Alternative Bearers for Rail

COLA Meeting 7th March 2022

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1 Guglielmo Marconi University

2 University of Rome Tor Vergata

3 Roma TRE University

4 Radiolabs

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Outlines

1. COLA Agreement
   - Status of COLA agreement
   - Update on shared AB4Rail deliverables
2. Workshop “Aerial technologies as Alternative Bearers for railway”
3. D3.4
4. Conclusions

COLA Agreement

Status of COLA Agreement

- Cola Agreement
  - Annex2: shared and completed
  - Overall document: to be finalized (OK from Radiolabs)

  - Waiting for OK from X2Rail-5 partner and final signature

- Annex 2 Contents:
  1. General agreement on Collaboration
  2. Who does the work: rules for the collaboration
  3. Technical Notes of X2Rail-5 and AB4Rail relevant for the Collaboration Agreement
     - List of AB4Rail Deliverables to be shared with CoLa partners (Finalized)
     - List of X2Rail-5 WP3 Deliverables to be shared with AB4Rail (Finalized)

Workshop
“Aerial technologies as Alternative Bearers for railway”

AB4Rail workshop with LEO/HAPS stakeholders

- Eligible ABs: LEO, HAPS and FSO
- AB opportunities for the railway operators

  Due to the availability of Starlink constellation by the end of 2022 in Europe, S2R JU members could have the possibility to:

  - participate to the experimental trials with SpaceX
  - contact the members of HAPS alliance for possible joint initiatives concerning the applications of 5G on HAPS.
- The aim of the workshop is to identify what synergies can be established among them from the industrial and scientific point of view.

AB4Rail workshop with LEO/HAPS stakeholders: draft agenda

Start	End	Topic	Partner	Duration
9:30	10:10	**Welcome and introduction** • Start of the meeting • Hosting • European Railway Agency (ERA) • European Space Agency (ESA) • Shif2Rail	• Alessandro Neri (President of Radiolabs Consortium) • Romeo Giuliano (Università degli Studi "G. Marconi") • Thomas Chatelet (?) (ERA) • Enrico Spinelli (ESA) (?) • Goradz Marinic (S2R) (?)	40 min
10:10	10:30	**S2R X2Rail-5 and synergies with AB4Rail project**	Ulrich Geier (X2Rail-5, Kontron)	20 min
10:30	10:50	**AB4Rail Project Overview** • Partner introduction • Project goals and objectives • Project Timing • Work plan	Franco Mazzenga (RDL) (AB4Rail Project Coordinator)	20 min
10:50	11:00	**Break**		10 min
TECHNICAL SESSIONS: 11:00 – 12:30				
11:00		Satellite and terrestrial networks: State of the art of their integration	Enrico Spinelli (?) (ESA)	
		GEO, MEO satellites for transport sector	Telespazio	
		LEO satellites: current status and applications in transport sector	One Web (Intermatica) (?)	
		HAPS: current status and applications in transport sector	Thales Alenia Space (?)	
		Hybrid Satellite/Terrestrial Broadband for the Real World	Diego Lopez, Sales Manager, Strategic Projects, Hispasat (?)	
		The Rail Networks of Tomorrow will Ride on Satellite Connectivity	Steven Tompkins, Director of Sector Development, Inmarsat (?)	
ROUND TABLE: 12:30 – 13:00				
		"HAPS and LEO HTS: which synergies for rail?"	Moderator: Francesco Rispoli (RDL)	30 min
13:00		**End of meeting**		

21 march ?

AB4Rail workshop at CSNDSP 2022

Biennial since 1998

CSNDSP 2022

1st Workshop on Communication Technologies and Systems for Automotive and Rail

Co-located with 13th IEEE/IET *International Symposium on COMMUNICATION SYSTEMS, NETWORKS & DIGITAL SIGNAL PROCESSING (CSNDSP'22)*

20-22 July 2022, Porto, Portugal

Workshop organizers

Prof. Franco Mazzenga, **General Chair**
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Dr. Alessandro Vizzarri, **Co-Chair**
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Technical Program Chairs

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Deliverable D3.4

Identification of transport protocol for railway applications

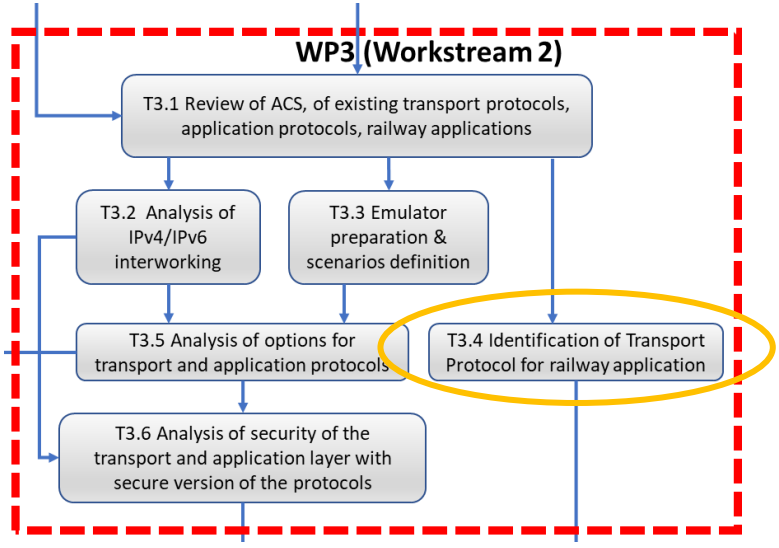
D3.4 overview

- Starting point
  - D3.3, IP Emulator and scenarios definition.
- Title: “Identification of Transport Protocol for railway application”
- Deadline: 31th January 2022

- Objectives: Investigating the behavior of the communication transport protocols on realistic railway scenarios

- Deliverable structure:
  - Rail scenario and radio plan
  - Traffic source and metrics
  - Emulation analysis and results

- Next steps
  - Application protocols assessment
  - Security protocols analysis



Purpose of D3.4

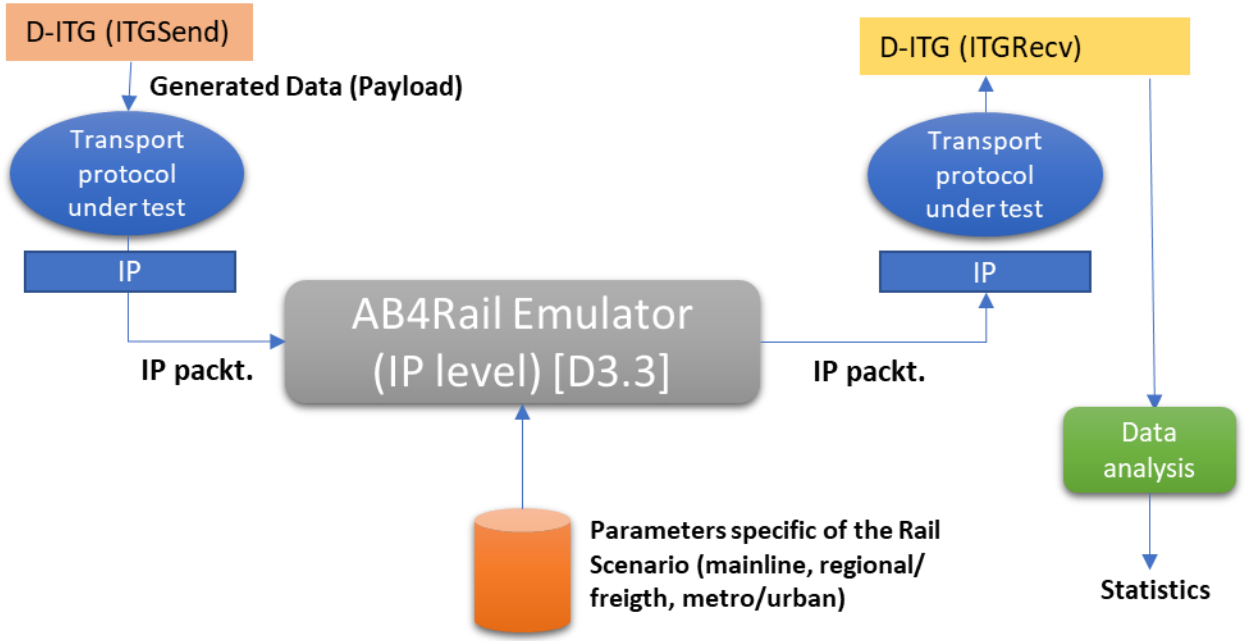
- **Main aim**: Investigating the behavior of the communication transport protocols on realistic railway scenarios.

- Considered traffic sources
  - Constant Bit Rate (CBR), i.e. applications for video streaming
  - Variable Bit Rate (VBR), i.e. skype call or video call
  - File transfer, i.e. file download/upload

- Considered transport protocols
  - Transport Control Protocol (TCP), Cubic
  - TCP Bottleneck bandwidth and round-trip propagation time (BBR);
  - User Datagram Protocol (UDP);
  - Stream Control Transmission Protocol (SCTP)

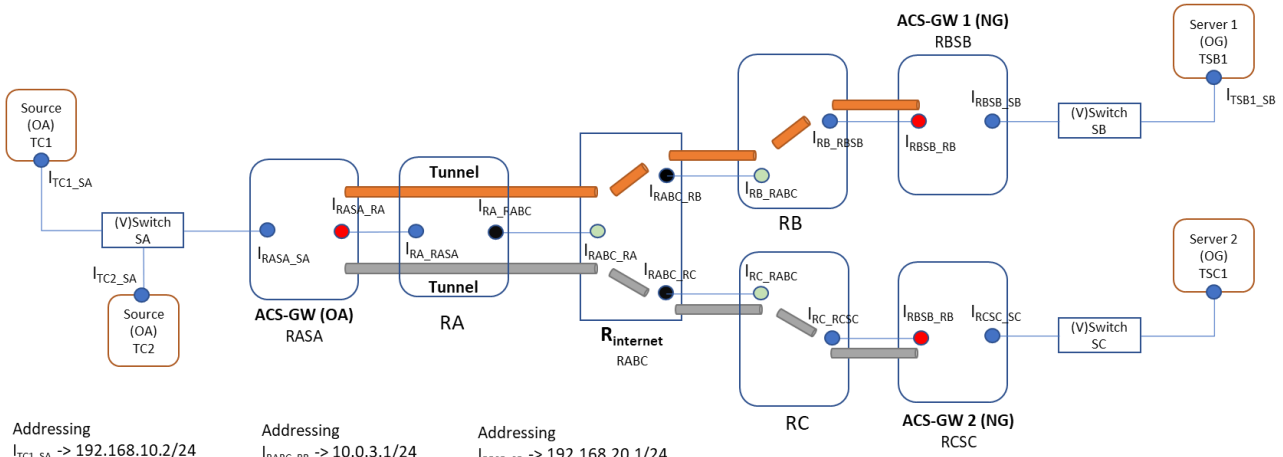
Emulator and transport layer analysis

- Generating data traffic (CBR or VBR).
- Injecting it in the emulator/simulator + specific rail scenario parameters
- Collect statistics: one-way transmission latency, throughput, download time
- Analysis of results



Emulator setup

- IP impairments: latency, packet loss and available transmission bandwidth



Addressing
I_{TC1_SA} -> 192.168.10.2/24
I_{TC2_SA} -> 192.168.10.3/24
I_{RASA_SA} -> 192.168.10.1/24

I_{RASA_RA} -> 10.0.1.1/24
I_{RA_RASA} -> 10.0.1.2/24

I_{RA_RABC} -> 10.0.2.1/24
I_{RABC_RA} -> 10.0.2.2/24

Addressing
I_{RABC_RB} -> 10.0.3.1/24
I_{RABC_RC} -> 10.0.4.1/24
I_{RB_RABC} -> 10.0.3.2/24
I_{RC_RABC} -> 10.0.4.2/24

I_{RB_RBSB} -> 10.0.5.1/24
I_{RBSB_RB} -> 10.0.5.2/24

I_{RC_RCSC} -> 10.0.6.1/24
I_{RCSc_RC} -> 10.0.6.2/24

Addressing
I_{RBSB_SB} -> 192.168.20.1/24
I_{TSB1_SB} -> 192.168.20.2/24

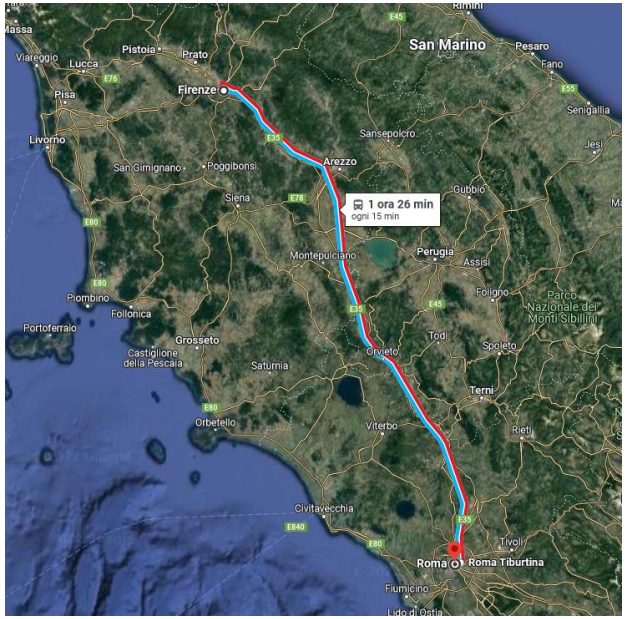
I_{RCSC_SC} -> 192.168.30.1/24
I_{TSC1_SC} -> 192.168.30.2/24

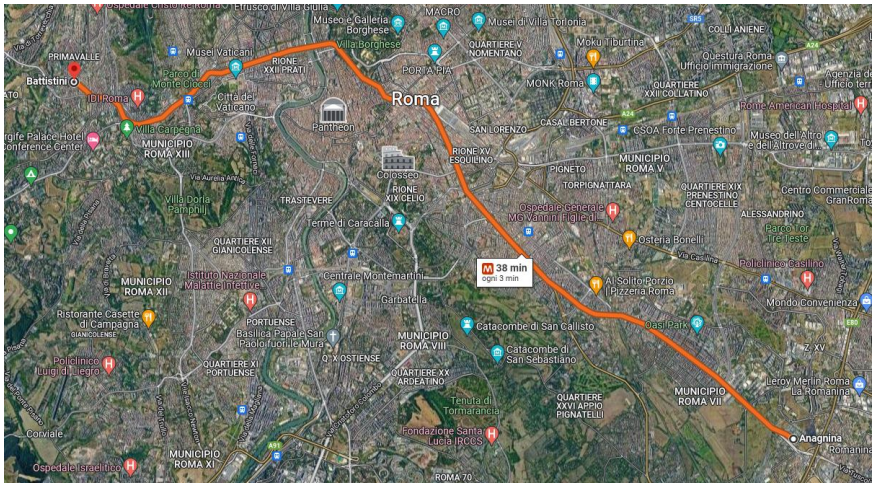
Linux Traffic Control – specifications

I_{RASA_RA} -> traffic limitation (tc) – OA-> NG (red)
I_{RBSB_RB} -> traffic limitation (tc) – NG1-> OA (red)
I_{RCSC_RC} -> traffic limitation (tc) – NG2-> OA (red)
I_{RA_RABC} -> netem - OA->NG1,2 (RAN - common) (black)
I_{RABC_RA} -> netem - NG1,2->OA (RAN - common) (green)
I_{RABC_RB} -> netem - OA->NG1 (wired=core+Internet) (black)
I_{RB_RABC} -> netem - NG1->OA (wired=core+Internet) (green)
I_{RABC_RC} -> netem - OA->NG2 (wired=core+Internet) (black)
I_{RC_RABC} -> netem - NG2->OA (wired=core+Internet) (green)

Rail lines

- Rome – Florence, high speed line
- Rome – Florence, regional line
- Metro A, Rome





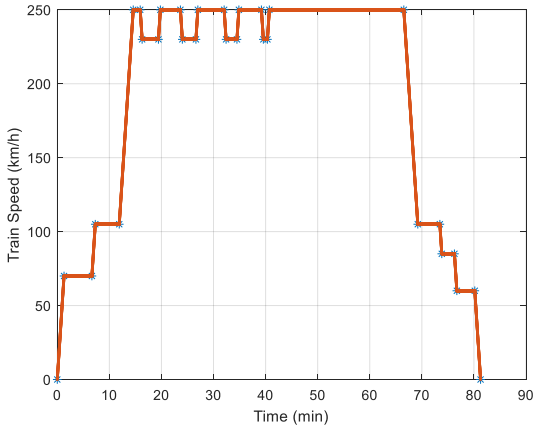
Train speed and number of trains in an LTE cell

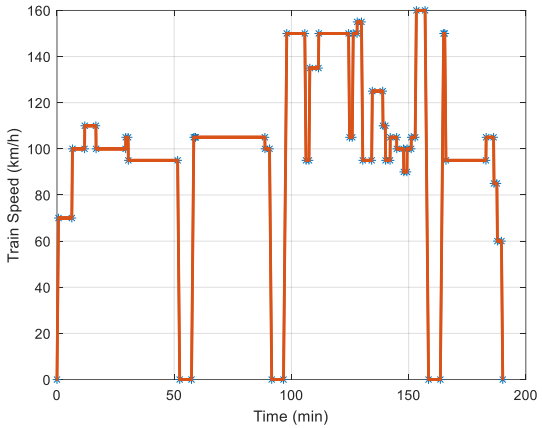
Firenze-Roma, high speed line

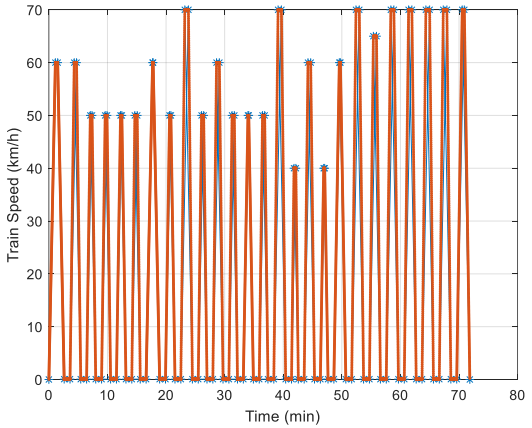
Firenze-Roma, Regional line

Metro A line Roma

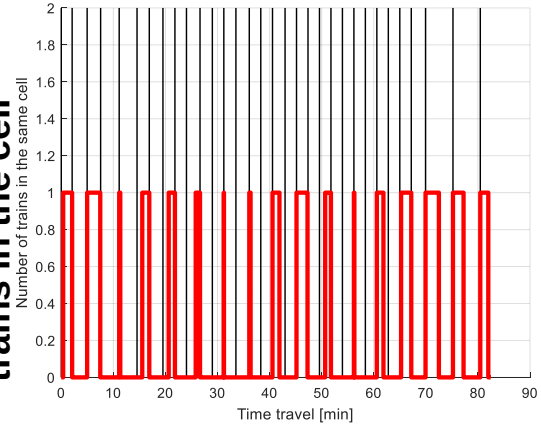
Train speed

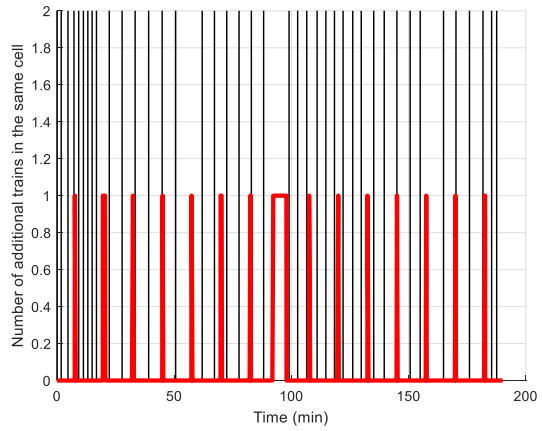






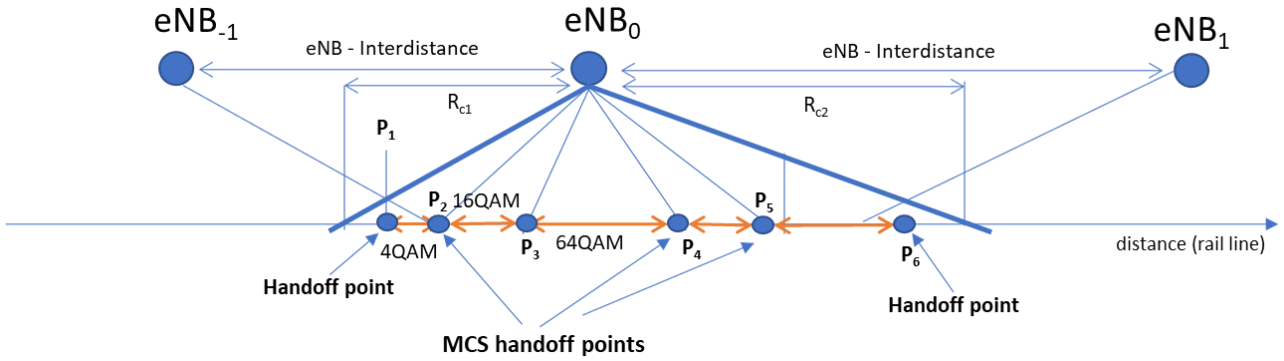
Number of additional trains in the cell





eNB model and modulation/coding scheme (MCS)

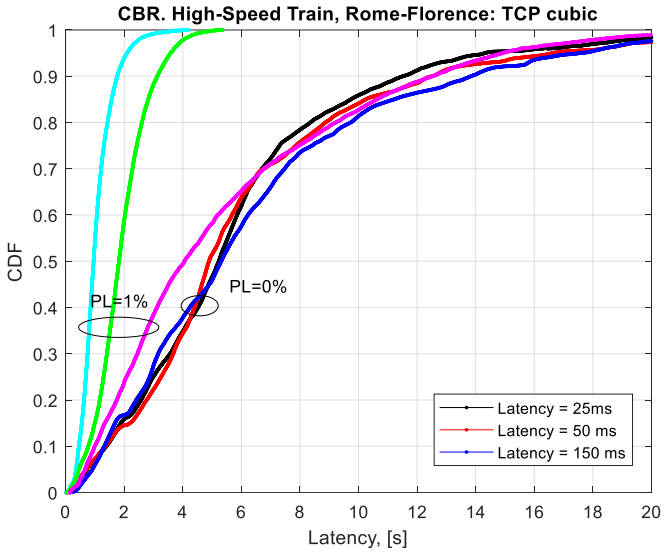
- Handover points, threshold = -115 dBm (at QPSK ¾)
- Propagation model: Okumura-Hata

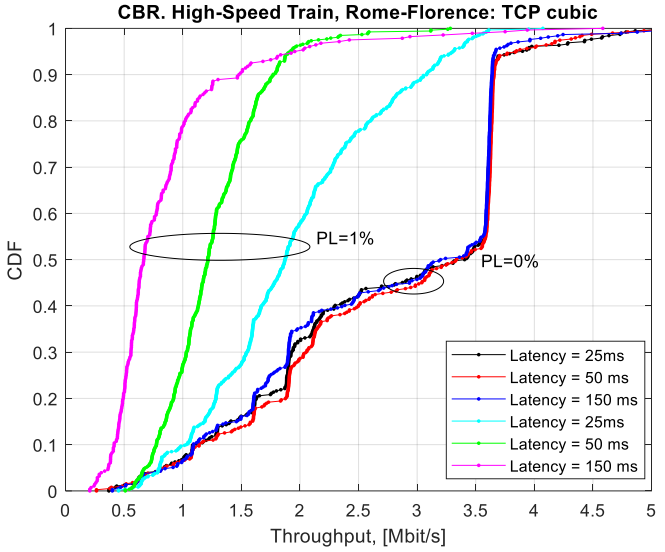


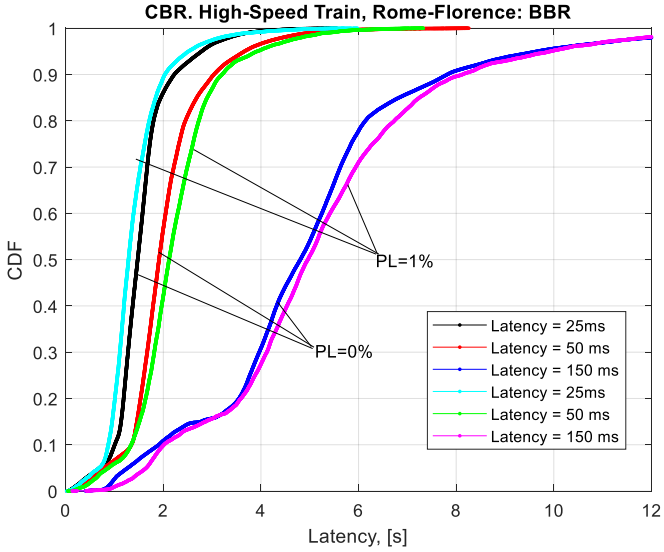
Distance between elements	Value
d_eNB – Urban	3.36 km
d_eNB – Suburban	9.12 km
d_eNB – Rural	9.6 km

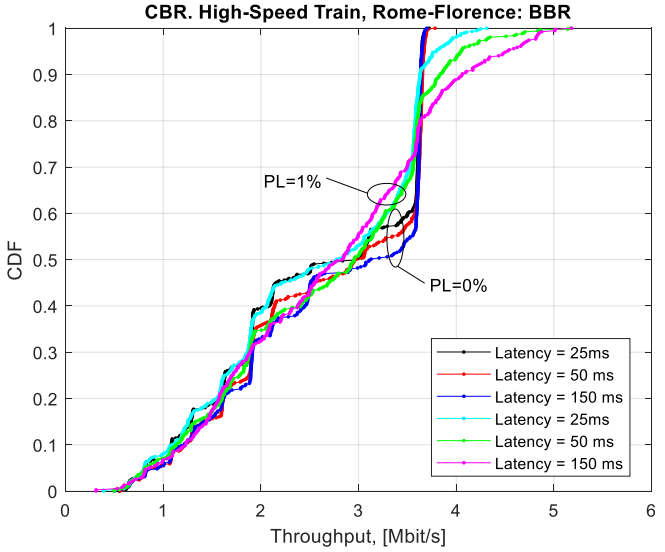
LTE/5G with 1.25 MHz
In the GSM-R band

Results: CBR for cubic and BBR, high speed line

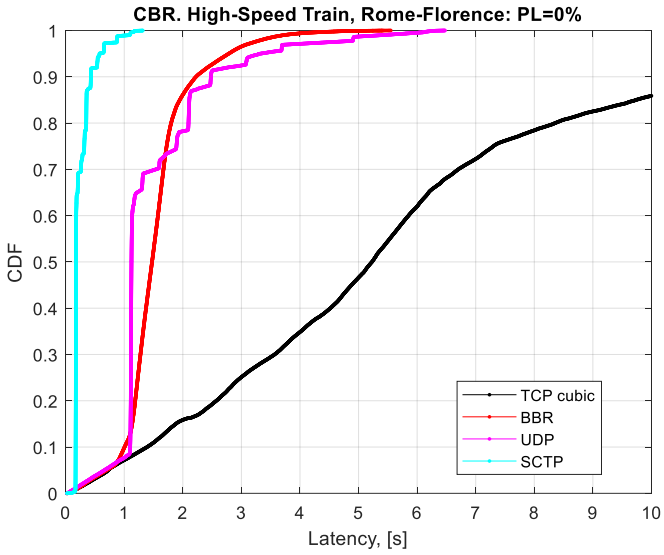


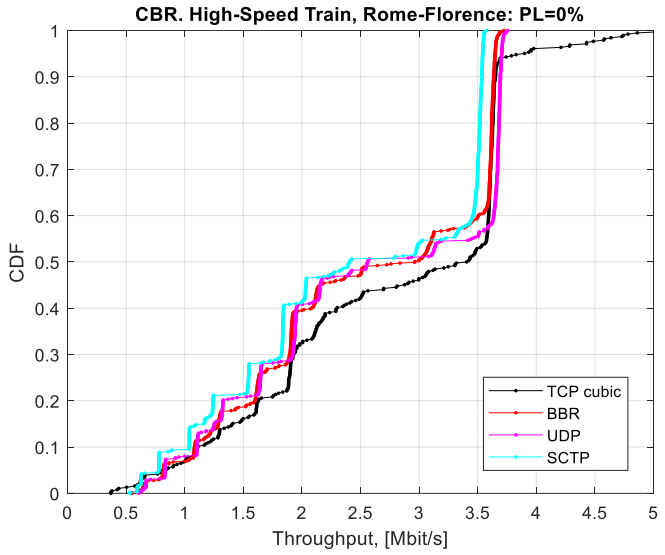


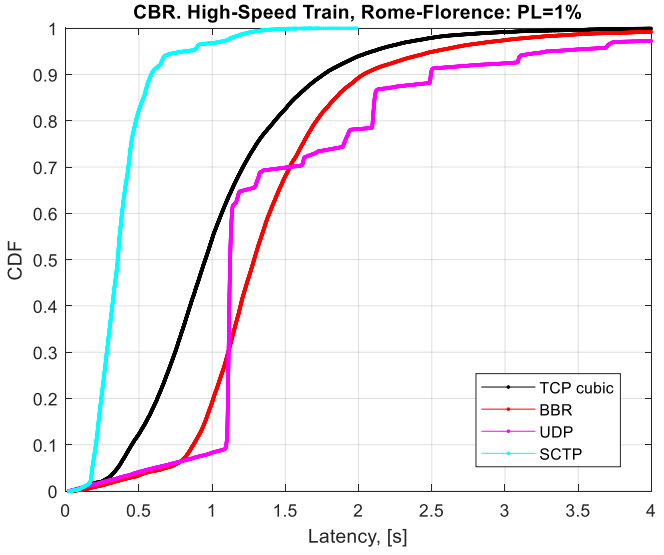


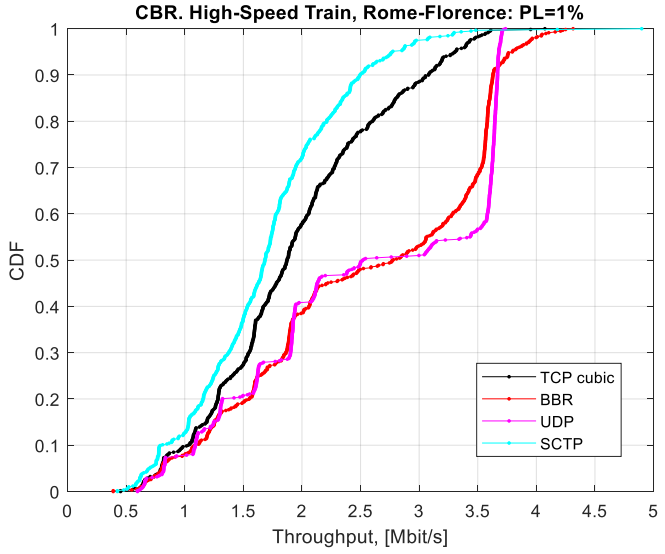


Results: protocol comparison, CBR, high speed line

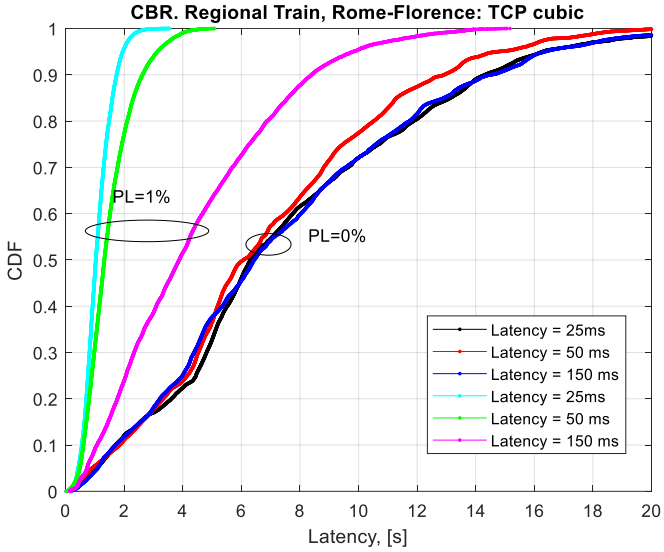


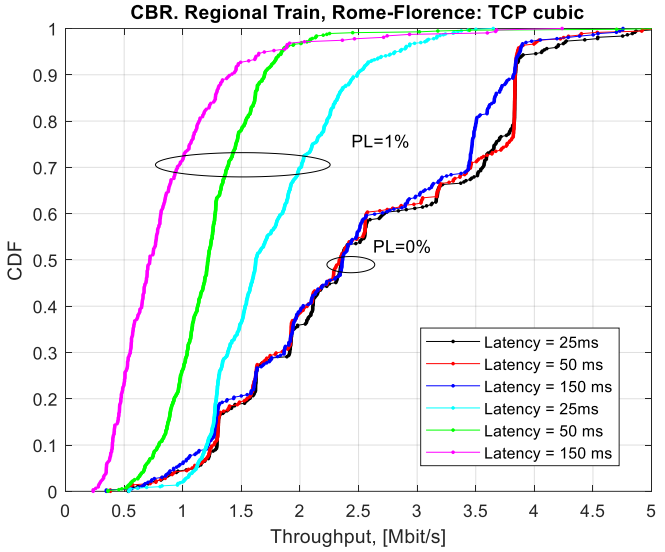


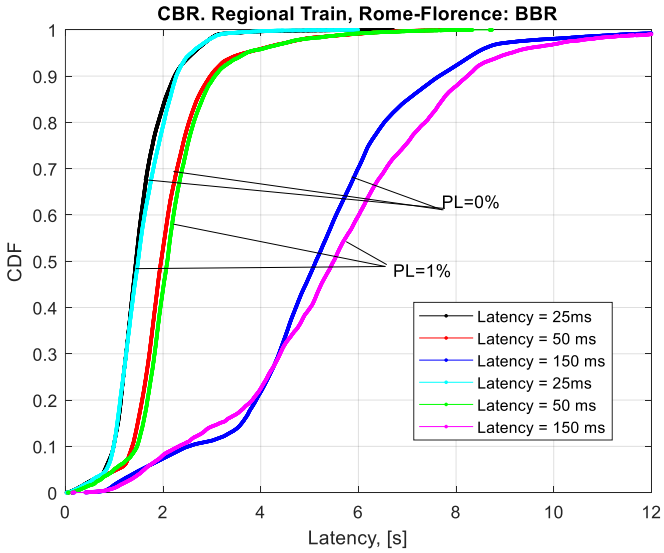


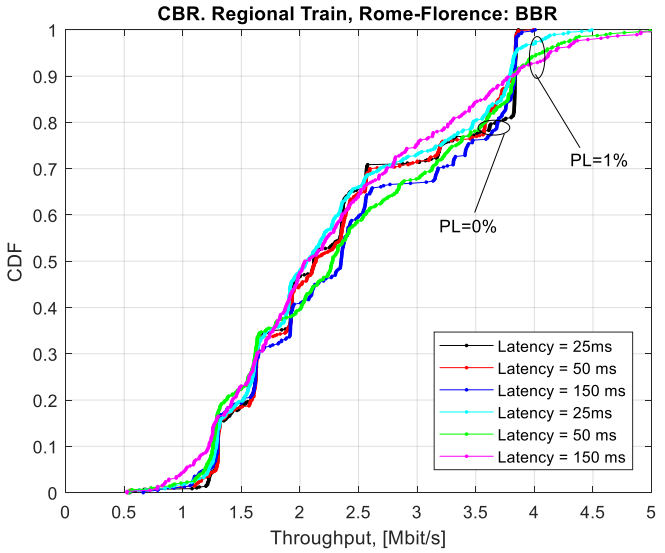


Results: CBR for cubic and BBR, regional line

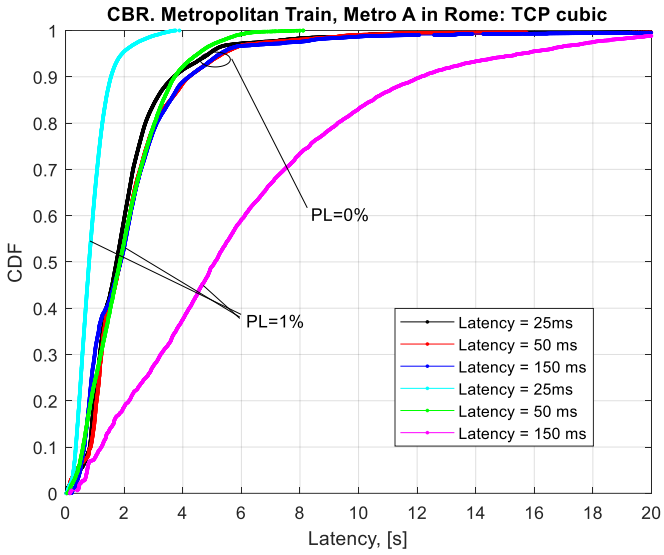


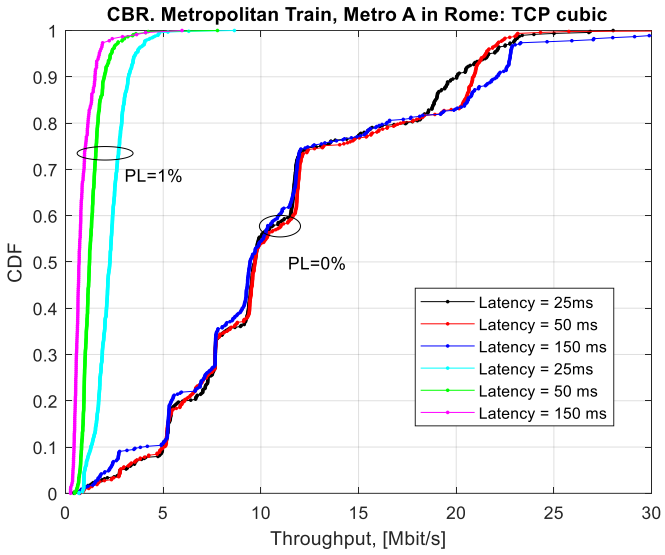


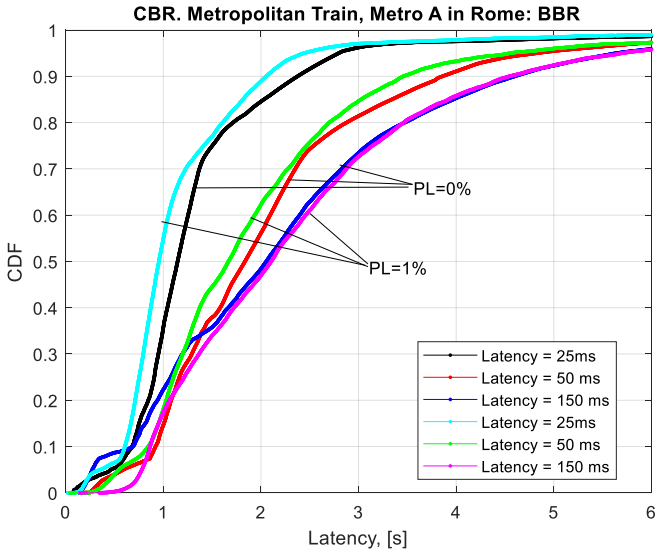


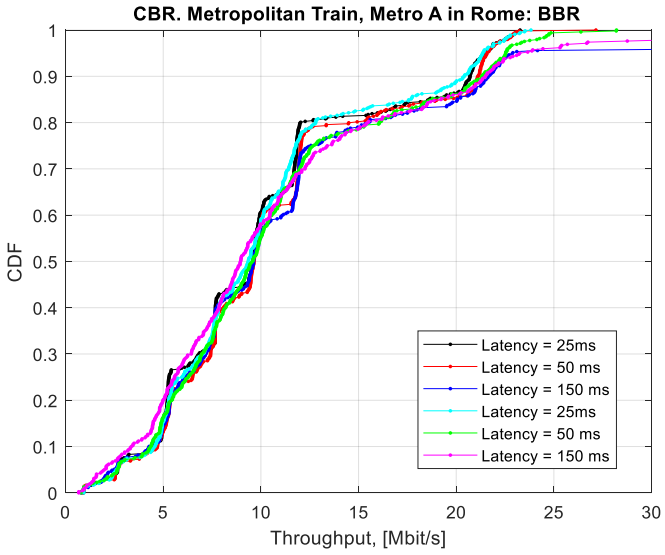


Results: CBR for cubic and BBR, Metro line

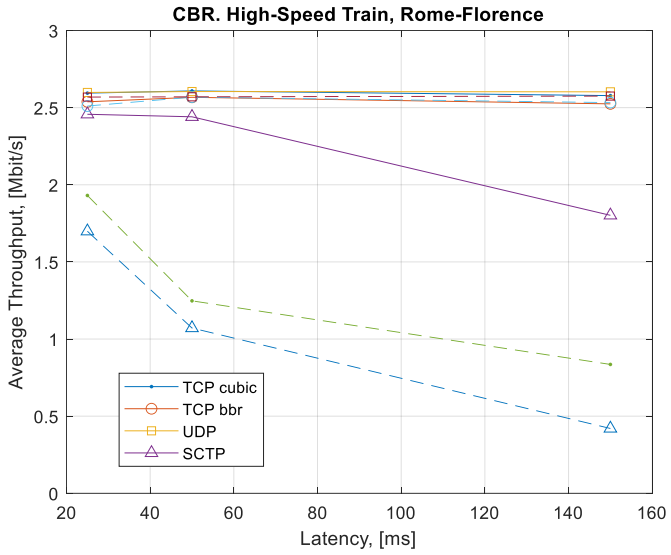


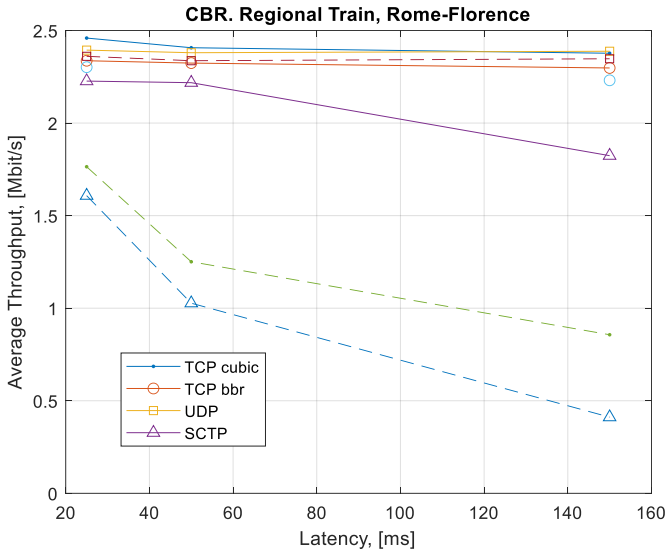


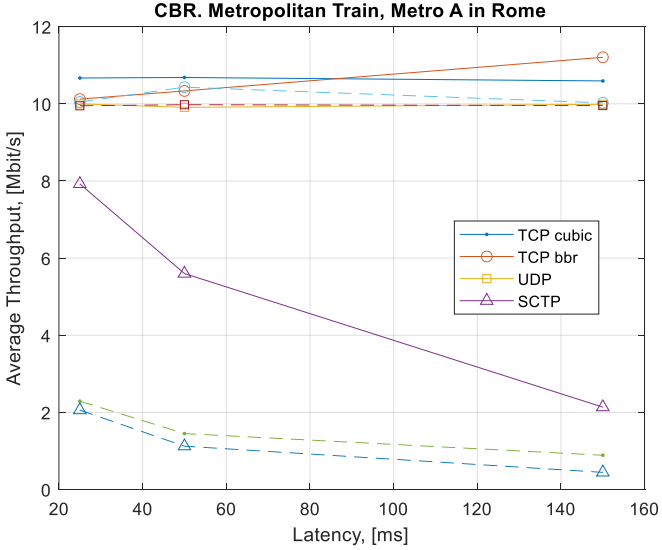




Average Throughput vs latency

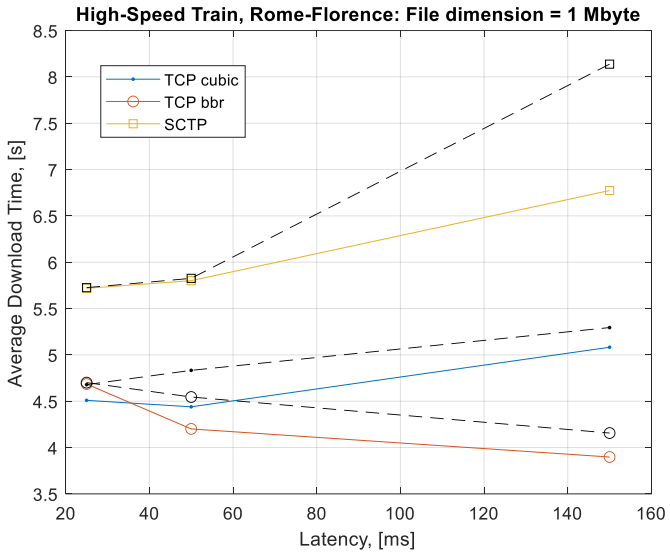


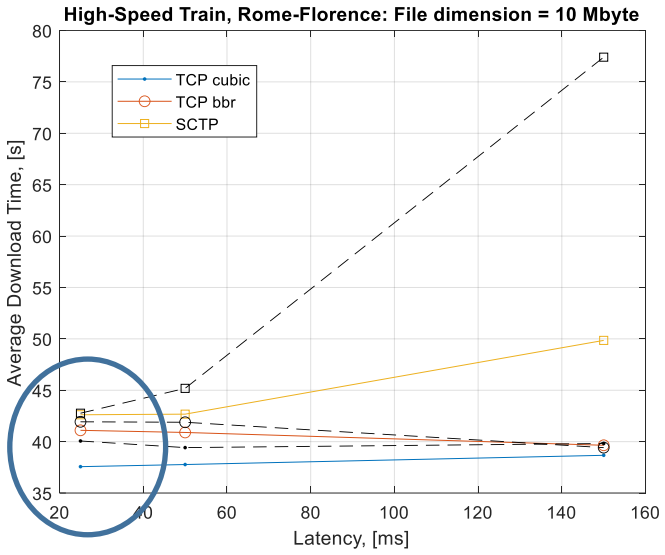


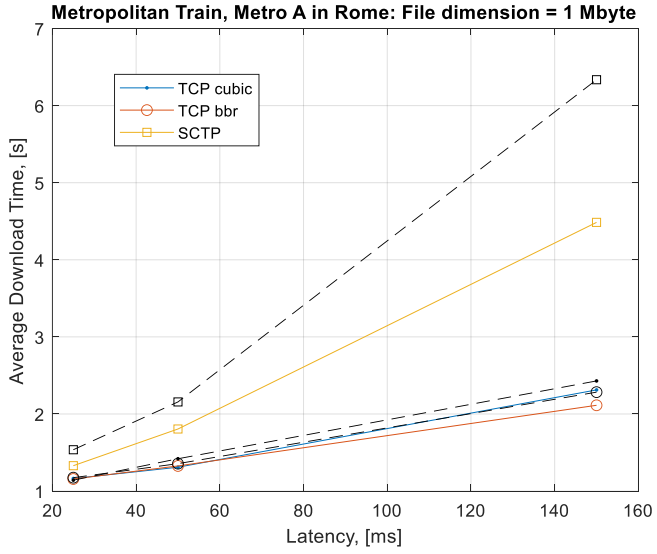


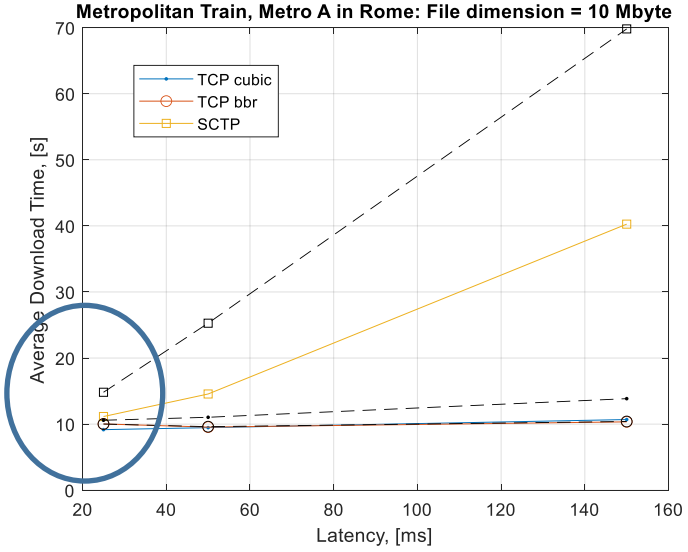
- Transport protocols: TCP cubic, TCP BBR, UDP and SCTP
- Three scenarios: High-Speed, Regional, Metropolitan
- Lossless case (PL = 0%, solid lines), lossy case (PL = 1%, dashed lines)

Average Download Time vs latency: TCP cubic, BBR and SCTP, High-Speed line



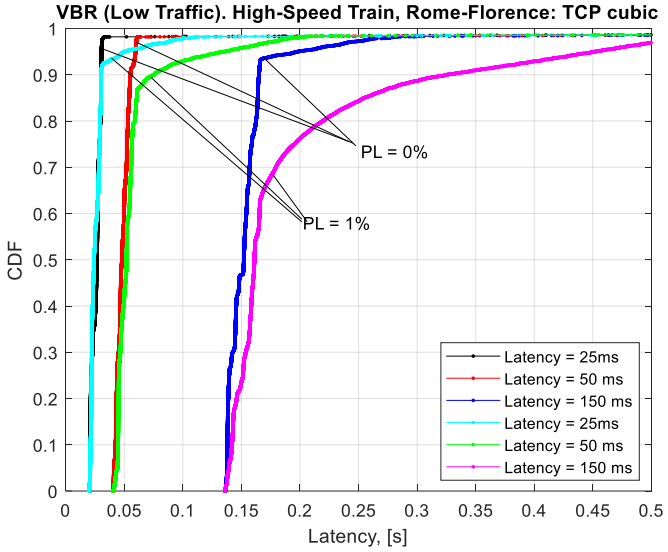


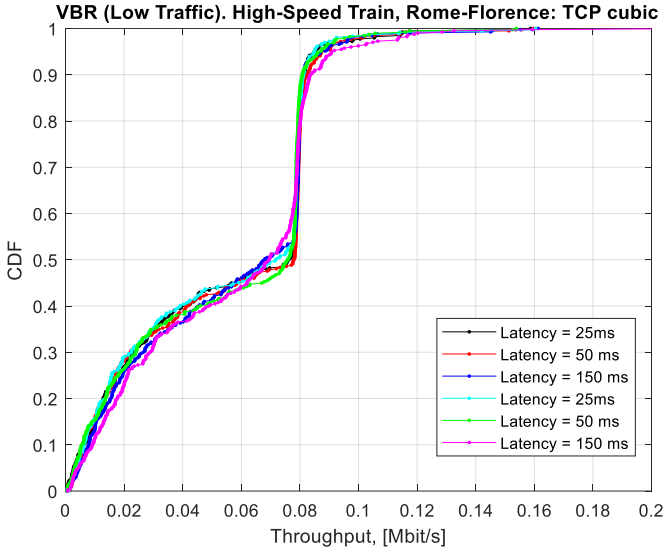


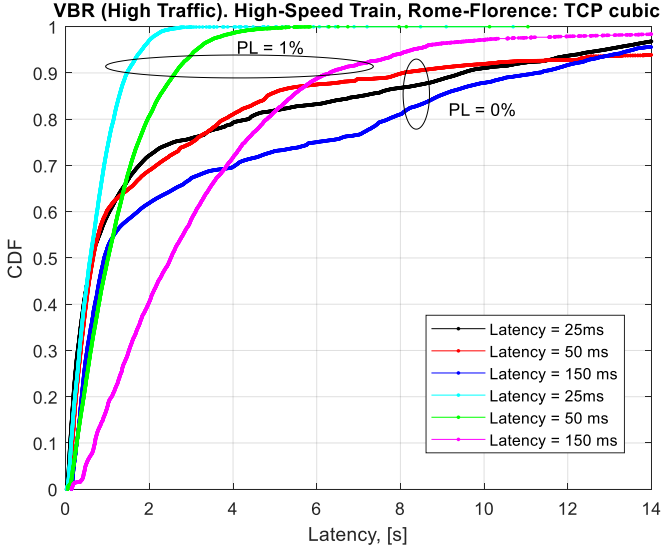


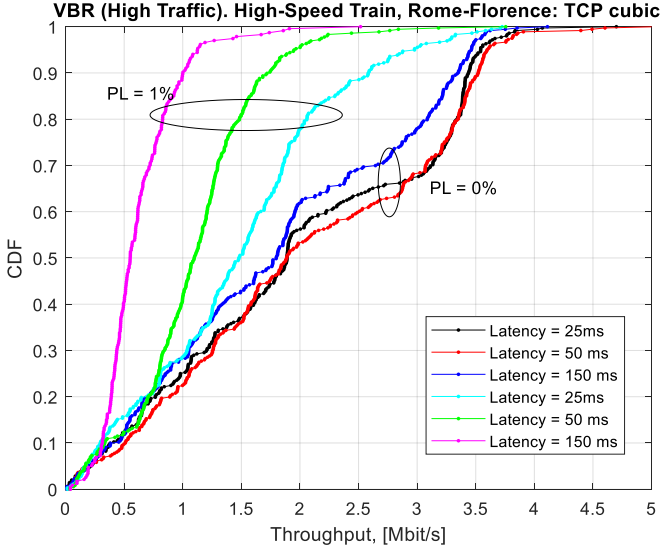
PL = 0% (colored), PL = 0.1% (black/dashed)

Results: VBR for TCP cubic, high speed line

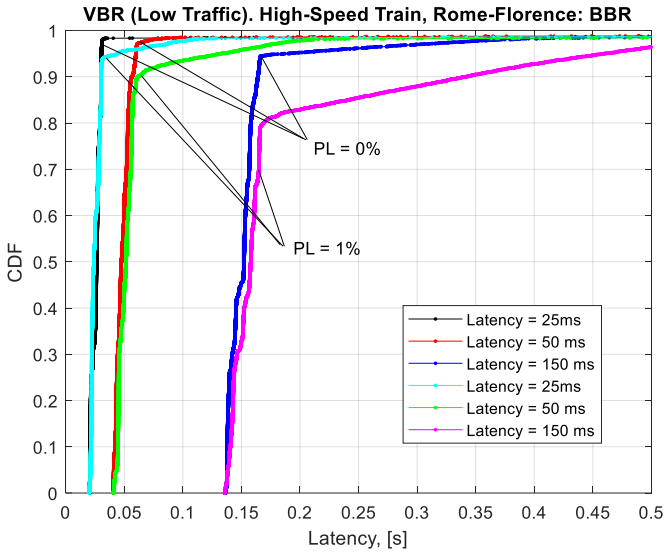


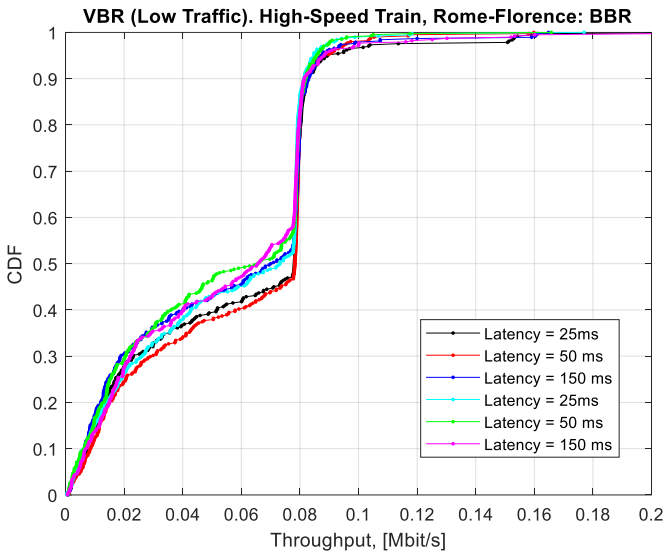


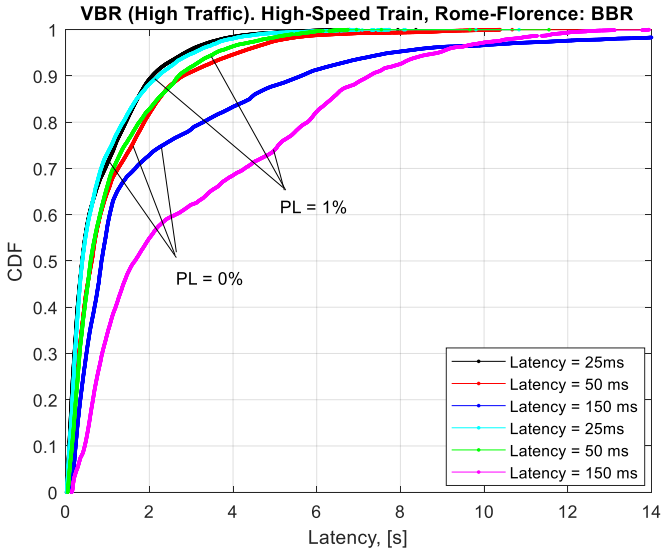


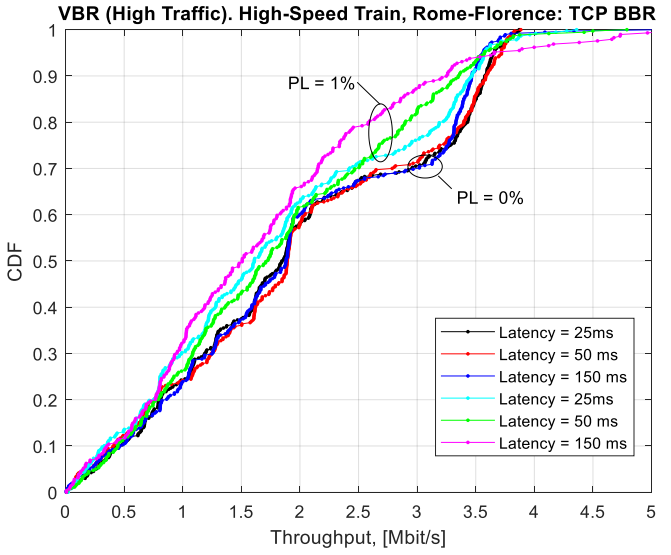


Results: VBR for TCP BBR, high speed line

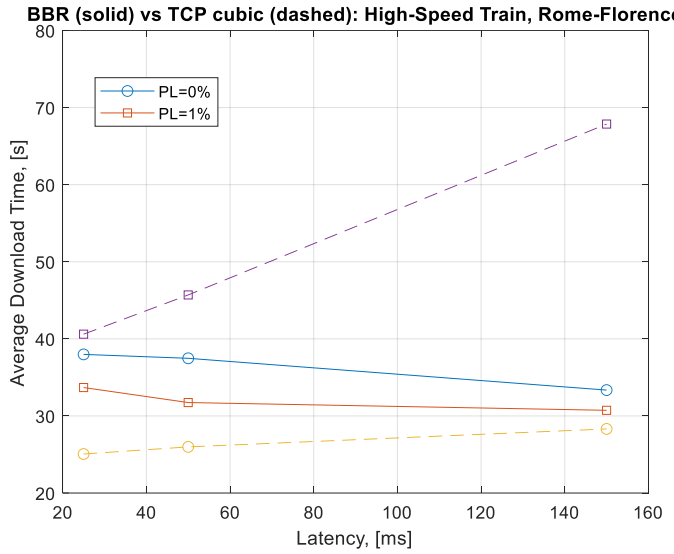


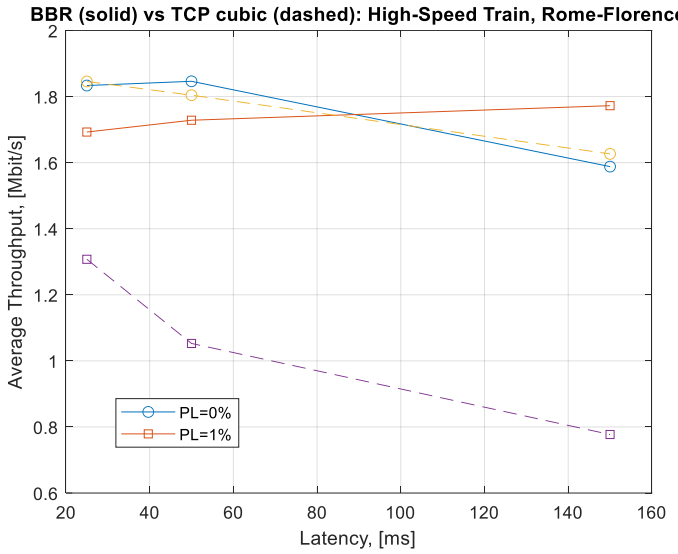


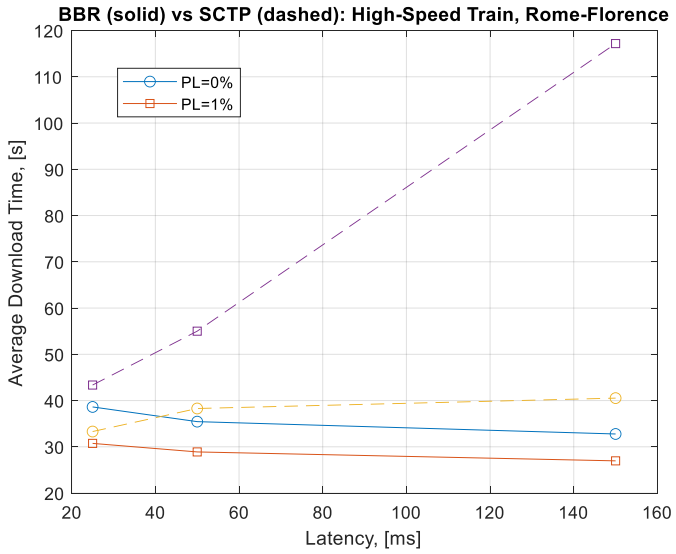


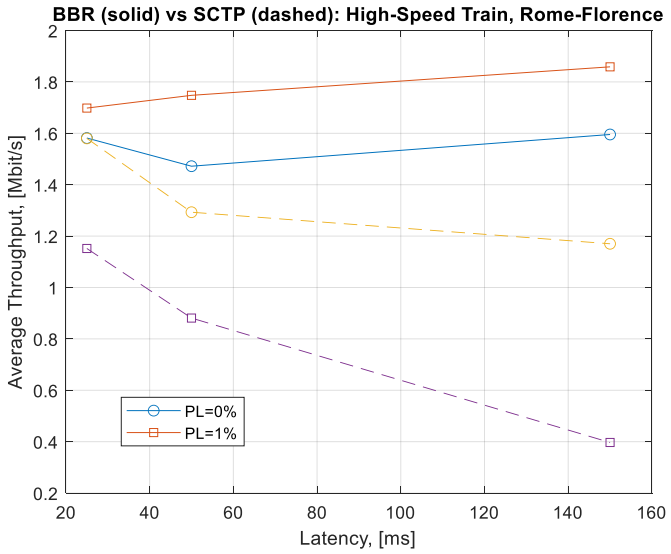


Coexistence with BBR: TCP cubic & SCTP, high-speed line









Conclusions and remarks

- Packet loss is the most influencing channel parameter
  - For PL=0%, TCP cubic and TCP BBR are able to track the available transmission channel capacity in all the considered scenarios at the expense of increased packet latency
- For PL = 1%, TCP BBR is able to track the available transmission channel capacity
  - BBR experienced similar TH for PL=0% and PL=1%, in every scenario
- SCTP (single stream) tries to save latency
  - SCTP particularly interesting for signaling services characterized by low data rates but requirements on latency.
- Similar behavior of TCP cubic, TCP BBR and SCTP passing from CBR to VBR, for high bit rates traffic sources
- Coexistence: BBR vs TCP cubic and BBR vs SCTP
  - Similar behavior (channel TH partition) when PL=0%
  - BBR acquires more bandwidth for PL=1%

Thank you for your attention!

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