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# ADAPTATION OF CLOUD THEORY IN THE INFOCOMMUNICATION SYSTEM OF AUTONOMOUS VEHICLES

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## ABSTRACT

Transport infrastructures are part of the global transport architecture. The operation of each nation's transport infrastructure is essential for the sustainability of national economies. Therefore, these systems are considered as critical infrastructures from the perspective of national security. It is understandable that smart mobility is one of the indicators of the smart city concept. An important element of the transportation system is the IT infrastructure, which is connected to the local systems of smart cities. In the system of a smart city the central management subsystem is the server component and the moving objects are the client devices. Autonomous vehicles can obtain the information they need for transport from their on-board equipment, from the central control of the smart city or from each other. The most important requirement of the autonomous vehicle's own system is high availability with adequate performance. For this reason, it is worth examining the applicability of availability-enhancing technologies in these vehicles. This article examines the adaptations of the cloud system requirements and cloud building technologies in the infocommunication system of autonomous vehicles.

## KEY WORDS

cloud requirements, cloud building technology, adaptation, autonomous vehicles

## CLASSIFICATION

ACM: K.6.5, C.0
JEL: R41, O39

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## INTRODUCTION

An important requirement for existing systems is sustainability. The smart city concept has evolved as a result of sustainability. The core infrastructure is the basis of the smart city model, which incorporates infocommunication technology in accordance with modern requirements [1]. The model groups the resource elements that are the indicators of habitat sustainability. This model is one of the technologies determining the near future, and is therefore an important element of both R&D [2] and education [3, 6].

Smart mobility is an indicator of the smart city concept [7]. Central regulatory systems are essential for smart mobility. In the model, mobile units (autonomous vehicles) are considered as the local elements. Local mobile elements can acquire information by interpreting their environment, from the central components and from each other. The autonomous vehicle system makes decisions [8, 9] based on the information thus obtained. In this model IT problems are augmented by the system of control [10-13], which is usually implemented by IoT devices.

This study with a service-centered approach examines the problems related to the infocommunication systems of autonomous vehicles on philosophical foundations. This way the research is based on a unified method. Furthermore, it provides an opportunity to adapt solutions to similar problems related to cloud building technologies in the infocommunication system of autonomous vehicles.

## PROBLEMS OF THE ICT SYSTEM OF AUTONOMOUS VEHICLES

Organizing problems around philosophical questions unifies the methods of investigation. The main philosophical issues and the related problems are as follows [14]:

- existence problem: the equivalent of examining the long-term existence of things. This is the issue of high availability. This problem occurs in practice for all vital elements. For example, positioning, keeping the vehicle on the track, brake assistance, other safety features,
- knowledge problem: the equivalent of knowing the structure of things. This is necessary to achieve a flexible structure, which is an issue of the IT architecture. As a practical problem, parts of the vehicle's infocommunication system may not be interchangeable, so a complete subsystem may need to be redesigned and implemented,
- the problem of action: the equivalent of the functionality of things. The question of performance is relevant here, and response time is the most important parameter. This problem is relevant to all solutions that require large amounts of data to be processed. The security features mentioned above can also be mentioned: positioning, keeping the vehicle on the track, brake assistance,
- the problem of truth: the equivalent of the validation, control and response to environmental changes. This models the operation of the system without an organic change. The most important aim is to make a prompt decision. This problem is relevant to all solutions that are for safety and require large amounts of data to be processed,
- change management: the equivalent of the study of the long-term sustainability of the system, which includes organic changes [15-17]. Currently automating organic change is not in the scope for smart systems.

## THEORETICAL SOLUTIONS IN CLOUD SYSTEMS

Problems similar to those mentioned above also appear in general infocommunication systems. Solutions to problems with general purpose systems led to the development of cloud technology. Accordingly, the features of infocommunication clouds include high availability flexible architecture, which together with full control allows for adequate performance and response time. The technologies used to build infocommunication clouds are as follows [18]:

- cluster technology ensures high availability through the distribution of tasks,
- grid technology is also based on the division of tasks, but its main purpose is to speed up processing, which ensures fast response time,
- split technology for disaster tolerance,
- virtualization provides flexibility and layered architectural independence.

All these technologies can achieve the required availability and performance. This way they can offer an answer to the problems of the infocommunication system of autonomous vehicles. However, these technologies also serve to enhance IT security [19-21]. Increasing IT security also implies the security of transported people [22]. Therefore, in the case of autonomous vehicles, the issue of IT security is closely linked to the issue of physical security [23-25].

## ADAPTATION OF SOLUTIONS

The adaptation of infocommunication cloud solutions requires that the autonomous vehicle infocommunication architecture is similar to the cloud architecture [26]. To achieve this, one should build the following layer structure:

- the energy layer converts natural resources into physical infocommunication resources for infocommunication devices,
- the hardware layer transforms the physical infocommunication resources into logical infocommunication resources,
- the virtualization layer reorganizes the logical infocommunication resources in the manner and to the extent necessary for the operational layer,
- the operational layer creates the desired services using the energy provided by the logical infocommunication resources,
- the management layer provides control over time operation.

The energy, hardware and management layers of the structure to be developed may be the same as those of other vehicles, provided they meet reliability requirements. However, it is worthwhile designing virtual and operational layers, so that physical devices and infocommunication services are separated, and the cloud technologies used to solve the problems are applied between the two. Accordingly, the two affected layers also perform the following virtual functions (Figure 1.):

- resource virtualization,
- application of cloud technology solutions:
  - grid technology
  - cluster technology
  - split technology
- service virtualization

## CONCLUSIONS

Sustainability efforts have resulted in the creation of a smart city model. One of the indicators of the smart city concept is smart mobility [7]. The local components of smart mobility are the autonomous vehicles. The problems of autonomous vehicles are worth discussing on a philosophical basis. It allows us to adapt unified solutions from other areas.

Philosophical topics are organized around issues of existence, knowledge, action, truth and change [14]. As a result, the infocommunication problems of autonomous vehicles are related to availability, flexible architecture, performance and control. In general-purpose IT systems,

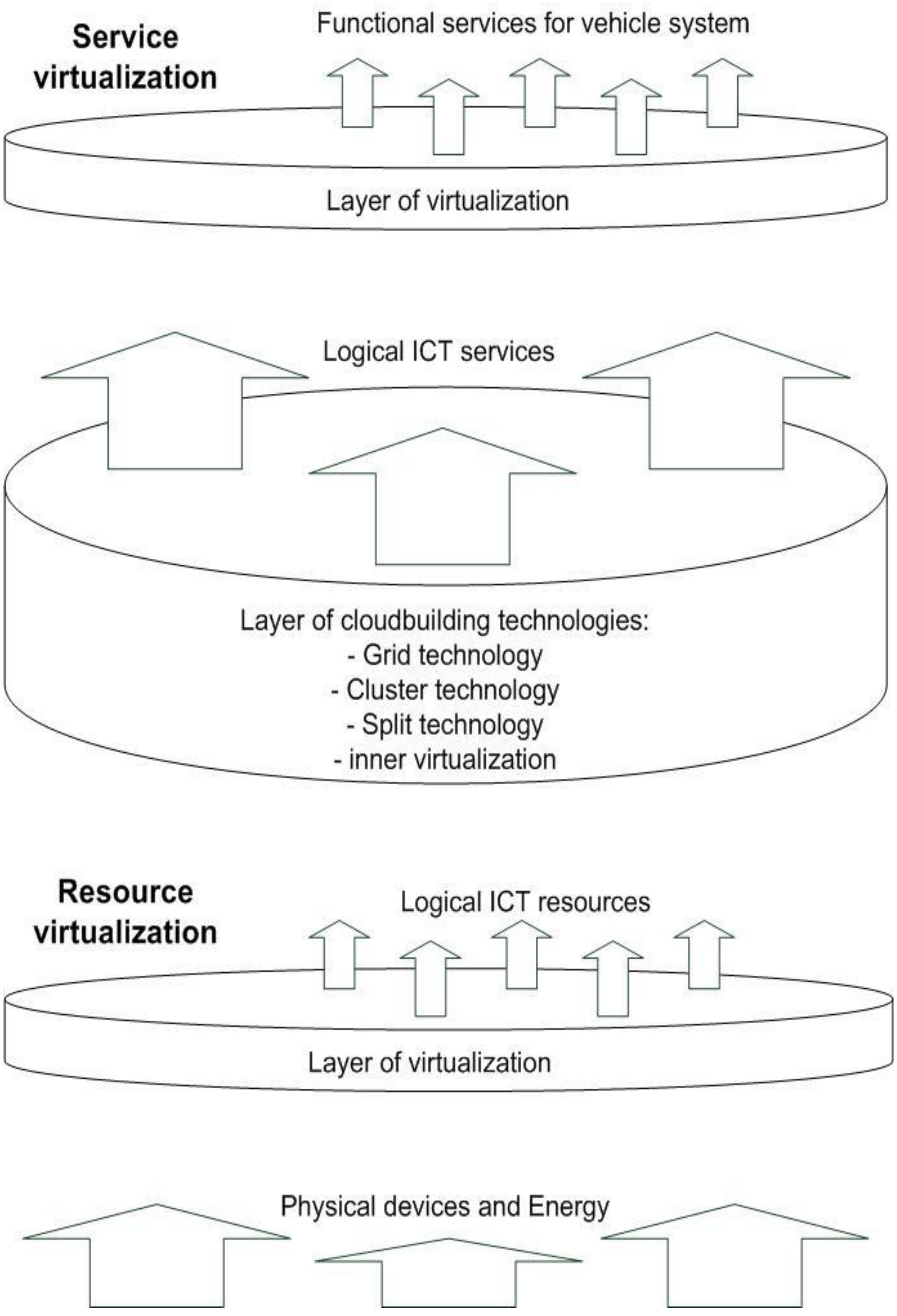


**Figure 1.** Cloud technologies in the ICT layers of vehicles.

solving similar problems has led to the emergence of infocommunication clouds [18]. Therefore, it is worth exploring the applicability of cloud technologies in autonomous vehicle systems.

The research shows that the structure of the infocommunication system of autonomous vehicles could be designed according to the structure of general infocommunication systems. This is how cloud technologies can be applied. The layers to be created include the energy layer, the hardware layer, the virtualization layer, the operational layer and the management layer [26]. In order to solve the discovered problems, the virtualization layer and the operational layer should be designed so that physical resources are covered from the lower layers, and only the end services are visible to the upper layers, while cloud technologies are applied in these two layers.

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