

Internet Performance Issues for Safety-Critical Applications

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Internet Issues (1)

- Its very nature
 - A network of networks
- Connectivity – the only concern?
 - “Can you ping?” (If yes, everything is OK.)
- Shared resources and the best-effort paradigm
 - “Jantelagen”: “Du skall icke tro att du är bättre än vi.”
 - No guarantees
 - IP (layer 3) uses datagrams
 - No explicit quality feedback between the layers
 - TCP (layer 4) “times out”

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Internet Issues (2)

- Few QoS standardization and handling efforts
 - IntServ does not scale
 - Island-type solutions
 - MPLS (DiffServ) in the core
 - Industrial real-time Ethernet at the edge
- QoS handling – if any – is mainly left to the end systems/application
 - RTCP (layer 7): monitors quality for real-time applications
 - TCP (layer 4): loss and sequence recovery at the cost of delay
- Motto: **Help yourself!**

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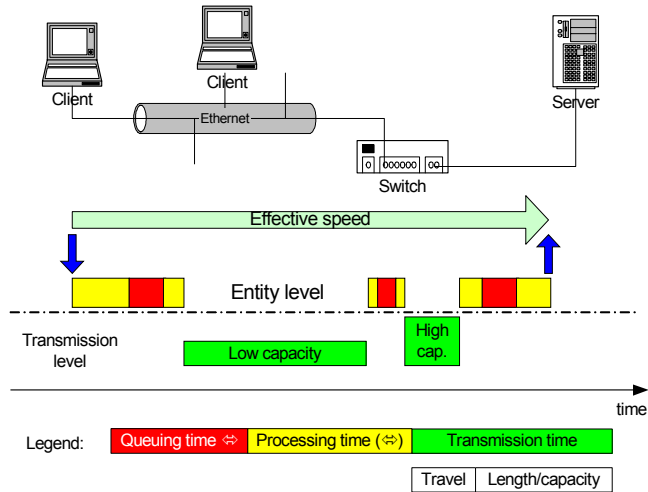
... And Some Consequences

- Packet streams
 - Meet braking transport capacity limitations (bottlenecks)
 - Interfere with (= brake) each other
- User-perceived Quality of Service (QoS) in terms of
 - Speed: **Too low and varying** ⇔ **delay and jitter**
 - Accuracy: **Too low** ⇔ **losses**
 - Reliability: **Not dependable** ⇔ **time-/drop-outs**
- **Perceived speed < installed capacity**

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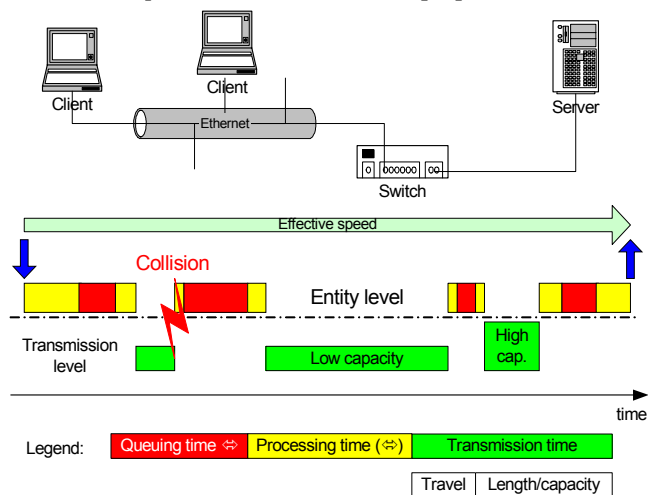
Perceived Speed



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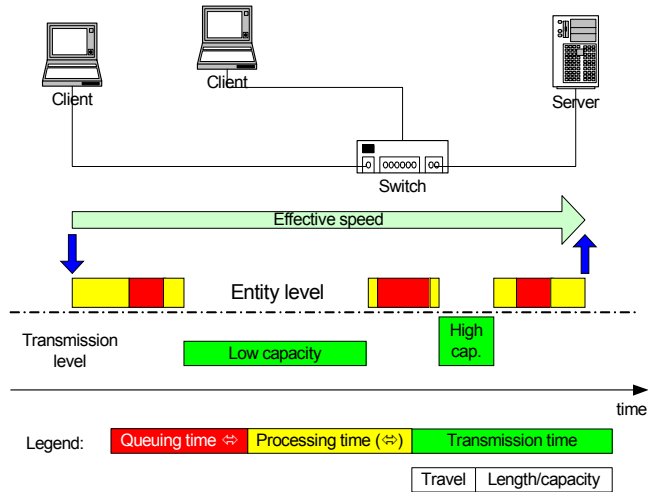
Perceived Speed – Shared (1)



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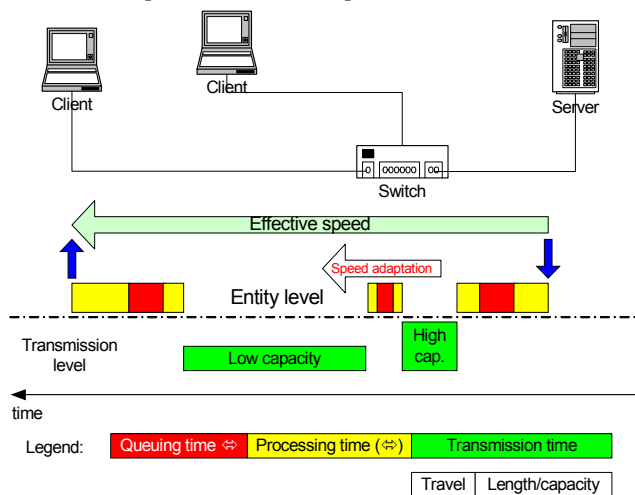
Perceived Speed – Shared (2)



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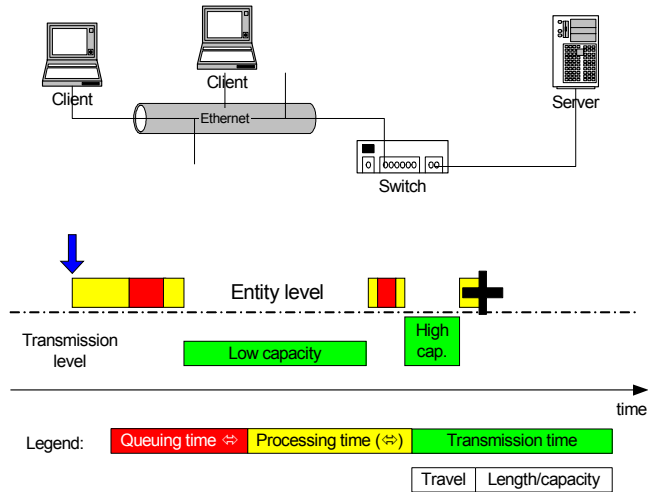
Perceived Speed – Shaped



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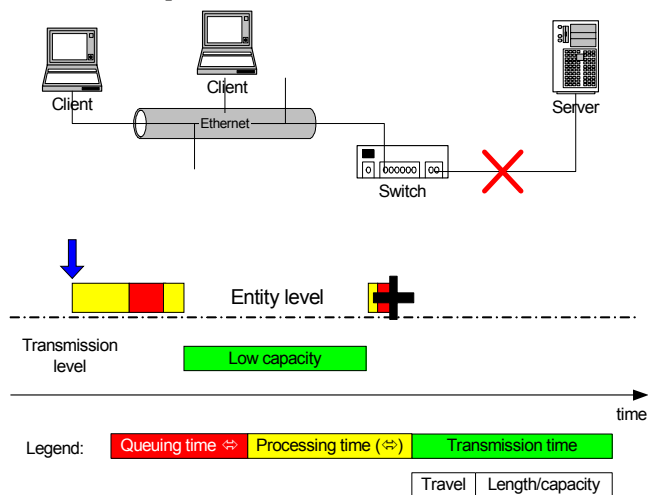
Loss Due To Overload



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Dependability



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Some QoS Degradation Measures (1)

- One-way delay
 - Problematic due to time synchronization
 - NTP useful in local environments
 - GPS might help
- Round-trip delay
 - Determines download times
 - Approximately available through ping
 - Active measurement: implies extra load; just probing
 - Upper bound for the one-way delay
 - Asymmetrical delays are quite normal

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Some QoS Degradation Measures (2)

- Delay jitter
 - Comparably simple to obtain
 - Trend analysis required
- Loss
 - To be observed on upper layers
- Reliability
 - Real-time applications: Frequency of time-outs
 - General: Relative downtime

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Safety-Critical Applications

- Needs:
 - Minimal delay and (additional) jitter
 - Keep timing relationships as good as possible
 - No loss
 - **Information = feedback in case of problems**
- Characteristics:
 - **Streaming**: amount ΔL within each ΔT
 - Control; voice; video; ...
 - **Messaging**: amount L to be received within T
 - Alarms; notifications; ...
 - **Interactive**: amounts $L_{C \rightarrow S} + L_{S \rightarrow C}$ to be received within T

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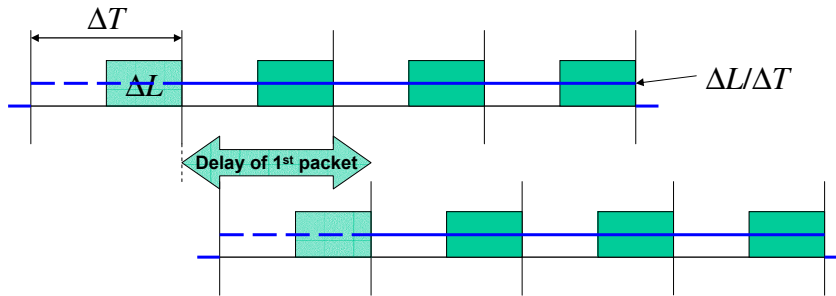
Speed Considerations

- Close to limiting factor: **lack of transport capacity**
 - ⇒ Queuing ⇒ delay, jitter
 - ⇒ Loss
- Calculation of **end-to-end-perceived speed**
 - Time synchronization upon arrival of first packet
 - As perceived by the receiver
 - Bandwidth changes along the way through the network reflect jitter and loss
 - Focus on streaming services
 - Provides speed information even for messaging/interactive services

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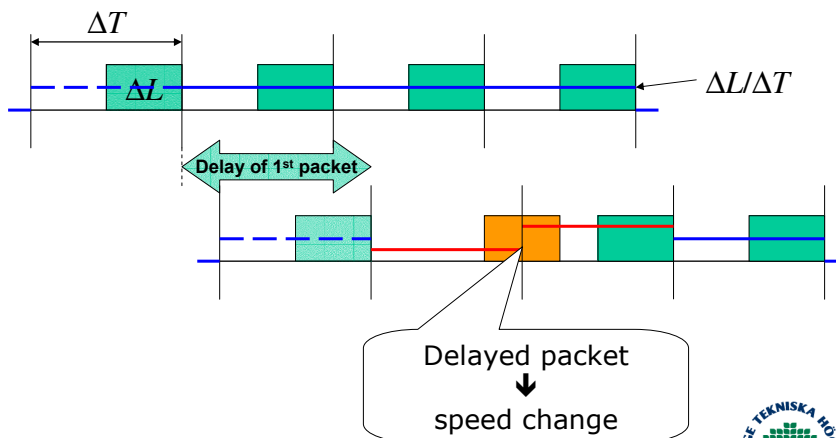
End-To-End Perceived Speed – Ideal Case



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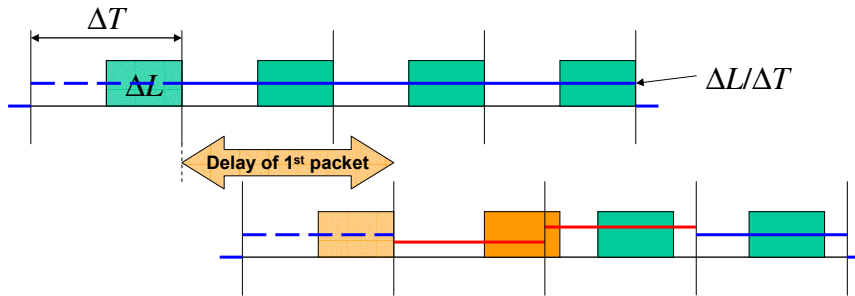
End-To-End Perceived Speed – Jitter (1)



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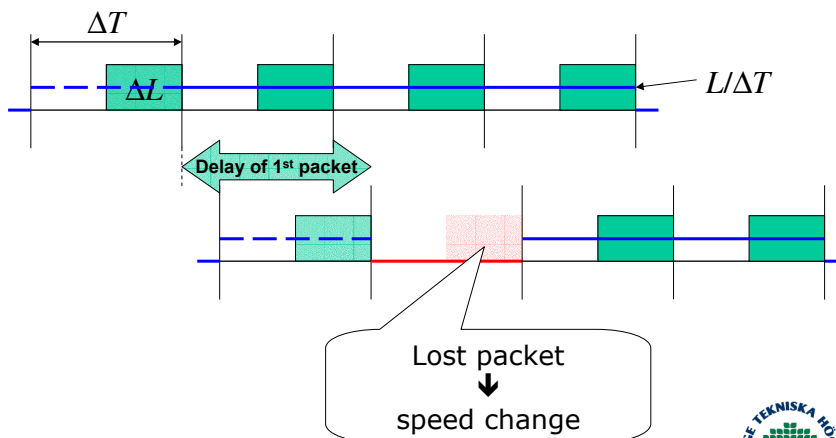
End-To-End Perceived Speed – Jitter (2)



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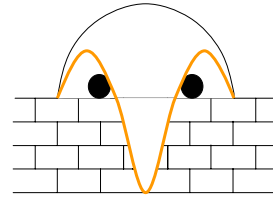
End-To-End Perceived Speed – Loss



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"Kilroy was here"



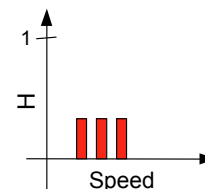
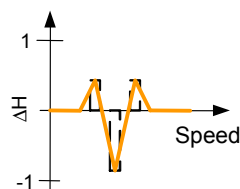
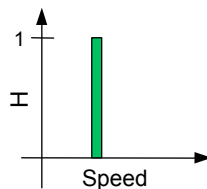
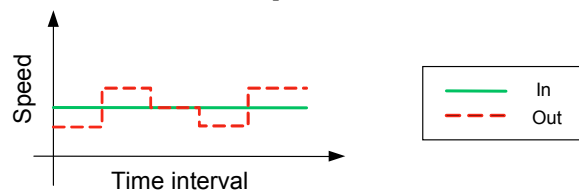
- <http://www.kilroywashere.org>

- End-to-end-perceived speed measurements and histograms tell about
 - Type of bottleneck
 - Severity of disturbance
- "Kilroy indicator" = histogram@output - histogram@input
 - Observation window ΔW
 - Averaging interval ΔT
 - Speed discretization ΔR



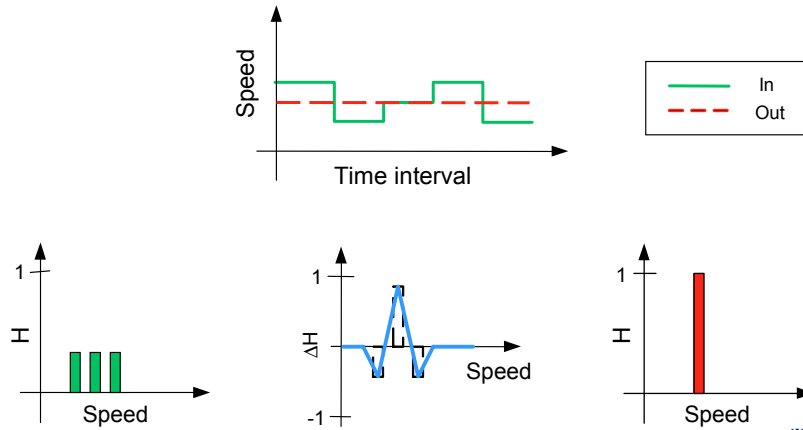
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Shared Bottleneck - Example



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Shaping Bottleneck – Example

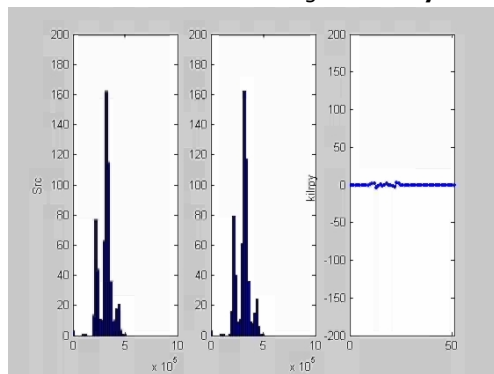


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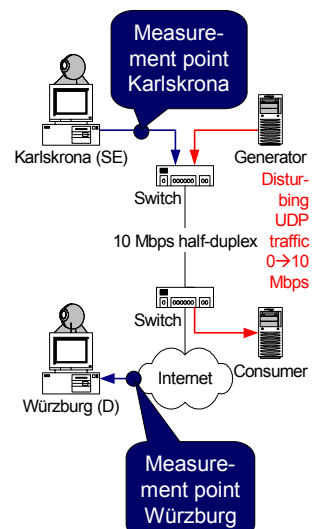


Video Experience of an Artificial Bottleneck

Speed histogram Difference
Karlskrona Würzburg "Kilroy"



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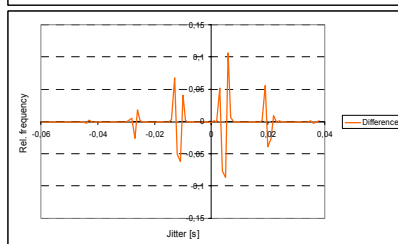
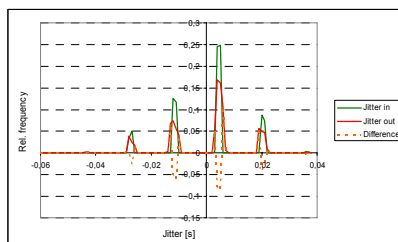
A Closer Look on Audio

- One packet à 492 B each 60 ms
- Inter-packet jitter
 - Observation window = 1 min
 - Jitter = Packet inter-arrival time - 60 ms
 - Discretization = 1 ms
- Speed
 - Observation window = 1 min
 - Averaging interval = 60 ms
 - Speed discretization = 10 kbps
- Different levels of disturbance

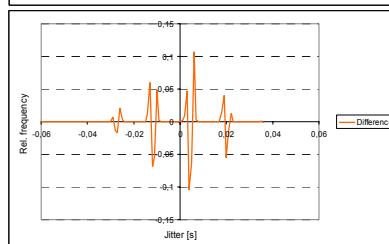
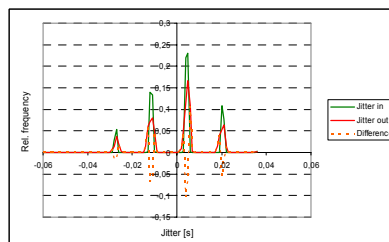


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Jitter – Disturbance 0 Mbps



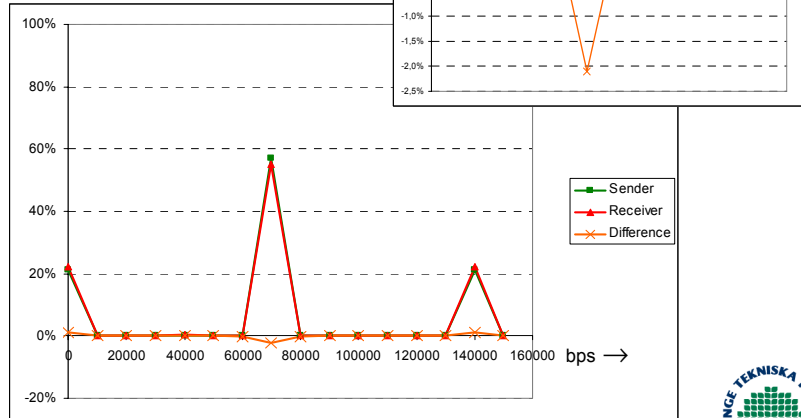
6 Mbps



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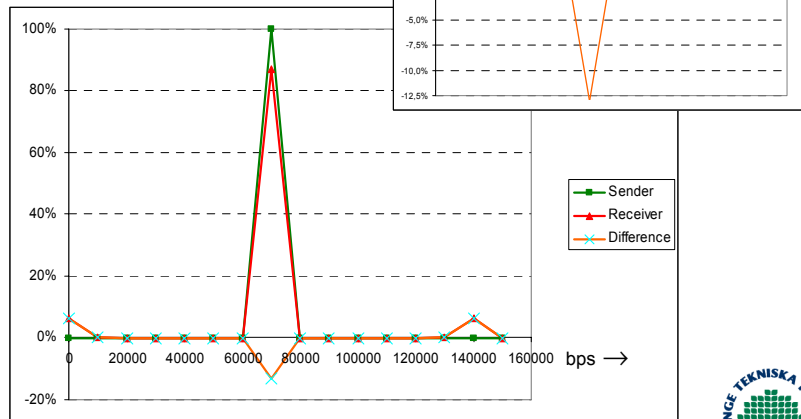
Speed – Disturbance 0 Mbps



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Speed – Disturbance 6 Mbps



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Speed Comparisons

- + Reflects flow of packets
 - + Takes packet lengths into account
- + Comparable to installed capacities
- + Comparable to expected behaviour
 - + See whether packets come "too late"
- + Comparable to behaviour at inlet
 - Requires exchange of speed histograms
- + Feedback facility

- Dependency on first packet
- Short flows
- Granularity/discretization

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Conclusion And Open Issues

- Quality of Service problems in terms of
 - Speed
 - Accuracy
 - Reliabilityare well reflected in **speed changes**
- Important: Time scale of interest

- Time synchronization issue and one-way delays via Internet
 - Measurement
 - Guarantee

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**Thanks for listening 😊
Any questions?**

