



Giesecke+Devrient
Creating Confidence

Whitepaper

G+D Filia[®] Unplugged

Secure offline digital payments



Contents

Glossary.....	3
1. Introduction	5
2. Filling the gaps with offline payments	7
2.1 Financial Inclusion	8
2.2 Resilience	9
2.3 Cash-like features.....	11
2.3.1 Privacy.....	12
2.3.2 Universal usage, accessibility, and the matter of trust.....	12
2.4 Innovative use cases for the tokenized economy	13
3. Stakeholders of offline payments.....	14
3.1 Consumers	14
3.2 Banks.....	14
3.3 FinTechs.....	15
3.4 Mobile money service providers.....	16
3.5 Central Banks	16
3.6 Industry.....	17
3.7 Merchants.....	17
4. G+D Filia® Unplugged	18
4.1 Ecosystem	18
4.2 Security approach.....	20
4.3 Concepts and components	21
4.4 Wallet form factors	22
4.5 Use cases.....	23
4.6 Integrations to existing systems for different stakeholders	26
5. Way forward	28
About Giesecke+Devrient	29

KEY FINDINGS

- Offline digital payments are capable of bridging existing gaps:
 - enhancing financial inclusion and payments resilience,
 - supporting cash-like features in the digital world (such as privacy, universal usage, and accessibility),
 - and assisting innovative use cases for the tokenized economy
- Various stakeholders from the private and public sectors can benefit from offline digital payments: users, businesses, and regulators
- Peer-to-peer payments, merchant payments and automated payments in the Internet of Things are some of the prominent use cases for offline digital payments
- G+D Filia[®] Unplugged is a solution enhancing an existing payment system (such as an Instant Payments System or a Mobile Money System) by providing seamless, offline-capable digital payments



Glossary

Account-to-account (A2A) is a type of payment scheme where money is transferred directly from one bank account to another bank account.

Central Bank Digital Currency (CBDC) is a digital representation of a country's or region's existing currency issued directly by the central bank and usable in electronic payments that can be legal tender. [\(Source\)](#)

→ **Retail CBDC** is a digital version of an existing national currency, i.e., cash. It represents an additional means of payment that can be exchanged 1:1 for cash and bank deposits.

→ **Wholesale CBDC** is a digital currency issued by a central bank that is exclusively available to financial institutions for processing transactions in central bank reserves.

Tokenized Deposit is a tokenized form of commercial bank money. The tokens are primarily intended to support the digitalization of business processes.

eSIM (embedded SIM) is a form of SIM card consisting of software installed onto a chip that is permanently embedded in a device, such as a mobile phone. Typically, an eSIM can be remotely updated to allow access to a mobile network, without having to physically replace a SIM card.

G+D Filia® Unplugged is a solution enhancing an existing payment system (such as IPS or MoMo), by providing seamless, offline-capable digital payments.

Instant Payment System (IPS) is a payment system allowing for almost immediate transfer of money. They often work on an A2A basis.

Internet of Things (IoT) refers to the network of physical objects – “things” – that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. In an industrialized world, machines can thus communicate amongst each other. It is a key component in automation processes for the manufacturing industry, in smart cities, healthcare, transportation, and many other sectors.

Machine-to-machine (M2M) payments are executed autonomously by and between machines. Often associated with IoT, it enables higher efficiency in payments since no intermediaries are needed and small values can be transacted.

Mobile Money (MoMo) is a payment service provided by a mobile network operator to their subscribers. Individual accounts are identified by the subscriber's mobile phone number and can be accessed using any mobile phone (including feature phones). Transactions are initiated and recorded in real-time using SMS and do not require internet but mobile network connectivity.

Offline digital payment is a transfer of monetary value between devices that takes place without requiring connection to any ledger or backend system. This could be due to a system outage, or in the absence of internet or telecommunications connectivity. [\(Source\)](#)

Secure Element (SE) is a physical component of an electronic device that securely stores and protects sensitive data and applications. Compared to software-based solutions, it provides higher security and can protect from attacks from malware, hackers, and other malicious actors. Typical applications for SEs include payment cards, mobile phones, and identification cards. [\(Source\)](#)

1. Introduction

There are many reasons why around [1.4 billion people worldwide](#) are not included in the formal financial system. While some people deliberately choose not to participate, most are involuntarily excluded due to lack of services and economic barriers to access. Some people cannot afford to maintain minimum balances, to pay high banking fees, and/or to purchase expensive devices – not to mention technical barriers such as lack of connectivity. Regardless of the reason, the unbanked population is the last vital segment of society that needs to be reached to provide people and small businesses access to affordable financial services in the digital world.

Promoting digital financial inclusion encourages the adoption of digital payment methods such as cards, instant payment systems, and digital currencies. These instruments offer efficient and secure transaction options. By promoting the digital economy, financial service providers (FSPs) can extend their support to the underserved population.

G+D has been supporting projects focused on digital financial inclusion and witnessing how affordable and secure offline payments could remove the barriers that exclude people from participating in the financial sector. There are various scenarios that fall into this category.



One example is people living in remote locations that are not served by traditional financial services. They do not have internet connectivity (and sometimes even electricity), cannot afford to buy a smartphone and have to make long journeys to find the nearest bank branch.

Besides bringing excluded people into the formal economy, many developed economies are also keen on other opportunities that offline functionalities bring. Some primary points of interest here are enhancing the resilience, sovereignty, and innovation in the payment systems. Incidentally, the [European Central Bank included offline functionality as an integral component of the upcoming digital euro](#) to enable European citizens pay in everyday situations throughout the entire euro area.

In our [project with the Bank of Ghana](#), we tested consecutive dual offline payments in off-grid locations, where both the payer and the payee are offline. Imagine rural market vendors and customers being able to make and accept digital payments, without the need for network connectivity and smartphones, using readily available smart cards.

A strong move towards tokenization driven by many market players is creating new business models for the industry, as well as the financial sector, which can become an important enabler for Industry 4.0 and the Internet of Things (IoT). As economies become more interconnected, IoT will revolutionize business transactions and foster the development of new payment ecosystems. As this transformation necessitates seamless and secure interaction between devices as well as efficient and instant payments, the offline functionality brings great potential to innovative Machine-to-Machine (M2M) payments.

This paper gives an overview of offline payments from the perspectives of a wide range of stakeholders. This includes not only central banks, but also Instant Payment Systems (IPS), Mobile Money Service Providers (MoMos), commercial banks, FinTechs, and other industry players, all of which are potentially interested in enhancing existing payment systems with an offline functionality. Proceeding from existing market pain points, we highlight the opportunities and use cases for offline payments and propose a practical solution and methods of its integration into the existing payment systems. Finally, we sketch a way forward.



2. Filling the gaps with offline payments

As we move towards a progressively digitized world, the role of digital online payments continues to surge in importance, transforming financial transactions at an unprecedented pace. However, in this environment of rapidly-evolving technology, many stakeholders within the payment ecosystem are seeking to incorporate offline capabilities to enhance the effectiveness and convenience of online payment methods.

Consider an analogy: You want to watch an episode of a beloved TV series during a weekend far in the mountains. For such purposes, streaming providers allow users to download content to a device.

Now, apply this scenario to payments. The analogy of “downloadable money” might work with IPS such as [PIX in Brazil](#) or [UPI in India](#). Once the money is “downloaded” to an offline-capable wallet, it is possible to seamlessly pay anywhere and anytime.

This consideration is driven by existing pain points in the current system that fail to deliver optimal performance. In this section, we discuss these motivations, providing a comprehensive understanding of why offline capabilities are a valuable addition to digital payment systems.

2.1 Financial Inclusion

Currently, participation in the digital economy is restricted to those who have access to the digital world. This access is not merely defined by the availability of the internet but also by possessing the necessary device such as a smartphone, which serves as the key to this digital gateway. While the digital economy is thriving and expanding, it remains inaccessible to a significant part of the population, especially in developing countries.



Financial inclusion is essential to participate in the digital economy

One of the essential challenges faced by developing countries is the high number of unbanked individuals. A combination of factors contributes to this issue, most notably mistrust, lack of financial education, and inability to fulfil the requirements for opening a bank account – perhaps due to the lack of proper identification documents, the prohibitively high cost of maintaining a bank account and making transactions. Technical barriers such as the need for an expensive device and lack of connectivity contribute to a significant number of people remaining unbanked. As a result, their access to financial services is limited, with cash being the only means of payment for this group.

However, a shift towards digital financial inclusion is possible. Introducing a digital payment solution with offline capabilities can foster that. It could serve as the first entry point for many individuals into the world of digital financial transactions, thereby overcoming the barriers that they are currently facing. The main advantage of offline-based digital payments is that no continuous internet connection is required, thus making it accessible even to those living in remote, off-grid areas.

To prove this statement with a real project, [G+D partnered with Banco do Brasil](#) to test an offline payment solution within the Central Bank Digital Currency (CBDC) pilot of the Brazilian Digital Real Electronic (DREX). This allows the exploration of payment use cases using the Brazilian digital currency in situations where there is no internet connection or electricity.

The design of the digital payment solution should incorporate careful consideration of wallet form factors and transaction mechanics. Wallet devices should be as cheap as possible to manufacture, and easy to distribute. This also applies to Point of Sale (POS) terminals which, preferably, can be upgraded instead of replaced. The digital payment

solution with offline capabilities should be implemented with interoperability in mind, enhancing existing payment instruments and networks.

By bridging this digital divide, we can empower previously excluded populations to participate in the digital economy and increase their potential to prosper. Inclusion in the digital financial world not only provides the opportunity for economic progress, but also contributes to overall economic growth in a country. Therefore, [digital financial](#)

[inclusion can be seen as a significant step towards economic equality and a model for inclusive growth of the economy including GDP growth, as well as a link to poverty reduction.](#)

2.2 Resilience

The efficiency of online payment systems is fundamentally linked to the availability of a stable internet connection. These systems perform ideally in countries with consistent internet access, thereby promoting seamless financial transactions, for example utilizing mobile devices like smartphones. Nevertheless, even in this technologically-advanced age, the reality might lag behind this ideal.



Contrary to common belief, internet access, even in highly industrialized economies, is not uniformly reliable. The situation tends to be even more challenging in developing countries where infrastructure for reliable internet access is often insufficient. For instance, despite the rapid growth of mobile internet connections in Africa, [only around 29% of people in sub-Saharan Africa are connected to mobile internet](#). Such inconsistency in internet coverage can significantly hinder the effectiveness of online payment systems and consequently affect user confidence.

To address this issue and increase the resilience of an online payment system, incorporating a complementary offline solution into the online payment system can be beneficial. A payment system that also works independently of an internet connection ensures that transactions can be carried out anywhere and anytime: a key feature of a reliable currency system.

Imagine the following scenario: We are in a busy marketplace intending to make a digital payment using a smartphone. The internet network on the market is unstable because it cannot cope with the data traffic coming from all the visitors. Once we have initiated the digital payment to the vendor, the transaction hangs incomplete for some time. Such uncertainty compromises the trust in digital payments and leads to fears that the transaction did not go through or that we pay the merchant twice with the second attempt.

The introduction of an offline solution could establish a stable and reliable payment system that is not affected by the unpredictability of internet connectivity. This not only augments the robustness of the overall payment system but also bolsters public confidence in the payment scheme, thereby fostering a more inclusive and accessible cashless economy.

Regardless of the extent of a country's internet coverage, power or internet outages can also occur due to unforeseen events such as earthquakes, floods, or other severe

weather conditions. This becomes increasingly prevalent due to climate change. For

any payment system to earn widespread trust, it must reliably operate even under these challenging conditions.

G+D explored, jointly with the Hong Kong Monetary Authority and Standard Chartered Bank, [compelling offline use cases for the hypothetical e-HKD](#).

Take Hong Kong, a region with a high level of mobile network penetration. Even there, typhoons might cause network issues. Thus, even in advanced economies, the need for offline is crucial to support resilience in the payment system.

Extreme weather events aside, the problem is acute for African countries, too. There is a higher proportion of its internet traffic on mobile devices than any other continent, with many of its businesses relying on the internet to deliver services to their customers. [As operators of several subsea cables reported failures in March 2024, at least ten West and Central African countries had been left without internet service.](#)

An offline digital payment solution provides a reliable means for transactions across a range of scenarios where connectivity is compromised.



2.3 Cash-like features

Offline digital payments can be designed to offer cash-like features such as enhanced privacy, universal usage, accessibility, and trust.

Cash remains the most universally accepted and preferred means of payment across the globe with [around \\$40 trillion in physical money circulating worldwide in 2023](#). Despite the uptake of digital payment methods, people continue to value the unique characteristics that cash offers.



There's a need for a digital complement to physical cash with the same characteristics

One of the primary advantages of cash for end users is the anonymity it provides. In cash transactions, the identities of both payer and payee are irrelevant. All that matters is that the banknote itself is genuine. This level of privacy is unmatched by digital payment methods, given their account-based authentication and verification process which focuses on the transacting parties' identities.

Cash transactions also offer immediate settlement of funds. Unlike traditional bank transfers and card payments – which take time to process – cash transactions are instantaneous and final. This is not just a small detail: instant settlement means that funds can be used immediately by the payee, which is particularly important for users who need immediate cash on hand, such as small merchants.

Moreover, cash has no prerequisites. It can be spent and received without any technical device or bank account, making it universally accessible to society. This is a significant advantage, especially in regions with limited access to digital infrastructures. Cash can be used for transfers fully “offline”, without any need for connectivity. It is a reliable form of payment, including for situations where digital payments currently fail.



In today's increasingly digital world, there is a growing need for a digital complement to physical cash, retaining the same characteristics. While digital payments offer numerous benefits, they often fall short of providing privacy, immediate settlement (which generates risks for merchants accepting online payment instruments), and offline usability. This in turn provides an opportunity: incorporating an offline component into online payment schemes to solve these crucial issues.

2.3.1 Privacy

Cash-like features, such as enhanced privacy in transactions, are highly valued by many. This is still mainly possible through physical cash transactions, which allow individuals make payments without leaving a digital footprint. However, electronic transactions, which are becoming increasingly prevalent, are usually monitored, creating concerns about privacy and data security.

Incorporating an offline component into a digital payment system could address these concerns. From a technical perspective, consecutive offline payments can support anonymous transactions. Hardware wallets with pre-defined holding and/or transaction limits can be provided to end users – in theory, even without Know-Your-Customer (KYC) in practice, according to the local legal framework. This allows users to transact completely anonymously – an experience that was tested and validated in multiple pilot projects conducted by central banks with the G+D solution.

Such a technology could significantly increase the acceptance of this form of payment among end users. The ability to choose between traceable online transactions and more private offline transactions gives end users control over their data and privacy, which could be one of the factors in their decision to adopt this payment method. In this way, the digital payment system could offer the best of both worlds, combining the convenience of online transactions with the privacy of cash transactions.

2.3.2 Universal usage, accessibility, and the matter of trust

The success and adoption of a payment scheme are largely dependent on its widespread acceptance within the entire payment ecosystem. This high level of acceptance creates trust, a crucial factor in developed and developing economies alike. Only when the usage of the digital payment method is ensured everywhere and at all times do people start to trust it. This is comparable to the value of a currency itself, which is not tied to a physical commodity, but rather to the confidence and trust that people place in it. For this trust to be maintained, the currency must be universally accepted and reliable.

However, acceptance and reliability can be limited by external factors beyond the control of the issuer, such as internet access. For instance, online payment acceptance may be restricted in rural areas where internet connectivity is sparse; yet, there is still a demand for digital transactions among small merchants. This limitation could potentially erode the trust in the payment scheme, undermining its stability and thereby affecting the economy.

Integrating offline capabilities into an online payment scheme helps here as well. It ensures that transactions can be conducted seamlessly, regardless of the connectivity. This strengthens trust in the payment system as it guarantees that transactions can be carried out by anyone, anywhere, at any time.

2.4 Innovative use cases for the tokenized economy

The emergence of the IoT has paved the way for advancements in M2M payments. These are transactions executed automatically between machines, a development that enhances efficiency in manufacturing plants. This simplifies internal billing processes by eliminating the need for manual interventions, thereby streamlining operations.

As factories are often connected to the internet, one might think that online solutions would be sufficient for these digital payments. However, this is not always the case. Certain production areas, particularly in sensitive sectors, may require air-gapped operations, a security measure that involves isolating a computer or network from the internet.

Moreover, overreliance on connectivity poses a considerable risk: an internet outage could disrupt M2M payments and thus also the production process. In such scenarios, offline payment mechanisms become essential as a contingency plan. They ensure uninterrupted payments, thereby increasing the resilience of a production plant.

While online M2M payment solutions may be convenient, the incorporation of offline payment capabilities can significantly enhance the robustness of the entire production operations.



Offline payments mechanisms can be a contingency plan for M2M payments



3. Stakeholders of offline payments

3.1 Consumers

Adding an offline feature to digital payment systems can benefit everyone, whether they have a bank account or not. It makes payments more accessible and reliable, even for tech-savvy people who are accustomed to digital payment methods. This means consumers can still use their preferred payment method even in the event of internet disruptions, giving them a smoother experience.

For societies that primarily use cash, this new feature can open up significant opportunities. It provides another easy and convenient way for people to make secure digital transactions without the need for expensive devices like smartphones. A simple smart card can help them start making digital transactions at a low cost. Subject to already existing market infrastructure, it can be another low cost device, for example, a feature phone with a SE deployed on a SIM card. This offline feature makes digital transactions available to more people.

Also, having an offline option can increase people's trust in the payment system. This is because they know their transactions can continue even if the internet goes down. This makes the payment system more sturdy and dependable.



3.2 Banks

Banks can become more attractive to customers by offering offline services. Though, this has already been the case, for example, card payments on a plane, innovative offerings in this domain might contribute to keeping existing customers and even bringing in new ones attracted by the reliability of offline services.

An innovative application could take the form of tokenized deposits. Banks could tokenize their commercial deposits and offer services on such



a tokenized platform. For commercial banks this raises the potential to play an important role in the emerging use cases and business models e.g., via IoT, where a tokenized payment approach is a crucial way to support M2M payments. If commercial banks issue tokenized deposits, adding an offline capability would strengthen the overall performance of such a token.

Moreover, the development of offline services aligns with the global trend driven by central banks worldwide, focusing on the introduction of CBDC with both online and offline capabilities. Compatibility between commercial bank deposits and CBDCs is key to maintaining the relevance and efficiency of commercial banks in an evolving payment ecosystem. It is therefore essential that financial institutions invest time and resources in understanding and adapting to both online and offline token payment systems.

3.3 FinTechs

Financial technology companies can stand out from traditional banking institutions by leveraging technology to create new financial services. They can offer comparable benefits as banks without the need for physical branches (the factor which impacts the cost structure of banks). One of their main advantages is the ability to offer more services to different types of people, no matter where they live. This means they can help people in cities and in the countryside; each having their individual needs. FinTechs can customize their services to fit these different needs, helping to connect traditional banking with the digital world. This new approach lets them define their own unique place in the financial industry: provide wallets, applications, and other services to customers; develop products and services for merchants to accept offline digital payments; provide innovative services, such as M2M payments, to promote the digitization of financial services and commerce.



3.4 Mobile money service providers

MoMos have significantly contributed to financial inclusion, particularly in developing countries, by providing an accessible platform for digital transactions. Although they enjoy wide popularity, many end users still convert money they receive in their mobile money wallets into cash (“cash out”). This might be due to the fees charged for digital payments as well as the high level of trust that people have in cash – namely, the security of being able to make payments at any time.



To expand the societal impact of MoMo, mobile network operators can introduce consecutive dual offline payments, allowing transactions even without stable network connectivity. As of now, a transaction with mobile money requires at least a 2G connection to the mobile network, which can be a challenge for transactions in rural and off-grid areas. Adding an offline feature could potentially attract a broader customer base, including those who have been unable to join the mobile money payment network due to lack of prerequisites or those living in remote areas with unstable network connectivity. Such an expansion could facilitate greater financial participation and economic growth.

3.5 Central Banks

In an increasingly digital financial landscape, central banks worldwide are not only exploring online CBDC solutions, but also the potential of offline capabilities. Some recent examples include the [European Central Bank, which is considering the integration of offline solutions into the potential digital euro](#) and the Swedish Riksbank investigating offline payments in the [e-krona pilot phase 4](#).



One of the primary motivations for this approach is resilience and financial inclusion. By adding offline capabilities to CBDC offerings, central banks can ensure their services reach all citizens, including those with limited or no access to the internet. This strategy could be a crucial step in bridging the digital divide in financial services.

3.6 Industry

As we transition into the era of Industry 4.0 and the IoT, there is a growing need to consider how transactions are initiated, processed, and managed. This new landscape, characterized by M2M interactions, may benefit from a tokenized payment system to execute transactions efficiently and securely. Businesses should explore these secure payment mechanisms to facilitate seamless transactions in this interconnected ecosystem.



In some scenarios, such as high-security production plants, it might be beneficial for these M2M payments to operate in offline mode. This approach could help mitigate potential cyber threats and protect vital operational data by minimizing online exposure. Therefore, as we navigate this digitally interconnected future, developing secure and efficient transaction solutions will be crucial for the successful integration of Industry 4.0 and IoT systems.

3.7 Merchants

Offline transactions provide merchants with the benefit of immediate funds settlement. Final settlements with conventional payment instruments such as cards typically take 1-3 business days. Hence, merchants receive money to their bank account with a significant delay. In contrast, transactions with offline tokens are immediate and absolute, allowing the funds to be promptly utilized by the recipient. In particular, it can be crucial in specific scenarios and business processes, for example, immediate need in payment for delivered goods at a grocery store.

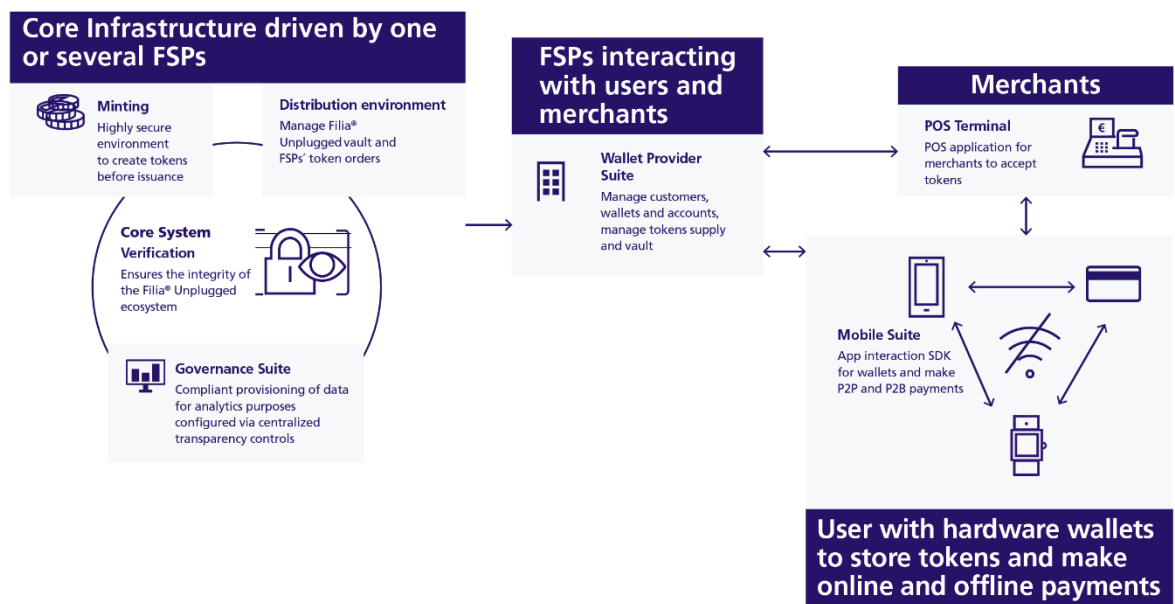


4. G+D Filia® Unplugged

G+D Filia® Unplugged is a solution providing seamless offline-capable digital payments that can be integrated into an existing payment system such as retail CBDC, commercial banks' tokenized deposit system, IPS or MoMo system. The system is designed to provide reliability, security, and trust. It functions seamlessly even in the absence of connectivity, ensuring reliable payments that can be conducted anywhere, anytime and by everyone.

It means, G+D Filia® Unplugged has been created with user experience in mind, lowering the barrier even for non-tech-savvy individuals. This approach is aimed at fostering broad adoption, making secure offline payments accessible to everyone.

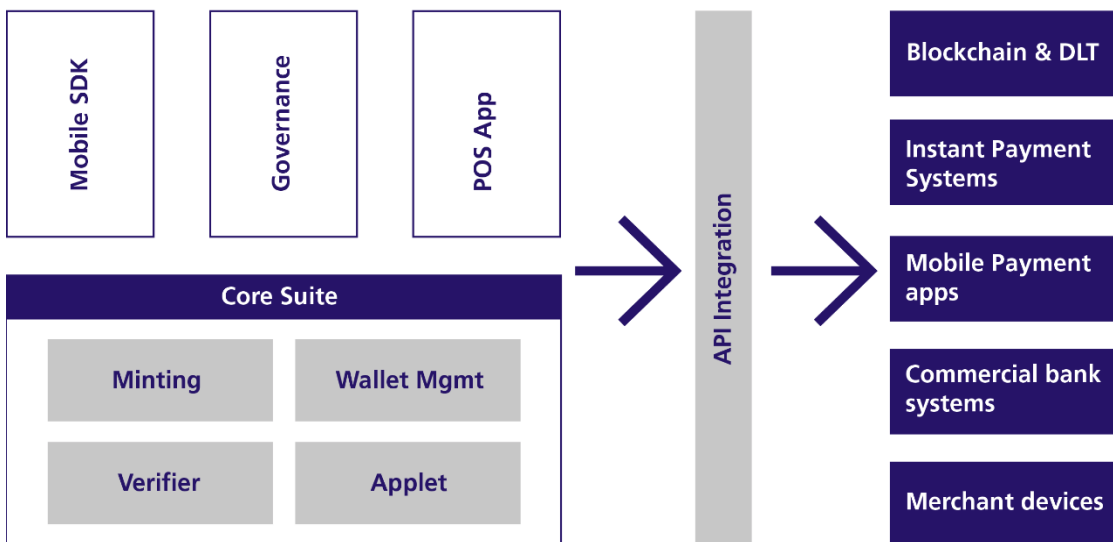
4.1 Ecosystem



Filia® Unplugged ecosystem is based on a modular approach where different players might perform various roles. Core functions and interaction with end users can be performed by one FSP (say, an IPS or MoMo service provider) or such functions can be jointly provided by different entities composing an alliance. Moreover, depending on the ecosystem design, core functions can be performed by a single non-FSP entity as well, e.g., by a central bank if it is used as extension to a CBDC solution.

Core functions are designed to ensure the integrity of the system by providing the digital money tokens through minting and managing their distribution. Additionally the core functions also include operating the Verifier for token verification and taking care of the system's governance.

Subsequently, same or another FSP manages all interactions with end users and commercial players in the ecosystem. FSPs play a crucial role in onboarding users to this new system when integrating as additional feature into their mobile apps (see figure below). They not only facilitate the initial setup but also provide ongoing support as required, ensuring a smooth and user-friendly experience. Most important, they are the entry point for the offline tokens to enable the offline ecosystem when customers exchange e.g. deposit money on a bank account for offline tokens. This presents a unique opportunity for FSPs to offer new and beneficial solutions to their customers, enhancing their service portfolio and customer satisfaction. Furthermore, it can be an opportunity for FSPs to access new fields of businesses, such as providing services for unbanked and underbanked people.



Components and interfaces of Filia

End users and commercial players make use of tokens in their daily lives and businesses. For this purpose, they can rely on a broad variety of different form factors. Tokens can be used for payments by end users but money can also be withdrawn from or deposited to FSPs in exchange of other means of payments e.g. cash or bank deposit money. End users can also pay merchants who can interact with FSPs in the same way.



4.2 Security approach

To ensure a high degree of security, G+D Filia® Unplugged includes three protection layers:

- strong hardware security to prevent malicious participants in the system;
- encrypted payment protocols for payments over any communication channel;
- and a verification instance as the authority to check authenticity of monetary value.

Starting with the hardware security: G+D Filia® Unplugged is built on SEs, as the most reliable source of trust in offline environments. Those dedicated chips enjoy widespread use across many industry sectors, for example automotive, manufacturing, and telecommunication. A system for Public Key Infrastructure (PKI)

operating in the background ensures that only trusted hardware wallets can participate in the offline ecosystem. These wallets can be used for consecutive offline payments.

The suite of payment protocols is the second key component of G+D Filia® Unplugged. The core protocol describes how tokens are created and can flow through the wallet ecosystem, countering double spending. Additionally, more sophisticated payment protocols ensure secure token exchange even over untrusted communication channels, and therefore prevent money loss or theft even if the transaction gets interrupted, which is particularly important in offline use cases.

The third layer of security is the Verifier, a backend component forming an integral part of G+D Filia® Unplugged. It acts as an authoritative instance to check the validity of the tokens that are circulating in the ecosystem. Any wallet can query the Verifier during intermittent online access, to verify all tokens that it received offline. This ensures the authenticity and validity of each token in circulation, providing a secure and reliable offline payment solution. While this verification step is occasionally

necessary, it is important to note that offline transactions are final at the moment of payment, providing immediate settlement and certainty for both parties involved. An issuing entity which is liable for the issued value might have a high interest in having the offline tokens reconciled (checked with the verifier) occasionally, to ensure the integrity of the system and detect irregularities as soon as possible.

4.3 Concepts and components

While G+D Filia® Unplugged is designed to function independently of internet connectivity and only requires two offline wallets to perform a transaction, it does comprise some online components. These work together to ensure the smooth operation of the payment system, providing a seamless user experience as well as enabling the issuing entity to enforce its governance principles.

One of the key concepts is the ability to mint tokens, which is usually conducted by the issuing entity. G+D Filia® Unplugged offers a separate component for the creation of the tokens to be distributed offline ensuring that only the legitimate entity has the authority to issue money. This process is carried out in a highly secure environment, maintaining the integrity and trust in the currency and can even be distributed for the sake of resilience.

Distribution of the tokens to end users is facilitated by FSPs. It may occur that one FSP is also the issuer of the tokens or more than one issuer are allowed to mint tokens within an ecosystem. For the purpose of distributing money to end users, G+D Filia Unplugged® provides a component as well.

One of the possible scenarios can be exchanging for bank deposit money. In general, tokens are not just issued, but often exchanged for another means of payment. This process resembles the traditional cash cycle, where the central bank creates and issues cash to financial institutions, which then distribute it to their customers most commonly via ATMs where the bank account balance is deducted as soon as cash is withdrawn. The G+D Filia® Unplugged approach allows a smooth transition from traditional to digital currency, leveraging existing financial infrastructure. Additionally, those financial institutions manage the integration into other payment schemes (refer to section 4.6. “Integrations to existing systems for different stakeholders”).

To ensure trust and consistency in the system, the tokens have to be verified by the online verification instance occasionally as stated in above as the third layer of security. It is also delivered by G+D Filia Unplugged® solution. To fulfil different requirements, there are various ways the Verifier can be structured. In case there is only one entity to be responsible for operating the Verifier, it can be set up as a distributed database approach to ensure resilience and performance. If the circumstances of the Verifier deployment requires more than one entity to jointly operate the verifier, it can be based on a DLT foundation as well.

4.4 Wallet form factors

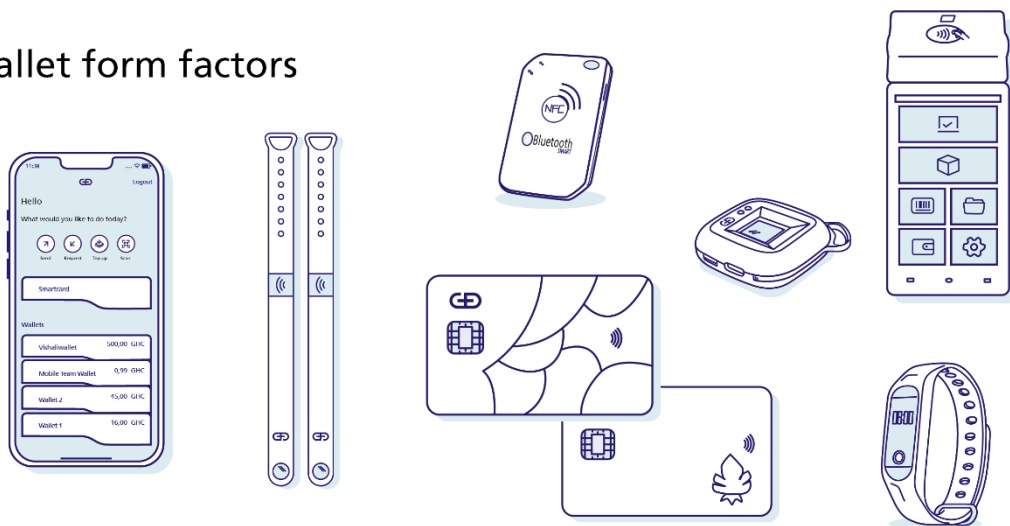
To foster widespread adoption of the G+D Filia® Unplugged solution, a diverse range of form factors can be made available to end users.

With G+D Filia® Unplugged, offline use cases can be performed on multiple wallet form factors, depending on end user preferences and payment scenarios. These include smartphones, smart cards, wearables, or other devices that contain communication capabilities and a SE. Even more so, payments can be conducted over various communication channels, such as NFC, Bluetooth, or Wi-Fi.

Hardware wallets for offline payments require a SE. G+D Filia® not only supports smart card SEs, but can also be deployed on SIM cards, eSIMs, and secure elements embedded in smartphones (eSEs) or other devices.

Beside end user focusing form factors, G+D Filia® Unplugged is also available for integration with a variety of embedded or retrofitted SEs of machines and devices in production environments. An integration for M2M payments is therefore seamless and can be readily achieved.

Wallet form factors



4.5 Use cases

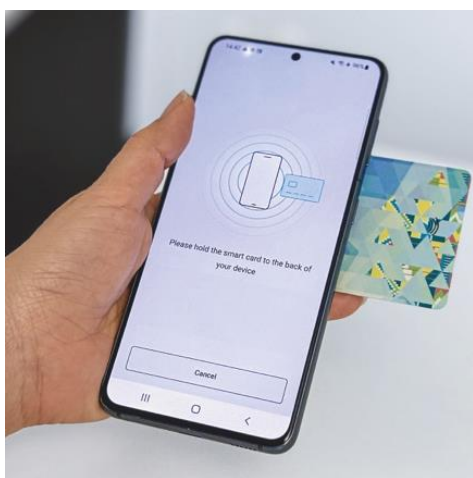
Offline payments can be effectively adopted in a variety of scenarios.

Some of the most common use cases for consumers include peer-to-peer payments between individuals (P2P or Person-to-Person) and payments at merchants (P2B or Person-to-Business). Offline payments would be commonly used in retail or in-person sales where the customers traditionally pay with cash. This is most typical for remote or rural areas, in which internet connectivity may be unreliable or unavailable. Imagine rural markets where both a vendor and a customer are offline. Consecutive dual offline payments enable sending and accepting digital payments in an instant and cheap way. Funds can be immediately re-spent by the receiver.

The range of possible practical applications for offline payments extends even further. One of the vivid examples is “payment in transit”. Public transportation often uses traditional offline payment methods such as cash or transport cards. In doing so, the offline functionality can be added to other payment rails. Depending on the market, it can be, for instance, an IPS or a MoMo.

Another good example is retail payments at events or festivals where quick transactions are required. Offline payments can speed up the process and have been often used. Some of the prominent examples of P2P and P2B offline payments are outlined below.

When G+D Filia® Unplugged is integrated into an existing payment infrastructure such as retail CBDC, commercial banks’ tokenized deposit system, IPS or MoMo system (see Section 4.6 for more details about such integration), the end user’s offline wallet can be seamlessly topped-up from their online wallet.



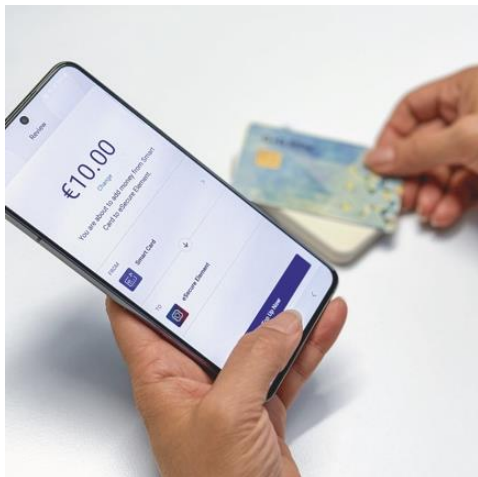
Top-up or sending money from online wallet to smart card

To transfer money from an online wallet app on a smartphone to an offline medium like a smart card, the end user simply needs to hold the smart card to the smartphone’s NFC reader. The NFC interface allows for easy topping up of the smart card, or to transfer funds from an online wallet using a smartphone to an offline device like a smart card.



Smart card at POS

A topped up smart card can be utilized at a merchant's checkout to pay for goods and services at a POS terminal, thus offering a streamlined payment method familiar to many. By simply holding the smart card near the NFC reader of the device, the tokens are transferred from the smart card to the device.



Smart card to phone's SE

The connection interface between an online wallet on a smartphone and a smart card can also be established through an external Bluetooth card reader. The Bluetooth Low Energy (BLE) device is therefore connected with the smartphone in order to execute the process of sending tokens from one wallet to the other.



Offline to smartphones' SE

A transaction with G+D Filia® Unplugged can also be performed between two smartphones without internet connectivity. The offline transaction is then performed using the smartphones' SEs.



SIM to smart card

A phone's SIM card can be used as a secure element, where tokens are stored in a secure manner. Through the common NFC interface, a transfer can be made from a SIM card to a smart card.



Phone's SE at POS

Transactions can also be executed from the phone's SE at a merchant checkout using the NFC reader on the POS device. A unique feature of this approach is that the smartphone can be switched off and still make offline payments. In this mode, the smartphone essentially acts as a smart card, with the tokens stored on the secure element, thus facilitating transactions even without the device being powered on.



Smart card to phone's SE with USB reader

The design for connecting two hardware wallets is flexible. An external USB card reader can also be used to establish a connection between the smartphone and a smart card, thus carrying out the transfer of the digital offline token from one form factor to the other.

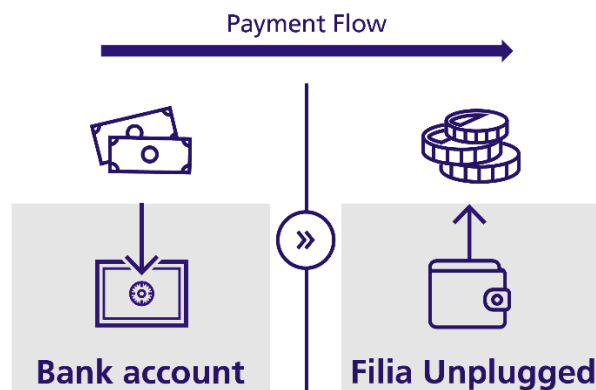
Watch our Demo videos:



4.6 Integrations to existing systems for different stakeholders

G+D Filia® Unplugged can be integrated into an existing payment infrastructure such as retail CBDC, commercial banks' tokenized deposit system, IPS, or MoMo system.

For an offline payment solution, the most suitable method to transit between payment schemes is to exchange value between the ecosystems by using exchange deposits. This approach allows for the seamless transition of value between different payment systems even in the absence of internet connectivity. Furthermore it decouples the technical solution from the payment scheme and is the most universal method of connecting various different payment schemes relying on various technologies and is comparably simple to implement.



To make it more tangible, take the example of the payment flow in a system where money from an account-based system, e.g. the bank's back-end system, is withdrawn as G+D Filia® Unplugged tokens at any kind of ATM: a customer already has a bank account at an FSP and requests tokens for offline use. Before providing the tokens, bank deposit money is transferred from the user's bank account to the bank's "offline exchange" account. This offline exchange account is linked to an "offline liquidity wallet" inside the G+D Filia® Unplugged ecosystem. The same amount sent to the exchange account is now taken from the offline liquidity wallet and is sent to the user's hardware wallet. As soon as the token is received by the hardware wallet, the exchange is completed and the user can start spending or storing the money offline.

Of course, there are different standard variants of the liquidity wallets characteristics and how it is provided with G+D Filia® Unplugged tokens is based on the use case to fulfill.

G+D Filia® Unplugged can be integrated with a bank account system or other systems based on different technologies as long as the link between an offline exchange wallet / account / storage to the offline liquidity wallet can be established. Based on this flexible approach, the integration of G+D Filia® Unplugged into an existing system could be easy. As the solution is already standardized and packaged, the backend

components can be deployed on industry standard cloud applications as well as on-premise data centres. The actual integration into the existing payment scheme (linking the exchange wallet / account / storage to the G+D Filia[®] Unplugged liquidity wallet and creating a coherent end-to-end flow) is an effort of a few days.

The exchange process can be managed by many entities within the payment ecosystem, with FSPs being the most likely candidates. They are already integral to the financial transactions of their customers and are well-positioned to facilitate this exchange.

A bigger effort would be an integration to the merchant system to ensure payments with G+D Filia[®] Unplugged. If POS terminals are used, it is either required to integrate a wallet into the terminal or create an end-to-end flow from the payer's card through the terminal to the payee's bank account including an exchange from tokens to the form of money in the destination account. While the first option could be performed offline, the second option requires internet connection.

However, even state-of-the-art smartphones can be used for receiving transactions, which would enable merchants to utilize devices they already have and especially allow small merchants accept payments without the need of purchasing expensive POS terminals to accept digital payments.

As an outlook: in situations where an entity lacks trust, the exchange between G+D Filia[®] Unplugged tokens and another digital means of payment can be secured using smart contracts, such as Hashed Time Lock Contracts (HTLCs). These contracts ensure that the transaction is executed as agreed upon, providing an additional layer of security and trust in the exchange process. However, this additional layer of security impacts the cost of performance and has potential to lower end user experience.



5. Way forward

Digital online payments have been a significant catalyst for innovation in the financial sector in the last years. However, there may be instances where solely online solutions reach their limitations. For a payment system to garner full end user trust, constant availability is essential.

This is where G+D Filia® Unplugged steps in. We offer a solution that aims to bridge this gap by incorporating offline capabilities into any payment system. This ensures that transactions can still be conducted even in areas with weak or non-existent internet coverage. G+D Filia® Unplugged thereby broadens the horizons of digital financial transactions.

We invite you to further explore the potential of our advanced G+D Filia® Unplugged technology. Contact us for more information about the solution and testing G+D Filia® Unplugged in a sandbox environment. This secure, controlled setting allows you to explore how the technology works in real-time. Furthermore, we provide the option to conduct a Proof of Concept (PoC) and further test the technology in a closed environment with a predefined set of end users. This PoC aims to provide insights into the effectiveness and suitability of G+D Filia® Unplugged for your specific needs. Following this PoC, a pilot project expands this testing environment to a wider user base, thereby establishing a broader perspective on the technology's application and performance. Importantly, our technology seamlessly integrates with existing payment systems, further enhancing its functionality. And additional offline feature can be incorporated into the existing payment landscape, providing more flexibility and convenience. Join us in exploring the possibilities of this transformative technology.

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About Giesecke+Devrient

Giesecke+Devrient (G+D) is a global SecurityTech company headquartered in Munich, Germany. G+D makes the lives of billions of people more secure. The company shapes trust in the digital age, with built-in security technology in three segments: Digital Security, Financial Platforms, and Currency Technology.

G+D was founded in 1852 and today has a workforce of more than 14,000 employees. In the fiscal year 2023, the company generated a turnover of 3 billion euros. G+D is represented by 123 subsidiaries and joint ventures in 40 countries. Further information: www.gi-de.com.



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