Lecture Notes in Mobility

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Transport Transitions: Advancing Sustainable and Inclusive Mobility

Proceedings of the 10th TRA Conference, 2024 Dublin, Ireland - Volume 6: Connected Mobility Ecosystems

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The TANGENT Project Architecture: Towards New Traffic Management Approaches

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Abstract. The TANGENT project (www.tangent-h2020.eu/) aims to address the challenges of urban transportation, including traffic accidents, greenhouse gas emissions, and congestion. The project focuses on optimizing traffic management and enhancing mobility through a distributed, modular, and scalable architecture. TANGENT collects and harmonizes data from various sources, including sensors, users, vehicles, schedules, pricing, and traffic flows. It uses this data to create enriched information for different transport stakeholders. The project combines technologies such as data gathering, travel behavior modeling, traffic prediction and simulation, and transport network optimization to provide advanced transport management services. This paper is focused on presenting the project architecture developed to implement four services: data collection and harmonization, enhanced information service, real-time traffic management, and transport network optimization. The project involves a consortium of organizations from nine European countries and aims to pilot its integrated tool in multiple cities in 2024.

Keyword: Intelligent Transport Systems · Transport management · Multimodality · Data Harmonisation & Fusion

1 Introduction

With the growing number of vehicles and modes of transportation, and facing major challenges such as road traffic accidents, greenhouse gas emissions, and traffic congestion costs, it is essential to have efficient tools to optimize traffic management and enhance mobility in cities [1]. Transportation system managers are looking for new tools to address the integration of connected and automated vehicles, as well as innovative services to enhance traffic management operations. This requires collaboration between all private and public agents involved [2].

This paper presents the distributed, modular and scalable architecture designed for advanced transport network management, developed under the TANGENT project. The proposed architecture will contribute to support more efficiently traffic management in

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terms of congestion reduction, mitigation of environmental effects through the reduction of CO_2 emissions, and an increase in safety.

TANGENT deals with several heterogeneous data sources. This data is collected, harmonized, stored, processed and turned into enriched information to generate knowledge, inform the users and provide services to different transport stakeholders. In 2023, the project reached the milestone of validating its individual transport management technologies separately which, are being integrated into a single tool to provide the complete advanced transport management services. In 2024, the TANGENT integrated tool will be piloted in the cities of Lisbon, Rennes, Manchester and Athens.

TANGENT is being funded by the Horizon 2020 under the call 'Network and traffic management for future mobility'. This challenge aims to create and enhance smart systems and operational processes to monitor real-time traffic conditions and improve traffic flow performance. It also involves facilitating the real-time sharing of traffic information across networks and optimizing the entire system. TANGENT project counts with a consortium formed by 13 organizations (Universities, RTOs, SME and industry) from 9 different European countries (Spain, Italy, Belgium, the United Kingdom, Germany, France, the Netherlands, Portugal and Greece), and an external panel of experts, composed by vehicles manufacturers, road transport experts, City Councils, etc.

The paper is structured as follows. In Sect. 2 the main concept of TANGENT is introduced. In Sect. 3, the main services offered by TANGENT are presented and Sect. 4 gives an overview of the selected architecture. Finally, Sect. 5 summarizes the conclusions and next steps of this work.

2 The Concept of TANGENT Project

TANGENT provides a collection of tools to all traffic agents, managers and operators such as real time services, dashboards and simulation tools to orchestrate the different transport modes and systems to dynamically optimize traffic management operations in a multimodal transport network, considering also new modes of mobility. TANGENT combines several technologies to provide its services (see Fig. 1. TANGENT conceptual diagram.):

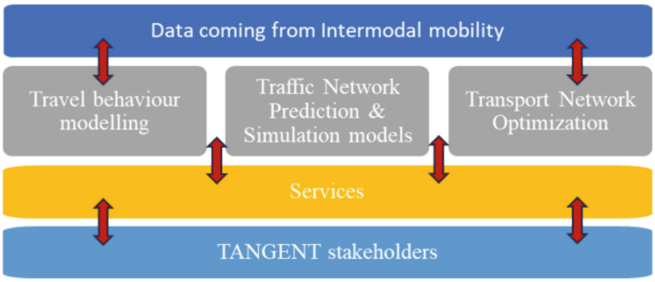

Fig. 1. TANGENT conceptual diagram.

- Data gathering of intermodal mobility, from sensors, users, vehicles, transport schedules, pricing, traffic flows, events, etc.
- Travel behaviour modelling, studying travel patterns of the individual transport users.
- Traffic Network prediction & simulation, creating models of demand and supply of transport, that enable to predict traffic congestion and potential bottlenecks.
- Transport network optimisation, to determine a set of actions for optimizing the traffic flows.

3 TANGENT Architecture

The TANGENT architecture is intended to define a distributed, modular and scalable system designed for advanced transport network management. The proposed architecture, shown in Fig. 2 is intended to define a structural framework to provide functionalities for current and novel modes of transport. These functionalities are classified into four services:

- Service 0 (S0). Data Collection and Harmonization Service.
- Service 1 (S1). Enhanced Information Service for Multimodal Transport Management Service.
- Service 2 (S2). Real-Time Traffic Management Service.
- Service 3 (S3). Transport Network Optimization for Transport Authorities.

TANGENT relies on data collected and harmonized by S0. S1 centralizes the data exchange between different system components and the Data API from S0. S1 delivers all project data centrally through the TANGENT API. S2 supports two subservices to handle the management of traffic whenever expected or unexpected events occur and depending on the level of severity of those incidents. And finally, S3 offers Network Optimization features, to assist S2 on the decisions to be taken upon those incidents. Further details about the services and their architectural implementation are given below.

– S0 - Data Collection and Harmonization

Data is the key element in TANGENT. How it's collected, transformed, processed, visualized and interacted with defines the scalability of the project. S0 will be responsible for providing access to the different data sources, external to the project, for each TANGENT case study, considering the requirements of both static and dynamic data.

S0 utilizes RDF standards for metadata and data source harmonization. Two types of interactions are expected: access to data sources in the native format through the Raw Data API, and access to harmonised data sources through the TANGENT API, as depicted in Fig. 3. Data sources are accessed by S0 to be collected or the sources access S0 to deliver the data. S0 then harmonizes it and delivers it to S1 through an API.

– S1 - Enhanced Information Service for Multimodal Transport Management

S1 plays a crucial role in data management and data delivery, being composed by the TANGENT API, the Dashboard and a Calculated Data module.

The TANGENT API serves as the central hub for exchanging data between various project components. This API implements a REST-based architecture alongside a message-oriented middleware (MOM) architecture. In both it uses JSON data encoding

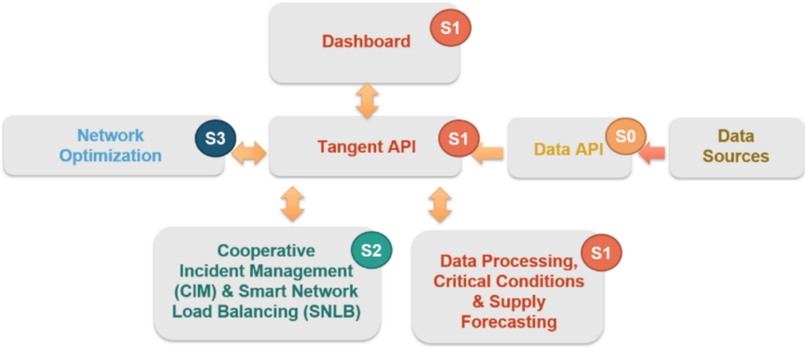

Fig. 2. Top-level technical architecture

for compatibility with modern API standards and OpenAPI specifications. It stores data in a Document Database, ensuring flexibility in handling structured and non-structured JSON data without the need for complex database mapping. Data from S0 is transferred to S1 through three channels: AMQP for real-time data, HTTPS fetching for larger data, and raw data proxying for specific data streams.

The Dashboard serves as the user interface for project stakeholders. It comprises modules for dashboard customization, data visualization, and integration with the TANGENT API and supports various UI modules. This service allows users to access live and future information about the roads and transport network.

The third module is the Calculated Data which consumes static and dynamic data from the TANGENT API and generates new data that is then fed to the TANGENT API using the AMQP Service when new data is ready. This data is composed of the Supply Forecasting module, responsible for forecasting traffic; the Data Processing module, responsible for extending dynamic traffic and forecast data with new calculated metrics more intuitive for visualisation in the Dashboard; and the Critical Conditions module, responsible for detecting anomalous events and modelling the duration of existing and detected events. This is shown in Fig. 3.

– S2 - Real-Time Traffic Management Services

S2 is composed of two subservices: Smart Network Load Balance (SNLB) and Cooperative Incident Management (CIM). SNLB and CIM are very similar processes that are used to handle network issues and incidents, tactically and strategically. Their purpose is to address and solve the event causing abnormal situations and resume normal operations. Both subservices are based on templates provided by S3. They start by notifying about specific degrading conditions of the transport network and suggesting a response plan for those situations. The difference between CIM and SNLB is that CIM involves several stakeholders at once, requiring their coordination by the system, whereas SNLB only involves a single actor from a single entity.

The transport network balancing provided by SNLB involves pre-defined triggers/conditions and rules for actions to be taken. These actions will suggest, for instance, new traffic lights timings changes to public transport (PT) scheduling, instructions for

Connected and Automated Vehicles (CAVs), dynamic toll pricings according to congestion levels and, also, information for passengers about specific traffic and transport conditions (e.g., inform about a closed metro line, protests blocking a bus route, usually providing alternatives). This balancing approach can cope with pre-defined scenarios where decision making is simple and does not involve more than one specific stakeholder. For more complex cases, human cooperation is necessary. This is where CIM comes in. Also based on triggers/conditions to be launched, CIM is configured and managed from the TANGENT Dashboard by the involved stakeholders in the existence of an event or incident in the transport network. CIM usually combines more than one action groups. Three CIM functionalities are being implemented: the synchronization of traffic control and public transport (PT), the synchronization of Demand-Responsive Transit (DRT) with PT and the synchronization of PT and the connected autonomous vehicles (CAV).

S2 is supported by three distinct modules: the Dashboard (S1), the Monitoring Module (S2), and the Response Module (S2), all interconnected through the TANGENT API. The Monitoring Module receives commands from the TANGENT Dashboard to monitor or stop monitoring Triggering Conditions. It then notifies the API about Triggering Conditions that fail or stop failing, which is subsequently consumed by the Dashboard in order to provide user alerts for the triggering conditions. These alerts allow the users to address the incident at hand using specific templates from S3 that relate the current abnormal transport network states with a response plan. The Response Module handles Response Plan Implementation, receiving requests to apply specific Response Plans and making relevant information available through the TANGENT API for involved parties. Additionally, it ensures the resumption of normal operational conditions by sending action information to the API for compliance by the operational systems of stakeholders. The Dashboard manages the state management and persistence of CIM, and SNLB entities and handles UI interactions for these entities and the interactions S3 - Transport Network Optimisation for Transport Authorities.

S3 is responsible for the creation of the Common Operational Picture (COP) used in CIM, the creation of the Response Plan Package (RPP) used in SNLB, and the simulation of 'What-if' Scenarios for urban mobility planning. Both the COP and RPP act as templates for response to pre-defined scenarios like a flood in a specific city or an overload in the metro network. Both contain the relevant information to suggest a response plan depending on the level of coordination mechanisms required. In addition, S3 also offers internal TANGENT stakeholders the possibility to execute the simulation of hypothetical transport network scenarios directly, where the only difference to the COP and RPP functionalities is that these scenarios are only simulated, not being subjected to any optimization process. S3 needs three modules to provide these functionalities together with the Dashboard from S1: The Optimisation Module, the Consensus Module and the Simulation Module. The Optimisation Module has an engine which oversees the control of a transport simulator and interacts with the TANGENT API. The Consensus Mechanism supports the Collaborative COP Preference and Consensus definition by weighting the Response Plans & KPIs preferences from each actor and producing a consensual view which is delivered to the Dashboard. The Simulation Module uses Aimsun Next traffic simulator to find the optimal response plan for each scenario.

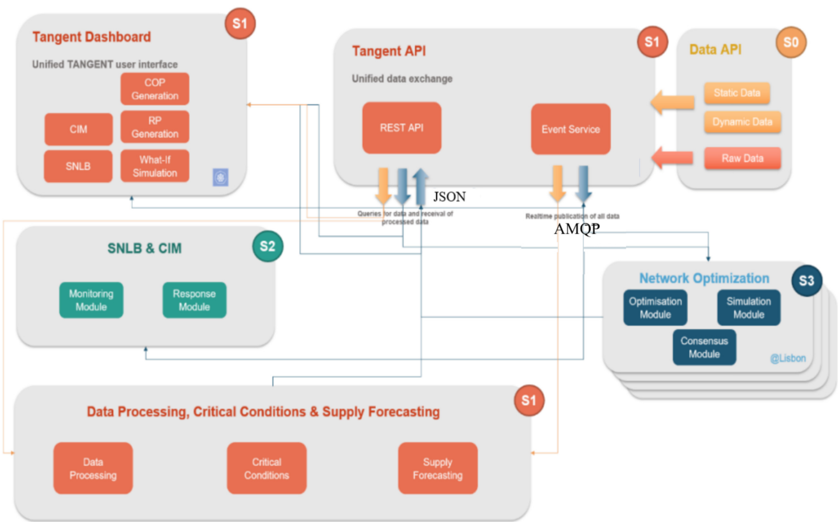

Fig. 3. TANGENT Detailed Technical architecture.

4 Conclusions and Next Steps

The TANGENT project is delivering a scalable modular platform for advanced transport network management. This paper presents an overview of TANGENT's underlying architecture, designed to manage urban transport networks after expected or unexpected incidents, providing a tool to allow coordination among transport stakeholders, thus reducing congestion, mitigating environmental effects through the reduction of CO_2 emissions, and increasing road safety.

The TANGENT project is currently testing its core technologies separately, followed by integrating them into a comprehensive tool and later be piloted in several European cities in 2024.

5 Disclaimer

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