DISTRIBUTED SYSTEMS:

LECTURE 12
TRANSPORTATION SYSTEMS

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My current research focuses on Mobility Modelling, Mobility Data mining, Mobile Phone Cellular Network data Analytics and Intelligent Transportation Systems (ITS).

**ITS Lab** research activities are covering four main directions:

- Mobility mining
- Advanced travel information systems
- Advanced driver assistance systems
- Vehicular networking

its.cs.ut.ee
Defining the **importance** of Distributed Systems in Transportation in one **Slides**

- **DS is everywhere** where you look:
  
  *Computer Science, Infrastructure design, Logistics, System engineering, …*

- **DS presence in transport systems:**
  
  *Urban Systems (traffic light, bus information panels, airport information panels, variable-message sign VMS, electronic traffic sign, …), passenger transport, …*

- **Complexity of Urban Dynamics:**
  
  *Infrastructure: roads, rails, fuel stations, train stations, bridges, energy, Communication network, terminals, facilities, …*

  *Vehicles: buses, cars, trains, trucks, boats, trams, …*

  *ICT: GPS, IoT, mobile network, …*

- **DS ensure proper functioning:**
  
  *Quality of information, Quality of services, Safety, Usefulness, Fluidity, …*

- **Today DS is integrated separately in each automated unit:**
  
  *Traveler’s information systems: bus lines, trains connections, flights, …*

  *Traffic management systems: bus routings, traffic lights, traffic count, …*

- **Mobility challenges and DS role in providing a solution:**
  
  *Smart Multimodal Urban Mobility Systems, raid sharing, EV, real-time systems, information systems, data management, …*
• Part I: Advanced traveler information systems
  • What is ATIS?
  • Role of ATIS
  • ATIS Systems

• Part II: Advanced traffic management systems
  • What is ATMS?
  • Role of ATMS
  • IRIS systems
  • Traffic light systems
PART I

ADVANCED TRAVELER INFORMATION SYSTEMS
(ATIS)
DEFINITION 1.1: ATIS
Advanced Traveler Information Systems are considered the core service of intelligent transportation systems and their main role is to support travellers in planning their journey efficiently in order to define their route, estimate travel time and avoid traffic congestions. Therefore, ATIS provides two types of information such as:

- Static information
  - Geographic data of stopped vehicles
  - Transport schedules
  - Etc,
- Dynamic information
  - Schedules
  - Weather conditions
  - Closed roads
  - ETAs
  - Etc,
ADVANCED TRAVELER INFORMATION SYSTEMS (ATIS)

FUNCTIONS 1.1: ATIS operational roles:

- Static and real-time traffic information
- Weather information
- Real-time information about public transport
- Parking information
CASE STUDY 1.1: Application of service-oriented architecture for public transport

DEFINITION 1.2: SOA
Service-oriented architecture is an architectural mindset that focuses on organising systems as reusable components (not fixed) by enabling heterogeneous, componentized and distributed application to work together.

WHY:
SOA ensure access to reusable components and I has been proven that it is:
- Language neutral integration
- Component reuse
- Organisation agility
- Leveraging editing systems
ADVANCED TRAVELER INFORMATION SYSTEMS (ATIS)

OBJECTIVE 1.1:

The main objective is to provide a framework designed for systematic development and deployment of telematic systems for improving public transport based on the ITS standards for system architecture, ubiquitous computing and service oriented architecture for distributed systems.
EXAMPLE II.1: Traveler information system

ATIS systems based on service-oriented architecture for Public Road Transport (*)
ADVANCED TRAVELER INFORMATION SYSTEMS (ATIS)

[Diagram showing various components of an advanced traveler information system, including vehicle infrastructure, user services module, communication thread, and service registration & discovery system.]
SUMMARY 1.1:

Services operations:
- Service initialisation and resource execution (start-up)
- Service advertisement and their availability
- Service execution
ADVANCED TRAFFIC MANAGEMENT SYSTEMS (ATMS)
ADVANCED TRAFFIC MANAGEMENT SYSTEMS (ATMS)

DEFINITION II.1:
Advanced Traffic Management Systems are responsible for streaming real-time transport data from the entire traffic infrastructures into one Transport Management Centre (TMC). The TMC is where all the data is processed in order to take intelligent measures for handling traffic jams, increasing mobility efficiency, maintaining and improving safety.

WHY:
ATMS helps in:
- Monitor
- Control
- Optimize
- Operate

ATMS are the eyes of Transport Management Centres which acts like a control room for mobility in smart cities.
ADVANCED TRAFFIC MANAGEMENT SYSTEMS
(ATMS)

FUNCTIONS II.1: ATMS operational roles:
• Real-time traffic monitoring
• Video analytics
• Active traffic management

Real time traffic monitoring
- Live public transport updates
- Re-routing
- Transparency
- Emergency responses
- Safety and control

Video analytics
- Traffic congestions detection
- Incident detection
- Counting vehicles and pedestrians
- Evaluating contingency actions

Active traffic management
- Variable Message Sign
- Traffic lights
- Road weather information
- Ramp meters
INFO:

ATMS are based on real time systems therefore the most common architecture pattern used in designing distributed aspect of ATMS is based on Master-slave architecture for guaranteeing interaction response times and in some cases you will find also Multi-tier client server architecture is adopted due to high volume of transactions to be processed by the server.
DEFINITION II.2: Master-slave architecture

Master-slave architecture is a model usually used for real time systems of asymmetric communication or control. This means that the system might have a separate processors associated with data collections, data processing and computation, and actuator management.

• “Master” is in charge of computation, coordination, communication and slave processes.
• “Slave” processes are focused on special actions like data acquisition from multiple sensors.
ADVANCED TRAFFIC MANAGEMENT SYSTEMS
(IRIS)

EXAMPLE II.1: IRIS

Intelligent Roadway Information System (IRIS) is an open source ATMS developed by Minnesota Department of Transportation. It is an integrated platform designated for transport agencies to perform traffic management, control and monitoring.

REMARK II.1:

The IRIS software is developed in java and it has an intuitive map based interface for operation management.

Source: https://mnit-rtmc.github.io/iris/installation.html
ADVANCED TRAFFIC MANAGEMENT SYSTEMS (IRIS)

EXAMPLE II.1: IRIS - Architecture

- **IRIS CLIENTS**
- **APACHE SERVER**
- **HONEYBEE**
- **DATABASE**
  - **POSTGRESQL**
- **CLIENT JAR MAP TILES**
- **LDAP (OPTIONAL)**
- **AUTHENTICATION SERVER**
- **TRAFFIC MONITORING AND CONTROL DEVICES**
- **JSON FILES**
EXAMPLE II.2: Traffic light Control Systems

Traffic light control systems are used to monitor and control the flow of traffic in intersection or junctions. Nowadays, the systems are even capable of estimating the traffic density and reporting incidents.

BRIEF HISTORY:

1722 London Bridge - traffic police
1868 First non-electric gas-lit traffic light
1912 Electric traffic light was developed
1914 Electric traffic was in use

Source: http://www.kbrhorse.net/signals/history01.html
**TERMINOLOGY II.1:** Green time

The green time is the time period in which the traffic signal has the green indication.

**TERMINOLOGY II.2:** Cycle or cycle length

The cycle is the total time for the signal to complete one sequence of signal indicator.

**TERMINOLOGY II.3:** Phase

Phase or signal phase is a set of intervals in which a designated movement is allowed to flow and to halt safety. There are three intervals in each phase: green, yellow, red.
EXAMPLE II.2: Traffic light Control Systems

Adopted network:
Junction of two roads with four lines each. Each line has two sensors that help in having more accuracy in handling the junctions by the controller.
**ADVANCED TRAFFIC MANAGEMENT SYSTEMS (TLCS)**

**DEFINITION II.3: Hierarchical TLC Architecture [*]**

Sensors are structured in following two groups or layers:

- Before light (BL)
- After light (AL)

Master node is in charge of decision-making and data aggregation.

**WHY:**

Advantages:

- Easing data aggregation
- Saving energy and bandwidth

ADVANCED TRAFFIC MANAGEMENT SYSTEMS (TLCS)

CONFLICT MATRIX

VEHICLE COUNTS

AGGREGATION PROCESS

EVALUATION

INFO PROPAGATION

Any conflict
Allowed conflict
Not Allowed conflict

Matrix I

Matrix II

PHASE PROCESSING

LISTING

SELECTION

DEFINING GREEN LIGHT TIME

STRATEGY EXECUTION
MOBILITY AND TRANSPORT RELATED COURSES

- MTAT.08.040 - Introduction to Intelligent Transportation Systems
- LTAT.06.014 - Data Science for Urban Mobility
- LTAT.06.015 - Mobility Modelling
REFERENCES


