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Which Network for Video on Demand?

JACQUES ROBADEY **With current access technologies, Telco's can offer broadband services such as Video on Demand (VoD). However, the service costs strongly depend on the network capacity used. A Content Delivery Network (CDN) can reduce the traffic and thereby lower costs. This article describes CDNs for VoD. It compares CDNs based on one central VoD server versus CDNs made up of several distributed servers.**

Broadband connectivity is already offered by most Telco's and cable TV operators. However, broadband services are still in testing and early deployment phases. One of the most promising broadband services is real Video on Demand (VoD). Residential customers can select the movie they want from a video offer displayed on their home TV screen. The movie starts as soon as they ask for it, with no previous reservation necessary (fig. 1). Pause, Fast Rewind and Fast Forward options can be used real time. Note that this is how real VoD differs from "near" VoD, where a selected movie starts at a specific time and cannot be stopped. Near VoD, also called "Pay TV," can be broadcast, while real VoD requires single-cast video streams. The required bandwidth in the network is small for near VoD and high for real VoD.

Real VoD imposes extended network requirements that can only be achieved with an efficient Content Delivery Network (CDN). The video content can either be centralised in one server, where all video streams originate, or decentralised with smaller local servers, as shown in figure 2. With the second option, the network use is reduced, but the number of servers is increased. To learn more about the optimal CDN, we have conducted a detailed network cost analysis for various CDN scenarios. The analysis below shows the principal cost tendencies for each scenario, depending on the number of real VoD customers. The service assumptions include the following:

- At least 500 movies are offered across Switzerland
- Peak VoD usage corresponds to 10% of the registered customers
- Other services (telephony and Internet access) are still available while VoD is running

The network dimensioning and costs were based on these assumptions and VoD market penetration. The analysis is based on the current Swisscom technology.

Requirements for the Transport Network

The client needs impose several network requirements:

1. Efficient codecs (protocols used for the video stream)
2. Real time QoS (Quality of service)
3. Correct network dimensioning
4. Optimal distribution of content servers

Points 3 and 4 correspond to the CDN.

Codecs

The video quality is considered sufficient with the following protocols: MPEG 2 using 4 Mbit/s, MPEG 4-H264 with 1.5 Mbit/s and Windows media player 9 with 1 Mbit/s [1]. The official video standard MPEG is used by 99% of the TV market: MPEG 2 is commercially available, while MPEG 4

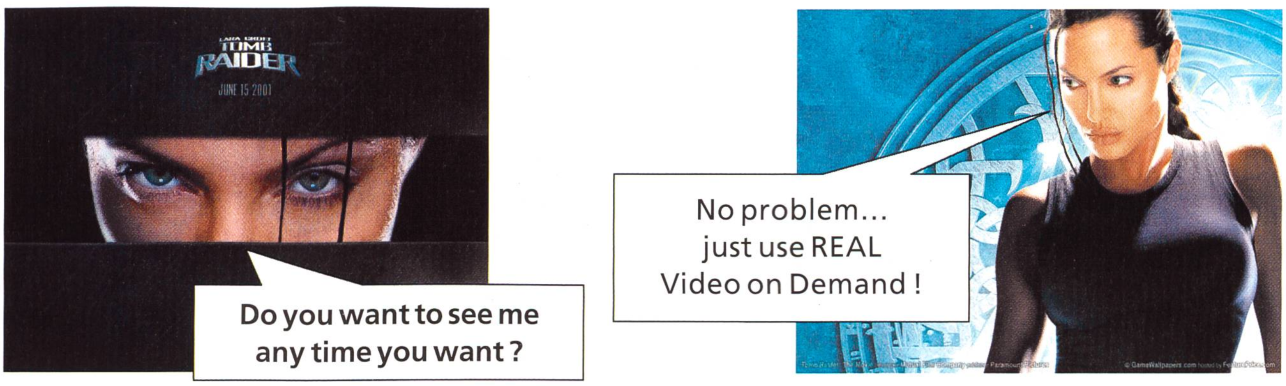


Fig. 1. Real Video on Demand (VoD) is the only alternative to stay at home and to watch your preferred movie when you want, as soon as you want, and as much as you want.

is still under development. Windows media player is also available, but it is a Microsoft proprietary solution. A bandwidth *between* 0.7 and 4 Mbit/s is required for the video streams.

QoS
There are three ways to achieve video QoS. The first is by over-dimensioning the network; the second is the use of Class of Services (CoS) with video traffic prioritisation; the last one is based on Leased Lines. Long term, the CoS may be the optimal solution.

Content Delivery Network
Many network solutions can deliver VoD to end users. However, the cost of each solution can differ significantly. To understand the different strategies, a description of the transport network is necessary. In the case of Swisscom, the transport network is divided into three main parts (fig. 3): the Core, the Metro and the Access networks. These parts are shown in blue, green and red, respectively.

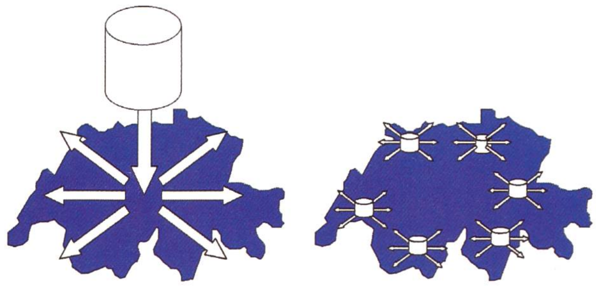
The Core links the main centres of the country. The Metro is a regional network. The interconnections between Core and Metro networks occur in the main nodes displayed in blue and called FUS (Fernnetz Übergangstelle). The small nodes of the Metro network, displayed in green, are called RUS (Regionale Übergangstelle). The third part of the Swisscom network corresponds to the Access network (in red). It links the local node directly to end customers via one dedicated cable.

Both Core and Metro networks are based on optical fibres and have a high transport capacity, while the Access network, based on the old twisted-pair technology, has capacity limitations. Because of this bandwidth limitation, Access is the first VoD bottleneck. The current Swisscom Access technology ADSL (Asynchronous Digital Subscriber Line) is already sufficient for one VoD channel per household. Only a simultaneous run of several broadband services for one household would require an Access upgrade.

For the Core and Metro networks, each capacity upgrade requires heavy investments in link-termination equipment. Optical multiplexers, routers, SDH and GbE (Gigabit Ethernet) transmitters all need capacity improvement. We can significantly reduce costs by keeping the transport capacity through the Core and Metro to a strict minimum. This is particularly important because peak video services traffic happens during the same evening hours as peak Internet use. Since video services increase a traffic peak rather than fill a traffic dip, they will need a direct network capacity increase.

A decentralised CDN can noticeably reduce the network usage [2] as video streams only use the network between servers and end customers. With regional servers, only local traffic is generated. This results in moderate network costs but higher server costs (fig. 2).

Here, briefly, are the advantages and drawbacks of centralised CDNs with one server versus distributed CDNs: Centralised CDNs are simpler to build, manage and maintain; for increasing numbers of both customers and movies, an upgrade of the central server will suffice. The drawback of centralised CDNs is their significant network capacity requirement.



Centralized option: one VoD server is used for all Switzerland.

Decentralized option: one VoD server per region. Higher server costs are compensated by significant savings in the transport network.

Fig. 2. Centralised and decentralised options for VoD Server.

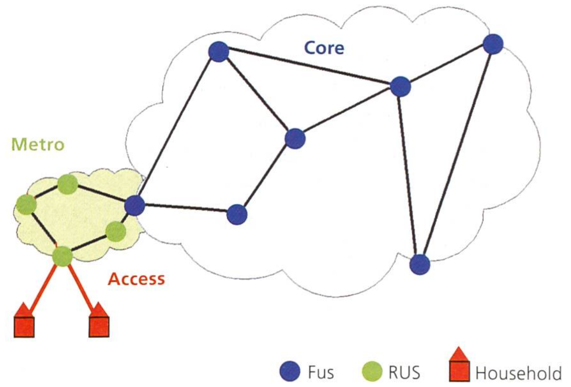


Fig. 3. Simplified transport network topology with Core in blue, Metro in green and Access in red.

Distributed CDNs need more, though smaller, VoD servers. Management and maintenance costs are increased, but the network usage is minimised. Distributed CDNs are also less sensitive to server and network failures.

Cost Analysis of Centralised versus Decentralised CDN
The results of the cost study for several CDN scenarios are presented below. The costs correspond to the network and server costs, including maintenance and management. The used network corresponds to the Swisscom IP platform IPSS. No access costs are included in this analysis because the model assumes an offer to ADSL customers only (e.g. no upgrade needed). The VoD costs that are not related to the transport network are also not included; they correspond to Set-Top box and home networking, film licences, and related expenses.

In order to get results applicable to all Swiss customers, the calculations were performed for one regional (or Metro) network, displayed in green (fig. 3). This could be the suburb of Basel, the canton of Graubünden, or any other region. Figure 4 shows the resulting VoD costs per year and customer in terms of registered customers in a region. For the centralised CDN, all streams come from a central server

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Conclusions and Outlook

The network requirements for VoD services have been studied in detail. The first conclusion concerns the current ADSL Access network. Its transport capacity is sufficient to carry at least one video channel. Only a simultaneous run of several broadband services for the same household could require an upgrade for Access. Second, we noticed that money can be saved in the core network with an efficient CDN. A strategy to correctly distribute Content VoD servers has been defined. The CDN must begin with one centralised server and additional servers must be installed in a region as soon as a critical number of customers are registered there. That number depends on the required bandwidth for the video codec.

Finally, we observe a rapid drop in per-customer network and server costs with the first users, and cost stabilisation with a regional customer-base of several thousand. In this case, VoD CDN costs per customer are relatively small and should not be a barrier for a successful VoD implementation. Movie licence costs and the contracts which allow us to keep film stock current and appealing would be the main limitations.

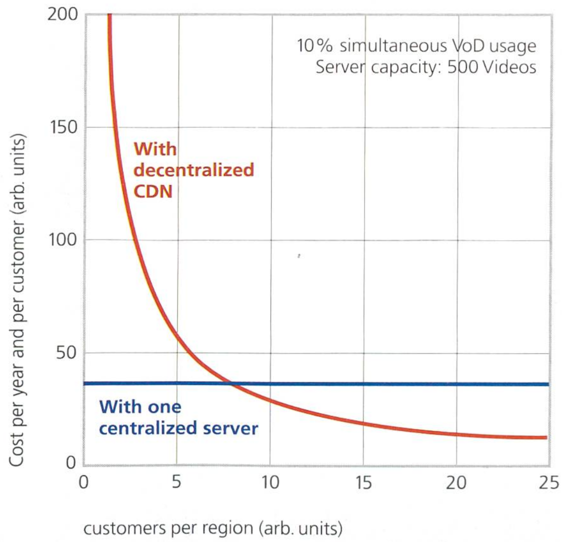

Fig. 4. VoD network and server cost per customer as a function of a regional customer-base (green cloud of fig. 3). VoD should begin with a centralised CDN. As soon as a critical amount of regional customers are reached, the decentralized CDN is the most economical solution.

(located, for example, in Zurich) and are distributed to customers through Core, Metro and Access networks.

The costs per customer correspond almost exclusively to the transport of the video stream. They are therefore independent from the customer-base as illustrated by the blue line in figure 4. For the distributed CDN, a second server is placed in the regional POP (FUS) and the streams run from this POP to the customers. Most of the costs are due to the additional server and diminish as 1/x with the number of customers as shown by the red curve.

The VoD service should be centralised in a first phase. However, as soon as the number of customers reaches several hundred in a region, the set-up of a local server is the most economical solution. If we take this rule for all of Switzerland, we see that the optimal CDN is neither centralised, nor fully distributed, but corresponds to a hybrid network. The regions with a high population density will rapidly require a regional server, while the less densely inhabited areas will remain linked to a central server.

Figure 4 shows a rapid decrease of costs per customer with increasing customer base. After several thousand customers per region, the cost per customer begins to flatten out. The stabilised value corresponds to the network streaming costs between server and customer, and the costs of one server divided by its dedicated customers. It represents a value between 10–40 Swiss Francs per year and per customer, depending on the chosen video codec and its bandwidth.

It is important to note that these calculations are based on VoD viewing behaviour with a peak of 10% simultaneous usage. If many customers register for the VoD service and then use it only infrequently, costs will be lower, as will demand for bandwidth and server upgrades. This shows one very interesting characteristic of VoD for Telco's. Video on Demand only requires a pay-as-you-grow network and server investment. In this respect, VoD is not a high-risk market because the investment is proportional to its success. In contrast, TV delivery will require significant upfront investment (multi-cast technology and bandwidth upgrade) although audiences may be small at the outset – i. e. the reverse of the pay-as-you-grow model.

With VoD, as soon as simultaneous VoD users reach several hundred in a region (corresponding to breakeven costs), the cost per simultaneous customer is reduced to a small constant value. This is the ideal VoD penetration for both Telco's and VoD users.

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