Advanced Computer Networking (ACN)

Exercise 4 – Solution

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Outline

Announcements

For questions and problems:

- Always use this mail address: `acn@net.in.tum.de`

Deadline first version:

- The deadline for the first version of Tutorial 4 has passed 15 minutes ago
- Commit and push your solution, if you haven't already

Next week:

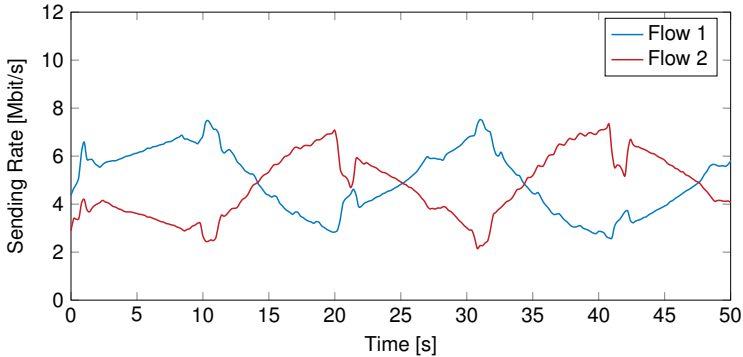
- Tuesday: Guest lecture
- Thursday: No lecture
- Deadline for Problem 2 of the projects is on **Tuesday, 19.12. 16:00**
- Second deadline for this tutorial is on **Thursday 21.12. 14:00**!
- First lecture in 2024 **Tuesday 9.1.2024 16:00**!

Announcements
Guest Lecture on Tuesday, Dec 19

- Presenter: Dr. Cornelius Diekmann
  - 2017 PhD: "Formal Verification of Network Security Management"
  - since 2017: Working for Google as Site Reliability Engineer (SRE)
- Topic: The Art of SLOs
  - Service Level Objectives (SLO) are used to define reliability goals for services
  - Experience how to define and achieve realistic SLOs for services
- Lecture will be streamed
- Lecture will NOT be recorded

1 a)

One of the flows uses Cubic congestion control, the other one BBR. Identify which of the flows uses BBR. No credits without short reasoning.



Tutorial 4 – Problem 1: TCP Congestion Control Fairness

1 b)

Write a function `compute_sum()` which computes the total sending rate of two flows. It receives two lists and should return a list of the same size.

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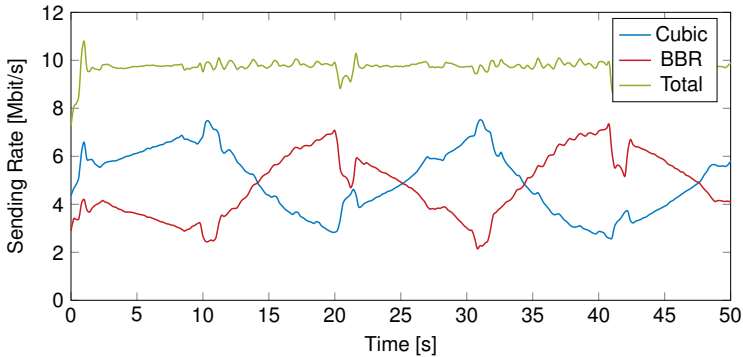

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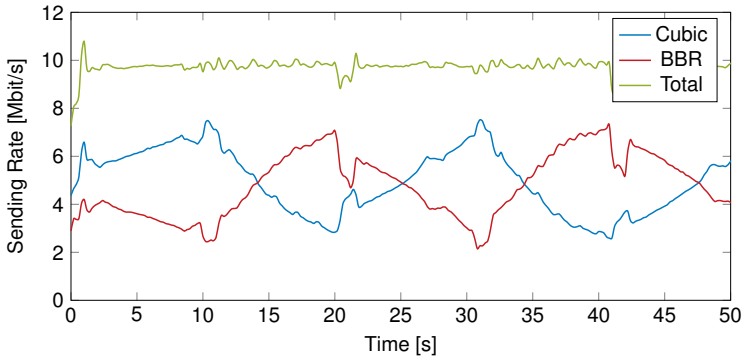

1 c)

Based on your results from b) estimate the bottleneck link's capacity. What happens if the total sending rate of the two flows exceeds this value?

Tutorial 4 – Problem 1: TCP Congestion Control Fairness

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- BDP = RTT $\cdot$ Bandwidth
- kbit = 10^3 bit
- From b): Bandwidth is 10 Mbit/s = $10 \cdot 10^6$ bit/s
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In the following you will quantify the fairness of the two flows using Jain's Fairness Index. Explain two advantages of this index.

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- It is within a fixed interval and always returns a value between 0 and 1
- It is scale free which means that its input does not have to be normalized
- It can be computed over an arbitrary number of flows
- It can be easily interpreted by humans. It is $\frac{k}{n}$ if there are k flows perfectly fair while the other $n - k$ shares are 0

Tutorial 4 – Problem 1: TCP Congestion Control Fairness

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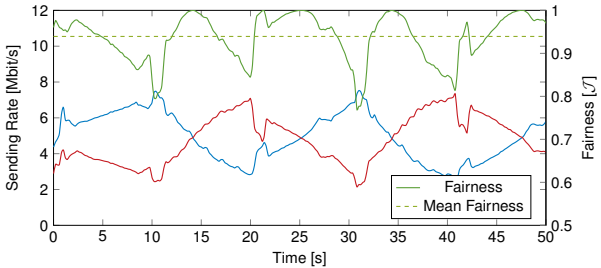

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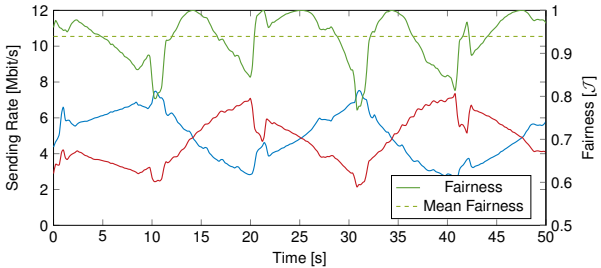

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Considering the results from e), assess the fairness between Cubic and BBR.

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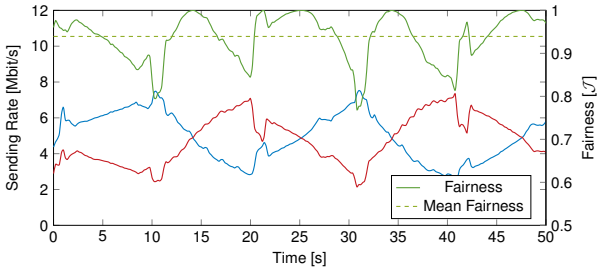

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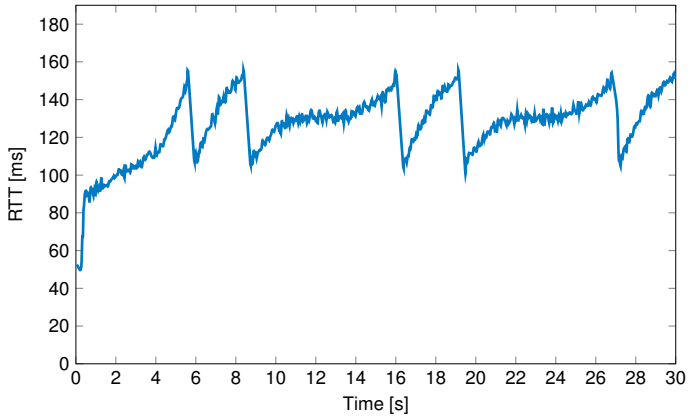
Considering the results from e), assess the fairness between Cubic and BBR.

```
Flow1 transmitted 4.98 Mbit/s on average.
Flow2 transmitted 4.75 Mbit/s on average.
This results in a total fairness of 0.99945
```

2 a)

Have a look at the above graph. Which congestion control algorithm was used by the TCP sender?



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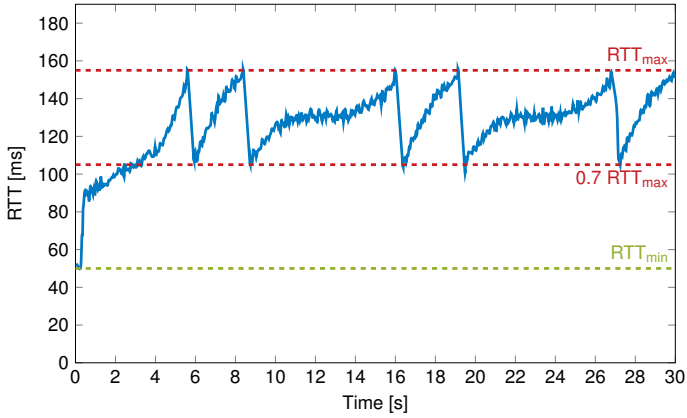

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Input: Samples S,α
Output: EWMA E of S
Initialize E with first sample;
for s in S **do**
  E += $E[-1] \cdot (1 - \alpha) + s \cdot \alpha$
end
return E

Sample		EWMA
5		5
6	$5 \cdot 0.8 + 6 \cdot 0.2 =$	5.2
10	$5.2 \cdot 0.8 + 10 \cdot 0.2 =$	6.16
2	$6.16 \cdot 0.8 + 2 \cdot 0.2 =$	5.328
5	$5.328 \cdot 0.8 + 5 \cdot 0.2 =$	5.2624
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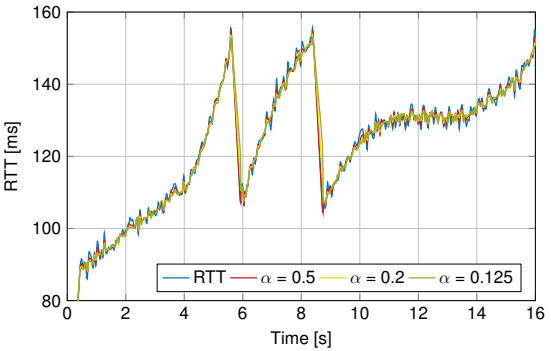
Compare the results when using different values for alpha and explain how it impacts the resulting average.



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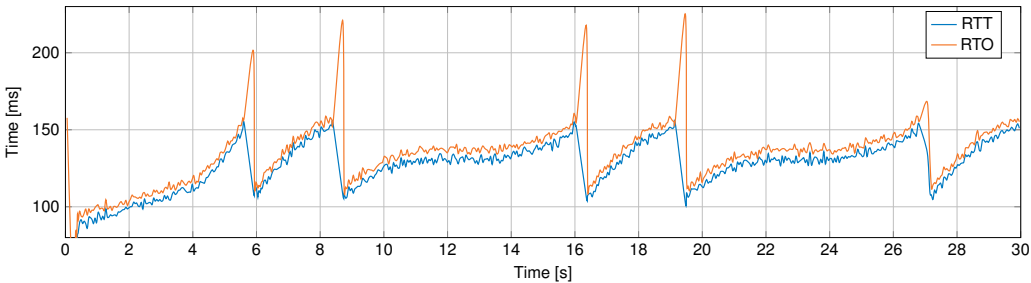
Discuss the influence on TCP if the RTT is considerably overestimated or underestimated.



Tutorial 4 – Problem 3: QUIC

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Name all protocols which are usually (e.g. HTTP/1.1) used on top of IP when you visit https://acn.net.in.tum.de. Which protocols will be used when you would visit the same page with HTTP/3?

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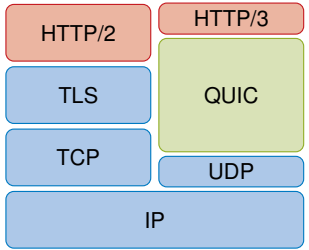
QUIC differentiates between packets and frames. Name all packet types available in QUIC.



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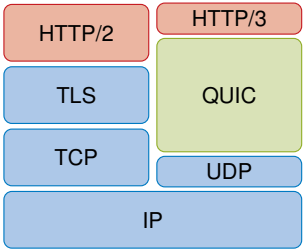

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- `https://www.rfc-editor.org/rfc/rfc9000.html#table-5`
- `https://www.rfc-editor.org/rfc/rfc9000.html#name-short-header-packets`

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Name 5 frame types specified in the RFC.

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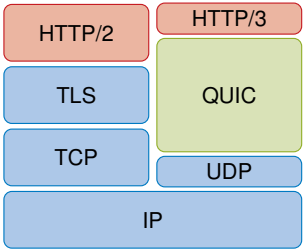

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- `https://www.rfc-editor.org/rfc/rfc9000.html#name-frame-types-and-formats`

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Which QUIC version is used in this connection. Paste the version ID as well as which version is specified by it. Also, find out which QUIC implementation was used to generate the qlog file.

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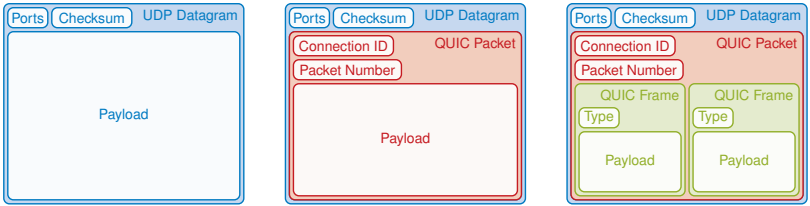
Name the packet type included in this event and explain why this packet type has to be used. Name and briefly explain all frame types in this event.



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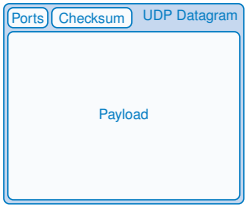

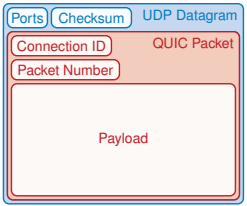

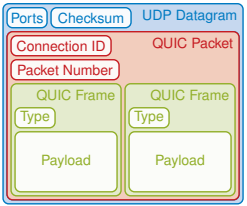

3 f)

Which event carries the response of the server? How large is the file requested by the client?

Next Steps:

- Update your solution
- Do not copy-paste this sample solution