



About me

- Affiliations

- Senior Scientist at TNO
- Associate professor at TU Delft

- Fields of interest

- Quality of Experience (QoE) multi-media services
- Robustness of networks



What is TNO?

- Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
- TNO Mission: To apply scientific knowledge in order to strengthen the innovative power of industry and government



TNO Information and Communication Technology

- Slogan: “Innovation with ICT”
- About us
 - Established: 1 January 2003
 - Bundling of former KPN Research with TNO’s ICT related departments
 - One of the largest ICT knowledge centers in Europe
- Key figures
 - Annual turnover: EUR 40 Mio
 - 375 professionals
 - Locations in Delft, Groningen and Enschede

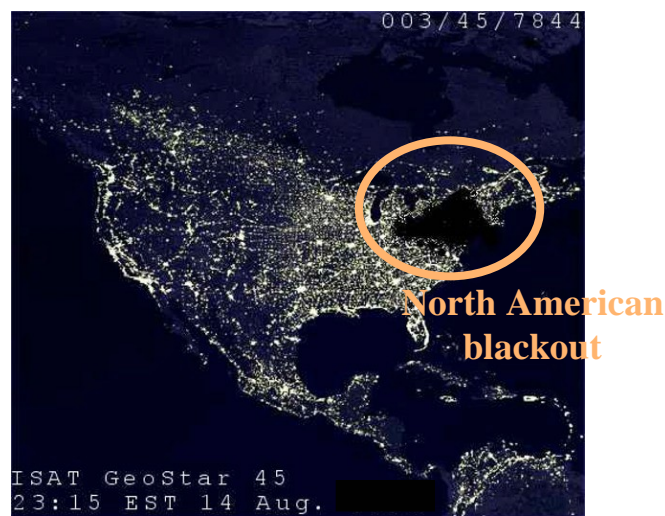


Quality of ICT Networks: 2 perspectives

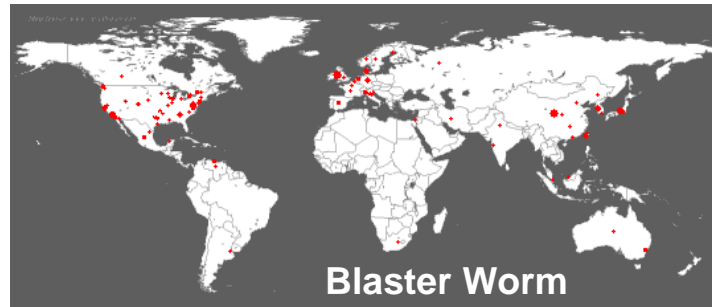
- Can the ICT network deal with attacks/failures/overload?
 - Robustness of ICT networks
- If the ICT is available, how well do services perform?
 - Quality of Experience for ICT networks



Part 1: Robustness of ICT Networks



Een paar dagen daarvoor...



- “Alarm systemen faalden door besmetting met Blaster Worm”



Vitale ICT Infrastructuren

- Nederland in toenemende mate afhankelijk van technisch hoogstaande ICT infrastructuur

“De beschikbaarheid en betrouwbaarheid van de ICT infrastructuur is van vitaal belang, zowel economisch als maatschappelijk”

- Kennisprogramma Vitale ICT Infrastructuur stelt TNO in staat markt te bedienen.



Belangrijkste vragen klanten/stakeholders

- Hoe realiseren we robuuste ICT infrastructuren?
- Hoe waarborgen we de continuïteit en kwaliteit van ICT diensten en ICT-afhankelijke diensten?

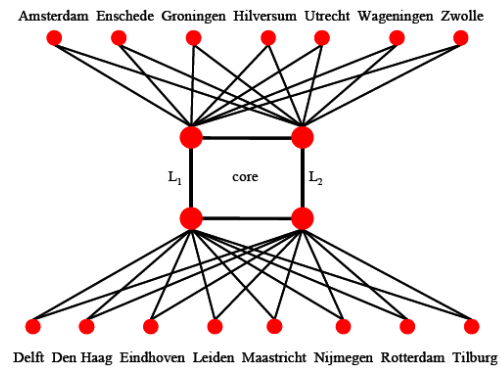


Focus

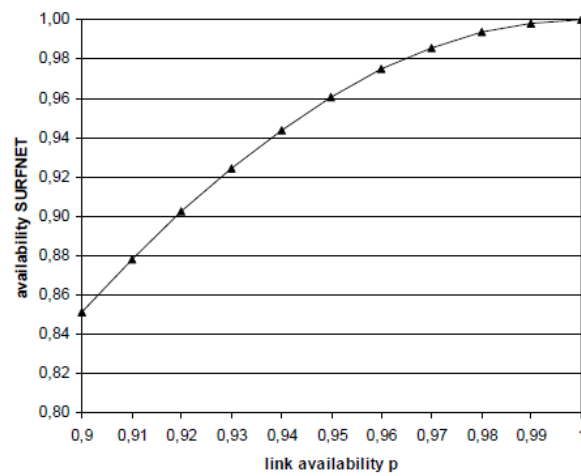
- Technische betrouwbaarheid
 - Methodieken voor ontwerp en analyse van robuuste ICT infrastructuren
 - Control mechanismes voor het realiseren van robuuste ICT diensten
 - Bescherming van vitale ICT infrastructuren
- Exploitatie en risicobeheersing
 - Methodieken voor ICT continuïteitsmanagement
 - Economische aspecten van ICT continuïteitsmanagement.



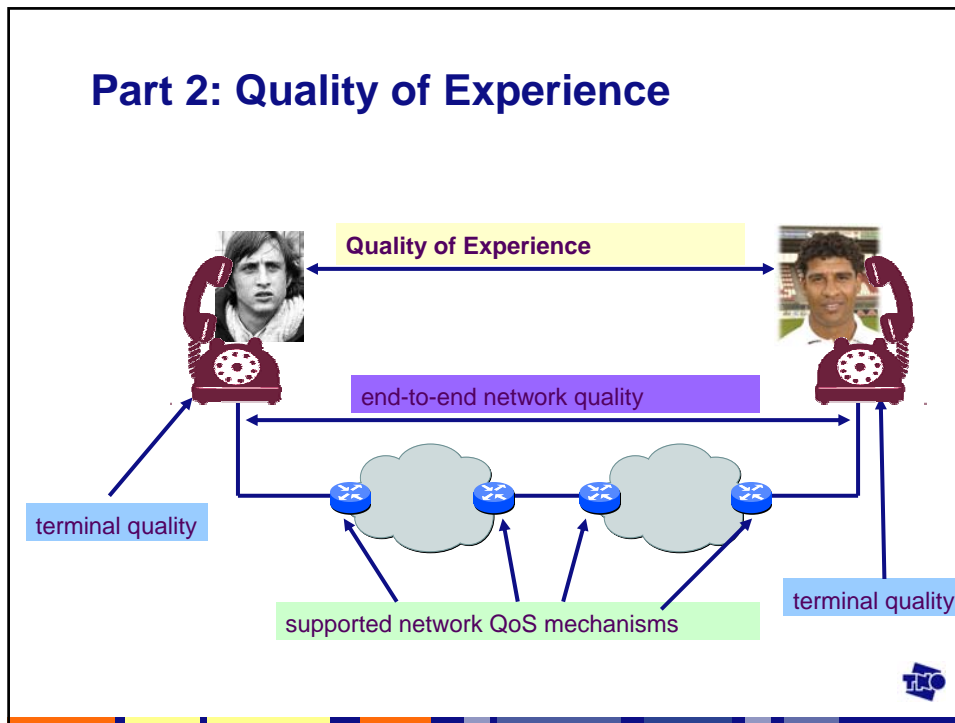
Voorbeeld (1/2)



Voorbeeld (2/2)



Part 2: Quality of Experience



Scale for rating Quality of Experience

- Opinion Score (ITU-T P.800): value on a 5-point scale
- Outcomes are averaged: Mean Opinion Score (MOS)

Rating (MOS)	Quality	Degradation
5	Excellent	Imperceptible
4	Good	Perceptible, not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

Assessment of Quality of Experience

- Subjective measurements
 - Using a test panel
 - Expensive
- Objective measurements
 - Glass box : focused on the specifics of the system under test
 - requires extensive knowledge of the system under test
 - mapping of system parameters to perceived quality
 - Black box: not focused on the specifics of the system under test
 - requires no knowledge of the system under test
 - requires extensive knowledge of human perception



Voice-over-IP (1/2)

- Conversational quality: three components



Voice-over-IP (2/2)

- PESQ (Black box) [TNO: ITU-T P.862]
 - Apply for speech sample with 1% loss



- E-model (Glass box)
 - MOS score as function of
 - Network quality (delay, packet loss, echo loss, ...)
 - Terminal quality (codec, error concealment,)
 - Formula: see ITU-T G.107

	A	B	C	D	E
1	E-model according to updated Appendix I G.113				
2					
3	EchoLoss [dB]		codec	delay [ms]	loss
4	65		G.729	100	5.00%
5					
6					
7					
8	MOS				
9	3.34				GSM quality
10					

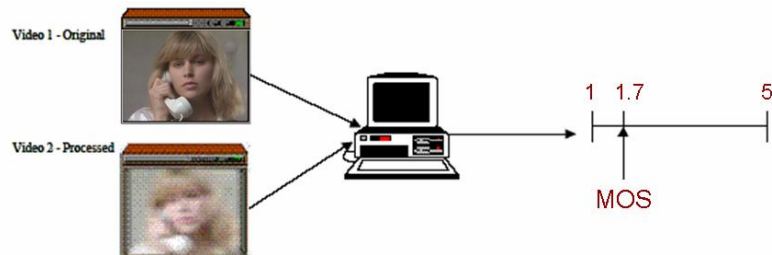
Quality of Experience for Video (1/5)

- End-to-end perceived audio-visual quality depends on
 - **Pure video quality** aspects
 - e.g. spatial temporal coding distortions
 - **Pure audio/speech** aspects
 - e.g. listening quality
 - **Audio/video interaction**
 - asynchrony ("lip sync")
 - **Channel zapping quality**



Quality of Experience for Video (2/5)

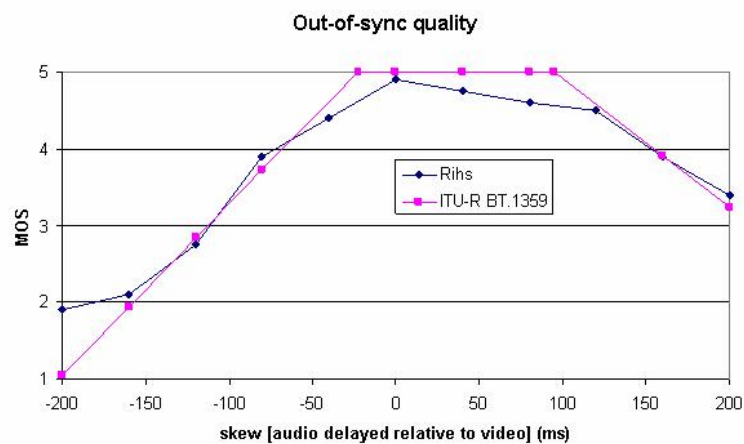
- Video-only quality
 - PEVQ: Perceptual Evaluation Video Quality (ITU-T Rec. J.247)



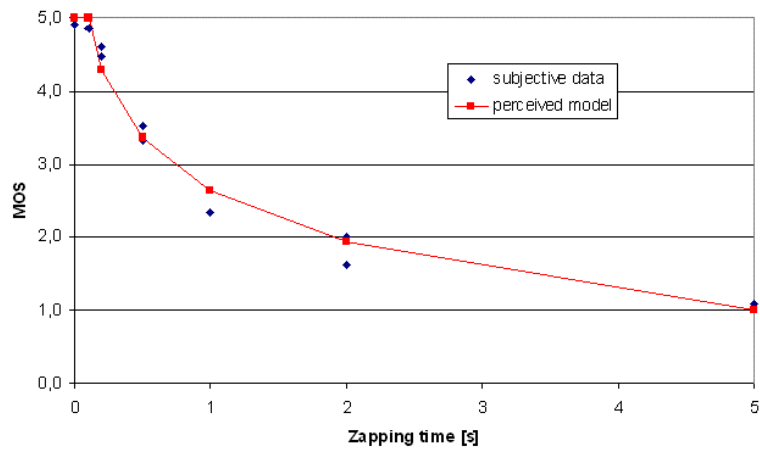
- Audio-only quality
 - PEAQ: Perceptual Evaluation Audio Quality (ITU-T BS.1387)



Quality of Experience for Video (3/5)



Quality of Experience for Video (4/5)



Interactive Gaming (1/3)

- Perceived Quality depends on type of game
 - First Person Shooter (FPS)
 - Real Time Strategy (RTS)
 - Massive Multiplayer Online Role Playing Games (MMORPG)
- FPS has most stringent requirements



Interactive Gaming (2/3)

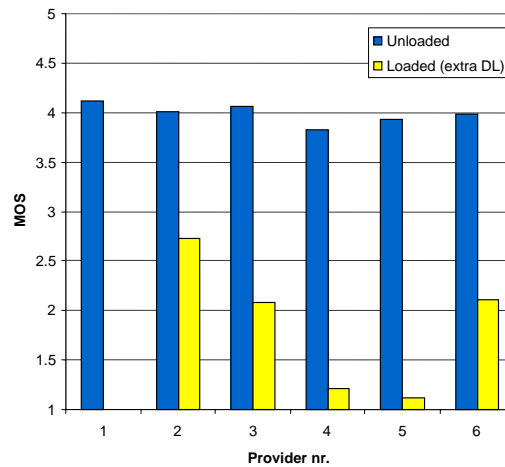
- TNO developed e2e testprotocol for Interactive Gaming
 - Determine Quality of Experience (MOS) from
 - Round Trip Time (= Ping)
 - Jitter
 - Packet Loss
 - Developed method is called G-Model



Interactive Gaming (3/3)

- Assess Gaming Quality for 6 broadband providers in the Netherlands

- unloaded network
- during heavy download



Wrap-up

- Two perspectives w.r.t. Quality of ICT Networks

- Perspective 1: Robustness of ICT networks

- Kennisprogramma Vitale ICT Infrastructuur

- Perspective 2: Quality of Experience for ICT networks

- Objective measurements for
- Voice, Video, Gaming, Web services

- Also active in

- Capacity management
- Dimensioning & planning

