Network building system for VANET technology based on SDN/MAC

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Abstract. This article discusses the application of a multi-level cloud architecture in VANET networks, which is based on MEC technology. The article presents two ways of interaction of lower-level computing clouds when transferring data from one transport to another. In the framework of this work, simulation modeling was carried out in the Any Logic software package, and network delays were compared between two different models of interaction between computing objects. The advantages and disadvantages of these methods of interaction are given.

1. Introduction

In the modern world, a new technological revolution in wireless networks is unfolding. The 5G network is a new standard for reliable wireless communication, designed to transmit a stream of information with minimal delays at high speeds. It is closely intertwined with the development of the "Internet of Things" (IoT). Both concepts can dramatically change everything in our lives, giving “smart” devices the opportunity to interact with each other [1].

A striking example of such integration can be cars in which the role of the driver is performed by a computer system that includes monitoring, analysis and decision-making systems. The computer system has quite high requirements: from reliability to security. Such a concept can become part of one large communication system [2].

2. Methods

To exchange information, our transport must have the necessary means of communication [3]. Existing wireless and broadband networks, as well as VANET networks, can be used for this purpose. The VANET network is a decentralized network without a dedicated server, where the infrastructure is distributed among communication centers [4]. However, the possibility of using such a network is different and it is necessary to take into account all approaches when designing it.

Research on PPP (5G Infrastructure Public Private Partnership) believes technology SDN (software defined networking) and MEC (edge computing multiple access) and D2D (of device-to-device) and NFV (network functions virtualization) – the basis for the reduction of the load on the core network and reducing the circular delay [5].
The main paradigm of MEC is to process data as close to the user as possible at the boundary of the underlying network and radio access. It is this principle that helps to reduce round-trip latency and network loads. It is assumed that the network with MEC technology will have a multi-level cloud structure that uses three types of computing clouds: micro-cloud with small computing and storage capabilities—the lower level; mini-cloud with large, compared to micro-cloud, computing and storage characteristics—the middle level; main-cloud with the largest computing and storage capabilities in the entire network—the top level [6]. If the data from the IoT devices cannot be processed by the micro-cloud, it is sent to the mini-cloud for processing, and if it is not able, the data is transmitted to the main-cloud. The micro-cloud can be responsible for processing data in a single cell, the mini-cloud will be connected to the base station controller, and the main-cloud can act as a server. The gap between the mini-cloud and the main-cloud is any existing core network [6-8].

3. Results and discussion

In this paper, we consider a multi-level cloud architecture based on MEC technology. As a result of the simulation, two approaches to the interaction of computing clouds will be compared: micro-cloud interacts directly with the neighboring micro-cloud—the first approach, micro-cloud interacts with the neighboring micro-cloud through the upstream mini-cloud—the second approach. The advantages and disadvantages of both methods are also considered.

![SDN/MEC-based VANET network Architecture.](image)

We propose to use an architecture that is divided into three levels, according to the type of computing clouds used (Figure 1). The first level will have a micro-cloud on the car, and in its coverage area—devices that generate traffic. Also, each micro-cloud will be responsible for processing requests from neighboring micro-clouds. Next, the data will be transmitted to the mini-
cloud – this is the second level of our architecture, consisting of a basic road station (RSU) element. The RSU is a stationary VANET node located in close proximity to highways. It is on the stationary node that the mini-cloud will be hosted. It is assumed that the mini-cloud will have information about the micro-clouds under its control, located on the machines, as well as about all the services of each micro-cloud under its control.

If the second layer is overloaded with incoming information, the third layer will be connected, consisting of the main-cloud, which stores absolutely all information about the connected transport, and the SDN controller, which will help to abstract the control layer from the data transfer layer, which will effectively use the network bandwidth for transmitting statistical information and control messages.

To compare the two approaches to the interaction of computing clouds, a simulation model was built in the Any Logic software package.

In the table 1 shows the parameters of the simulation model.

| Table 1. Parameters of the simulation model |
|--------------------------------------------|
| **micro-cloud** | **mini-cloud** | **Comments** |
| **Broadcast Mbps** | 3 | 9 | Delivery time to the computing cloud |
| **N, piece** | 30 | 100 | Processing speed of the computing cloud |
| **Transfer to the computing cloud, piece** | 100 | Number of simultaneously processed packets |
| **Packet size, bytes** | 1 440 | Number of simultaneously transmitted packets |

In this work, two experiments were carried out: with low and high load in the network. In the first experiment, the intensity of user requests was low, which led to the absence of queues for processing and transmitting data packets in the network. Therefore, this experiment did not take into account the delays in finding packets in queues.

In the second experiment, processing queues appeared on the computing clouds due to the high intensity of user requests. Therefore, the delay in finding packets in the queue had a big impact on the overall delay in processing requests.

Table 2 shows the results of the experiments, which show that the total delay of direct interaction between the micro-cloud of two neighboring machines will be less than the total processing delay when transmitting user data through the higher-level mini-cloud. At the same time, the total delay of the first approach was less at both low load and high load. In Figure 2, the red line refers to the first proposed approach (direct micro-cloud interaction between two machines), and the yellow line refers to the second approach (interaction between two machines via mini – cloud).

| Table 2. Results of the conducted experiments |
|-----------------------------------------------|
| **Delay, milliseconds** | **No load** | **With load** |
| **Direct interaction** | 3 | 5 |
| **Via mini-cloud** | 18 | 27 |
Figure 2. The total delay in processing user requests (on the left—with low load, on the right—with high load)

4. Conclusion
To sum up, it was found that when microcloud interacts directly with each other, the delays are reduced, but the radius of interaction of the machines will not be large. In the second approach, when the interaction occurs through higher levels, the interaction radius increases significantly, but the delays increase. It is proposed to use the first approach of interaction of machines, if the distance between them is not large.

The second approach is proposed to be used for the interaction of machines that are very far from each other, but still located in the zone of the same mini-cloud.

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