

Experimental Analysis of the QoS/QoE Relationship for Different Services

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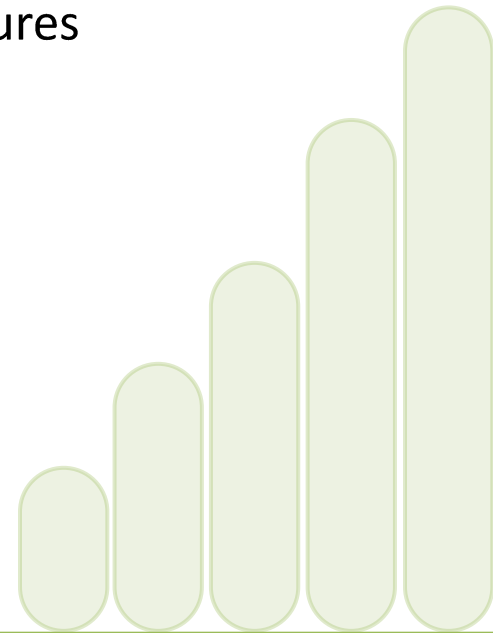
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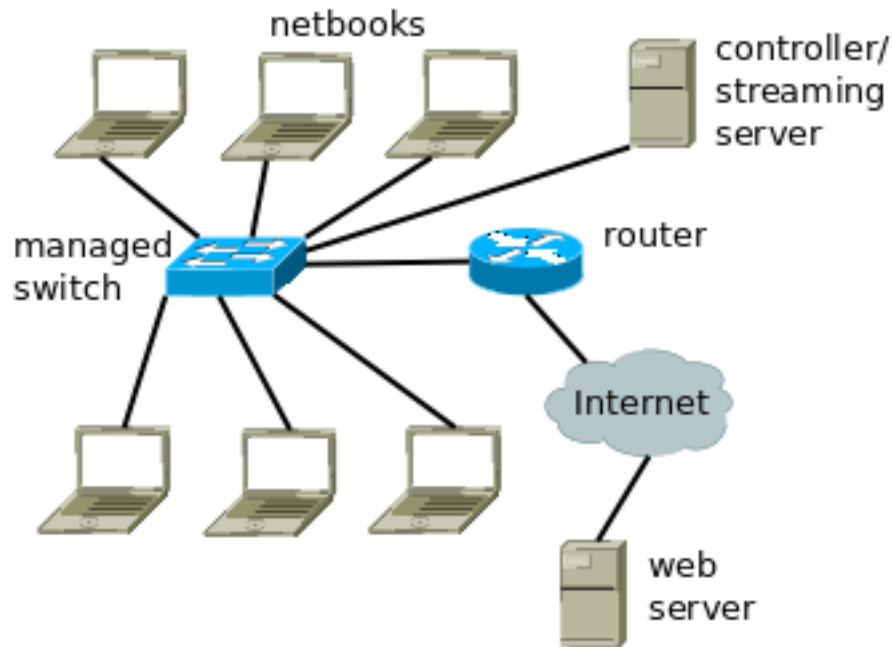
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- Network operators are facing increasing user demands
 - Measurement of Quality-of-Service (QoS) no longer sufficient
 - Quality-of-Experience (QoE) must be considered as well
- QoE examples
 - Video: fluency of movement, artefacts
 - Web page: speed of building up the page, missing pictures
- Network operators face two tasks
 - Prediction of QoE for a given network
 - Dimension network appropriately for a given QoE
- QoS to QoE mapping involves human perception
 - Cannot be derived mathematically or by simulations
 - Experiments with humans needed
- Experimental campaign performed in this work

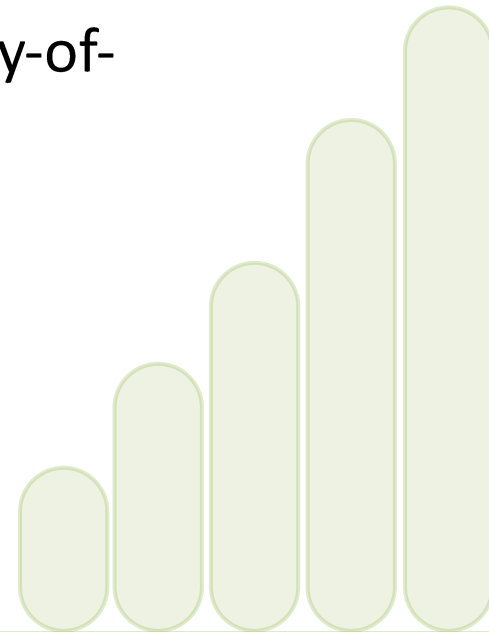




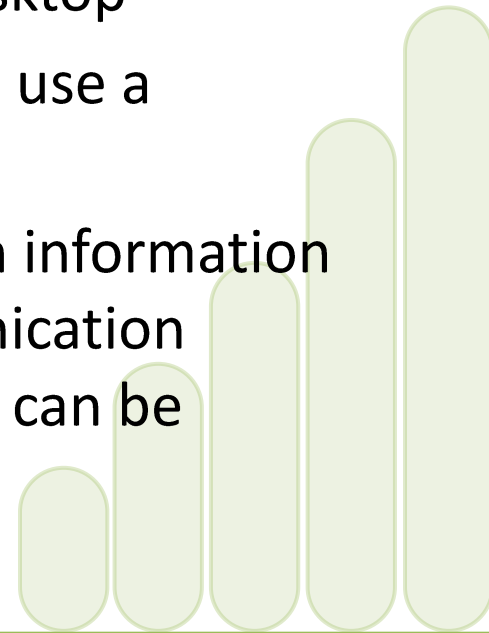
- Managed switch allows limitation of link speed for up- and downlink
 - link speed used as the QoS criterion
 - Server provides video stream and controls switch and netbooks
 - Router connects setup to Internet to access public web server
 - Netbooks: 26cm (10") display, 1024x600 pixels
- 3 services tested: video streaming, video conferencing, web browsing

- User screening asking about
 - age and occupation
 - type of used computing/communication devices
 - knowledge of technical terms
 - amount of time spent with using different services
- Individual tests of services
 - Video streaming: server plays out a video scaled to netbook's screen resolution – client software: Videolan Client (vlc)
 - Web browsing: browser is started with a preconfigured web server located in the Internet (www.bremen4.de) – client software: Firefox
 - Video conferencing: probands are connected pairwise – Software: Skype

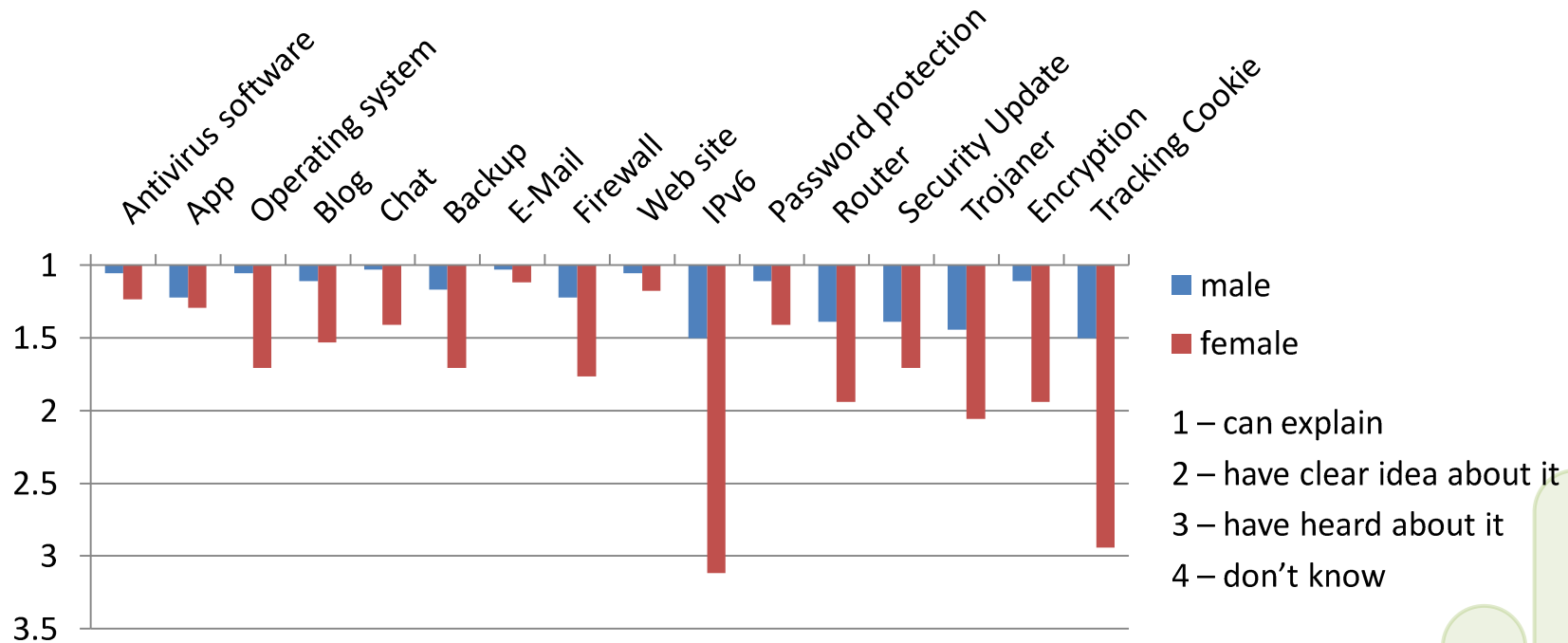
- For none of the services, the audio part was tested
- Each service is tested with different link speeds
 - one speed is repeated in order to identify possible memory effect
- After each leg of each service test, user is asked about the satisfaction he/she got using the service (Quality-of-Experience, QoE)
- 6 users are tested at a time



- Total: 35 users
- Gender
 - Male: 18
 - Female: 17
- Occupation
 - Student: 21
 - Employee: 10
 - Other: 4
- Age
 - Below 20 years: 6
 - 20 to 40 years: 29
- Young audience, in large part from university environment
- All users use at least a laptop or desktop
- 28 users also use a smartphone
- Good skills in information and communication technologies can be expected

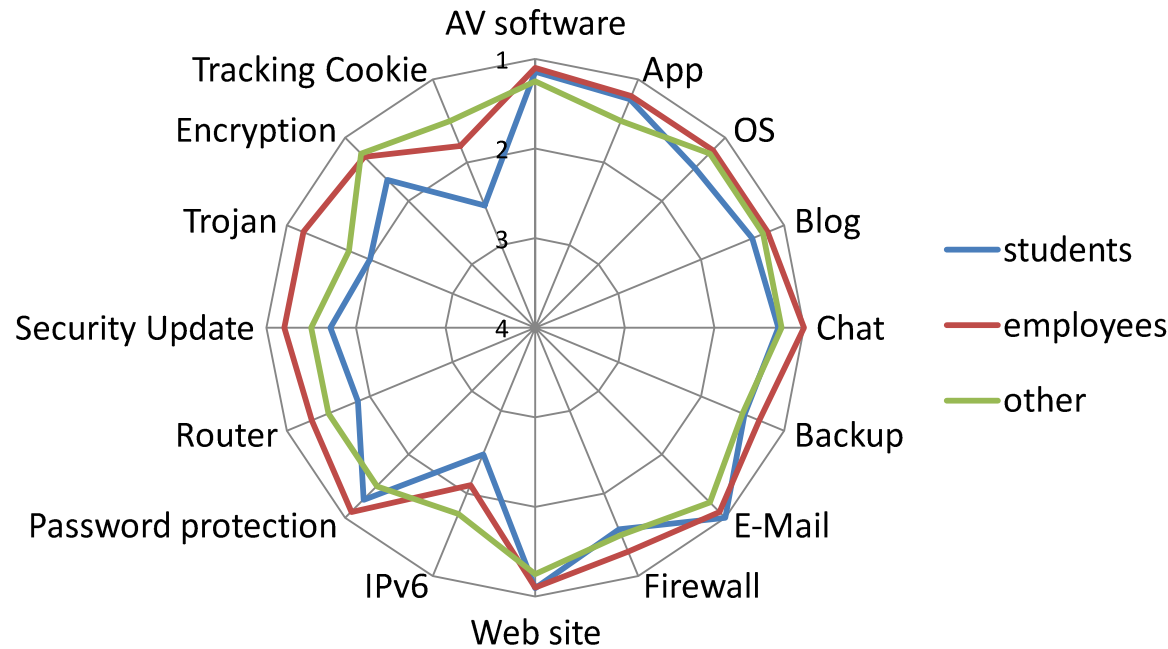


Estimation about knowledge of technical terms – by gender



- In general, high knowledge level – testers are experienced with communication and computing technologies
- Male users estimate their knowledge higher than female users for some less-known keywords

Results: estimation about knowledge of technical terms – by occupation



AV software – antivirus software

OS – operating system

1 – can explain

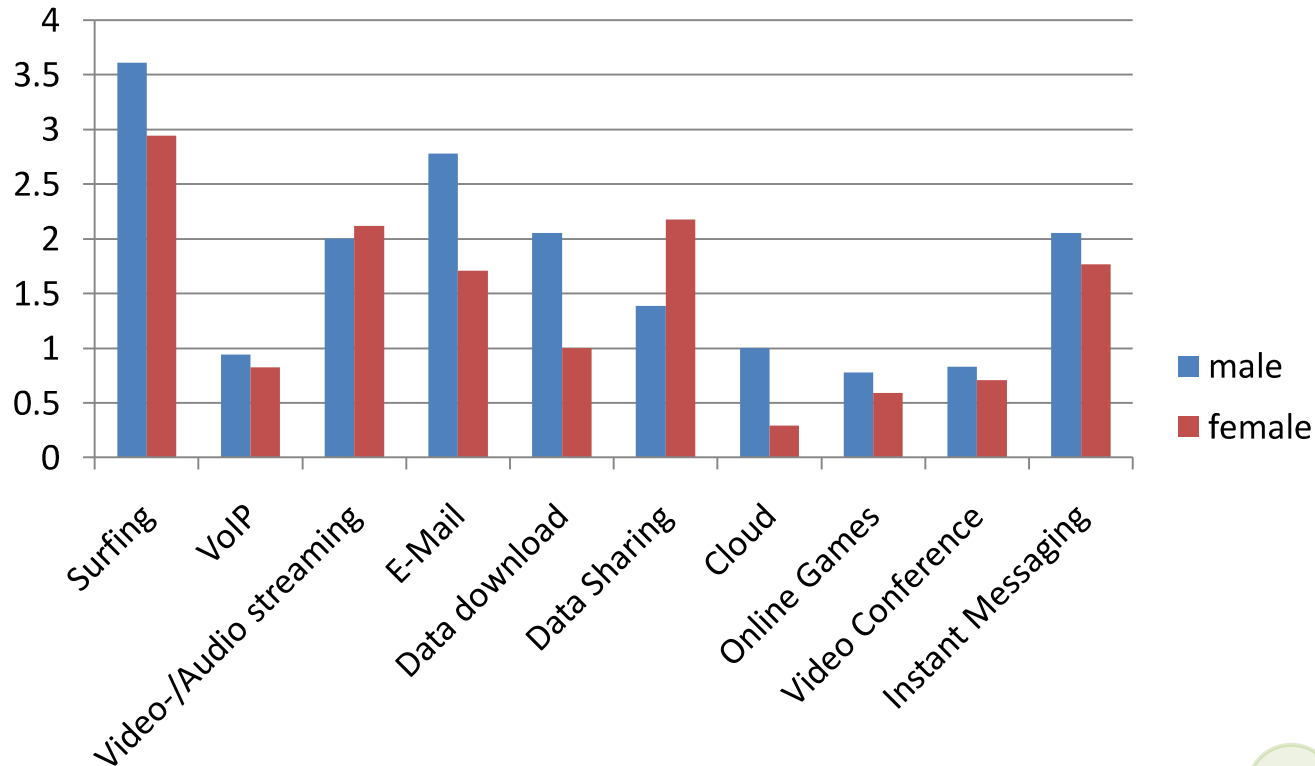
2 – have clear idea about it

3 – have heard about it

4 – don't know

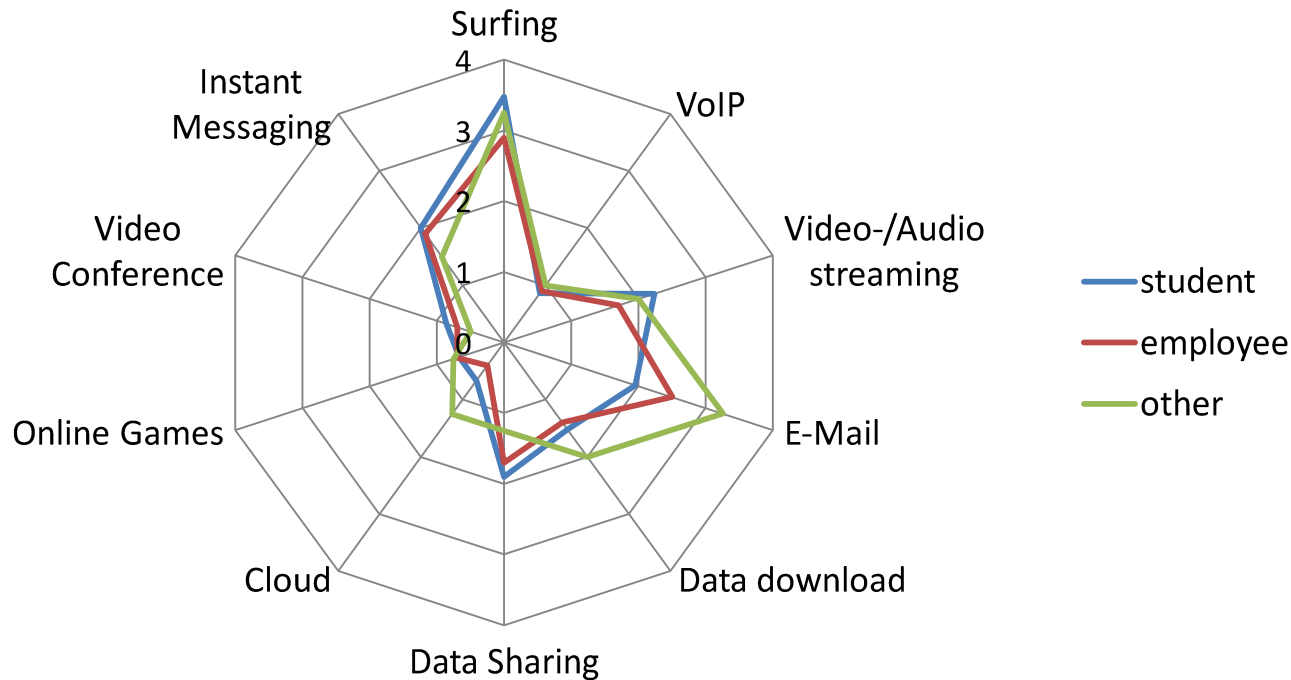
- In general, high knowledge level – testers are experienced with communication and computing technologies
- Employees estimate their knowledge highest for some less-known terms, students lowest

Average service usage per day – by gender

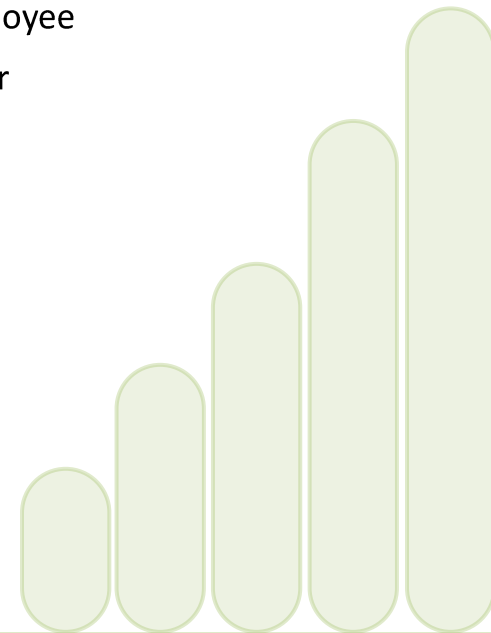


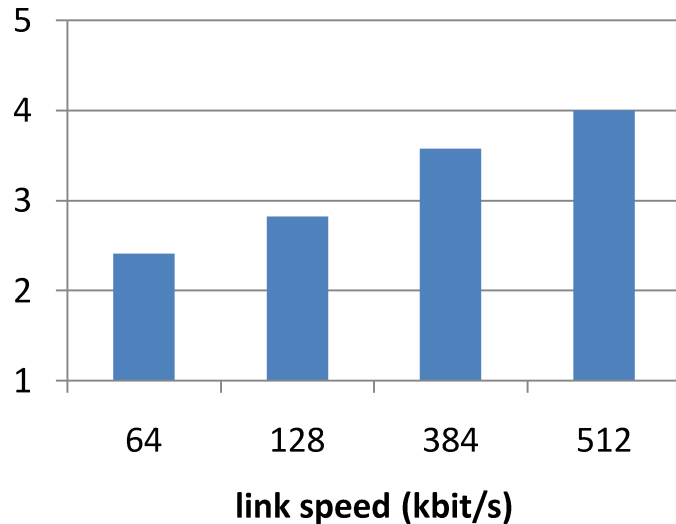
- Most popular for both genders: Surfing, video streaming, IM
- Significant differences between genders for E-Mail, data download, data sharing, cloud usage

Average service usage per day – by occupation

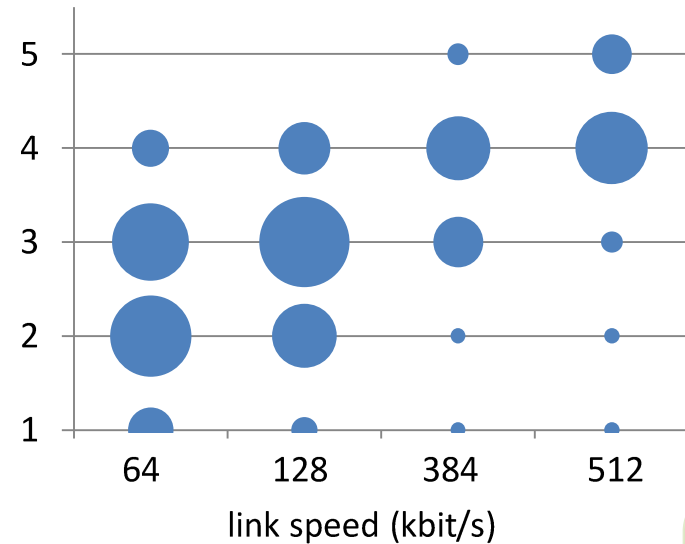


- Most popular: Surfing, E-mail, video streaming
- No significant difference between user groups



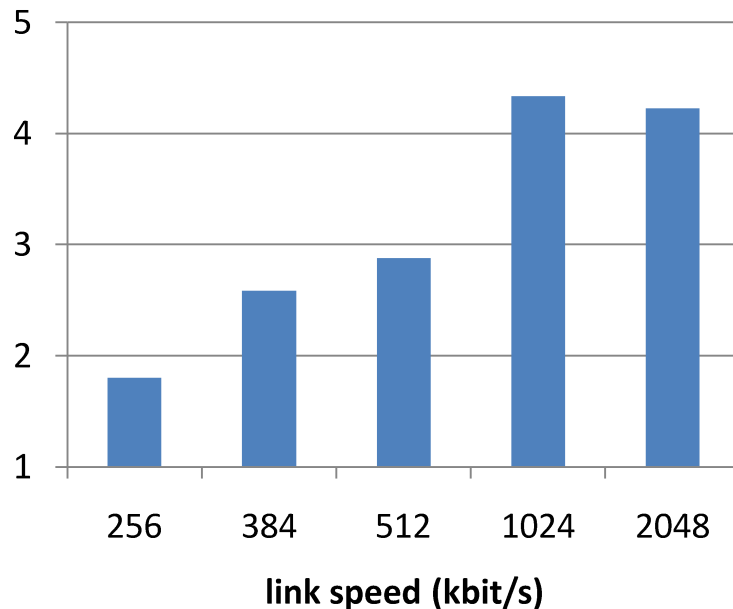


Mean Opinion Score (MOS) vs. link speed

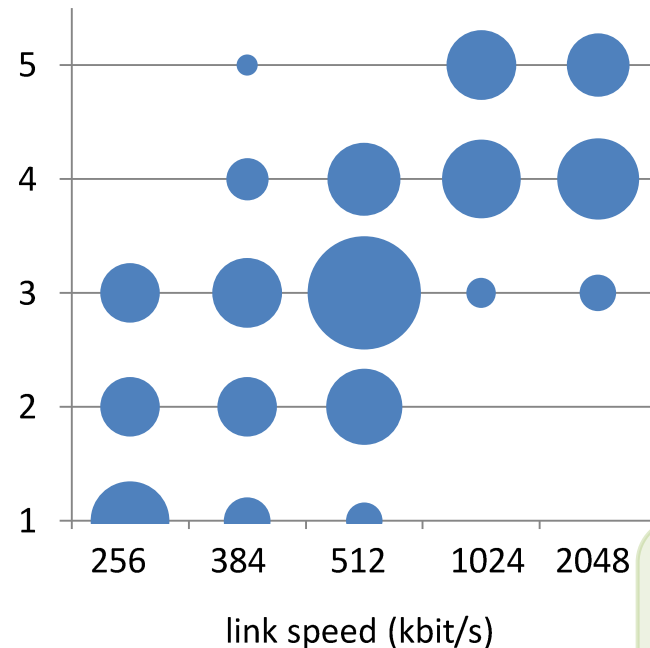


Number of occurrences (indicated by bubble area) of Individual Opinion Score (IOS) vs. link speed

- MOS/IOS trend follows link speed
- Even with good link, MOS higher than 4 cannot be achieved
- For many users, saturation effect for IOS=4 as shown by IOS chart

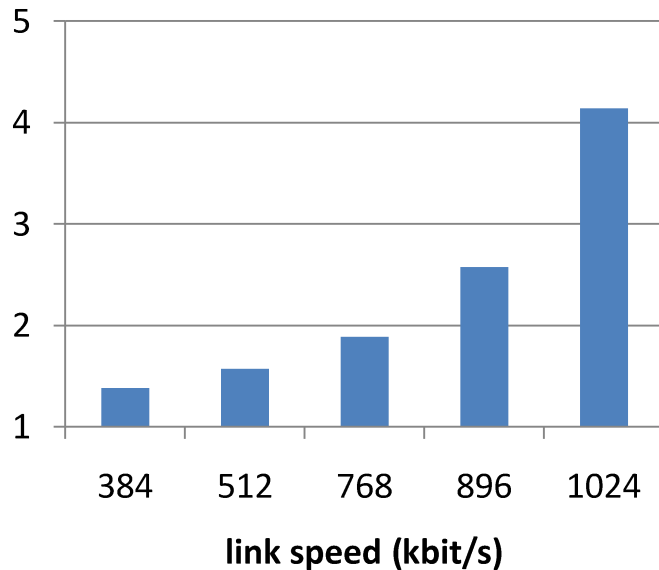


Mean Opinion Score (MOS) vs. link speed

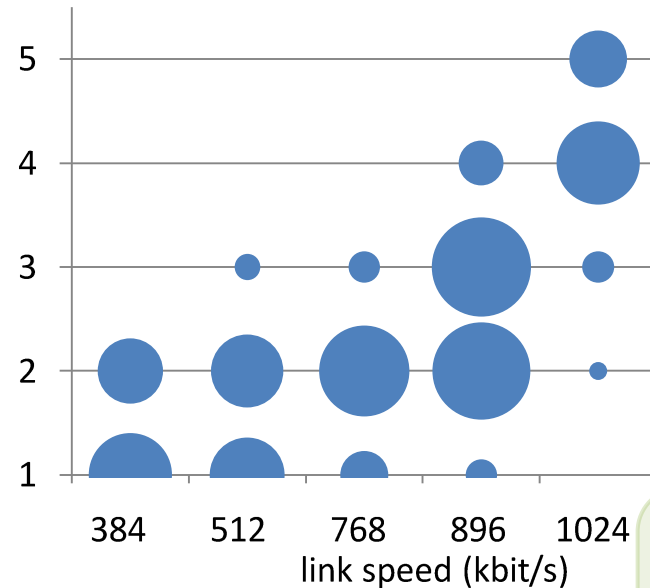


Number of occurrences (indicated by bubble area) of Individual Opinion Score (IOS) vs. link speed

- MOS/IOS trend follows link speed until 1024 kbit/s, then runs into saturation
- Due to a few “runaway users”, MOS for 2 Mbit/s slightly below 1 Mbit/s
- Large IOS deviation for 384 kbit/s



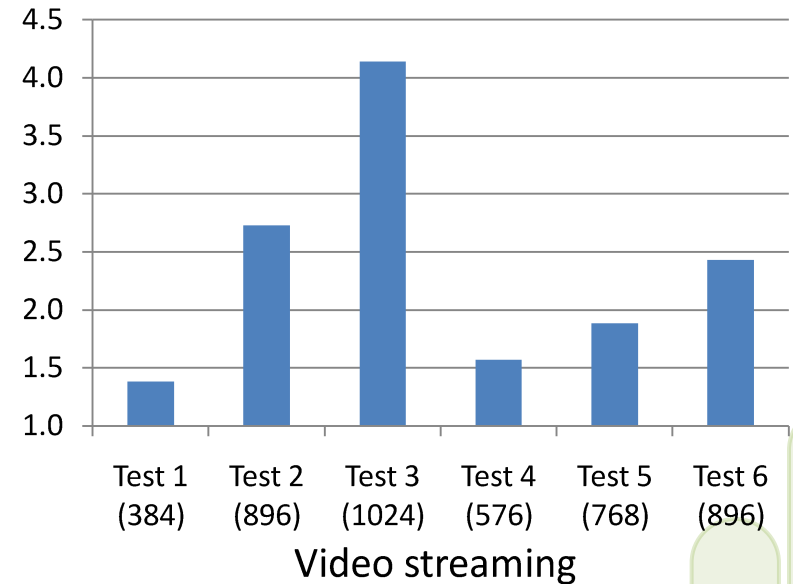
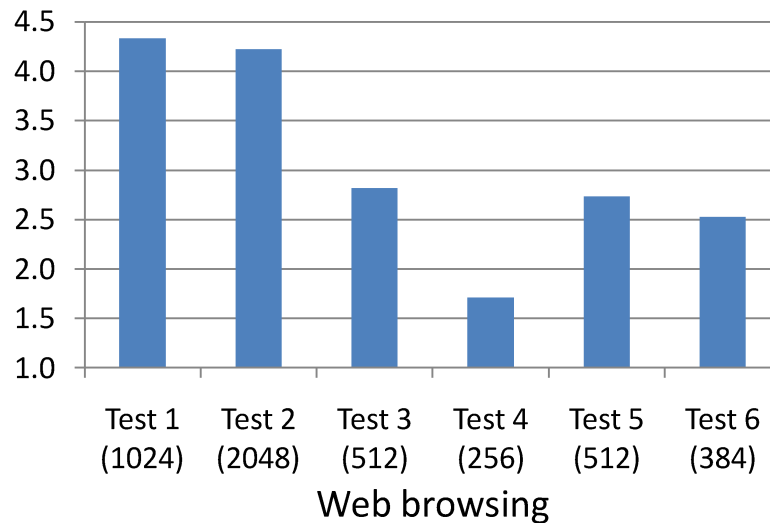
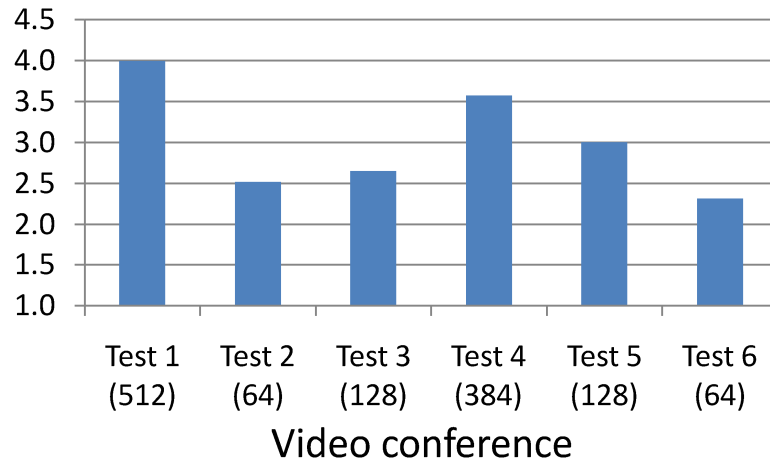
Mean Opinion Score (MOS) vs. link speed



Number of occurrences (indicated by bubble area) of Individual Opinion Score (IOS) vs. link speed

- MOS/IOS trend follows link speed
- Trend suggests that a higher MOS would be achieved with higher link speed

Is there a memory effect?

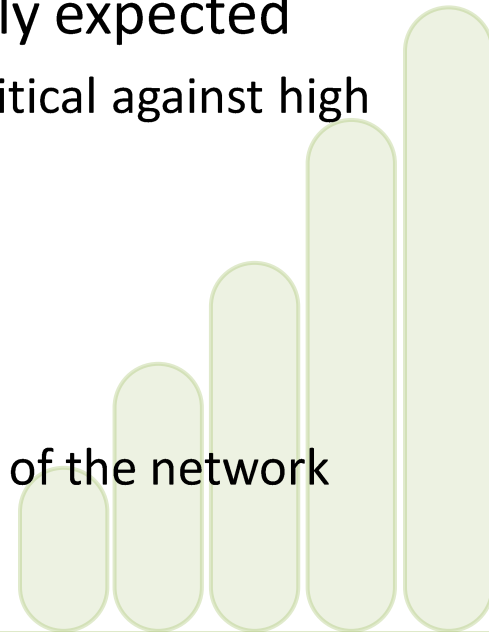


In the figures:

Numbers in parentheses: link speed (kbit/s)

- Results are from the same test series as MOS vs. link speed results
- No significance for memory effect can be observed

- Tests show the dependency between QoS and QoE
 - Expected trend that the QoE increases along with higher QoS is confirmed
 - Results of individual users for a particular test widely match
- MOS results are in a smaller range than originally expected
 - Users are less critical against low quality, but more critical against high quality
 - For network operators, acceptable MOS values are:
 - between 2 and 3 for “normal” users
 - around 4 for “privileged” users
 - Results are sufficient to identify the critical threshold of the network quality



- Results serve as a basis for later field tests
- Smartphone app for network measurements in the field under development
 - Measurement of QoS parameters during ongoing network activities
 - Users run an application on a smartphone
 - When first starting the app, a screening form similar to the lab tests is presented asking for user's age, occupation, network usage habits etc.
 - Randomly, users are asked for a MOS evaluation after the end of a call, web session, file download etc.
- Supplement to lab test
 - Larger numbers of users resp. samples and users
 - Users use the services in real-life conditions (e.g., while being on a train) which can affect the QoE

Thank You!

Questions?

