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CITY TRAFFIC SIMULATION ON MICROSERVICES

Abstract: *Population growth and urbanization in Kazakhstan have led to significant traffic management problems in large urban areas. Initiatives such as intelligent road systems, real-time traffic information, and traffic management have been implemented to address these issues. However, congestion and delays remain as major problems. Effective traffic modeling is necessary to understand traffic patterns, identify bottlenecks, and implement effective solutions for reducing congestion. Microservice architecture has recently become a trend owing to its advantages, and the authors of this paper propose the use of microservices for urban traffic modeling to solve these problems. In this study, any moving object between two points: a car, a bicyclist, or a pedestrian – was presented as an actor. Each actor is represented as a microservice. They communicate their movements through city microservice. After sending their movements, a red line is displayed on the map, indicating their travel paths. This solution helps to simulate movement more realistically because each microservice is independent and can move randomly.*

Key words: *urbanization, traffic, microservices, simulations, city traffic simulation.*

Introduction

The growing population and urbanization trends in Kazakhstan are expected to lead to a significant increase in the population of urban areas, which, in turn, poses considerable challenges in managing traffic in large urban areas. To address these difficulties, various initiatives have been undertaken, such as the development of intelligent traffic systems, real-time traffic information, traffic-control management, and accident-alert systems. Despite these attempts, traffic congestion and delays continue to pose significant challenges. Efficient traffic simulations play a crucial role in understanding traffic patterns, identifying bottlenecks, and implementing effective solutions to alleviate congestion. Moreover, the consequences of traffic congestion are far-reaching, including increased fuel consumption, accidents, air pollution, and economic costs. For instance, in the United States alone, traffic jams result in billions of wasted hours, dollars, and fuel consumption (Arnott and Small 1994) [1]. Accurately estimating travel time is vital for individuals and businesses, as it impacts economic activities and overall societal well-being. To solve these issues we propose traffic modeling on microservices. Microservices have become popular in recent years, and many studies have been conducted in this area. Several studies have compared microservices with other types of architecture [2] [3], and many have pointed out that microservices have a number of advantages. Some researchers have attempted to apply the benefits of microservices to other areas. For example, Razzaq applied microservices to IoT [4]. In this study, we attempted to apply microservices to city traffic simulations.

Related works

Pump et al. suggested building microsimulations for urban transportation using microservice concepts [5]. Their objective was to develop a decision support tool that integrates two distinct simulation frameworks: AnyLogic and MatSim. These frameworks are connected by a bonding layer. The bonding layer employs the idea of small independent components by confining simulations to a single logistic concept, while the frameworks and other microsimulations provide more comprehensive perspectives.

The definition of microsimulation used in reference [5] varies from the microsimulation models detailed by Merz [6] and other researchers. Microsimulation models are constructed using microlevel information and only simulate a small portion of the system being studied, without establishing a specific pattern for the model's development. Although our paper's simulation scenarios may be considered microsimulation models, the modeling process and simulation theory underlying these scenarios are beyond the scope of this research.

The authors of [7] provide an in-depth analysis of a microservices and REST-based agent-based traffic simulator prototype. The prototype's development showcases the effectiveness of Agent-Based Modelling in creating simulations. A standout aspect of this method is the adaptability it offers in selecting how to implement the agent component of the simulation. By utilizing HTTP as an interface between the agent and its environment, it becomes feasible to employ any programming language or agent framework capable of communicating with services via HTTP.

Implementation

The idea is to represent each road user as an independent and separate microservice, i.e. each road actor is a microservice. This solution will help to model road traffic more realistically, since each actor will be independent and will move randomly. The city itself will also be in the form of a microservice, it will be responsible for communication between other microservices, transfer data between them (Figure 1) and play the role of a store.

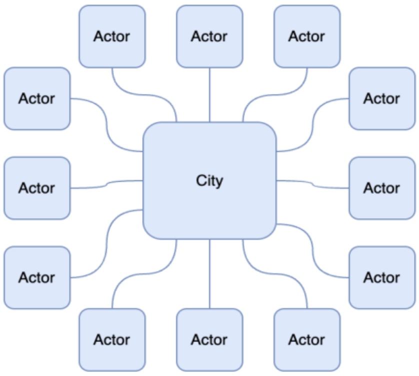

Figure 1 – Relation of city microservice with other microservices

We use the open source project Graphhoper [8] for route planning. It provides an API for point-to-point route planning and many other navigation-related functions. For map representation, we used the free and publicly available geographic database Open Street Map (OSM) [9]. Both services can be easily integrated into the project. So there are 4 services and each was wrapped in a container using a docker file, and a docker-compose file was used to manage all containers [10]. To run the application, you just need to run the docker-compose up -d command. This command will start the application with a single road user. To increase the number, you must explicitly specify how many are needed for a particular service. In our case we need to increase the number of road users: docker-compose up – scale actor=50 -d. This command will create 50 actors. Road actors can be any moving object between two points. It can be a car, a bus, a bicycle, etc. Each actor sends their location through the city (Figure 2).

```
data class Message(
    val line: List<Coordinate>,
    val detail: Int
)

data class Coordinate(
    val long: Double,
    val lat: Double
)
```

Figure 2 – Kotlin data class for actor’s location messages

As soon as an actor sends his coordinates, a line is drawn on the map to indicate his movement. To display the map, we used JavaScript and npm [11] to pull dependencies. For testing, we used a map of Astana city and used only cars as actors. Therefore, in Figure 3, a screenshot is shown during the simulation.

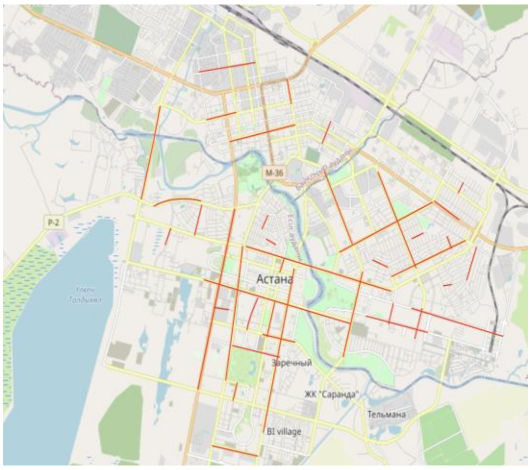

Figure 3 – Screenshot of running simulation

Conclusion

We were able to apply the concept of microservices to urban traffic modeling. This solution allows for more realism, as each actor is independent and moves randomly. However, the solution is not perfect and can be improved. We now present some improvements that can be made in future work. First, a microservice city may fail if the number of actors increases. As the city stores messages, a distributed database can be used. Second, additional user integration can be added. Add the ability to select parameters for the simulation: city, coordinates, number of actors, and their roles

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МИКРОСЕРВИСТЕРДЕГІ ҚАЛАЛЫҚ ТРАФИКТІ МОДЕЛЬДЕУ

Қазақстанда халықтың өсуі мен урбанизация ірі қалалық аудандарда жол қозғалысын ұйымдастыруда елеулі проблемаларға алып келді. Осы мәселелерді шешу үшін Интеллектуалды жол жүйелері, нақты уақыттағы жол қозғалысы туралы ақпарат және жол қозғалысын басқару сияқты бастамалар жүзеге асырылды. Алайда кептелістер мен кідірістер негізгі проблемалар болып қала береді. Жол қозғалысын тиімді модельдеу қозғалыс заңдылықтарын түсіну, қиындықтарды анықтау және кептелісті азайтудың тиімді шешімдерін жүзеге асыру үшін қажет. Жақында микросервистік архитектура өзінің артықшылықтарының арқасында трендке айналды және осы мақаланың авторлары осы мәселелерді шешу үшін қалалық трафикті модельдеу үшін микросервистерді пайдалануды ұсынады. Бұл зерттеуде екі нүкте арасындағы кез – келген қозғалатын объект: автомобиль, велосипедші немесе жаяу жүргінші-актер ретінде ұсынылды. Әр актер микросервис түрінде ұсынылған. Олар өздерінің қозғалыстары туралы "қала"микросервисі арқылы хабарлайды. Сіздің қозғалыстарыңыз туралы деректерді жібергеннен кейін карта олардың қозғалыс жолын көрсететін қызыл сызықты көрсетеді. Мұндай шешім қозғалысты шынайы модельдеуге көмектеседі, өйткені әрбір микросервис тәуелсіз және ерікті түрде қозғала алады.

Түйін сөздер: *урбанизация, жол қозғалысы, микросервистер, модельдеу, қалалық трафикті модельдеу.*

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МОДЕЛИРОВАНИЕ ГОРОДСКОГО ТРАФИКА НА МИКРОСЕРВИСАХ

Рост населения и урбанизация в Казахстане привели к значительным проблемам с организацией дорожного движения в крупных городских районах. Для решения этих проблем были реализованы такие инициативы, как интеллектуальные дорожные системы, информация о дорожном движении в режиме реального времени и управление дорожным движением. Однако заторы и задержки остаются основными проблемами. Эффективное моделирование дорожного движения необходимо для понимания закономерностей движения, выявления узких мест и реализации эффективных решений по снижению заторов. В последнее время микросервисная архитектура стала трендом благодаря своим преимуществам, и авторы данной статьи предлагают использовать микросервисы для моделирования городского трафика, чтобы решить эти проблемы. В данном исследовании любой движущийся объект между двумя точками: автомобиль, велосипедист или пешеход – был представлен как актера. Каждый актер представлен в виде микросервиса. Они сообщают о своих перемещениях через микросервис «город». После отправки данных о своих перемещениях на карте отображается красная линия, указывающая путь их движения. Такое решение помогает более реалистично моделировать движение, поскольку каждый микросервис независим и может двигаться произвольно.

Ключевые слова: *урбанизация, дорожное движение, микросервисы, симуляции, моделирование городского движения.*

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GENERAL QUESTIONS OF SELECTION AND APPLICATION OF COMMUNICATION PROTOCOLS OF «SMART HOUSE» SYSTEM

Annotation: *The article considers SMART technology, in particular smart house and basic communication protocols used for data exchange. Smart house technology additionally bears the name «home automation». Home automation in modern conditions allows the user or consumer to flexibly manage and independently configure the system, depending on the requirements of the user. One of the stages of customization of smart home technology is the selection of communication protocol for data exchange within the smart home system.*

To implement data exchange in smart home technology, it is necessary to properly approach the choice of communication protocols. Smart home technology uses several types of devices: controllers, sensors, acoustics. Since not all devices support existing protocols, there are also unique devices that support several of the existing protocols. There are several protocols used in smart home technology: ZigBee, Z-Wave, Wi-Fi.

In this article the analysis of two main wireless protocols operating at high frequencies, namely ZigBee and Z-Wave. Correctly selected protocols implement fast data transmission without loss. In addition, it will be possible to realize the needs of the user or user, which are set by the system.

Key words: *protocol, Z-Wave, ZigBee, wireless technology, smart home, home automation.*

Introduction

In the period of automation of all spheres of human activity, issues of management of household appliances that provide a comfortable existence of the person, which is defined as the concept of «Smart House», become relevant. This concept is dynamically developing, as the technologies that provide it, do not stand still, new devices, devices and gadgets appear to improve and comfort human life.