

Intelligent Transport System for Emergency Management

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Abstract— The goal of using an Intelligent Transport System (ITS) for emergency management is to optimize emergency response operations—reducing response time, improving coordination, and ensuring safer and faster mobility for emergency vehicles like ambulances, fire trucks, and police cars. This paper presents a developing a prototype ArcGIS dashboard for intelligent traffic system with integration of data sources like traffic sensors, emergency vehicle GPS, and incident data. Sample ArcGIS dashboard design for traffic management has been developed.

Keywords—intelligent transport system, emergency management, intelligent traffic system, geographic information system, ArcGIS

I. INTRODUCTION

The Intelligent Transport System (ITS) is an information and communication technology-supported and integrated transportation system. ITS encompasses sustainable, safe, and interconnected transport systems [1]. The ITS uses information and communications technology in transport infrastructures and vehicles to improve their safety, reliability, efficiency and quality. These innovative systems have the potential to reduce congestion, lower emissions and optimize urban mobility.

There are three main types of ITS [2]:

- Mobility ITS, which provide the shortest route, using data about distance, time, energy consumption, etc.
- Safety ITS, which reduce collisions, incidents and delays through warnings and alerts.
- Environment ITS, which make journeys more environmentally-friendly.

The main elements of ITS for emergency management are:

1. Real-time traffic monitoring
2. Traffic signal control systems
3. Incident detection and management
4. Vehicle tracking and fleet management
5. Traveler information systems
6. Data analytics and predictive tools

The ITS for emergency management combines advanced technologies that can improve the operational efficiency and the safety and response capabilities of emergency services such as ambulance, fire, police and disaster response teams. It integrates communication, sensing, and data processing to

enable real-time decision making and coordinate among the agencies.

II. THE ARCHITECTURE OF AN INTELLIGENT TRANSPORT SYSTEM

The ITS architecture is the framework that determines how components of an ITS work together to serve ITS functions, such as traffic management, emergency response, public transit, and traveler information. It consists of three main layers (Fig.1) :

- Physical layer;
- Communication layer;
- Application layer.

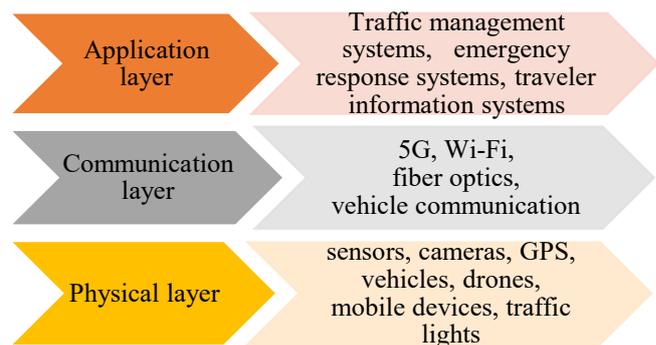


Figure 1. The architecture of ITS

The physical layer is responsible for collecting a real-world data. This layer includes sensors, cameras, GPS, vehicles, drones, mobile devices, traffic lights.

The communication layer transfers data between devices and systems. It includes wireless communication (5G, Wi-Fi), wired networks (fiber optics) and vehicle communication.

The application layer processes data and provides useful information. Traffic management systems, emergency response systems, traveler information systems are examples.

The methodology for implementing an ITS involves a systematic approach that integrates hardware, software, data, and human coordination to improve transportation efficiency, safety, and emergency response. Below is a summary flow:

Problem Analysis → Data Collection → System Design → Integration → Simulation → Implementation → Testing → Monitoring and Optimization

As a result of using an ITS for emergency management, we can optimize emergency response operations such as

reducing response time, improving coordination, and ensuring safer and faster mobility for emergency vehicles like ambulances, fire trucks, and police cars.

ITS for emergency management can be used effectively by the following system:

- Real-time vehicle tracking
- Emergency vehicle priority at traffic signals
- Dynamic route guidance and navigation
- Incident detection and automatic alert systems
- Integrated communication and coordination
- Public alert and information dissemination
- Post-incident analysis and learning

ITS uses the following tools and technologies:

- **Sensing and detection technologies** for gathering real-time data on traffic, vehicles, and environmental conditions such as cameras, radar, infrared and ultrasonic sensors, etc.
- **Communication technologies** for data transmission between vehicles, infrastructure, and control centers.
- **Data processing and analysis** for analyzing collected data and making decisions or predictions. Examples are artificial intelligence, machine learning, big data analytics and cloud computing.
- **Control and management systems** that act on the data to manage and optimize transport. Examples are traffic management systems, traveler information systems, adaptive traffic signal control systems
- **Geographic information systems (GIS)** for route planning, mapping, and spatial analysis of traffic patterns.
- **Autonomous vehicle technologies** such as autonomous driving systems and telematics.
- **User interface and mobile technologies** like smartphone apps.

III. IMPLEMENTATION OF ITS

ArcGIS by Esri is a powerful GIS platform that plays a critical role in the development and operation of ITS. It allows for the integration, analysis, and visualization of spatial data to support real-time traffic management, route optimization, and emergency response.

ArcGIS supports intelligent traffic systems by:

- Real-time traffic monitoring and visualization
- Dynamic routing and navigation
- Emergency management
- Traffic signal optimization and planning
- Incident detection and reporting
- Public information tools

- Data analytics and predictive modeling

Table 1 summarizes the common ArcGIS tools used in ITS.

Table 1. Common ArcGIS tools used in ITS

| Tool | Purpose |
|------------------------|---|
| ArcGIS Dashboard | Real-time traffic/incident display |
| ArcGIS Network Analyst | Route optimization and travel time analysis |
| ArcGIS GeoEvent Server | Real-time streaming of traffic and emergency vehicle location data |
| ArcGIS Pro | Advanced spatial analysis and mapping |
| ArcGIS Online | Sharing maps and data with the public and other agencies |
| ArcGIS Indoors | Used in large facilities (e.g., airports or stadiums) for internal traffic planning |

An effective ArcGIS dashboard for traffic management includes the following elements:

- **Interactive map:** Displaying real-time traffic conditions, incidents, and vehicle locations.
- **Traffic indicators:** Showing metrics like average speed, congestion levels, and incident counts.
- **Route planning tools:** Allowing users to input destinations and receive optimal routing suggestions.
- **Emergency vehicle tracking:** Monitoring the location and status of emergency vehicles in real time.

Data sources are:

- **Traffic cameras and sensors:** Integrate data from city's network of traffic cameras and sensors to monitor real-time traffic conditions.
- **GPS data:** Utilize GPS data from emergency vehicles and public transportation to track their locations and optimize routes.
- **Weather data:** Incorporate weather information to assess its impact on traffic and adjust recommendations accordingly.

- **Public reports:** Allow citizens to report incidents or hazards via a mobile app, integrating this data into the dashboard.

Developing a prototype ArcGIS dashboard for intelligent traffic system includes the following steps:

Step 1. Define scope and requirements

The goal is real-time traffic monitoring and emergency response support.

Key components are:

- Live traffic data (sensor feeds, congestion levels)
- Emergency vehicle GPS tracking
- Incident reports (accidents, road closures)
- Public alerts and route suggestions

Step 2. Prepare data layers in ArcGIS (Table 2)

Table 2. Data layers in ArcGIS

| Layer | Source | Format |
|--------------------------------------|---|-------------------------------|
| Road network | OpenStreetMap / City GIS | Shapefile / Feature Layer |
| Traffic congestion | Sensor API / city data feeds | GeoJSON / REST API |
| Emergency vehicle locations | GPS data | Live feed via GeoEvent Server |
| Incidents (accidents, road closures) | Main state traffic police department / public reports | CSV / REST API |
| Traffic signal status (optional) | Smart traffic system API | REST / JSON |

Step 3. Set up real-time data integration using ArcGIS GeoEvent Server to connect live data streams.

Step 4. Build ArcGIS dashboards

The filters can be applied for:

- Districts in city
- Vehicle types (ambulance, fire, police)
- Incident severity

Step 5. Share the dashboard with stakeholders (transport department, emergency services).

Simulation mode for testing. If real-time data is not available yet, we can simulate:

- Vehicle movement (using time-enabled data or animation tools in ArcGIS Pro).
- Incident injection (mock data in CSV updated every few minutes).

The following tools used:

- ArcGIS Online / Enterprise
- ArcGIS Dashboard
- ArcGIS GeoEvent Server (for live data integration)
- ArcGIS Pro (for data preparation)

The prototype project on ArcGIS Online was created. We need the ArcGIS API for Python.

Creating sample data and demo dashboard include:

- Create mock data (CSV or GeoJSON) with:
 - Sample GPS points of emergency vehicles
 - Simulated traffic incidents in Baku
 - Road congestion status
- Upload these as hosted feature layers in ArcGIS Online.

- Design a sample ArcGIS dashboard layout for:
 - Map view (with vehicle and incident icons)
 - Real-time indicators
 - Time filters and charts

Example of simulation a moving emergency vehicle:

```
from arcgis.gis import GIS
from arcgis.features import FeatureLayer
import random

gis = GIS("home")
layer = FeatureLayer(
    ("https://services.arcgis.com/.../FeatureServer/0")

# Simulate a moving vehicle
new_location = {
    "geometry": {"x": 49.867, "y": 40.409},
    # Sample coordinates in Baku
    "attributes": {"OBJECTID": 1, "status": "Active"}
}

layer.edit_features(updates=[{"attributes":
    new_location["attributes"],
    "geometry":
    new_location["geometry"]}]])
```

Creating mock data script:

```
import csv
import json
# Sample emergency vehicle data (CSV)
emergency_vehicles = [
    {"id": 1, "type": "Ambulance", "lat": 40.4093,
     "lon": 49.8671, "status": "Active"},
    {"id": 2, "type": "Fire Truck", "lat": 40.4130,
     "lon": 49.8750, "status": "En Route"},
    {"id": 3, "type": "Police Car", "lat": 40.4080,
     "lon": 49.8600, "status": "Idle"}
]
with open("emergency_vehicles.csv", "w", newline="") as csvfile:
    fieldnames = ["id", "type", "lat", "lon", "status"]
    writer = csv.DictWriter(csvfile, fieldnames=fieldnames)
    writer.writeheader()
    for vehicle in emergency_vehicles:
        writer.writerow(vehicle)
# Sample traffic incidents data (GeoJSON)
traffic_incidents = [
    {"id": 1, "type": "Accident", "lat": 40.4115,
     "lon": 49.8723, "severity": "High"},
    {"id": 2, "type": "Road Work", "lat": 40.4072,
     "lon": 49.8651, "severity": "Medium"},
    {"id": 3, "type": "Congestion", "lat": 40.4120,
     "lon": 49.8705, "severity": "Low"}
]
geojson_data = {
    "type": "FeatureCollection", "features": [
        {
            "type": "Feature",
            "geometry": {"type": "Point",
                        "coordinates": [i["lon"], i["lat"]]},
            "properties": {
                "id": i["id"],
                "type": i["type"],
                "severity": i["severity"]
            }
        }
        for i in traffic_incidents
    ]
}
with open("traffic_incidents.geojson", "w") as geojson_file:
    json.dump(geojson_data, geojson_file, indent=2)
```

The benefits of using ITS for emergency management are:

- Faster emergency response;
- Improved coordination among agencies;
- Enhanced safety for responders and civilians;
- Reduced fatalities and damage in critical situations.

IV. CONCLUSION

ITS are key to a sustainable future for the transport industry. To improve road safety and combat rising emissions and congestion, ITS apply a variety of information and communication technologies to all types of passenger and freight transport, making transport safer, more efficient and sustainable.

The ITS has been developed for emergency management. Sample ArcGIS dashboard design for traffic management has been developed. Python script written for real-time GPS data integration with ArcGIS Online.

The use of ITS that combine advanced technology and data analysis improves safety and makes traffic more efficient. The outcomes are:

- Reduced traffic congestion: by providing real-time traffic information and route optimization, drivers can avoid congested areas, leading to smoother traffic flow.
- Improved emergency response: real-time tracking of emergency vehicles allows for quicker response times and better coordination.
- Enhanced public awareness: citizens can stay informed about traffic conditions and incidents, leading to safer driving behaviors.
- Data-driven decision making: traffic authorities can analyze trends and patterns to make informed decisions about infrastructure improvements and policy changes.

REFERENCES

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