Performance Comparison of Different Data Rate Adaptation Mechanisms

Martin Belzner (1), Herbert Haunstein (1), Dieter Stoll (2)

(1) University of Erlangen-Nuremberg, Institute for Information Transmission, Cauerstr. 7, D-91058 Erlangen
e-mail: {belzner | haunstein} @ LNT.de
(2) Lucent Technologies Network Systems GmbH, Thurn & Taxisstr. 10 D-90411 Nuremberg
e-mail: dieterstoll@alcatel-lucent.com

Abstract Different data rate adaptation mechanism and their influence on network and traffic characteristics are visualized in radar plots in order to provide a fast and fair comparison of multiple parameters at the same time.

Introduction
In today's transport links in core and metro area networks are often underutilized and transport capacity is wasted by the resource providers. This overprovisioning helps on the one hand to guarantee certain service level agreements (SLA) like transmission delay and packet loss rates and can on the other hand in some cases not be avoided due to the transport network granularity (e.g. SDH/SONET containers or optical wavelengths). Dynamic bandwidth adaptation (DBA) and optical burst switching (OBS) aim to provide optimal use of transport resources while at the same time minimize the overall resource allocation. Recent researches have shown different aspects of various parameters sets for DBA and OBS and their influence on the network and traffic characteristics. However these investigations, while examining several parameters of the traffic and adaptation algorithms fail to give a representative overview comparing the different transport techniques. Therefore a fair comparison of different parameters or implementations is in most cases not possible. While one parameter might certainly positive influence some characteristic of the traffic it impacts at the same time other important features, too. We examine in this paper DBA, OBS and static bandwidth allocation (SBA) and their influence on the network and traffic. We show how to optimally visualize the simulation results.

Transport adaptation mechanisms and their impacts on the network and traffic characteristic
In this paper we simulated the adaptation of incoming packet traffic via a network node onto an outgoing transport interface. For the statistical analysis we sampled the output traffic in 1ms time intervals. We compare an OBS algorithm as in [1] with an open loop control DBA algorithm similar as presented in [2] and static bandwidth allocation. The OBS algorithm assembles the bursts considering an allowed maximum delay for the packets as well as a maximum burst length. If one of the two restrictions is reached the queued up data is transmitted in a burst. Our DBA algorithm implementation stepwise allocates transport bandwidth depending on the measured arrival rate. The transport bandwidth is increased or reduced in steps of one by a defined transport container capacity (representing a SDH/SONET Virtual Container) if a defined threshold is reached. In the static allocation case the outgoing transport bandwidth was set to a fixed value of 50Mbps. As input for our simulations we used a traffic trace captured from a 100Mbps wide area transport link of the WIDE network [3] with an average utilization of 32Mbps. For DBA and SBA the network node buffer size was set to 500Kb thus defining a maximum allowed delay of about 1ms for the SBA case. The bandwidth adaptation interval for our DBA was set to 10ms. The max-delay and max-burst-length for the OBS algorithms were set to 1ms respectively to 500Kb. In the following section we show how these different transport bandwidth adaptation algorithms influence various network and traffic characteristics. Besides the transport bandwidth savings and overprovisioning (defined here as mean data rate divided by the allocated bandwidth) we took a closer look at the Hurst parameter at time scales above and below 100ms, burst length distribution, the coefficient of variance and peak to mean ration as important factors for network designing. We investigated the packet delay distributions as well as buffer utilization as indicator for achievable quality of service (QoS).

Simulation Results for different transport adaptation mechanisms
Figure 1 shows the simulation result for the three transport mechanisms compared to the original traffic in a radar plot. The size of the enclosed areas generally implies the achievable performance. However it is important here to consider the weighting of the chosen axes as the directly change the shape of the covered area. In our plot axes and weighting have been chosen such that smaller covered areas indicate better performance. We propose this visualization method because multiple parameters can be investigated at the same time in order to allow a fair comparison. From Figure 1 it can be seen that while OBS and DBA show a better transport resource utilization (smaller covered area in the upper part of the plot) they introduce impairments on the QoS and network design. The required burst assembling time as well as the required buffering with DBA induces significant delay to the transported packets. The Hurst parameter for short range time scales increases
through burst assembly however the long-range
dependence is not influence implicating that large
buffers might be required at following network
elements. From the covered areas we can see that
SBA still provides good overall performance.
Additionally DBA and SBA provide the advantage of
improved network planning as resources are directly
reserved for the transport e.g. prior to the transfer or
during runtime. The maximum results from the
simulation can be found in Table 1.

![Figure 1: Radar plot of network and traffic characteristics for OBS, DBA and SBA](image)

Table 1 Simulation Results for different transport
adaptation methods

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. allocated Bandwidth</td>
<td>100 Mbps</td>
</tr>
<tr>
<td>Coefficient of variation (1ms sampling)</td>
<td>0.6559</td>
</tr>
<tr>
<td>Peak/Mean Data Rate (1ms sampling)</td>
<td>3.3208</td>
</tr>
<tr>
<td>Hurst Parameter (short range) (&lt; 100ms)</td>
<td>0.5513</td>
</tr>
<tr>
<td>Hurst Parameter (long range) (&gt; 100ms)</td>
<td>0.6623</td>
</tr>
<tr>
<td>Avg. Burst Length (back-to-back packets)</td>
<td>61094</td>
</tr>
<tr>
<td>Avg. Queue Length (1ms sampling)</td>
<td>56791 bit</td>
</tr>
<tr>
<td>Avg. Queuing Delay</td>
<td>1.8 ms</td>
</tr>
<tr>
<td>Overprovisioning</td>
<td>0.675</td>
</tr>
</tbody>
</table>

Influence of different simulation parameters
The proposed visualization method also allows giving
a quick overview of the performance of an algorithm
with different parameter sets. From Figure 2 it can be
seen that changing a single parameter of the burst
assembling algorithm presented above, e.g. the
allowed maximum burst size, has strong influence on
the network and the achievable QoS as well. Overall
larger assembly times (either through large allowed
delays or burst sizes) generally reduce the achievable
QoS. However they smooth the traffic at short range
time scales. Longer assembly delays also lead to
larger bursts which reduce signaling overhead and
bandwidth utilization in optical burst switching
scenarios. Table 2 shows the maximum result
 corresponding to the plot from Figure 2.

![Figure 2: Burst switching with different parameters](image)

Table 2 Simulation Results for burst switching with
different parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. allocated Bandwidth</td>
<td>32045 Kbps</td>
</tr>
<tr>
<td>Number of Bursts</td>
<td>796037</td>
</tr>
<tr>
<td>Hurst Parameter (short range) (&lt; 100ms)</td>
<td>0.3956</td>
</tr>
<tr>
<td>Hurst Parameter (long range) (&gt; 100ms)</td>
<td>0.6623</td>
</tr>
<tr>
<td>Avg. Burst Length (back-to-back packets)</td>
<td>324575 bit</td>
</tr>
<tr>
<td>Avg. Queue Length (1ms sampling)</td>
<td>214149 bit</td>
</tr>
<tr>
<td>Avg. Queuing Delay</td>
<td>6.7 ms</td>
</tr>
<tr>
<td>Coefficient of variation (1ms sampling)</td>
<td>1.3418</td>
</tr>
</tbody>
</table>

Conclusions
In this paper we have compare different adaptation
mechanisms for the efficient transport of packet traffic
in a core or metro network. We showed how burst
switching, dynamic bandwidth adaptation and static
provisioning influence various traffic characteristics.
We elaborated that algorithms which try to improve
bandwidth utilization generally decrease the
achievable QoS. Furthermore we showed how
visualization with a radar plot helps to give a better
impression over an adaptation method with different
parameters and their impacts on multiple traffic and
network characteristic. From the radar plots the
influence of an algorithm or adaptation method on the
network and traffic can be directly evaluated through
the covered area. In our future work we will also
address packet loss and blocking probability as well
as different traffic loads.

Acknowledgements
This work has been funded in parts by the German
Ministry for Research and Education (BMBF Grant
01BP554)

References
3 WIDE Project http://www.wide.ad.jp