

ROMES Insight and TTI-View to verify Root Causes for Bad Throughput

PDCP Downlink “out of window” – Meaning of Dropped OOW

What “Dropped OOW” Means:

Dropped OOW (Out Of Window) refers to a PDCP-layer discard event defined in 3GPP TS 38.323.

A PDCP PDU is dropped as Out-Of-Window when:

Its PDCP sequence number (SN) falls outside the current PDCP reordering window at the receiver.

This typically happens when:

- PDCP packets arrive too late
- PDCP packets arrive too far ahead
- PDCP reordering timer expires
- Excessive out-of-order delivery occurs between multiple radio legs

Once a PDCP PDU is OOW:

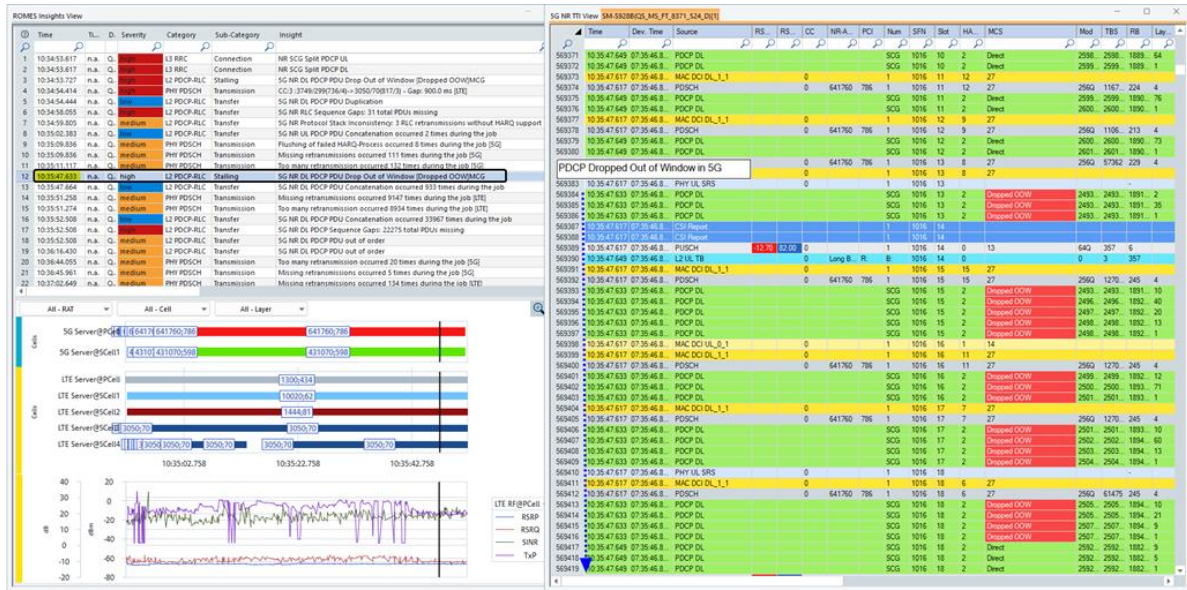
- It will not be delivered to upper layers
- It is not retransmitted
- The loss is permanent and visible to TCP as packet loss

PDCP maintains a reordering window defined by the PDCP sequence numbers (SNs). Each PDCP PDU (data packet) carries a PDCP SN (e.g., 12-bit or 18-bit depending on configuration).

For very high throughput > 500 Mbit/s, the 18 bit SN-Length is a must!

The window defines the range of PDCP SNs that are considered “valid” or “expected” at a given time.

If a PDCP PDU arrives with an SN smaller than the lower edge of the window (too old) or larger than the upper edge (too far in the future), the QC-Chip/Device (info is picked up by ROMES) flags it as “out of window”. These packets are dropped because PDCP can’t correctly reorder or deliver them.



Example: PDCP Dropped OOW both in NR and LTE

The below example shows a lot of PDCP Dropped OOW both in NR and LTE. This rings the alarm to the gNB PDCP Flow Control on X2-Interface.

However the number of Bytes Dropped Out of Window must be counted to determine if it represents a serious threat for the throughput over air because:

the number of PDCP DL Packets Dropped OOW have to be sent over the air-interface and thus is a waste of time and reduces thus reduces the overall Throughput:

Note:

MCG = LTE Master Cell Group, SCG = NR Secondary Cell Group

Time	Dev	Time	Source	R	R	C	N	P	Path	SFN	Slot	RB L	State	Start	Stop	RLC SN	#P Packets	#P Bytes	Rx Delay	Rx Next	Next Cnt	PDCP Start Cnt	PDCP Stop Cnt
40	10:34:53.727	07:34:52.9	PDCP DL						MCG	747	8	2	Dropped OOW	7019	7019	108	1	1500				7019	7019
41	10:34:53.727	07:34:52.9	PDCP DL						MCG	748	0	2	Dropped OOW	7020	7020	110	8	12000				7020	7020
42	10:34:53.727	07:34:52.9	PDCP DL						MCG	748	0	2	Dropped OOW	7028	7028	111	1	1500				7028	7028
43	10:34:53.727	07:34:52.9	PDCP DL						MCG	748	8	2	Dropped OOW	7029	7029	111	4	6000				7029	7029
44	10:34:53.727	07:34:52.9	PDCP DL						MCG	748	8	2	Dropped OOW	7033	7033	112	1	1500				7033	7033
45	10:34:53.789	07:34:53.0	PDCP DL						MCG	749	8	2	Dropped OOW	6901	6901	75	1	1500				6901	6901
46	10:34:53.789	07:34:53.0	PDCP DL						MCG	749	8	2	Dropped OOW	6902	6902	76	1	1500				6902	6902
47	10:34:53.789	07:34:53.0	PDCP DL						MCG	753	3	2	Dropped OOW	6903	6903	76	2	3000				6903	6903
48	10:34:53.789	07:34:53.0	PDCP DL						MCG	753	3	2	Dropped OOW	6905	6905	77	1	1500				6905	6905
49	10:34:53.914	07:34:53.1	PDCP DL						SCG	761	0	2	Dropped OOW	8014	8014	100	1	1500				8014	8014
50	10:34:53.914	07:34:53.1	PDCP DL						SCG	765	5	2	Dropped OOW	8015	8015	101	1	1500				8015	8015
51	10:34:53.914	07:34:53.1	PDCP DL						SCG	765	5	2	Dropped OOW	8016	8016	102	1	1500				8016	8016
52	10:34:56.617	07:34:55.8	PDCP DL						SCG	1021	1	2	Dropped OOW	227691	227691	165973	1	1500				227691	227691
53	10:34:56.617	07:34:55.8	PDCP DL						MCG	5	8	2	Dropped OOW	227714	227714	995	1	1500				227714	227714
54	10:34:56.617	07:34:55.8	PDCP DL						MCG	6	3	2	Dropped OOW	227840	227840	1016	1	1500				227840	227840
55	10:34:56.617	07:34:55.8	PDCP DL						MCG	6	4	2	Dropped OOW	227862	227862	0	1	1500				227862	227862
56	10:34:56.617	07:34:55.8	PDCP DL						MCG	6	4	2	Dropped OOW	227862	227862	1020	1	1500				227862	227862
57	10:34:56.617	07:34:55.8	PDCP DL						MCG	6	5	2	Dropped OOW	227877	227877	5	1	1500				227877	227877
58	10:34:56.664	07:34:55.8	PDCP DL						MCG	6	5	2	Dropped OOW	227886	227886	7	1	1500				227886	227886
59	10:34:56.617	07:34:55.8	PDCP DL						MCG	9	3	2	Dropped OOW	228281	228281	90	1	1500				228281	228281
60	10:34:56.617	07:34:55.8	PDCP DL						MCG	10	2	2	Dropped OOW	228468	228468	143	1	1500				228468	228468
61	10:34:56.617	07:34:55.8	PDCP DL						MCG	10	5	2	Dropped OOW	228493	228493	152	1	1500				228493	228493
62	10:34:56.617	07:34:55.8	PDCP DL						MCG	10	5	2	Dropped OOW	228500	228500	154	1	1500				228500	228500
63	10:34:56.617	07:34:55.8	PDCP DL						MCG	10	6	2	Dropped OOW	228516	228516	159	1	1500				228516	228516
64	10:34:56.617	07:34:55.8	PDCP DL						MCG	10	7	2	Dropped OOW	228538	228538	165	1	1500				228538	228538
65	10:34:56.617	07:34:55.8	PDCP DL						MCG	10	8	2	Dropped OOW	228563	228563	171	1	1500				228563	228563
66	10:34:56.617	07:34:55.8	PDCP DL						SCG	10	15	2	Dropped OOW	227739	227739	166021	1	1500				227739	227739
67	10:34:56.617	07:34:55.8	PDCP DL						SCG	10	16	2	Dropped OOW	227740	227740	166036	15	22500				227740	227740
68	10:34:56.617	07:34:55.8	PDCP DL						SCG	11	0	2	Dropped OOW	228102	228102	166249	1	1500				228102	228102
69	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	0	2	Dropped OOW	228282	228282	90	2	3000				228282	228282
70	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	0	2	Dropped OOW	228284	228284	91	1	1500				228284	228284
71	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	0	2	Dropped OOW	228469	228469	143	2	3000				228469	228469
72	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	0	2	Dropped OOW	227715	227715	995	4	6000				227715	227715
73	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	0	2	Dropped OOW	227719	227719	996	1	1500				227719	227719
74	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	0	2	Dropped OOW	227841	227841	1017	4	6000				227841	227841
75	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	0	2	Dropped OOW	228471	228471	144	1	1500				228471	228471
76	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	0	2	Dropped OOW	227845	227845	1017	1	1500				227845	227845
77	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	227863	227863	0	3	4500				227863	227863
78	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	227878	227878	5	5	7500				227878	227878
79	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	227883	227883	6	5	1500				227883	227883
80	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	228472	228472	144	4	6000				228472	228472
81	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	228476	228476	145	1	1500				228476	228476
82	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	228571	228571	173	8	12000				228571	228571
83	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	227846	227846	1017	1	1500				227846	227846
84	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	227847	227847	1018	1	1500				227847	227847
85	10:34:56.617	07:34:55.8	PDCP DL						MCG	11	1	2	Dropped OOW	227863	227863	1021	1	1500				227863	227863

Why Dropped OOW Happens in BOTH MCG and SCG?

This is the most important observation --> PDCP Is Common for MCG and SCG.

In EN-DC:

- PDCP is located in the gNB
- PDCP splits traffic across MCG and SCG
- Reordering is done after packets return from both legs

So although packets are transmitted via:

- MCG (LTE-PCell)
- SCG (NR-PSCell)

→ They share the same PDCP sequence space and reordering window

Therefore:

If reordering fails → both legs can show Dropped OOW

Latency Asymmetry Between MCG and SCG

If MCG and SCG have:

- Different RTTs
- Different HARQ / scheduling delays
- Different BLER / retransmission behavior

Then PDCP packets may arrive:

- Too late from one leg
- Too early from the other

This causes:

- PDCP SN gaps
- Reordering timer expiry
- OOW discards on both MCG and SCG flows

Transport-Layer Interaction (TCP)

When:

- Server A shows high RTT, retransmissions, and slow ramp-up
- TCP retransmissions cause PDCP SN bursts
- Re-injected TCP segments arrive out of order

This further stresses PDCP reordering and accelerates OOW conditions.

Why Dropped OOW Is Severe

Dropped OOW events are not radio retransmissions:

- They happen above RLC/MAC
- HARQ and RLC AM cannot recover them

Impact:

- Direct packet loss at PDCP
- TCP sees loss → retransmissions
- Throughput collapse
- MCS and RB utilization drop