artificial intelligence (AI) systems have the capability to analyze intricate data sets in real-time, offering immediate notifications and facilitating prompt actions to detect and prevent suspected fraudulent activities. Implementing this proactive strategy not only improves the security of e-commerce platforms but also mitigates the potential for financial loss and boosts client confidence. As these technologies advance, their incorporation into fraud detection systems will probably become more complex, providing enhanced defense against the constantly evolving online financial risks [57].

4.2. Biometric authentication methods

Biometric authentication solutions are becoming increasingly crucial in e-commerce payments as they provide advanced security measures to combat fraud and prevent unauthorized access. These approaches employ distinct physiological or behavioral attributes of individuals, such as fingerprints, facial recognition, iris scans, or speech patterns, to authenticate identity. Biometric authentication integrated into payment systems offers a more secure and user-friendly alternative to conventional password-based techniques [97, 98]. By utilizing biometric data, which is fundamentally distinct to each person and challenging to duplicate, these systems minimize the likelihood of identity theft and account breach. For instance, fingerprint recognition technology enables rapid user verification without the need to remember intricate passwords, while facial recognition systems provide the convenience of contactless authentication via device cameras. Implementing biometric authentication in e-commerce payments not only improves security but also optimizes the user experience, resulting in faster and smoother transactions. Nevertheless, it also gives rise to worries surrounding the confidentiality of data and the possibility of unauthorized access to biometric information, highlighting the necessity for strong encryption and safeguards for data protection. Biometric authentication is anticipated to have a significant impact on the future of safe online transactions as e-commerce progresses [58].

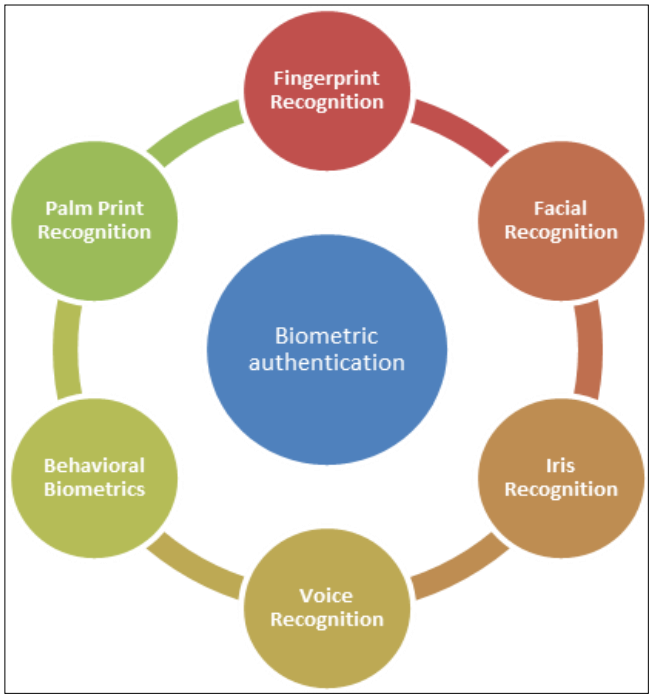

Fig 4: Biomatric authentication

4.3. Emerging technologies (blockchain, IoT):

The payment systems used in online commerce are undergoing a change as a result of the introduction of new paradigms for security, efficiency, and user experience brought about by emerging technologies such as blockchain and the Internet of Things (IoT) [100]. The blockchain technology, which is characterized by its immutable and decentralized ledger, provides increased transparency and security for transactions. This, in turn, reduces the likelihood of fraudulent activity and minimizes the requirement for financial intermediaries. This technology not only makes it possible to conduct international transactions more quickly, but it also streamlines payment procedures by doing away with the delays that are typically associated with banking. The Internet of Things, on the other hand, incorporates commonplace items into the payment environment, making it possible to conduct transactions without any interruptions using connected devices. In order to make transactions more convenient and to reduce friction at the point of sale, smart devices have the ability to automatically manage payments based on circumstances that have been prescribed in advance. Collectively, these technologies are bringing about a transformation in the manner in which transactions are carried out. They are bringing about a future in which payment systems will be more user-centric, efficient, and secure, thereby adapting to the ever-changing requirements of the digital economy [59].

5. Potential impact of technological advancements:

The manner in which transactions are carried out has been dramatically altered as a result of technological improvements in e-commerce payment systems, which will have a significant impact on the future of online shopping and financial transactions. As the pace of digital innovation quickens, the sector is undergoing a change as a result of the incorporation of advanced payment technologies such as blockchain, biometric authentication, and artificial intelligence. By enhancing security, streamlining transaction procedures, and providing a more seamless customer experience, these innovations deliver additional benefits. Additionally, biometric authentication, which includes fingerprint and facial recognition, strengthens security by guaranteeing that only authorized users are able to complete transactions. Blockchain technology provides unprecedented transparency and fraud prevention by establishing immutable transaction records. By providing dynamic fraud detection, personalized payment experiences, and automated customer care, artificial intelligence contributes to the further refinement of payment systems. These technologies, when combined, not only enhance the effectiveness and security of online business transactions, but they also make it easier for people all over the world to access and participate in the market, thereby satisfying a wide variety of consumer preferences and requirements. As these innovations continue to develop, they have the potential to propel additional expansion in the e-commerce sector, thereby generating new opportunities and difficulties for both consumers and businesses alike [59].

Conclusions

The landscape of e-commerce payment systems is characterized by rapid expansion and diversification, driven by technology advancements and increasing consumer

expectations. In conclusion, this landscape is characterized by the same characteristics. In light of the fact that digital transactions are becoming an increasingly important part of the economy on a worldwide scale, it is impossible to emphasize the significance of payment solutions that are safe, effective, and user-friendly. By including a wide variety of payment methods, the industry is demonstrating its dedication to catering to the varied requirements and preferences of customers. These payment methods include the conventional credit and debit cards as well as developing choices such as digital wallets, cryptocurrencies, and biometric verification measures. When it comes to protecting user data and preserving trust, it is essential to place a strong emphasis on adopting stringent security measures and guaranteeing compliance with regulatory regulations. As the growth of e-commerce continues, businesses need to maintain their flexibility by embracing cutting-edge payment solutions while simultaneously ensuring that transactions are both seamless and secure. Not only do the continual developments in payment systems improve the user experience, but they also contribute to economic growth by making it easier for people to connect with financial transactions in the digital marketplace.

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