

Offline Digital Eurozone Train Tickets

Carlos Biddle, Gabriel Mares-Pardalakis, Martin Paraire

February 15, 2025

1 Introduction

With the European Commission's promotion of the Interrail pass through the DiscoverEU program, it is natural that an adequate service for train reservations should follow to support this program.

Currently, Interarail ticketing systems rely heavily on staff or online connectivity and centralized platforms to handle high-volume transactions, often during rush hours, which creates barriers for cross-border users, and regions with limited connectivity, notably with the Commission establishing the partnership with notional train network to areas outside the eurozone and European Union, like Turkey or the United Kingdom.

Currently, although Interrail ticketing systems have centralized ticket reservation on their website, end-reservation must still be performed on the train operator company's own website and thus relies heavily on online connectivity and centralized digital platforms, which also creates friction on train exchanges, notably when having to re-order a new ticket in case a customer has missed their train due to a delayed train.

Such reliance on connectivity and fragmented national platforms limits interoperability and undermines the DiscoverEU program.

Therefore, this paper calls for the implementation of a new Central Bank Digital Currency (CBDC)-enabled system that would support secure offline transactions and seamless train ticket reservation. Furthermore, as Kiff notes. (2024), 94% of central banks were exploring a CBDC in 2023, with 104 jurisdictions investigating retail CBDCs, with a currency union as one experiment.

Therefore, this paper proposes the establishment of a new rCBDC for the train transportation within the European Union area, with the ambition of a growing system to include a pan-european ticketing system to accompany the growth of the Interrail System.

2 Current Problems

Currently, the Interrail Pass relies on the coordination of multiple payment systems used by national railway operators. Information is isolated on a single website and not shared on a single platform, creating cross-border frictions and network-constrained environments that are highly vulnerable to connectivity failures and interoperability issues, because a customer from one country may experience connectivity issues in another, preventing them from accessing their wallet. Furthermore, during train network disruptions, automatic ticket replacement and validation may fail, with multiple operational platforms serving as information sources.

Existing solutions cannot pace with these challenges. Mobile app-based ticketing typically requires a stable network connection, making it ineffective in areas with poor connectivity or for customers with inadequate coverage plans. Furthermore, Card providers in traditional card-based payment systems charge currency exchange fees, and transactions require terminals with continuous Wi-Fi or network access, further limiting their reliability.

Together, these limitations highlight a need for a more resilient, low-dependency ticketing approach that can operate safely and reliably under varying network conditions. Therefore, a Central Bank Digital Currency (CBDC) enabled solution could directly address these challenges. By leveraging a terminal or scanner installed on trains, integrated into passenger mobile applications, or used at ticket inspector terminals, travellers could pay with locally stored digital coins. These digital coins would have to be bought on a transnational distributed ledger technology, with ticket issuance, would be instantaneous and independent of real-time connectivity.

To enable this system, customers would redeem retail CBDC (rCBDC) against their national currency, allowing digital coins to be loaded into their wallets or devices. This ensures offline-capable transactions while maintaining full integration with existing monetary systems. Moreover, these digital tokens could be designed to automatically redeem or transfer value when a passenger misses a train for a valid reason, such as delays or cancellations. The system could detect eligible scenarios and either reassign the ticket to a later service or convert the unused digital coin back into rCBDC.

The rCBDC would be managed by a transnational network, with all transactions mediated via bridges (smart contracts) that link customers' real-asset wallets to platforms handling ticket sales and registration using rCBDC.

3 Stakeholders & Incentives

For this ticketing system to be viable, incentives must align with passengers, train operators, intermediaries, and public authorities.

For travellers, the main benefits are reliability and convenience. Payments in this case wouldn't depend on the WiFi or the ticket machines working. This reduces stress during rush hour, cross-border trips, or in rural areas. Also, instant settlement reduces the risk of payments failing or cards being temporarily blocked when you're travelling abroad. If you design refund or rebooking processes around the original payment (without changing the currency), passengers also benefit from faster resolution in cases of delays. Because rCBDC would be legal tender issued by the central bank, users would likely view it as a safer option that relies solely on commercial card networks.

Train operators mainly benefit through lower costs and more efficient operations. We know card payments include interchange and scheme fees, and the risk of chargebacks. However, a retail CBDC could reduce merchant service fees and eliminate chargebacks, thanks to the finality of instant settlement. Cash-handling costs would also decrease. Working offline can help collect more fares in areas with poor connectivity and ease queues during peak periods. Additionally, fewer technical payment failures mean easier boarding and fewer customer disputes.

With the intermediated model, wallets would be distributed by regulated PSPs. This ensures they remain involved in an active role. PSPs could benefit from increased wallet usage, higher transaction volumes, and opportunities to offer additional services such as identity verification, fraud monitoring, and integration with transport apps. The model keeps their customer relationship while introducing a new settlement rail backed by the central bank.

Authorities benefit from improved payment reliability and less reliance on non-European card networks. Our ticketing system supports the EU's strategic autonomy objectives while reinforcing the DiscoverEU programme. It also enhances financial inclusion by making digital payments accessible even in areas with weak infrastructure.

4 Business Model

Our proposed system should remain simple. Consumers wouldn't be charged fees for using rCBDC to purchase tickets (as with cash). Operators would pay a small

transaction fee to PSPs, likely lower than traditional card merchant fees, since it avoids interchange and scheme charges.

PSPs can generate revenue through wallet services, partnerships with transport operators, and potentially premium features (such as travel budgeting tools or identity-linked services). Initial costs for infrastructure (e.g., upgrading mobile ticket validators) could be supported by EU digital infrastructure or mobility funding programmes to encourage adoption.

Since rCBDC settlement is final and immediate, operators would benefit from improved cash-flow management, and simpler reconciliation could help lower back-office costs.

5 Compliance & Consumer Protection

This system would comply with AML/CFT and GDPR requirements through an intermediary model. PSPs would conduct customer checks to comply with EU standards. A tiered wallet system could allow users to hold small amounts with a simpler sign-up process, while higher balances would need full KYC verification.

Offline payments would have strict limits to prevent double-spending and reduce fraud risks. Securely stored hardware data in devices could retain value temporarily and be synchronized once connectivity is restored.

As far as data protection is concerned, the central bank wouldn't directly access personal data in transactions. Instead, PSPs would handle customer data in accordance with GDPR requirements, ensuring it's transparent and kept to a minimum.

Strong consumer protection mechanisms (e.g., dispute resolution and the ability to trace transactions once reconnected) would help maintain trust relative to existing digital payment systems.

6 Rollout Strategy

Rolling it out in phases would reduce risk. A pilot could start with a limited group of national rail operators in the Eurozone, focusing on offline ticket validation. Following evaluations, the system could be extended to cover cross-border DiscoverEU routes.

We'd need partnerships between the ECB, national central banks, major PSPs, and selected rail operators. Clear communication with users would strengthen reliability. We're starting small with trains so people can see the rCBDC actually makes life easier. Once it works well in this environment, it can be used for other everyday services too.

7 Technical Outline and User Journey

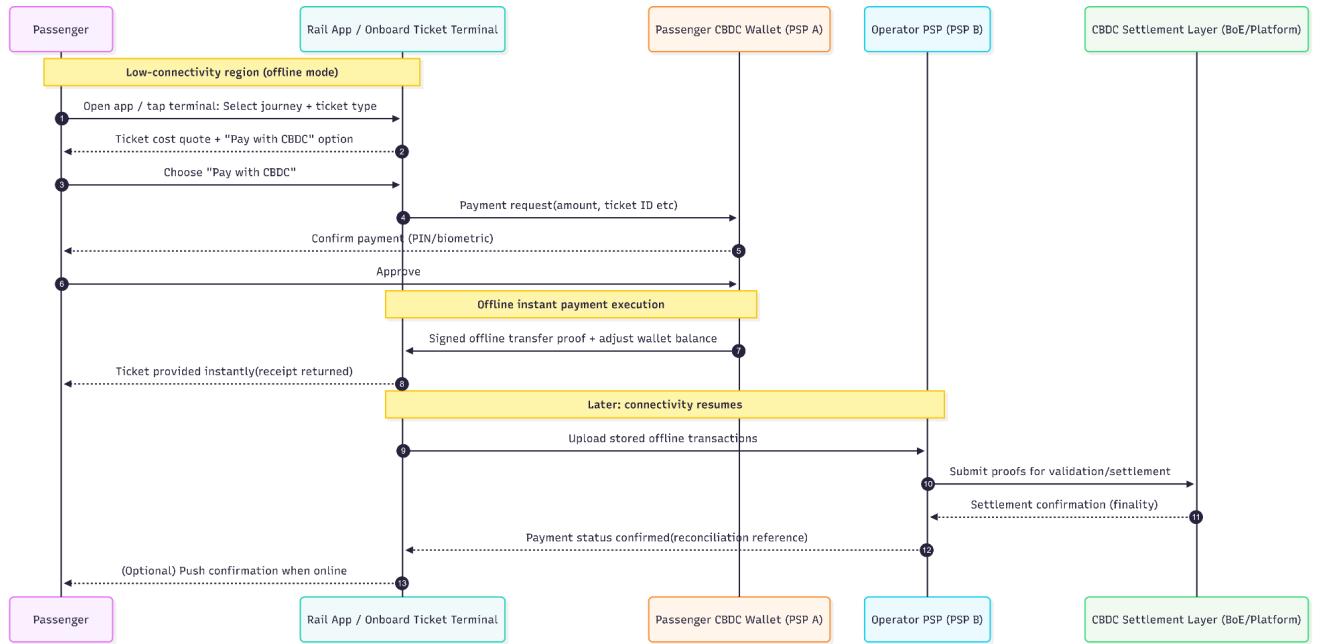
The typical interaction with the CBDC use case is as follows:

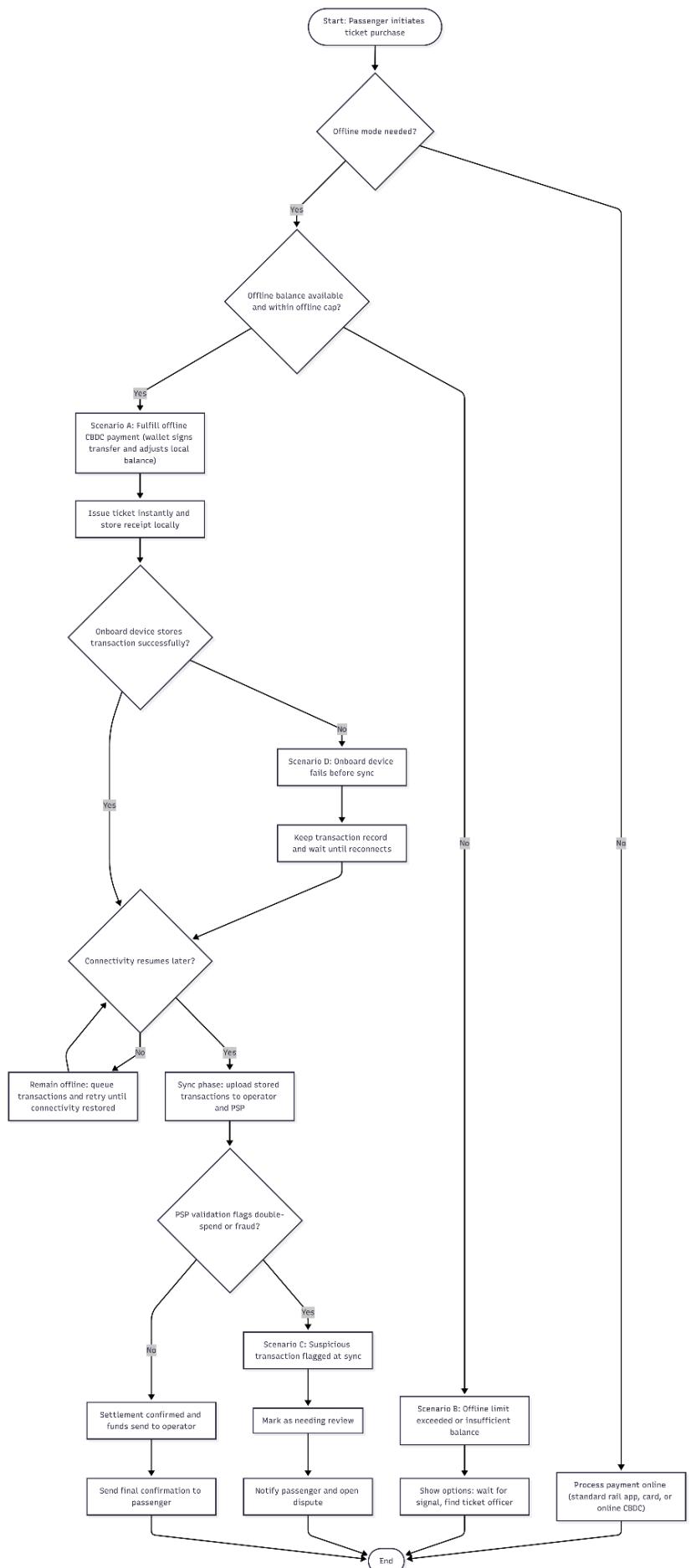
Passenger already has wallet/account with digital euros -> Passenger boards train without ticket (that has no or patchy internet connection) -> Passenger uses mobile app to select route or uses onboard terminal interface -> App or terminal shows price and payment option and chooses “pay with digital euro” -> passenger wallet requires pin and shows balance stored inside and they approve payment -> wallet transfers value locally to operator terminal/device and signs transaction and stores proof for when wifi is restored. The rail system provides QR code tickets and receipt allowing passengers to travel. When wifi restored, the transactions are sent to the train operator PSP, who verifies signatures and records the digital euro transaction to the ledger -> final state is a valid ticket for the passenger, and revenue is captured for the operator

In this scenario, the terminal is on the train (e.g., a screen with a scanner mounted on the train's wall) and serves as the core device used by the train provider. It fetches data and synchronizes with the provider over the internet and must store the most recent prices, availability, subscriptions, seat reservations, and other ticketing data. A core issue is long offline periods may lead to serious desynchronization e.g. prices change or a customer pass is cancelled due to fraud while offline. This is more an issue with provider ticketing backend than CBDC, but it means viable use cases will be restricted to brief offline periods. Moreover, instead of pure automated onboard terminals making transactions, the more riskless implementation may be ticket officer terminals with CBDC payment option. Additionally, per-transaction and cumulative spend caps would be required to limit risk of exploits due to the technology being primarily used offline.

Conclusion

This paper proposed offline-capable rCBDC and the ways it could reduce issues with cross-border payments, address connectivity issues and simplify ticketing for European rail. The digital euro can be used as a transport payment channel, not merely as a general-purpose currency, to help address the shortcomings of scattered and unreliable ticket reservation systems. The viability of the proposal depends on adoption and operational problems more than CBDC itself - ticketing synchronization and offline risk. CBDC for rail should not be seen as a unique solution to rail payment problems, but as a helpful buffer, aiming to add a reliable fallback under unique stress conditions where other payment methods are insufficient.





Bibliography

¹Kiff J. (2024), Kiffmeister Chronicles, 5 September,
<https://kiffmeister.com/2024/09/05/jurisdictions-where-retail-cbdc-isbeing-explored-3/>