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Edited by Janis Zaharans and Inga Saknite
Institute of Atomic Physics and Spectroscopy, University of Latvia
4 Skunu Str., Riga, Latvia
Phone: +371 67 225 493
Fax: +371 67 225 217
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A "FUZZY" DILEMMA OF TRAFFIC MANAGEMENT

Jans Jeļinskis

Institute of Telecommunications
Riga Technical University, LV 1048 Riga, Latvia
e-mail : jans.jelinskis@rtu.lv

I`d like to start with the completely inveterate statement – the communication technologies in present days are experiencing dramatically noticeable turn in the philosophy basis which is underneath the whole field. Mostly all of data transfer related services more and more tightly merges together "under the hood" of the TCP/IP networks. Data communication protocols as well as various multimedia applications change the nature of traffic which is not any more so smooth and "obedient" as we were used to. The traffic demand became so spontaneous. And I assume we have to add the human nature "to the equation" – as we are using the applications when, and how we want them to use – we have really gone mobile nowadays! Also the "appetite" of the demand is dynamic – from the "change" to the tens of Mbps. So, we are dealing with the nature itself - unpredictable, fractal and beautiful. The self-similar nature of traffic makes it so challenging to cope with. Scale invariance is an exact form of self-similarity – the traffic behaves the same when viewed at different degrees of magnification – it is bursty. And it makes no difference if you try to analyze the 10 second segment or some several hours interval, you will always see the same bursty picture. We know or can easily find main traffic pattern trends – with long term analysis – no big deal. We can see the daily, weekly, monthly trends. But are we able to forecast short term (seconds) traffic changes? We would like to! There are numerous researches that claim we can….anyhow I respectfully disagree! Not really! As in fact – often it makes no sense anymore. The chaos makes this world to be so divert and unpredictable.

Now, taking into the consideration all the things mentioned above, we have to make the next step and draw the picture of the data connection link and routing devices that are operating under such conditions. Those devices have to make the CAC (Connection Admission Control) decisions – whether to allow the connections (provide the resources to the application) or not. Under the bursty traffic the link is consecutively over utilized or underutilized. The packet service time in the case of bursty traffic is far away from the classic M/M/1 queue. It tends to start growing exponentially on the significantly smaller utilization values than we would expect. Except of link utilization, there are also numerous QoS parameters, such as delay, packet losses and jitter that we should care about. It means that we are not able to rely on the classical threshold based decision making that "cares" only about the utilization. If there are any spare resources, we give them to the requester, if there are not – "Better luck next time!" Such an approach doesn't really try to provide admissible QoS parameters for the connection; it cares about the resource utilization, and as it was mentioned before, this is a "one way ticket". If we want to cope with the present world and the present applications, generating bursty and scale invariant traffic, we have to be more versatile. While making the CAC decision, we have to take into account the QoS level requested, as well as the actual network state, to be able to check on if we can provide the QoS the application requires. The "best effort" is not in the latest fashion anymore. And I have some extra – the modern fast optical networks provide unprecedented amount throughput that means we have to be fast with the decision on the router side.

The next reflection will be quite short and is dedicated to values we measure on the network. Let imagine that we try to measure the QoS parameter values mentioned earlier or some other network state descriptors such as link utilization. If we try to be very precise (so to be able to make the precise decision) we run against the wall again! Does it really matters if we are so precise if those values we cope with are changing so rapidly and in such unpredictable manner? In most cases it makes no sense to be precise with the details – we have to be able to detect the right direction of actions instead of make the fine-grained calculations.

So...here we are! We have to make the "filigree" decision – and we have the dilemma. The environment is changing. The traffic is bursty. The demand is dynamic. We are not able to get to know «what's next». We need to have lots of parameters being analyzed simultaneously as well as we have to be pretty fast with the decision.

And at this very moment I`d like the reader to think it over: if we cannot change the world, probably we have to change the approach! What if we do not care about the details…? What if we do not try to forecast and to be precise…? And....what if it really works?

Ladies & Gentlemen I'm pleased to introduce you "fuzzy logic". Fuzzy logic provides an opportunity to deal with the notion of approximate reasoning – that's what we need! It allows making decisions based on IF-THEN fuzzy rules – one compact knowledge base for decision making. The detailed mathematical description and the aspects of implementing the concept of fuzzy logic may be found in many scientific publications of its founder, professor Lotfali Askar-Zadeh, but I like to focus on the Fuzzy-CAC control. In the "fuzzy" case we don't try to forecast anything – we take things as they are. We fuzzify the crisp input data (let them be QoS or network state parameter values) to the linguistic fuzzy values - it makes it possible to not care about the preciseness. Then we make the decision based on compact and comprehensible linguistic IF-THEN rules – it allows the multiple parameters being analyzed simultaneously within the admissible time frame. And the fuzzy inference system, after the deffuzification, gives us the crisp decision value. Voilà!

The experimental results [1] show that the fuzzy-CAC in opposition to classical threshold-CAC makes it possible to be effective while accepting the unpredictable traffic behavior. We can "see the whole picture" of the decision – the fuzzy inference system allows to go through all of the "possible decisions" in parallel and conclude with just the "right direction of actions" – and that's exactly what we tend to find. Fuzzy decision system if flexible – we can freely modify the linguistic membership functions of the input parameters, fuzzyfication regularities and deffuzification methods. The IF-THEN rule based knowledge base can be dynamically updated and adjusted. In other words – it is one great tool to cope with the nature as it is and to provide the QoS to the modern fast optical networks.

Concluding the reflections – we can win the battle with the nature, but we can`t win the war. The stochastic character of the present traffic dictates the rules and sometimes we really have to accept the things as they are. And when we do so, there is a possibility that we will find unexpectedly interesting solutions and alternative approaches to the desired solution.

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