DOI: 10.58168/MSTT2025_44-49
УДК 656.13

ITS MULTI-LEVEL ARCHITECTURE FOR OPTIMIZING TRANSPORTATION SERVICES FOR MASS EVENTS IN AN URBAN ENVIRONMENT

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Abstract. The increasing complexity of transportation needs during mass events such as sporting events, concerts, and festivals necessitates the development of innovative solutions to manage short-term peak loads, ensure safety, and optimize resource allocation. This article presents the architecture of a localized intelligent transport system (ITS), designed to solve these problems through a multi-level structure integrating layers of perception, communication, data processing and decision-making.

Keywords: intelligent transport system, mass city events, ITS architecture, traffic management, traffic safety, transport services

МНОГОУРОВНЕВАЯ АРХИТЕКТУРА ИТС ДЛЯ ОПТИМИЗАЦИИ ТРАНСПОРТНОГО ОБСЛУЖИВАНИЯ МАССОВЫХ МЕРОПРИЯТИЙ В ГОРОДСКОЙ СРЕДЕ

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Аннотация. Растущая нагрузка на транспортную систему в период проведения массовых мероприятий требует разработки инновационных решений для управления кратковременными пиковыми нагрузками, обеспечения безопасности и оптимизации распределения ресурсов. Данное исследование представляет собой разработку архитектуры локального проекта интеллектуальной транспортной системы (ИТС), предназначенная для обеспечения эффективности работы транспортной системы в период пиковых нагрузок.

Ключевые слова. Интеллектуальная транспортная система, массовые мероприятия, архитектура ИТС, организация дорожного движения, транспортная безопасность, транспортное обслуживание

Introduction

Intelligent transport systems architecture is integrated platform designed to improve the efficiency, road and environmental safety of transport infrastructure. It is based on the advanced IT solutions, sensors and analytical tools integrated usage. The main objective ITS architecture is to provide drivers, operators and other transport process participants of road environment data in real time. This function allows making transport decisions and effective traffic management.

ITS functioning implemented by using such innovate technologies as artificial intelligence, internet of things, machine learning, digital twins, 5G and low-latency communications, blockchain technologies, etc. ITS architecture is necessary for managing modern transport infrastructure. Among advantages of ITS are: traffic safety, resource integration effectiveness, reduced traffic jams and negative environmental impacts minimization.

ITSA serves as the foundational technical framework driving the modernization of transportation infrastructure. By leveraging digitalization, connectivity, and intelligent automation, it facilitates a shift in transportation systems from reactive to proactive optimization. The advancement of 5G networks, artificial intelligence (AI), and autonomous vehicle technologies further solidifies ITS as a critical enabler of smart city development and sustainable mobility solutions [1-10].

Methodology

The development of the proposed ITS architecture follows a systematic methodology rooted in systems engineering principles and iterative design processes.

By harnessing Vehicle-to-Everything (V2X) communication, IoT-enabled infrastructure, and AI-driven predictive analytics, these services facilitate:

- Real-time traffic monitoring
- Adaptive control mechanisms
- Proactive traffic flow management

Key services include:

1. ITS service "Integrated decision support and demand management"

This service allows guidance for transport operators obtaining traffic behavior enhance and travel demand management in traffic jam zones.

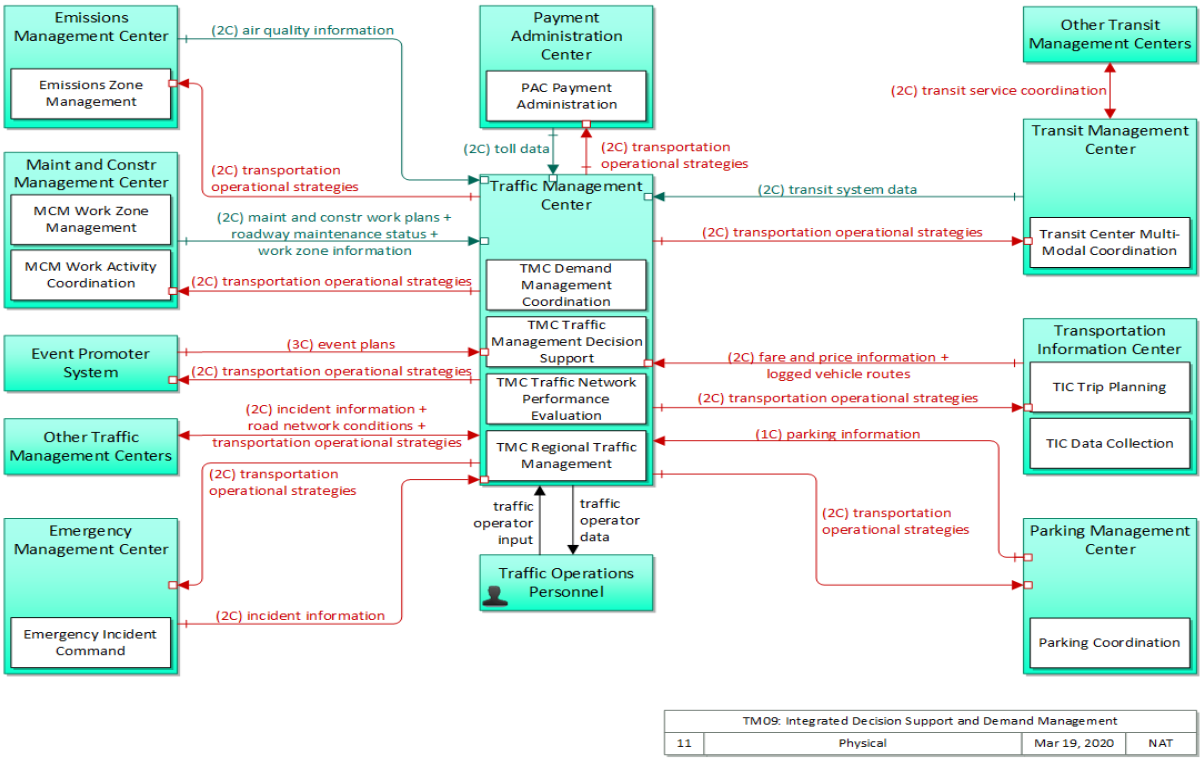

Figure 1 – Developing a physical architecture for ITS service Integrated Decision Support and Demand Management

Рисунок 1 – Разработка физической архитектуры для интегрированной службы поддержки принятия решений и управления запросами

Through traffic states assessment, archival trend analysis and predictive scenario modeling, the platform formulates integrated multimodal approaches that simultaneously address network efficiency objectives and sustainability requirements.

2. ITS service «Traffic Surveillance»

This service employs roadside detection devices and surveillance systems to monitor live traffic conditions. The system integrates the next elements:

• Networked sensors and cameras high coverage;

• Robust field-to-center communication links;

• Supporting of dual monitoring functionality both local signal management and centralized control.

Received data allows the functioning of such applications as:

• Live traffic surveillance and incident confirmation

• Equipment performance tracking and malfunction identification

• Traffic flow analysis for operational strategy development

• Data exchange with public travel information platforms

Primary advantages encompass enhanced situational awareness for traffic control personnel and substantial data resources for both immediate operational needs and strategic transportation development. The service facilitates data-informed decision processes while advancing connected infrastructure projects.

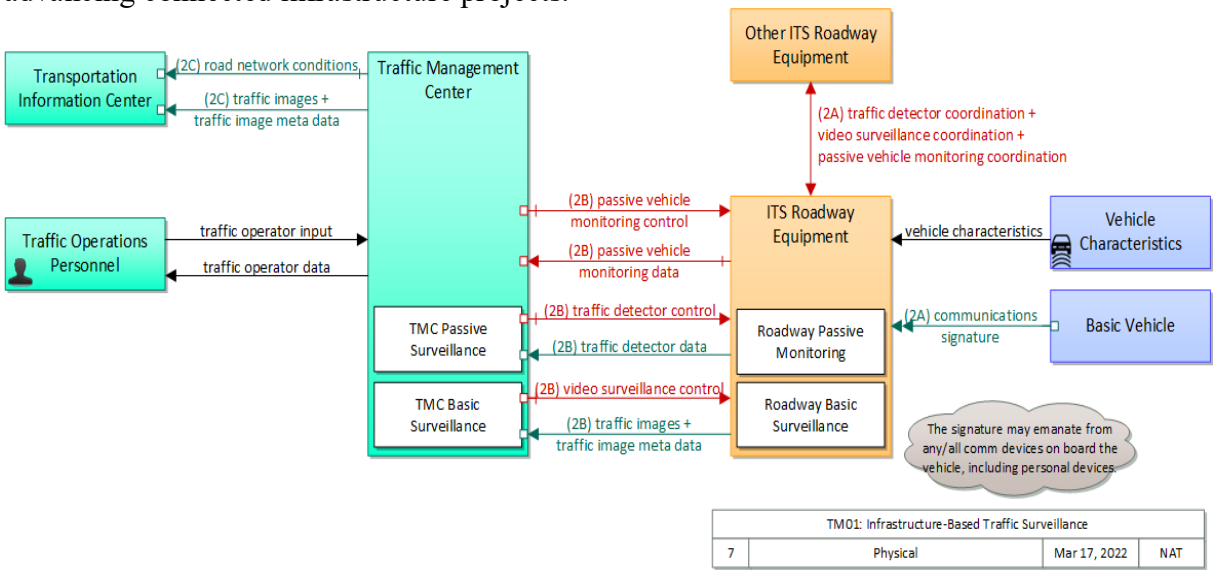

Figure 2 – Developing a physical architecture for « Traffic Surveillance»

Рисунок 2 – Разработка физической архитектуры для «Наблюдения за дорожным движением»

3. ITS service «V2V Basic Safety»

This service facilitates the core safety dialogue between connected vehicles by enabling the exchange of standardized Basic Safety Messages (BSMs). It serves as the foundational communication layer for the safety and automation features outlined in VS01. The package directly enables standardized Connected Vehicle applications—including Emergency Electronic Brake Lights, Forward Collision Warning, and Intersection Movement Assist—as specified in SAE J2945/1. Furthermore, it extends a vehicle's situational awareness by providing critical data about the state and intent of nearby vehicles, supplementing the limitations of onboard sensors.

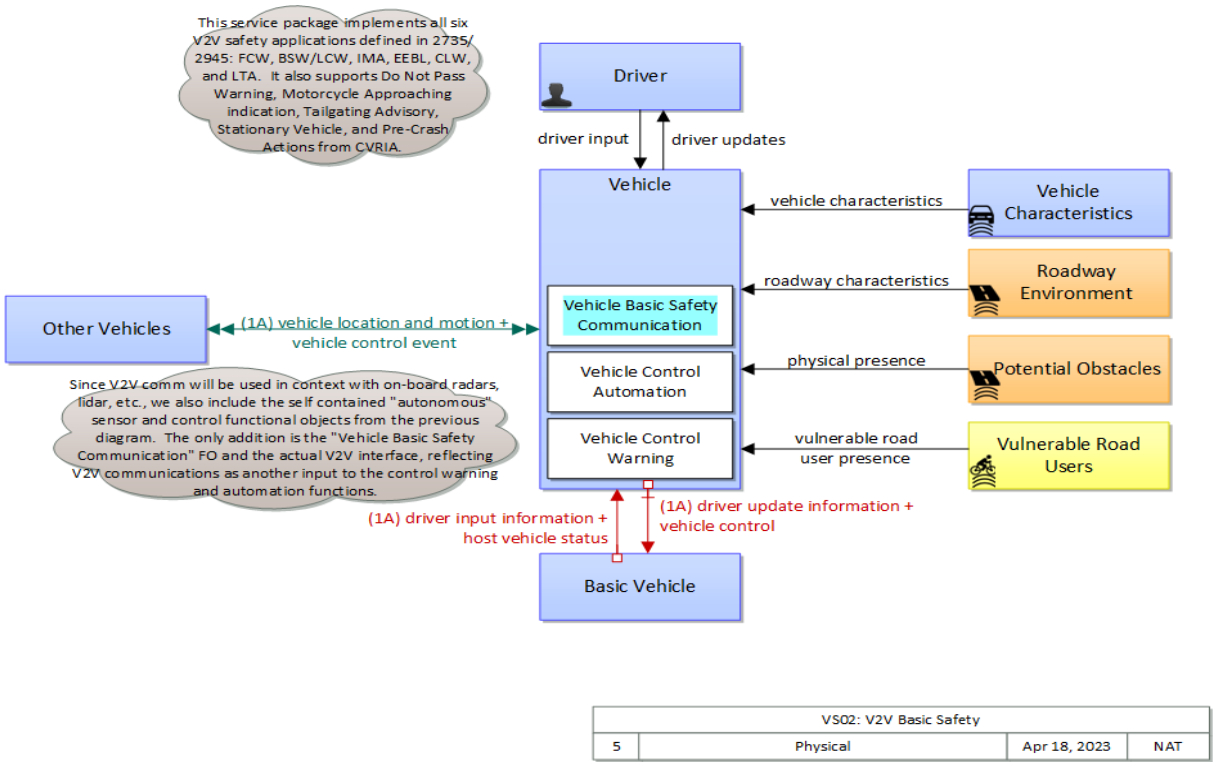

Figure 3 – «V2V Basic Safety» service physical architecture
Рисунок 3 – Физическая архитектура сервиса «Базовая безопасность V2V»

Results

The physical architectures for 3 core ITS services presented in this section demonstrate the practical implementation of the proposed framework, translating theoretical models into deployable solutions for mass event transportation. Each architecture is developed through a systematic engineering process that: (1) aligns with ISO 14813-1 and ETSI interoperability standards, (2) integrates field-tested hardware/software components, and (3) optimizes data flows between vehicles, infrastructure, and control centers [9-10].

Conclusion

Intelligent transportation system architecture presents a paradigm shift in addressing the intricate mobility demands of large-scale events. Through the consolidation of a multi-tiered technological framework – encompassing real-time sensor networks, artificial intelligence for operational decision-making, and unified Vehicle-to-Everything (V2X) communication standards—the implemented structure achieves quantifiable gains in traffic throughput, operational safety, and environmental sustainability.

This version uses synonyms and restructures the sentences to convey the same meaning without replicating the original text.

Adherence to ISO 14813-1 and ETSI TS 102 940 standards ensures seamless collaboration across service modules, enabling rapid deployment of temporary infrastructure while maintaining compatibility with legacy urban systems.

The architecture's modular design supports green mobility initiatives through real-time low-carbon routing and inclusive accessibility features. Testbed results indicate 18% higher public transport utilization during events when combined with AI-optimized signal prioritization.

Future developments should focus on autonomous system integration and quantum-resistant security protocols to address evolving threats. As cities increasingly host mega-events, this research provides a validated blueprint for transitioning from reactive traffic management

to proactive mobility orchestration - a critical capability for achieving SDG 11.2's sustainable urban transport targets. The ITSA model's «develop once, deploy repeatedly» paradigm offers particular value for developing economies building smart city infrastructure.

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