Offline Digital Eurozone Train Tickets

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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 his train due to a delayed train.

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

Therefore, this paper calls for the implementation of a new Central Bank Digital Currency (CBDC)–enabled system that would allow for secure offline transactions, to allow for seamless train ticket reservations. Furthermore, according to Kiff. (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 exacerbate 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 can charge currency exchange fees, and transactions require terminals with continuous Wi-Fi or network access, further limiting their reliability. Finally, slower cash-based transactions require human mediation and often interfere with other train staff responsibilities, such as ticket inspection, thereby imposing opportunity cost on transaction time.

Together, these limitations highlight a systemic need for a more resilient, low-dependency ticketing approach that can operate 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 that in turn, with ticket issuance, would be instantaneous and independent of real-time connectivity.

To enable this, customers would redeem retail CBDC (rCBDC) for their national currency, allowing digital coins to be loaded into their wallets or devices. This ensures seamless, 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 handled by a transnational network on which all transactions would be handled using bridges (smart-contracts) to handle transactions between customers' real-assets wallet and the 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:

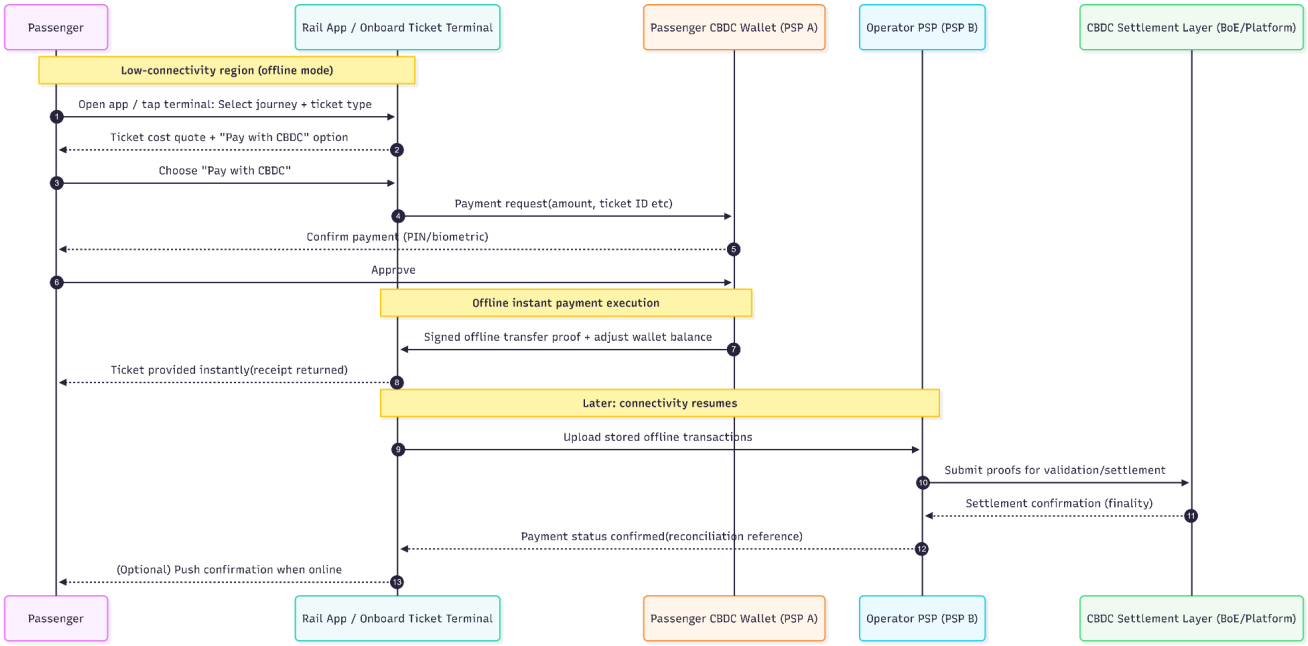
Passenger already has wallet/account with digital euros -> Passenger boards train without ticket (that has no or patchy internet connection) -> Passenger uses mobile app to select route or uses onboard terminal interface -> App or terminal shows price and payment option and chooses “pay with digital 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

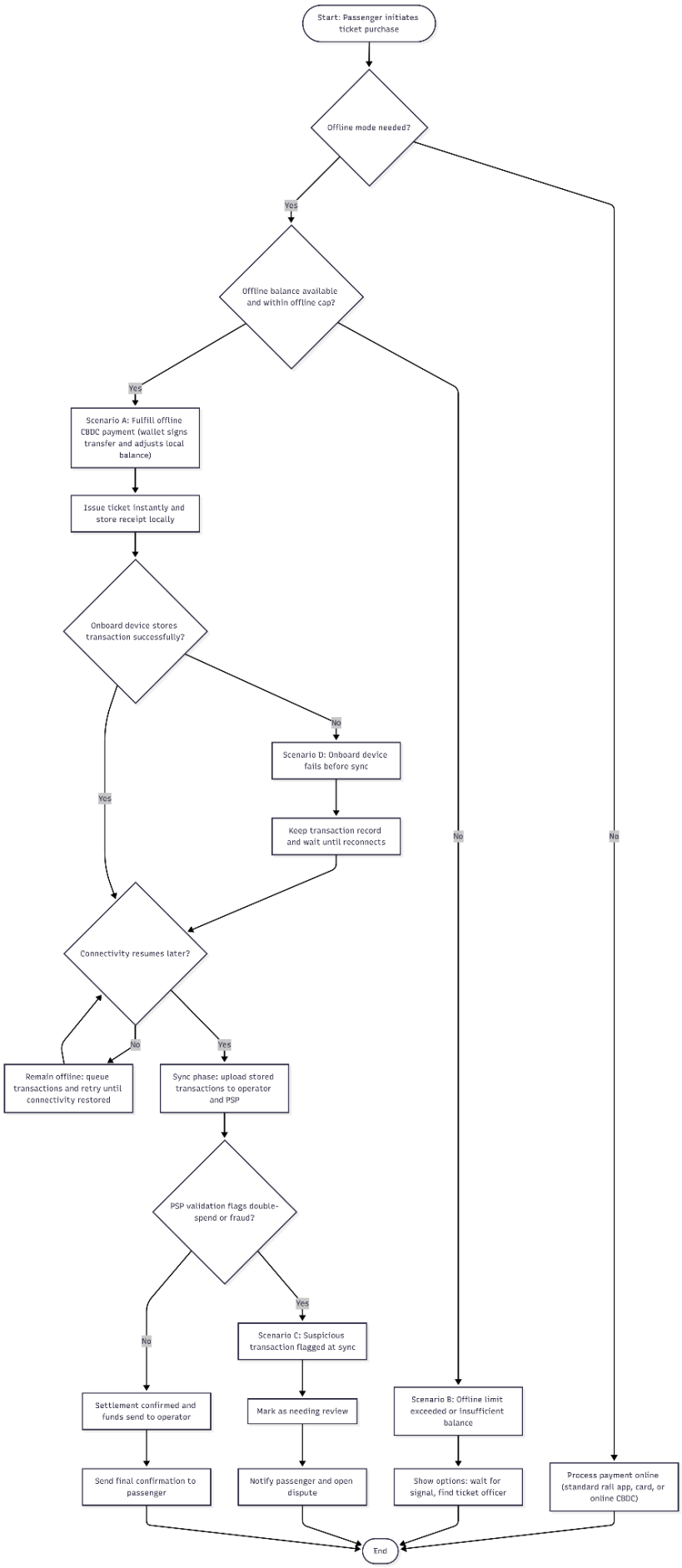
In this scenario, the terminal is on the train (e.g., a screen with a scanner mounted on the train's wall) and serves as the core device used by the train provider. It fetches data and synchronizes with the provider over the internet and must store the most recent prices, availability, subscriptions, seat reservations, and other ticketing data. A core issue is long offline periods may lead to serious desynchronisation 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 retail CBDC 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 for transport payment conduit, not only as a general-purpose currency, and help address the shortcomings of scattered ticket reservation systems. The viability of the proposal depends on adoption and operational problems more than CBDC itself - ticketing synchronization, offline risk


Passenger
Rail App / Onboard Ticket Terminal
Passenger CBDC Wallet (PSP A)
Operator PSP (PSP B)
CBDC Settlement Layer (BoE/Platform)
Low-connectivity region (offline mode)
1 Open app / tap terminal: Select journey + ticket type
2 Ticket cost quote + "Pay with CBDC" option
3 Choose "Pay with CBDC"
4 Payment request(amount, ticket ID etc)
5 Confirm payment (PIN/biometric)
6 Approve
Offline instant payment execution
7 Signed offline transfer proof + adjust wallet balance
8 Ticket provided instantly(receipt returned)
Later: connectivity resumes
9 Upload stored offline transactions
10 Submit proofs for validation/settlement
11 Settlement confirmation (finality)
12 Payment status confirmed(reconciliation reference)
13 (Optional) Push confirmation when online
Passenger
Rail App / Onboard Ticket Terminal
Passenger CBDC Wallet (PSP A)
Operator PSP (PSP B)
CBDC Settlement Layer (BoE/Platform)


Start: Passenger initiates ticket purchase
Offline mode needed?
Yes
No
Offline balance available and within offline cap?
Yes
No
Scenario A: Fulfill offline CBDC payment (wallet signs transfer and adjusts local balance)
Issue ticket instantly and store receipt locally
Onboard device stores transaction successfully?
Yes
No
Scenario D: Onboard device fails before sync
Keep transaction record and wait until reconnects
Connectivity resumes later?
No
Yes
Remain offline: queue transactions and retry until connectivity restored
Sync phase: upload stored transactions to operator and PSP
PSP validation flags double-spend or fraud?
No
Yes
Settlement confirmed and funds send to operator
Send final confirmation to passenger
Scenario C: Suspicious transaction flagged at sync
Mark as needing review
Notify passenger and open dispute
Scenario B: Offline limit exceeded or insufficient balance
Show options: wait for signal, find ticket officer
Process payment online (standard rail app, card, or online CBDC)
End

Bibliography

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