The Impact of Network Capacity on Quality of Communication Infrastructure for Intelligent Agriculture

Petr Koudelka, Jan Marecek, Vlastimil Slany, Pavol Findura, Miroslav Pristavka

Abstract: *The technological drafts and systems belonging to intelligent agriculture category are based on the utilization of information and communication technologies. On 25 November 2015, Regulation (EU) 2015/2021 of the European Parliament and of the Council laying down measures concerning access to the open internet access came into force. This Regulation aims to establish common rules to safeguard equal and non-discriminatory treatment of traffic in the measures of internet access services and related end-user's rights. Open internet access (network neutrality) is the foundation for Intelligent Agriculture services. Based on the general mathematical model of the access network and practical experiences from real network traffic it turns out that to the current method need to add the measurement of qualitative parameters according to ITU-T Y.1564 standard. The results of this complex method allow to indicate an insufficient capacity of the distribution network and other anomalies in the access network which could do a creation of discrepancy or even an unavailability of internet access service, respectively intelligent agriculture service. The article is focused the issue of the impact of QoS parameters on the compliance with network neutrality.*

Keywords: *network capacity, intelligent agriculture, quality of communication infrastructure, communication infrastructure*

INTRODUCTION

On 25 November 2015, Regulation (EU) 2015/2021 of the European Parliament and of the Council laying down measures concerning access to the open internet access came into force [1]. In its statement about network neutrality, Czech Telecommunication Office ("CTO") generally defined four data parameters in the form of transmission speeds of both directions (upload, download). These parameters must be part of the contracts of service providing, including impact of discrepancy as indicators of the fact that the performance of the service doesn't achieved agree parameters. CTO has established a method of inspection existence of discrepancy as indicators of the fact that the performance of internet access service doesn't achieved agree parameters or unavailability of service itself, according to the method based on IETF RFC 6349, [2]. In special situations, for example in case of dedicated lines or in case of measurement on the demarcation points DeP < 6 is possible to use methods based on ITU-T Y.1564 standard, see Fig. 1, [3]. Practical experience of the CTO from real measurements of access networks point out that the very problematic phenomenon of the present is the insufficient capacity of the distribution network, eventually access network [4].

General Behaviour of the Distribution Network

The general model of the internet access service behavior can be based on the general model of the structure of the access network and its connection to the internet as defined by the CTO in its updated methodology for measuring and evaluating data parameters of fixed and fixed wireless access, see Fig. 1. We mark the capacity of a distribution network which ensuring connectivity for access points, by the parameter μ and the other parameter $\mathcal{N}$ marks a set of content providers (CP_s), whose services (not only based on the intelligent agriculture technologies), are used by end-users of an internet service providers (ISPs), [7]. The mark m_i denote a group (count) of end-users (intelligent agriculture services) for every $CP_i = \mathcal{N}$. We can define $\theta_i \triangleq m_i \lambda_i$ in a form of required data throughput of a Content Provider service, where λ_i is the average data throughput per end user. The total required data throughput of a distribution network may be written as:

$$\phi \triangleq \sum_{k \in \mathcal{N}} \theta_k \qquad (1)$$

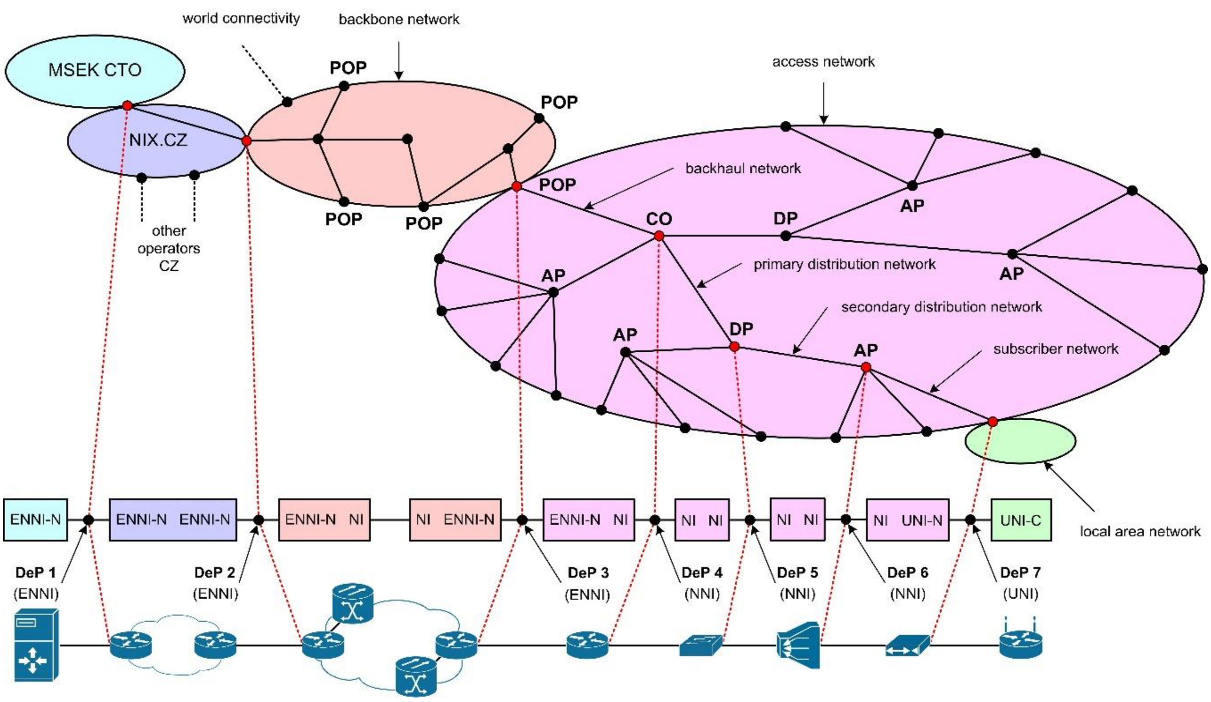

Fig. 1 General model of structure of access network and its connection to the internet

We can define the system usage of the distribution network as a function of μ and θ, if we know the capacity of the distribution network μ and the required data throughput θ :

$$\phi \triangleq \Phi(\theta, \mu). \quad (2)$$

Assuming knowledge of an average data throughput of the end user λ_i, we can write the function of system use of distribution networks in the form of:

$$\lambda_i = \lambda_i(\phi). \quad (3)$$

Denote the end users using the services of content providers in the form of the vector $\overrightarrow{m}$. Fig. 2 shows a general model of distribution network behavior ($\overrightarrow{m}$; μ) where the end user vector $\overrightarrow{m}$ and the distribution network capacity together determine the system utilization of the distribution network ϕ a and for each of the content providers CP_i the required data throughput θ_i. Since the system utilization of ϕ has an increasing character due to the required data throughput θ_i. Since the system utilization of ϕ has an increasing character due to the required data throughput θ_i, which with the increasing system utilization, approaching the overload status, is declining, the resulting system utilization of the distribution network should be in balance. We can thus write that ϕ is a system utilization of the distribution network ($\overrightarrow{m}$; μ), if the following conditions are met:

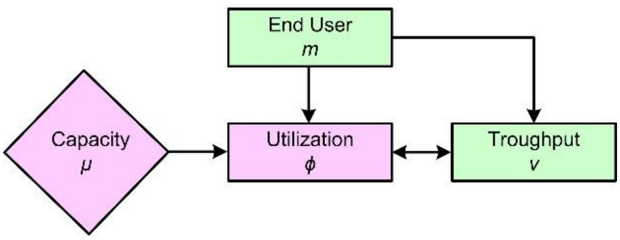

Fig. 2 General model of distribution network behavior

$$\phi = \Phi\left(\sum_{k \in \mathcal{N}} m_k \lambda_k(\phi), \mu\right). \quad (4)$$

Fixed Wireless Access and IoT

Fixed Wireless Access (FWA) test technology, which includes the widely used Wi-Fi technology (IEEE 802.11n, IEEE 802.11ac) in the Czech Republic, has also been included in the group of fixed electronic communications networks, as well as in recent years a popular way to connect via mobile service technology at a fixed location (LTE 3.9G, LTEAdvanced 4G mobile network). In 2015, 20.2 PB of data were transmitted via the mobile service at a fixed location in the Czech Republic, 37.23 PB of data in 2016 and 88.9 PB of data in 2017. This is more than a five-fold increase compared to 2015. When we compare the total volume of data transferred on mobile networks with the transferred data volume only within the mobile service at a fixed location, we find that the key service accounts for 48.6 percent of the total data volume, which is the proportion and impact of this service on the overall quality of the Internet access service.

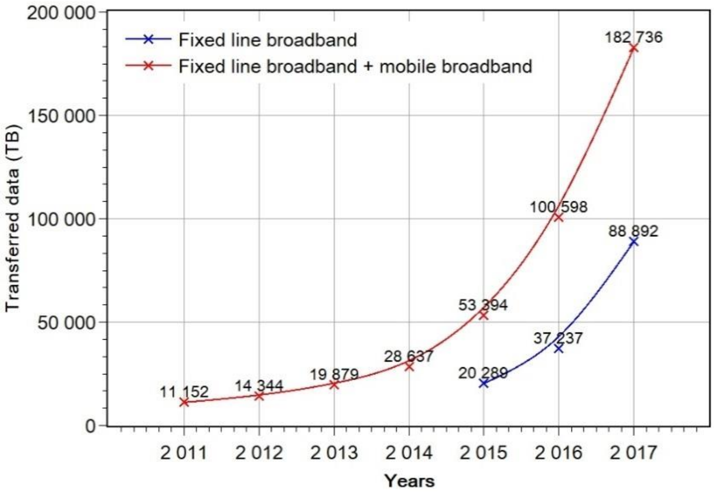

Fig. 3 The total volume of data transferred on mobile networks

Due to the dynamic increase in the number of mobile networks, the assumption was made as to the extent to which the capacities of the distribution and connection networks μ for the general development of services belonging to the intelligent agriculture set of technologies, which undoubtedly will bring significant additional system load Φ . Example is general development of services belonging to the intelligent agriculture set of technologies, which will undoubtedly bring significant additional system load:

- Minimum speed $R_{\min\left(\frac{up}{down}\right)} = \frac{16}{16}\mathbf{kb/s}$.
- Maximum speed $R_{\max\left(\frac{up}{down}\right)} = \frac{2.0}{20}\mathbf{Mb/s}$.
- Normally available speed $BDR\left(\frac{up}{down}\right) = \frac{1.6}{16}\mathbf{Mb/s}$.

Measurements were made off-peak (t_0 = 08:00:00), in the afternoon at the beginning of the peake (t_0 = 14:00:00) and in the evenings during the peak (t_0 = 20:45:00). Fig. 4 shows the measurement results according to the CTO methodological procedures in accordance with Regulation (EU) 2015/2120. From the measured values TCP $\mathbf{aTR_{down}}$ data drop below the defined DZV threshold is noticeable. It is obvious that in the afternoon there was a large repetitive deviation from the currently available speed, even in the even hours a very long deviation from the normally available speed.

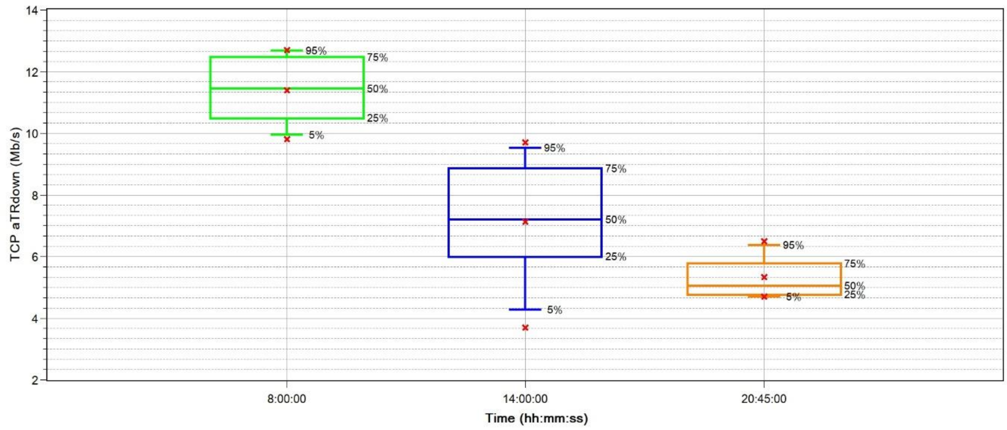

Fig. 4 TCP throughput TCP aTRdown mobile network at fixed access point

Impact of Qualitative Data Parameters on TCP throughput

Based on the mathematical model of behavior of the Internet access service and in the context of Regulation (EU) 2015/2120 we can determine that the resulting value of the measuring download or upload data process is the equivalent of data throughput on the end user's side TCP aTR $\equiv \nu$. The same as the system utilization of the distribution network, which is defined as $\Phi(\theta, \mu) = \frac{\theta}{\mu}$, we can define the system utilization of the user network as:

$$\Psi(\theta, \mu) = \frac{\theta}{\nu}, \tag{5}$$

which is so indirectly dependent on available data throughput ν . Due to the influence of the capacity of the distribution network and the influence of the results due to the buffers, respectively, an increase in frame delays or frames loss, respectively it is necessary to perform the measurement of the qualitative parameters according to the standard ITU-T Y.1564, which may indicate problems with insufficient distribution or access network capacity μ .

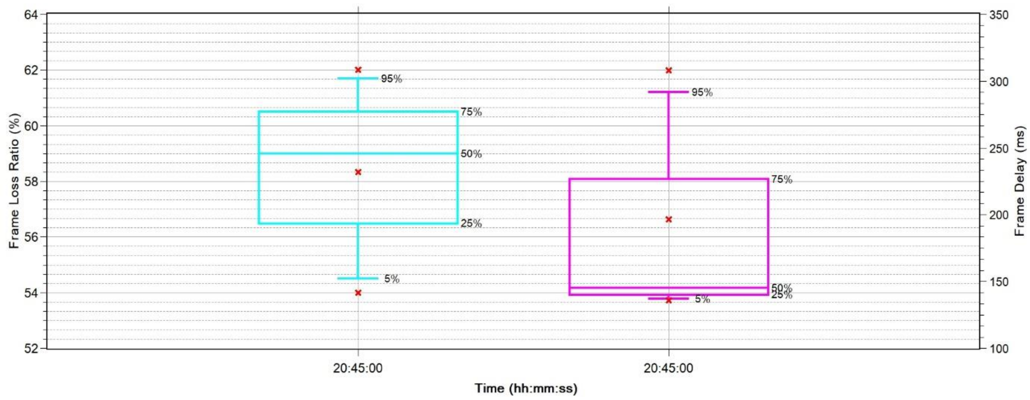

Fig. 5 Frame delay FD a Frame loss ratio FLR mobile services in fixed point (= 20:45:00).

Fig. 5 shows the result of measuring qualitative parameters of mobile data service at a fixed location (t_0 = 20:45:00). The specific monitored qualitative data parameters were Frame delay and Frame loss ratio. It turned out, that the throughput decrease was make by overloading of the distribution network. The result of the measurements shows that it is necessary for the operator to strengthen the capacity of the distribution network and the pitfalls of intelligent agriculture deployment.

RESULTS AND DISCUSSION

The article aims to analyse the impact of the distribution network's capacity on the intelligent agriculture service. Technology concepts and systems within the intelligent agriculture category are based on the use of information and communication technologies. The basic prerequisite for providing the intelligent agriculture service is to provide a stable internet access service. It turns out that the deployment of intelligent agriculture technologies needs to pay close attention to sufficient capacity of the distribution network. The general mathematical model of the distribution network behaviour as well as the measurement results show that, in touch with the Regulation (EU) 2015/2120, it is not enough to check for deviations or unavailability of the service, but also to measure qualitative data parameters that may indicate insufficient distribution network capacity. For example, in benchmarking with the technical specification of MEF 23.1, Performance Tier 2 (Regional), CoS Low.

ACKNOWLEDGEMENT

The research was financially supported by the AF – IGA IP 2016/44 – Návrh procesu monitoringu dat v extrémních prostředích a následné automatizované zpracování naměřených dat.

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