# The Role of Networks in the Digitalization of Transit Flows

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**Digital technologies are breathing new life into modern global transit and logistics systems. The article shows that 5G, edge computing and blockchain technologies play a key role in the digitalization of transit flows. 5G networks provide high speed and very low latency, enabling a wide range of IoT devices. Edge computing, on the other hand, allows for fast, on-site processing of data, reducing time loss compared to traditional cloud-based systems. The application of these approaches minimizes time losses in transit processes and ensures real-time decision-making. The article demonstrates the effectiveness and security of automated systems by giving examples from pilot projects implemented in ports such as Algeciras and Barcelona. At the same time, storing data in a single, immutable ledger through blockchain technology ensures synchronous and transparent sharing of information. As a result of this integration, the efficiency of logistics operations increases, bureaucratic barriers are reduced, and global transit systems become more reliable, operational and competitive. In addition, the applied technologies ensure the accuracy, security and timely delivery of data, which enables agile decision-making and efficient operations in the logistics sector. Thanks to these integrated systems, transit flows are optimized, trade processes are accelerated and competitive advantage is ensured.**

***Keywords— digital transport-logistics, electronic freight documents, digital integration, digitalization of transit flows, international trading platforms***

## I. Introduction

Digital technologies are rapidly permeating global transit and logistics systems, leading to the digitalization of freight transportation, vehicles, and supply chains. By digitalizing transit flows, it is understood that the monitoring, management, and coordination of data concerning the movement of cargo and vehicles is carried out in real time through electronic systems. At the heart of this process lies the role of various network technologies. In particular, telecommunications networks with high transfer capacities and distributed data exchange platforms enable the collection, transmission, and processing of information in real time. For example, the extensive coverage, low latency, and ability to connect multiple devices simultaneously of a 5G network turn it into a foundational platform for implementing many new technologies in logistics and transportation. Thanks to such advanced networks, data gathered from IoT sensors installed in vehicles and infrastructure can be delivered instantly to central systems and stakeholders. Consequently, efficiency along transit routes increases, transparency rises, and decision-making becomes more operational.

At the same time, the digitalization of transit flows brings about new challenges. The primary challenge is ensuring data synchronization and establishing reliable real-time data availability. Since numerous systems and stakeholders (carrier companies, logistics operators, customs authorities, ports, etc.) are involved in the digital transit ecosystem, sharing data in a timely, consistent, and proper manner is critical. Otherwise, the capabilities offered by digital technologies are not fully realized—data delays and inconsistencies can slow down transit processes or lead to incorrect decisions.

This article analyzes the problem of data synchronization and real-time data transmission delays in digitalized transit systems. In addition, two main approaches are presented for solving the problem—the integration of 5G with edge computing and blockchain-based data sharing protocols—accompanied by technical justifications, real examples, and practical applications. These approaches aim to demonstrate how they can serve to provide instantaneous, reliable, and efficient data exchange in the digital transit ecosystem.

## II. Problem Statement

The main problem encountered in the digitalization of transit flows is the synchronization of data exchange and delays. In current traditional systems, data is often shared in a fragmented and delayed manner among various parties, which diminishes the benefits of digital integration. For example, in traditional logistics networks, the lack of complete system integration results in an absence of real-time visibility into the status and movement of cargo. At the same time, when different databases and protocols are used, the problem of data inconsistencies arises, and having different information about the same cargo in different systems leads to errors in decision-making and uncoordinated operations.

The above problem indicates that reliably solving data synchronization and minimizing delays is the primary priority of the digital transit ecosystem. To achieve this, both a high-speed, low-latency communication infrastructure and reliable, distributed data sharing mechanisms are required. In the following sections, the two main technological solutions that meet these requirements—the integration of 5G networks with edge computing and blockchain-based distributed data exchange protocols—will be analyzed in detail, demonstrating how they are technically justified and tested through real pilot projects.

## III. Main Part

5G and Edge Computing Integration:

One of the most promising approaches to reducing data transmission delays in transit flows is the combined implementation of 5G mobile network technology with edge computing. 5G—the fifth-generation mobile communication technology—offers much higher data transmission speeds (measured in gigabits) compared to previous generations, as well as latency in the range of single-digit milliseconds. While typical delays in 4G LTE networks are around 50–100 ms, in 5G networks this duration can drop to between 1 and 10 ms. At the same time, 5G allows for a high capacity of devices for IoT connectivity and enables network slicing, which facilitates the effective support of applications with varying requirements (for example, sensors, autonomous transportation, audio/video streaming) on the same infrastructure. All these features are extremely important in fields such as transit and logistics that require real-time responsiveness.

On the other hand, the concept of edge computing (or multi-access edge computing, MEC) envisages moving the processing and analytics of data from the central cloud to the periphery of the system—that is, to nodes located near where the data is generated. In the traditional cloud model, the large volumes of data packets generated during transit (for example, sensor readings from cargo, video footage from vehicles, etc.) are transmitted over the network to a remote data center, where they are processed and then the response is sent back via the network. In this model, both the network load is high and an unavoidable delay, dependent on distance, occurs. Edge computing, however, allows data to be processed locally on an edge device (such as a router, base station, or local server), thereby eliminating the time required for the data to be sent to and returned from a central system. As a result of local processing, decisions or critical notifications can be executed almost instantly (in real time), while only the data deemed necessary is transmitted to the central system. Thus, when 5G and edge computing are applied together, a synergistic effect emerges that eliminates network delays—5G provides a reliable and fast connection, while edge computing localizes processing operations that are sensitive to delays on that connection. This approach, in particular, enables the operational responsiveness required for critical decisions in transit flows. Studies show that with 5G + MEC integration, near-instant response times can be achieved, whereas traditional cloud-centric architectures cannot demonstrate such reactivity with delays exceeding 50 ms. Consequently, losses incurred from delays in managing transit processes are reduced, and data is disseminated throughout the system as quickly as possible.

The real-world application of 5G–MEC integration can already be observed in various transportation and logistics scenarios. For example, major seaports have begun to deploy 5G networks and establish edge computing resources to accelerate transit flows. In a pilot project implemented at the Port of Algeciras in Spain, numerous cameras and sensors were integrated using the 5G infrastructure provided by Vodafone and Huawei to create an automatic license plate recognition system for vehicles. Thanks to this system, especially during periods of massive transit flows such as the "Strait Crossing Operation," the flow of vehicles entering the port is automatically regulated toward the berths. Due to the low latency and high reliability of the 5G connection, the images captured by the cameras are processed immediately at edge computing nodes, and the corresponding guidance instructions are delivered to drivers. Vehicles are directed to appropriate terminals in real time, preventing traffic jams and expediting the loading process. In a second scenario tested by the same port, a facial recognition system for identifying suspicious individuals was established through high-resolution cameras connected to a 5G network and supported by edge computing resources—this system also sends real-time alerts to security agencies, thereby strengthening operational security within the port area. These examples demonstrate that in transit hubs such as ports, both operational efficiency and security are significantly improved thanks to the fast connection provided by 5G and the processing power of edge computing.

Another pilot project regarding the use of 5G and MEC technologies in transit flows is being carried out at APM Terminals in the Port of Barcelona. The aim of this project is to establish an ultra-reliable, low-latency communication platform among cranes, trucks, and workers within the port to minimize the risk of collisions. The solution leverages the C V2X (Cellular Vehicle-to-Everything) protocol and takes advantage of the several millisecond latency benefit of the 5G network to coordinate the positions of moving vehicles and people. Advanced algorithms supported by edge computing predict possible collision scenarios and send real-time alerts to both the vehicle dashboard displays and the mobile devices of on foot workers. Such a system accelerates internal logistics processes in the port while ensuring worker safety—5G/MEC integration helps prevent accidents by delivering critical information without delay.

Not only in port and terminal areas but also throughout the production and supply chain, the combination of 5G and edge computing yields significant benefits. For example, consider a large manufacturing enterprise: end to end visibility is necessary to coordinate internal plant processes with external logistics operations. With a solution equipped with a 5G ultra broadband network and local edge computing, the manufacturer can monitor production conditions in real time, track inventory in the warehouse, and coordinate the transportation of products almost without delay. Trials have shown that the 5G/MEC infrastructure, when combined with AI (artificial intelligence) technologies, enables the manufacturer to fully optimize the supply chain: as a result, maintenance needs are predicted in advance before equipment failure occurs in factories, unexpected downtimes are reduced, and product warehousing, order processing, and delivery are synchronized within a single system. Leading companies implementing such systems observe a reduction in idle time for trucks and pallets, an increase in worker productivity, and a shortening of the period from order to delivery. As seen, the integration of 5G and edge computing increases operational efficiency by ensuring that data is collected and shared without delay along transit flows, while also accelerating the transition to a flexible, adaptive logistics model.

Blockchain-Based Data Sharing Protocols:

Another fundamental approach to solving the data synchronization problem is the implementation of distributed data exchange protocols based on blockchain technology. Blockchain is a chain of consecutive “blocks” on which data is recorded on a distributed network rather than on centralized servers, making it practically impossible to alter. Although this technology originally emerged in the cryptocurrency ecosystem, in recent years it has promised extensive potential in the field of supply chain and logistics. On blockchain based platforms, all events and operations related to transit (for example, the departure of cargo, border crossings, deliveries, etc.) are recorded in a single digital ledger (distributed ledger). This ledger is shared among all trusted participants in the network, and no changes can be made to any record without a collective consensus. As a result, all parties see the same version of the data, eliminating discrepancies and ensuring real time updates. Blockchain data incorporates a “trust by design” principle: every piece of data recorded is verified with cryptographic signatures and is permanently embedded by subsequent blocks in the chain. This preserves the accuracy and integrity of the data throughout the transit process and minimizes the potential for external tampering or fraud. For instance, rather than maintaining separate records in different systems by various companies (carriers, forwarders, customs, etc.), a single “source of truth” is established on the blockchain—allowing all participants access to a fully synchronized database regarding cargo location, status, and document conditions. Such an environment of real time updated and shared information can eliminate issues such as data discrepancies, delays, and multiple data entries that were previously encountered.

One of the attractive features of blockchain technology in transit flows is the automation of processes through smart contracts. A smart contract is a piece of program code operating on the blockchain that is automatically executed when predetermined conditions are met. In the transit ecosystem, by using smart contracts—for example, the system itself can make a payment to the carrier as soon as the cargo reaches its destination, or warehouse entry permission is automatically granted when goods are released from customs. Such automated steps reduce delays and bureaucratic obstacles caused by human factors while also ensuring that data is updated simultaneously for everyone. An important aspect is that blockchain based protocols can be integrated without radically altering existing systems—in other words, companies can share their output data on the blockchain without completely replacing their internal data systems. This overcomes the limitations of protocols such as EDI (Electronic Data Interchange) that have been in use for decades. For example, large companies like Walmart Canada are already applying blockchain technology for settlements with truck carriers. Walmart Canada has established a blockchain based platform in collaboration with its carriers for the synchronization of cargo data and automatic settlement within its supply chain. Through this platform, logistics information about voyages, shipped goods, etc. is instantly mutually updated between Walmart and the carrier parties, resulting in both easier tracking of cargo along its route and the automation of invoice creation and payment once delivery is completed. According to the company, this approach has completely ensured the synchronization of logistics data, eliminating the time spent on manual checks and removing payment delays.

Real world examples of blockchain applications are evident on a global scale as well. The TradeLens platform, developed jointly by IBM and Maersk—which is well known in international maritime shipping—enables numerous parties (shipping lines, port operators, customs agencies) to share information about container shipments on a single network via blockchain. The primary objective of the TradeLens platform is to eliminate frictions in data exchange within global trade, reduce the total time cargo spends in transit, and decrease the resources spent on documentation processes. During its operation, the platform has managed to attract more than 20 major port and terminal operators as well as several large container shipping lines worldwide. One of the results obtained on routes where TradeLens has been implemented is that the transit time for some container shipments was reduced by 40%. That is, a shipment that previously took, for example, 10 days has been reduced to 6 days due to the documentation and data transmission process. This is a striking statistic that demonstrates how the synchronous and operational sharing of data in transit flows can directly influence physical delivery times. On the TradeLens platform, every event from a container’s departure to its arrival at the destination port was recorded on the blockchain instantly, making it visible to all participants (sender, carrier, port, customs, etc.). As a result, preparations for unloading at the port, the electronic submission of customs declarations in advance, and other processes are carried out on time, reducing idle periods caused by waiting for data.

The blockchain approach is not only an initiative of the private sector but is also being considered by international organizations in the improvement of transit procedures. For example, the Global Transit Document (GTrD) initiative, proposed within the framework of TRACECA (Transport Corridor Europe Caucasus Asia), aims to create a single digital transit document based on blockchain technology. This document will be used on multimodal routes, where container shipments pass through several countries and are transported using different modes (rail, maritime, road). Thanks to the GTrD, instead of cargo being documented separately at each border, the declared data will be recorded once on the blockchain and reliably tracked throughout the chain. Thus, if this approach is implemented, there may be no need for repeated customs checks in each country during transit, as all relevant authorities (for example, the customs agencies of the participating countries) will rely on the same digital record. This would reduce bureaucratic obstacles in international transit flows and create a more transparent and predictable environment.

In conclusion, blockchain based data sharing can be regarded as a revolutionary tool that ensures reliability and synchronization in transit flows. With the application of this technology, the risk of data distortion, delay, or concealment is minimized because every operation is confirmed and recorded with the network’s consensus. As a result, a trust environment is established among all participants in the transit process: everyone knows that the data in the chain is accurate and immediately accessible. In a synchronized data environment, the various segments of logistics operations—from warehousing to transportation, from insurance to customer delivery—can all operate on the basis of complementary data. This, in turn, increases the overall speed and efficiency of transit flows.

## IV. Conclusion

Digital technologies are ushering in a new era in the management of transit flows: real time monitoring of cargo and vehicles, process automation, and instantaneous sharing of data among stakeholders have become possible. However, for these achievements to be fully realized, data synchronization and the elimination of delays are fundamental prerequisites. The approaches analyzed in this article—the integration of 5G with edge computing and blockchain based data sharing protocols—address these critical requirements of digital transit systems.

5G and edge computing solutions bring changes at the infrastructure level of the transit ecosystem: they accelerate network connectivity, reduce delays by shifting data processing to the edge, and enable local decision-making. As a result, the inconsistency between the physical transit flow and the accompanying digital data flow is minimized—that is, data regarding cargo movement is disseminated throughout the network almost simultaneously. On the other hand, the application of blockchain based protocols offers innovation at the application level: by forming a single source of trustworthy data, it ensures synchronization among systems and facilitates process automation. These technologies complement each other in solving both the physical connectivity and data reliability challenges of the digital transit ecosystem.

Real world examples show that the application of these approaches yields concrete benefits: at ports, 5G accelerates cargo handling and reduces waiting times; in supply chains, production and logistics are coordinated more flexibly through 5G/MEC; and at the same time, sharing transit data on blockchain platforms speeds up documentation processes, eliminates delays, and increases supply transparency. Thus, in the context of digitalizing transit flows, the role of networks—as communication networks and data networks alike—is decisive.

Looking to the future, it can be predicted that these technological solutions will deepen and expand further. With the increasing number of IoT (Internet of Things) devices, the volume of data in the transit ecosystem will rise exponentially—requiring a distributed 5G/MEC infrastructure to manage it. At the same time, blockchain based consortiums and standards may be established to create a digital trust environment among various companies and government agencies. The intersection of these two directions could result in a fully integrated, intelligent transit network: at every stage—from vehicle sensors to port management systems—the collected data is rapidly processed at the edge and reliably shared on the blockchain. Such an integrated digital transit ecosystem will ensure faster, safer, and more efficient movement of cargo.

In conclusion, the role of networks in the digitalization of transit flows is indispensable. By implementing the right network solutions, we can achieve complete alignment between physical logistics systems and digital information systems, ensuring that data flows in a timely, synchronized, and reliable manner. This, in turn, paves the way for a new phase of productivity in trade and transportation, providing competitive advantages for countries and companies alike. As the use of network technologies such as 5G, edge computing, and blockchain continues along the path of digital transit transformation, transit routes will become more "intelligent" and efficient, and global trade flows will become more predictable and optimized.

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