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Master's Degree in Engineering and Management

Master Thesis

Mobile Payments: Emergence of Dominant Design in Layered Architectures

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Contents

Chapter 1

Introduction

Mobile payments have been gaining widespread popularity and acceptance in recent years, with an increasing number of consumers shifting towards cashless payment methods.

Technologies that allow mobile devices to initiate a payment transaction continue to spread across the globe. Fintech services have grown significantly over the years, allowing easy and high-quality online banking and payment services. These IT innovators have put the financial sector under pressure.

Additionally, the coronavirus pandemic has resulted in organizations and governments encouraging the use of new payment methods instead of physical cash to prevent the spread of the virus. These two factors have turned the rise of mobile payments into one of the most significant developments in current financial behavior.

Countries and regions have taken significantly different approaches to mobile payments. For some regions, mobile payments were an addition to existing digital payments. For others, mobile payments are the main way to introduce people to digital payments in the first place. The COVID-19 outbreak accelerated these developments, though, and mobile payments are likely to stay.

The increasing adoption of digital and mobile payments in the financial technology sector has led to the emergence of various new solutions, as the **mobile payments**' sector continues to grow, a question arises: **is there an emerging dominant design?**

The identification of a dominant design within the mobile payment sector is crucial for businesses and policy makers as it can shape the direction of the industry and determine the success of future innovations.

This thesis aims to analyze the mobile payments' solutions from the multiple technological layers point of view, identifying the potential emergence of a dominant design.

More specifically:

- in the **first chapter *Mobile Payments' solutions & FinTech sector*** a fintech overview and a deep mobile payments' sector analysis is presented. The vast subject of fintech is introduced from a historic point of view to analyze how this concept has evolved over time and how the actual technological level has been reached. A subsequent in depht analysis of digital and mobile payments is conducted, considering both global and italian recent trends, major use cases and the current main technological solutions. This first chapter ends with summary tables of those technologies and a payment landscape analysis introducing the payment value chain, which will be further analysed in the third chapter.
- In the **second chapter *Innovation Theory and its application on mobile payments sector*** a comprehensive analysis of relevant literature of innovation theory is reviewed: firstly is presented the concept of dominant design, from the first work of Abernathy & Utterback to the modern literature. Secondly it has been considered product architecture

theory, focusing in particular on the layered modular architecture and its peculiarities. Such architecure is tipical of product-services such as mobile payments platforms and therefore it has been essential for the subsequent analysis.

- In the **third chapter *Methodology*** is presented the analysis' methodology that has been applied: as tools for this assessment swim lane diagrams and block diagrams have been considered. The former with the aim of a process architecture modelling whereas the latter for a high level system modelling. Findings of such diagrams have been later considered for the evaluation of the layered architectures of mobile payments solution, aiming at identifying regular and recurrent pattern among the various cases analyzed.

- In the **fourth chapter *Profiling the Dominant Designs*** other considerations have been made in order to profile the future possible emerging dominant design, or better said designs: the analysis conducted in the third chapter made clear that various solutions are present for different use cases, coexisting all together. In order to frame what are the most promising solutions, depending on the use case considered, four different factors have been analyzed: complementary assets, network externalities, economies of scale and consumers' requirements, all together impacting on the diffusion level of the mobile payment solutions and on the relative stability over time.

Chapter 2

Mobile Payments' solutions & FinTech sector

2.1 Definition of Mobile payment

In their article, Dahlberg et al. (2008) proposed a definition for mobile payments as

payments for goods, services, and bills with a mobile device by taking advantage of wireless and other communication technologies

More specifically some sources use digital payments and mobile payments interchangeably, although they are technically different from each other: mobile payments are digital payments performed exclusively with a mobile device, such as smartphone or wearable devices.

This industry represents a subsector of the FinTech one.

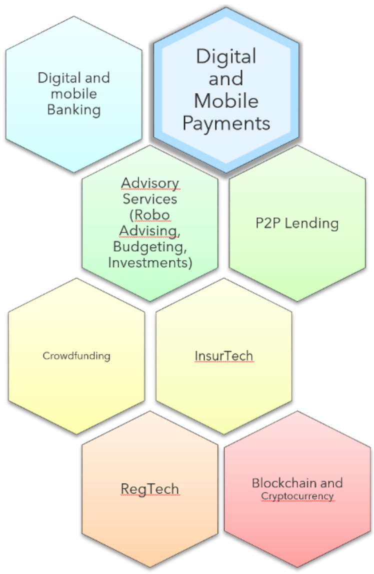


Figure 2.1. FinTech Universe.

2.2 FinTech Overview

2.2.1 FinTech Definition

Fintech, short for Financial Technology, is a cross-disciplinary subject that combines Finance, Technology Management, and Innovation Management [Leong, Sung 2018]. The definition can further be elaborated as "any innovative ideas that improve financial service processes by proposing technology solutions according to different business situations, while the ideas could also lead to new business models or even new businesses".

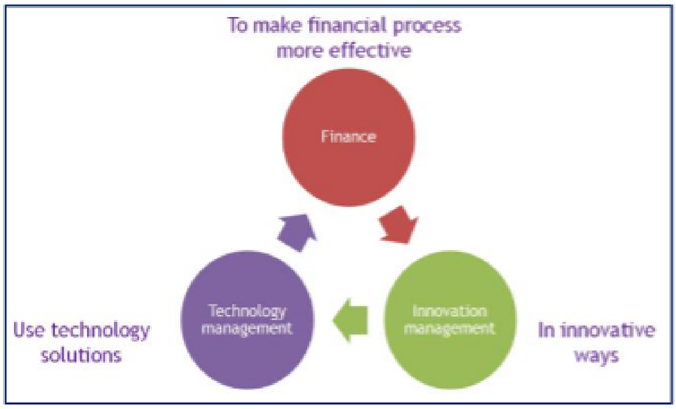


Figure 2.2. Definition of FinTech [Leong, Sung 2018].

The term Fintech is used to described new tech that seeks to improve and automate the delivery and use of financial services. At its core, fintech is utilized to help companies, business owners and consumers better manage their financial operations, processes, and lives by utilizing specialized software and algorithms that are used on computers and, increasingly, smartphones.

Broadly, the term "financial technology" can apply to any innovation in how people transact business, from the invention of digital money to double-entry bookkeeping.

In the 20th Century, the term was initially applied to the technology employed at the back-end systems of established consumer and trade financial institutions.

Since the end of the first decade of the 21st century, the term has expanded to include any technological innovation in the financial sector, including innovations in financial literacy and education, retail banking, investment and even crypto-currencies like Bitcoin: the financial crisis of 2008 triggered new financial innovations, integrating digital technologies such as the internet, smartphones, and artificial intelligence (AI) with financial services, offering new value-added and making it possible to provide services at a lower cost than previously [Takeda, Ito 2021].

Since then, however, there has been a shift to more consumer-oriented services and therefore a more consumer-oriented definition. Ozili (2018) explained it more simply: "The term FinTech denotes "financial technology" and is defined as the delivery of financial and banking services through modern technological innovation led by computer programs and algorithms." Takeda (2021) adopts a simple definition of FinTech: "financial innovation realized by information technology (IT)."

Up until now, financial services institutions offered a variety of services under a single umbrella: the scope of these services encompassed a broad range from traditional banking activities to mortgage and trading services.

In its most basic form, Fintech unbundles these services into individual offerings creating new markets for them. The combination of streamlined offerings with technology enables fintech companies to be more efficient and cut down on costs associated with each transaction.

The following characteristics are common to all Fintech companies:

- accessibility to services
- elimination of bureaucracy
- simplicity (advanced user experience)
- transparency
- lower pricing due to lower costs: there are minimal structural costs.

In 2017, Leong et al. wrote: "With the inexorable march of technological advances and digital transformation, we are now witnessing rampant disruptions in highly regulated sectors such as banking and finance, especially with the development of FinTech, a broad umbrella term that describes disruptive technologies in the financial services sector."

If one word can describe how many fintech innovations have affected traditional trading, banking, financial advice, and products, it's disruption, like financial products and services that were once the realm of branches, salesmen and desktops move toward mobile devices or simply democratize away from large, entrenched institutions. Startups disrupt incumbents in the finance industry by expanding financial inclusion and using technology to cut down on operational costs. Existing financial institutions must develop their businesses in step with the financial regulations of the country they operate in.

Banks in particular tend to be conservative, and lacking in customer service. Under these conditions, the emergence of FinTech has revolutionized the financial industry and attracted worldwide attention. For these reasons, research studies on FinTech have increased greatly in recent years [Takeda, Ito 2021].

Considering the banking sector specifically, what can be said regarding the relationship between Fintech companies and traditional banks? It's not clear whether these services are complementing the bank or competitors.

The traditional banking sector has innovated very little in the last 20 years: the last truly disruptive innovation occurred 20 years ago with the introduction of internet banking, so we are talking about the introduction of technology but not user experience, business banking applications have remained outdated.

Automated algorithmic wealth management systems for small investors can be considered as a complement to traditional banks; otherwise, it would be too costly as operation for a traditional bank to carry out.

Regarding the users of FinTech solutions, there are four broad categories:

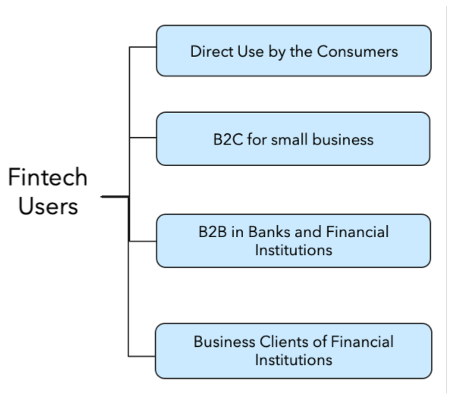


Figure 2.3. FinTech Users' categories.

Trends toward mobile banking, increased information, data, and more accurate analytics and decentralization of access will create opportunities for all four groups to interact in so far unprecedented ways.

2.2.2 Sector's evolution

The development of FinTech is closely related to the development of enabling technologies.

First financial globalization: from analogue to digital (1838 to 1967)

Even if this industry is often regarded as a recent union between financial services and information technology, the interconnection between these two sectors can be traced back to the 19th century with the introduction of the telegraph, commercially used since 1838, along with the laying of the first transatlantic cable in 1866. These two important elements provided a key infrastructure for the first major financial globalization dated back the end of the 19th century.

Along them, other technologies such as railways, canals, steamships contributed to the development of financial interconnection across border, enabling rapid financial information throughout the world.

Financial globalization kept steady for decades, during which several technological developments, particularly in the field of communications and information technology, contributed to the innovation process in the financial industry.

A large part of our financial technology infrastructure was created from 1950 through 1970, beginning with the introduction of the modern-day credit card by Diners Club in 1950.

In 1960, the Quotron system began to appear on brokers' desks as the first electronic system to provide stock market quotations. They looked very much like large desktop computers.

In 1966, the global telex network was established, which sought to provide the framework for future financial technology development in the international arena. That was followed by the creation of the Clearing House Interbank Payments System, which allowed the most active banks in the world to transmit and settle payments in American dollars.

Later in 1967 with the introduction of the Automatic Teller Machine (ATM) a modern FinTech era began: until that year the financial service industry, even if strongly linked to technology, was still a largely analogic industry, the combined impact of all the mentioned innovation allowed the shift from an analogue industry to a digital one.

Modern FinTech era: development of traditional digital financial services (1967 to 2008)

Since the introduction of the calculator and ATMs in 1967, the manipulation and transfer of digital information have become increasingly important. Financial services saw a transformation from analog to digital services, and as a result, the financial industry became entirely automated. This second major change period can be seen until 2008 financial crisis.

Key developments set the foundations for the second period of financial globalization: in the area of payments, the Inter-Computer Bureau was established in the UK in 1968, forming the basis of today's Bankers' Automated Clearing Services (BACS), while the US Clearing House Interbank Payments System (CHIPS) was established in 1970.

Fedwire, originally established in 1918, became an electronic instead of a telegraphic system in the early 1970s. Reflecting the need to interconnect domestic payments systems across borders, Society of Worldwide Interbank Financial Telecommunications (SWIFT) was established in 1973, followed soon after by the collapse of Herstatt Bank in 1974, which clearly highlighted the risks of increasing international financial interlinkages, particularly through the new payments system technology.

This crisis triggered the first major regulatory focus on FinTech issues, in the form of a series of international soft law agreements on developing robust payments systems and related regulation. The combination of finance, technology and appropriate regulatory attention is the basis of today's US $ 5.4 trillion a day global foreign exchange market, the largest, most globalized and most digitized component of the global economy

In the area of securities, the establishment of NASDAQ in the US in 1971, and the end of fixed securities commissions and the eventual development of the National Market System marked the transition from physical trading of securities dating to the late 1600s to today's fully electronic securities trading. In the consumer area, online banking was first introduced in the US in 1980 (although abandoned in 1983) and in the UK in 1983 by the Nottingham Building Society (NBS). (Arner, Barberis, and Buckley 2015)

Financial institutions boosted their internal IT usage during this time, gradually displacing most paper-based processes.

In the 1980s, banks began to utilize the sophisticated data and record-keeping systems available through large mainframe computers, some of which took up whole floors. Up to this point, most of the FinTech advancements were contained behind the scenes, in the back offices of banks and investment houses. In 1982, E-Trade brought FinTech to the light of day for the public with its electronic trading system available for individual investors. ("The Evolution of Fintech -The New York Times" 2016)

Back in the 1990s the financial industry became a massive IT buyer, not changing this position over the years until now, increasing those investments in the last decade indeed, supporting exponential growth of players.

However, it was the emergence of the Internet that set the stage for the next level of development, beginning in 1995 with Wells Fargo using the World Wide Web (WWW) to provide online account checking. By 2001, eight banks in the US had at least one million customers online, with other major jurisdictions around the world rapidly developing similar systems and related regulatory frameworks to address risk. By 2005, the first direct banks without physical branches emerged (e.g. ING Direct, HSBC Direct) in the UK.

By the beginning of the 21st century, banks' internal processes, interactions with outsiders and an ever increasing number of their interactions with retail customers had become fully digitized, facts highlighted by the significance of IT spending by the financial services industry. In addition, regulators were ever more using technology, especially in the context of securities exchanges.

Democratizing Digital Financial Services? (2008 to present)

Until 2008 traditional financial services dominated the FinTech industry, providing financial products and services to consumers.

A mindset shift has occurred from a retail customer perspective as to who has the resources and legitimacy to provide financial services. Whilst it is difficult to identify how and where that trend started, it is possible to say that the 2008 GFC represents a turning point and has catalyzed the growth of the newest FinTech era.

This huge crisis changed things radically: public perception of banks deteriorated, the 2008 GFC created a crack in people's trust towards banks, services to be chosen for managing their finances have been questioned.

As the financial crisis morphed into an economic crisis, along with the general public's distrust of the traditional banking system, many financial professionals either lost their jobs or were now less well compensated. This under-utilized educated workforce found a new industry, FinTech, in which to apply their skills.

Post-financial crisis regulation has increased the compliance obligations of banks and altered their commercial incentives and business structures. In particular, the universal banking model has been directly challenged with ring-fencing obligations and increased regulatory capital changing the incentive or capacity of banks to originate low-value loans. Furthermore, the (mis)use of certain financial innovations, such as collateralized debt obligations (CDOs), has been regarded as a contributor to the crisis by detaching the credit risk of the underlying loan from the loan originator.

As a result, since 2008, the business models and structures of banks have been reshaped: all these elements contributed to the recent growth in the number of FinTechs, or new technology-driven players in the financial services industry. Today, FinTechs are companies that combine cutting-edge technology and business models to facilitate, improve, and disrupt financial services.

Post-2008 an alignment of market conditions supported the emergence of innovative market players in the financial services industry. Among these factors were:

- public perception
- changing consumer behavior
- regulatory scrutiny
- political demand
- economic conditions
- technological improvements toward an increasingly connected digitalized world (Internet and smartphones in particular)

The entrepreneurial intuition was to identify a potential for creating new services from scratch that would overturn the previous paradigm. The customer is thus placed at the center, creating user experiences thanks to very intuitive and very simple applications: through them operations are made possible from anywhere in the world, instantly. New startups along with tech giants have started to provide financial services and products to businesses and consumers.

Thanks to the World Wide Web's introduction of Web 2.0, anyone who is knowledgeable in coding can develop a dynamic, interactive website that uses the Cloud as the middleman for the transmission of data. For FinTech companies looking to replace financial channels and upend established business models, this opened up an entirely new market.

As more and more FinTech firms have introduced significant innovations to the market, banks and other financial services companies have anxiously watched. Some of these more traditional companies have started to interact with FinTechs through partnerships, incubator programs, and outright acquisitions.

Figure 2.4. Recent timeline of sector evolution. Source: Statista Report 45600 "FinTech In-depth Market Insights & Data Analysis" (2022).

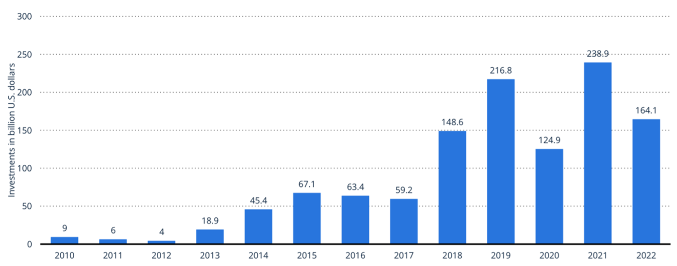


Figure 2.5. Total value of investments into fintech companies worldwide from 2010 to 2022 (in billion U.S. dollars). Source: Statista Report 26515 "Fintech"(2022).

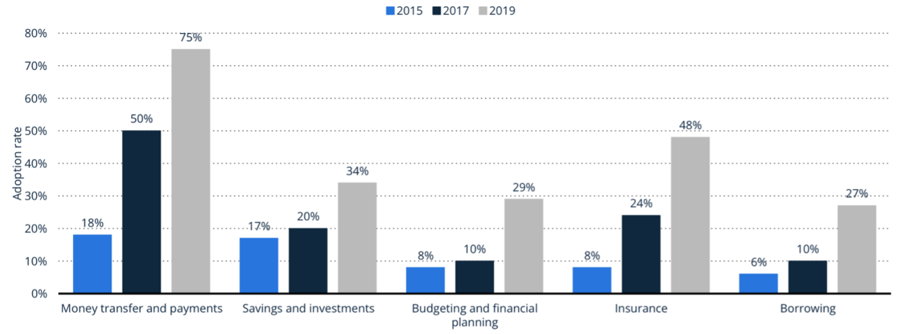


Figure 2.6. Consumer fintech adoption rates globally from 2015 to 2019, by category. Source: Statista Report 26515 "Fintech" (2022)

2.2.3 FinTech's Subsectors

As previously mentioned, mobile payments represent a subsector of the vast fintech industry: driven by advancements in technology such as the internet revolution, the mobile internet and smartphone revolution along with the increasing demand for more convenient and efficient financial services, fintech has grown explosively.

Now the term describes a broad variety of technological interventions into personal and commercial finance: the term FinTech is nowadays not limited to specific sectors or particular business models but covers the entire range of services and products.

Figure 2.7. Fintech sectors.

The various Fintech applications, in terms of products and services, can be grouped into the following seven main categories, covering different sectors and industries:

1. Advisory service: Personal finance management or budgeting applications and Investment management through robo advising
2. Financing: Crowdfunding or p2p lending
3. Compliance: RegTech
4. Insurance: Insurtech
5. Blockchain-based financial services, cryptocurrency
6. Digital & Mobile Banking
7. **Digital & Mobile payments**

Advisory services: personal finance and investment management

Advisory service refers to provide suggestions to users according to a set of rules and criteria. Financial institutions such as private banks, registered investments advisors and bank brokers have always offered wealth management services to their customers, in particular higher-end ones with an investable capital.

Since the 2008 GFC and the consequent loss of trust from customers towards consolidated intermediaries, companies in the digital technology sector have emerged with completely innovative concepts for investing and consulting. Start-ups have been able to take advantage of their high-tech skills and develop more straightforward and affordable ways to provide financial advice in an innovative way while traditional asset management companies struggled to change their business models and internal organizational structures to comply with the new regulatory requirements and the complexity of crisis-driven consolidation.

The investment management sector covers all kind of related services, such as investment advice, asset management consultation, customer supports and management decision makings. More specifically two advisory services solutions can be identified:

- Personal finance management tools such as apps and software that help individuals manage their personal finances through budgeting, saving, and investing. These tools can provide users with a holistic view of their financial situation and offer personalized financial advice.
- Investment management services including portfolio management, and analytics services, with the usage of technology to provide low-cost investment advice and portfolio management.

As a sub-topic under advisory service, robo-advisor, is now an emerging topic in investment sector [Sironi 2016]. Robo-advisor serves as financial adviser that provides automated financial advice or investment management for clients. Based on advanced technologies, such as artificial intelligence, big data and machine learning, Robo-advisor can provide personalized suggestions to clients in more effective ways, while the suggestions can also be updated according to real-time data (e.g. the latest oil price fluctuation or stock index, etc.).

Financing: crowdfunding and p2p lending

Financing refers to any acts of obtaining funds for business activities from different sources.

This traditional method implied that, in order to raise money, a series of compulsory stages had to be followed: conduction of a market research, development of a business model, creation of a thorough business plan, construction of a prototype, and then wealthy entrepreneur or institution had to be found to to fund the idea.

These traditional funding sources, which constrained options to a select group of important players, included banks, business angels, and venture capital firms, government funds, stock market and others.

The developments of FinTech provide many new alternative financing ways, that is, a financing channel which is outside the traditional systems. An example are digital lending platforms: these are online platforms that connect borrowers with lenders, such as peer-to-peer lending, online marketplace lending, and online lending to small businesses. These platforms can provide borrowers with access to credit at lower costs and faster processing times than traditional lending institutions.

For example, crowdfunding provides an alternative way for businesses to obtain funds at lower cost or in a way that was not possible traditionally, dramatically simplifying the traditional model.

It is an effective tool for start-ups and entrepreneurs to bridge the funding gap between earliest stages of funding and later growth of capital [Scholz 2015].

P2P lending can be viewed as a two-sided market similar to the traditional banking system. P2P platforms primarily aim to network users who are lenders and borrowers.

While creditors search for ways to invest money as efficiently as possible, always taking a certain level of risk, borrowers, who face different levels of insolvency risk, look for sources of liquidity for their businesses. P2P websites serve as middlemen and enable the matching of supply and demand, trying to fulfill the demands of both parties. (Alexander, Alexander, and Daniel 2011)

Compliance: RegTech

Compliance refers to conforming with a set of regulations, such as specifications, policy, standard or law. Nowadays, compliance becomes a key business process for many businesses. On this, using technologies to enhance regulatory processes is also referred to RegTech (Regulatory Technology) [Schuettel 2017]

Regtech includes compliance management and regulatory reporting solutions for financial institutions. These solutions help financial institutions to comply with regulations and to report their activities to the relevant authorities.

Insurance: Insurtech

The term Insurtech refers to the technology offering innovative insurance products, such as usage-based insurance, telematics, and on-demand insurance.

Given the extent of technological advancements made in other financial services industries, the insurance sector has not undergone significant change, and digitalization is still behind other industries.

Existing applications of insurance services involve using wearable computers (e.g. hand belt with digital device) which send users' health data to insurance company, so that personalized insurance package can be designed.

Blockchain-based financial services and cryptocurrency

Blockchain, widely studied over the last years, refers to a sort of distributed registry or decentralized database which keeps track of digital transactions. Rather than having a central administrator as a traditional database, there is a network of replicated and synchronized databases, visible to anyone inside the network.

Many relevant techniques and applications had been proposed by different scholars in relation to the use of this technology within the fintech sector:

- decentralized smart contract system based on blockchain [Kosba et al 2016]. Smart contracts utilizing computer programs together with blockchain to automatically execute contracts between buyers and sellers.
- a protocol using blockchain to protect personal data [Zyskind et al. 2015]
- a study was conducted to review the main principles behind blockchain technology and some of its cutting-edge applications [Pilkington et al 2016]
- debates about the pros and cons of Bitcoin, for examples, discussing if Bitcoin will become a major currency [Luther, White 2014]

2.3 Digital and mobile payments

As anticipated, digital and mobile payments represent one of the various facets of the vast FinTech sector. On payment aspects, cashless payment is the key development trend.

2.3.1 Brief History of mobile payments solutions

1997 was the year, when the mobile payment of services or goods was enabled for the first time in the world when Coca Cola in Helsinki came out with a beverage vending machine, where users could pay for the beverage with just an SMS message. Around the same time, the oil company Mobil, also came out with an RFID device called Speedpass. This device helped its users to pay for their fuel at the gas stations by simply slipping the device at or near the sensors placed on the pump.

These two services are considered as the pioneers of mobile payment. Both the services were based on the SMS and the payments were made by a mobile account that was linked to the user's device. Initially, the payments were limited to smaller amounts and that's why they were often referred to as micropayments.

The mobile payment systems based on SMS soon evolved into the world's first phone-based banking service launched by the Merita bank of Finland in 1997.

In 2007, Vodafone launched one of the largest mobile payment systems in the world. It was based on USSD/SMS technology and offered various kinds of macro and micro payments. Vodafone launched this service in Tanzania and Kenya with the cooperation of the local telecom operators.

During 2011 some major players like Apple and Google entered the field of mobile payment.

Google became the first major company to come up with its digital mobile wallet solution. The wallet was based on the NFC technology and allowed the customers to make payments, redeem coupons, and earn loyalty points. However, Google wallet was used as only one phone model and was accepted by a limited number of merchants. Even after all these limitations, it turned out to be popular among the users.

Apple followed Google's footsteps to come up with their app called Passbook in 2012. Passbook targeted coupons and boarding passes instead of mobile payments.

Although, two years later Apple launched its pay service in US called Apple Pay at the launch of iPhone 6.

The year 2015 was a remarkable year for mobile payment as Samsung Pay and Android Pay were released. Technological innovations have played a significant role in shaping and changing the payment mechanism: among the most powerful example we can find the one linked with the smartphone evolution and adoption's growth.

COVID-19: impact on m-payments

The COVID-19 pandemic has had a significant impact on many aspects of our daily lives, including how we make and receive payments. Mobile payments, in particular, have seen a significant increase in usage due to the pandemic: the COVID-19 outbreak accelerated the adoption of mobile payments, changes in the way transactions are conducted occurred since the diffusion of the pandemic.

With physical stores closed or operating with reduced capacity, many consumers have also shifted their spending to online shopping.

Studies have found that the coronavirus can survive on solid surfaces like coins and paper money for three hours to four days (The Telegraph, 2020). As money tends to pass between a buyer and a seller, m-payments solutions have been considered one of the most optimal and hygienic forms of payment to reduce the spread of viruses. This is because the transaction does not require any physical contact for it to be completed. Due to the pandemic, M-payment is no longer regarded as a form of convenience but more of a necessity.

As people have been encouraged or mandated to stay at home to help slow the spread of the virus, many have turned to online shopping and mobile payments as a way to make purchases without leaving their homes.

Payments today: an industry undergoing a radical change

Today, it is spreading, amongst the users, the will to have an optimal payment experience, in terms of speed, convenience, multi-channel accessibility and safety.

Aside from them, other factors are currently impacting on the payment industry, as the following scheme summarizes.

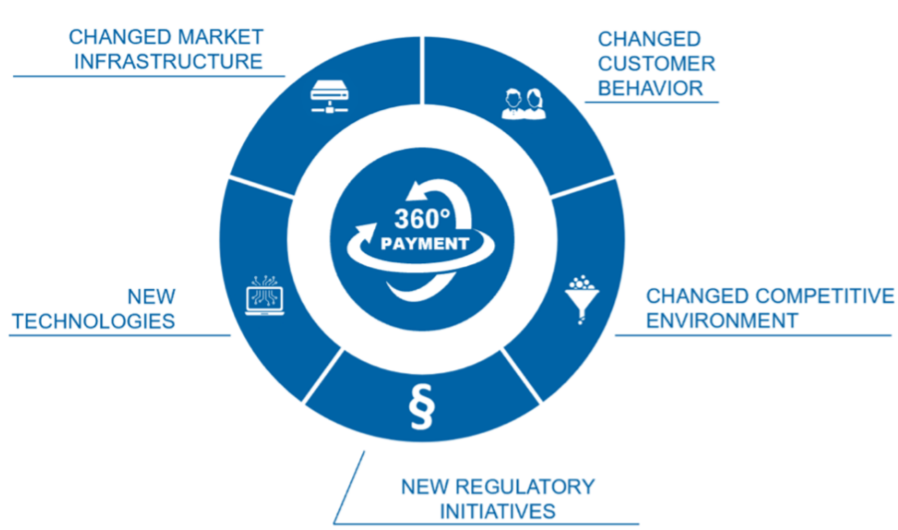


Figure 2.8. Five factors impacting payment industry. Source: Bankinghub.com.

Five actors have currently an impact on the payment industry

1. **Changed customer behavior**: as part of digitalization and new innovative competitors joining the market, payment service providers have to cope with changing customer requirements. The factors critical to success here include a clear customer orientation and a high degree of flexibility in payment solutions.

   Aside from these success factors, it is also important to meet central requirements for the payment procedure from the customer's perspective:

   - Fast and immediate execution and settlement of national and international payments around the clock (24/7)
   - Simple and smooth processing of payments without media/channel interruptions
   - Secure and permanent data and transaction security and transparency to protect against fraudulent activities
   - Cost effective reduction of existing costs for executing (international) transactions

2. **Changed competitive environment**: innovative payment methods such as mobile payments are already a reality in many countries, and new domestic and international solutions are regularly being added Europe. The rapidly growing number of new competitors is intensifying the dynamics, and at the same time the new providers are intensifying the market environment with their aggressive pricing models and their ranges of modern and flexible products. Numerous fintech companies have successfully managed to fill the customer interface in B2B and B2C. Even world-leading fintech companies such as Wirecard, Adyen, TransferWise and PayPal now have to assert themselves against the large tech corporations (GAFA: Google, Apple, Facebook, Amazon) which have significant dominance over (mobile) devices and customer data.

3. **New regulatory initiatives**: the legislative pressure on the payments sector has increased considerably in recent years. Regulatory initiatives and requirements must be anticipated promptly and implemented efficiently. The regulatory initiatives are mainly aimed at further

harmonizing payments, increasing consumer protection and 1) promoting innovation. In particular, the new EU Payment Services Directive PSD II enables innovation and increased competition among other things by opening up account information to third parties. At the same time, PSD II increases the security of payments through stricter requirements for customer authentication. In the next few years, we expect further consumer protection oriented initiatives to be taken, which will be combined into a kind of PSD III.

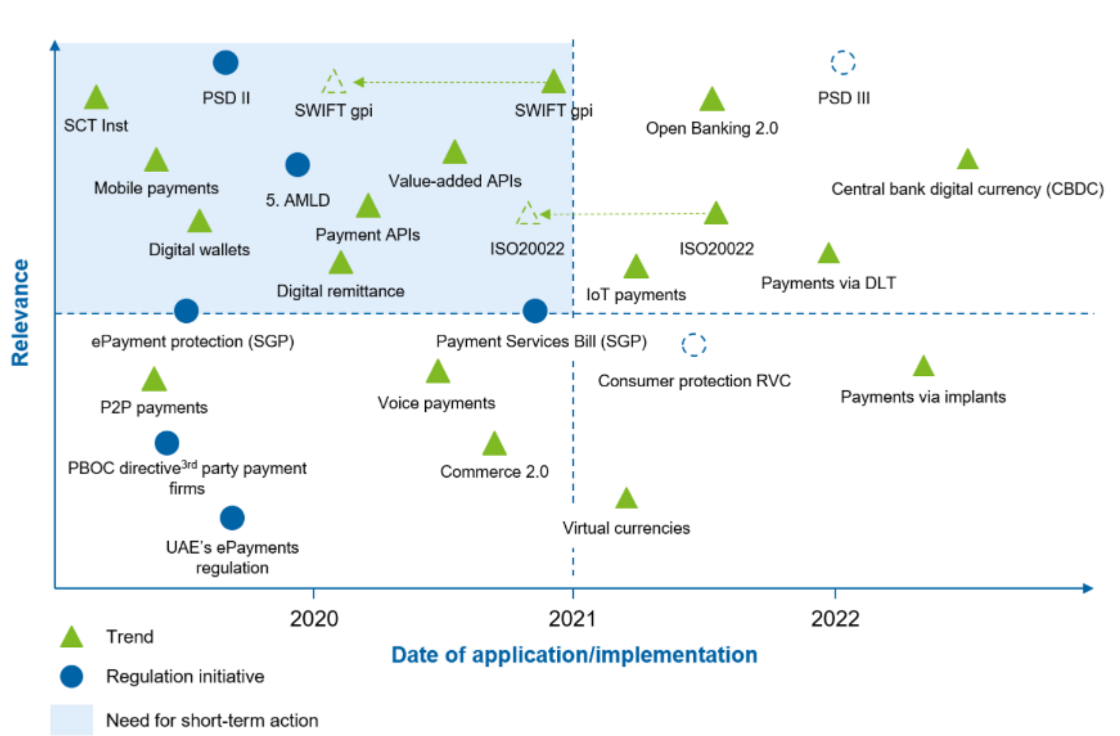


Figure 2.9. Overview of trends and regulatory initiatives in payments (extract). Source: Bankinghub.com.

4. **New technologies**: the increased competitive pressure, caused by fintech and big tech companies, among others, is pushing existing market participants to invest. This is because, in a direct comparison, the new competitors have significantly lower basic costs due to their "greenfield" platforms, some of which are very focused, and strong IT teams. The use of modern technologies offers the necessary flexibility to respond to ever changing customer requirements. At the same time, existing manual processes are improved and costs are significantly reduced. Two promising technological developments in payment are artificial intelligence (AI) and open banking.

5. **Changed market infrastructure**: at the same time, various global initiatives are being worked on with the aim of modernizing the payment infrastructure. The modernization includes the renewal of clearing and settlement mechanisms, the introduction of real time gross settlement systems and the consolidation of TARGET services on a central platform. Examples include new standards for international payments such as SWIFT gpi and new communication standards such as ISO 20022. This requires planning and implementation efforts with a high involvement of resources on the part of the market participants, which must be made in line with the implementation of regulatory requirements.

2.3.2 General Conceptual Schema

As mobile devices have been transforming into personal trust devices, mobile payment is recognized as interactions between parties in a e-payment system with specific context (e.g. business models, player relationships) and capabilities (mobile device capabilities) so that there is at least one party as a mobile user.

Basically, the context of mobile payments includes any payment in which a mobile device is used in order to "initiate, activate, and confirm" the payment. The mobile payment services are often carried out through a none bank party (such as financial and credit institutions) independent of pre existing bank accounts.

Mobile payment systems evolve with new technologies.

As the following shows, m-payment system is merely registering and forwarding the authorized and validated payment transactions. Payment system life-cycle includes payment request creation, payment request authorization, and payment request committal.

Principally, m-payments occur between four stakeholders:

- mobile consumers, subscribed to a service
- merchants, providing product or service to consumers
- payment service provider, which controls the payment process
- trusted third party that administers the authentication of other players and the authorization of payment settlement.

Different roles can be merged into one party and act as one player. For example, payment service provider, which controls payment process and trusted third party, can act as the same stakeholder.

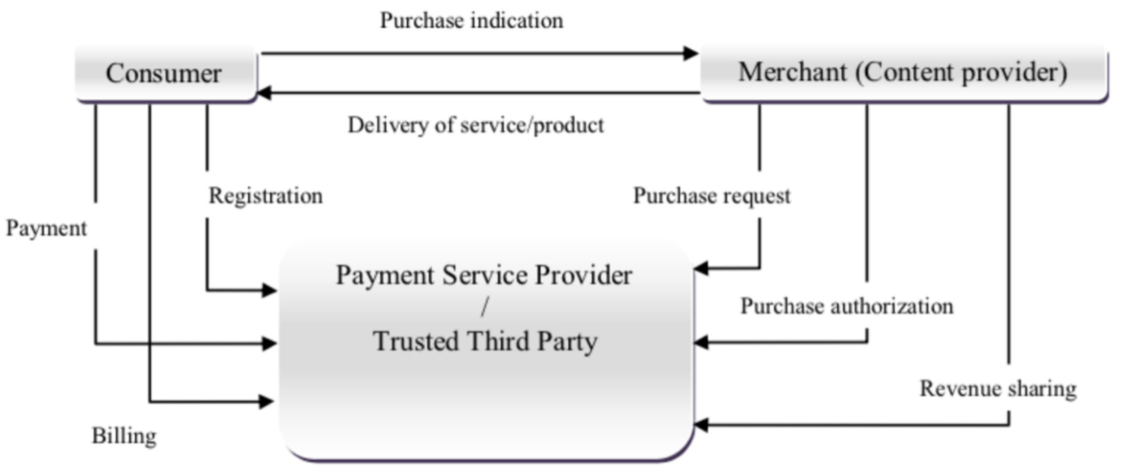


Figure 2.10. Conceptual schema of the Mobile Payment System. Source: Pouralinazar (2013).

2.3.3 Recent Global Key Development Trends

On payment aspects, *cash vs cashless* is a central theme.

No longer king, cash remains essential. The decline of cash continues with -6% CAGR projected through 2026, as consumers gravitate to the ease, convenience and safety of digital payments, also promoted by governments.

Yet a "cashless society" isn't on the immediate horizon. Cash continues to play an essential role in most economies, accounting for over $7.6 trillion in global consumer spending in 2022.

Consumer use of credit cards remains strong, while sources of credit are diversifying.

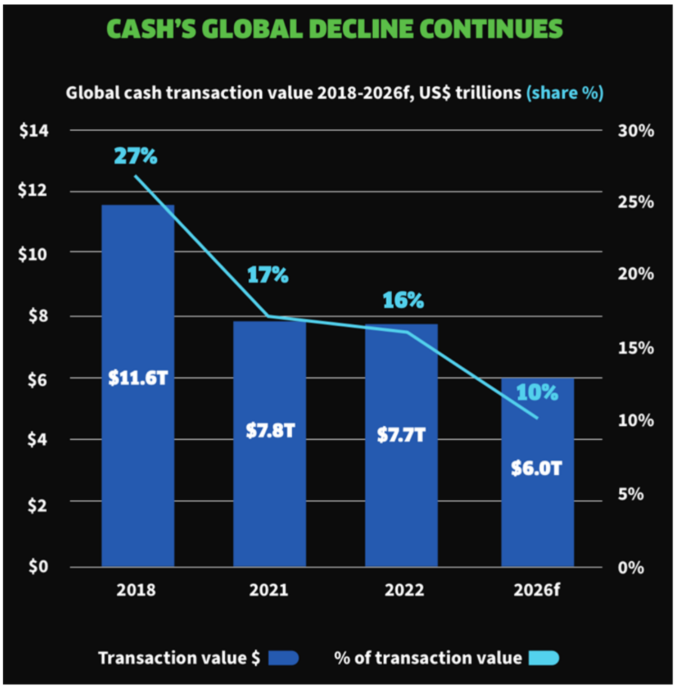


Figure 2.11. Global cash decline 2018-2026, US$ trillions (share %). Source 2023 Global Payment Report, Worldpay from FIS.

Despite a forecast of modest share declines, global credit card transaction value continued to rise both in store and online. Credit card spend exceeded $13 trillion across all channels in 2022. Consumers preferences for credit at checkout, in addition to direct credit card use, are broadening to include credit card funded digital wallets, BNPL and other POS financing offered by banks, fintechs and merchants.

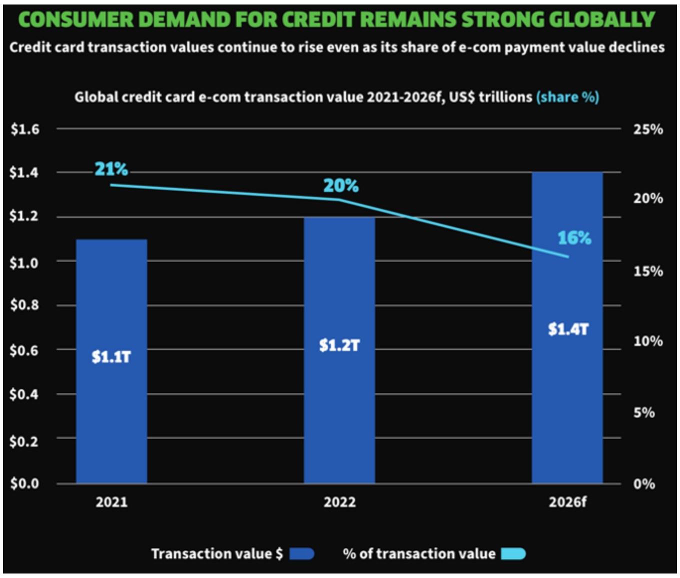


Figure 2.12. Global credit card e-com transaction value 2021-2026, US$ trillions (share %). Source: 2023 Global Payment Report, Worldpay from FIS.

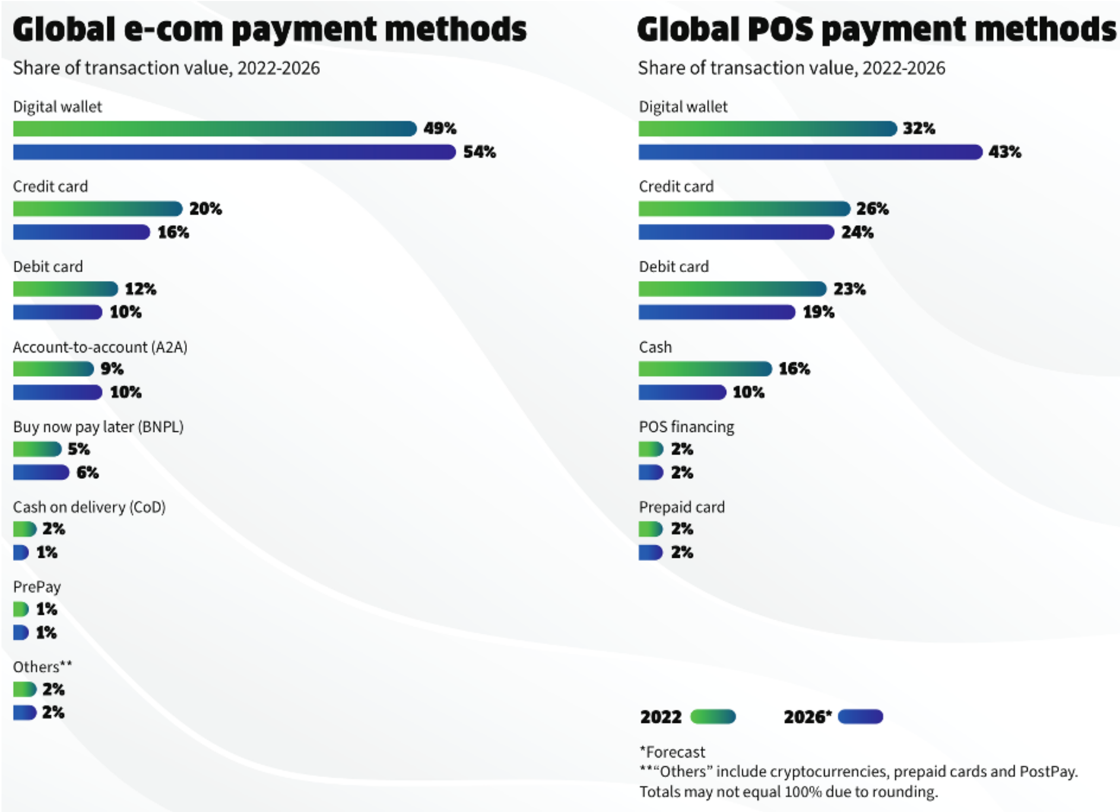


Figure 2.13. Global e commerce payments methods and POS payment methods considering the share of total transaction values, 2022-2026. Source: 2023 Global Payment Report, Worldpay from FIS.

Among the many recent development, the following elements elements must be highlighted:

- **E-commerce role and impact on m-payments**
- **Real-time payments**
- **Mobile wallets**

E-commerce role and impact on m-payments

The increase in digital payment typologies, and in particular the mobile segment, has been undoubtedly influenced by the growth of e-commerce, which facilitated and encouraged the development of new "payment experiences".

The spread of smartphones has contributed to the development of e-commerce platforms, and these latter have contributed to the creation of new forms of digital payments.

2021 witnessed strong global e-commerce growth of 14% as the global economy began to recover from early impacts of COVID-19, exceeding US$5.3 trillion in transaction value.

The explosive growth in global e-commerce that took place during the first two years of the pandemic cooled in 2022, but only slightly. Global e-commerce transaction value grew by a healthy 10% from 2021-2022.

The share of mobile commerce exceeded that of desktop e-commerce in 2021, with transaction value from mobile devices reaching 52% of all e-com spend.

With 9% CAGR forecast from 2022-2026, global e-commerce transaction value is projected to rise from roughly $6 trillion in 2022 to over $8.5 trillion in 2026.

By 2025, e-com is expected to account for 12% of global consumer spend, with 59% of that e-com spend transacted via mobile devices. While e-com growth is expected to slow in APAC (Asia-Pacific) due to lingering COVID impact and market maturation, e-com will continue to grow dramatically in the LATAM (Latin America) with 19% CAGR and MEA (Middle East-Nord Africa) regions with 20% CAGR through 2025.

E-commerce payment preferences continue to shift away from cash and credit cards towards digital wallets and buy now, pay later (BNPL). Contributing factors in credit cards' declining share include the rise of alternative payment methods, volume shifting to credit- and debit-linked digital wallets, consumers opting for interest-free credit in the form of BNPL and credit-centric verticals like travel still recovering from pandemic impacts. Accounting for 21% in 2021, credit's share of global e-com spend is projected to fall to 18.8% in 2025, though absolute value will rise to over US$1.56 trillion. Debit is projected to fall less dramatically, from 13.2% of e-com transaction value in 2021 to 12.9% in 2025, with absolute value rising to over US$1.07 trillion.

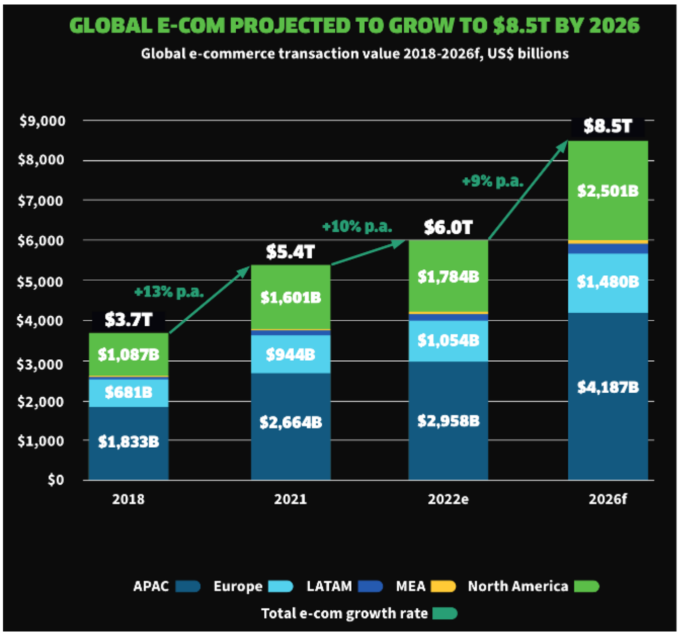


Figure 2.14. Global e-commerce transaction value 2018-2026, US$ Billions. Source: 2023 Global Payment Report, Worldpay from FIS.

All regions except Europe saw double-digit growth from 2021-2022, with a high of 21% in MEA. Moreover, 37 of the 40 markets covered in GPR 2023 saw double-digit YoY growth from 2021-22. LATAM, MEA and Southeast Asia (except for Thailand at 9%) remain high-growth markets, with CAGRs in the mid-teens projected through 2026.

Real-Time payments

Also called instant payments, these refer to payment infrastructure that allows for near immediate initiation and, especially, settlement of transactions, even outside of regular banking hours.

A real-time payment is an inter-bank fully electronic payment system in which irrevocable funds are transferred from one bank account to another, and where confirmation back to the originator and receiver of the payment is available in one minute or less.

Along with e-commerce and mobile wallets, real-time payments currently represent a global payment trend.

Real-time payments enable frictionless commerce where the entire payment process occurs seamlessly and immediately. But a modern, open payments system also provides opportunities to develop creative overlay services on top of the faster payment rails, built along modern open banking standards through API-based services.

Services such as account aliases and proxy, request to pay, P2P, payee confirmation and payments at POS have now become standards in almost all live countries, with an increasing number moving toward API-based interfaces and ISO messaging to ease access.

- **account aliases and proxy**: many real-time schemes give users multiple options for identifying the recipient of a payment. All services allow payees to enter the bank account number (IBAN) of the recipient, but to make the services more convenient, other unique identifiers can be used including mobile phone number and email address. All participants must register for the service to use the proxy identifier that is centrally mapped to a destination bank account with a proxy addressing
- **request to pay**: A request to pay overlay service will allow any business or individual wishing to receive a payment to send an electronic request for that payment to the debtor account. The request will be received by the payer, most likely via an electronic interface such as a mobile banking app, showing the requested amount and the due date. They will then be presented with several choices (pay in full, pay part, ask for an extension, decline payment, Send a message). If the payer chooses to make a payment, the payee will be notified whether the payment is in part or in full and when it has been confirmed.

A set of processes and systems that define the end- to-end real-time payment process, from initiation to clearing and settlement is defined real-time scheme. Each country will typically have a domestic scheme except for the eurozone countries which all centrally utilize the SCT Inst scheme.

As schemes around the world move closer to standardization and interoperability to promote commerce, cross-border real-time payments could become as routine as domestic payments.

An important consequence of RTP rails is the takeoff of A2A (Account-to-account) payments: nearly 70 real-time payment schemes are providing the high-speed payment rails that enable new A2A payment use cases.

A2A payments are, as the name suggests, payments made directly from one account to another. A2A has long been popular for business-to-business (B2B) and person-to-person (P2P) use cases.

Today, A2A is emerging as a force in person-to-business (P2B) payments. Merchants are drawn to A2A as they reduce the cost of payment acceptance versus cards while offering instant settlement of funds. Consumers are drawn to A2A payments by their safety, simplicity and speed. Some merchants are also offering customers discounts as an incentive to pay with A2A.

When transacted over RTP rails, A2A offers directness, immediacy and lower cost. The impact of A2A payments is amplified by their often dramatically lower cost to merchants, as transactions are not intermediated by major card networks and thus not subject to interchange fees. A2A payments therefore pose a significant threat to disrupt legacy payment value chains.

A2A is disrupting payment value chains with lower costs of payment acceptance versus cards. Global A2A transaction value surpassed $525 billion in 2022 and is projected to grow at 13

Mobile wallets

A mobile wallet, also known as digital wallet, is a financial transaction application that runs on mobile devices such as smartphones or wearables, letting individuals to store funds, send and receive money through mobile devices, securely storing payment information, and track payments history. Digital wallets essentially eliminate the need to carry a physical wallet by storing all consumer's payment information virtually, securely and compactly.

It can be filled through:

- credit or debit card transaction: globally 22% of mobile wallet users typically use credit card to fund their digital wallet purchases, while 27% prefer debit cards.
- bank transfers, 34%

- money transfers from another person's digital wallet (P2P transaction)

Digital wallets may be included in a bank's mobile app, in online payment platforms like PayPal or Alipay, or in contactless apps: among the latter the most famous mobile wallets providers are Apple Pay and Google Pay. Some mobile wallets can be used for both POS and online purchases, others are more suitable for one transaction type.

The card information stored in a wallet and choose to use for a transaction is transmitted from the device to the POS terminal, connected to payment processors. Then, through the processors, gateways, acquirers, or any other third parties involved in credit and debit card transactions, the payment is routed through the credit card networks and banks to make a payment.

The use of mobile wallets is poised to grow significantly nearly doubling in market size between 2020 and 2025: mobile wallets are forecast to become a major addition to payment options available across the world.

Currently the leading payment method globally both in e-com and at POS, mobile wallets growth continues to accelerate, increasing that leadership position.

While APAC remains an outlier with the overwhelming majority of wallet share, digital wallets are now the leading e-com payment method in Europe (having taken the lead in 2021) and North America (where wallets passed credit cards for leading status in 2022).

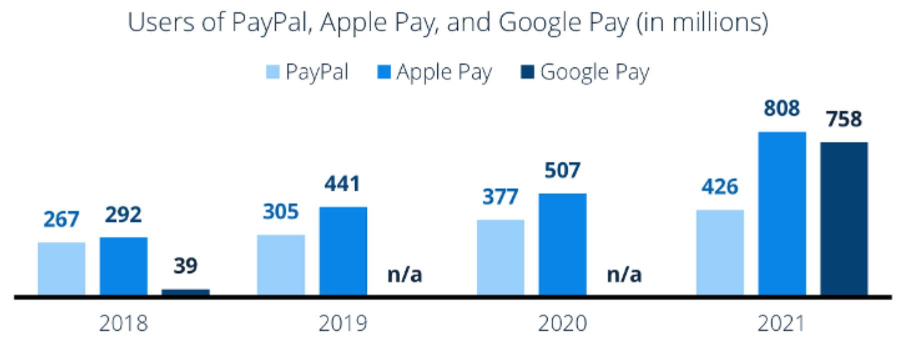


Figure 2.15. Users of mobile wallets (PayPal, Apple Pay, Google Pay) in millions, 2018-2021. Source: Statista Report 115749 "The many faces of global mobile payments" (2022).

Figure 2.16. Mobile wallets transaction value for every world area, US$ 2020-2025. Source: Statista Report 115749 "The many faces of global mobile payments" (2022)

The competitive landscape for wallets is varied and dynamic.

Local and regional providers lead in most markets. Providers range from fintechs, neobanks and banks to super apps, Big Tech and device manufacturers.

China has long been the global leader in digital wallet adoption, with Alipay and WeChat Pay as the main players. The prominent role of e-commerce marketplaces like Alibaba and JD.com, the success of super app ecosystems and the rapid adoption of QR codes at POS have all contributed to the dominance of wallets in China.

North America's credit and debit card markets are increasingly intermediated by a handful of major digital wallet brands. These initially consisted of PayPal, Google Pay and Apple Pay, but challengers such as Shop Pay (Shopify's checkout solution) and Cash App Pay (recently becoming an open loop wallet) have joined the playing field.

PayPal is the leading wallet in Belgium, France, Germany, Italy, Spain and the U.K., with significant share in most other European markets. Other international brands, such as Apple Pay, Google Wallet and Amazon Pay, are also popular in Europe, as are many local payment apps, including MobilePay in Denmark, Vipps in Norway, BANCOMAT Pay in Italy and Lydia in France.

LATAM has seen Mercado Pago (the payment arm of LATAM's largest e-commerce marketplace, Mercado Libre) revolutionize digital payments across most of the region.

However, local digital wallets are emerging among the leaders in their respective markets. These include MACH Pay in Chile, PicPay in Brazil, and Nequi and RappiPay in Colombia. MTN MoMo, from MTN, a leading mobile network operator across MEA, is poised for significant future growth in South Africa as banks remove ticket size limits on mobile payments and provide consumer incentives at partner merchants.

Digital wallets extend their omnichannel dominance: wallets such as Alipay, PayPal and Apple Pay remain the leading payment method globally in e-com (49% share) and at POS (32% share), accounting for around $18 trillion in consumer spending. Wallets remain among the fastest growing payment methods with 15% CAGR at POS and 12% annual growth in e-com forecast through 2026.

Wallets are projected to rise to 52.5% of transaction value in 2025. Growth will be driven by digital wallets offering superior checkout solutions, flexibility in underlying payment methods, their anchor role in e-com marketplace ecosystems and local wallets consolidating into regional and global super apps. APAC continues to set the pace in digital wallet use driven by the overwhelming popularity of Alipay and WeChat Pay; digital wallet's share of APAC e-com is projected to rise from 68.5% in 2021 to 72.4% (over US$3.1 trillion) in 2025.

2.3.4 Focus on Italy

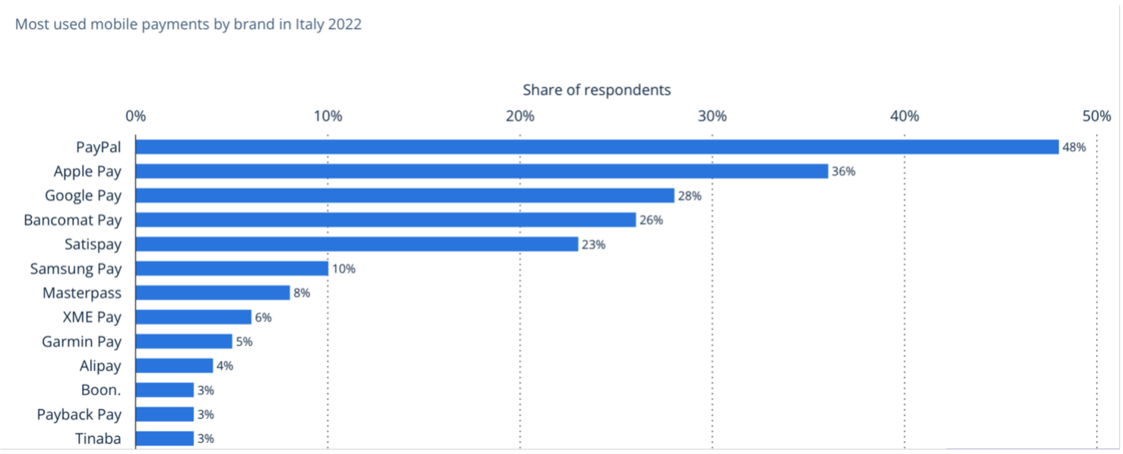


Figure 2.17. Most used mobile payments by brand in Italy 2022. Source: Statista Report 89027 "Payments in Europe" (2022).

Digital wallets are Italians' preferred payment method when shopping online, accounting for 33.6% of e-commerce transaction value.

Credit cards (23.9%) are projected to decline through 2025, while debit is forecasted for a slight uptick from a 7.6% 2021 share.

Cash remains strong at the POS at over 27.2% in 2021 and is expected to maintain nearly 20% share through 2025. Cash remains an important part of the Italian payment landscape, representing 27% of 2022 POS spend. The future of cash in Italy is uncertain: in 2022, Italian

Prime Minister Giorgia Meloni sought to reverse previous Italian government policy by proposing regulations that would raise cash withdraw limits and allow merchants to refuse card payments for transactions of less than 60 euros. That plan faces resistance from both Italy's central bank and the EU.

Italy has one of the largest prepaid card markets in the world. In 2022, prepaid cards represented 9% of e-com transaction value (highest among all markets in GPR 2023) and accounted for 12% of POS spend (second only behind Saudi Arabia). Called PostePay, as they are obtained at the Italian postal service, Poste Italiane, these physical and virtual cards are available in a wide variety of categories and help serve consumers distrustful of the formal banking system as well as immigrants who are unbanked.

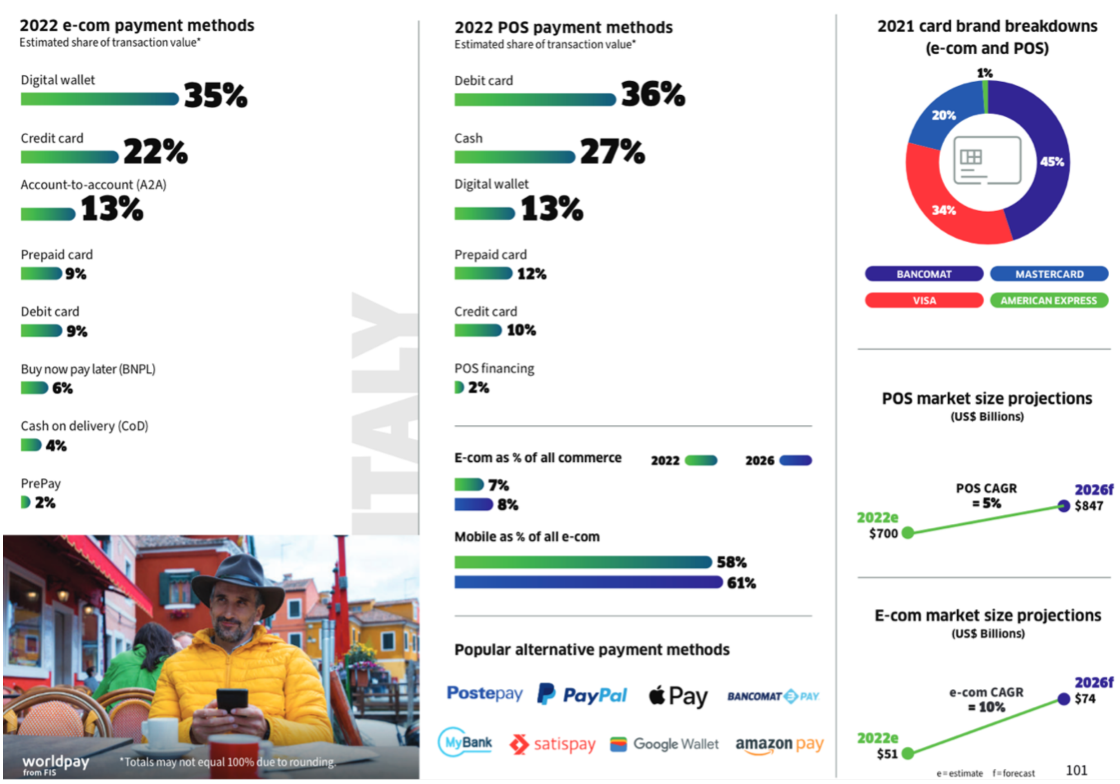


Figure 2.18. Italy's mobile payments overview (2023). Source: 2023 Global Payment Report, Worldpay from FIS.

e-com

Italy is experiencing powerful e-commerce growth, projecting 16% CAGR through 2025.

Real-Time Payments

Italy does not have a domestic-based real-time payments service. The system went live in 2017 and is operated by EBA CLEARIN Gand the European Central Bank (ECB) using both RT1 and TARGET Instant Payment Settlement (TIPS).

Real-time payment services in Italy are provided by SEPA, short for Single Euro Payment Area, with SCT Inst (SEPA Instant Credit Transfer) real time payment scheme through RT1 and TIPS.

To boost uptake, an API service is planned, and domestic automated clearing houses will have to transfer to TIPS to offer instant payment services.

Banca d'Italia (Bank of Italy, Italy's central bank), along with Deutsche Bundesbank, Banque de France and Banco de Espana, operates and manages the TIPS instant payment service. As part of that function, Bank of Italy has conducted cross-border, cross-currency and cross-system instant payment tests with the Arab Regional Payments Clearing and Settlement Organization (ARPCSO). The BUNA-TIPS experiment is one of many promising collaborations toward international real-time payment system interoperability.

Mobile Wallets

Mobile wallets surpassed 10% POS share in 2021 and will continue to rise, while credit, debit and retailer/bank financing will maintain steady share through 2025.

Digital wallets remained the leading payment method online in 2022, channeling 35% of e-com transaction value. In addition to global brands Apple Pay, Amazon Pay, Google Wallet and PayPal, PostePay, the wallet for the widely used prepaid cards, is a popular option.

Wallets are gaining popularity at POS, jumping from 10% of POS transaction value in 2021 to 13% in 2022.

2.3.5 Use Cases

Analyzing the multitude of mobile payment solutions, three use cases emerge depending on the context in which the payment takes place.

Remote or Online Payments

All consumer transactions made via the Internet, directly related to online shopping for products and services.

Online shopping surged worldwide in particular during the pandemic in 2020 and 2021, and the share of mobile commerce exceeded that of desktop e-commerce in 2021.

Online transactions can be made via various payment methods, more specifically payment preferences are shifting away from credit/debit cards towards new solutions: contributing factors in credit/debit cards' declining share include the rise of alternative payment methods, card usage volume increasingly shifting to pass-through digital wallets. More specifically, increasingly preferred payment methods for this kind of transactions are:

- Online payment providers, such as PayPal
- Digital, or mobile, wallet

These services use a wireless network and are usable through an application installed on the mobile phone, either through internet browsing, or by sending an SMS.

Proximity or POS Payments

Also known as contactless mobile payments.

Transaction at POS, short for Point of Sales, are in-store purchases which, aside from cash and credit or debit cards, are processed via:

- smartphone or wearables payment applications
- mobile wallets

from a person to merchant or institution.

Differently from tap to pay transactions initiated with credit or debit cards, the payments are made by a wireless interaction of the smartphone or wearable's app with a suitable payment terminal belonging to the merchant.

The data transfer can be made:

- via wireless standard NFC
- by scanning a QR code to initiate the payment
- MST

The COVID-19 pandemic disproportionately impacted point-of-sale (POS) transactions carried out in traditional brick-and-mortar stores

Payment behavior also changed dramatically. The pandemic accelerated the use of digital payments due to hygiene concerns about physically handing over cash or typing in PIN codes. Cashless payments, including mobile wallets, are estimated to go up and become a new norm.

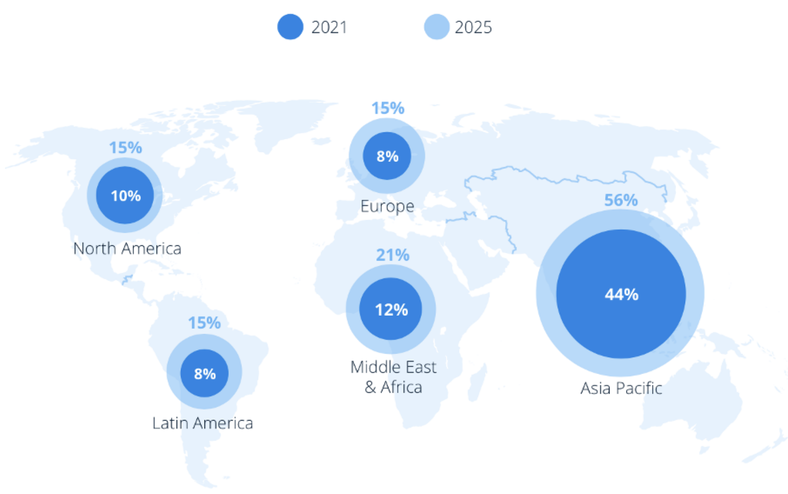


Figure 2.19. Share of mobile payments in overall POS transactions worldwide in 2021 with a forecast for 2025. Source: Statista Report 115749 "The many faces of global mobile payments" (2022).

Statista estimates that contactless or proximity payments by smartphone are most prevalent in China, Vietnam, South Korea, and Russia.

In these countries, at least 25 percent of the population had used a smart device, either a smartphone or wearable device, to make at least one contactless payment in 2021. A similar ranking from eMarketer in July 2021 stated that nearly 90 percent of Chinese smartphone users performed a contactless payment in the previous six months.

Findings on tap-to-pay transactions within regions are also interesting. Research from Mastercard in 2018 and 2019 noted major differences between European countries. In 2018, it was estimated that contactless payment with either card or mobile device made up around 80 percent of POS transactions in Poland, as opposed to four percent in Belgium. Whilst this did increase for Belgium during the pandemic, domestic sources suggest a 35 percent market share, it shows how individual countries approach these payments differently.

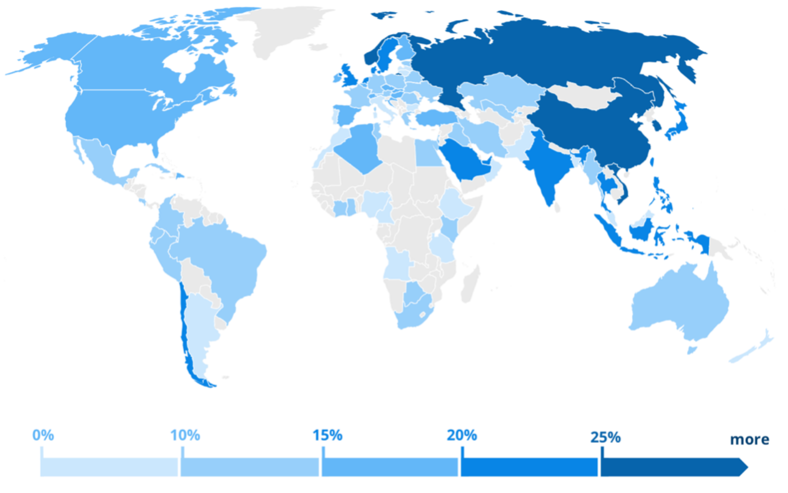


Figure 2.20. Penetration rate for mobile POS payments within the 80 biggest economies in the world in 2021. Source: Statista Report 115749 "The many faces of global mobile payments" (2022).

Comparison of Remote and POS payments market segments

Digital commerce, through which remote payments take place, represent a larger segment compared to POS payments, with $3,466.6 billion in transaction value instead of $2,008 in 2020.

The following graph shows a projection of 5 years for the two segments at a global level.

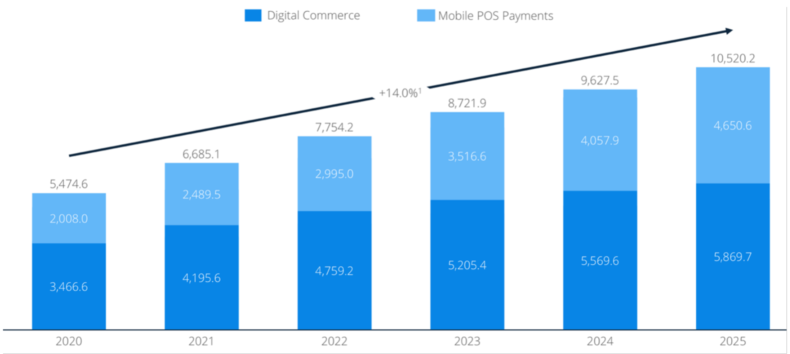


Figure 2.21. Global transaction value forecast in billion US$. Source: Statista Report 41122 "Fintech Report, Digital Payments" (2021).

Europe shows the highest growth, the following graph shows a regional comparison between China, USA and Europe in terms of growth in transaction value, forecasted from 2020 to 2025.

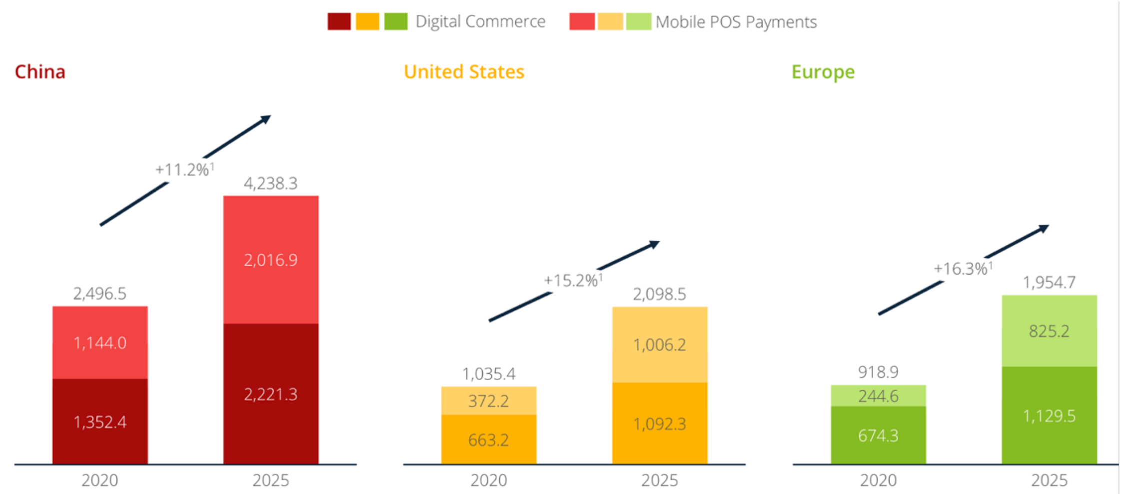


Figure 2.22. Transaction value forecast in billion US$. Source: Statista Report 41122 "Fintech Report, Digital Payments"(2021).

P2P Transactions

Short for Peer to Peer, for P2P transaction is intended a money transaction from one person to another through an intermediary payment application, a money transfer app, shared by the two peers.

This type of transactions can occur in various situations, such as money transfers among friends and family.

Examples of such service providers are PayPal, Satispay.

Both serve also other purposes being online payment providers.

Other examples of P2P services are:

- Money Transfer, which concerns with immigrant transfers, cash flows that these people send to their relatives left in their countries of origin. Once again, these services use mobile network for distance transfers, and are usable via applications or sending SMS.
- Venmo, which is a mobile person-to-person payment service that allows users to transfer money and send payments to other peers. Users link their debit and credit cards online and can transfer money to all recipients. Paypal acquired Venmo in 2013. Until now the service is available in the US only and Paypal is providing all money transmission.

2.3.6 Main Technologies

Focusing on technological aspects: what are the solutions thanks to which payments can be carried out?

NFC

NFC, short for Near field communication, is a wireless technology that allows two smart devices to connect and transfer information using electromagnetic signals.

It requires two devices to be within about 4 centimeters from each other to connect. NFC is an extension of RFID technology, which relies on radio waves to track goods, supplies, and merchandise. NFC replaces RFID chips with microchips that can store and encrypt information. While RFID devices are passive and so lack the ability to access information, NFC-enabled devices do: transactions using NFC-enabled debit and credit cards happen when the card is brought closer to an NFC-compliant payment terminal, so that data is transmitted between the card and the payment processing system to complete the transaction.

NFC technology works by combining four key elements:

1. an NFC microchip within a device, which acts as an antenna and receiver;
2. a reader/writer that scans and allows NFC devices to access data;
3. an NFC software application on the device that can use data received by the NFC chip;
4. an information or communications service provider (ISP) that manages all device communications that occur through the ISP.

An NFC-enabled device can operate under three different modes:

Read/Writer Mode: a reader/writer is an NFC-enabled device that manages and coordinates information sent between and received by two or more NFC devices and a handful of other devices that do not yet feature NFC technology. Examples of reader/writers include point-of-sale (POS) systems, cell phones, tablets, and RFID-enabled cards. In reader/writer mode, NFC-enabled devices communicate and exchange data based on instructions from the reader/writer.

Peer-to-Peer Mode: this P2P mode enables two NFC-enabled devices to exchange information directly. For example, a peer-to-peer device may exchange data with an RFID-enabled device or some other type of NFC device without the assistance of a reader/writer.

Card Emulation Mode: in this mode, an NFC-enabled device functions as an NFC payment card or virtual credit/debit card. When an NFC-enabled device is activated in this mode, it emulates a payment card or other physical card in card readers, magnetic-stripe readers, and contactless card readers used to make payments directly from your mobile device. In this way the smart device can be used in place of debit or credit cards, combined with financial transaction applications called mobile wallets. NFC technology is in fact one of the most used for mobile payments, it drives mobile wallet services like Google Wallet and Apple Pay.

In terms of security, NFC uses 128-bit or higher encryption to guarantee privacy of transactions. Also, NFC uses tokenization instead of storing credit card information, retailer cannot see credit card number.

Figure 2.23. Illustrative example of NFC payments functioning. Source: Statista Report 115749 "The many faces of global mobile payments" (2022).

NFC links the payment and reader devices wirelessly when they are closer to each other. Once connected, the payment can be initiated from the payer's devices like smartphones and smartwatches through the installed payment applications like Google Pay, Samsung Pay, Apple Pay, etc. Then, the payer must just hover the device near the payment terminal, and NFC chips exchange encrypted data for completing the transaction within few seconds.

A contactless payment is a transaction that requires no physical contact between a device like a smartphone and a payments terminal. When a contactless payment is initiated (by a customer holding or tapping a mobile device to the payments terminal), the NFC technology goes to work. Using a specific frequency, the NFC-enabled reader and the smartphone pass encrypted information back and forth to each other to complete the payment. This all takes just seconds. Speed, in fact, is one of the main feature parts of NFC payments.

QR Code

Short for Quick Response, QR code is a two-dimensional code which, differently from a bar code, can store a larger amount of information per unit area. The use of QR codes to initiate real-time payments is a growing phenomenon and provides both parties with a simple and quick way to accept and make payments.

Standardized QR codes allows customers to make instant payments for goods and services from different funding sources (mobile wallets, cards, bank accounts) by scanning a QR code on a smartphone to complete all the payment details, only requiring approval from the payee. It can be read by a camera, such as smartphones' built-in cameras, directly from it or from a mobile banking or payment app.

QR codes can be processed differently:

- Scanning recipient's QR code with a smartphone: the user has to open the phone camera or the relevant QR code scan app. Afterward, the code that is displayed on an individual product, paper bill, or at a store's checkout is scanned redirecting the user to a payment page or a mobile payment solution such as a mobile wallet to complete the transaction. This is the most common way of conducting a QR payments.

- Retailers scanning QR code on user's phone screen: the user opens the payment app once the total transaction amount is set in the POS system of the retailer. The QR code payment app displays a QR code that identifies with the user's card details. The retailer then scans the QR code with a scanner thus concluding the transaction.

- App-to-app payments: both the sender and the recipient open their applications. The sender then scans the unique QR code that is generated in the recipient's application. The sender, at last, confirms the amount to be paid and taps to complete the payment.

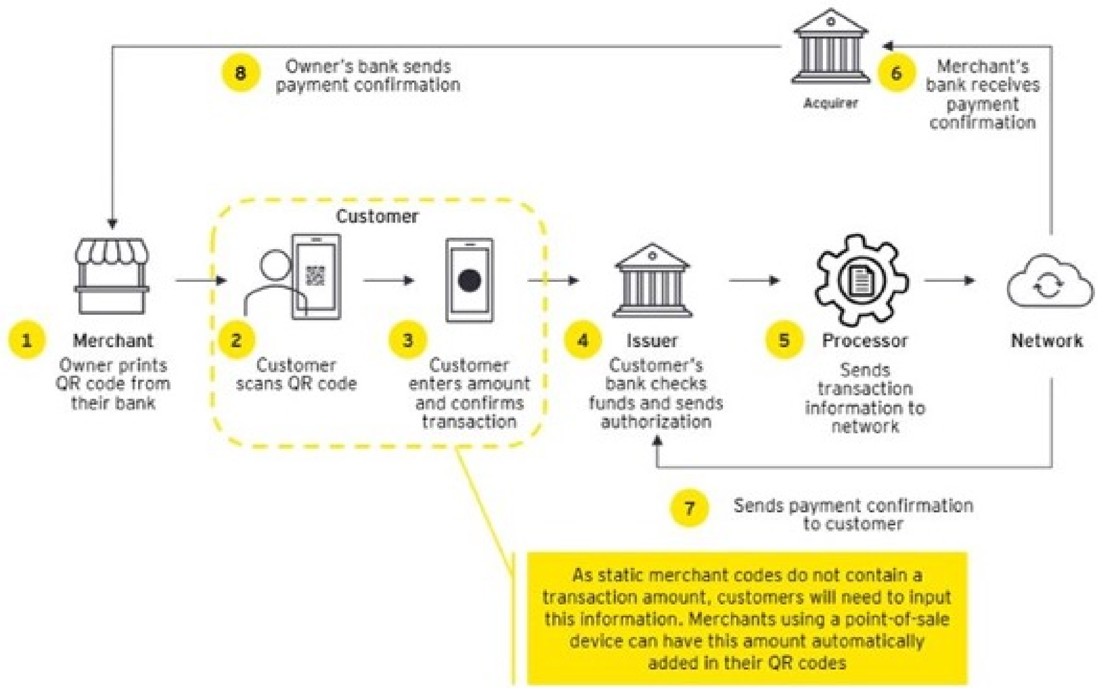


Figure 2.24. Illustrative example of QR code payment flow for the merchant-presented mode. Source: EY report.

Among the contactless mobile payment's solutions, QR codes has increasingly grabbed headlines since 2020.

Gathering the opinions of consumers from the U.S., the UK, Germany, France, and the Netherlands, consumer research from MobileIron revealed a drastic change in the use of QR codes.

In September 2020, three in 10 respondents had performed a QR payment transaction at least once; however, this changed to eight in 10 by April 2021.

By 2021, the survey had excluded Dutch consumers and added respondents from both China and Japan, which might have significantly altered survey results.

As the following graphic shows, the Far East and China has the largest market for QR code transactions.

Market research firm AMI observes that QR codes were increasingly offered in Argentina and Mexico to integrate more people into financial services. However, these payments made up less than one percent of all face-to-face transactions in 2021. As Latin America digitalizes further, it is expected that the use of QR codes will increase as well.

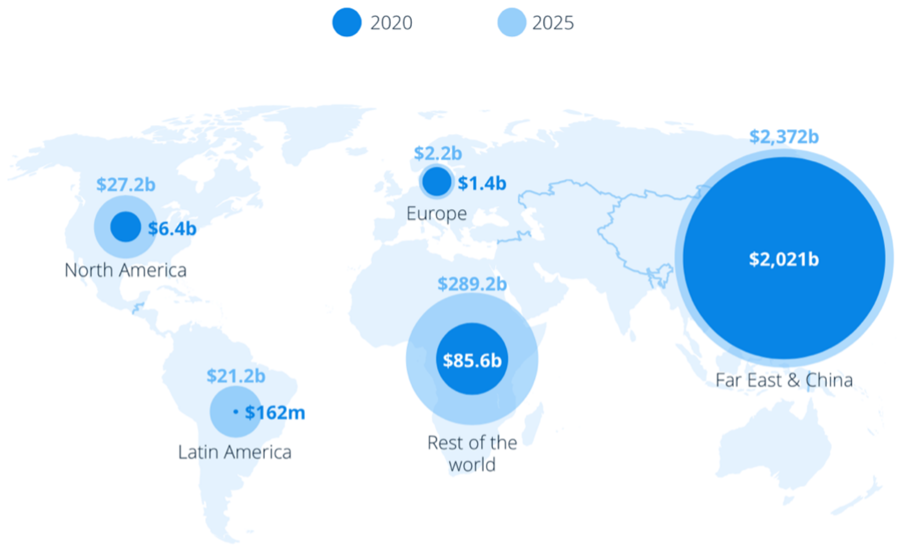


Figure 2.25. Market size of QR code transactions in 2020 with a forecast for 2025 (in billion U.S. dollars). Source: Statista Report 115749 "The many faces of global mobile payments" (2022).

MST

Magnetic secure transmission (MST) is the same technology used by magnetic card readers for reading a card when swiped through a slot on a POS.

A smartphone which incorporates this technology is able to generate an encrypted field, a magnetic signal that mimic magnetic stripes on traditional payment cards, that the POS can read. Thus, MST emulates swiping of a physical card without the need to upgrade the terminal's software or hardware. Using this technology, it is possible to encode payment information in the magnetic signals generated by the MST device, which is similar to embedding such information in a magstripe card.

MST is particularly useful when applied to mobile payment systems. For example, if a smartphone is equipped with MST, credit card information is provided to such an MST device through the user interface, and the user can use the MST device for payment by generating magnetic signals containing the credit card information. Thus, payments can be made without credit cards.

MST technology was developed and patented by LoopPay, subsequently acquired by Samsung Electronics. Therefore, the patents related to MST now belong to Samsung Electronics and it's currently used in Samsung Pay.

Difference with NFC

The two technologies are quite similar: in both cases, users upload their credit card data into a mobile payment app on their smartphone and then use it to make purchases in brick-and-mortar retail stores. These card details are encrypted within the phone and provide one-time authorization tokens for each individual purchase.

NFC and MST, both contactless payment solutions, only require that the mobile device or wearable to be within physical proximity of the terminal to complete a transaction.

The key difference is interoperability: NFC requires an NFC-enabled card reader whereas MST works with many more types of card readers, including those powered by NFC payment technology. Because Samsung Pay incorporates both NFC and MST technologies, it works almost anywhere you can swipe or tap your card.

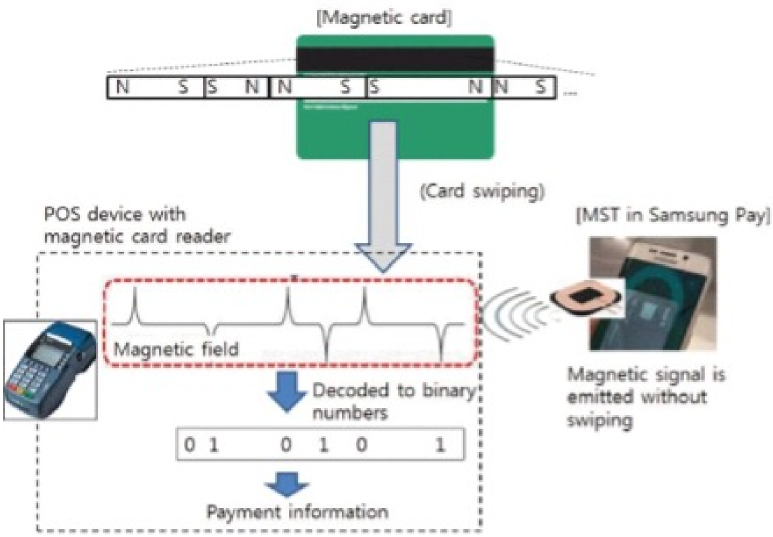


Figure 2.26. Overview of MST.

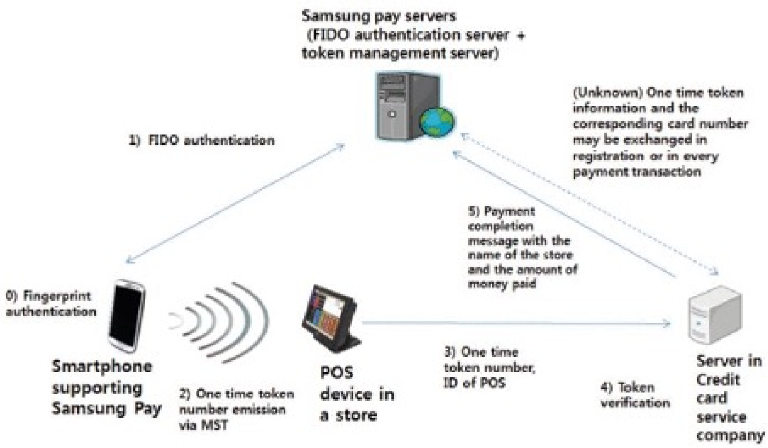


Figure 2.27. Overview of the payment protocol in Samsung Pay.

Mobile Money

Mobile money is a form of mobile payment in which a phone is involved in the transaction, and value is stored in the so-called cash in / cash out method using a SIM card. An example includes sending prepaid money from a telco provider to another person via SMS.

Quartz Africa, writes that companies like Safaricom, Vodacom, and Airtel Africa were all looking to invest in or enter partnerships for mobile payments across various countries on the continent in 2020. Interestingly, these three examples are not banks or fintech but telecom companies indeed.

The companies' efforts to expand their financial services embodies a phenomenon that should not be confused with mobile wallets: mobile money.

Some sources refer to this as stored value mobile wallets since this kind services function somewhat like mobile wallets in that they allow people to send, receive, and store money on a phone. The main difference is that this does not require a bank account. Instead, the apps largely rely on cellphone networks to function and, therefore, are not provided by banks or fintech but telco companies, so-called mobile network operators (MNOs).

These payments are common in countries where many people are unbanked, excluded from financial services, but do own a basic cell phone since smartphone penetration is low and internet access scarce (FernÃ¡ndez, 2015 and Lowry, 2016). Also, the use of cash may be common but risky. Africa is the global leader in mobile money, with sub-Saharan Africa home to over half of the world's active accounts in 2021.

The use of SMS for mobile payment requires a communication protocol enabling the exchange of short text messages between two mobile devices (Valcourt et al., 2005). SMS employs the following technologies:

- GSM (Global System for Mobile Communications)
- GPRS (General Packet Radio Services)
- UMTS (Universal Mobile Telecommunications System) (Sebola and Penzhorn, 2003).

The most famous example of this service is Mpesa, launched in 2007 by the two largest mobile network operator in Kenya: Vodafone and Safaricom.

The operating system is as simple as it is effective: through a network of agents located throughout the territory, users can purchase credit (called "e-float") or convert it into cash.

Credit is exchanged between users through an SMS system that tracks inflows and outflows, to register for the service at the agents, a valid document is required, and transactions between users can begin immediately.

Mpesa customers can perform a considerable number of operations using a simple SMS:

- transfer money between registered and unregistered users
- pay household utility bills
- transfer credit from a phone to a bank account, although not yet in all countries where the system is widespread

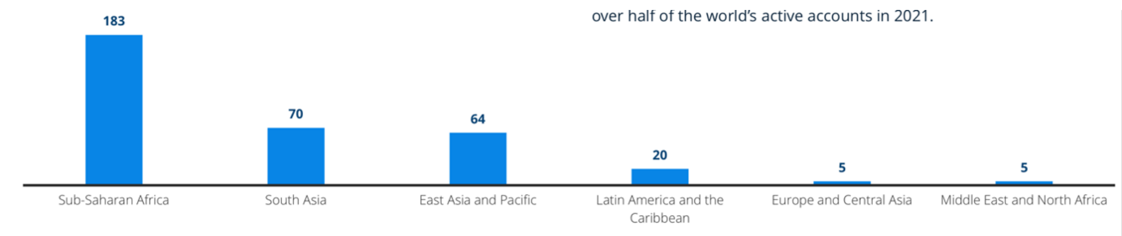


Figure 2.28. Number of active mobile money accounts worldwide in 2021, by region. Source: Statista Report 115749 "The many faces of global mobile payments" (2022).

As anticipated, Telco-led mobile money is especially prominent in sub-Saharan Africa.

Figures from the World Bank Global Findex database in February 2021 showed that 21 percent of the adult population in the region held a mobile money account in 2017, "nearly double" the share from 2014.

It adds that most of the population are financially illiterate or unbanked, meaning they do not use traditional bank accounts or other financial services, and are consequently of high importance for any COVID-19 support plans.

However, mobile money figures across Africa vary, which is evident when comparing the transaction volumes of several countries. For instance, mobile money in Kenya and Tanzania was much bigger than elsewhere. McKinsey explains that East Africa and Ghana were more mature than, for example, Zimbabwe and Ivory Coast due to regulation. Ghana actively allowed telecom providers to offer their own mobile money accounts whilst discouraging exclusivity from agent banking.

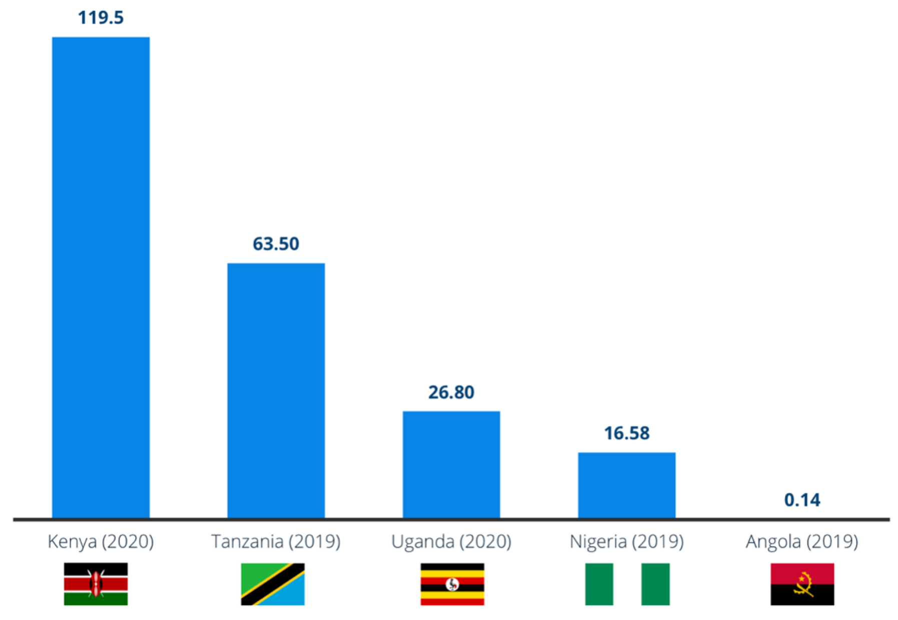


Figure 2.29. Estimated volume of mobile money transactions in selected African countries (billion U.S. dollars). Source: Statista Report 115749 "The many faces of global mobile payments" (2022).

Payment App: Cloud Based

Cloud-based payments are payments conducted over the Internet, payment processing solutions that rely on cloud computing technology to store, process, and transmit payment data, and are hosted on remote servers and accessed through the internet. They can be accessed from anywhere with an internet connection.

Cloud-based payment systems typically offer a range of payment processing features, including payment gateway integration, payment acceptance, fraud detection, and transaction processing. These systems can also be easily integrated with other software applications, such as e-commerce platforms or point-of-sale (POS) systems, and can offer enhanced security features, such as tokenization and encryption, to protect sensitive payment data.

This type of payments is initiated differently by the user depending on the specific service: for example, transactions can be done manually within the payment application by typing in an account-linked phone number or email. A user can connect to his/her account, as funding sources, a bank account or credit/debit card. In this sense, a cloud-based approach places the mobile payment provider in the middle of a transaction between the user and the business.

Example of cloud-based payment systems available on the market are: Paypal, Satispay and Alipay.

PayPal, more specifically, is a widely used online payment system that supports both personal and business transactions. It offers a range of payment options, including credit or debit cards, bank transfers, P2P transfers, with all money transfers conducted through the internet. With roots that can be traced back to the late 1990s, PayPal's business model revolves around its online payment services and the acquisition of other businesses to further strengthen its competitive position.

Satispay is a mobile payment platform that enables users to make instant payments from their smartphones. It relies on cloud computing technology to process payments, store payment data, and facilitate P2P transactions between users. It provides businesses with a payment system that enables them to accept payments from customers in real-time. Satispay also offers a range of value-added services, such as invoicing, recurring payments, and loyalty programs. It supports multiple payment methods, including credit cards, bank transfers, and it offers enhanced security features, such as tokenization and encryption, to protect sensitive payment data.

Alipay is a third-party mobile and online payment platform, integrated in smartphone through the Alipay Wallet App. It represents the most popular payment platform in China with over 1 billion users as of 2021. It was launched in 2004 as an online payment platform and has since expanded to offer a wide range of financial services, including credit card bill payments, bank account managements, P2P transfer, bus and train ticket purchases, food orders, vehicle for hire, insurance selection and digital identification document storage. As for POS payments, QR code payment codes are used, making them the most popular payment method in China.

As shown in the following image, PayPal is the most widely used online payment brand, apart from China, for which a completely different story takes place.

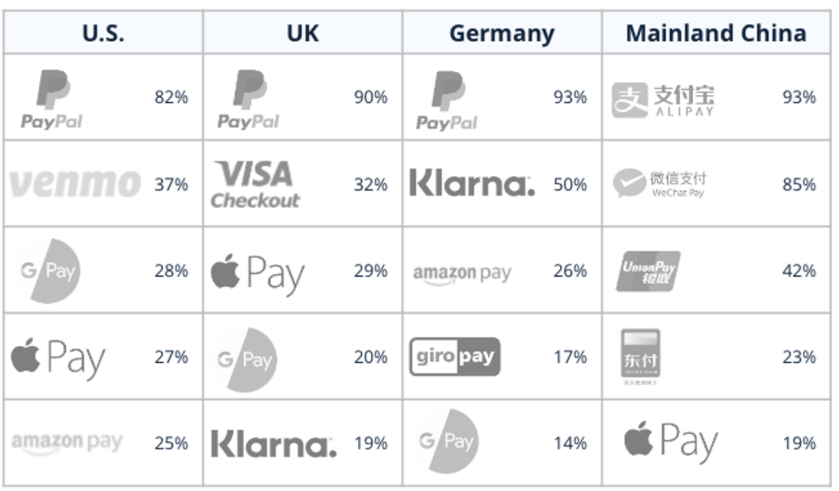


Figure 2.30. Top 5 brands of mobile payments apps, geographical comparison. Source: Statista Report 45600 "FinTech In-depth Market Insights & Data Analysis" (2022).

Example of system architecture:

1. **User Interface Layer or Presentation Layer**: front-end through which the customer interacts with the payment system. It is responsible for displaying information to the customer such as items they are purchasing and the total amount to be paid. It also receives input from the customer, such as their payment information and shipping address.

2. **Application or Service Layer**: responsible for handling the business logic of the payment process, for example validating the customer's information, calculating the total amount to be paid, and communicating with the data and security layers to authorize the payment.

   It also communicates with the network layer to send and receive data. In general, it provides payment services to users, made up of user authentication, payment request, payment processing, user management, payment methods.

3. **Data Layer**: it stores and retrieves data related to the payment, such as customer information and transaction history. It may include a database, such as a SQL or NoSQL database, to store this information.

   It is responsible for tasks such as storing customer information, retrieving transaction history, and updating the status of a transaction.

4. **Payment Gateway** (Data communication Service): responsible for receiving payment information from customers, encrypting the information, and transmitting it to the transaction processing layer, it also integrates with the merchant's checkout system to initiate transactions, connecting the digital payment system to the financial system, such as the bank's payment processing network.

5. **Security or Engine Layer**: composed of payment processing engine, transaction validation, fund availability check, transaction execution, transaction confirmation, error handling, fraud detection, fraud prevention.

   This layer handles security-related tasks to protect sensitive information and prevent fraud. It may include encryption, authentication, and other security measures to protect the customer's information and the integrity of the transaction.

6. **Infrastructure Layer**: Hardware or software support (servers, databases, networks, and storage systems) and data storage.

7. **Network Layer**: This layer handles the communication between the different components of the system. It is responsible for tasks such as sending data between the presentation layer, application layer, and payment gateway, and handling network-related issues such as latency and reliability.

All these layers are related, working together in a coordinated manner to facilitate the end-to-end process of a mobile payment.

They rely on each other to complete the transaction and ensure the security of the payment process.

The presentation layer receives input from the customer, the application layer processes it and communicates with the data and security layers to validate the information and authorize the payment.

The network layer facilitates communication between these layers and the payment gateway, which processes the payment and communicates with the financial system to complete the transaction.

2.3.7 Summary Tables

Mobile Payment Solution: NFC	
Technology involved	NFC
Actors involved	• Customer • Merchant • Payment Processor • Financial Infrastructure (Issuer & Acquirer bank, Card Network)
Network involved	Card Network
Complementary systems	• POS Card reader, NFC enabled • Virtual Wallet App containing Credit/Debit card
Business model	B2C
Proximity: classification based on the physical location of a consumer. • Close proximity at the counter of a store • Remote payments, such as online payment through a mobile phone	Close proximity

Mobile Payment Solution: QR code	
Technology involved	QR code
Actors involved	• Customer • Merchant • Payment Processor • Financial Infrastructure (Issuer & Acquirer bank, Card Network)
Network involved	Card Network
Complementary systems	• Mobile banking app/ Payment App
Business model	B2C
Proximity: classification based on the physical location of a consumer. • Close proximity at the counter of a store • Remote payments, such as online payment through a mobile phone	Close proximity

Mobile Payment Solution: MST	
Technology involved	MST
Actors involved	• Customer • Merchant • Payment Processor • Financial Infrastructure (Issuer & Acquirer bank, Card Network)
Network involved	Card Network
Complementary systems	• POS Card reader, MST enabled • Virtual Wallet App containing Credit/Debit card
Business model	B2C
Proximity: classification based on the physical location of a consumer. • Close proximity at the counter of a store • Remote payments, such as online payment through a mobile phone	Close proximity

Mobile Payment Solution: Mobile Money	
Technology involved	SMS
Actors involved	• Customer • Merchant • Mobile Network Operator (Telcom) • Authorised agent
Network involved	Cellphone network
Complementary systems	• MNO's payment app
Business model	B2C
Proximity: classification based on the physical location of a consumer. • Close proximity at the counter of a store • Remote payments, such as online payment through a mobile phone	Remote

Mobile Payment Solution: Cloud Based	
Technology involved	Internet, cloud computing
Actors involved	• Customer • Merchant • Payment Processor • Financial Infrastructure (Issuer & Acquirer bank, Card Network)
Network involved	Card Network
Complementary systems	Payment app
Business model	B2C
Proximity: classification based on the physical location of a consumer. • Close proximity at the counter of a store • Remote payments, such as online payment through a mobile phone	Remote

2.3.8 Payment Landscape

The payment landscape is constantly evolving, with many businesses rapidly responding to the latest developments and challenges.

Mobile payments, as a trend, can include many different names and solutions, in addition merchant systems coexist with the consumer payment methods, as they process the same payments.

Most consumer mobile payments belong to a selected few: in terms of market size, the top players on the consumer side make up a far bigger market share.

As the following graph shows, while the leading five merchant-focused providers are sizable, processing 7.2 trillion U.S. dollars in total payment volume (TPV) in 2021, the top six consumer-focused players achieved a combined 16.3 trillion U.S. dollars in processed payments in 2021.

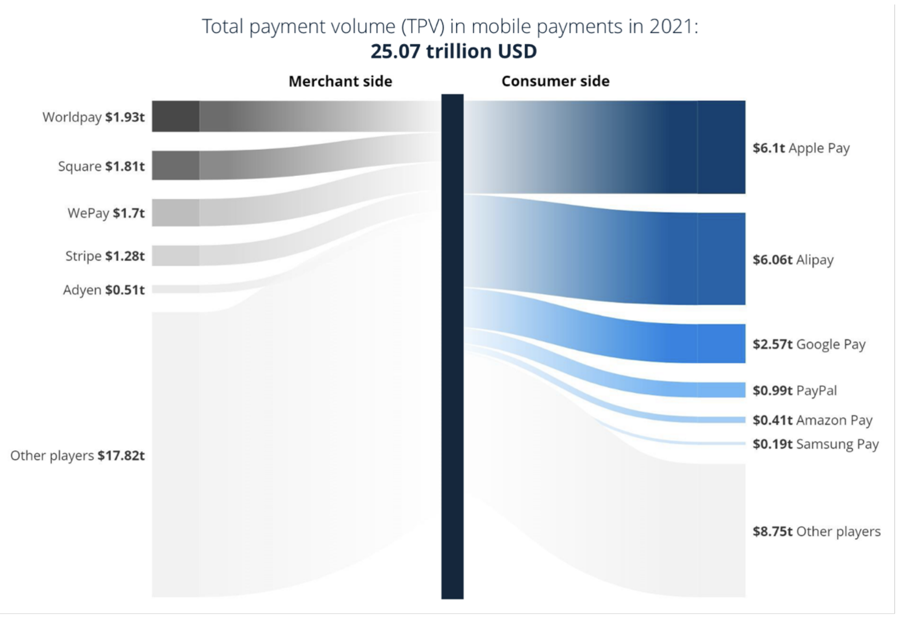


Figure 2.31. Total payment volume (TPV) in mobile payments in 2021. Source: Statista report 116606 "The business model behind mobile payments" (2022).

User sizes vary significantly: the six top players companies make up nearly half of the mobile payments market worldwide in terms of processed payment value on the consumer side.

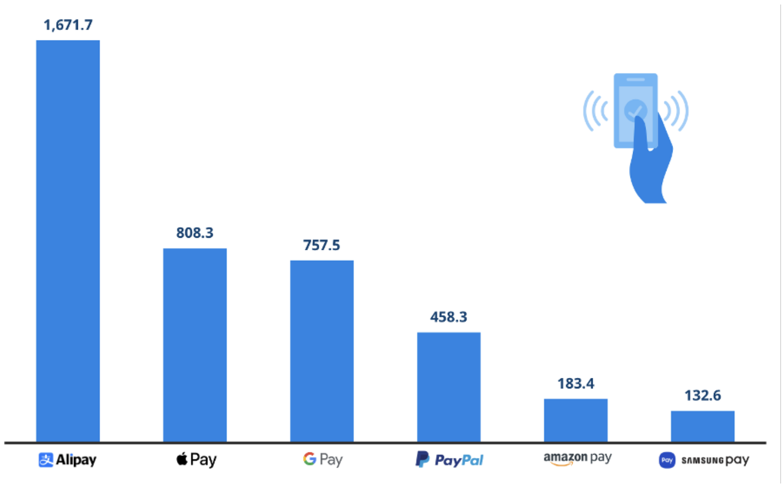


Figure 2.32. Number of worldwide users of the main six mobile payment method in 2021 (Million users). Source: Statista report 116606 "The business model behind mobile payments" (2022).

Considering the distribution between online and offline mobile payments, differences arise between countries. For all the 10 countries considered in the following graph the online segment of mobile payments was higher than offline POS systems in 2021. Processed mobile payments in the United Kingdom, for instance, were worth 538 billion U.S. dollars, of which 71 billion U.S. dollars were POS transactions. E-commerce has been a big driver for mobile payments, with most of the six focus payment methods having an online implementation.

		POS		Online	
		Total payment volume (TPV)	Share in national mobile payments	Total payment volume (TPV)	Share in national mobile payments
North America	United States	$384.58b	20.4%	$1,497.48b	79.6%
	Canada	$34.96b	21.5%	$127.95b	78.5%
Asia	China	$4,806.85b	43.0%	$6,381.54b	57.0%
	South Korea	$62.07b	25.8%	$178.40b	74.2%
Europe	Germany	$61.33b	12.8%	$416.24b	87.2%
	United Kingdom	$71.33b	13.2%	$467.47b	86.8%
	France	$38.89b	16.3%	$200.13b	83.7%
	Italy	$45.64b	25.2%	$135.14b	74.8%
	Spain	$53.09b	29.3%	$127.96b	70.7%
Afr.	South Africa	$10.38b	43.6%	$13.43b	56.4%

Figure 2.33. Distribution of online and offline mobile payments in selected countries. Source: Statista report 116606 "The business model behind mobile payments" (2022).

Moving toward the payment value chain, a complex network of actors emerge: after a mobile payment transaction takes place, to ensure that it is quickly and securely authorized, processed and settled several actors are involved in the payment value chain which can vary depending on the specific mobile payment system being used. The web of involved actors is complex but generally the core ones are:

- **User/Consumer**: The person who initiates the mobile payment transaction by using their mobile device to pay for goods or services.
- **Merchant**: The merchant or business that accepts the mobile payment from the consumer, both in a close proximity situation or remotely. In case of NFC or MST technology involved, the merchant needs to have, respectively, an NFC or MST enabled payment terminal.
- **Payment Processor**: The payment processor acts as an intermediary between the consumer, merchant, and financial institution. They handle the authorization, processing, and settlement of the transaction. Depending on the payment method, it has to support NFC, QR code, MST or SMS technologies. In the case of cloud-based payments, such as through PayPal, the payment processor is represented by Paypal itself.
- **Acquiring Bank**: The acquiring bank is the financial institution that processes the transaction on behalf of the merchant. They are responsible for ensuring that the transaction is authorized and settled.
- **Issuing Bank**: The issuing bank is the financial institution that issued the consumer's payment card or mobile payment account. They are responsible for authorizing and processing the transaction on behalf of the consumer.

- **Card Network**: The card network, such as Visa or Mastercard, provides the infrastructure that enables the transaction to take place. Cards are stored virtually in a smartphone through a mobile wallet solution, or can be linked to a cloud-based payment service such as PayPal. This card network ensure that the transaction is secure and that the funds are transferred from the issuing bank to the acquiring bank.

- **Mobile Network Operator**: In some cases, the mobile network operator may be involved in the mobile payment value chain, particularly if the mobile payment is being made through SMS. It may provide the infrastructure that enables the transaction to take place and may also take a fee for their services.

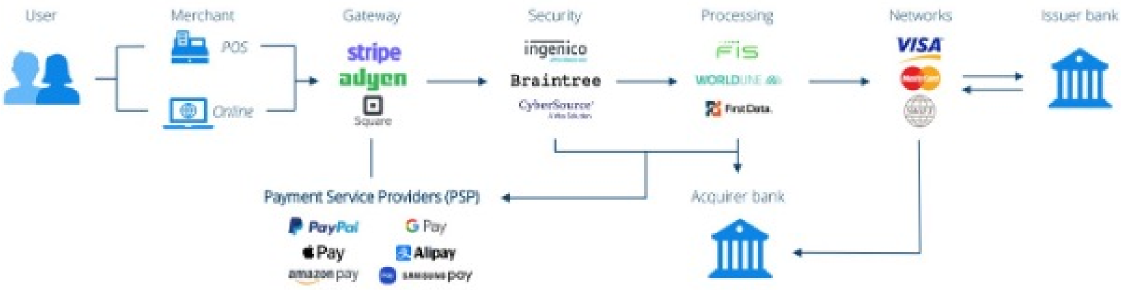


Figure 2.34. Payment Value Chain. Source: Statista Report 116606 "The business model behind mobile payments" (2022).

Broadly speaking, there are three types of players in the digital commerce payments market:

- providers with their own wallet such as Venmo and PayPal
- online payment interface providers such as Stripe
- B2B offline payment providers such as Square

These providers make money by charging fees for each transaction, which is usually paid by the merchant.

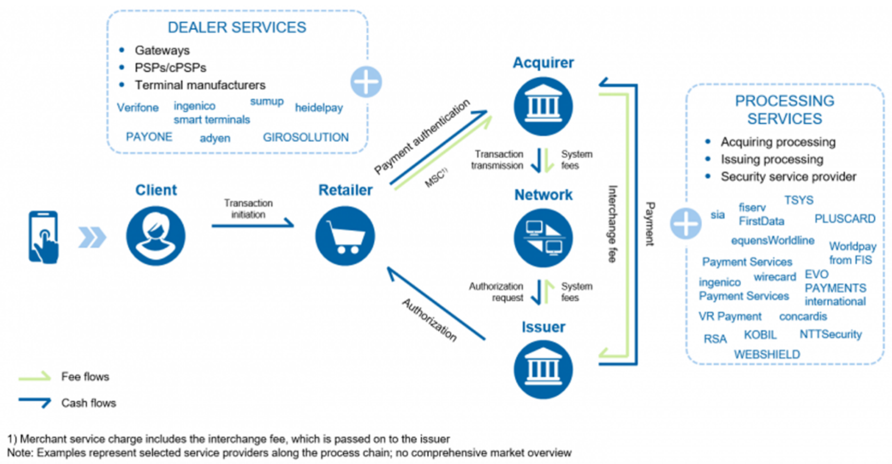


Figure 2.35. Overview of market participants in payments (using the example of a card transaction). Source bankinghub.eu.

In the following chapter, after a deep dive in the Dominant Design and product's architecture concepts, all the mobile payments solutions will be thoroughly analyzed from the process architecture point of view.

Chapter 3

Innovation Theory and its application on mobile payments sector

As anticipated, this thesis aims at analyzing current developments in the mobile payments' field, determining whether a Dominant Design is emerging, but what is a Dominant Design?

3.1 Dominant Design Theory

Dominant design is a concept in the field of technology and innovation that describes the emergence of a common and widely accepted technical solution, components and features (i.e. the architecture) for a product or technology within a particular industry or market. This dominant design usually becomes the standard for other companies to follow and compete against.

The concept of dominant design plays a key role in studies on technological cycles and evolution, as well as in the performance and survival of firms. When a dominant design emerges in a technology or industry, it marks a significant turning point by resolving uncertainty and signaling maturity: once a dominant design emerges, it becomes difficult for new designs to compete, the industry enters a stable period of incremental improvements to the dominant design.

This shift is usually accompanied by changes in the nature of innovation, from product to process innovation, a shift in the locus of competition, and the number of firms in the industry causing a so-called shakeout. Consumers also tend to adopt the dominant technology on a mass scale.

3.1.1 Origin of Dominant Design concept: Abernathy & Utterback Theory (1975)

The concept has undergone theoretical evolution since it was first proposed in 1975 thanks to the studies on industrial innovation of William. J. Abernathy and James M. Utterback. In their book "A Dynamic Model of Process and Product Innovation" they argued that in many industries there is a predictable pattern of technological change, where a series of competing designs eventually converge on a single dominant design.

The two theorists stated that the innovation process's characteristics systematically vary based on the development state of the firm's technology production process and on firm's environment and strategy, aimed at competition and growth.

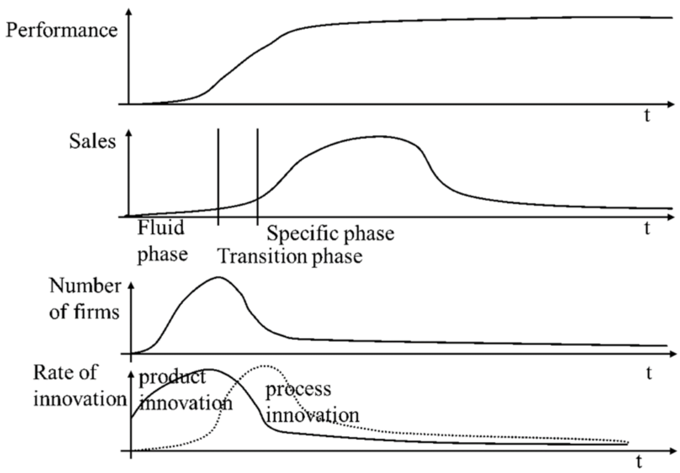


Figure 3.1. "The Abernathy and Utterback's Model" Management of Innovation and Product Development. Cantamessa M, Montagna F (2015). P. 61.

Abernathy and Utterback empirically tested the feasibility of their proposed model with the help of data coming from Myers and Marquis' study (Myers and Marquis, 1969), regarding several successful innovations of 120 companies in 5 different sectors, demonstrating its substantial reliability.

The initial model proposed by Abernathy and Utterback solely pertained to the production industry of discrete products (i.e. products that are made up of component assemblies and for which it is therefore possible to define an architecture) without taking into account continuous products and services. For this reason, the model is questionable, the theory will in fact be adapted.

Nonetheless, it represented a pivotal moment within innovation dynamics study: until 1975 most research on this issue were primarily descriptive, lacking a solid theoretical foundation.

The conceptual foundation for a model that incorporates these mutual linkages between innovation, competitive strategy, and state of process development stems from the merging of two separate, but complimentary lines of investigation explored independently by the authors. The former line has focused on the link between a firm's competitive environment and the aims driving the pattern of innovation it pursues: performance maximizing, sales maximizing or cost minimizing. The second line of investigation has looked at the link between the evolution of a firm's production process characteristics and the sort of inventive activity it engages in, such as the type, source, and stimuli of innovation.

In terms of the proposed development of the production process, the model's underlying basic idea is that it evolves over time towards an increasing level of output productivity: capital intensity rises, productivity rises through specialization and better division of labor, product design becomes more standardized, and material flow within the process assumes a more linear flow quality, the process scale becomes larger. The unit of analysis is frequently not the firm, but rather the whole production process utilized to create a product. The key assumption of the model is that a manufacturing process evolves and changes over time in a consistent and traceable manner.

They proposed a **model of process development**: the production process' evolution is seen as composed of **three stages of development**, common across all various industries and sectors studied.

1. **Uncoordinated or Fluid Phase**: Both the product and the method undergo significant changes rates, and there is great variation across competitors. At this stage, the process is described as "fluid," with insecure links between the various elements of the process, which is distinguished by manual and non-standardized operations. In this stage, the manufacturing system responds easily to industry changes, although it is noticeably inefficient.

2. **Segmental or Transition Phase**: The manufacturing process begins to grow, the product matures, and price competition becomes more intense. Operations become more specialized, business routines emerge, and the production system becomes more efficient as a result of the integration of automation and accurate and strict process controls. Certain subprocesses can be highly automated, while others are mostly human, resulting in a production process with a more "segmented" quality.

3. **Systemic or Specific Phase**: Investments in businesses are increasing significantly, and the development of manufacturing processes reaches a high level of efficiency, making process improvements increasingly difficult. Since even little changes affect other aspects of the process or the design of the product, the process is so well integrated that any changes are extremely costly.

Along with the process development, Abernathy & Utterback consider a **model of product development**. More specifically they state that a product innovation is a new technology or combination of technologies introduced commercially to meet a user or a market need. A basic idea underlying the proposed model of product innovation, as with process development, is that products will be developed over time in a predictable manner:

1. **Performance-maximizing** phase: initial emphasis is set on product performance, with a firm that may try to be the first to introduce technically advanced products. The technology, in fact, is still immature with low performance, therefore its demand will consequently be low as well.

   The industry is most likely made up of a few enterprises, either new and small or more established corporations entering a new market by using their technological strength.

   Even though it is difficult to make profit in this stage, firms start to enter in the industry, since it is seen a promising perspective. Each firm carries a stock of prior competencies and assets leading to an extremely diversified range of technical solutions: the market is ill-defined at both the product and process levels, correlating to the fluid phase, the products lack standardization, and the manufacturing method is unsophisticated.

   Innovation is typically driven or encouraged by new market demands (or opportunities), and in order for it to be effective, it must carefully identify the product requirements rather than increasing performance through new scientific or even more sophisticated technologies. Innovation indeed presents a very high rate without leading to significant progress. This is due to the fact that the various firms present in the market are not concentrating their efforts in the same direction, no generation of cumulative progress is happening, since it is based on the imitation and improvement of competitors' inventions.

2. **Sales-maximizing** phase: there is an emphasis on product variety, with a firm that watches others innovate but be ready to quickly adapt and introduce new product variations and features.

   It is considered that both producers and end users have some experience with the technology and the product, lowering market uncertainty, boosting competitiveness primarily on differentiation, and allowing select product designs to becoming industry benchmarks. As a result, there is a large range of goods available, as well as the introduction of new components.

   This product innovation phase roughly correlates to the process development transition phase. A substantial increase in output demand might promote process changes, resulting in process innovation that is relatively discontinuous, requiring a new organizational structure in response to variations in production or product design.

3. **Cost-minimizing** phase: finally, an emphasis on product standardization and costs when firms enter the market later in the product life cycle with simpler and less expensive versions.

   The market is firmly defined at this point, and the product life cycle is evolving, making it more standardized and minimizing product variation. At this phase, competition is mostly at the price level, diminishing profit margins as well as the number of companies operating within the sector, which effectively becomes an oligopoly in which efficiency and economies of scale are extremely important. The shift is therefore from product to process innovation.

As a result, manufacturing becomes more "capital intensive," with the primary goal of decreasing production element costs. During this phase, which correlates to the process development specific phase, any change entails large interdependent changes in the product and process, with very high costs and negligible returns. Innovation happens mostly at the supplier level, where it may benefit from much higher incentives and be adopted by major enterprises in the field.

This concept has the benefit of distinguishing between the inventive patterns of firms in an industry at a particular moment and those of a specific firm at different times depending on dominating competitive strategy.

What follows it's a graph which describes the relationship between a segment stage of development, considering both the product's and process' innovation, and the rate of innovation itself.

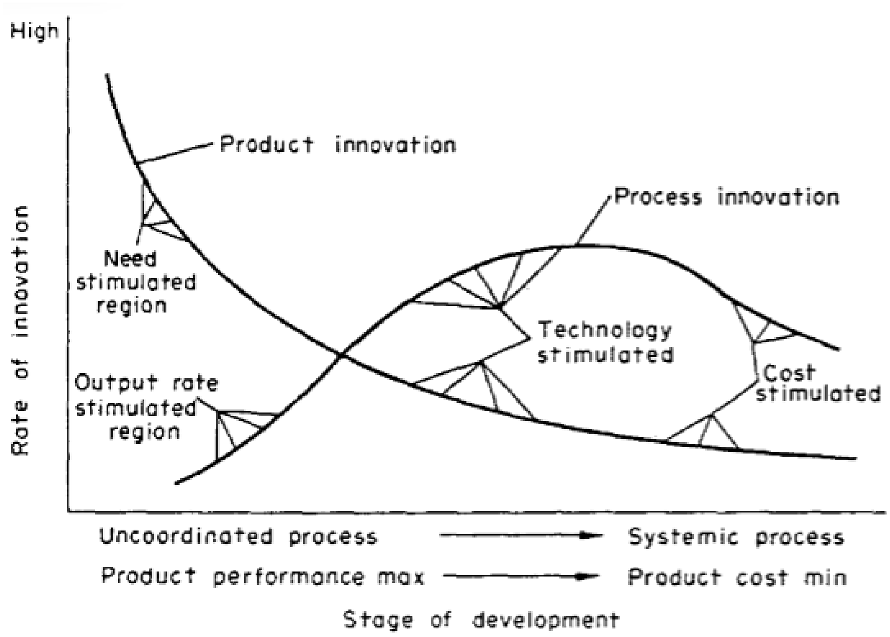


Figure 3.2. "Innovation and stage development", A Dynamic Model of Process and Product Innovation, Abernathy & Utterback, 1975.

Changes in frequency of innovation are shown on the vertical axis, related to the stage of process and product development on the horizontal axis. The graph in this way implies an orderly and even progression of product and process development, standardization and increase in sales volume. Process segments which exhibit the highest rates of improvement in productivity do indeed seem to progress rapidly through the stages indicated.

During the **transition phase** the industry stabilizes over one product architecture, recognized as the emerged **dominant design**.

What happens, considering the s-curve graph of performance evolution, is a steep growth: product performance takes off due to the joint effort of all the competitors on the market which now share the same, dominant, design. They all imitate each other producing cumulative advancement. As a result of the improved performance and the common, more recognizable product, client adoption increases, thereby increasing sales.

This event triggers what is called **1st shakeout**: the number of active enterprises begins to diminish, firms whose assets and abilities do not match the emerged dominant design face a forced exit from the industry or a retreat into specialized niches where they may still compete in.

Growing sales and this first industry shakeout imply that a surviving firm will see better growth rates than the whole market.

Although they may perceive this as good news, it also poses a substantial challenge, and not all businesses will be able to maintain such rapid growth rates. Finding managers to run it, managing expanding personnel, developing a sustainable and established organization, and generating funds to finance manufacturing facilities and working capital are a few of the challenges that must be overcome. As a result, many firms will fail in this endeavor, perpetuating the shakeout and fostering the expansion of survivors.

The process does not stop: in the following step called **specific phase**, a **2nd shakeout** takes place. In a market with rising demand, businesses attempt to compete on price and quality. As a result, they switch their attention from product to process innovation. Prior to the introduction of the dominant design, limited sales and product unpredictability made businesses less concerned with production. However, it becomes technically practical and strategically significant to develop the process because the product's dominant design is now stable and there is a rising demand for it. As a result, businesses create capital-intensive, product-specific machinery that is optimized, enabling both considerable scale economies and greater quality: cheaper production costs, cheaper pricing, and more demand follow as a result.

This new, optimized, process accelerates the shakeout since it determines a MES, short for minimum efficient scale. In general, this typically results in an oligopoly.

3.1.2 Theoretical evolution of Dominant Design concept

In the following years after the original work of Abernathy and Utterback, the same theory underwent several developments.

Radical and Incremental Innovation

Research expanded on the dominant design concept, exploring how it applies to different industries and how it interacts with other factor such as regulation, consumer preferences and industry structure.

In 1978, a new work of Abernathy & Utterback named Patterns of Industrial Innovation focused on the evolution of several efficient production sectors such as light bulbs, paper and steel. Those sectors, in particular, are characterized by high production volumes, a well-defined reference market, low unit profit margins, and competition based mainly on price.

They found that innovation can be also interpreted as incremental, simply involving the improvement of existing products and/or processes without causing the creation of new technological paradigms, but improving the efficiency of production factors and the competitiveness of the industry instead, a minor but frequently ignored factor in previous innovation studies that implied that innovation manifested itself only as a new product on the market: radical innovation.

The researchers discovered that innovations involving large production sectors have consistently been strongly correlated with countless small improvements in the production chain in smaller businesses, both in terms of cost reduction and improvement in the performance of the finished product, and are then exploited by large firms that monopolize the market.

This phenomenon primarily affects industries with highly specialized production lines, where the growth of economies of scale and a mass market are crucial but also greatly raise the cost of implementing direct changes.

Things are different when it comes to radical innovation: the development of new goods that ask for the realignment of corporate goals or manufacturing facilities tends to result in the emergence of organizations outside the production chain that are dedicated to a certain production system. They identified similar characteristics in radical innovations, including the fact that these businesses are typically found close to markets with robust scientific research universities that support entrepreneurial enterprises or academic research institutions.

New goods' competitive advantage is built on performance superiority rather than low startup costs, which tends to result in much larger unit profits. Initial performance in this setting is frequently ambiguous and challenging to comprehend: as a result, customers are crucial in defining the product's qualities since they have a more "intimate" awareness of products requirements.

This ambiguity regarding product performance encourages innovation in small businesses that are known for their high technical flexibility, capacity for external change, and positive interactions with their surroundings.

The firm grows significantly and starts to devote more resources to enhancing manufacturing, marketing, and customer service when a new product establishes a new market and is increasingly demanded by customers wanting to satisfy a growing need.

With this events' chain, radical innovation gives way to incremental innovation. This change is strongly related to the evolution of the product's dominant design, which Abernathy and Utterback refer to as a "milestone" in the shift from radical to gradual innovation. This strengthens product standardization, encourages the growth of economies of scale, and encourages rivalry between firms based on both the costs and performances of their products. The two theorists predict that a dominating design will most likely have one or more of the following characteristics: the dominating design enhances the value of possible advances in other components of the product or process, when applied to a technology, it overcomes technological limitations that previously constrained earlier art without imposing new ones, the product assures expansion into new markets.

There is in this way, for the first time, a definition of the dominant design as "a single architecture that establishes a domain in the product category."

Tradeoff between Productivity and Innovation

Abernathy, alongside the model developed together with Utterback, produced in a study individually made called *The Productivity dilemma: roadblock to innovation in the automobile industry.*

According to this study, the car industry has typically concentrated on increasing productivity through standardization, specialization, and mass production processes, resulting in economies of scale and cost savings. These same strategy, have however made it difficult for the industry to adapt to changes in customer demand and launch new goods that need major retooling and restructuring.

The work investigates the trade-offs between productivity and innovation, stating that while high levels of productivity might give short-term gains, they can also generate roadblocks to innovation by limiting firms' capacity to adapt to new technology and changing customer tastes.

The report also emphasizes the impact of institutional variables in defining the industry's approach to efficiency and innovation, such as government regulation and labor unions. According to the author, these institutional considerations have frequently reinforced the industry's emphasis on productivity above innovation.

Abernathy, after all these considerations, argues that in order to address the productivity dilemma, the industry should embrace a more flexible and decentralized manufacturing method that allows for greater experimentation and innovation: this will require adjustments in organizational structures, managerial methods, and institutional arrangements.

The considerations made in this work lead Abernathy to a reinterpretation of the process' and product's innovations trends previously proposed in the first model together with Utterback, in the sense that the emergence of a dominant design leads to a reduction in product innovation (the product is indeed stabilized over the dominant design architecture) whereas process innovation increases, the overall efficiency of the process increases until an optimum is reached. After this maximum level in process innovation, its rate of innovation decreases reaching on the long run the corresponding rate for product innovation.

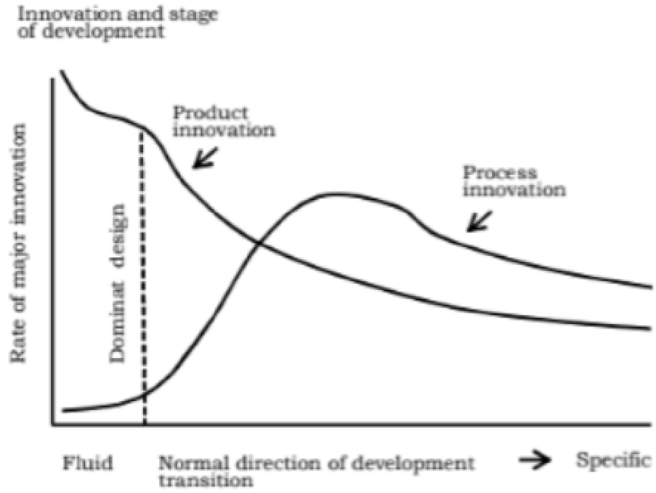


Figure 3.3. "Innovation and stage development". Source: "Productivity dilemma: Roadblock to innovation in automobile industry" (1978).

The Technology Cycle

Built on Abernathy and Utterback's model, the 1990's work *Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change* of Philip Anderson and Michael Tushman an evolutionary model of technological change is proposed in which a technological breakthrough, or discontinuity, initiates an era of intense technical variation and selection, culminating in a single dominant design. This era of ferment is followed by a period of incremental technical progress, which may be broken by a subsequent technological discontinuity. In this sense, the two authors argue that technological change occurs in cycles that consist of three phases:

- a **technological discontinuity phase**, followed by
- the **emergence of a dominant design**, then
- **era of incremental change**.

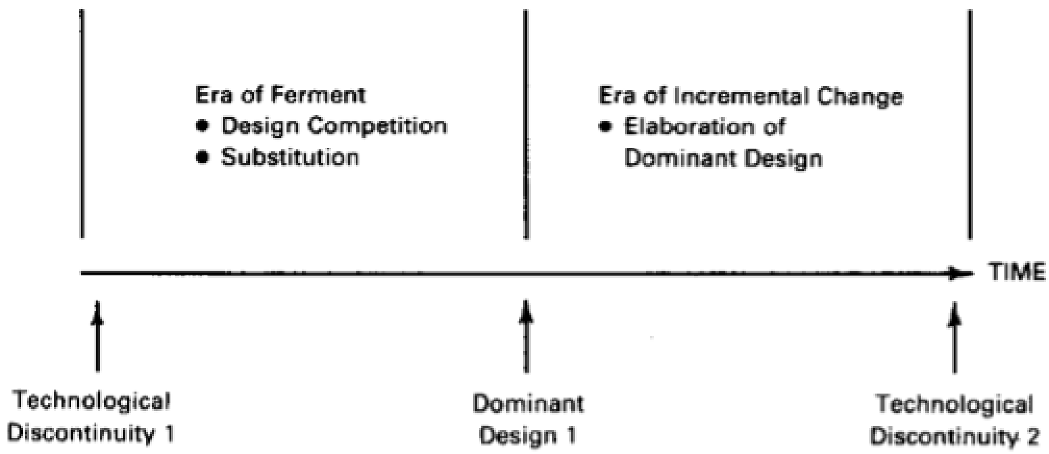


Figure 3.4. The technology cycle. Source: Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change (1990).

According to the two authors a breakthrough innovation, or **discontinuity** is characterized by the emergence of a new technology or design that disrupts the existing dominant design, leading to a period of rapid innovation and experimentation, inaugurating an **era of ferment** in which competition among variations of the original breakthrough culminates in the selection of a single dominant configuration of the new technology.

This **dominant design** becomes widely accepted and adopted by the industry. Successful variations are preserved by the **incremental evolution** of this standard architecture until a new discontinuous advance initiate a new cycle of variation, selection, and retention. As illustrated in the figure 3.4, the key punctuation points are technological discontinuities and dominant designs, which delimit eras of ferment and eras of incremental change. More specifically, the introduction of a radical advance, that starts the era of ferment, increases variation in a product class. A revolutionary innovation is crude and experimental when introduced, but it leads to an era of experimentation as organizations struggle to absorb, or destroy, the innovative technology. This era of ferment is characterized by two distinct processes: competition between technical regimes and competition within the new technical regime. This period of substantial product-class variation and uncertainty ends with the emergence of a dominant design.

The authors suggest that the cyclical nature of technological change has important implications for firms and industries. They argue that firms must be aware of the potential for technological discontinuities and be prepared to adapt their strategies and structures in response. They also suggest that industries must be open to experimentation and innovation, and that they must be willing to embrace new technologies and designs to stay competitive.

Tushman and Anderson also characterized technological discontinuities as **competence-enhancing** or **competence-destroying**. A competence-destroying discontinuity, typical of a radical innovation, renders obsolete the expertise required to master the technology that it replaces, whereas a competence-enhancing discontinuity, typical of an incremental innovation, builds on know-how embodied in the technology that it replaces, this type of innovation introduces new technical parameters by increasing the optimum level of achievable performance, working on the existing technological paradigm without making it obsolete. A key concept emerged from the work of Tushman and Anderson is about the definition of the first empirical method to identify a dominant design: a single configuration, or a narrow range of configurations, can be considered as dominant design if accounting for over 50% of new product sales or new process installations, also maintaining the 50% market share for at least 4 years.

Innovation's Trajectories

In the work of Utterback and Suarez of 1993 named Patterns of Industrial Evolution, Dominant Designs and Firms' is explored the way in which a dominant design, defined as a specific path along an industry's design hierarchy, establishes primacy among competing design paths, considering also the consequences in terms of innovation and competition. In particular, the dominant design which emerges in each industry is not necessarily the result solely of technical potentials but also of timing, collateral assets, and other circumstances. Design trajectories and paths are influenced by both technical and market factors.

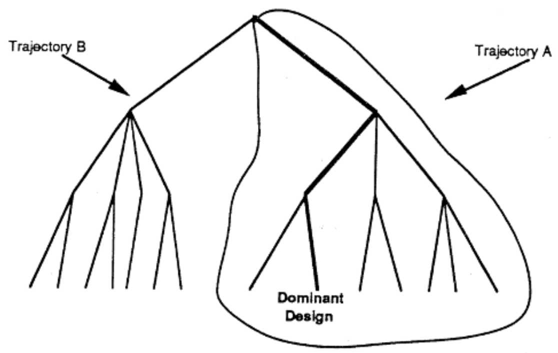


Figure 3.5. Design Hierarchies and Dominant Designs. Source: Patterns of Industrial Evolution, Dominant Designs and Firms' Survival (1993).

After the emergence of the dominant design different consequences occur in different contexts, so that in one case major innovations in an industry seem less and less likely to occur short of a wave of new entrants and increasing competition. In contrast, another circumstances would lead to entry and innovation following the appearance of the dominant design, implying that firms can pursue widely different strategies so long as their strategy is linked to the state of evolution of their core technology.

Utterback and Suarez also introduced the idea that a dominant design is related to information economies for users, thus, for a design to be dominant or a standard requires a degree of experimentation and a rich collaboration between producers and users, not simply a synthesis of parts and functions in a product.

A key consideration of the two authors is that a dominant design will embody the requirements of many classes of users of a particular product, even though it may not meet the needs of a particular class to quite the same extent as would a customized design. Nor is a dominant design necessarily the one which embodies the most extreme technical performance. A dominant design will, however, represents a milestone or transition point in the life of an industry. A dominant design is generally the product of the experiments, technical possibilities, choices and proprietary positions of its day, therefore its emergence is the result of a chance combination of organizational, economical and organizational factors.

In addition, Utterback and Suarez classified a number of non-technological factors that have a significant impact on the establishment of a dominant design:

1. **Possession of collateral/complementary assets**: they have a reinforcing-loop relationship with dominant designs. Also, these assets may help a firm to impose its design as the dominant one, and, in turn, the possession of a dominant product often helps a firm accumulate collateral assets at a higher pace than before.

2. **Industry regulation and other form of government intervention such as large purchases**: they have the power to literally enforce a given design as the dominant one.

3. **Strategic maneuvering at the firm level**: the strategy followed by the competing firms may also help determine the dominant design.

4. **Existence of bandwagon effects or network externalities in the industry**: it often prompts and accelerates the emergence of a dominant design. In case like this, firms which are able to achieve larger scale more quickly than their competitors may have a better chance of winning the race to settle the dominant product.

5. **Management of the user-producer connection**: the way each firm manages its user interface may have a significant effect on firm's ability to impose a dominant design. A dominant design is also partly the result of market learning, therefore close contact with users during the early period of experimentation will help firms determine which product features consumers look for, so that they can include those features in their designs.

In a subsequent work of the same two authors together with Christensen entitled *Strategies for Survival in Fast-Changing Industries* they carefully analyze the evolution of a specific industrial sector, the rigid disk drive, and define in an alternative way to the previous one the dominant design: ”a dominant design emerges in a product category when the product design specifications (which consist of a single or a group of design elements) define the architecture of the product category, that is, the relationship between its elements”.

Criticism to the concept

The initial model proposed by Abernathy and Utterback **solely** pertained to the production industry of **discrete products**, made up of component assemblies and for which it is therefore possible to define an architecture, without considering continuous products and services.

Nowadays, the digitalization of almost every industry makes questionable this original model: Abernathy and Utterback proposal is based on a **rigid architecture**, caused by specific investments in tangible or intangible assets, whereas many contemporary products, based on digital technology, are characterized by a very high degree of modularity, meaning that they are based on components that are functionally independent and can interoperate through well-specified and non-specific interfaces.

Thanks to digital technology, firms can directly select functional elements, later combine them together will require limited integration work, and would allow the development of a wide variety of products with relative ease. Differently from the original model, the effect of organizational learning and economies of scale are found at the components' level, not at the product level. For this reason, it would not be so clear for a dominant design to emerge at the highest product level, remaining only visible at the components' one.

Barriers to entry, shakeouts, lock-in effects, and vertical integration phenomena may also become less intense.

Another criticism can be traced back from the growth of **product-services**: this is the case for mobile payments solutions.

Because the Abernathy-Utterback model sees assembled goods and services as two rather antagonistic worlds, it lacks a clear interpretive tool for the scenario of product-services. Only a few studies have been conducted on this topic (Cusumano et al. 2006), which imply that service innovation is the third "wave" after product and process innovation.

One plausible idea is that in a product and service bundle, one of the two will win and determine the dominant design and the associated lock-in consequences, while the other will serve as a complementary commodity.

Predicting which of the two elements will play a central and which will play a supporting role is difficult, but clues may be provided by examining aspects such as

- standardization
- modularity
- economies of scale
- learning effects

and their relative role.

While the core concept of a dominating design continues to be a helpful tool for studying technological systems, academics continue to investigate various modifications and expansions of the concept in response to new advancements and problems.

In general, the prevailing design concept has progressed from a simple framework for understanding technological evolution to a more rich and complicated collection of theories and models.

3.1.3 Application of Dominant Design Theory on mobile payments' sector

What follows is a contextualization of some of the most important developments of the dominant design theory within the mobile payments' sector.

For each concept considered, specifying the relative academic work, a contextualization within the mobile payment sector has been proposed.

The various paths taken by the theory have been clustered in **four categories** depending on the addressed theme by the considered academic works:

1. **Technology Cycles** The concept of the dominant design can be traced back to the work of Abernathy and Utterback (Utterback and Abernathy,1975; Abernathy, 1978; Abernathy and Utterback, 1978). Studying technological evolution, their work and subsequent research have noted that such evolution is not random, but follows a cyclical pattern of variation, selection, and retention.

    - **Radical and Incremental Innovation** (Abernathy & Utterback 1978): Incremental innovation, differently form a radical one, represents a continuous improvement of an already existing technology, this kind of innovation is also associated to an architectural innovation. The improvement of mobile phone utility from calls and texting to payment facilitation represents incremental innovation.
    - **Trade-offs between process (productivity) and product innovation** (Abernathy 1978): users (consumers and merchants) expect the mobile payment platforms to be productive or, more specifically, fast, reliable and secure. At the same time product innovation has to be considered: mobile payment providers must invest in new technologies and features to remain competitive and meet changing consumer and merchant needs, ensuring at the same time that their platform remains secure and reliable in order to mantain user trust.
    - **Development management conducting *technological pioneering*** (Rosenbloom & Cusumano 1987): the pioneeristic business model MPesa has lead to a competitive advantage over other competitors. Nowadays the mobile money market in Kenya is dominated by Safaricom's M-Pesa which accounts for close to 99 percent of mobile money transfer subscriptions.
    - **Technological cycle consisting in 1st Discontinuity, Era of Ferment, DD, Era of Incremental Change, 2nd Discontinuity** (Anderson & Tushman 1990): considering the current situation from Anderson and Tushman's theories point of view, the industry is in a era of ferment, characterized by a lot of competition and rivalry in the market. Digital payments, starting with card payments, created a technological discontinuity followed by the just mentioned era. The next event is the emergence of a dominant design, then followed by an era of incremental change. The payment industries are currently exposed to a great deal of experimentation with product design and features.

2. **Dominant Design Emergence** While the concept of the dominant design is rather straight-forward, important questions remain with regard to exactly when and how a dominant design actually emerges. In other words, when can it be concluded that a dominant design has emerged, and what mechanisms drive the selection process among competing designs? One approach to determining a dominant design's emergence is to track competing designs 'market share.

    One approach to determining a dominant design's emergence is to track competing designs 'market share. When one design accounts for over 50% of new product sales or new process installations over a significant duration, it can be concluded that it has achieved dominance (Anderson and Tushman, 1990). This threshold of 50% market share and the definition of a 'significant duration' (4 years for Anderson and Tushman, 1990) can, of course, be arbitrary and case specific. They are, however, data driven, relatively easy to apply, and generally in line with notions about dominance, and have thus been used extensively.

    A somewhat different approach has been followed by scholars, which sees products as nested hierarchies of subsystems and linking mechanisms (Henderson and Clark, 1990; Murmann and Frenken, 2006).

    - **Framework for defining innovation: incremental, radical, modular, architectural** (Henderson and Clark, 1990): the mobile payment sector is facing not only an incremental innovation but also an architectural one: existing services are reconfigured, new technologies (such as cloud computing, AI ML, data science & analitics, IoT, Cyber-security, APIs) are progressively involved changing existing interfaces between the current elements.

- **Products as nested hierarchies of subsystems and linking mechanism** (Murmann and Frenken, 2006): like the industries considered by Murmann & Frenken in their work, the mobile payment sector is a complex technological system, for which multiple level of analysis can be conducted (system, subsystem, component).

But what really are the mechanisms behind this convergence on one dominant design? Scale economies and network externalities have been offered as two possible explanations (Klepper, 1997)

- **Scale economies and network externalities as mechanism behind the convergence towards a dominant design** (Klepper, 1997): in the mobile payment sector, both scale economies and network externalities play an important role: the former in reducing the per-unit cost of transactions as the number of transactions increases. This can lead to significant cost savings for mobile payment providers as they scale up their operations. The latter are also important as they can create a positive feedback loop, the more users a mobile payment platform has, the more attractive it becomes to other users, leading to even more users joining the platform.

If scale economies and network externalities alone suffice to drive the selection process, even small random shocks that give one design a head start can determine which design eventually dominates. Other scholars, however, have focused more on the role of agency and sociopolitical factors in this process. A dominant design can emerge from the deliberate actions of powerful actors such as a dominant producer (e.g., IBM's success ful efforts to impose its chosen standard in PCs as the industry standard to be followed by the majority of other manufacturers as well), an important consumer (e.g., the government), or industry standard-setting bodies. Similarly, the dominant design can be the result of firms strategic maneuvering and forging of alliances (Cusumano et al., 1992)

- **Dominant Design as the result of firms strategic maneuvering and forging of alliances** (Cusumano et al., 1992): in the context of the mobile payment sector (highly competitive and characterized by low product differentiation) companies should engage in strategic maneuvering to differentiate themselves from their competitors and gain a competitive advantage.
- **Importance of sociopolitical and institutional factors** (Suarez & Utterback 1995): also for the mobile payment sector we can find the same elements described in the article, all of them play an important role: powerful actors like dominant producers (Paypal, Apple, Google, Samsung), industry standard setting bodies (EMVCo, NFC forum, PCI Security Standrds Council). The mobile payment sector is overall impacted by a range of sociopolitical and institutional factors, which have to be navigated in order to develop effective strategies for adoption, regulation, and growth.
- **Impact of entrance timing and collateral assets** (Utterback & Suarez 1993): in the mobile payment sector there is still no a clearly emerging dominant design, several competing platforms and tecnologies are currently coexisting, however there are strategic elements which can favor a firm: an earliest entrant like PayPal is an example of entrance timing advantage which enabled it to establish a strong brand and user base before other competitors entered in the market.

It is widely accepted that the design that achieves dominance is seldom the most technologically advanced one; while achieving dominance certainly requires good performance for the task at hand, social, political, and organizational dynamics appear to play an even more important role in driving the process of design selection. The problem at such early stages of a technology cycle is that the functional implications of different designs are not well known or understood, and the metrics on which performance will be evaluated are not yet well defined (Clark, 1985)

- **Technological superiority as not the crucial determinant** (Clark 1985): Clark's statements are applicable to the mobile payment sector, being still in the early stages of development: the functional implications of different mobile payments design and metrics on which performance will be evaluated are still being explored. For example, many ongoing researches regard security, convenience, and acceptance of different mobile payment platforms. In this context, the market concept of what is desirable and valuable may be more influential then technological superiority in determining which mobile payment platform will become dominant. Factors such as user experience, convenience and acceptance may be more important in the early stages of development than technological superiority.

3. **Cognitive, Political and Social factors impacting on design evolution** Even though the importance of social, cognitive, and political factors in influencing technological evolution has been recognized even in the very early research on the matter, few scholars had studied these factors in detail (an early exception is Clark,1985). Some recent studies have attempted to fill in this gap.

    - **How producers' background impacts on understanding new industries and on introducing new designs** (Benner & Tripsas 2012): the mobile payment sector is still considered a recent industry, in which entrepeneurs and firms entering may have different prior industry affiliation impacting the way they approach and frame opportunities and the way they adopt strategy. For example: individuals coming from financial services industry may frame opportunities in terms of risk management and compliance, while those with a background in the mobile technology may frame opportunities in terms of user experience and technical innovation.
    - **Influence of old paradigm on the new one even in case of discontinuous innovation** (Dosi & Nelson 2013): old paradigms and path dependencies impact also in the mobile payment sector, limiting the adoption and evolution of new technologies and business models. For example, traditional payment methods such as credit cards and cash may be deeply ingrained in the habits and practices of consuemrs or merchants, making it difficult for new mobile payment technologies to gain widespread acceptance.
    - **Influence of old and familiar artifacts on how users understand and adopt new products** (Birgham & Kahl 2013): in order to adopt and use mobile payment technology effectively, users must be able to make sense of the technology and understand how it fits into their daily lives and routines. This process can be helped by the use of analogies from familiar technologies or systems such as credit cards or online banking. Users may need to assimilate analogies from different contexts, deconstruct these anologies to identify relevant elements, and unitize these components into a coherent framework that can guide their use of the mobile payments.
    - **Concurrency of technological evolution and categorical evolution** (Suarez et. al 2014): in the work of Suarez et al. the term category is referred to group of products which are perceived similar by stakeholders. Considering the mobile payment sector we can identify for example POS mobile payments or remote payments: firms focusing on different category of service may face different opportunities and challenges. In any case, whatever the category, mobile payment providers must be able to identify the optimal timing for entry into the market and develop effective strategies to compete in such a rapidly evolving and competitive industry.

4. **Limitations and Critique** While particularly important for understanding the process of technological innovation and technology cycles, the concept of the dominant design also has some limitations.

    As previously mentioned, an important limitation can be traced back from the growth of product-services: this is the case for mobile payments solutions. Because the Abernathy-Utterback model sees assembled goods and services as two rather antagonistic worlds, it lacks a clear interpretive tool for the scenario of product-services. Only a few studies have been conducted on this topic (Cusumano et al. 2006), which imply that service innovation is the third "wave" after product and process innovation.

    - **Product-service** (Cusumano et al. 2006): the mobile payments industry is classifiable as a service industry with the dominant form of value creation being the provision of payments services to customers. As the authors suggest, this kind of industries evolve over time through a process of commoditization in which previously differentiated product or services become standardized and commoditized.

In addition to this, another important limitation is the fact that in most cases the emergence of a dominant design can only be assessed post facto. This inability to anticipate which design will dominate offers little guidance to firms.

Even though literature on the matter makes it clear that entry to an industry after the emergence of a dominant design is problematic, it does not offer many tools for earlier entrants that need to navigate the uncertainty that is prevalent before the dominant design is established.

Such early entrants, then, seem to have two options other than just betting blindly on any one design. First, they can try to impose their chosen design as dominant through deliberate actions that aim at influencing the selection process. Such strategic maneuvering generally requires building mutualistic coalitions or ecosystems around the chosen design in order to give it adequate momentum.

- **Imposition of a chosen design as dominant** (Cusumano et al.,1992): what stated in the work of Cusumano et al. can be applied to the mobile payment sector, in the sense that the dominant design that will emerge (or more probably, the plurality of them) will be the result of many factors such as the firms strategic maneuvering and alliances, mass market dynamics (influenced by consumer preferences and technological advancements). This complex web of actors and influences does not help in determining what the dominant design will be.
- **Imposition of a chosen design as dominant** (Wade, 1995): Wade argues that the adoption of a new technology is influenced not only by the technical characteristics of the technology itself, but also by the social and cultural context in which it is adopted, this is applicable to mobile payments solutions (for ex. social norms and cultural values around the use of cash or credit cards influence the adoption process). The formation of organizational communities or bandwagons that promote the technology within the industry could be represented by a group of financial institutions or merchants which, forming a community to promote the adoption of a particular mobile payment platform, would lead to an increase adoption and usage of it.

This is, however, a risky option. Even designs that are technologically superior and supported by large and powerful corporations can fail to achieve dominance, as vividly demonstrated by the case of Sony's Betamax (Cusumano et al., 1992). Firms that invest heavily in and commit to a specific design that fails to achieve dominance face a significant risk to fail as well, especially when they are relatively small and cannot afford a repositioning.

Alternatively, firms can hedge their bets by investing in multiple designs at the same time. Rather than being fully committed to any specific design, these firms can test the waters, acquire valuable firsthand knowledge about consumer preferences, and develop skills that will allow them to change course quickly if necessary and adopt the dominant design as soon as it emerges.

- **Investing in multiple designs** (Sorenson, 2000): firms that follow this strategy can have lower failure rates, but usually also do not aspire to influencethe industry's evolution or become market leaders. The mobile payment sector is still without a dominant solution: investing in multiple design could help mobile payment providers to identify emerging trend and customer preferences, adapting their platform accordingly: many payment methods (NFC, QR code, biometric authentication etc) and many platform's features are currently present, once preferences will emerge firms will then shift resources towards that preferred design.

From the mobile payments sector's analysis, carried out in the previous chapter, what comes out is the fact that there are **various solutions for different use cases: many technologies and many layers of technology coexist, there is no optimal solution compared to others since mobile payments sector is still in a fluid phase**.

Perhaps the right question is not which of the competing technologies will win, but how they will interact and co-exist with one another.

Maybe there will be different paradigms for different payments' use cases, after all, from the users' perspective, the kind of technology is almost irrelevant, what matter are things like consumer experience and data security.

In order to rigorously conduct this analysis is necessary to identify and model each solution's architecture.

3.2 Product Architecture Theory

The concept of **dominant design**, as previously mentioned, refers to the architecture of the product or process which becomes common and widely accepted over the other possible architectures proposed on the market.

Product architecture can be defined as the main components that make up the product and their mutual relationships. These relationships may be due to functional interactions, physical proximity, or even unintended influence.

According to Henderson and Clark's taxonomy of innovation, product architecture has a role in shaping organizational routines since the design of each component will generally be assigned to a specific organizational entity, and these entities will have to communicate with each other in a way that replicates the pattern of intercomponent relationships. Therefore, product architecture and the organization will share a similar structure.

In their work "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", Henderson and Clark demonstrated that the **traditional categorization** of innovation as either incremental or radical is **incomplete** and potentially misleading, in addition it does not account for the sometimes disastrous effects on industry incumbents of seemingly minor improvements in technological products.

The two authors stated that there is evidence that numerous technical innovations are not classifiable as incremental or radical, instead they involve apparently modest changes to the existing technology leading to quite dramatic competitive consequences. The paper provides a **valuable framework** for understanding the concept of architectural innovation and its impact on established firms in the industry.

More specifically, architectural innovation refers to the innovation of an architecture of any product that changes or modifies the way various components of the system link or relate to each other, leading to an overall improvement of the product leaving the core design concepts (and thus the basic knowledge underlying the components) untouched.

The paper further investigates the challenges that established firms face in responding to architectural innovation, suggesting that they are often constrained by their existing architecture, which limits their ability to reconfigure their products and processes in response to new technologies or customer needs.

The proposed way to classify innovation can be summarized in the following scheme, **four types of innovation are identified**.

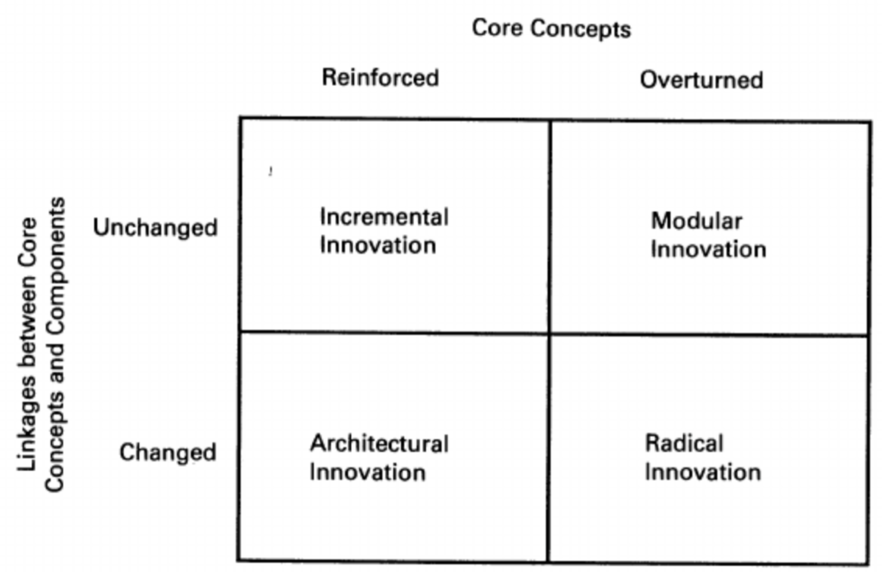


Figure 3.6. A framework for defining innovation. Source: Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms, Henderson & Clark (1990).

A **radical innovation** establishes a new dominant design and, hence, a new set of core design concepts embodied in components that are linked together in a new architecture. Both underlying technology and product architecture change. This kind of innovation is of course the most difficult to pursue, even though it is not very common, and firms will also be well aware of the problems they will face when tackling it. When dealing with radical innovation, firms are often so wary of architectural change that they will try treating it as modular, by changing product subsystems one by one, but trying to steer away from altering their mutual relationships. This hesitation in embracing radical innovation opens up interesting opportunities for firms that, instead of making piecemeal changes to the existing architecture, accept the challenge of jointly changing technology and product architecture.

Incremental innovation refines and extends an established design. Improvement occurs in individual components, but the underlying core design concepts, and the links between them, remain the same. In incremental innovation, neither the underlying technology, nor product architecture will change. This kind of innovation can be costly to achieve, in terms of effort, but is not difficult to manage, since it completely replicates the experience gained with previous products.

A **modular innovation** only changes the core design concepts of a technology. It is an innovation that changes a core design concept, the underlying technology, in one or more functional elements, without changing the product's architecture. In this case, the innovation in the affected modules may be significant and difficult to pursue, since it requires changing the competencies used. However, problems will be limited to the affected modules, and the development of the complete product will therefore be relatively easy to manage.

An **architectural innovation** changes only the relationships between the functional elements, while the underlying technology does not change. It generally hard to manage, since the organizational routines that allow the development of a consistent product will not be immediately available, but will take some time, and probably some costly mistakes too, to develop. This will be especially true if the new pattern of relationships between components is known ex-ante. In some cases, architectural innovation may take companies "by surprise" because seemingly minor innovations unexpectedly change intercomponent relationships.

3.2.1 Initial Classification: Integral vs Modular Architectures

A subsequent definition of product architecture (Ulrich 1995) states it as *the relationships between its functional elements, the mapping among functional elements and physical components and the interfaces among physical components.*

The focus now extends from components to functional elements, fulfilling a specific function of a product: with this point of view, architectures can be classified according to the mapping between functional elements and physical components.

Two architectures have dominated physical product design form many years: **integral** and **modular**.

Integral architectures are characterized by functional interdependence between components, with each function being fulfilled by multiple components and components embodying multiple functions. In particular we talk about **associations m:n, 1: n, m:1** (Ulrich & Seering, 1988).

- in the case of an **m:1** association, a single component is able to fulfill m functions at the same time, and independently from other components. This is called **function sharing**. In general, this choice leads to greater complexity in the detailed design phase and the use of ad hoc components. However, a single component able to fulfill more than one function can often lead to substantial savings concerning cost and weight

- with **1:n** associations, a single function is fulfilled jointly by n components who do not serve other functions. This can be viewed as a shorthand representation of multiple 1:1 associations, since it is likely that the function could have been exploded into n sub-functions, each leading to a 1:1 association with the corresponding components.

- the case of an **m:n** association exhibits an arrangement in which components are functionally interdependent. This leads to an integral architecture in which detailed design becomes somewhat involved. In fact, any change carried out on one function or component will propagate to the other ones, thus triggering a chain of design iterations that will end only when a solution that satisfies the requirements cast by each function is found. Managing the detailed design process for products characterized by this type of architecture requires significant experience.

In general, within this architecture of complex and overlapping mapping between components and functional elements, the interfaces between each building block are not standardized and are tightly coupled (Ulrich 1995). As a result, changes in one part of a product typically affect the rest of the product, often unpredictably.

Modular architectures are, instead, characterized by functionally independent components or subsystems. Each component therefore is in charge of implementing a single function, and each function is fulfilled by a single component: an ideal modular architecture implements a one-to-one mapping between functional elements and physical modules (Ulrich 1995). More specifically, modular architectures can be:

- **slot-based**, if the interconnections between pairs of components are not based on a standard interface

- **sectional** if the interface between each pair of interconnected components is standardized

- **bus-based** if components will not be directly connected with each other, but through a common component (called bus) and using a standardized interface.

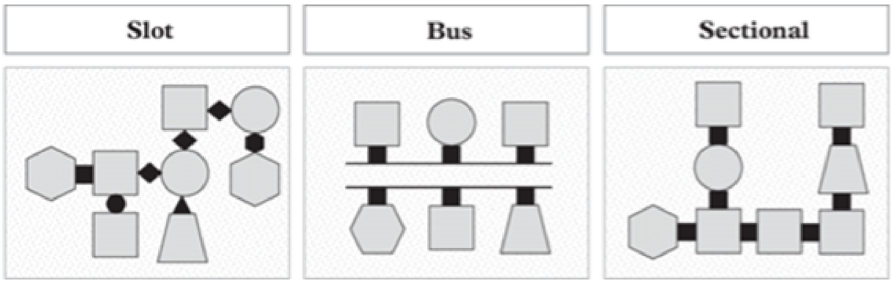


Figure 3.7. Slot, bus and sectional architectures of components interfaces. Source: Categorizing modularization strategies to achieve various objectives of building investments, Peltokorpi et al. (2017).

In principle, this classification of product architecture should apply to the entire product. However, it is possible or complex artifacts to exhibit portions that appear to be integral, while other ones may instead be modular.

Differently from integral architectures, interfaces of modular ones between components are standardized, product can be decomposed into components that can be recombined (Schilling 2000). These standardized specifications defining interfaces enables an indipendence between components, allowing an interoperability between them.

Impact on firms' strategies

The type of architecture that is used by a firm casts a strong influence on aspects that are relevant at both tactical and strategic level.

Considering for example **modular architectures**, a consequence of such is **product variety**: platform products and modular architectures enable the simultaneous supply of distinct product variations based on the shared platform, as well as rapid transitions between subsequent product releases and product generations.

Thanks to the prespecified interfaces between the loosely coupled components, complexity is reduced and flexibility in design is increased: this configuration significantly facilitates detailed design activities, a modification to the performance required of a certain function will require changing the corresponding component but it is unlikely that this change will propagate and require any redesign of other components.

The following three benefits can result from this strategy:

- the company can target a variety of vertically and horizontally distinct market segments, which is obviously advantageous for its pricing power
- platform components are produced in large quantities, which can result in significant economies of scale
- the overall effort put into developing the platform and product derivatives can also result in economies of scale because of the high volume that comes from all the product lines.

Additionally, modular designs might make it possible to produce goods with combinatorial variation, where a core product can be simply modified by adding or modifying the number of components.

Further, the company may decide to split up assembly activities and place them closer to the client because significant economies of scale often occur at the component production level rather than at final assembly.

Finally, a highly modular design can enable a company to sell a wide range of fundamental and compatible building pieces, leaving it up to consumers or vendors/installers to structure the final "product".

Integral architectures, in general, are not very good at supporting product variety. There could, however, be some exceptions. For instance, an integrated design may enable a drastic reduction of the bill of materials (for example, disposable razors) in the case of relatively basic items manufactured in big numbers, hence facilitating product diversity.

3.2.2 Layered Modular Architecture

How can mobile payments be classified? Surely not as purely modular or purely integral. Such product/services fall under a hybrid categorization, known as **Layer Modular Architecture**, recently born due to digital innovation.

This architecture is in fact a **hybrid** of the **modular** architecture of a physical product, made up of physical components, and the **layered** architecture of digital technology, as the digital control system that monitors and integrates these physical components.

As **digital innovation** spreads, firms increasingly embed digital components into physical products, the Layered Modular Architecture emerges

Digital Innovation

How can digital innovation be defined? According to Schumpter (1934) it is the carrying out of new combinations of digital and physical components to produce novel products.

A necessary but insufficient condition for digital innovation is that the new combination relies on **digitization**, which is the encoding of analog information into digital format. Digitization makes physical products programmable, addressable, sensible, communicable, memorable, traceable, and associable (Yoo 2010).

Digital innovation furthermore requires a firm to revisit its organizing logic and its use of corporate IT infrastructures.

Key functions and capabilities of industrial-age products have been digitized thanks to the miniaturization of hardware, increasingly powerful microprocessors, inexpensive and reliable memory, broadband communication, and efficient power management, profoundly changing the industrial structure and competitive landscape, blurring industry boundaries and creating new threats and opportunities.

Three unique characteristics of digital innovation can be identified:

1. the **reprogrammability**: a digital device consists of a processing unit that executes digitally encoded instructions and a storage unit that holds both instructions and the data being manipulated in the same format and in the same locations (Langlois 2007). As long as users agree on the meaning of the digital data and have the wits to come up with new instructions to manipulate the data, the architecture offers flexibility in the way data is manipulated. Thus, unlike analog technology, a digital device is reprogrammable, enabling separation of the semiotic functional logic of the device from the physical embodiment that executes it. The reprogrammability allows a digital device to perform a wide array of functions (such as calculating distances, word processing, video editing, and Web browsing).

2. the **homogenization of data**: an analog signal maps changes in a continuously varying quantity on changes in another continuously changing quantity. As such, analog data implies a tight coupling between data (e.g., texts and pictures) and special purpose devices for storing, transmitting, processing, and displaying the data (e.g., book and camera). In contrast, a digital representation maps any analog signal into a set of binary numbers, i.e., bits (a contraction of binary digits). This leads to a homogenization of all data accessible by digital devices. Any digital contents (audio, video, text, and image) can be stored, transmitted, processed, and displayed using the same digital devices and networks. Furthermore, unlike analog data, digital data originate from heterogeneous sources and can be combined easily with other digital data to deliver diverse services, which dissolves product and industry boundaries. Thus, the homogenization of data along with the emergence of new media separates the content from the medium.

3. the **self-referential nature** of digital technology: digital innovation requires the use of digital technology (e.g., computers). Therefore, the diffusion of digital innovation creates positive network externalities that further accelerate the creation and availability of digital devices, networks, services, and contents (Benkler 2006, Hanseth and Lyytinen 2010). This, in turn, fosters further digital innovation through a virtuous cycle of lowered entry barriers, decreased learning costs, and accelerated diffusion rates. The drastic improvements in the price/performance of computers and the emergence of the Internet have made the digital tools necessary for innovation more affordable to a broad spectrum of previously excluded economic and innovative activity. Digital technology, therefore, has democratized innovation and almost anyone can now participate.

The Layered Architecture of Digital Technology

The characteristics of digital technology pave the way for layered architecture (Adomavicius et al. 2008, Gao and Iyer 2006) and this is perhaps best exemplified by the Internet.

Differently from modular architectures, which provide a scheme by which a physical product is decomposed into loosely coupled components, is attributed functionality, and is then interconnected through prespecified interfaces (Baldwin and Clark 2000, Ulrich 1995), the layered architecture of digital technology (Adomavicius et al. 2008, Gao and Iyer 2006) is embedded into physical products, enhancing product functionality with software-based capabilities.

It consists of **four layers: devices, network, services and contents** (Benkler 2006, Farrell and Weiser 2003).

The layer metaphor implies a hierarchical dependence between the different layers, with the higher-level ones relying on the lower-level ones for their functionality. Each layer has a clearly defined interface or API to communicate with other layers, and is responsible for different aspects of the system's functionality, with each layer building on top of the layer below it.

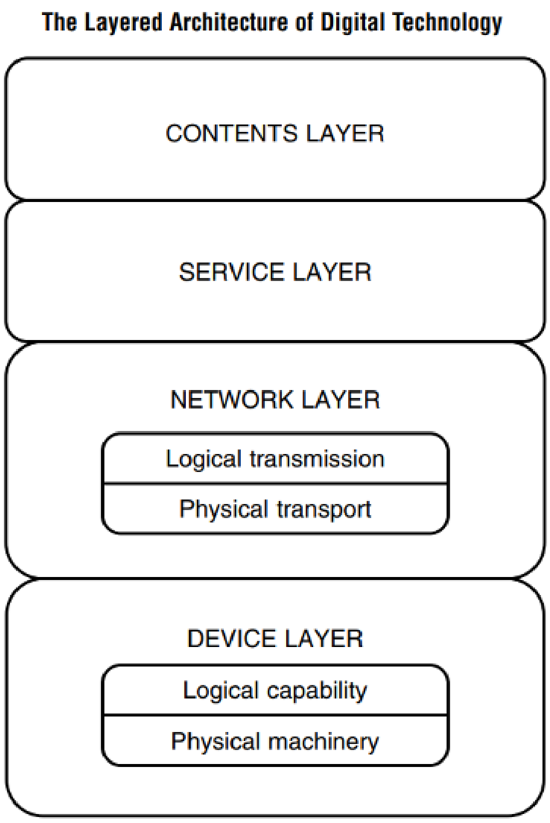


Figure 3.8. Layered architecture of digital technology. Source: The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research, Yoo et al. (2010).

Starting from the lower level layer we have:

1. **Device layer**: it can be further divided into a **physical machinery layer** (e.g., computer hardware) and a **logical capability layer** (e.g., operating system) which provides control and maintenance of the physical machine and connects the physical machine to other layers
2. **Network layer**: is similarly divided into a **physical transport layer** (including cables, radio spectrum, transmitters, and so on) and a **logical transmission layer** (including network standards such as TCP/IP or peer-to-peer protocols)
3. **Service layer**: deals with application functionality that directly serves users as they create, manipulate, store, and consume contents (e.g. applications)
4. **Contents layer**: includes data such as texts, sounds, images, and videos that are stored and shared. The contents layer also provides metadata and directory information about the content's origin, ownership, copyright, encoding methods, content tags, geo-time stamps, and so on.

The layers manifest two critical separations:

1. that between device and service because of **reprogrammability**
2. that between network and contents because of the **homogenization of data**

Even if the layers present a hierarchical dependence, the individual deign for the elements belonging to every layer can be conducted with a minimum consideration of the other ones. Thanks to this, is possible to pursue combinatorial innovation by gluing components from different layers using a set of protocols and standards to create alternative digital products (Gao and Iyer 2006). Combined with the rapid diffusion of personal computers and the Internet, the layered nature of digital technology has brought unprecedented levels of generativity (Tuomi 2002, Zittrain 2006) Though layered architecture has been discussed in IS literature (Adomavicius et al. 2008, Gao and Iyer 2006), little attention has been paid to its implications for product innovation. The digitization of physical products challenges some of the fundamental assumptions about product architecture and organizing logics.

Going back to the **Layered Modular Architecture**, it can be considered as an **extension of the modular architecture** of physical products **incorporating four loosely coupled layers of contents, service, network and device**: in this sense the layered architecture adds **generativity** to the modular one in a continuum form.

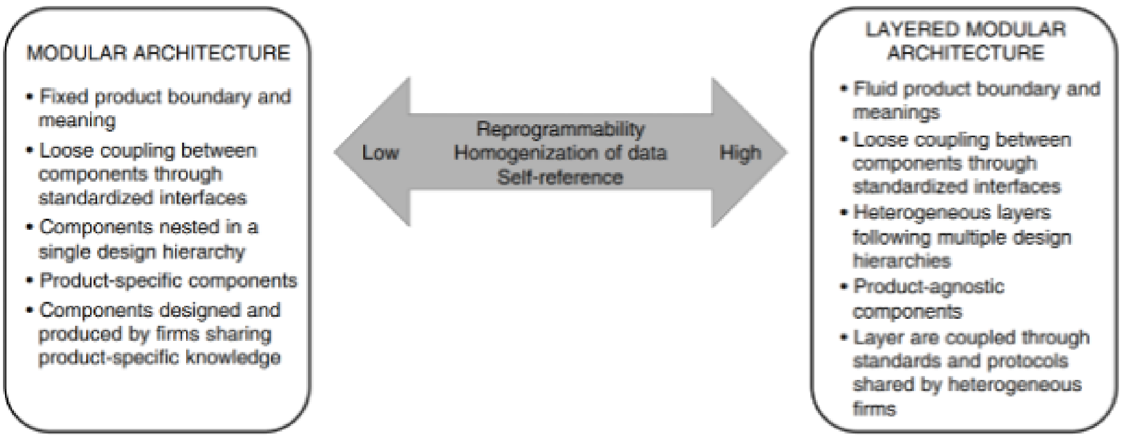


Figure 3.9. The Layered Modular Architecture Continuum. Source: The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research, Yoo et al. (2010).

The important aspect of the continuum is the low to high degree of **reprogrammability**, **homogenization** of data and **self-referentiality**:

- Re-programmability allows a device to be redesigned so that different functionalities can be added
- Homogenization of data allows the presentation of contents using various devices instead of a particular device as in case of analog devices
- Self-referentiality means that digital technology is required for digital service innovation (Kallinikos et al. 2013; Yoo et al. 2010a)

Traditional **modular** architecture is based on a fixed product boundary.

The modular design of such a product is initiated by decomposing the product into components following a functional design hierarchy (Clark 1985, Baldwin and Clark 2000). Therefore, the relationships between the product and its components are nested and fixed. Given the nested nature of relationships and the fixed product boundary, aggregating all components will make up the whole product. A modular product prior to digitalization has a **fixed purpose** use.

In addition, in a modular architecture, the design of a component is driven by the functional requirements created within the context of a given product. That is, **components** in a modular architecture are **product specific**, components are designed and produced by specialized firms that all share product-specific knowledge.

The primary goal of modularity is to reduce complexity and to increase flexibility (Schilling 2000, Simon 1996). The flexibility is accomplished through substitutions of components within a single design hierarchy.

Layered modular architecture does not have a fixed boundary at the product level. The design of a component thus requires little product-specific knowledge. The **usage** of the product with this architecture are **fluid**.

That is, **components** in a layered modular architecture are **product agnostic**.

A product is inductively enacted by orchestrating an ensemble of components from a set of heterogeneous layers, each of which belongs to a different design hierarchy (Clark 1985). Therefore, the designers of components in a layered modular architecture cannot fully know how the components will be used. As such, a layered modular architecture offers **generativity**, i.e., *a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences* (Zittrain 2006). Generativity in a layered modular architecture is accomplished through loose couplings across layers whereby innovations can spring up independently at any layer, leading to cascading effects on other layers (Adomavicius et al. 2008, Boland et al. 2007).

Components in a **modular** product fall under a single design hierarchy, components in a **layered modular** architecture participate in multiple heterogeneous design hierarchies.

Unlike the **flexibility** of a **modular** product that produces differences in degree, the **generativity** of a **layered modular** product produces differences in kind. Generativity is the capacity of digital technology to generate change and support people in innovation (Zittrain 2006). A layered modular product remains fluid and is open to new meanings. Unlike the **purely layered** architecture (Gao and Iyer 2006), however, the **generativity** of a digitized product with a layered modular architecture is **constrained** by characteristics of the physical components of the product.

The modular architecture and the layered modular architecture form the two end points of a continuum as firms embed digital components into their products. Traditional industrial-age, single purpose products manifest one end of the spectrum while conventional digital products with general computer hardware form another end. Many digitized products will fall somewhere in the middle.

With continuous digitalization, the degree of re-programmability, homogenization of data and self-referentiality increases. Therefore, digitalization of a non-digital modular product or service gradually takes them towards layered modular architecture.

Layered Modular Architectures and Dominant Design

The fact that mobile payments are characterized by a layered modular architecture will surely have an impact on the emerging dominant design within the sector.

The layered modular architecture of mobile payment solutions allows for a high degree of flexibility and customization, making it difficult for a single dominant design to emerge: multiple layers that can be customized and combined in different ways create different payment solutions.

This modularity allows for greater flexibility and innovation in the design and implementation of mobile payment systems, leading to different solutions tailored for different needs, use cases or user groups.

How could the different dominant designs emerge? Different mechanisms may happen:

- different firms and organizations may converge on certain design standards and best practices. Over time, these standards and practices become widely adopted, leading to a dominant design that is recognized and accepted across the industry.
- the emergence of a dominant design may be driven by customer preferences. As customers begin to use and interact with different layered modular products or services, they may develop preferences for certain design features or components. These preferences can drive firms to adopt similar design approaches, leading to a dominant design that reflects the needs and preferences of the customer base.
- the emergence of a dominant design may be influenced by technological advancements or changes in the broader market. For example, a new technological innovation may make certain design features or components more efficient or effective, leading to their widespread adoption and the eventual emergence of a dominant design.
- Other important factors could be complementary assets, network externalities, economies of scale.

The relative impact of all these factors on the mobile payments' solutions will be later discussed in the last chapter.

Chapter 4

Methodology

As previously seen, mobile payments solutions' architecture presents this hybrid structure between the modular architecture of a physical product, made up of physical components, and the layered architecture of digital technology, as the digital control system that monitors and integrates these physical components

These two architectures are orthogonal to each other (Lee & Berente 2012).

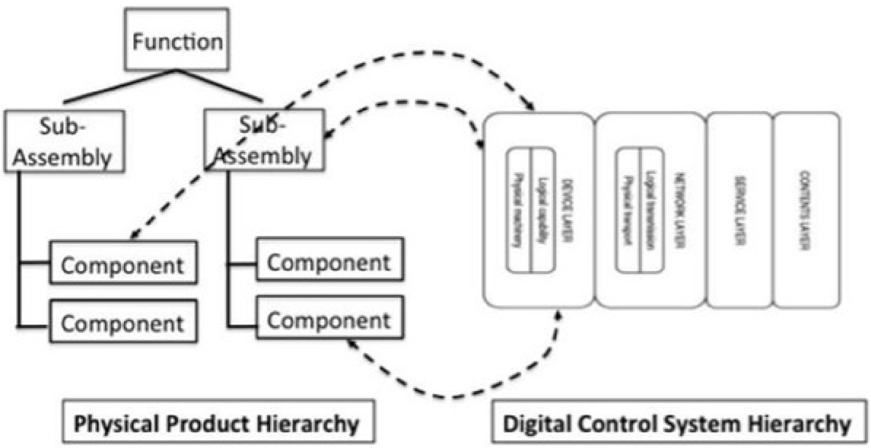


Figure 4.1. Visualization of the layered modular architecture: orthogonal relationship between a digital control system and a product hierarchy (Hylving & Schultze 2013).

The figure highlights how digital products connect to different parts of the physical product hierarchy, integrating functionality and data from components that were traditionally separate.

To answer the question

is there an emergent dominant design within the mobile payment sector?

it has been conducted a **rigorous analysis of the major eight different mobile payments solution**:

- POS Payments
  - NFC, card network involvement
  - MST, card network involvement
  - QR code, card network involvement
- Remote or Cloud based Payments

- Debit or Credit Card, Card Network Involvement
- Debit or Credit Card + payment app, Card Network Involvement
- No Debit or Credit Card, only payment app balance involvement
- SMS
- P2P

For each solution it has been elaborated:

- A **swim lane diagram** with the objective of process architecture modelling
- A **block diagram** for a high level system modelling
- A **layered architecture evaluation**, identifying the most crucial layers

Following those graphs a general scheme has been synthetized, identifying a possible regular and recurrent pattern among the various cases analyzed.

The following swim lane and block diagrams graphs are referred to the NFC solution only. For all the other graphs see Appendix.

4.1 Swim Lane Diagrams: Process Flow Architecture

A mobile payments solution typically involves several stages in the process flow. A general overview of the process and the relative **common steps** can be the following one:

1. **Registration**: the first step is for the user to register for the mobile payments solution. This usually involves downloading an app and creating an account with their personal information, such as their name, email address, and phone number. Some mobile payments solutions also require users to link a payment method, such as a credit card or bank account, to their account.
2. **Authentication**: once the users have registered, they need to authenticate themselves to use the mobile payments solution. The way this action is conducted depends on how the payment is initiated. Whatever the mean of payment, the costumer/user has to unlock his/her mobile phone in order to access to it, this can be done typing a PIN, or via a biometric aunthentication.
3. **Payment request**: the user initiates a payment request by selecting the recipient and entering the amount to be sent. The recipient can be another user of the same mobile payments solution or a merchant who accepts payments through the solution.
4. **Payment processing**: the mobile payments solution processes the payment request by verifying the user's account balance or payment method, checking the recipient's account information, and initiating the transaction. This may involve communicating with external payment processors or banks to transfer funds between accounts. This step usually include security checks to verify whether the payment is legitimate and that the recipient is authorized to receive the payment.
5. **Notification**: Once the payment has been processed, the user and recipient receive a notification confirming the transaction. This may include details such as the amount, date, and time of the payment.
6. **Settlement**: The final stage of the process is the settlement, where the funds are transferred between the user's account and the recipient's account. This may take a few minutes or up to a few days, depending on the payment method and the processing time of the banks or payment processors involved. Once the payment is authorized, the amount is deducted from the user's account or credit balance. The payment provider settles the payment with the merchant or recipient, either by transferring funds electronically or by providing a credit to the merchant's account.

From this general scheme it's possible to identify recurrent **common flows**:

- **Information flows** such as
  - User payment information (account or credit card numbers, transaction amounts and details)
  - Authorization requests and confirmation
  - Settlement / payment confirmation
- **Monetary flows** such as:
  - Payment amount
  - Fees

The **specific actions, actors, and information flows involved in the mobile payment process may vary depending on the type of payment solution being used**.

Proximity mobile payments technologies (NFC, MST, QR code) are used for in-person transactions where the mobile device is held close to the payment terminal or scanner. The process flow for proximity mobile payments typically involves the following steps:

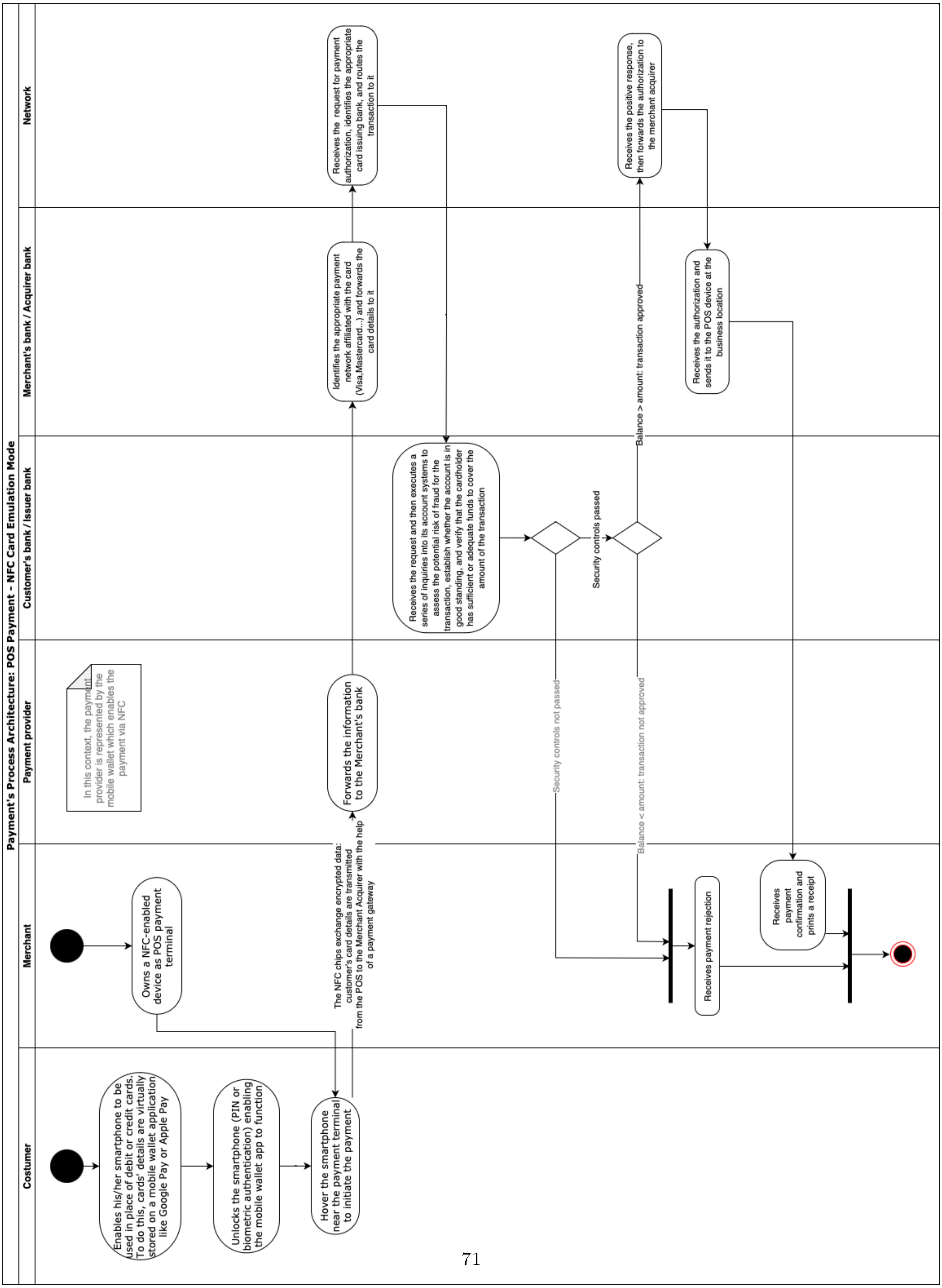
- **Authentication**: the mobile payments solution authenticates the user through biometric authentication or a PIN.
- **Initiation**: the user initiates the payment by holding the mobile device close to the payment terminal or scanner.
- **Payment processing**: the payment is processed by communicating with the payment terminal or scanner using NFC or MST technology or by scanning a QR code.
- **Confirmation**: The user receives a confirmation that the payment has been made.

Remote mobile payments technologies (Debit or credit card for online payments, payment app such as PayPal, P2P payments) are used for transactions where the user is not present at the point of sale. The process flow for remote mobile payments typically involves the following steps:

- **Authentication**: the user authenticates through a username and password or biometric authentication.
- **Initiation**: the user initiates the payment through an app or website.
- **Payment processing**: the payment is processed by communicating with the payment processor or bank using the user's debit or credit card information or through a payment app such as PayPal.
- **Confirmation**: The user receives a confirmation that the payment has been made.

Overall, the **primary difference in the process flow between proximity and remote mobile payments is the method of initiating the payment and the authentication process**. For proximity payments, the user initiates the payment by holding their mobile device close to the payment terminal, and the authentication is typically done through biometric authentication or a PIN. For remote payments, the user initiates the payment through an app or website, and the authentication is typically done through a username and password or biometric authentication.

POS Payment: NFC



Process architecture depicted through the swim lane diagrams seems to change depending on the payment method.

Great differences takes place if cards, and the relative circuit along with Issuer/Acquirer Banks, are directly involved instead of virtual wallet accounts, that may be connected to credit/debit cards too, but without the need to involve them at the transaction moment.

4.2 Block Diagrams: High Level System Modelling

Now we move from a dynamic to a static view of mobile payments: the following block diagrams enable a vision of the relationships between the different actors involved in a mobile payment solution.

Such actors can be broadly summed up in the followings.

- **Customer or User**: the person who initiates the mobile payment transaction by using their mobile device to pay for goods or services or to transfer an amount to a peer.
- **Merchant or Recipient**: the merchant or business that accepts the mobile payment from the consumer, both in a close proximity situation or remotely. In case of NFC or MST technology involved, the merchant needs to have, respectively, an NFC or MST enabled payment terminal. In case of a P2P payment, the two peers, in order to transfer a certain amount, have to share the same mobile payment app.
- **Customer's Bank or Issuer Bank**: the issuing bank is the financial institution that issued the consumer's payment card or mobile payment account. It is responsible for authorizing and processing the transaction on behalf of the consumer: it receives the transaction data from the acquirer and authorizes or declines the payment transaction based on the cardholder's available funds and other factors.
- **Merchant's Bank or Acquirer Bank**: the acquiring bank is the financial institution that processes the transaction on behalf of the merchant and routes it through the card networks to the issuing bank. They are responsible for ensuring that the transaction is authorized and settled.
- **Payment Processor**: within this category it's possible to identify two subcategories which are the **Payment Service Provider (PSP)** and the **Payment Gateway**, working together to process the transactions.
  - Payment gateways collect a customer's personal information and submit it securely to a PSP
  - The PSP then facilitates communication between the merchant's bank account and a customer's bank account, processes the transaction, and informs the merchant's bank account of successful payment.

  Payment processors function as an intermediary between a merchant's bank account and a customer's bank account. In general handling the authorization, processing, and settlement of the transaction. In the case of cloud-based payments, such as through PayPal, the payment processor is represented by Paypal itself.
- **Network (Credit Card Circuit, SWIFT)**: payment network between financial institutions that enables the processing of payment transactions. It's responsible for routing the transaction data between the acquirer and the issuing bank and ensuring the security and accuracy of the transaction. The card network, such as Visa or Mastercard, provides the infrastructure that enables the transaction to take place. Cards are stored virtually in a smartphone through a mobile wallet solution, or can be linked to a cloud-based payment service such as PayPal. This card network ensure that the transaction is secure and that the funds are transferred from the issuing bank to the acquiring bank.

- **Mobile Network Operator**: in some cases, the mobile network operator may be involved in the mobile payment value chain, particularly if the mobile payment is being made through SMS. It may provide the infrastructure that enables the transaction to take place and may also take a fee for their services.

These actors coexist in a stratified way: several layers work together to facilitate and enable the transactions. Examples of them are:

Application: it can be considered as the topmost layer of the architecture and is responsible for providing the user interface and the user experience. It includes applications such as mobile payment apps, digital wallets, and online money transfer services.

Payment processing: responsible for processing and managing the payment transactions. It includes payment gateways, payment processors, and other intermediaries that facilitate the transfer of funds between the payer and the payee.

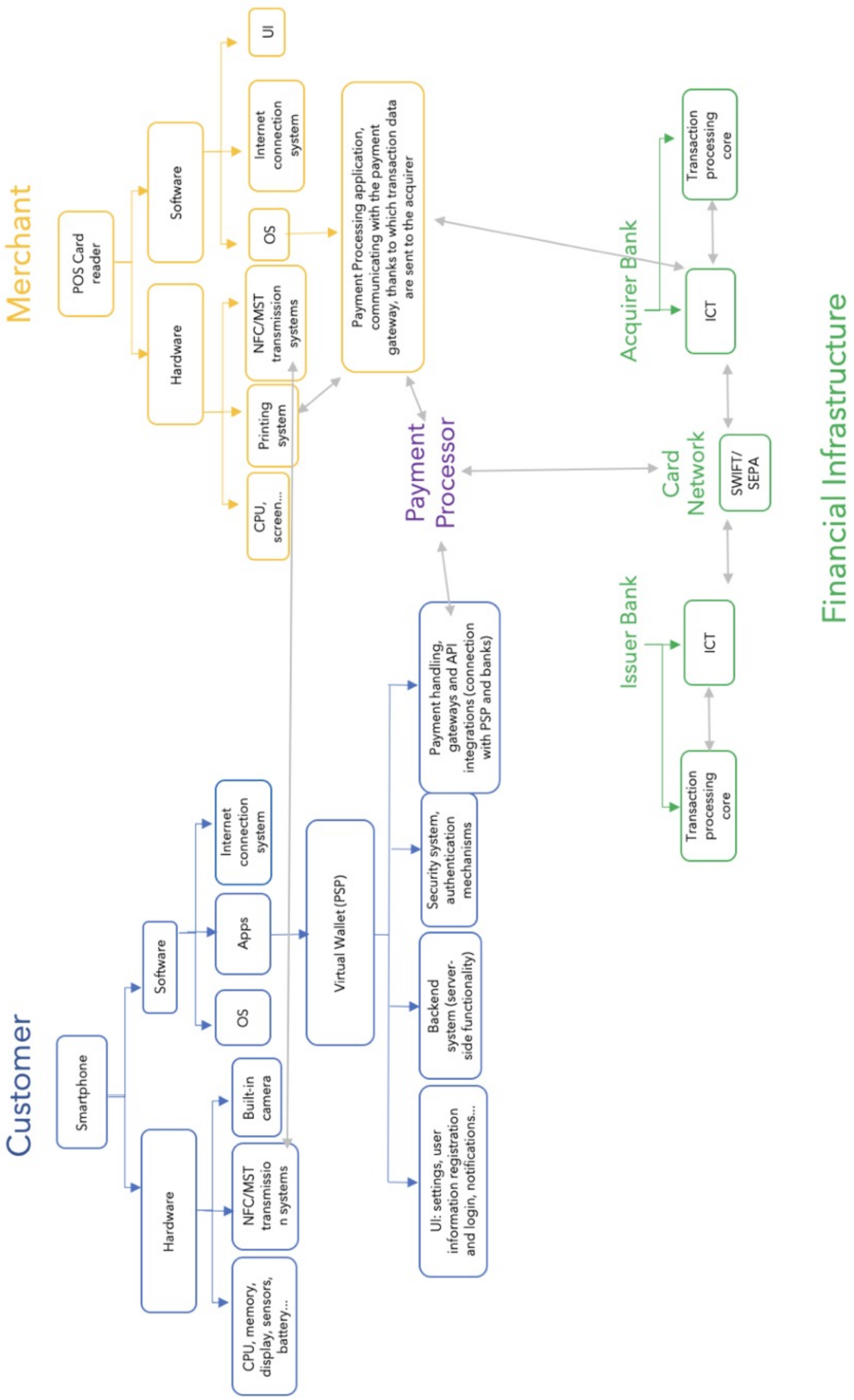
Financial infrastructure: it includes the financial infrastructure that supports the payment transactions, such as banks, card networks, and other financial institutions. It is responsible for clearing and settling the payment transactions, as well as for providing access to funding sources and other financial services.

Network infrastructure: the underlying layer that enables the communication and connectivity between the different components of the architecture. It includes networks such as the internet, cellular networks, and other communication infrastructure.

Again, it's important to underline that, depending on the specific mobile payments solution, actors and layers will vary.

POS Payments: NFC and MST

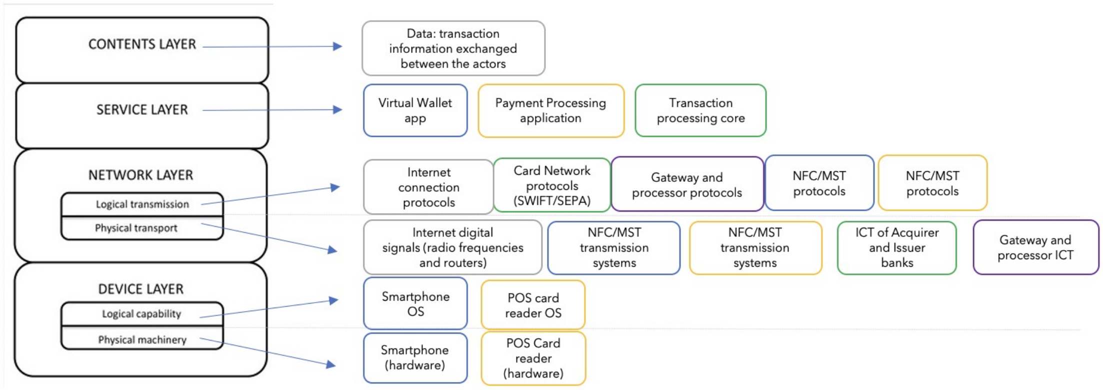
The followings block diagram and layered architecture evaluation diagram refer both to **NFC** and **MST** technology: MST and NFC share the same characteristics.



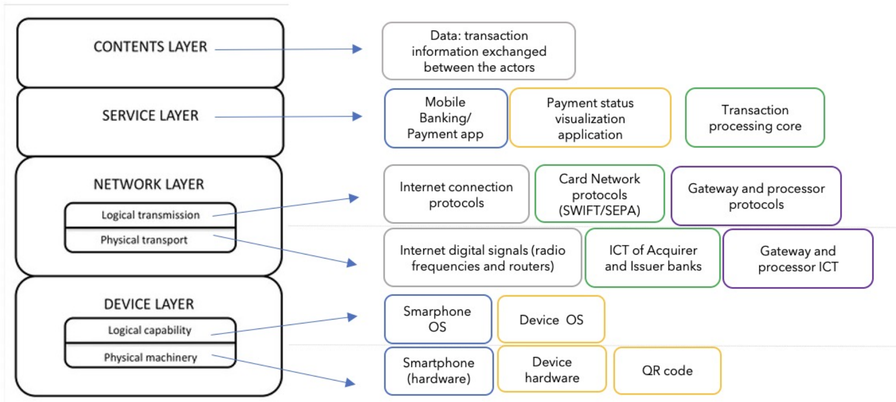
4.3 Layered Architecture Evaluation

Let's consider again the Layered Modular Architecture: analyzing the previously seen block diagram it's possible to detected a correspondence between the constituting elements of mobile payments solutions and this peculiar architecture, as shown in the following graphs.

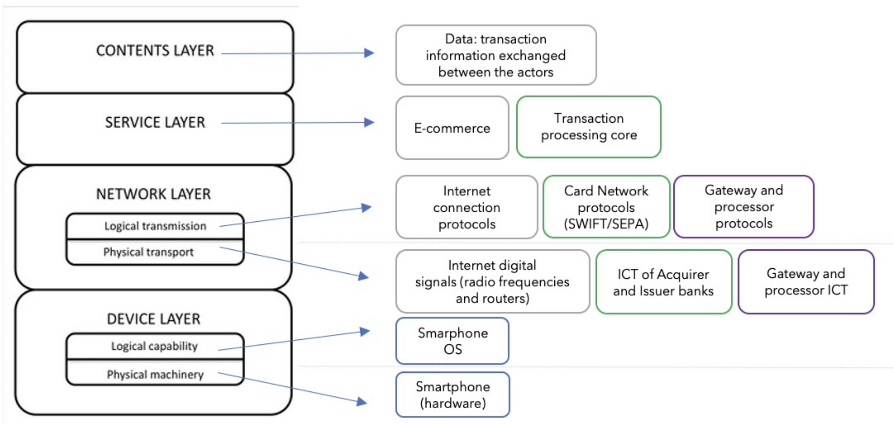
POS Payments: NFC and MST



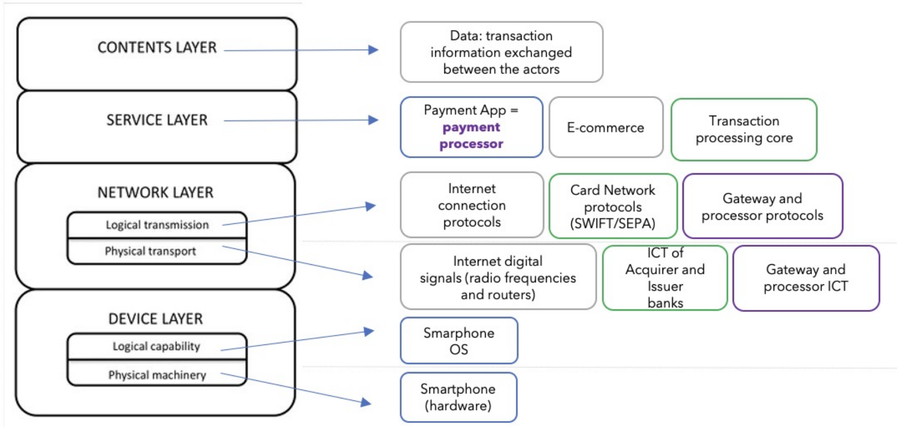
POS Payment: QR Code



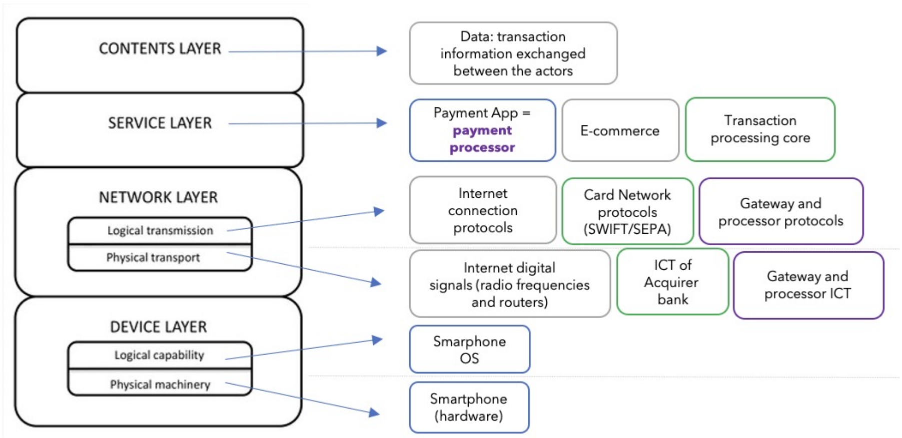
Remote Payment: Debit or Credit Card



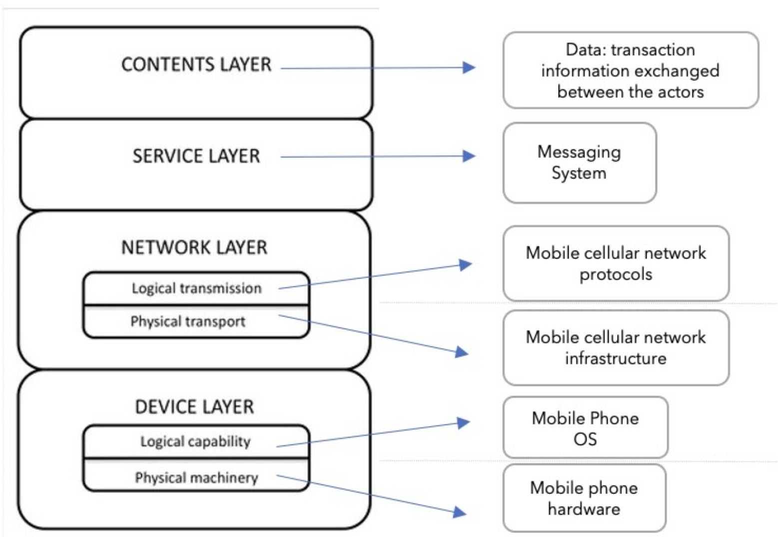
Remote Payment: Debit or Credit Card and Payment App



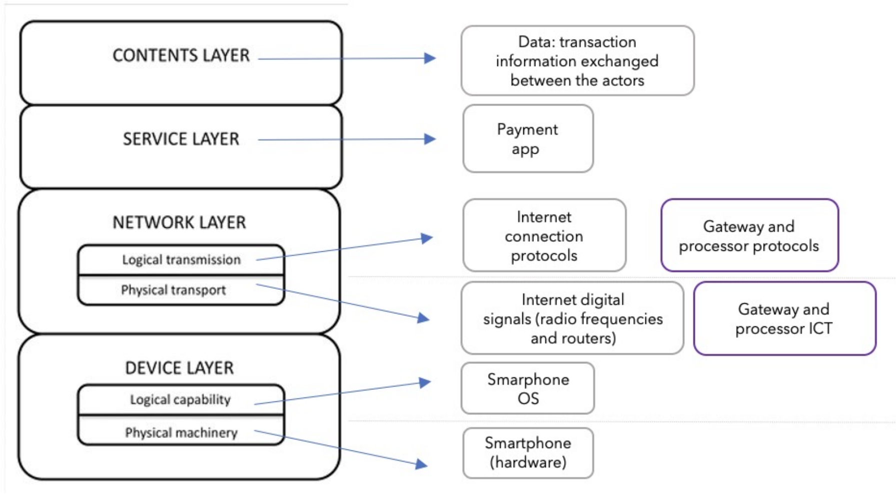
Remote Payment: Payment App balance involvement only



Remote Payment: SMS



Remote Payment: P2P

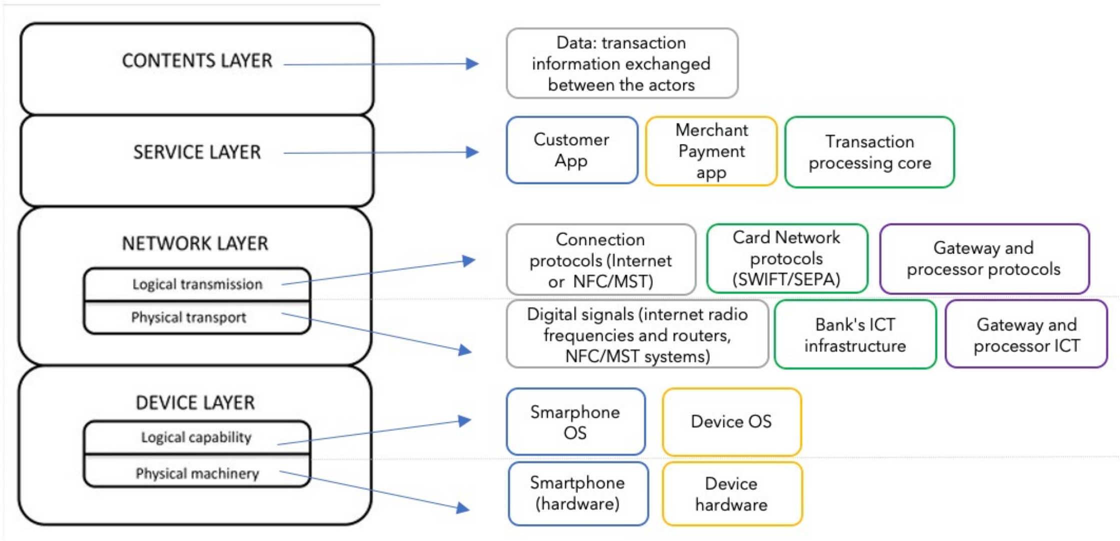


As expected, all the considered mobile payments solutions can be label as layered modular.

4.4 General Scheme

Comparing the **high level systems' models** a general scheme can be extrapolated, signaling a convergence towards a common architecture, excluding the SMS payment method which deviates from all the others, even if can be still labelled as modular layered.

The following scheme is therefore representative of all considered mobile payments solutions with the exception of the SMS one.



Even if, thanks to the analysis conducted, a general scheme is reached, we cannot yet talk of a single emerging dominant design: depending on the specific use case layers will adapt.

The fact that mobile payments are characterized by a layered modular architecture will surely have an impact on the emerging dominant design within the sector.

Multiple layers that can be customized and combined in different ways create different payment solutions. This modularity allows for greater flexibility and innovation in the design and implementation of mobile payment systems, leading to different solutions tailored for different needs, use cases or user groups.

4.5 Summary Table

As the graphs show, **every analyzed mobile payment solution fall into the modular layered architecture**.

In addition, among the four layers the most important is the network one.

Mobile Payment Solutions	**Architecture**	**Most relevant layer**
NFC	Modular Layered	Network Layer
MST	Modular Layered	Network Layer
QR Code	Modular Layered	Network Layer
Debit or Credit Card	Modular Layered	Network Layer
Debit or Credit Card + payment app	Modular Layered	Network Layer
No Debit or Credit Card, only payment app	Modular Layered	Network Layer
SMS	Modular Layered	Network Layer
P2P	Modular Layered	Network Layer

Chapter 5

Profiling the Dominant Designs

From this analysis shown in the previous chapters, **various solutions emerge for different use cases: many technologies and many layers of technology coexist**.

There is no optimal solution compared to others since mobile payments sector is still in a **fluid phase**, in which an intense process innovation is currently happening, with firm experimenting many alternative technical solutions.

Competition, different user preferences and evolving technologies currently result in an ongoing innovation and development within the mobile payment sector.

Perhaps the right question is not which of the competing technologies will win, but how they will interact and co-exist with one another.

Maybe there will be different paradigms for different payments' use cases, after all, from the users' perspective, the kind of technology is almost irrelevant, what matter are things like consumer experience and data security.

The emergence of a dominant design is indeed a chaotic process, with a high degree of ambiguity and uncertainty.

The different competitors will face many challenges in order to become dominant in the market, among the many:

- **Consumer adoption and trust**: the success of mobile payment solutions largely depends on them. Many consumers may be hesitant to adopt payment methods if they have concerns about their security and privacy. Mobile payment providers need to address these concerns by ensuring that their payment systems are secure, and that consumers' personal and financial information is protected.

- **Infrastructure requirements**: mobile payment solutions require a robust infrastructure to enable payments to be processed quickly and securely. This includes payment processing systems, hardware, and networks. In some regions, the infrastructure may not be developed enough to support mobile payments, making it challenging for mobile payment solutions to gain traction.

- **Interoperability between different payment systems**: essential for mobile payment solutions to become dominant in the market. Consumers need to be able to use their preferred payment method with multiple merchants, and merchants need to be able to accept different payment methods. Standardization of payment systems and protocols is necessary to ensure interoperability between different payment systems.

- **Regulatory environment**: it can also be a challenge for mobile payment solutions. Stricter regulations regarding payment processing and financial services can create barriers to entry for mobile payment providers.

- **Competition**: the mobile payment market is an highly competitive one, with many providers offering different payment solutions. Established payment providers such as banks and credit card companies may also offer their own mobile payment solutions, making it challenging for new entrants to gain market share.

- **Merchant adoption**: this is also critical for mobile payment solutions in order to become dominant in the market. Merchants need to be incentivized to accept mobile payments, and mobile payment providers need to ensure that their payment systems are easy to use and integrate with existing point-of-sale systems.

Addressing these challenges will be crucial for mobile payment solutions to become dominant in the market.

To answer the research question underlying this thesis *is there a an emerging dominant design within the mobile payment sector?* other considerations have to be done, taking into account, for each mobile payment's solution, several factors such as:

- **Complementary Assets**
- **Network Externalities**
- **Economies of Scale**
- **Consumers' Requirements**

All together **impacting on the diffusion level** of the mobile payment solutions and on the relative stability for a long time (lock in effect), therefore causing the **emergence of a dominant design**.

5.1 Complementary Assets

Complementary assets are resources or assets that are necessary to fully realize the value of an innovation. They can include a range of resources, such as human capital, financial resources, physical infrastructure, and complementary technologies.

From an innovation theory perspective, the success of an innovation is not just determined by the quality of the innovation itself, but also by the availability and effective utilization of complementary assets. This is because those kinds of resources are often required to support the adoption, diffusion, and commercialization of an innovation: this role highlights the key role of complementary resources to create an environment that enables the innovation to succeed.

Considering now the mobile payment sector, complementary assets can include a various range of resources, playing a crucial role in determining the diffusion level, stability and overall success of varios mobile payment solutions, examples of those assets and the relative impacts are:

- **Mobile devices**: every mobile payment's solution requires mobile devices. For determined technologies it's necessary specific hardware or software to enable mobile payments. The type and quality of mobile devices available on the market can impact on the adoption and usage of different mobile payment solutions.

- **Payment infrastructure**: mobile payments require a robust payment infrastructure to support secure payment transactions and ensure that funds are transferred accurately and efficiently. The availability and quality of payment infrastructure such as payment terminals, point of sale systems, and payment processing networks can impact the stability and reliability of mobile payment solutions. If, for example, payment processing networks are slow or unreliable, it can affect the overall user experience and adoption of mobile payments.

- **Payment processing networks**: Payment processing networks such as Visa and Mastercard, which are widely accepted by merchants, are critical complementary assets for mobile payment providers.

  This is not the case if the payment method does not involve a Card Circuit, as it happens paying through a payment app balance only.

- **Regulatory frameworks**: ensuring the security and privacy of mobile payment transactions, as well as compliance with anti-money laundering and anti-fraud regulations, representing an important complementary asset for mobile payment providers. Different regulations are in place for different countries. Regulations can also impact on the fees charged by financial institutions and mobile network operators and on the interoperability of different payment systems. Clear and favorable regulations can promote the adoption of mobile payments, while restrictive or unfavorable regulations can prevent their growth.

- **Financial institutions**: their involvement can impact on the adoption and usage of mobile payment solutions, providing banking services, such as account management and transaction processing, security and fraud prevention increasing confidence in mobile payments. Additionally, partnerships between financial institutions and mobile network operators or payment app providers can create incentives for users to adopt mobile payments.

- **Mobile network operators**: providing wireless data connectivity and mobile network coverage.

  Essential in the case of SMS payments

- **Merchants**: those who accept mobile payments and provide a seamless payment experience for customers are important complementary assets for mobile payment providers.

- **Marketing and distribution channels**: an effective marketing and distribution channel, such as a mobile app, social media, and partnership with other companies, represents an important complementary asset for mobile payment providers in order to reach potential customers and increase adoption rates.

Considering the different mobile payment solutions, the above complementary assets impact differently:

- **POS Payments (NFC, MST, QR code)**
  - NFC or MST payments require devices enabled to support such technologies capabilities. NFC payments require devices with NFC chips, MST payments require devices with magnetic stripe readers, the availability of compatible devices can limit the diffusion of these solutions.
  - Merchant adoption appears to be critical too since they need to be equipped with compatible POS terminals to accept such payment methods.
  - On the other hand, QR code payments can work on almost any smartphone with a camera and internet connectivity, making them accessible to a wider audience.
  - Payment infrastructure that supports NFC, MST, and QR code payments is necessary for these payment methods to be accepted at merchants.
  - Payment processing networks are also essential to ensure that transactions are processed quickly and securely, which is important for the stability of these payment methods.
  - Regulatory frameworks that support contactless payments can also encourage the adoption of NFC, MST, and QR code payments.
- **Remote or Cloud-Based Payments (Debit or Credit Card Payment)**
  - Financial institutions play a crucial role in supporting remote or cloud-based payment methods by issuing credit and debit cards and providing secure payment processing.

  - Mobile network operators can also support these payment methods by providing connectivity and enabling mobile payments through mobile carrier billing.
  - Marketing and distribution channels can also play a role in promoting these payment methods to consumers and merchants.

- **Payment App Payments**
  - Payment apps (like PayPal) rely on mobile devices and payment infrastructure to function. The widespread adoption of smartphones and mobile internet is crucial for the diffusion of these payment methods.
  - Financial institutions that support such payment apps, like banks and credit card companies, are also important for the stability of this payment method.
  - Merchants who accept payment apps' payments are necessary for this payment method to be widely used.

- **SMS Payments**
  - Mobile network operators play a crucial role in supporting SMS payments by providing connectivity and enabling mobile payments through carrier billing.

- **P2P Payments**
  - Payment apps that support P2P payments rely on mobile devices and payment infrastructure to function. The widespread adoption of smartphones and mobile internet is crucial for the diffusion of this payment method.
  - Financial institutions that support P2P payments, such as banks and credit card companies, are also important for the stability of this payment method.
  - Marketing and distribution channels can also play a role in promoting P2P payment apps to consumers.

A question arises: with these consideration, is it possible to define which mobile payment solution appears as the most favored by the relative complementary assets?

It's difficult to answer, as it depends also on other factors such as consumer preferences, regulatory environment, and the level of infrastructure development in a particular region or country.

Each mobile payment solution has different complementary assets, and many complementary assets are common to different mobile payment solutions. However, some mobile payment solutions have gained more popularity than others in recent years. For example, payment app such as PayPal, and P2P payments have gained significant traction due to their convenience and ease of use.

Contactless POS payments using NFC, MST, and QR code have also become more popular, especially in regions with a higher level of infrastructure development and merchant adoption. Additionally, the standardization of payment systems and protocols has enabled interoperability between different payment systems, making it easier for consumers to use different payment methods with different merchants.

Remote or cloud-based payments using debit or credit cards are also widely accepted and used, particularly in developed countries, favoured by the availability of payment processing networks, financial institutions and mobile network operators. These payment methods benefit from the stability of established payment processing networks and financial institutions, ensuring that transactions are secure and reliable.

SMS payments, on the other hand, have seen limited adoption due to security concerns and the availability of other more convenient payment methods, in general this last payment method is mostly adopted in unbanked regions such as sub-Saharan Africa.

The success of a mobile payment solution will depend on its ability to leverage the relative complementary assets.

5.2 Network Externalities

Network externalities influence exists when the perceived value of the service or the product increases as the number of users increases (Economides 1996). In the case of a product-service, network effects can lead to the adoption of a dominant design that is widely used and accepted by the market.

In mobile payments, the more merchants and consumers use a specific mobile payment service, the more valuable the service becomes to other merchants and consumers. This dynamic creates incentives for companies to adopt a widely used service design, making it more likely for a dominant design to emerge.

Network externalities explain how the utility of the product or service in question is linked to the number of its buyers.

Going more in detail, there are three types of network externalities that explain such relationship:

- **Direct Network Externalitiey effect**: felt directly as the number of users or customers for a product or service rises.
  - In the context of mobile payments: the value of a specific solution increases as more consumers and merchants adopt it, leading to a larger network and more opportunities for transactions.
  - Direct network externalities can create a virtuous cycle of adoption, where more users lead to more merchants accepting the payment method, which in turn attracts more users.
  - In terms of direct network externalities, payment solutions that are widely accepted by merchants and have a large user base, such as contactless payments using NFC, and remote or cloud-based payments using debit or credit cards, are more favored.
- **Positive influence**: felt directly as the user becomes able to interact with a larger number of users.
  - The size of the network contributes to the convenience of using a particular mobile payment solution since users can transact with a larger number of merchants or individuals.
- **Indirect effect of network**: felt as a result of an increment in product/service utility induced by the increment of the number of users. Network externalities also have an indirect effect that can be felt by the user as the increase in the number of buyers causes an improvement in the availability and quality of after sale services (Katz and Shapiro 1985).
  - The value of a mobile payment solution can also increase as more complementary products and services are developed around it. For example, the availability of loyalty programs or incentives for using a particular mobile payment solution can increase its attractiveness to consumers.
  - The availability of payment processing networks and infrastructure can also contribute to the adoption of mobile payment solutions since it becomes easier for merchants to accept the payment method.
  - In terms of indirect network externalities, payment app payments such as PayPal and P2P payments have gained significant traction due to their convenience, ease of use, and the availability of complementary products and services, such as loyalty programs and incentives for using a particular payment method.

Again, the question now is: with these considerations, is it possible to define which mobile payment solution appears as the most favored by the relative network externalities' support?

It's difficult to answer, other factors such as consumer preferences, regulatory environment, and the level of infrastructure development are involved. However, some mobile payment solutions have gained more popularity than others in recent years.

While **remote payments seem to be more mature than proximity payments**, as the earlier enjoy a larger more flexible market and the later suffer from time and place restrictions, both types can be integrated to improve the future market of mobile payment technology. The later can only be used within a close range of the point of sale (Gilje 2009).

Nonetheless, POS payments such NFC and MST, and remote payments involving debit/credit card or payment apps appear to be the most favored mobile payment solutions, based on the relative wide and well developed usage: these payment methods benefit from strong direct and indirect network externalities, contributing to their diffusion and stability.

5.3 Economies of Scale

When one design becomes dominant, firms may specialize in producing components or services that are compatible with that design. This can lead to economies of scale that make it more efficient for firms to continue using that design, further reinforcing its dominance.

Economies of scale are in fact cost advantages raised by companies when production becomes efficient, increasing the scale or size of its operations.

In the context of mobile payments, there is still no dominant design, yet is possible to identify various economies of scale that can be realized by mobile payment providers as they increase the number of users and transactions they process. The following economies of scale may play an important role in the emergence of such design.

- **Infrastructure Costs**: as the number of users and transactions increases, mobile payment providers can spread their fixed infrastructure costs, such as developing and maintaining payment processing systems and servers, over a larger number of transactions. This can lead to lower average costs per transaction, resulting in economies of scale.
- **Marketing Costs**: mobile payment providers can also benefit from economies of scale in marketing costs. As the number of users and transactions increases, the cost per user of marketing and advertising campaigns can decrease. This is because the cost of developing and executing marketing campaigns can be spread over a larger number of users.
- **Customer Service Costs**: like the previous two, as the number of users and transactions increases, this cost per user of providing customer service can decrease. This is because the cost of hiring and training customer service representatives can be spread over a larger number of users.
- **Negotiating Power**: mobile payment providers that have a large user base and process a high volume of transactions can have more negotiating power with merchants and other stakeholders in the mobile payment ecosystem. This can lead to better pricing and terms for the mobile payment provider, resulting in lower costs and higher profits.

Mobile payment solutions that can achieve economies of scale in infrastructure, marketing, customer service, and negotiating power can lower their costs, offer more competitive pricing, and improve their profitability. This can lead to greater adoption of their payment solution and a more stable position in the mobile payment market.

It is difficult to determine which mobile payment solution is the most favored in absolute terms, in general **remote payments such as debit or credit card payment, and payment app payments such as PayPal appear to be quite favored by the economies of scale** in various areas, including infrastructure costs, marketing costs, customer service costs, and negotiating power, contributing to their diffusion and stability.

The larger number of transactions in remote payments gives merchants and payment providers greater negotiating power with financial institutions and payment processing networks, leading to lower transaction fees and other costs.

	2017	2019	2020	2021	2022
Credit card (incl. "charge card" since 2021)*	40%	39%	38%	40%	40%
Debit card	35%	34%	29%	30%	31%
E-wallet, Digital/mobile wallet	3%	6%	10%	11%	12%
Cash	16%	15%	12%	11%	12%
Prepaid card	2%	2%	4%	4%	3%
POS financing*	-	-	4%	-	1%
Retailer/bank financing (split off from "POS financing" in 2021)*	-	-	-	4%	-
Buy Now, Pay Later (split off from "POS financing" in 2021)*	-	-	-	1%	-
Charge card*	4%	4%	4%	-	-

Figure 5.1. Market share of cash, credit cards, and other payment methods at POS, USA 2017, 2019, 2020, 2021, 20221. Source: Statista Report 39303 " Mobile Payment usage worldwide" (2022).

5.4 Consumers' Requirements

As mobile payments become more common and widely used, consumers are becoming more accustomed to certain features and functionality, such as digital wallets and biometric authentication.

This can lead to a design that is favored by consumers: preferences and needs of customers play a role in the emergence of a dominant design, if in fact customers prefer certain features or design elements, firms may adopt those features to satisfy customer demand, leading to the emergence of a specific, and dominant, design.

Service design and architecture can play a significant role in the adoption and usage of mobile payment services among consumers. Here are a few ways that service design and architecture can affect adoption and usage:

1. **User experience**: a well-designed and intuitive user interface can make mobile payment services more appealing to consumers, making it easier for them to navigate and understand the service. This can lead to higher adoption and usage rates: usability is the key to high conversion rates and consumer adoption.

2. **Convenience**: a service that is easy to use and integrates seamlessly with other tools and services that consumers already use, such as banking apps and digital wallets, can be more convenient for users and lead to higher adoption and usage rates.

3. **Security**: a mobile payment solution designed and built with robust security measures demonstrates a reliability which is sought after by consumers, leading to increased adoption and usage.

4. **Reliability**: stability and reliability of a service can increase users' trust, encouraging them to use the service more frequently, leading to higher adoption and usage rates.

5. **Personalization and customization**: both provide a better user experience for consumers and increase adoption and usage.

6. **Integration with existing infrastructure**: integration with infrastructure such as payment networks and gateways, can increase security, decrease costs and make the service more widely available. Seamless integration of payment processes has relevance in every context, be it online shopping, in-store purchases or peer-to-peer payments.

7. **Accessibility**: designing mobile payments services to be accessible to all users, regardless of their physical abilities, age or background can increase adoption and usage.

These seven elements can play a critical role in driving adoption and usage of mobile payment services among consumers. Service that are intuitive to use, easy to access, reliable, secure, and personalizable will tend to have higher adoption rates. Additionally, services that are integrated with existing infrastructure, and accessible to all types of users will tend to be more widely adopted.

Chapter 6

Conclusions

This thesis provides an analysis of the mobile payment sectors with the aim of defining the future emergent dominant design.

Thanks to the modelling of the architecture of the various solutions, conducted in the third chapter, it was possible to identify a general scheme. Still, we cannot yet talk of a single emerging dominant design: depending on the specific use case the layers which make up the modular layered architecture of the mobile payment solutions will adapt.

Indeed, the fact that mobile payments are characterized by a layered modular architecture will surely have an impact on the emerging dominant design within the sector.

The layered modular architecture of mobile payment solutions allows for a high degree of flexibility and customization, making it difficult for a single dominant design to emerge: multiple layers that can be customized and combined in different ways create different payment solutions. This modularity allows for greater flexibility and innovation in the design and implementation of mobile payment systems, leading to different solutions tailored for different needs, use cases or user groups.

Alternatively, a dominant design could emerge that provides a common framework or set of standards for the various layers of the mobile payment system. This could help to reduce complexity and increase interoperability between different payment solutions, making it easier for merchants and consumers to use and adopt mobile payments. Still, this possibility appears less probable.

A single dominant design will hardly emerge: the layered modular architecture of mobile payments provides both opportunities and challenges for such emergence. While it allows for greater flexibility and innovation, it also creates complexity and fragmentation, making it difficult to establish a single dominant design.

More realistically, the analysis conducted suggest that POS payments and remote payments transaction will be served by different mobile payment methods.

Thanks to the considerations made in the fourth chapter regarding complementary assets, network externalities, economies of scale and consumers' requirements it is possible to identify which solutions, among the many, are the most favorable: those that are most widely adopted, easy to use, and with lower transaction costs face a better projection.

It is important to note that different regions may have different preferences based on existing infrastructure and consumer habits. Based on the current trends, a few mobile payment solutions, depending on the use case considered, stand out:

POS Payments

- **NFC** (Globally): NFC-based payment methods like Apple Pay, Google Pay, and Samsung Pay are becoming increasingly popular due to their ease of use and compatibility with most modern smartphones and POS systems. This technology has a strong network effect, as more consumers and merchants adopt the system, the value of using NFC payments increases.
- **QR code** (Asia): QR code-based payment solutions like Alipay and WeChat Pay have gained significant traction, particularly in Asia. These systems are easy to use, require minimal hardware investments for merchants, and have low transaction costs. The popularity of these platforms has led to strong network externalities, with many consumers and businesses adopting them for daily transactions.

To foster a mobile payment solution, the necessary complementary assets such as a widespread network of merchants and consumers, compatible devices, and financial institutions' support are crucial. NFC and QR code-based payments have the advantage of being easily integrated into existing point-of-sale (POS) systems.

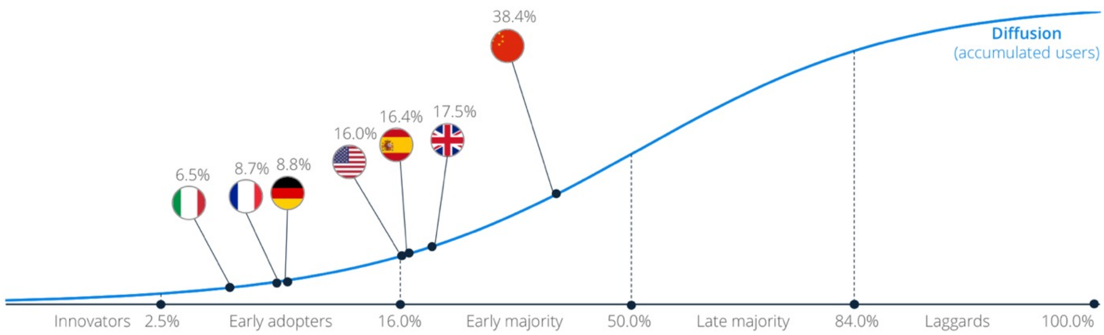


Figure 6.1. Innovation diffusion curve, penetration rate of POS payments for selected countries, 2020. Source: Statista Report 41122, Fintech Report 2021,Digital Payments.

Remote Payments

- **Payment app** (Globally) e.g., PayPal, Venmo, and Cash App: these services have seen widespread adoption due to their ease of use, low transaction fees, and integration with other online services. Due to the advantages of such mobile payment solutions a strong and growing user base is establishing, over and over profiting by the consequent network externalities effect: as more people join these platforms, the value of being part of the network increases.

In conclusion, NFC, QR code-based payments, and remote payment app solutions seem to be the most favorable mobile payment solutions due to their strong complementary assets, network externalities, economies of scale, and consumers' requirements considerations, leading the way and showing the potential of becoming dominant in the market.

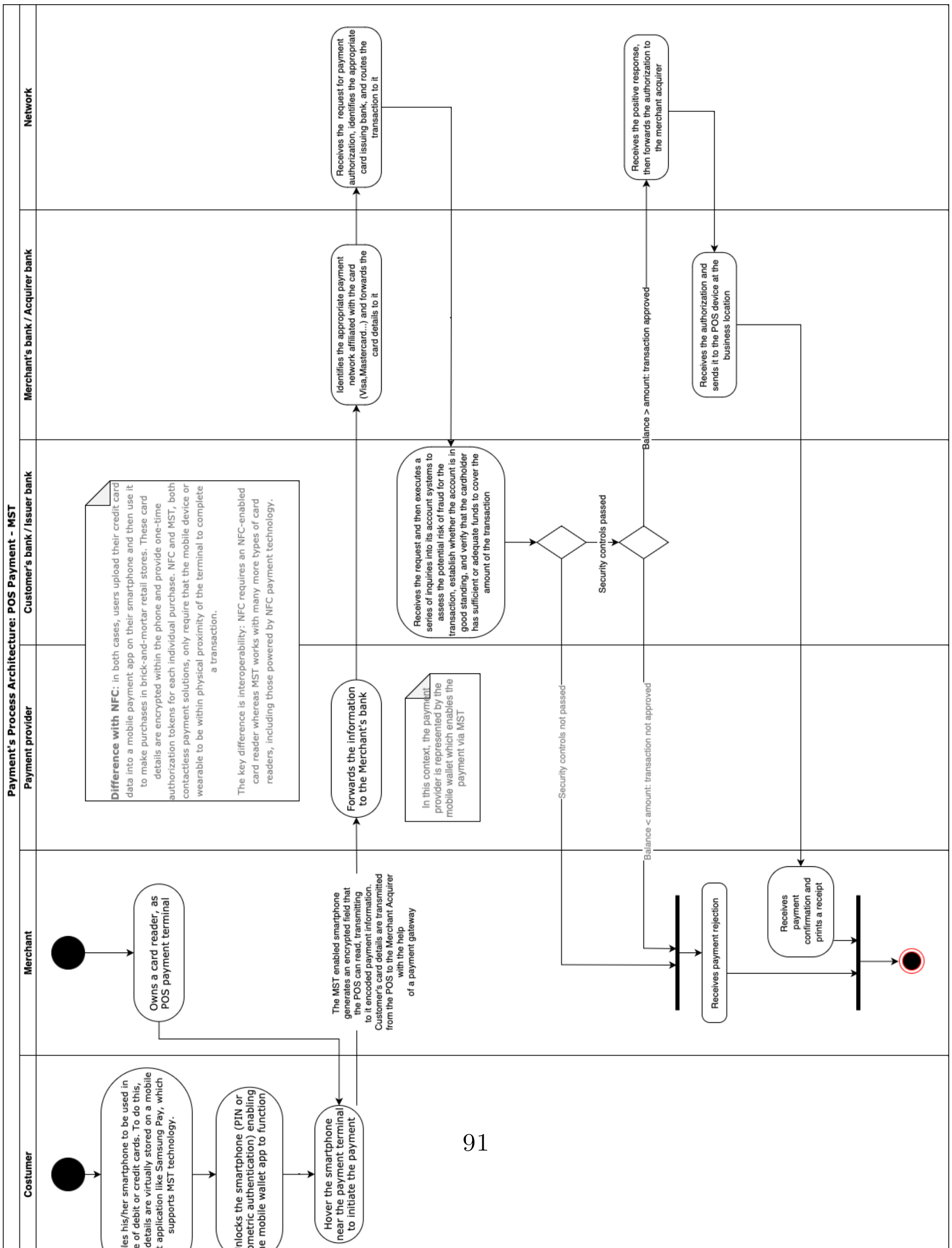
However, it is essential to note that the mobile payment landscape is constantly evolving, and new technologies and solutions may emerge that could disrupt the current state of the market.

Chapter 7

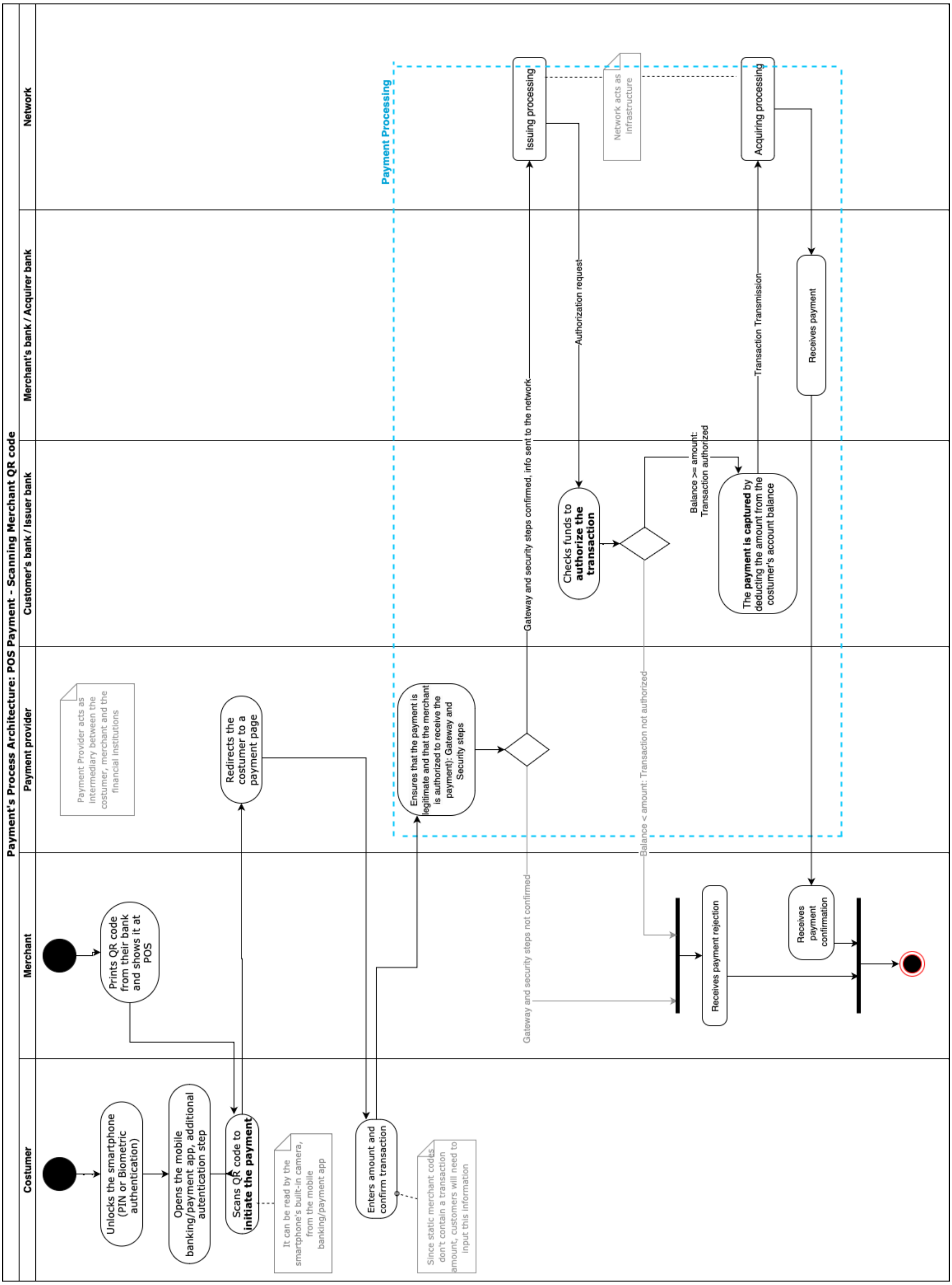
Appendix

7.1 Swim Lane Diagrams

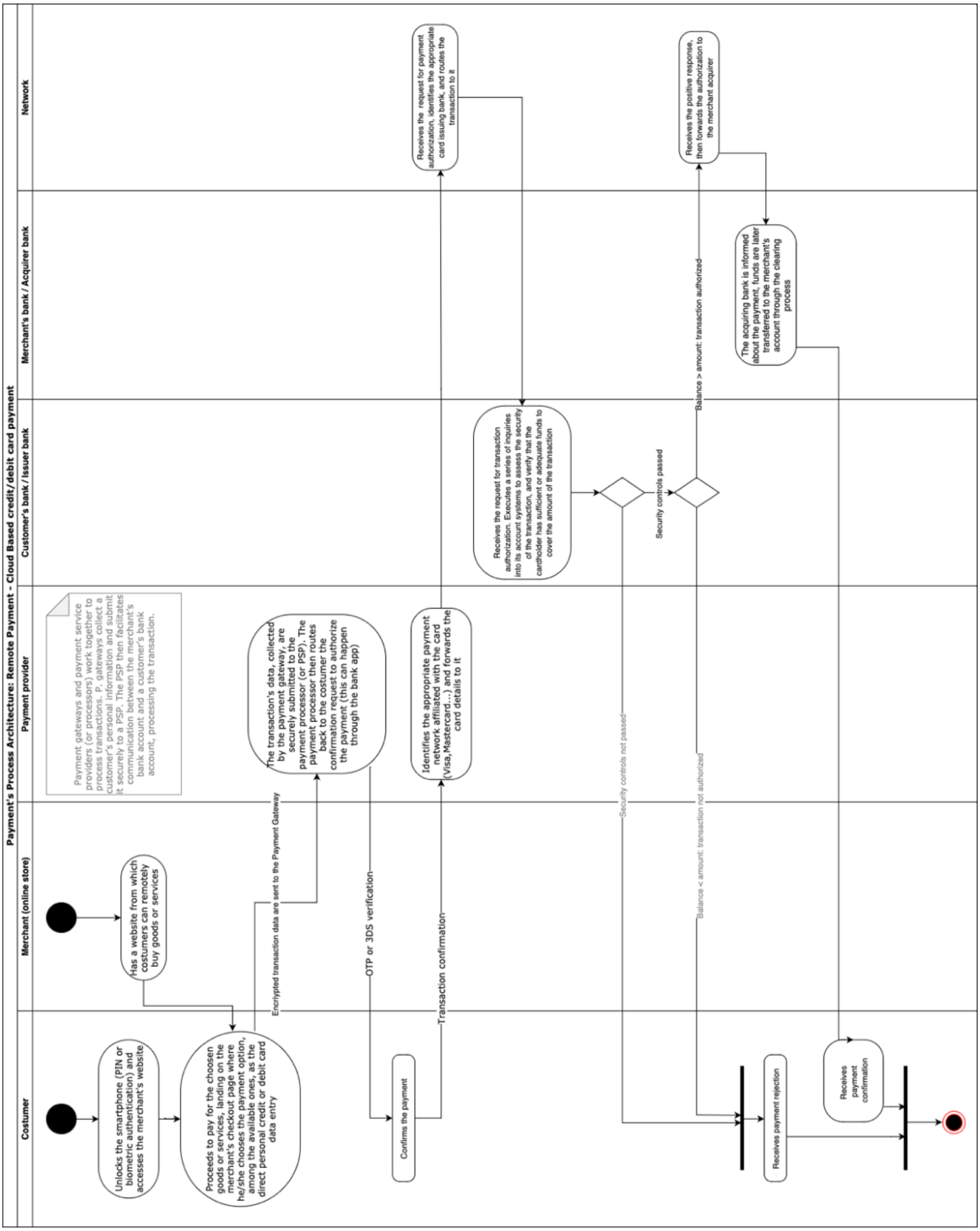
POS Payment: MST



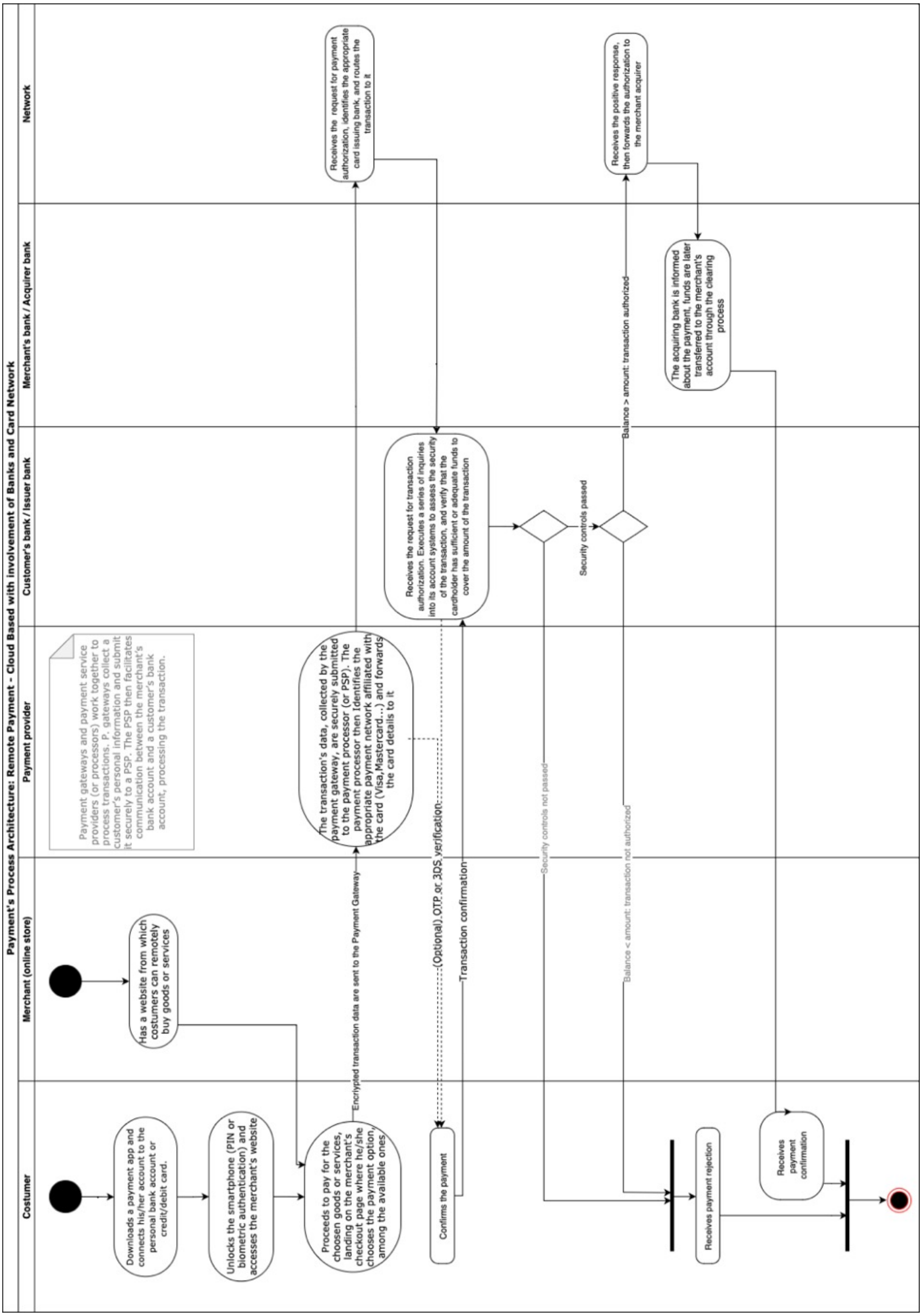
POS Payment: QR Code



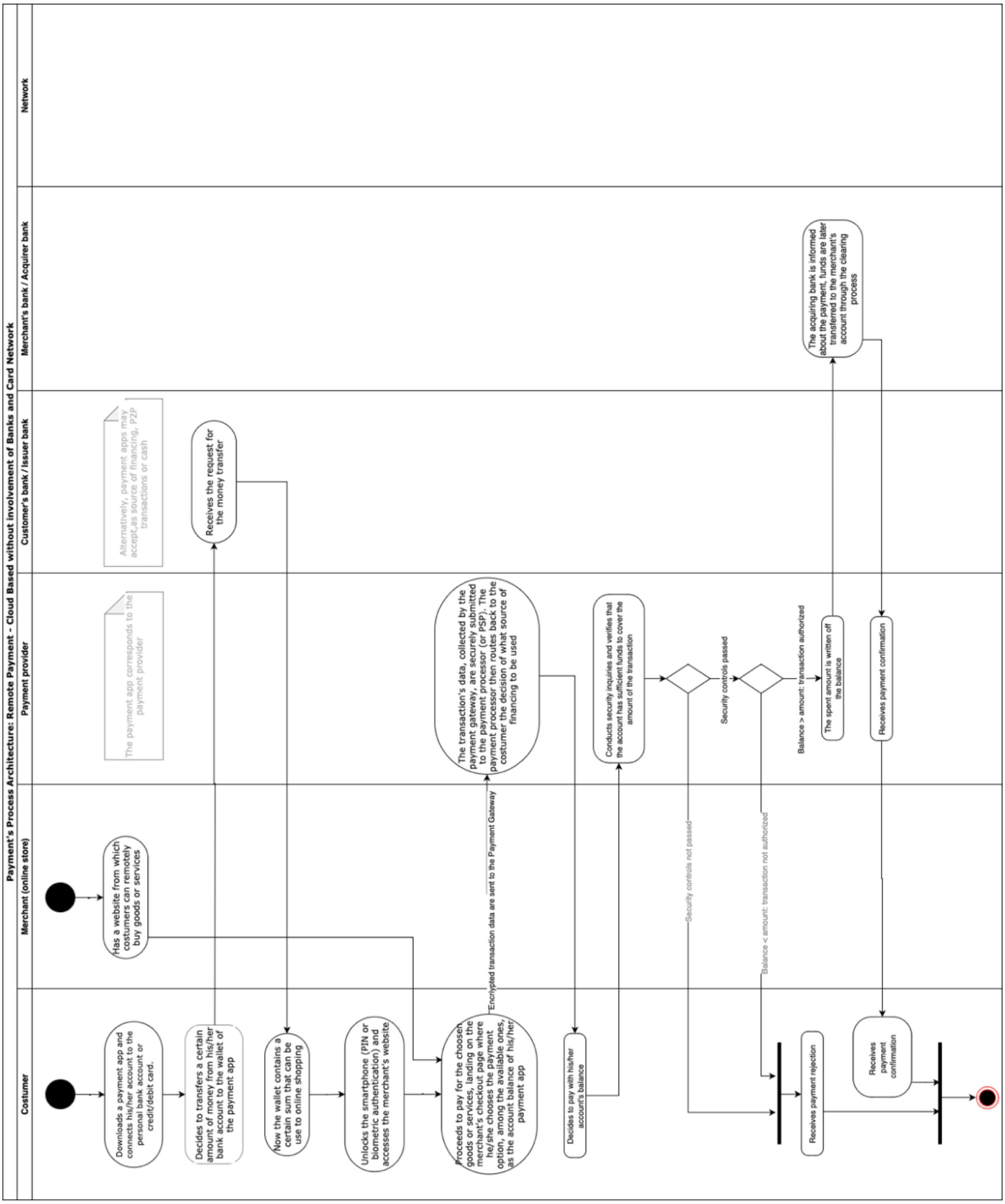
Remote Payment: Debit or Credit Card



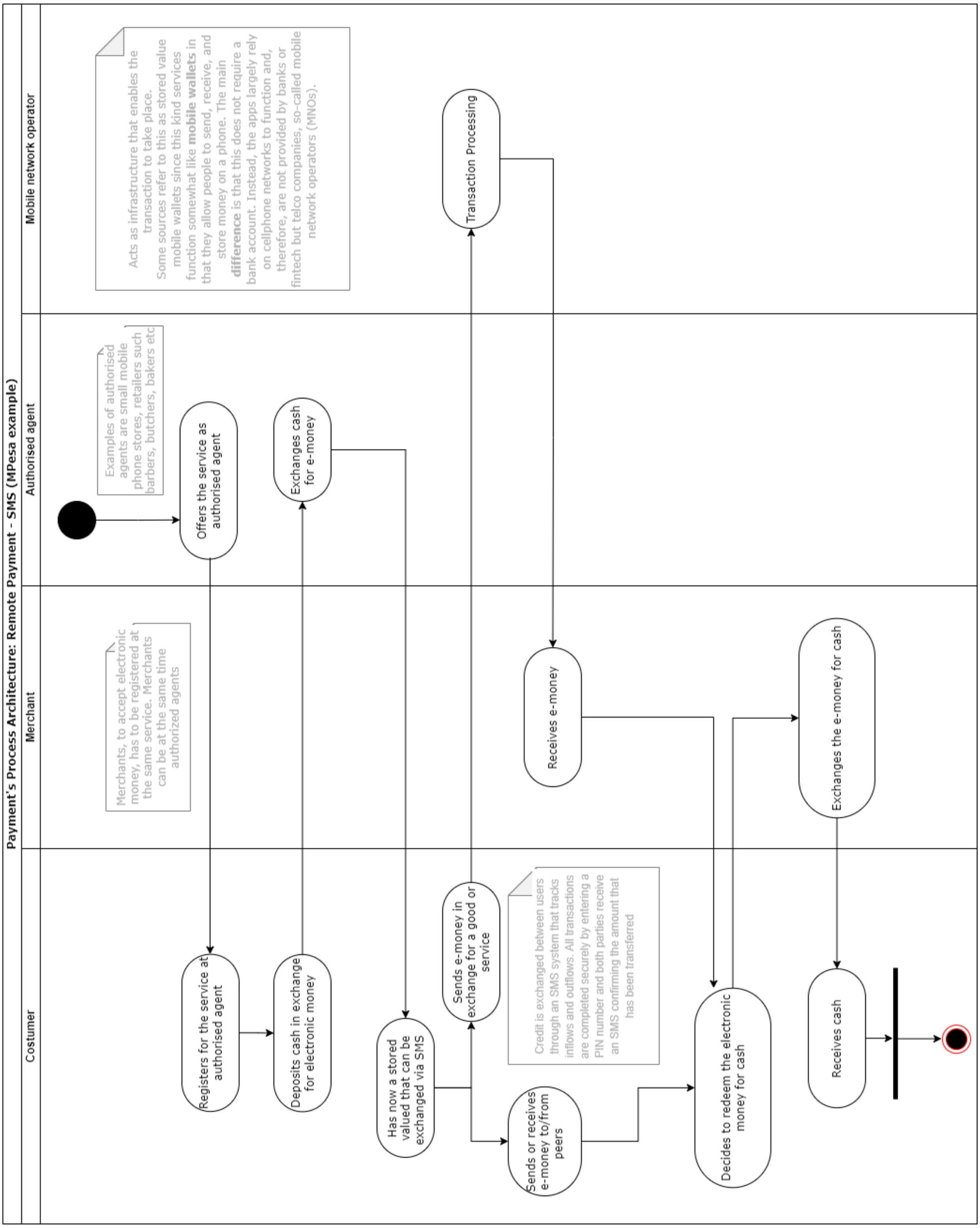
Remote Payment: Debit or Credit Card and Payment App



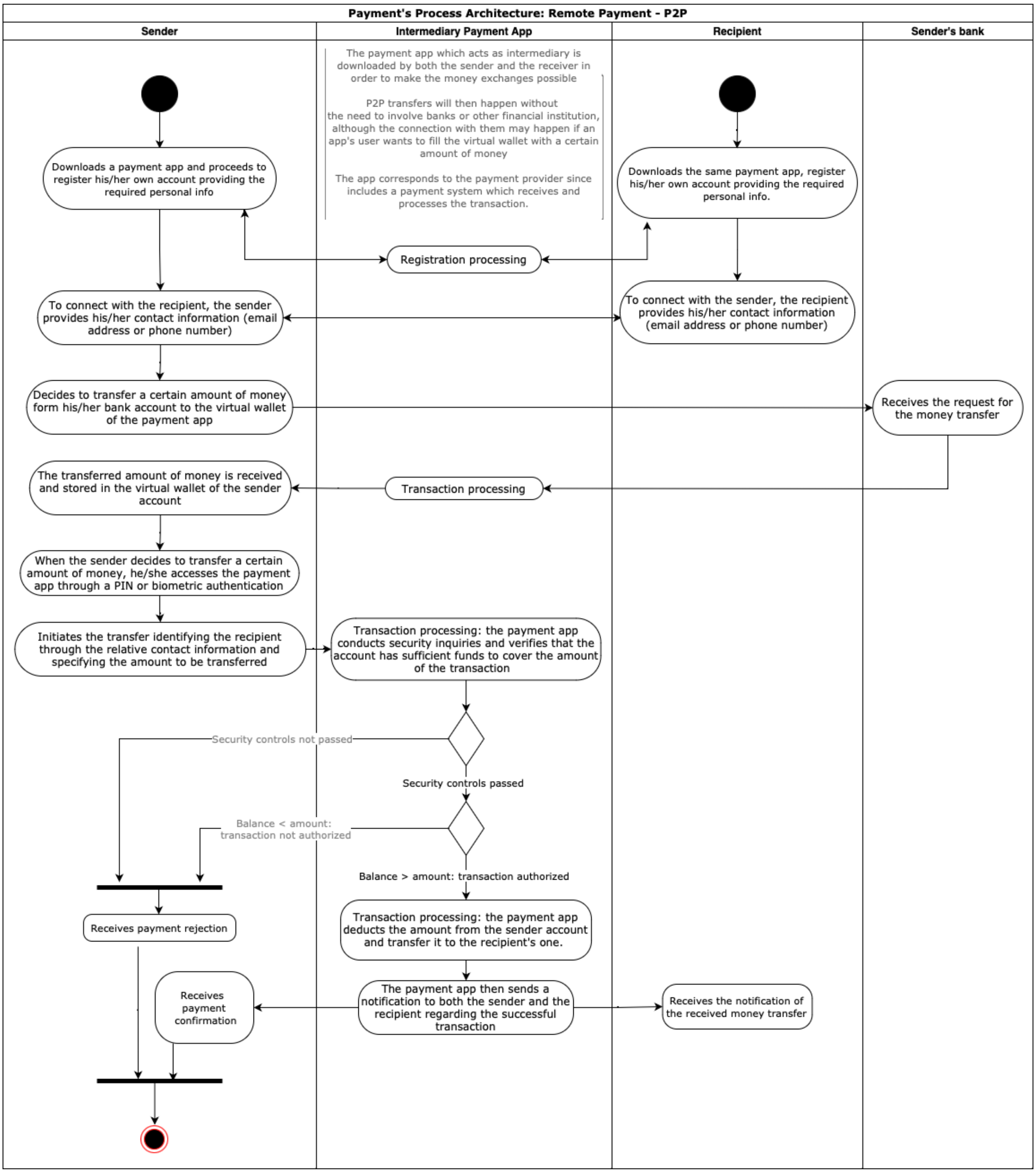
Remote Payment: Payment App balance involvement only



Remote Payment: SMS

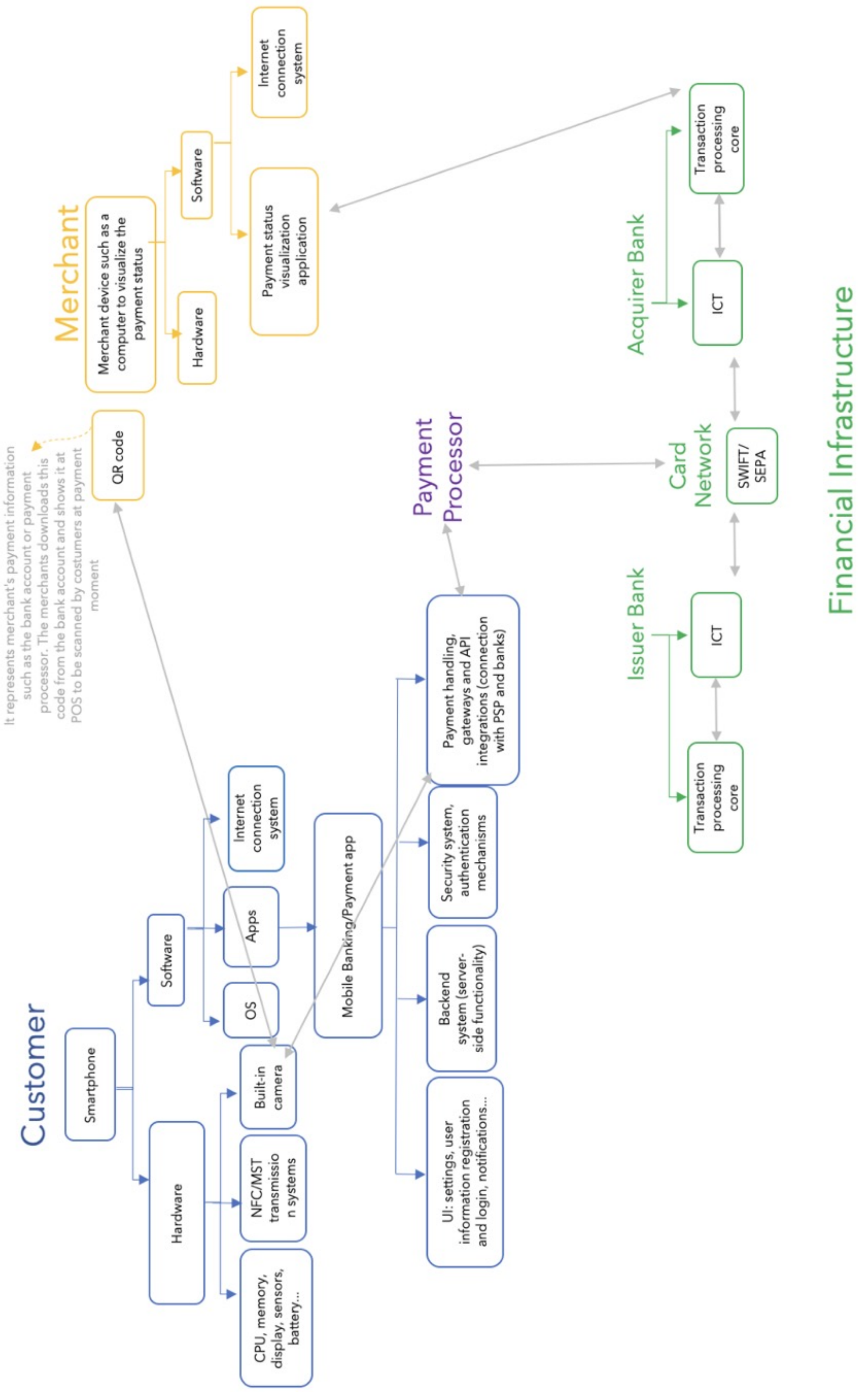


Remote Payment: P2P

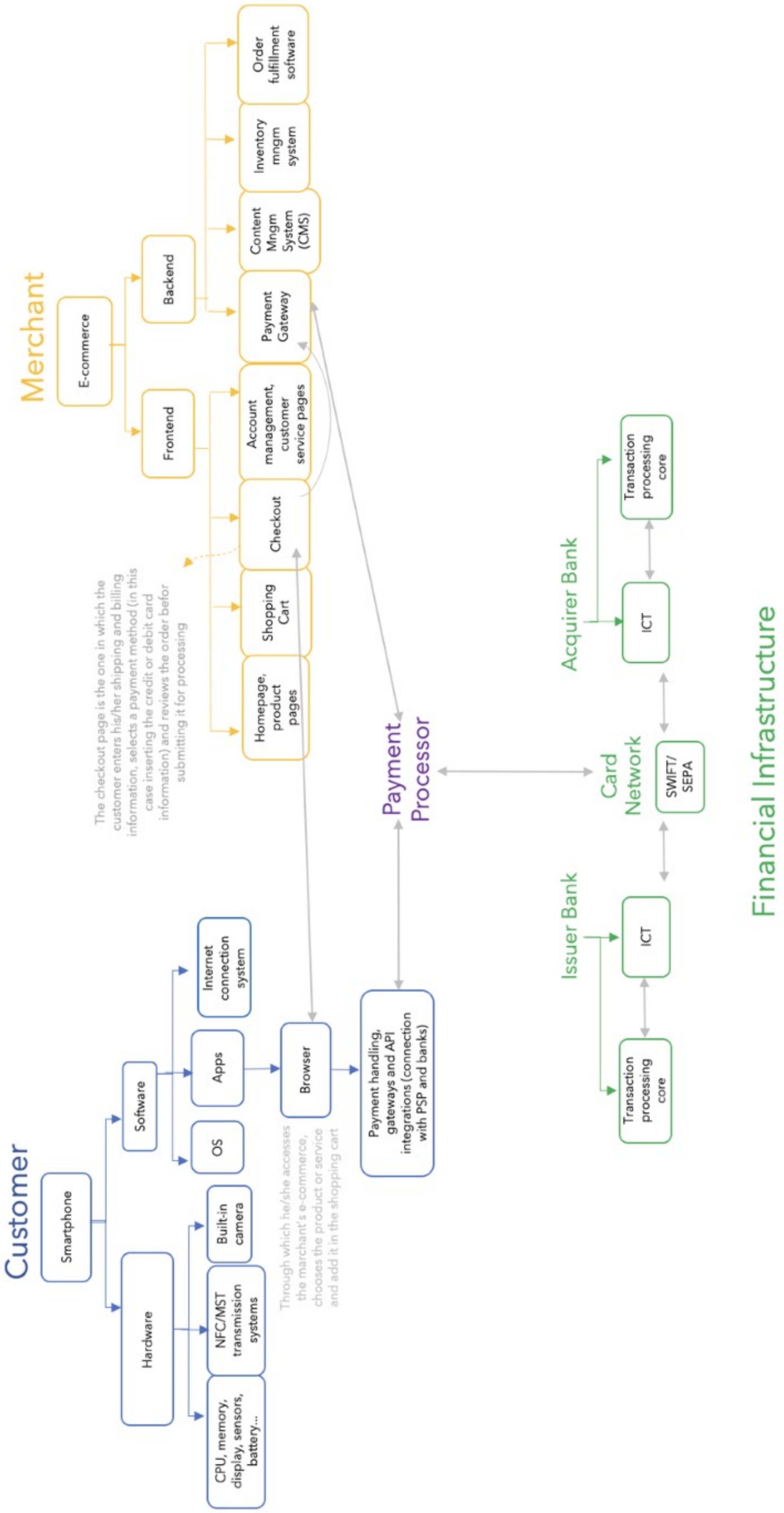


7.2 Block Diagrams

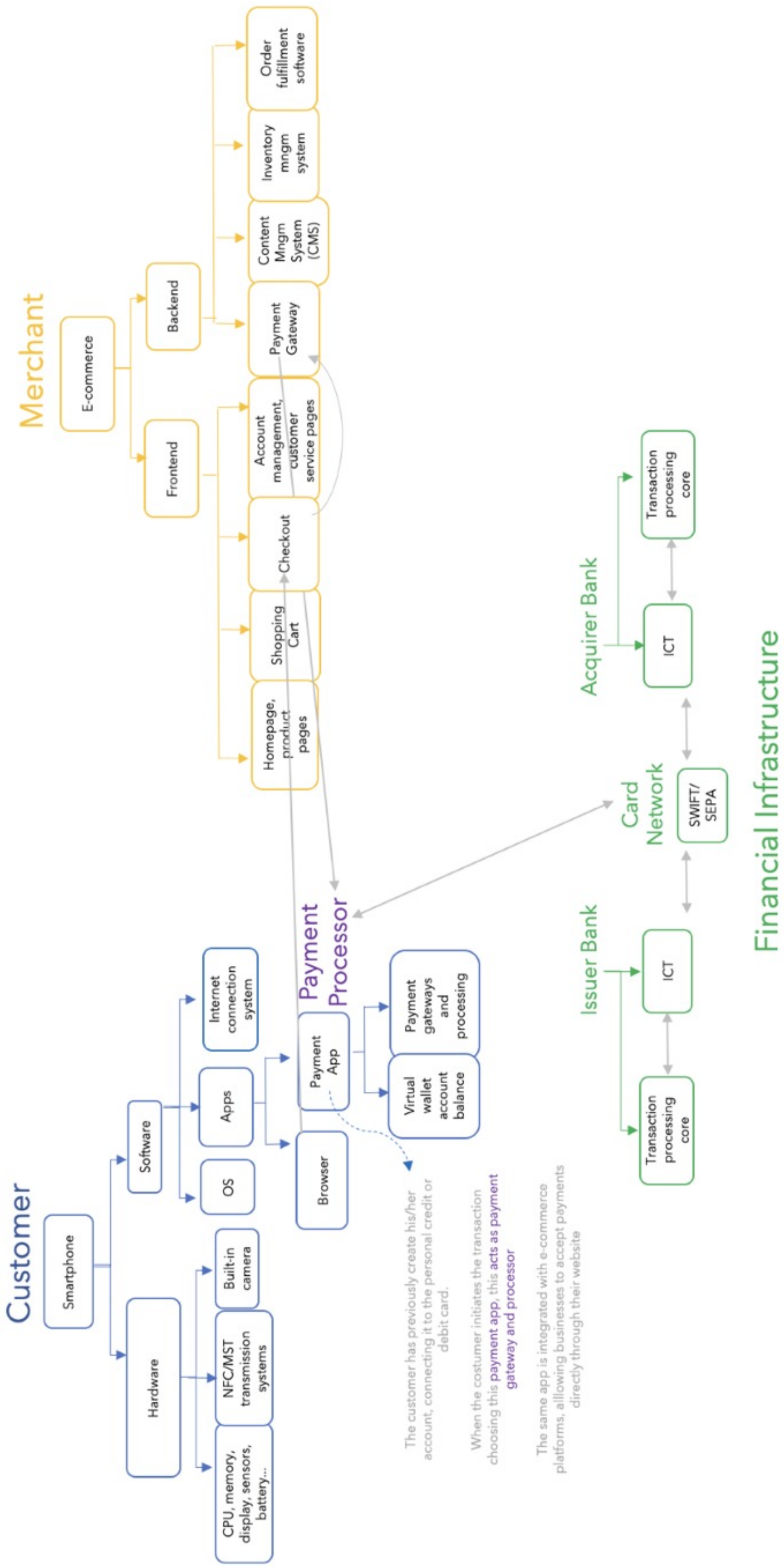
POS Payment: QR Code



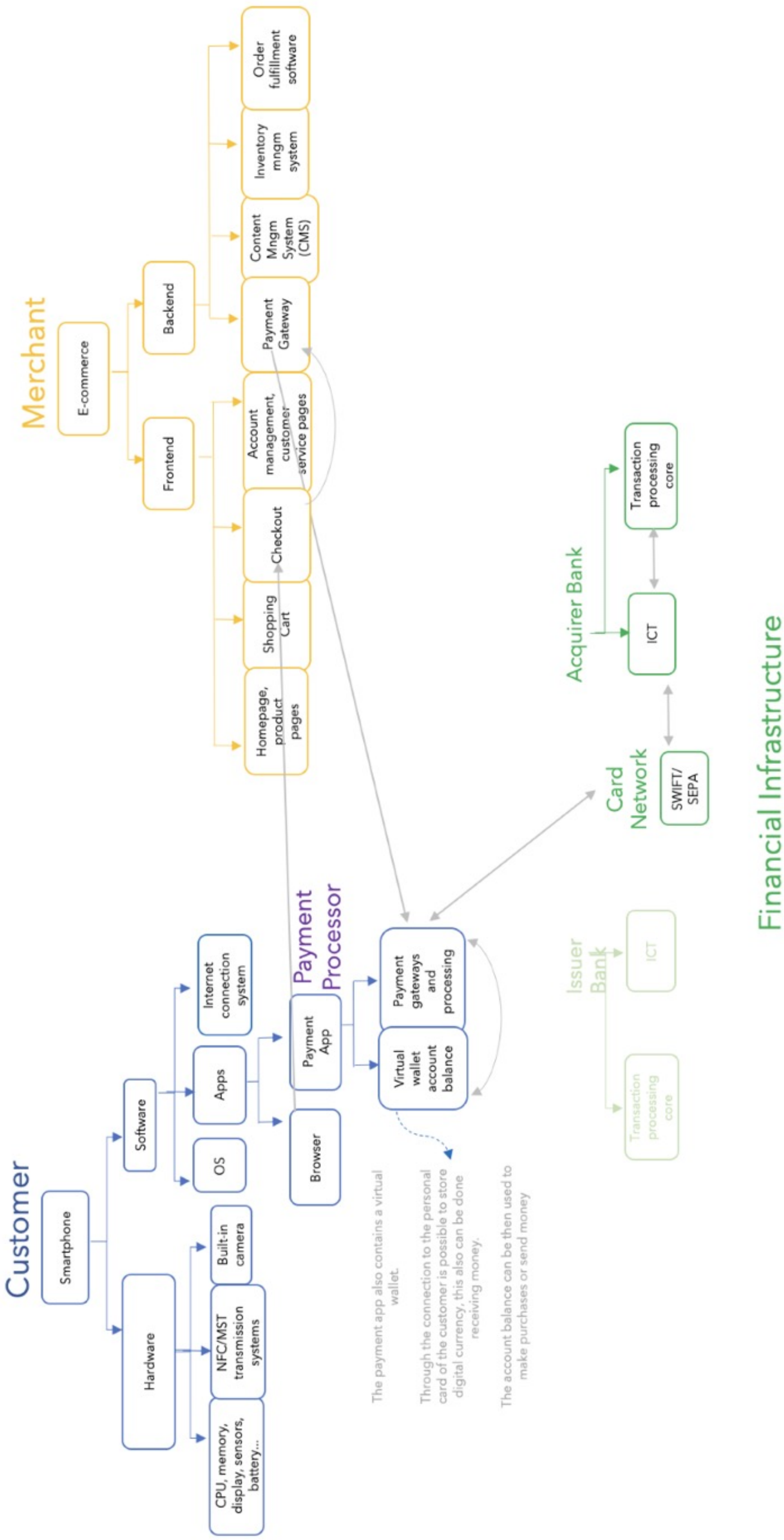
Remote Payment: Debit or Credit Card



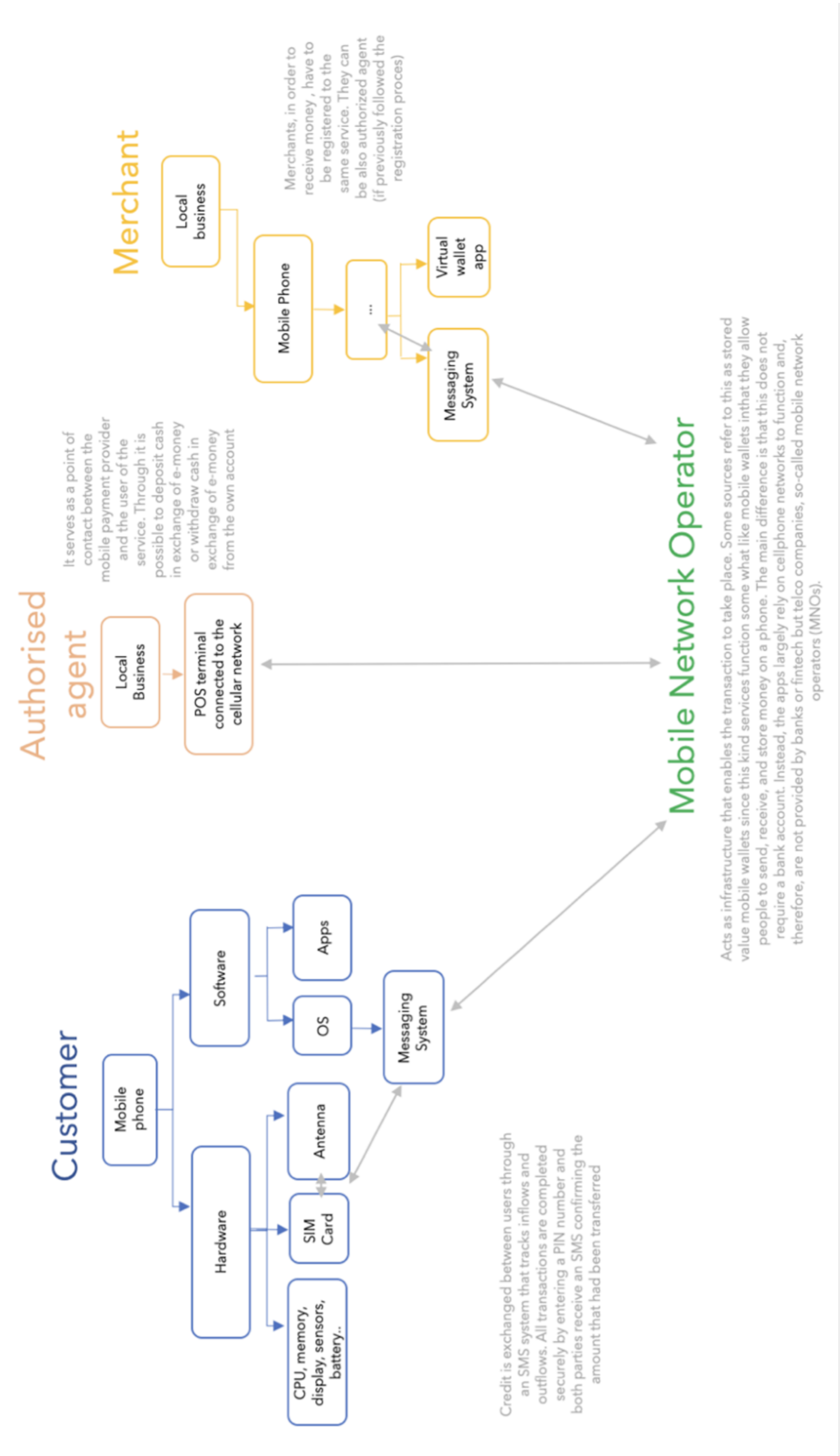
Remote Payment: Debit or Credit Card and Payment App



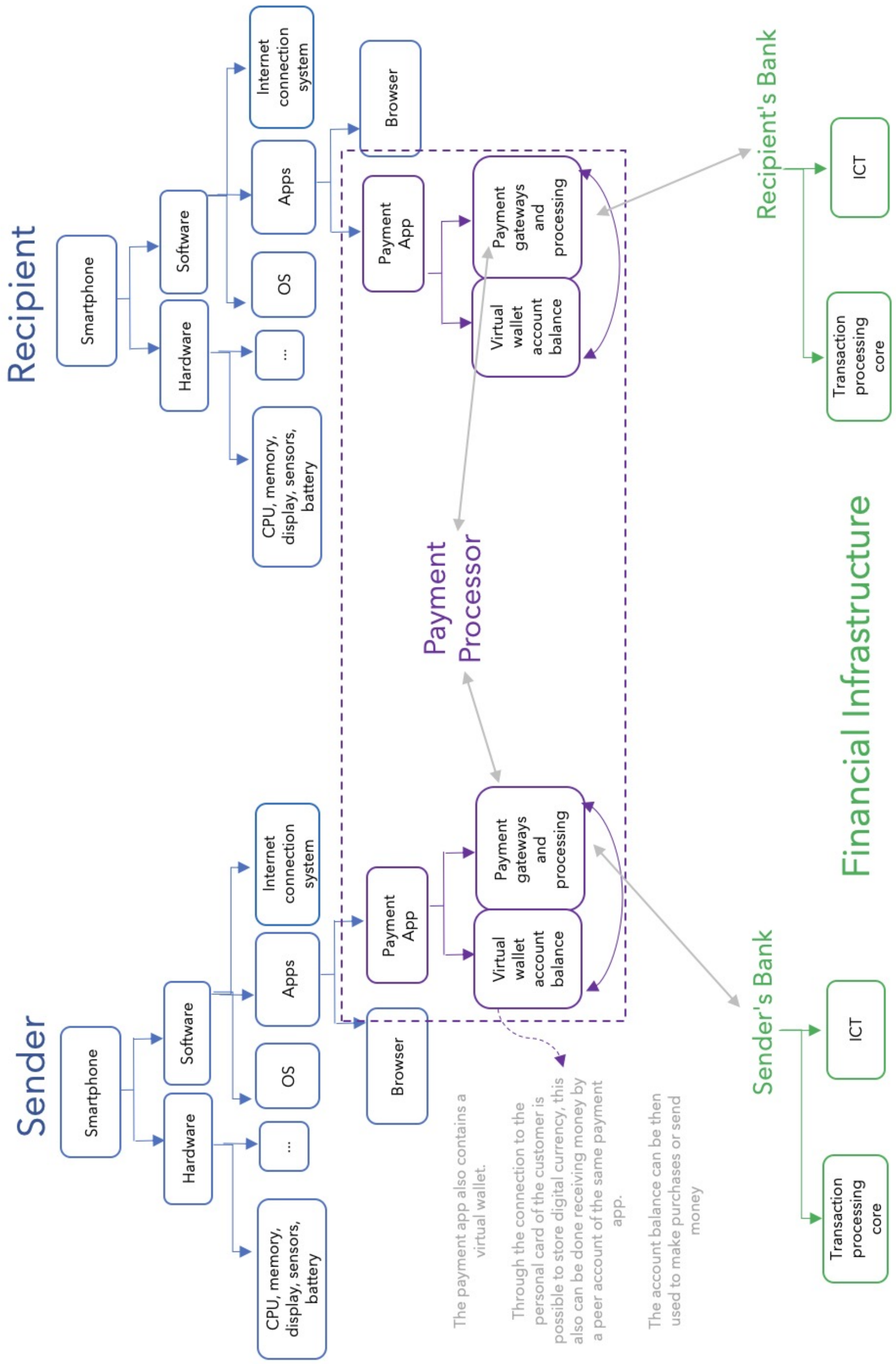
Remote Payment: Payment App balance involvement only



Remote Payment: SMS



Remote Payment: P2P



Chapter 8

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