Concept of cloud computing implementation as a platform for telemetry systems

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ABSTRACT
Nowadays operated telematics systems offer a large collection of different types of services requiring an effective transmission of data in complex structures. It is possible by the implementation of the present network solutions for the future of telecommunications and information technology. A high level of requirements for the quick access to transport resources and databases impose the necessity of making a number of processing operations information in a short time. Single computing machines are not able to do that. Therefore, the dynamic evolution is observed to combine the processing power of cloud computing. The advantage of this solution is a fulfillment of the requirements of security, reliability and quality while reducing costs. The authors of the article presented the concept of the use of private cloud for handling traffic between major railway hubs. Basis for this is representative model CC called „infrastructure as a service” designed for heterogeneous structures.

KEYWORDS: cloud computing, telemetry systems, IaaS

1. Introduction

The increasingly popular term in the field of IT is cloud computing can be observed in recent years. It is no longer a trend, but a well-developed technology which companies can increase their effectiveness and to pursue new projects. The IT industry is anticipated that in the near future 4 out of 5 businesses will benefit from at least one service in the cloud computing and 36% of all data will be stored in the cloud. It is predicted that by 2020 over 25% of all applications will have been available through the clouds. It is predicted that by 2020 over 25% of all applications will have been available through the clouds. In such a rapidly evolving technology of cloud computing, it is important to provide user access to the resources of the cloud regardless of the place of dislocation and conditions of network user. An access should be implemented according to the criteria adopted in the form of a defined set of system properties (e.g. in the form of potentiality, efficiency, quality, reliability and safety, etc.) determining the correct functioning of the system and its components in subjective or objective terms.

Many aspects of this research area is complex, and therefore narrowed the target to present a proposal to develop a distributed data processing focusing issue for applications in telematics rail transport. A detailed consideration will be a subject to implementation of future services for the trans-European rail system (TSI CCS). The main subject of research adopted telecommunications infrastructure (base) for future-proof architecture that supports a large number of rules applicable to the transmission of the “big” data stream and also representative in terms of the real environment. The dynamic evolution of hardware and software platforms offered by reputable suppliers in the market, technology and innovation is the other issue. It forces the rapid development and deployment of new services suited to the needs associated with the provision of safe and reliable transport of people and goods. Currently operated systems and networks in telematics are no longer able to handle large size data in nearly real time. Unfavorable phenomena become important in this themed especially for large data center and many services. There are problems in the management, therefore processing in the “cloud” seems to be a sought-network solution due to, the most important aspects such as reliability and safety.
The subject of the article is adequate to the current problems in real network environments protocol stacks TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) / IPv4 (Internet Protocol ver. 4) and v6, SSL (Secure Socket Layer), MPLS (Multiprotocol Label Switching), SIP (Session Initiation Protocol) and includes suggestions for their solution involving the use of the conception and CC were subjected to the process of validation in an environment similar to a real one. Then subjected to validation in relation to the suitability of technical and functional correctness. Proposed applications are the solution to these problems and many others resulting from the processing needs of the large size of many data during the implementation of a number of real time services with a guarantee of safety [1].

Considering modernity outlined research problem and its high practicality and usability in transport applications, the basic phenomena occurring during the implementation of the currently used network services should be studied in details. As a part of the work accurately specified and subjected to a thorough induction of the main characteristics of the software and network devices in terms of their reliability and safety.

2. Cloud computing

Cloud computing is a model that delivers and enables users to access resources via the Internet or locally using the local wired LAN or wireless WiFi. Resources can include computing resources, network bandwidth, processing and storage of data and applications and services. An essential characteristic of cloud computing, referred to in the definition of the US National Institute of Standards and Technology [2] we can include such as:

- on-demand self-service;
- wide access to the network;
- combining resources;
- flexibility;
- measurement services.

These features make it through the cloud, it is possible to effectively use the services implemented in the cloud. Due to the universality and technologies that provide an access to the Internet wherever dislocation and conditions of the network, the user using the services of cloud computing can (practically) everywhere access to the resources of the cloud. There are 3 types of cloud computing: public, private and hybrid. In this article, the authors based their concept on the private cloud (PC). PC is the term for their own (corporate) IT structure that provides IT services for a specific number of users, protected by the common system security (firewall). Advances in virtualization and dispersal of computers meant that network administrators and data center in the largest corporations can effectively become service providers that meet the expectations of users of IT within the corporation. Unlike the public cloud, private cloud is own network database that use cloud computing technologies, such as virtualization. Private cloud is managed by a company in which it operates.

One of the basic models of distribution of a cloud computing model is Infrastructure as a Service (IaaS), sometimes referred to as Haas (Hardware as a Service). An example of such a model can be a cloud Amazon Elastic Compute Cloud (Amazon EC2). In this model, the supplier provides the user with the necessary resources including servers (computing power), space for data storage (disk space) and link data between the client and the server.

3. The sensitivity of the information

The division of a complex technical object (e.g. the system) into its constituent parts - parts made dependent on the purpose of research aimed at validating service functionality in the system of transport telematics. It is a hierarchical, multi-level and in many cases it is one of the initial steps to develop a formal system description. In many scenarios, the treatment of the problem is
treated as a relatively indivisible. Substantive characteristic of TSI CCS, as a whole, is that its properties are not trivial functions of the properties of its elements, but they are instantiated, taking into account the relationships between the elements during the implementation of the algorithm functioning and taking into account external conditions (environmental impact). Accepting the assumptions of general systems theory, should be distinguished at least a few levels of the existence of systems. The study adopted the interpretation of “cybernetic system”, i.e. homeostat based on the transmission and interpretation of information. Interpretation of the suitability of the system by the theory [3] shown in (Fig. 3).

According to the assumptions of engineering network potentiality expresses the ability of the system (e.g. base - ICT network) to carry out the task in a specified time. The concept of time can be interpreted as an elementary unit of time. This unit should have a dimension adapted to the characteristics of the system and executed by system tasks.

Fig. 3. Graphic interpretation of the criterion of suitability of a temporary system [own study]

For data communications network, which provides services appreciably different times, the elementary unit of time (depending on the type of executed service) may have a value e.g. seconds, but also minutes or hours. The issue of the impact of the assumed value of the elementary unit of time on the numerical value of potentialities requires analyzing - before making a decision concerning the selection of the appropriate unit of time for each of the services provided. Instead, the service model is presented in (Fig. 4). [4]

Fig. 4. A simplified model of the system implementation services [own study]

The set of states operating system in terms of reliability is to describe the use of potentiality of dispose the following notation:

\[ E_j(t) = \begin{cases} E_{j,dis}(t) \geq E_{j,sym}(t) \quad \text{TSI CCS is able} \\ E_{j,dis}(t) < E_{j,sym}(t) \quad \text{TSI CCS isn't able} \end{cases} \]  

Then the potentiality of dispose is determined by [5]:

\[ E_{j,dis}(t,\epsilon) = f[P_{j,dis}(t,\epsilon), P_{j,sym}(t,\epsilon), P_{j,n,\pi,\epsilon}] \]  

where the probability of an airworthy condition: 
- \( P_{j,dis}(t,\epsilon) \) - system, taking into account the properties of the internal; 
- \( P_{j,sym}(t,\epsilon) \) - operator; 
- \( P_{j,n,\pi,\epsilon} \) - system take into account the exploitation exposure.

Further analysis will be narrowed to consider the essential element, which are identified by the internal properties (the impact of other components will be presented in subsequent publications): [5]

\[ P_{j,n}(t,\epsilon) \equiv f(K_{gi} / R_N, P_{mi}, P_{mi}) \]  

where:
- \( K_{gi} \) / \( R_N \) (RSR_k-z-n) – ready indicator or function of reliability: 
  - structure:

\[ R_{j,dis,sym}(t) = \sum_{i=1}^{n} (-1)^{i-1} \frac{(i-1)!}{i!} R_i(t) \]  

\( P_{m} \) – the probability of blockages in the l-th component of the system taking into account the model of service requests for the implementation of services (data transmission):

\[ P_{m,k}(A) = \frac{A^n N - \sum_{n=0}^{N} n! A^n N} {N(N-A)} \]  

\( P_{m} \) – the probability of loss data stream in the l-th component as a result of incorrectly functioning synchronization (signaling)\(^1\).

For the l-th node\(^2\) (\( P_{m,l} \)):

\[ P_{m,l}(x) = \begin{cases} \omega_{Kg,l} / \omega_{Rn,l} R_{l,I} \frac{\partial}{\partial R_{l,I}} P_{m,l}(t) P_{m,l}(t) \omega_{Rn,l} \omega_{Kg,l} P_{m,l}(t) \\ \omega_{Rn,l} R_{l,I} \frac{\partial}{\partial R_{l,I}} P_{m,l}(t) \omega_{Rn,l} \omega_{Kg,l} P_{m,l}(t) \end{cases} \]  

For the m-th resource transport \(^1\) (\( P_{m,m} \)):

\[ P_{m,m}(l) = \begin{cases} \omega_{Kg,m} / \omega_{Rn,m} R_{m,m} \frac{\partial}{\partial R_{m,m}} P_{m,m}(l) \omega_{Rn,m} \omega_{Kg,m} P_{m,m}(l) \\ \omega_{Rn,m} R_{m,m} \frac{\partial}{\partial R_{m,m}} P_{m,m}(l) \omega_{Rn,m} \omega_{Kg,m} P_{m,m}(l) \end{cases} \]  

where:
- \( \omega_{Kg,l} / \omega_{Rn,l} \) – the weight of impact ready indicator/ function of reliability on: 
  - \( \omega_{Kg,l} / \omega_{Kg,m} \) – l-th node,
  - \( \omega_{Rn,l} / \omega_{Rn,m} \) – m-th resource transport,
- \( \omega_{Kg,l} \) – the weight of the impact of software ownership by model on:
  - \( \omega_{Kg,l} / \omega_{Kg,m} \) – l-th node,
  - \( \omega_{Rn,m} / \omega_{Rn,m} \) – m-th resource transport,
- \( \omega_{Kg,m} \) – weight of impact property service model applications on:
  - \( \omega_{Kg,m} / \omega_{Kg,m} \) – l-th node.

\(^1\) Probability value is determined on the basis of technical parameters of the signaling system.
\(^2\) Telephone exchange, access and backbone router.
\(^3\) Link wireless and wired.
CONCEPT OF CLOUD COMPUTING IMPLEMENTATION AS A PLATFORM FOR TELEMETRY SYSTEMS

Obtaining and keeping the service provided (requiring data) at the appropriate level of quality is subject to a number of determinants. It is therefore proposed to accept that security is a quality support services. Security seems to be a critical determinant of current and future devices and systems data transport implementing newly developed techniques and technologies. The required level of safety can be achieved stage of development of new and modernization of existing systems (technical objects) by, inter alia matching system components with desired attributes, i.e. the confidentiality, integrity, non-repudiation and authentication. Ensuring the expected security is a desirable development in the terms of the correct operation and implementation of the declared system services (network) maintain the essential properties of the system despite the presence of undesirable and harmful human activity - users. On the basis of experience with the operation of the real network environments, and analysis of various studies, it is appropriate to say that due to the need to guarantee the confidentiality of data transport and not to disclose to unauthorized persons. Currently, conventional protecting data transmission protocols include SSL (Secure Socket Layer), IPSec (Internet Protocol Security, IP Security) and SCIP (Secure Communications Interoperability Protocol).

It is reasonable to data of uniform structure were stored in multiple network locations using connections to the system via a publicly available resources. Cloud computing environment provides compatibility clouds, making it possible to link together multiple cloud computing, creating a distributed data system. Suitable configuration of clouds can also create a copy of one cloud and store it on the other.

The credibility of the processed data forms the backbone of data (information) in the process of decision-making supplies and enforces the need for authorized access to defined areas (rasters) in the field of data insertion and update and acquisition. The recommended communication between data should provide in addition to the classic solutions also dedicated ie.: confidentially of data transport channels - Virtual Private Networks (VPN) built based on IPSec, SSL, SCIP;
• data encryption - algorithm AES 512 (Advanced Encryption Standard);
• authenticate users with access to the database should also be done with the use of authentication mechanisms, eg.: Kerberos, RADIUS or using public key infrastructure (PKI);
• detection and protection systems containing event logs on access and modifications to the information in the system.

4. The concept of CC as a platform for telematics

The concept of cloud computing as a platform for telematics systems should comply with the following assumptions:
• user access to the system regardless of the place of dislocation and conditions of the network using the latest standards, a wire (1 ÷ 100Gbit Ethernet) and wireless (LTE A, 802.11ac/d, 802.11q, WiMAX II+);
• ensuring the confidentiality and integrity of transmitted data;
• scalability, resource flexibility of cloud computing;
• resilience of the system to sudden changes in load in real time;
• compatibility with other systems of the same type;
• ensure an appropriate level of QoS in real time.

Below shows the general architecture of the proposed concept (Fig. 5). The user accesses the services in the cloud computing locally: a wired connection by using standard 1Gbit Ethernet and radio by standard 802.11ac; remotely via the Internet, including mobile Internet, i.e. LTE, 3G.

5. Tested environment

In order to verify the effectiveness and safety of the proposed concept studies were carried out on the actual architecture. The environment of test-bed is shown in Fig. 6.
The effectiveness of the system was tested using a traffic generator LanForge ICE, simulating therefore an increasing number of users in a moment of time, and the program IxChariot used to test applications under real conditions. Safety data was analysed using Wireshark network traffic analyser (Fig. 7).

Fig. 7. Functional Testing of Web Services (own study)

6. Results

First analysis was the architecture concept considering its reliability. The analysis shows the most sensitive points called “bottlenecks” that are the weakest point’s architecture. These points are shown in the figure (Fig. 8). Their failure may lead to temporary incapacity of the system. However, the routing mechanisms used are able to minimize the probability loss of communication between the nodes.

Fig. 8. Test bed - an indication of „bottlenecks” for the rail system TSI CCS (own study)

After analyzing the impact of the delay on the bandwidth links on the basis of the results plotted in the chart below (Fig. 9).

Fig. 9. The impact of the delay on throughput rate (own study)

The maximum throughput that is possible to achieve a 45 Mbps. As can be seen for a wired link delay is beginning to have an impact beyond the value of 4 ms. Each subsequent increase of delay reduces the maximum bandwidth and values above 500 ms is almost 0 Mbps. Half of the originally available bandwidth is obtained with a delay of about 10 ms. For wireless - WiFi - a significant impact on throughput can be observed at a value greater than 20 ms. Then the bandwidth is reduced by more than half. Just as in the case of wired throughput of close to zero to obtain a delay of over 500 ms. The difference resulting from the smaller impact of the delay on the WiFi (ranging from 10 ms to 40 ms), due to the use of the access point technology MIMO (Multiple In Multiple Out) used in the standard 802.11ac i 802.11q.

Based on these results the impact of packet loss, bandwidth prepared the chart below (Fig. 10). It follows from this that in the case of a WiFi connection 1% packet loss results in decreased throughput by about 50%. In the case of a wired connection bandwidth reduction occurs at about 2% of lost packets. Over 5% of deleted packets bandwidth falls below 5 Mbps, and at the level of 20% and more bandwidth is close to zero. Although the LAN had better outcomes, however, the instantaneous values of the deviation are larger in comparison with a WiFi connection.

Fig. 10. The impact of the drop (removal) packets on throughput rate (own study)

Analyzing the captured packets with Wireshark you can be seen (Fig. 11) that the use of data transmission via VPN tunnels prevents an intruder to read information.

Fig. 11. The captured packet transmitted between the „clouds” (own study)

This confirms the assumption of a concept that involves secure transmission of data keeping their confidentiality and integrity. The implemented process of testing the local used was 0.5 hour elementary time unit. The analysis can be stated that the longer the elementary unit of time, the more information can be sent over the network (because the greater the potentiality of dispose network in the unit of time). The value of the elementary unit of time amounting to 0.5h was determined on the basis of preliminary simulation studies aimed at determination of the optimum value taking into account both the accuracy of the final results and the
duration of the test. For smaller values of the elementary units of time there are large fluctuations potentiality (and potential) network. However, larger values of the individual elementary averaged over the potentiality (and potential) and are the cause of reduced susceptibility test results to fluctuations in demand for services and thereby reduce the reliability of statistical inference. Based on the results of the research was determined potentiality (Fig.12.).

![Image](https://via.placeholder.com/150)

**Fig. 12. The variation of the potentiality of dispose $E_{\text{dis}}$ (own study)**

The values are presented for representative “most traffic hours”. The variation demonstrates that it is possible to realize each network service. In the whole period time of test potentiality of dispose it is greater than the potentiality required for the test-bed. This is a situation where the system is not overloaded, and it is possible to realize new services. This shows that the cloud computing dynamically adapts to the needs of the environment for the desired number of resources.

### 7. Conclusion

Knowledge of the shape of the trajectory of potentiality, designated for the daily life of the network, can significantly affect the management of the process of exploitation of technical objects on the structure of the system. The impact of this is possible mainly thanks to the results of the synthesis of these characteristics in the process of formulating prognostic applications and operating decisions. These applications can be divided into two correlated sets. The first set may include requests shall be addressed to the supplier of services (on e.g. the management of network resources, the required properties of the operator, the desired effect under certain conditions, investments and financial resources) and the second set of conclusions identifying user satisfaction (due to e.g. the number of available services network required and acceptable until the completion of the requested service, billing for services rendered).

Synthesis trajectory of potentiality system requires that you have the necessary set of information including, inter alia:

- the dominant values of the basic volumes describing the state of the system (i.e. throughput rate, the number of input and output ports, computational power offered within the CC, routing protocols, etc.) and its changes as a function of time and the conditions of use;

- selected statistical reliability parameters (e.g. indicator technical readiness, intensity and the intensity of repair damage times the correct operation between damage and repair times), implying a value of the probability of an airworthy parts for specified time intervals (seconds forecasting);

- effects of destructive factors (exposure internal and external) system;

- information obtained in the process of surveillance, the aim of which is to detect the emergence of the state of unfitness network - and in particular the emergence of a state of emergency or danger; information is the basis for the decision to start procedures to ensure:
  - desired flow of data,
  - the behavior of the security (confidentiality, integrity, etc.).

- information on the possible use of therapeutic activities diminish the effectiveness of the impact of destructive factors and the impact of those activities on the increase in the value of potentiality and as a result of increased reliability.

To summarize, it is reasonable to say that, based on the analysis of the problems existing in the actual environments telematics proposed and started to implement the concept of cloud computing platforms to TSI CCS system in order to increase the efficiency of data processing within the framework of real time services. Tested in many scenarios subject applications in terms of functional suitability and safety data collected in defined aggregates, and network resources.

The analysis has provided valuable insights that indicate the need for further research in the following areas, ie.:

1. **Network Architecture:**
   - The use of optical access solutions for FTTH and FTTB and the use of MPLS technology.
   - Implementation broker bandwidth and guaranteeing QoS for efficient traffic management.

2. **Multimedia:**
   - Traverse NAT (PAT) address.
   - High level of services provided by media need to implement stringent requirements (in terms of time and area).
   - Providing access to many multimedia services to a mobile device (phone, note, etc.).
   - Cooperation and integration techniques common network environment provides a seamless service delivery of required network parameters.

3. **Security:**
   - Providing authentication, confidentiality and integrity of the user’s perspective, services and operator.
   - Offering secure converged network architecture, which should respect the separation of traffic signaling, control and management.

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