

Evolution of Digital Payment Systems and a Breakthrough

Suat Teker ^{a*}, Dilek Teker ^a and Irmak Orman ^{b#}

^a Department of Business, Isik University, Istanbul, Turkey.

^b Graduate School, Isik University, Istanbul, Turkey.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This analytical study examines the evolution of digital payment systems and the use by financial institutions and fintech companies in line with the changing user needs, along with the evolutionary developments in information technologies. It also makes a comparative analysis of digital payment platforms that are popularly used all over the world, e.g. PayPal, GooglePay, Wise. The introduction of the first ATM in 1967, the first contactless credit card payment in 1999, the introduction of blockchain in 2009, the emergence of GoogleWallet in 2011 and the introduction of Visa Click-to-pay in 2020 may be defined as the milestones of digital payment systems. Digital payment systems can be broadly classified as smart cards, online payments, mobile applications, blockchain transfers and biometric authentication. All payment systems in the world are generally shaped according to user needs. The exponential growth of e-commerce and the increasing influence of market regulators also contribute to shaping the future of payment systems. A decentralized monetary management is envisioned by the transition to a cashless economy, the emergence of new online financial institutions, and the adoption of blockchain and cryptocurrencies. It is concluded that the evolution of digital payment systems will expand convenience, refund, convergence, cross-border and time limitless transaction. With the increasing adoption of digital payment systems by all spenders, there is a clear transition towards a cashless economy. The current arguments in academic and professional platforms about the future of digital systems predict that by the 2050s, physical money will be completely out of circulation and these currencies will be replaced by virtual currencies that can easily be transferred over number of digital platforms.

PhD Program,

*Corresponding author: E-mail: suat.teker@isikun.edu.tr;

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1. INTRODUCTION

Money has been a medium of exchange throughout the history. Money enables the ability to buy foods and services, it has a store of value that provides purchasing power. Money has different values for today and tomorrow and it provides a unit of account to measure value. Payment systems enables money to function as media of exchange which transfers value from one account to another. All systems apart from the physical exchange of money (banknotes or coins) requires a ledger for record keeping

As financial systems became more complex and interconnected, ledgers also became deeper, connected. Technological developments, communication technologies and internet brought new innovations to payment systems and central

monetary transactions [1-5]. As all businesses digitized, so did banking and financial industries and financial technology (FinTech) developments introduced new payment systems as well as new currencies.

This study focuses on the developments on digital payment systems, how digital systems work, what are the most widely used digital payment infrastructures throughout the world and where the overall value exchange is going in the future.

Tangible financial transactions were made using cash or coins [6-9]. Digital payments are all transactions where the value is transferred from one account to the other using digital payment technologies. Until recently, digital payments were usually limited to electronic money transfers



Fig. 1. Types of digital payments

[10,11]. With fintech developments and the emergence of cryptocurrency, digital payment systems carry a wider meaning. Transfer of money from one account to another by using intangible digital transfer of money in reality covers the complete picture of digital payment systems. Individuals and institutions can manage their bank accounts and execute remote transactions by using web-based user interface systems [7]. The use of internet and technology in modern banking services including electronic payment systems improves banking performance and serves for convenience, the second best feature of digital payment after speed [12-14].

Digital payments have subsets depending on the platform and/or technology the value is transferred.

Smart cards that are commonly used in everyday life by people and businesses such as credit cards and debit cards are the most basic type of digital payments. Smart cards are usually provided by traditional banks and widely accepted globally [15,16]. Usage of smart cards are highly traceable. Even though smart cards are the most basic form of digital payment systems, they have been also evolving with technology. Mobile POS (point-of-sale) machines enhances easy payment and NFC (near-field-communication) facilitates contactless payments.

Online payment is still the most widely used form of digital payment system globally. With globalization and cross-border trade, businesses as well as individuals adapted to online payment systems provided by banks. EFT (electronic fund transfer) via IBANs (International Bank Account Number) are the most accepted form of payment in today's world [17-19]. Global banking systems record all monetary transactions that are made through online channels, and they are almost 100% traceable.

Mobile payment technologies enable users to transfer funds and value through electronic mobile devices such as smartphones, tablets or smartwatches. Mobile payment applications can also be used to transfer money to family and friends. Mobile payments are financially regulated and widely used by unbanked communities in developing countries.

2. CHARACTERISTICS OF DIGITAL PAYMENT SYSTEMS

According to Karnoukos and Fokus [20], mobile payment services need to have following characteristics:

- **Simplicity & Usability:** M-payment application should be simple and convenient
- **Universality:** Service should provide domestic, regional and global coverage for transactions between people and businesses
- **Interoperability:** Development should be based on international standards and open technologies that allow different systems to interact with each other
- **Security, Privacy & Trust:** Users should be able to trust a mobile application to share their security details and make monetary transfers. Privacy for transactions and anonymity is important as well as security against outside attacks.
- **Cost:** Mobile payment systems should cost less-to-none compared to other existing payment mechanisms
- **Speed:** Transaction speeds should be acceptable to users
- **Cross Border Payments:** Mobile payment application should be globally recognized and used world-wide to be accepted.

Mobile Wallets provided by technology moguls like Apple, Google and Samsung accelerated the shift from traditional banks to alternative fintech companies and applications. These wallets introduced new stakeholders such as mobile network operators, mobile device manufacturers and software providers to financial systems.

Fig. 1 summarizes the exchange between different parties and services through mobile payment systems with financial, mobile and technology exchange actors.

Digital payment systems are compared and evaluated based on common characteristics. Authenticity is important for checking identity and providing personal account information. Privacy is one of the key elements that needs to be established for all monetary transactions. Integrity of the system infrastructure is a standard for security whereas non-repudiation is a requirement for the completion of the payment. Expansion of the payment system is a customer expectation along with transaction efficiency. For providing a global service, compatibility and acceptability of the systems is also a requirement.

Transaction costs are still a competitive topic and an important revenue stream for online and mobile payment systems. Most banks have been

charging their customers for money transfers, especially for international transactions but new players such as blockchain instruments are creating a disruption at transaction costs. Atomic exchange, user range and value mobility

are commercial characteristics usually determined by the service provider whereas anonymity, convenience and mobility are shared standards in today's digital payment ecosystem.

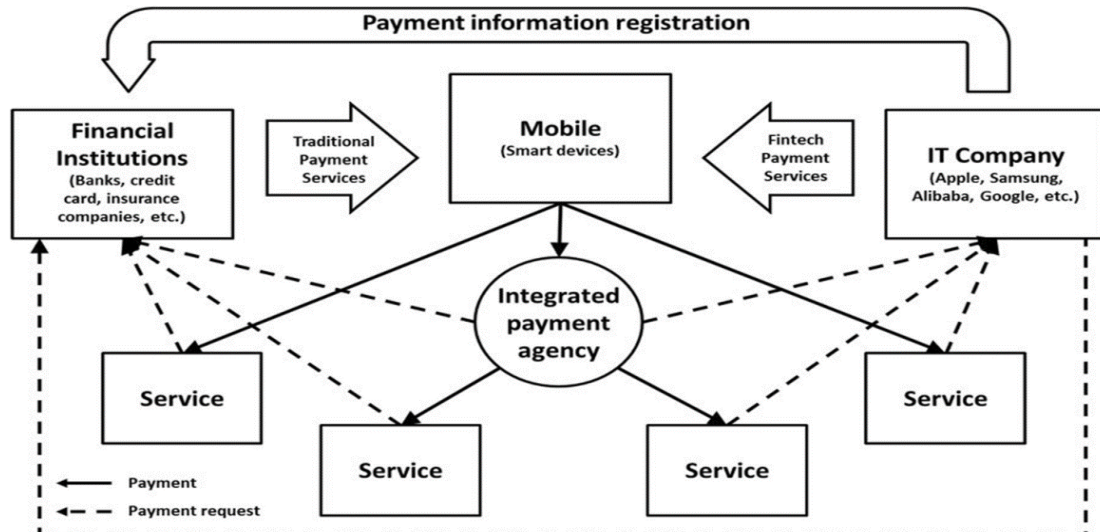


Fig. 2. Basic operations mechanism for digital payment systems

Source: Kang, et al. [21]

Table 1. Comparison of electronic check systems and online card payments

	Electronic check system	Online credit card payment (VCC & SLL)
Authenticity	Good: Digital signatures and digital certification are used to check identity.	Good: VCC uses card number and PIN to check identity. SLL uses only account information. Fair:
Privacy	Fair: Asymmetrical golden keys are used to calculate and transfer information but this may jeopardise payment account information.	Good: Actual card number is not sent through the internet in VCC. Fair: Actual card number is needed in SLL to conduct a transaction.
Integrity	Good: Information certification number and assymmetrical golden keys are used for higher security.	Good: VCC and SLL both use Hash function to ensure integrity
Non-Repudiation	Good: Digital signatures and digital checks are used to ensure non-repudiation	None: Cardholder can use the card without additional integrity
Expansion	Good: Consumer and store electronic checkbooks complete the transaction. Financial systems provide check certification and exchange	Very Good: Both VCC and SLL are globally accepted and used
Transaction Efficiency	Good: Transaction efficiency decreases if the transaction is offline	Good: Both VCC and SLL create efficient transactions
Compatibility	Good: Smmotly work with traditional financial organizations and checking accounts.	Good: VCC and SLL are compatible with all types of browsers
Acceptability	Poor: Consumer and store must both install a smart card reader	Good: Both VCC and SLL are widely accessible
Transaction Cost	Fair: Transaction costs are low. However, the system users must obtain smart cards digital certification	Fair: Transaction costs of VCC and SLL are close to credit card costs.

	Electronic check system and bear other fixed costs.	Online credit card payment (VCC & SLL)
Atomic Exchange	None: Check the authenticity first and pay later.	None: Use the service first and pay later for VCC and SLL.
User Range	Fair: Limited to checking accounts owners.	Fair: Both are limited to credit card owners.
Value Mobility	Users endorse their limits and limits can be transferred among parties.	None: No money can be transferred using online transactions among different parties.
Financial Risk	Fair: Consumer can stop check payments for fraudulent transactions	Low: Most risk is carried by credit card industry
Anonymity	None: All checking account owners must sign own names.	Good: CVV companies cannot obtain information about consumer VCC accounts while intermediaries cannot get the spending habits of consumers. Fair: SLL companies can obtain information about consumers VCC accounts while intermediaries cannot get the spending habits of consumers.
Convenience	Fair: Consumers should apply a bank for an electronic checkbook.	Fair: VCC consumers need to apply for a VCC account besides getting a credit card. Good: SLL consumers can make transactions if they have a credit card.
Mobility	Good: Includes signing and certification	Good: Both VCC and SLL carry no limit on where they can be used.

VCC: Voltage at the Common Collector; SLL: Security Socket Layers
Source: Adapted from Lee, et al. [22]

3. HISTORICAL EVOLUTION OF DIGITAL PAYMENT SYSTEMS

Historically, non-physical exchange of cash dates back to 1872 to Western Union’s 1st wire transfer by using a telegraph network. But it was almost a decade later when alternative payment system creation gained pace with the installation of the 1st ATM by Barclays Bank. In 1977, Merita Bank in Finland introduced mobile banking with SMS which paved the way to today’s mobile wallets and biometric authentication via mobile devices.

It was in 1995 when the first contactless payment was implemented in 1995 by Seoul Bus Transport. PayPay in 1999 launched its electronic money transfer service which is still widely used today. By millennium, WU.com was launched, Western Union’s online payment website. On 2003, Chinese E-commerce giant introduced AliPay, the first mobile payment platform. NTT Docomo launched the very first mobile wallet in Japan in 2004. By 2005, two-thirds of American adults owned a cell phone. As mobile communications and internet usage increased, payment applications around these technologies also increased.

A very important milestone for new-age digital payment systems is the launch of Bitcoin in 2009. Since then, developments in cryptocurrency, blockchain usage and a transition towards a decentralized monetary

system globally increased. Cryptocurrency mining, alternative token exchange and crypto-exchange has grown exponentially since the 1st launch of Bitcoin and is now considered to be the next-generation base of cashless economy for the future.

Fig. 1 shape explains historical evolution of digital payment systems.

Smart device producers like Apple and Samsung, marketplaces like Amazon and Alibaba, and Google introduced their own wallets in the second half of 2010. Apple introduced biometric authentication via finger prints in 2014. Face recognition followed afterwards.

In 2016, it was announced at Global Blockchain Forum that blockchain adoption rate reached 13.5% within financial services, surpassing the early adopters’ phase. Digital payment systems on all platforms, from mobile to online to blockchain had their largest disruption after Covid-19 global pandemic. People of all ages transitioned to online payments, mobile transactions and to a paper-free digital phase for convenience, speed and hygiene.

The trend towards a transition to digital payment systems will continue in the near future. Contactless cards, tap-to-pay systems, biometric payment cards (i.e fingerprints, face recognition) and mobile wallet usage will become mainstream for financial exchange.

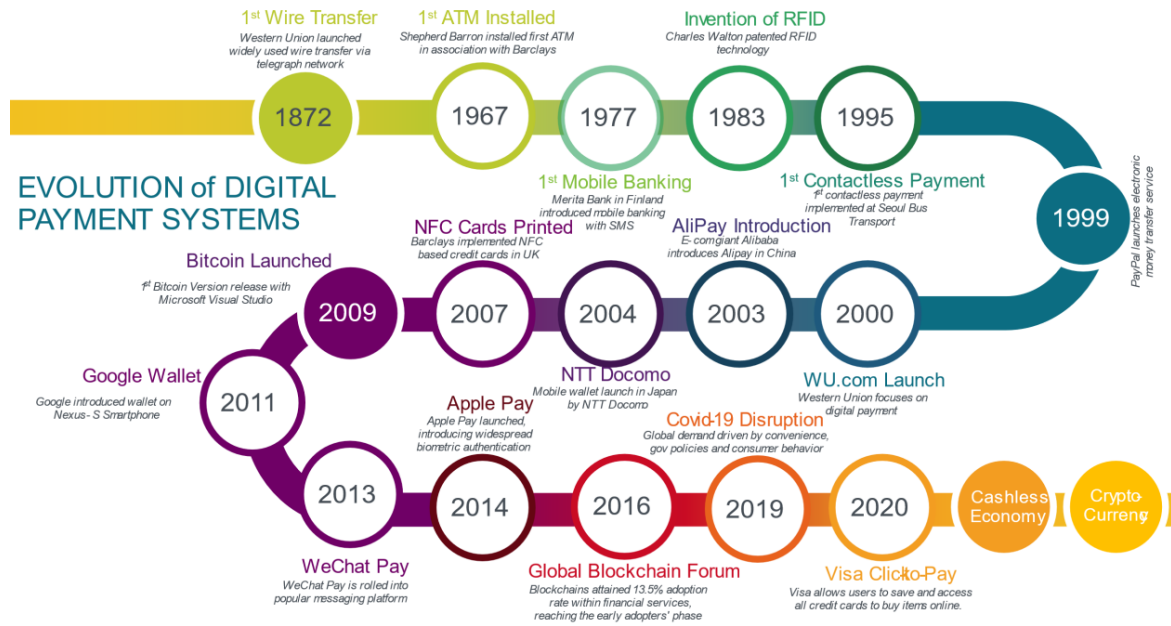


Fig. 3. Evolution of digital payment systems

4. COMPARISON OF MOBILE PAYMENT APPLICATIONS

A mobile payment can be simply defined as the transfer of funds among various accounts utilizing a portable electronic device. There are different mobile payment technologies that enable money transfer to friend, family or businesses. Online commerce, marketplaces and e-commerce platforms have adopted and enabled mobile payment systems as a natural result; semi-forcefully adopting their users.

It may be fair to state that mobile payments became popular in Asian and European countries much earlier than becoming common in USA and Canada [23]. Traditional Banks have adopted to online payment technologies as new players emerged in digital payments. Technology-based applications such as Apple Pay and PayPal have developed systems since 1994 allowing users to make payment by passing their smartphone screen under store barcodes or tap their phones against contactless terminals.

Table 2. Payment applications comparison

#	Payment apps	Fees	Transaction reachout	Payment system	Transaction time
1	PayPal	No charge in the U.S. for transferring money to friends and families. Other users pay 2.90% plus a fixed fee for sending money via credit cards and 5% for international transactions.	Domestic and all countries		It may take a day, sometimes longer.,
2	Venmo	No charge through the app transfers. 3% fee through credit card transfers. Instant payments costs 1%.	Domestic only	Standard bank transfer through the ACH network or you can keep money in Venmo account or your bank account.	Usually 30 minutes for Instant transfers, 1-3 business days for bank transfers.
3	Cash App	No (yes for credit card usage)	Domestic only	Maximum transfer amount is \$7,500 and lower limits	Within minutes

#	Payment apps	Fees	Transaction reachout	Payment system	Transaction time
				apply without verification, and users can buy and sell Bitcoin.	
4	Zelle	No fees for sending or receiving money via Zelle	Domestic only	Many big US banks offer Zelle.	Within minutes
5	Google Pay	No fees for sending money to friends and family members	Domestic and some countries	Integrated to other Google products including Gmail. Send or receive money using Gmail address.	Depending on the type of transaction, usually in 24-hours or 3-5 days.
6	Meta messenger	Meta account users can send money easily to businesses and friends who are on Meta, no fees	Domestic and some countries	A debit card must be linked to a Meta account.	Up to 5 days.
7	QuickBooks online mobile	Bank transfers, 1% max \$10; Cards-Swiped, 2.4% plus 25 cents; Cards-invoiced, 2.9% plus 25 cents; Cards-keyed, 3.4% plus 25 cents.	Domestic and some countries	Easy receipt of credit card payments and send customers a "Pay Now" link.	Funds arrive in user bank account the next business day with the GoPayment app.
8	Wise	Vary by country and currency	Used for international payments	Wise Batch Payment tool for payroll allows employers to pay employees in more than 45 currencies.	Up to 2 business days depending on the receiver country.
9	Stripe	2.9% plus 30 cents for each successful card charge	All major debit and credit cards in every country	Comprehensive dashboard offers many payment methods for mobile devices.	Instant payments to debit cards or bank accounts subject to daily payout limits.
10	FreshBooks	2.9% plus 30 cents on all credit card transactions; American Express at 3.5% plus 30 cents) and bank transfers at 1%	Connects over 14,000 banks through ACH payments and credit cards.	Edit, deliver, track, and successfully follow up invoices efficiently through FreshBooks Payments powered by WePay.	Two business days

Source: Adapted from Investopedia and the Balance Websites

Payment applications uses iOS for Apple phones and Android for other phones as operating systems. They enable international and domestic payments. There are some fees reflected on top of payments, depending on where the money is transferred and to whom. Payment method is usually easy by tapping a few touch screens, providing speed and convenience to its users. Transaction time depends on the payment application's terms, the corresponding account's availability and the payment application.

Physical wallets and plastic cards will disappear in the near future with the further penetration of payment applications. Biometric authentication such as fingerprints and face recognition will provide further privacy, security and decrease risk of fraud in transfers. Blockchain backed

digital applications will change the whole record keeping systems, forcing banks to digitalize as well.

Table 2 provides a comparison to top 10 most widely used digital applications.

5. CONCLUSION

A product or a service that has a value needed a form of exchange since the discovery of money by Lydians in BC 700. For decades, the exchange happened on physical medium with coins or cash. As centralized systems emerged, accounting and bookkeeping developed, and banks played a major role as authorities for monetary transactions. Developments in world wide web, telecommunication technologies and

smart devices, financial institutions changed form and structure too.

Digital payment systems offer various money transfer options to users with electronic checks, contactless credit cards and mobile wallets. The rapid increase in per capita consumption and expenditure amounts in recent years has encouraged more widespread use of digital payment systems. This trend points to a rapid transformation towards cashless economies. The convenience, security, decentralization, speed and privacy provided by digital payment systems cause these systems to be preferred more by all citizens of the world.

Each technology introduced adds value to transaction and spending experience of the individuals. The fact that users do not count a physical dime while paying creates a virtual feeling which makes spending easier. Tech-savvy generations that have been becoming financially responsible are born into such applications will carry the flag even further, creating an accelerated decline for the use of traditional payment methods.

The current arguments in academic and professional platforms about the future of digital systems predict that by the 2050s, physical money will be completely out of circulation and these currencies will be replaced by virtual currencies that can easily be transferred over number of digital platforms.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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