



Quality of Experience and its influence on networks



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- > Basic understanding of the Terms Quality of Experience (QoE) and Quality of Service (QoS)
- > See the difference between QoE and QoS
- > learn about network factors influencing the QoE per Service
- > Have a feeling for the difficulty to make objective measurement of QoE
- > learn why network operators should care about QoE

Quality Samples Audio / Video



- > Listen to the following three audio Samples



sound1

- > CD



sound2

wired phone



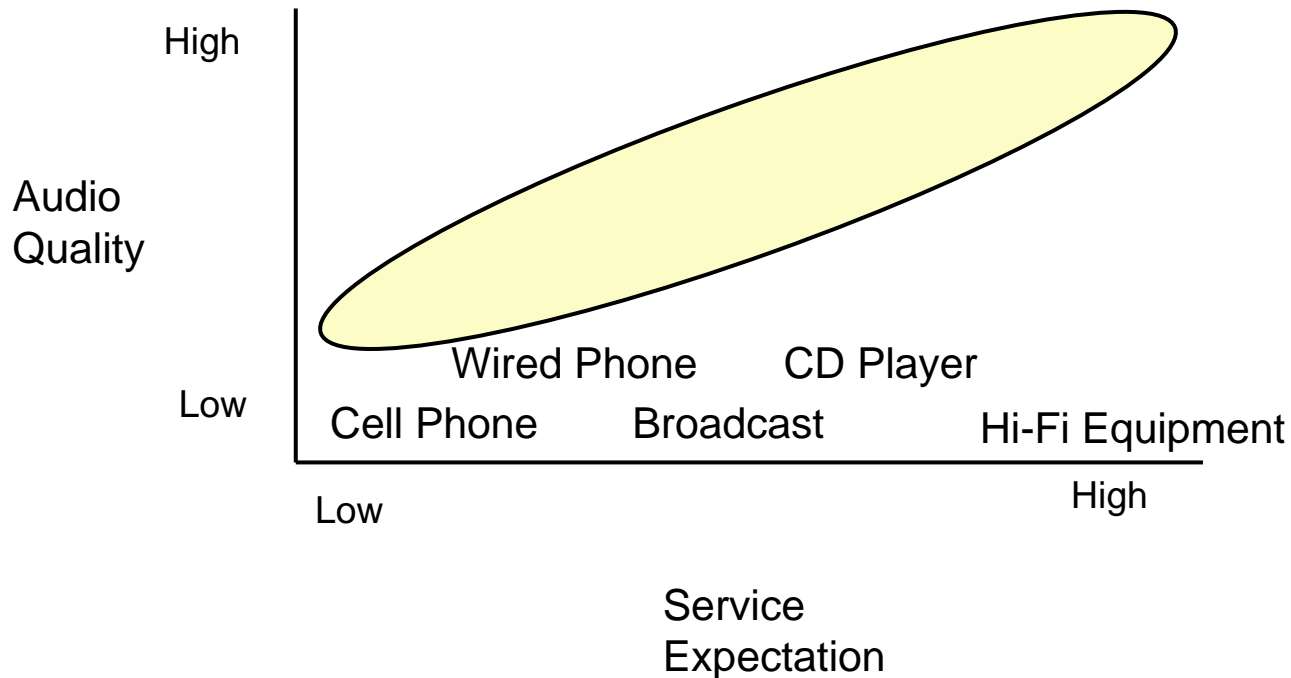
sound3

disturbed Network

- > Which one has the best quality?
- > Imagine you are a voice network operator, which quality would you make most money with?
- > Does a mobile operator make another quality decision than a wireline operator?

What to learn from this example

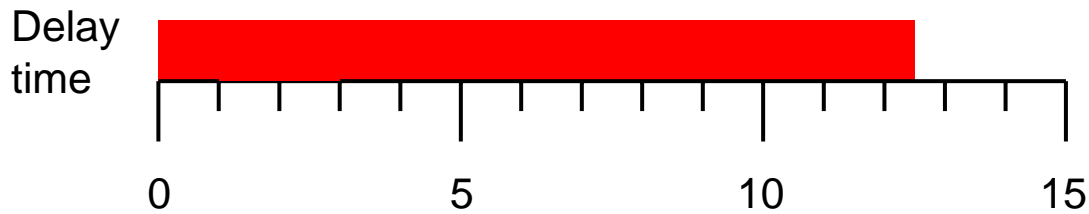
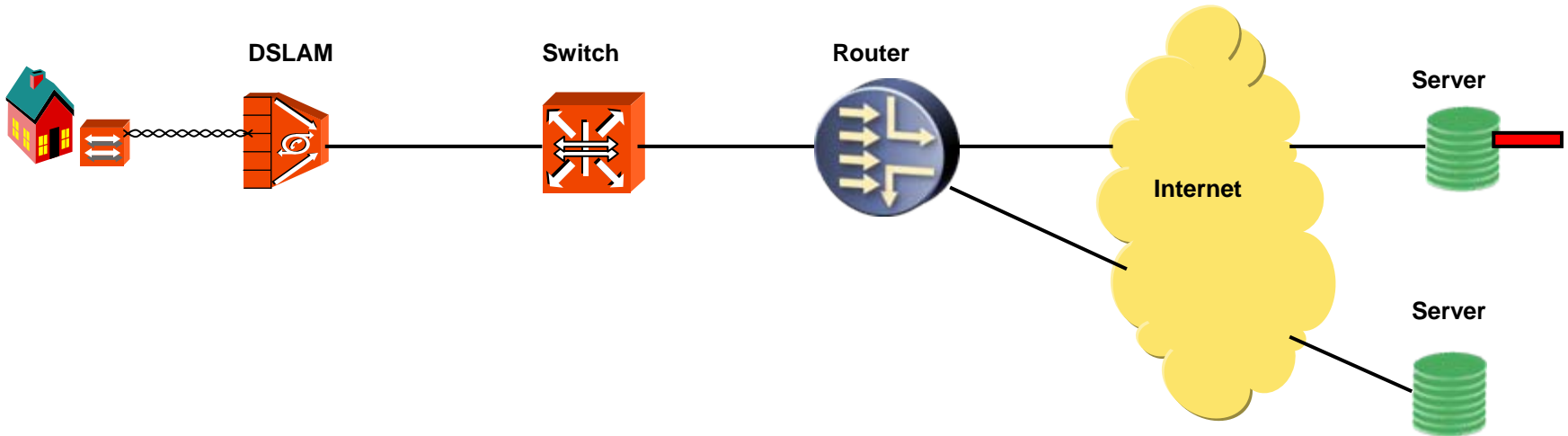
- > Quality of Experience is strongly depending on the expectations of the users about the offered service.



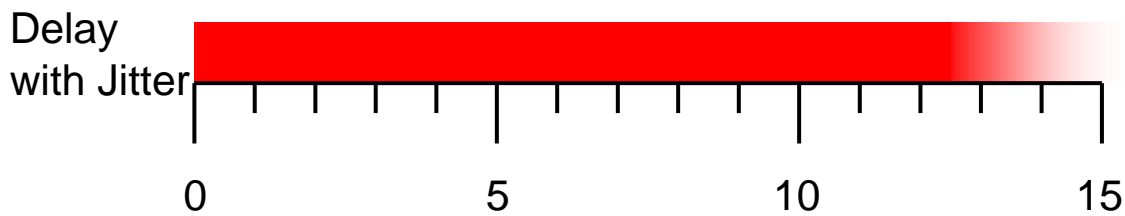
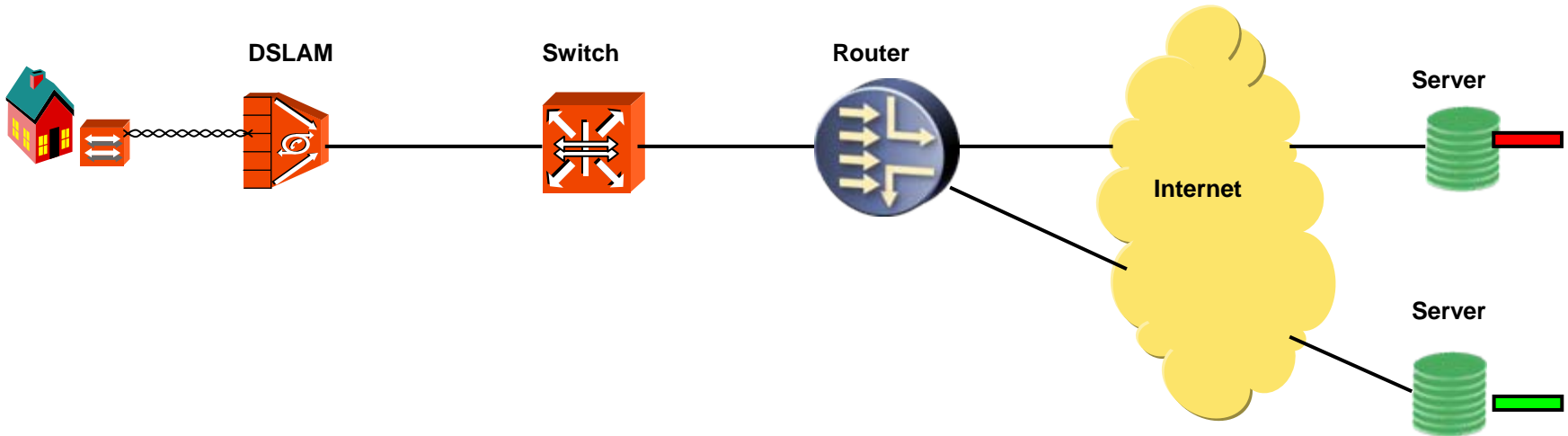
- > QoS was intended to reflect the users experience, but ended up in defining measurable network parameters like:
 - packet delay
 - jitter
 - packet loss ratio
 - throughput ((Kilo/Mega/Giga)bits per second)

- > These are objective values, which can be used as basis for contractual Service Level Agreements.

Qos Parameter: Delay



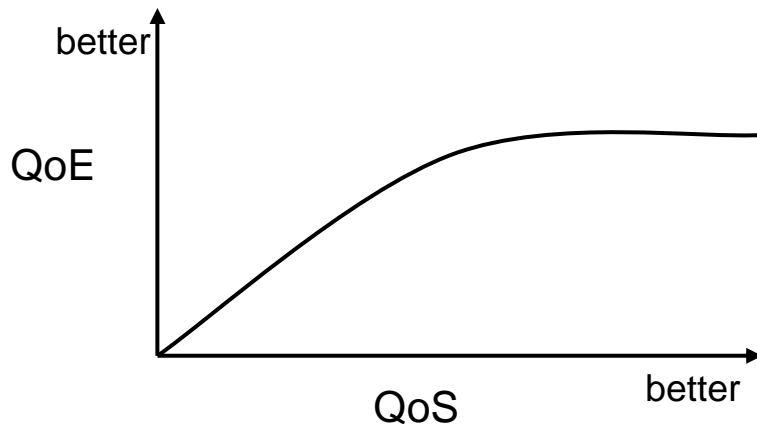
QoS Parameter: Jitter



Quality of Experience vs. Quality of Service



- > QoE now revives the view of subjective end user experience while using a service.
- > There is an relation between QoS and QoE, but unfortunately this relation is different for each service and in addition varies between users (with different expectations).

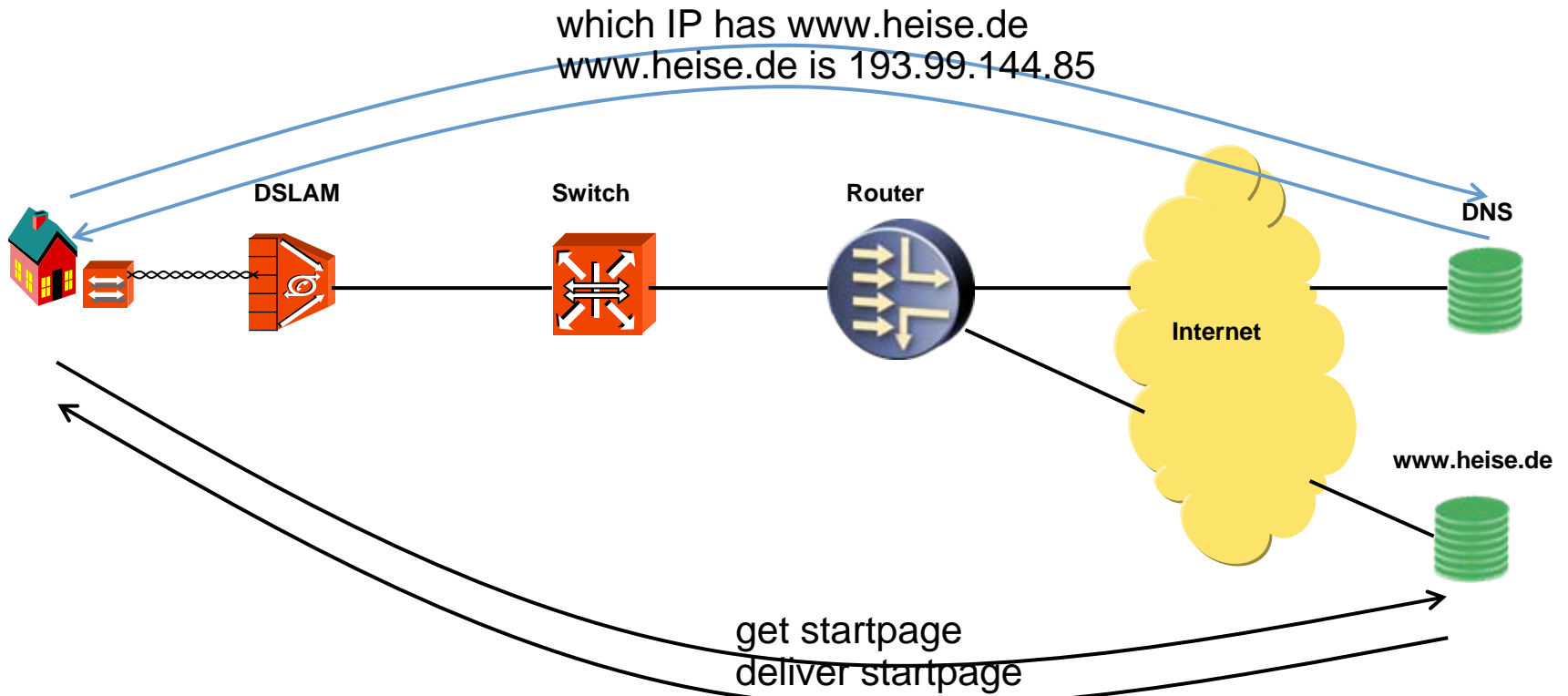


- > Please note also, that QoS is only one of several factors influencing the QoE of a service.

- > Three categories of Services:
 - Non Interactive -> no strong QoE requirements
 - Peer2Peer data exchange
 - Email / Newsgroups
 - File up/download (including Video files viewed after download finished)
 - Interactive
 - Web browsing
 - Real Time Interactive
 - Network Gaming
 - Voice over IP
 - Radio/Video Broadcast
 - Video on Demand (e.g. network video recorder)

- > What annoys most when surfing the net?
 - Nothing happens at all when clicking on a link for several seconds
 - Slow buildup of a page

Web Browsing sequence principle



- > Quality is influenced by many possible causes and the enduser has no way to find out where the problem originated.

- > Operators can influence the quality by:
 - Ensuring that their DNS Service is not overloaded
 - Ensuring, that little packet loss occurs

- > Many factors influence the gaming experience.
- > Sound, graphics and originality of the game are very important.
- > Main challenge for the network is caused by first person shooters, where the reaction time can decide about being (virtually) alive or dead.
- > Thus a short round trip time for packets from the User to the Server and back is necessary.
We talk about 100ms as acceptable limit.
- > Operators should ensure small delay for gaming traffic.

- > Remember the starting example?
- > Usually, VoIP Quality is good at 100 kbit/s -> bitrate is not a problem with today's broadband access networks.
- > Important is the delay, which should not exceed 250 ms
 - ever used a satellite phone? needs much discipline to wait for the answers from the other side.
- > Packet loss is also not a problem, as the VoIP Packets are quite small and little information is lost.
- > Other aspects for Quality of Experience cover for example the cell setup behaviour.

Video Quality Examples Source Quality Influence



High Bitrate Encoding

Low Bitrate Encoding

> Operators may choose to offer lower quality for cost reasons

Video Quality Examples network influence



- > The following examples show different Video Qualities due to network constraints:

(© 2006 Dreamworks Animation L.L.C., © 2006 DivX, Inc., www.divx.com)



M_18mbit.Ink



M_6mbit.Ink



M_pl1.Ink



M_pl001.Ink

- > 18 Mbit 6 Mbit 1% Packet Loss 0,01% P
(MPEG2 encoded video streams)

- > Throughput (cost issue from previous slide) and packet loss influence the quality

- > Low packet loss of most importance
- > Jitter could cause problems, but can be handled by large buffers in player
- > Delay is usually not a problem for video services.
- > Recommended packet loss ratio is $10e-4$ (i.e. only one of 10.000 packtes lost).
- > to achieve this on a transmission channel, the bit error rate must be at $10e-8$ (i.e. only one of 100 Million bits failed)

- > The following list summarizes the important demands for the network quality per service:
 - Web Browsing: little packet loss,
 - Network Gaming: small delay,
 - VoIP: small delay,
 - Video Services: little packet loss

- > Unfortunately delay and packet loss are contrary goals

- > For example on a DSL line, you can reduce packet loss by increasing the interleaving time, which directly translates into increasing the delay.

Challenge for Network Operators



- > The main goal for a Network Operator is to make money.
- > Thus he needs to find a compromise between the network costs and the quality he offers to his customers.
- > Knowing the influence of the network parameters on the Quality of Experience allows him to fine tune his network/operational costs.
- > As we have seen, this is not an straightforward task.

- > Test the impact of different network settings with several people and create a relation about the Quality they report and the according network settings.
- > This must be done for each service to be quality controlled
- > Next select the quality you want to offer and set and control your network with the according parameters out of the test results.

Summary



- > The Users judgement of Service Quality is important.
- > QoE tries to cover this, QoS is not directly usable as indication.
- > Many non network dependent factors influence QoE
- > Relation between QoE and Network QoS is service specific
- > Operators need a sophisticated planning of a networks considering:
 - Which services are most important
 - which type of customers are addressed
- > During operation, the Operators may choose to either:
 - Wait until customers complain before enhancing the network or
 - monitor the network and react in advance to bottlenecks.

Questions?