Blockchain Enables Traceability and Safety of Road Freight Transport

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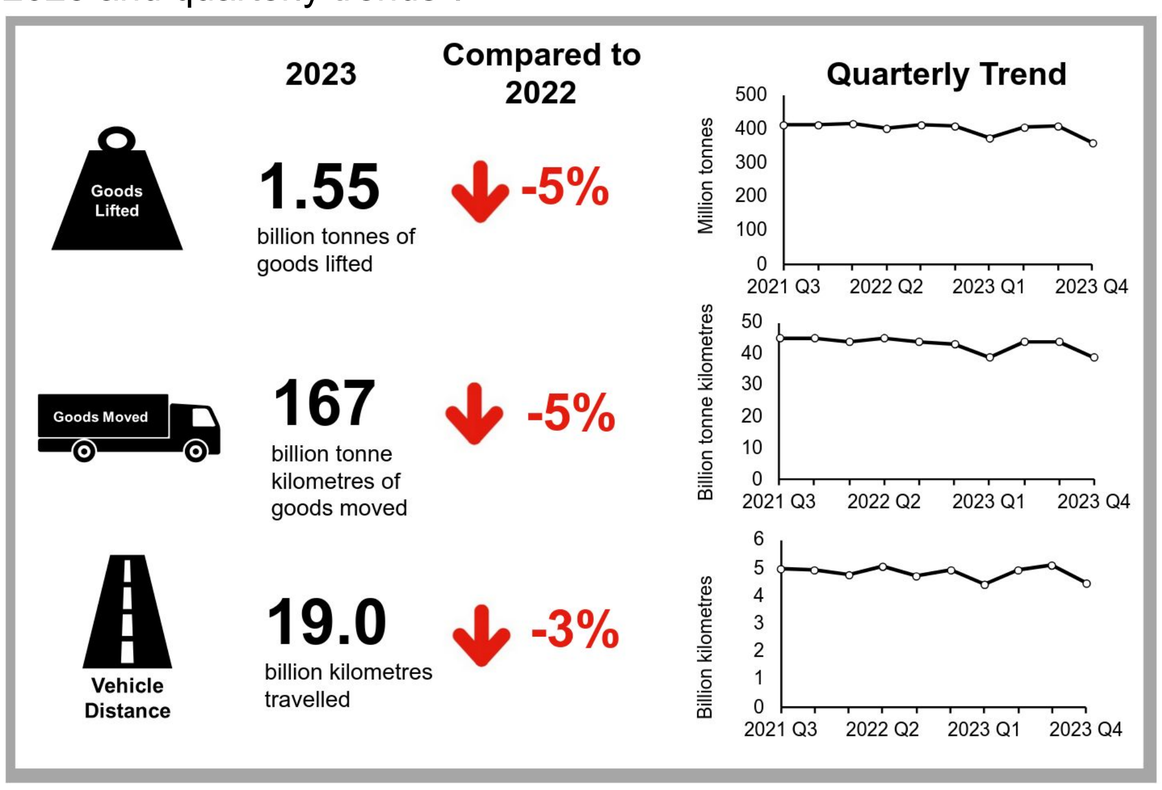
Introduction and Motivation

Blockchain integration within **Intelligent Transport Systems (ITS)** in the context of Industry 4.0 has the potential to revolutionise the transport sector by enhancing transparency, traceability, security, and efficiency[1]. By combining blockchain with ITS, **road freight transport** can benefit from **secure, real-time data sharing, automated processes** through smart contracts, and improved **traceability** across supply chains. This integration promises to **optimise logistics, reduce fraud, enhance regulatory compliance, and support emerging innovations** like autonomous vehicles and shared mobility, paving the way for smarter, more sustainable transport ecosystems.

Road Freight Statistics, United Kingdom

The Figure shows the total amount of domestic goods lifted, goods moved, and vehicle kilometres travelled by GB-registered HGVs in 2023 and quarterly trends[2].



Research Question and Methodology

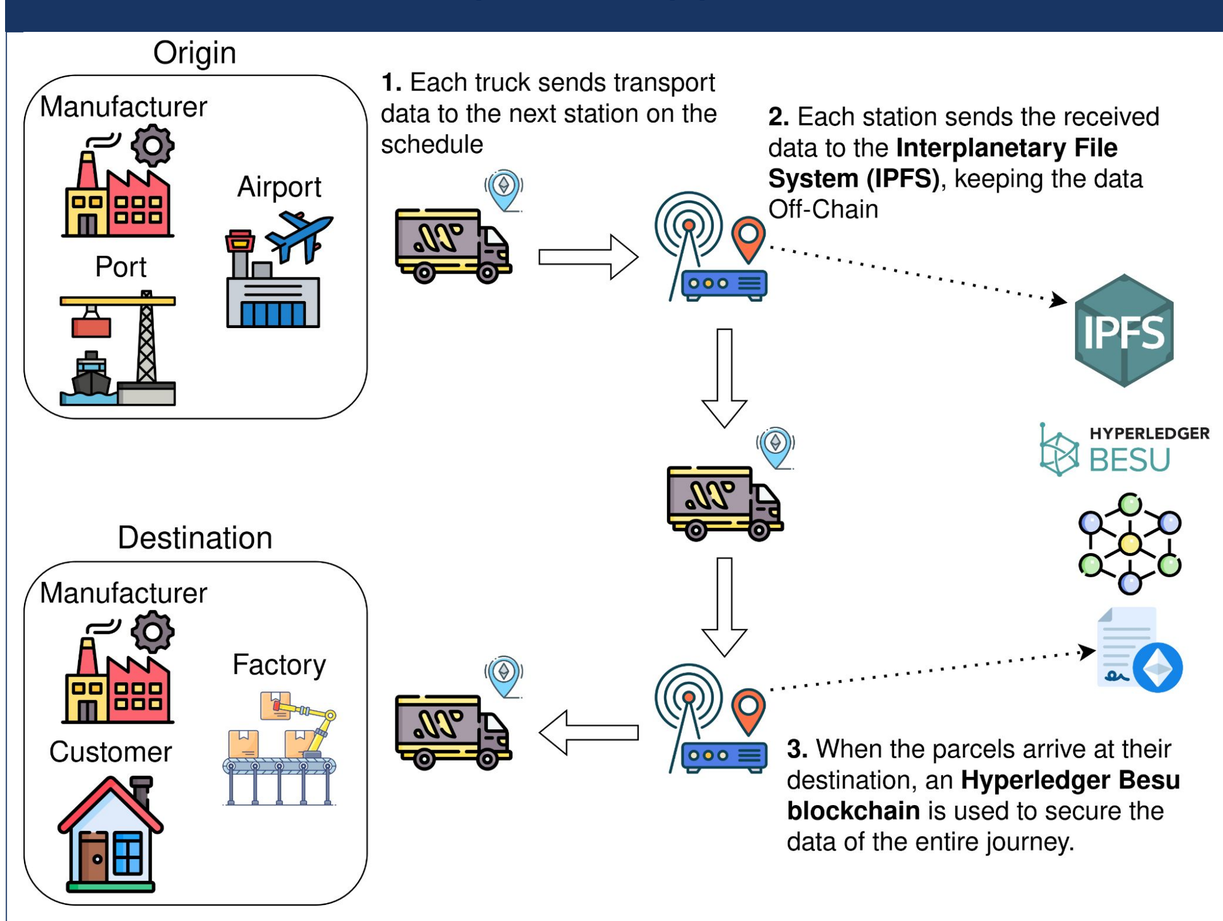
In the evolving landscape of Intelligent Transportation Systems[3] we derived the following research questions:

RQ. 1 - *How can the blockchain properties benefit the freight transportation system?*

RQ. 2 - *Is it possible to mitigate the scalability issue of the blockchain to facilitate its integration within ITS?*

Single Case Study Approach: the study focuses on the logistics companies that manage a large-scale road freight operation in the **UK**. Implementing blockchain technology within **freight tracking systems**, which is part of a broader ITS initiative, could resolve **transparency and traceability** issues. It should enhance **data security** through decentralised verification, protecting sensitive data from tampering or hacking.

Proposed Approach



Evaluation and Challenges

RQ.1: Blockchain's **decentralisation and transparency** properties have already led to improvements in **trust** between freight carriers, clients, and regulators. Early data shows enhanced real-time tracking accuracy, better compliance with environmental regulations, and reduced delays in cross-border transportation due to the automation of paperwork through **smart contracts**.

RQ.2: Blockchain scalability remains a challenge, the adoption of **private blockchains** can potentially mitigate the issue within the context of ITS by distributing data more efficiently across nodes. The integration of **Off-Chain** and **Layer 2 solutions** can further improve data throughput without compromising security.

C.1: The approach seems promising, but it is necessary to carry out an accurate **analysis of the current technologies** to understand the actual capacity and **availability** in terms of **standards** and **interoperability**.

C.2: Further analyses should be carried out to define the **actors involved**, the **roles** and who should be responsible for **managing the infrastructures**, implementing **access control mechanism** and preserving **privacy**.

Expected Outcome and Further Analysis

The proposed approach is currently under analysis. Combining **blockchain** and **off-chain** technology, such as IPFS, can be a strategy to circumvent the scalability issues of blockchain and benefit from its properties within ITS.

Further research is needed to explore the long-term sustainability and broad applicability of these solutions across freight transport. Moreover, the findings should be compared with similar case studies or pilot projects in other regions to understand whether the benefits and scalability solutions observed in this case are generalisable to other contexts.

1 - E. Irannezhad, Is blockchain a solution for logistics and freight transportation problems?, Transportation Research Procedia, Volume 48, 2020, Pages 290-306, ISSN 2352-1465, (https://www.sciencedirect.com/science/article/pii/S2352146520304397).
2 - https://www.gov.uk/government/statistics/road-freight-statistics-2023/domestic-road-freight-statistics-united-kingdom-2023
3 - R. Jabbar *et al*., "Blockchain Technology for Intelligent Transportation Systems: A Systematic Literature Review," in *IEEE Access*, vol. 10, pp. 20995-21031, 2022, doi: 10.1109/ACCESS.2022.3149958.