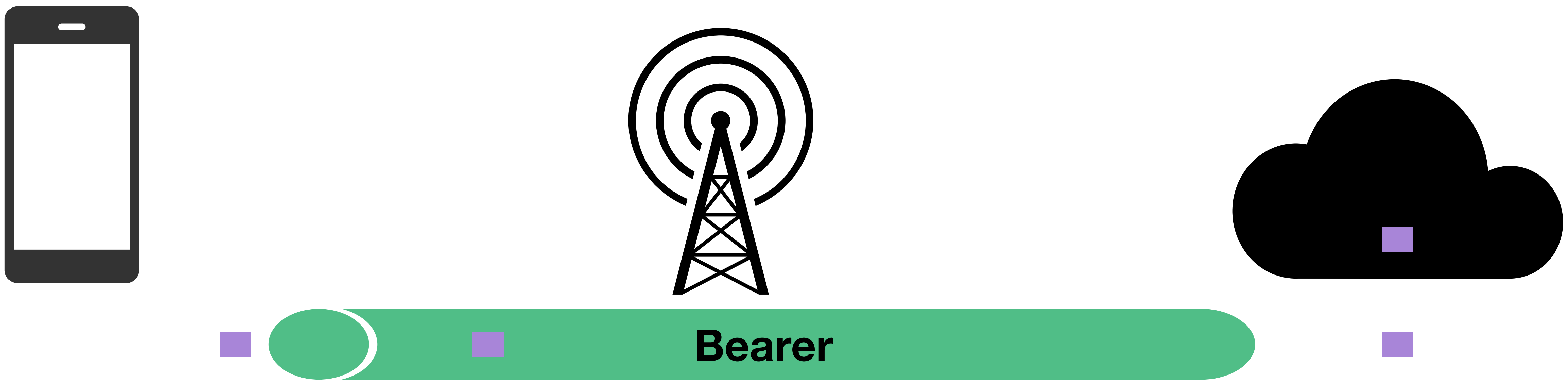
Tech

Energie, latence: je t’aime, moi non plus

Pierre Crepieux
@PCrepieux

orange™

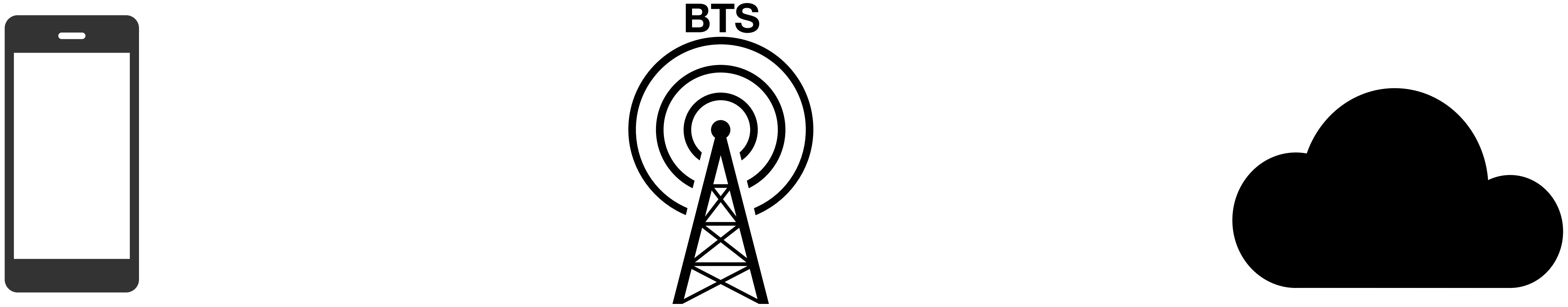
Le réseau mobile



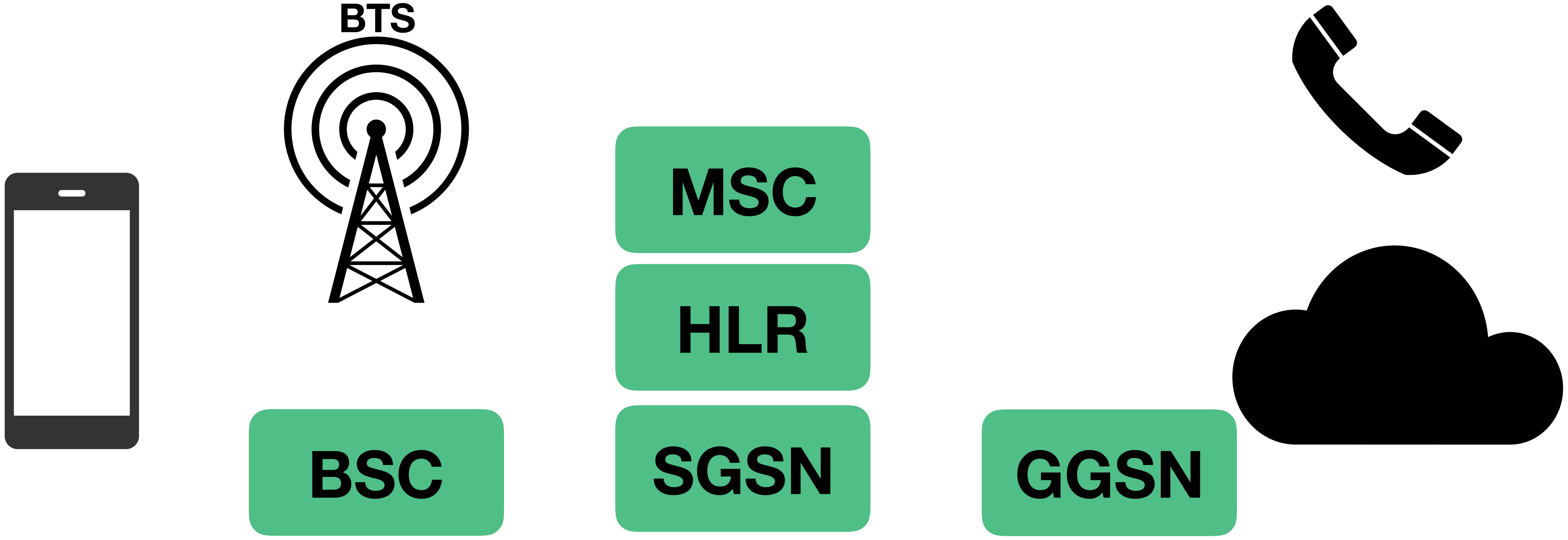
Le réseau mobile

Standard	3GPP version	Techno	Marketing	Débit	Latence	Modulation
issu de l'ETSI	Release 96	GSM	2G	100–400 Kbit/s	300–1000 ms	TDMA/FDMA
IMT-2000	Release 99	UMTS	3G	0.5–5 Mbit/s	100–500 ms	WCDMA
	Realease 7		3G+ (HSPA)	10 - 150 Mbit/s	50 ms	WCDMA (MIMO/CA)
IMT-Advanced	Release 8	LTE	4G	100 Mbit/s	50 ms	OFDMA
	Release 10	LTE-Advanced	4G+	300 Mbit/s	25 ms	OFDMA
IMT-2020	Release 15	NR	5G	1 - 10 Gbit/s	~1 ms	OFDMA based

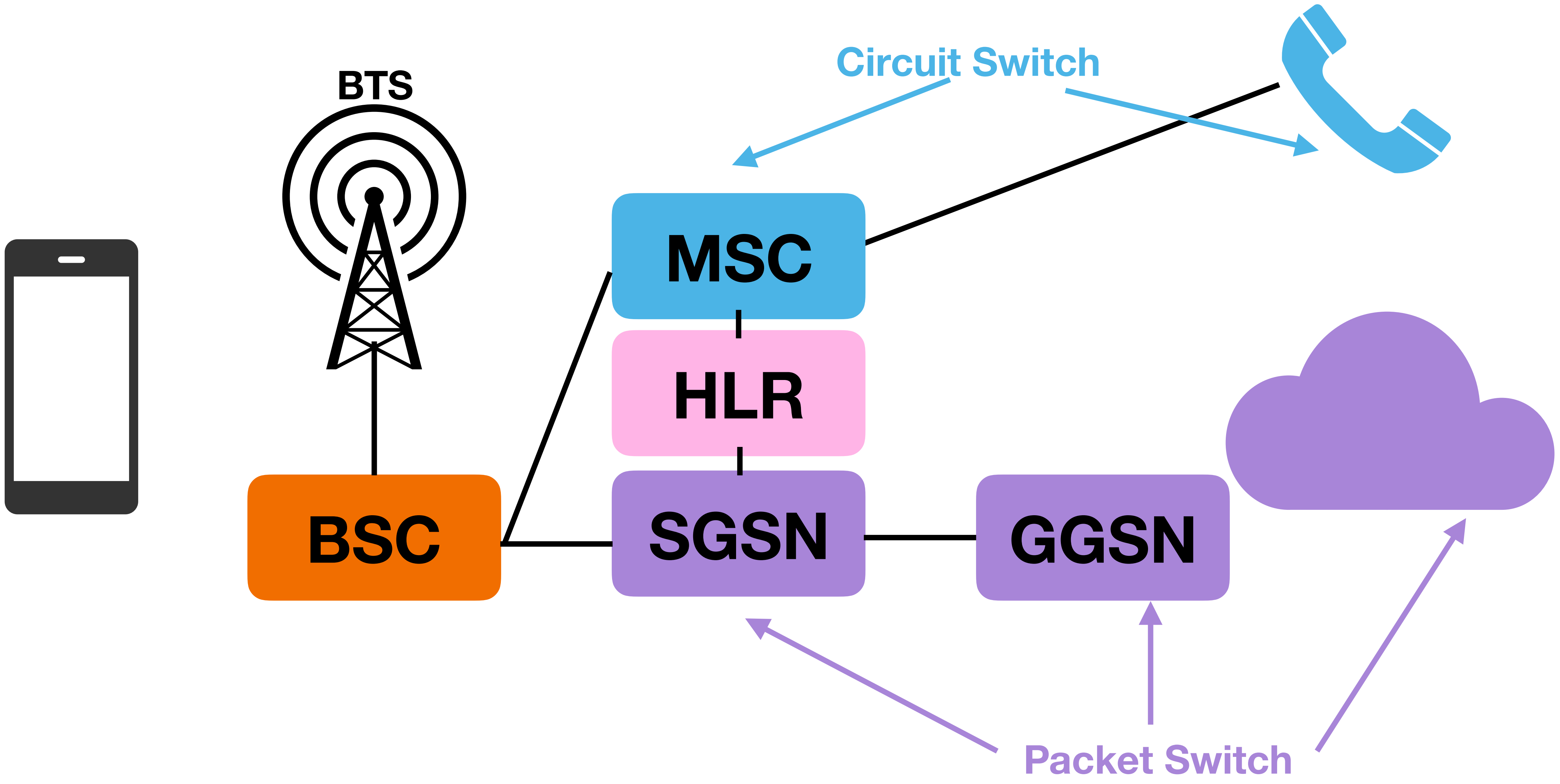
Le réseau mobile (ex: GSM)



Le réseau mobile (ex: GSM)

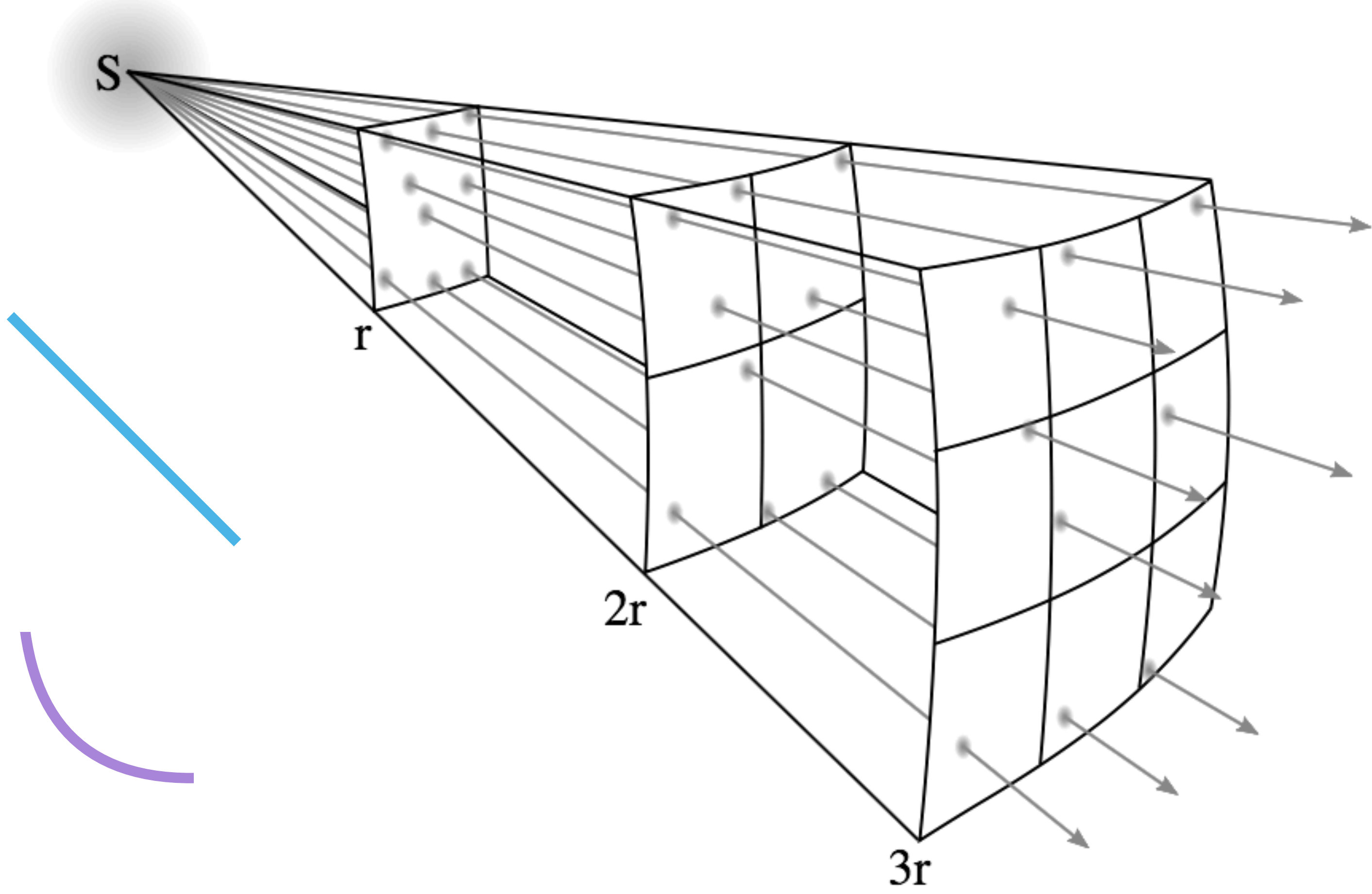


Le réseau mobile (ex: GSM)



Interface radio

- Le récepteur doit être constamment en écoute.
- L’énergie nécessaire à la transmission d’un signal sur une distance données est une relation:
- ***linéaire*** sur un réseau filaire
- ***inverse du carré*** sur un réseau sans fil.



source: https://en.wikipedia.org/wiki/Inverse-square_law

Interface radio

- Plus il y a d’utilisateurs dans une cellule → plus il y a de « bruit » sur l’interface air.
- Plus il y a de bruit sur l’interface air → plus la puissance d’émission augmente.
- Plus le débit de données est grand → plus on a besoin de puissance.

- Un modem peut consommer jusqu’à 2 Watts
  - 10Wh (capacité de batterie) se consomment rapidement

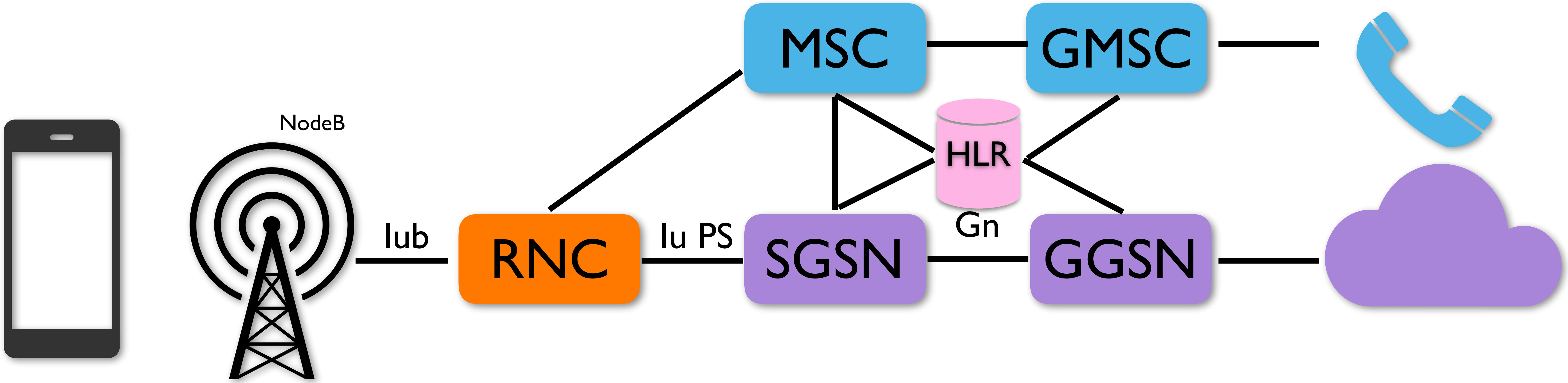
DRX

Discontinuous Reception

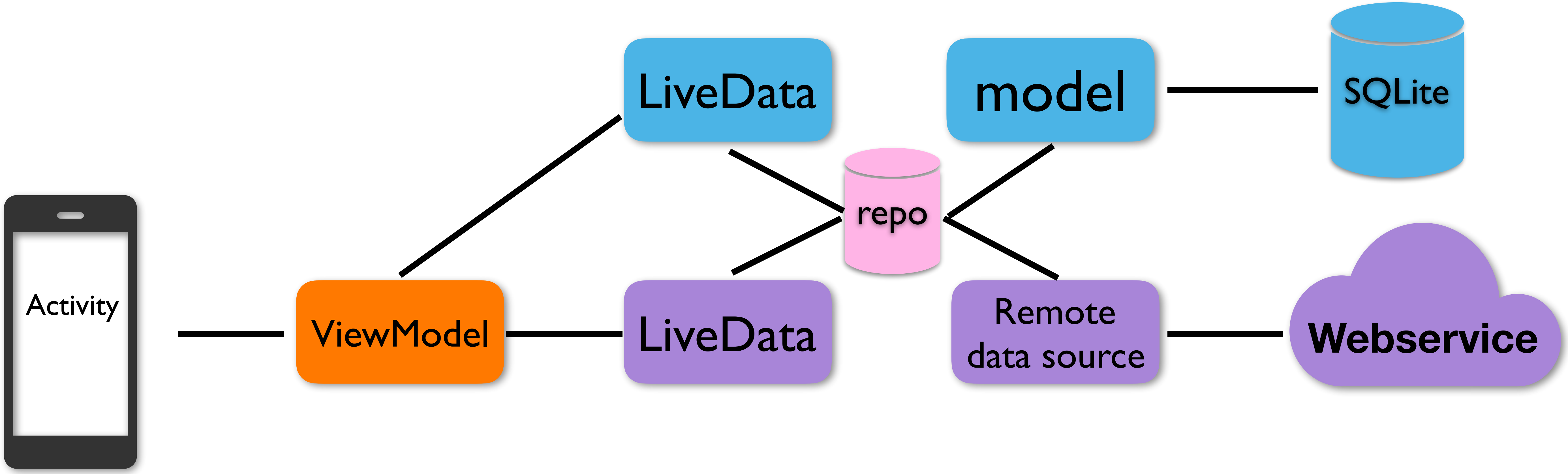
DRX

Discontinuous Reception

Architecture UMTS



Architecture d’une appli



Activity

ViewModel

LiveData

LiveData

repo

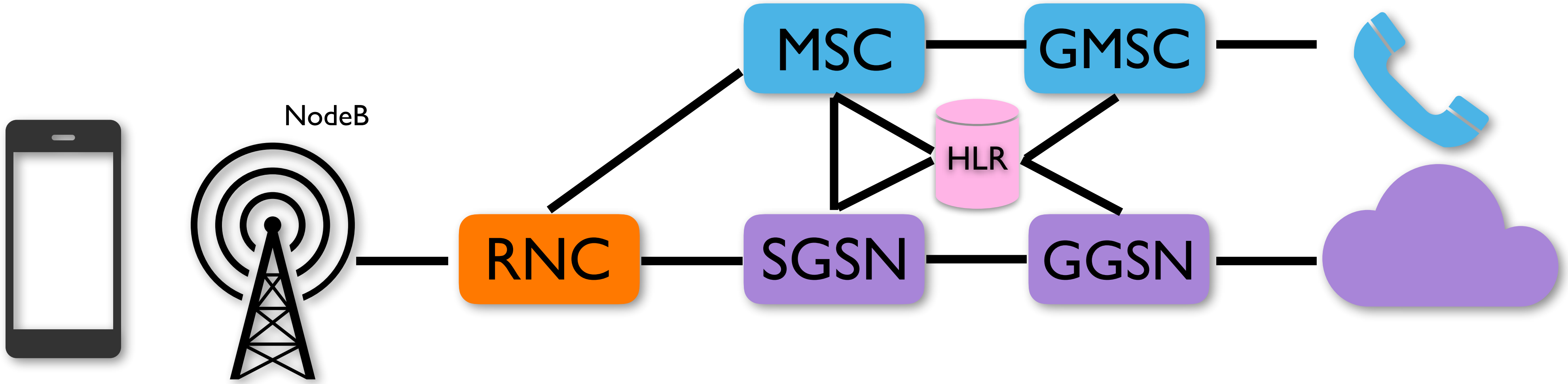
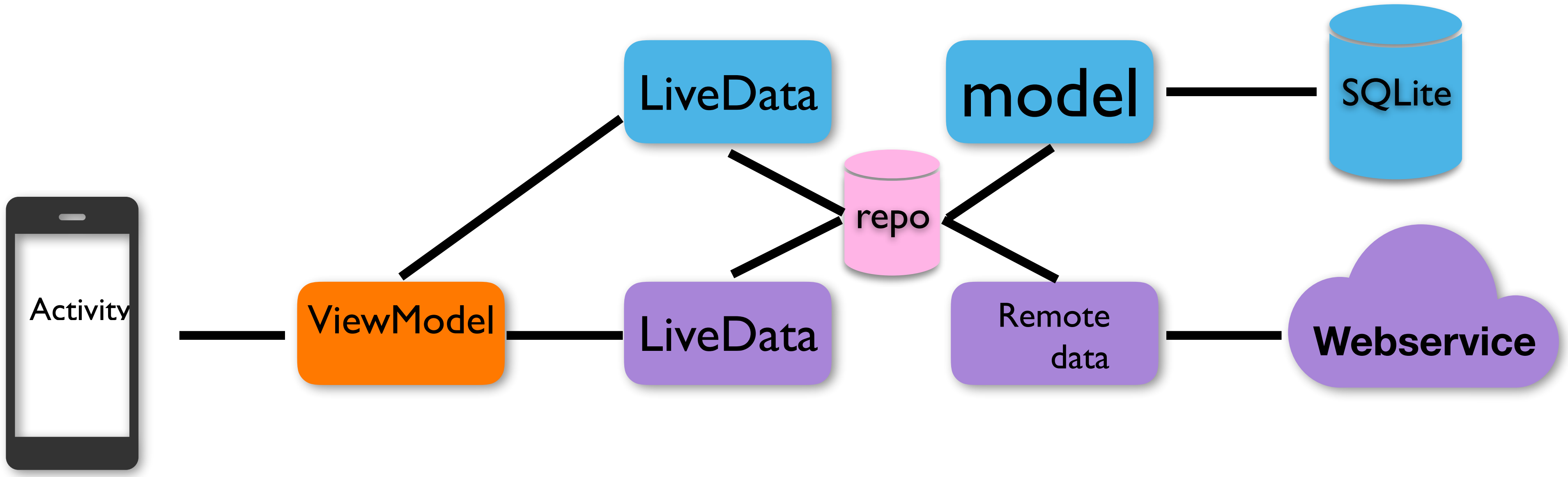
model

SQLite

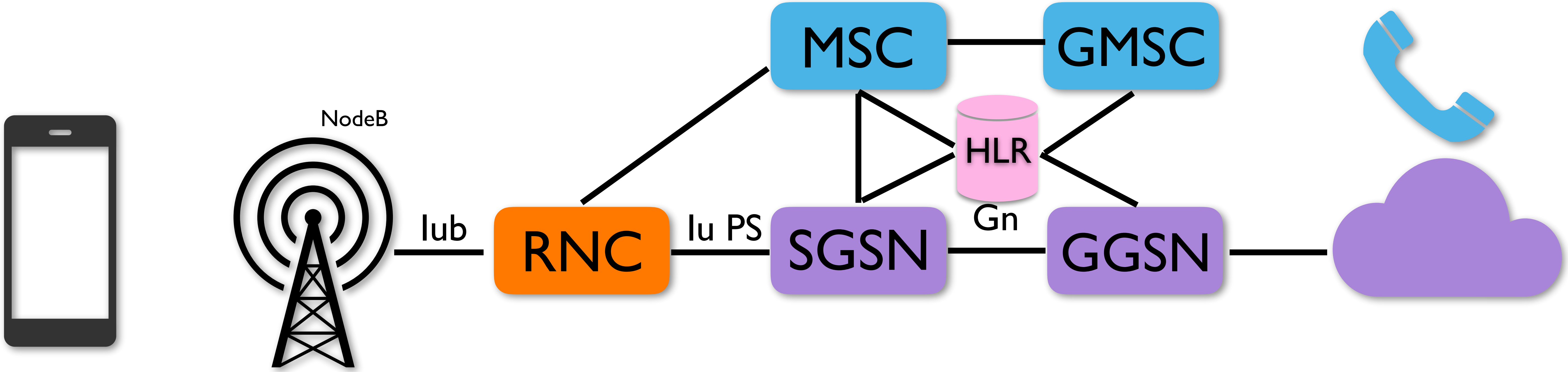
Remote data source

Webservice

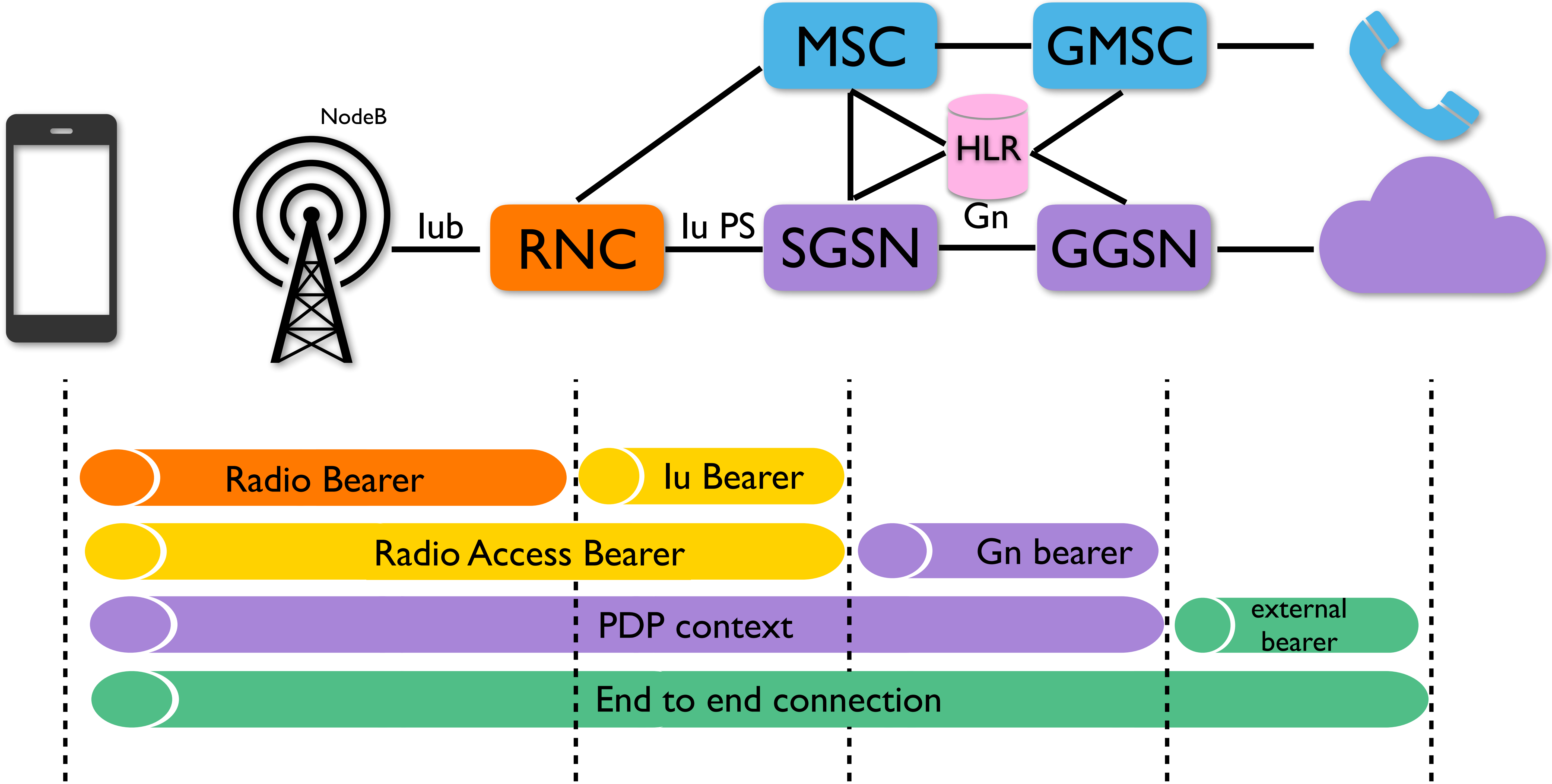
Architecture

	Architecture	TTL (Time To Live)
réseau		plusieurs années
application		quelques mois

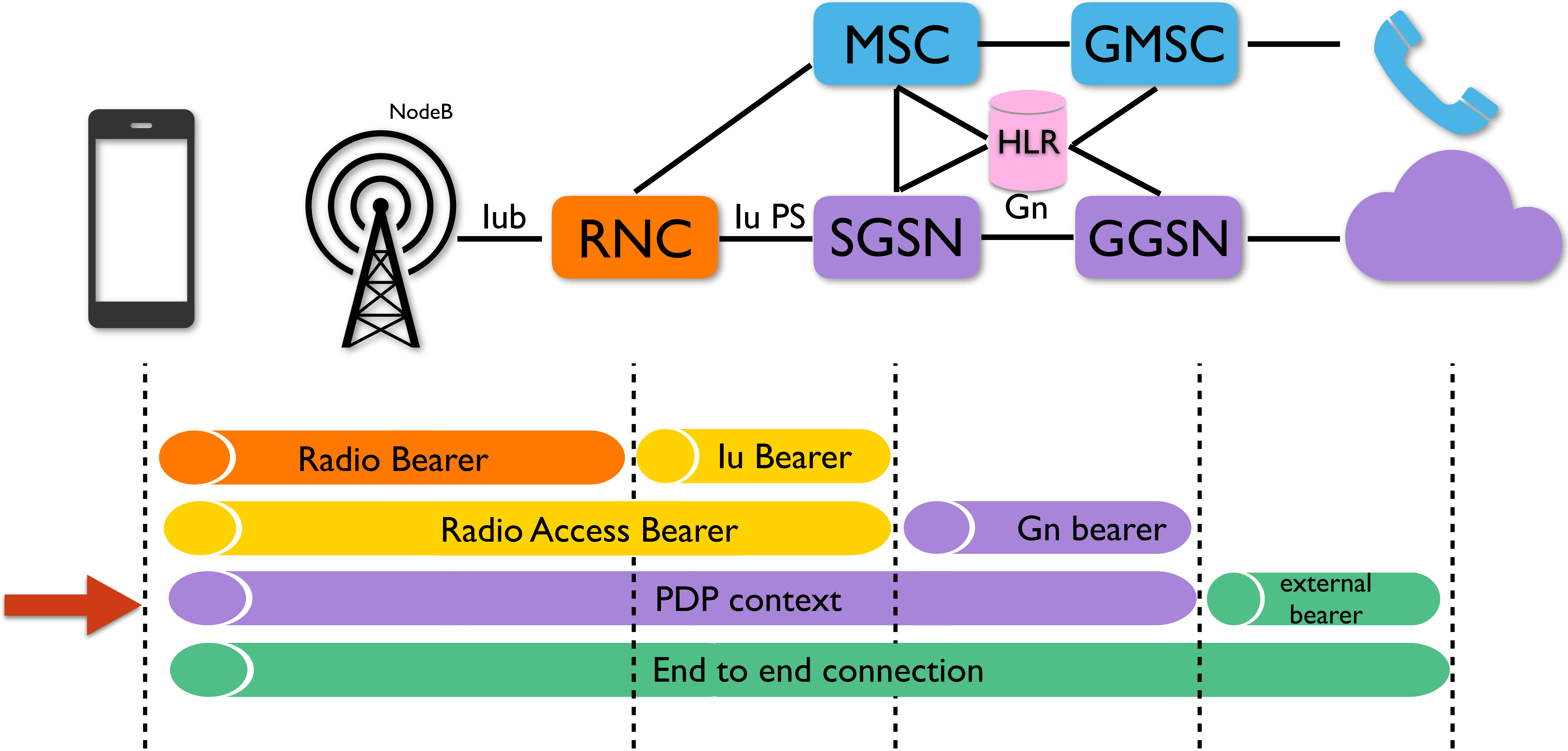
UMTS



UMTS


NodeB
Iub
RNC
Iu PS
SGSN
Gn
GGSN
MSC
GMSC
HLR
Radio Bearer
Iu Bearer
Radio Access Bearer
Gn bearer
PDP context
external bearer
End to end connection

UMTS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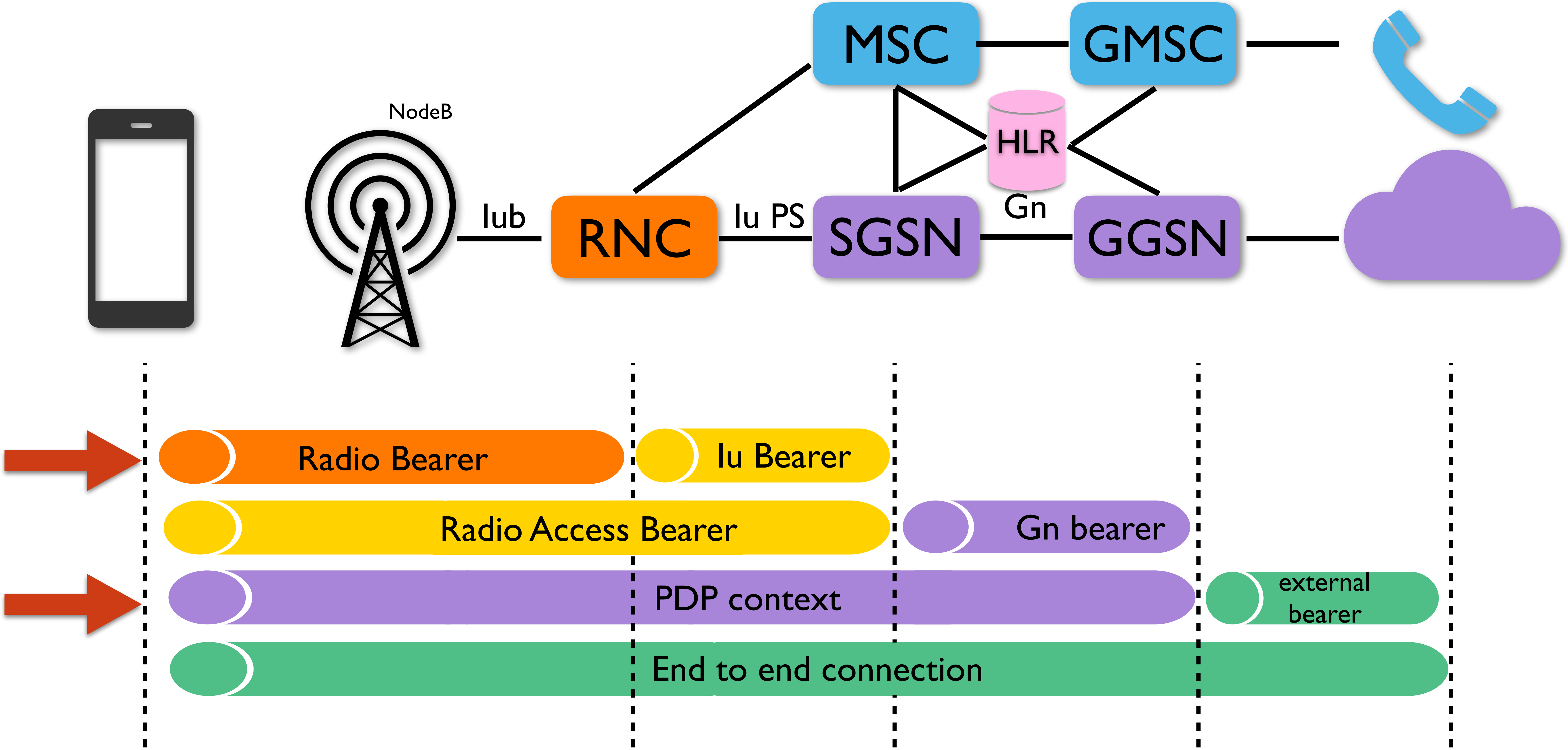

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Iub
RNC
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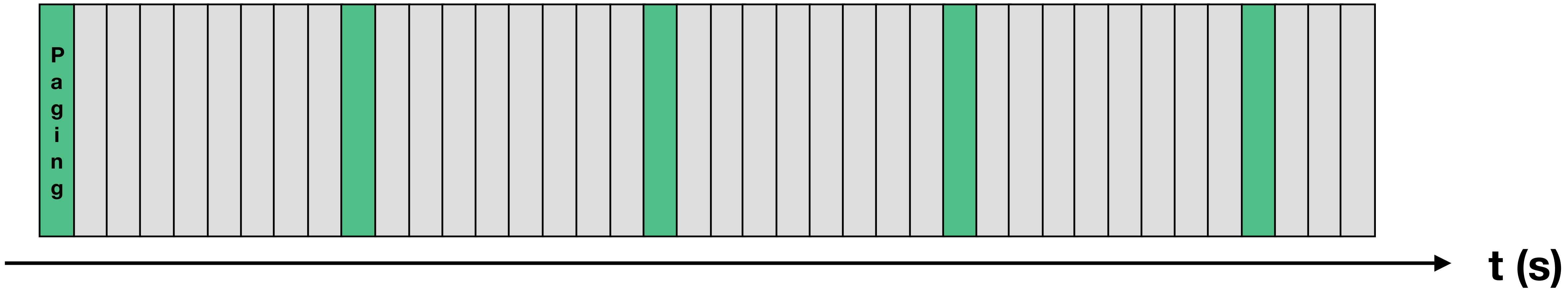
SGSN
Gn
GGSN
Radio Bearer
Iu Bearer
Radio Access Bearer
Gn bearer
PDP context
external bearer
End to end connection

I-DRX (DRX while Idle)

- En fonction de son état, un terminal doit rester en écoute de différents canaux
- Pour réduire la consommation d’énergie, un smartphone doit couper la radio autant que possible.
- Le traffic entrant est signalé sur le canal de Paging
- Ce canal est écouté périodiquement (en général ~1s)



Reduce Network Battery Drain

☆☆☆☆☆

Sommaire

Performance actions

Requests that your app makes to the network are a major cause of battery drain because they turn on the power-hungry mobile or Wi-Fi radios. Beyond the power needed to send and receive packets, these radios expend extra power just turning on and keeping awake. Something as simple as a network request every 15 seconds can keep the mobile radio on continuously and quickly use up battery power.

Reduce Network Battery Drain

☆☆☆☆☆

Sommaire

Performance actions

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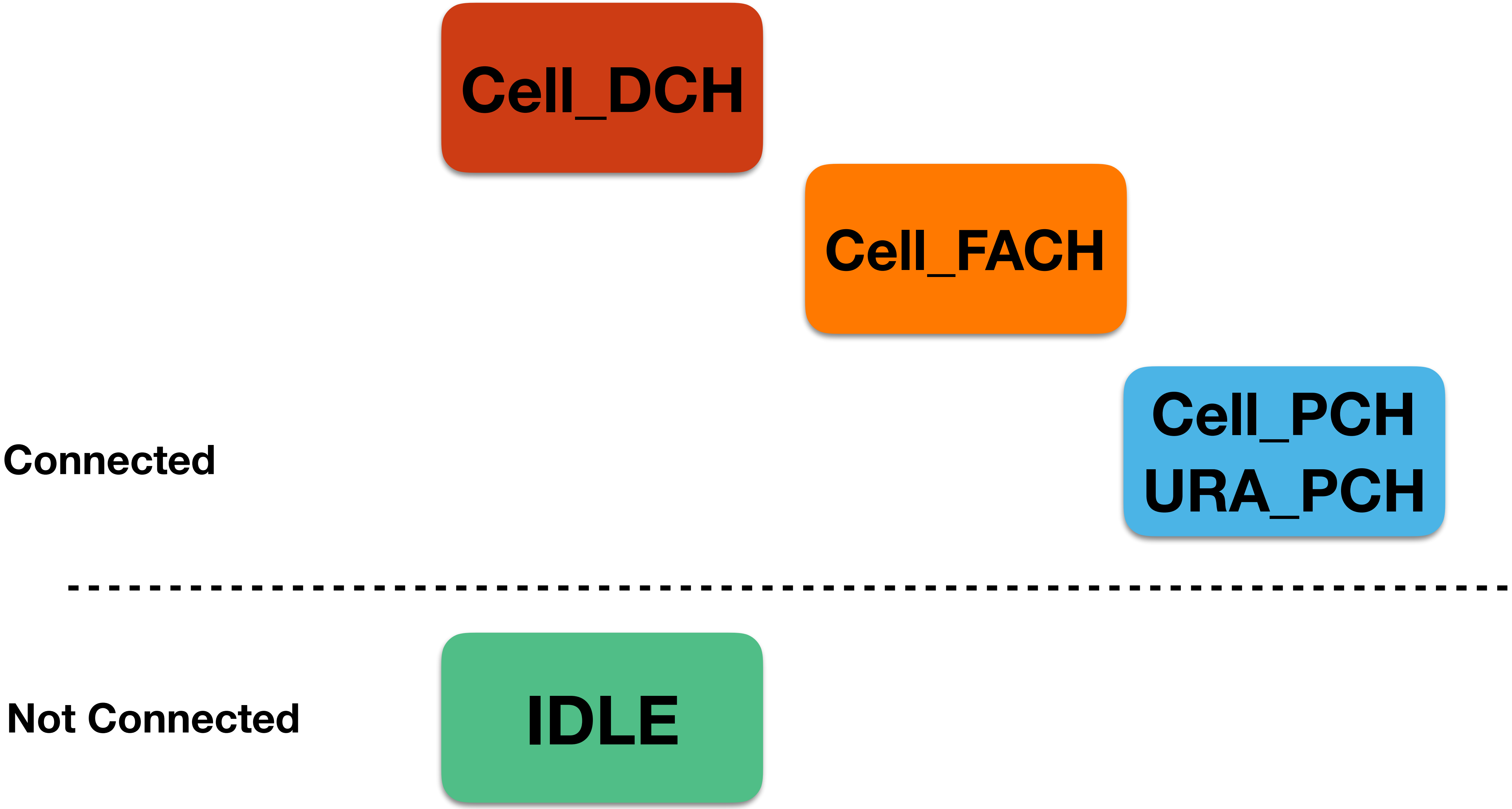
RRC (Radio Resource Control)

- Le RRC se décline sous plusieurs formes:
  - une fonction implantée dans le RNC (Radio Network Controller)
  - une connection entre un terminal (UE) et la fonction RRC
  - un protocole (du plan de contrôle)
  - une machine à états
- Objectifs:
  - établissement/configuration des bearers radio
  - paging/notification
  - Contrôle de QoS
  - …

UMTS RRC



Cell_DCH

Cell_FACH

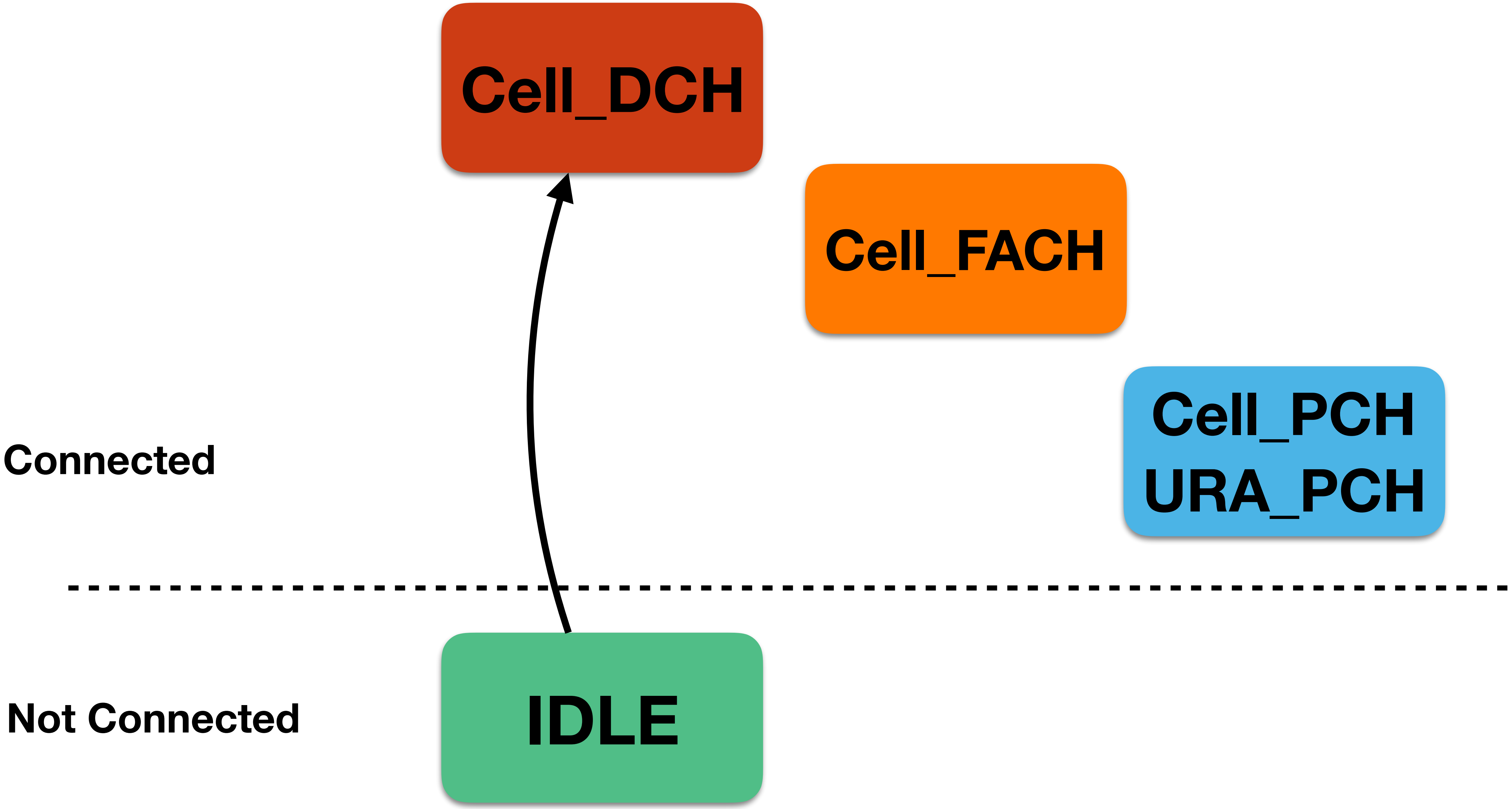
Cell_PCH
URA_PCH

Connected

Not Connected

IDLE

UMTS RRC



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URA_PCH

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Not Connected

IDLE

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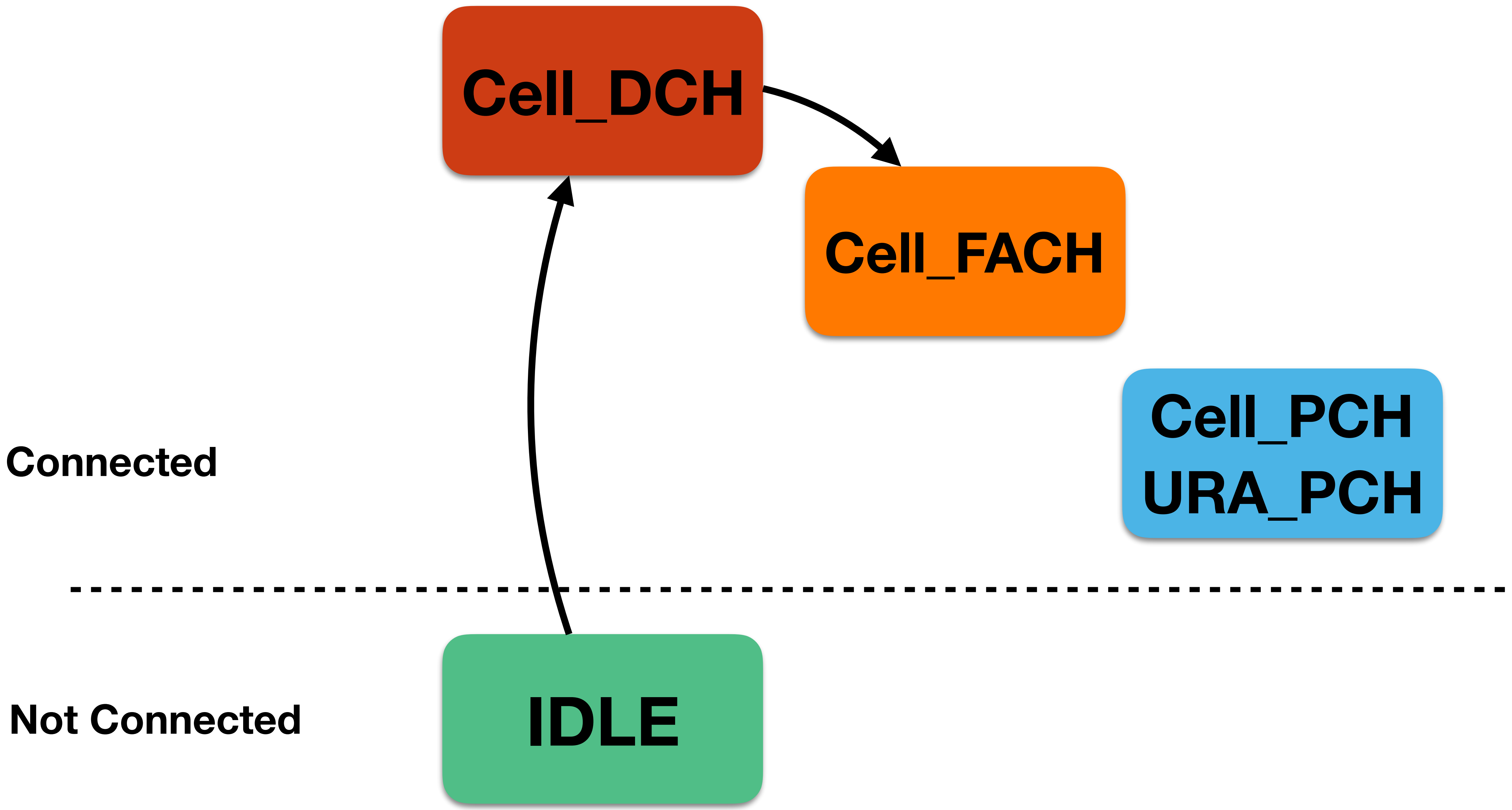

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Cell_PCH
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Not Connected

IDLE

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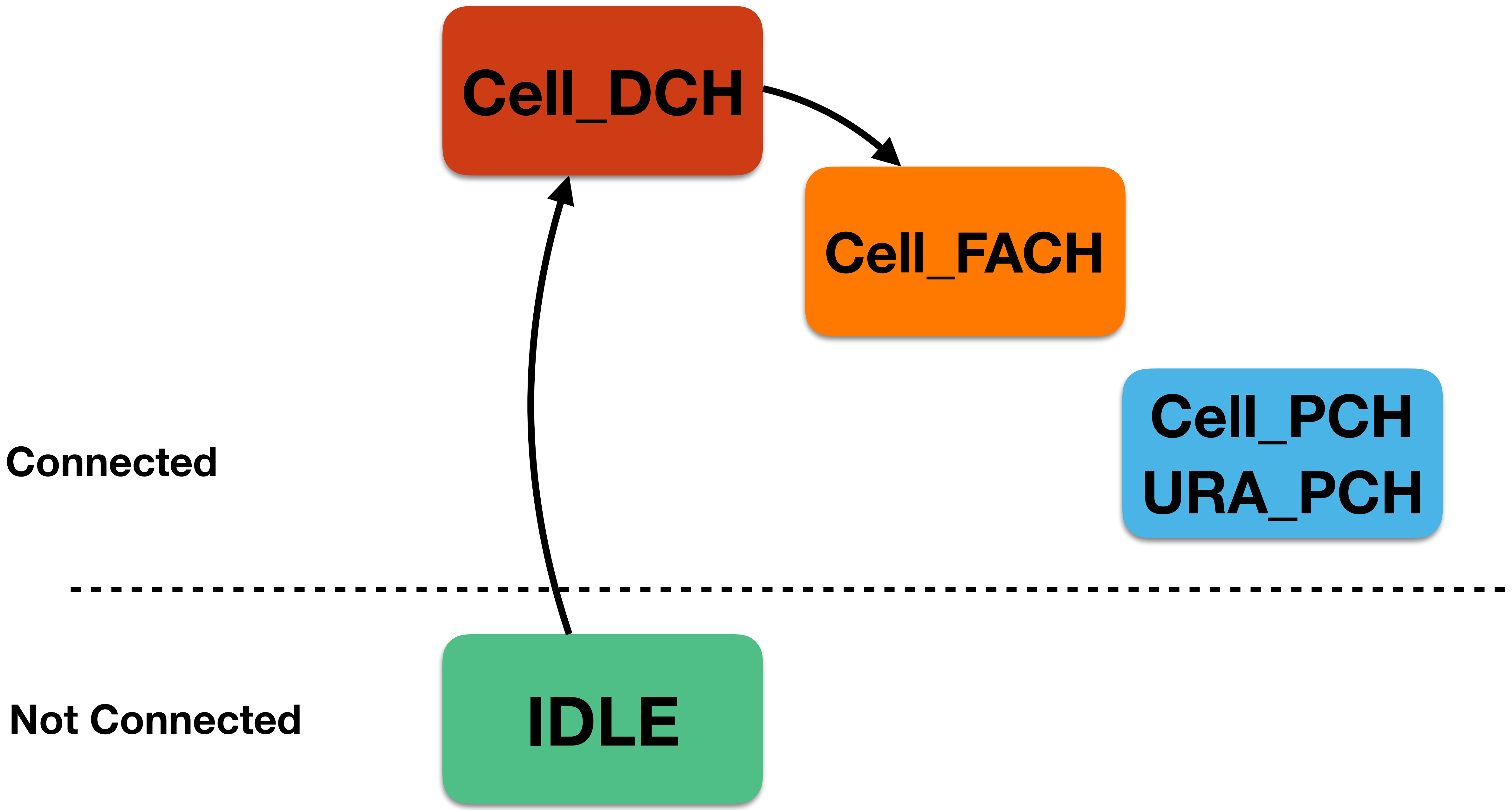

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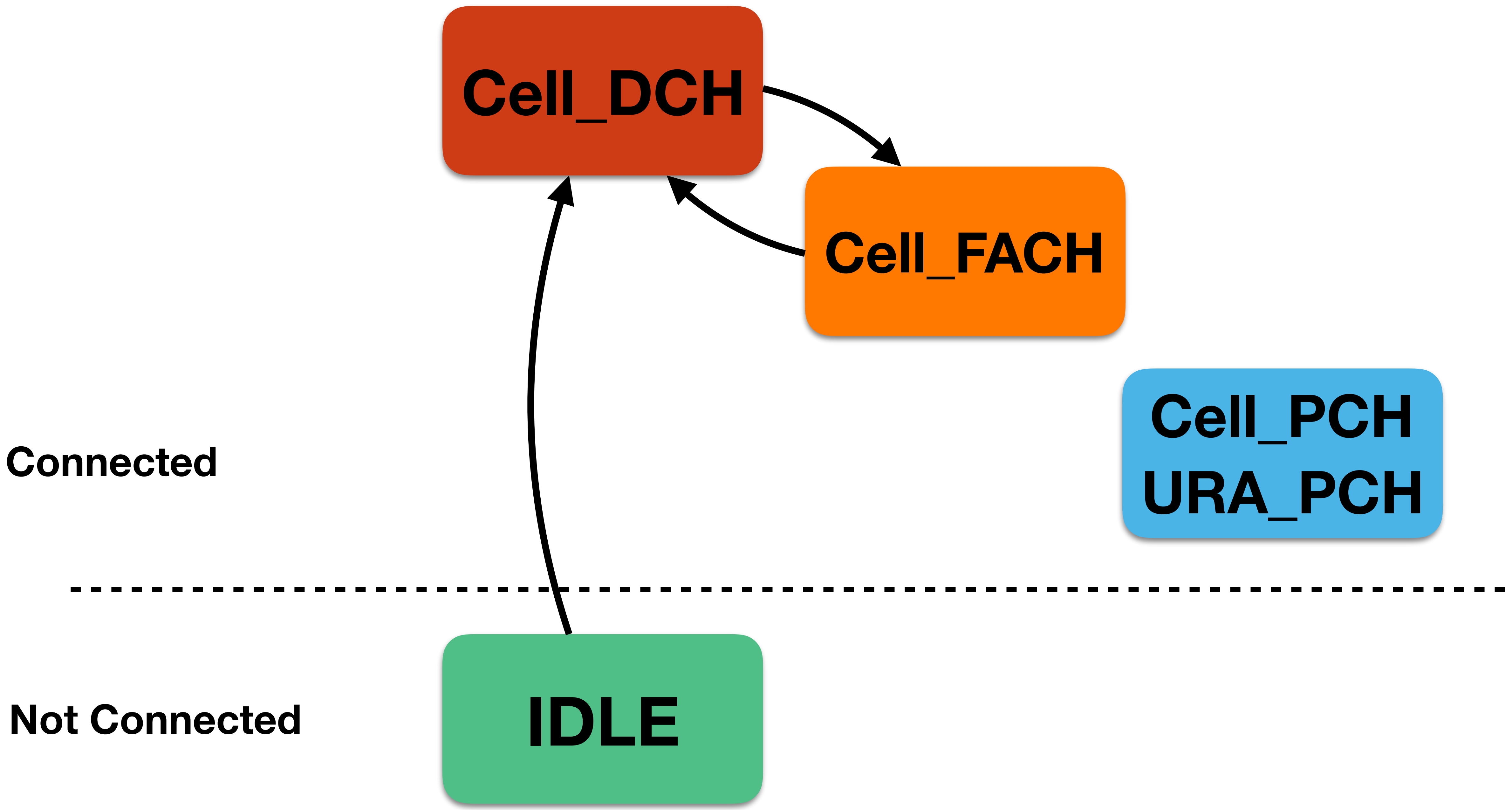
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IDLE

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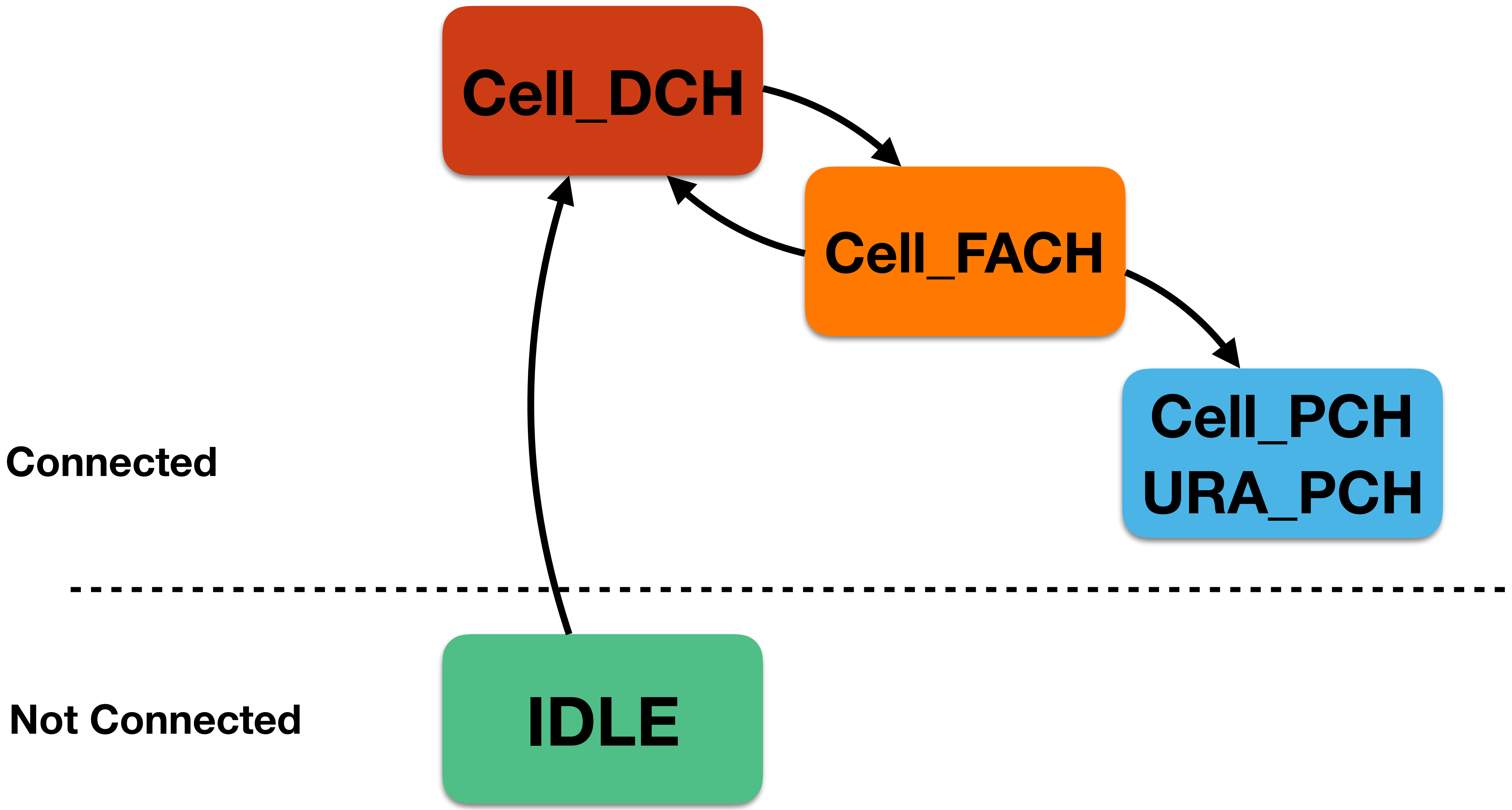

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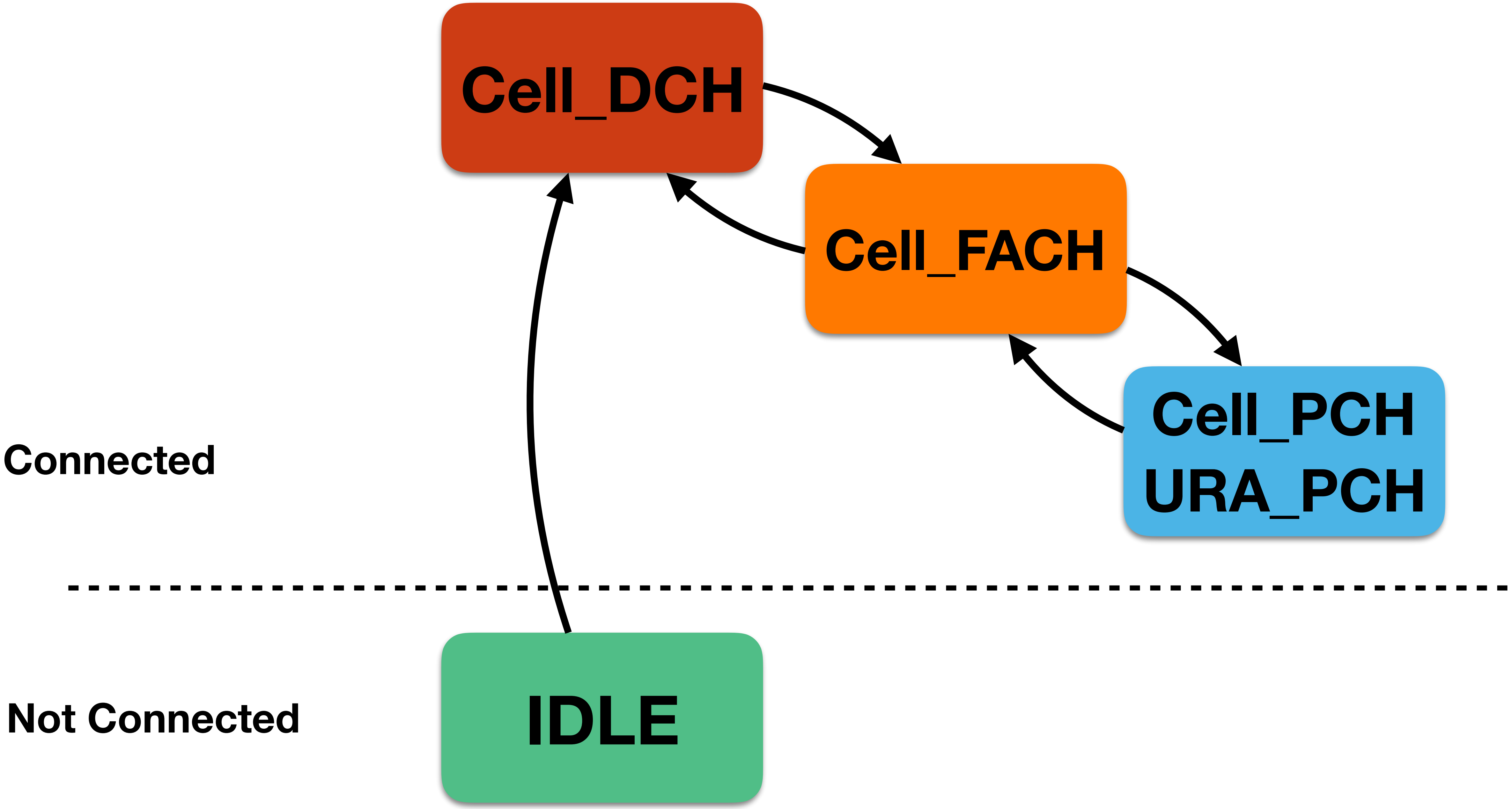
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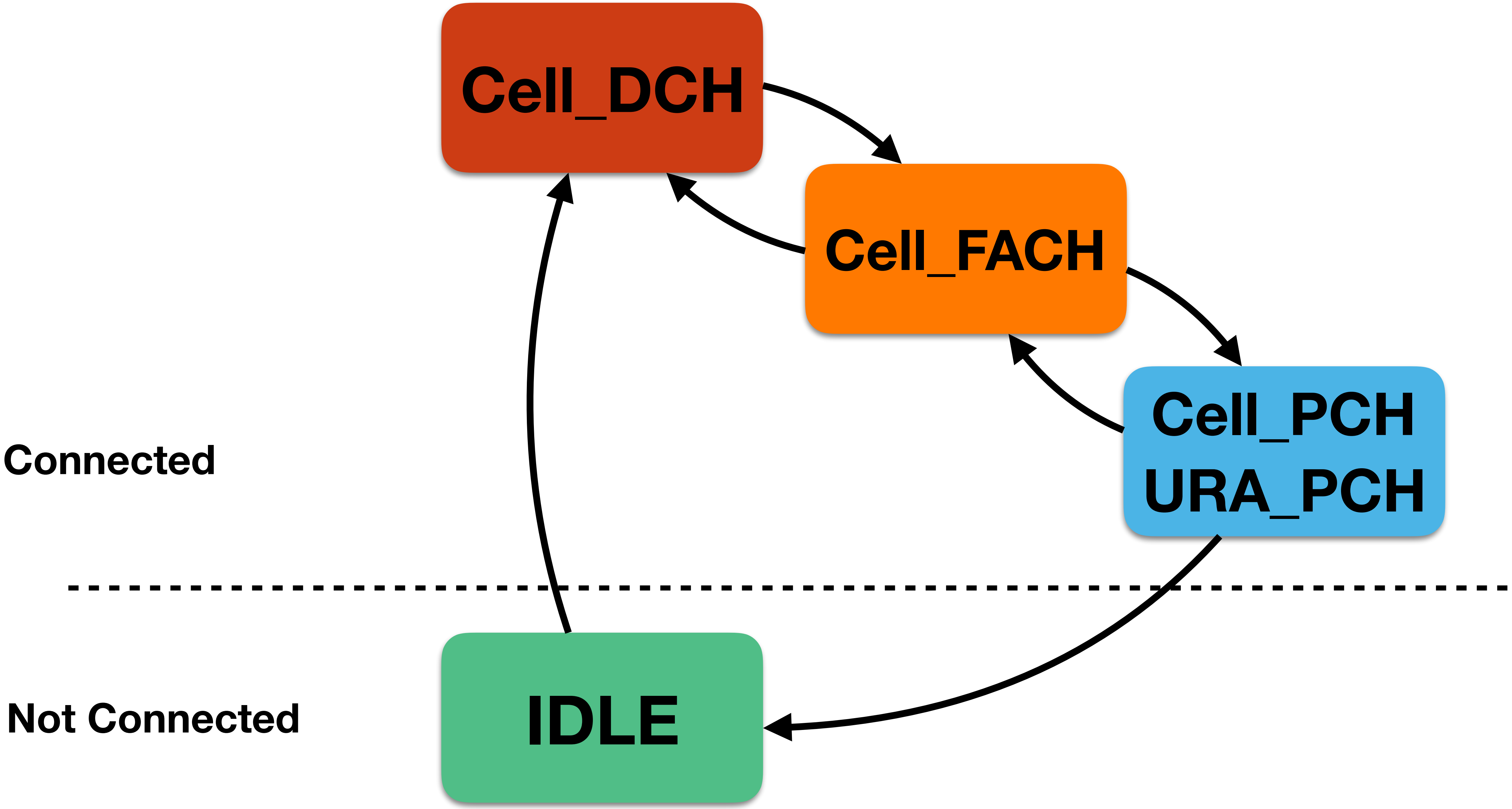

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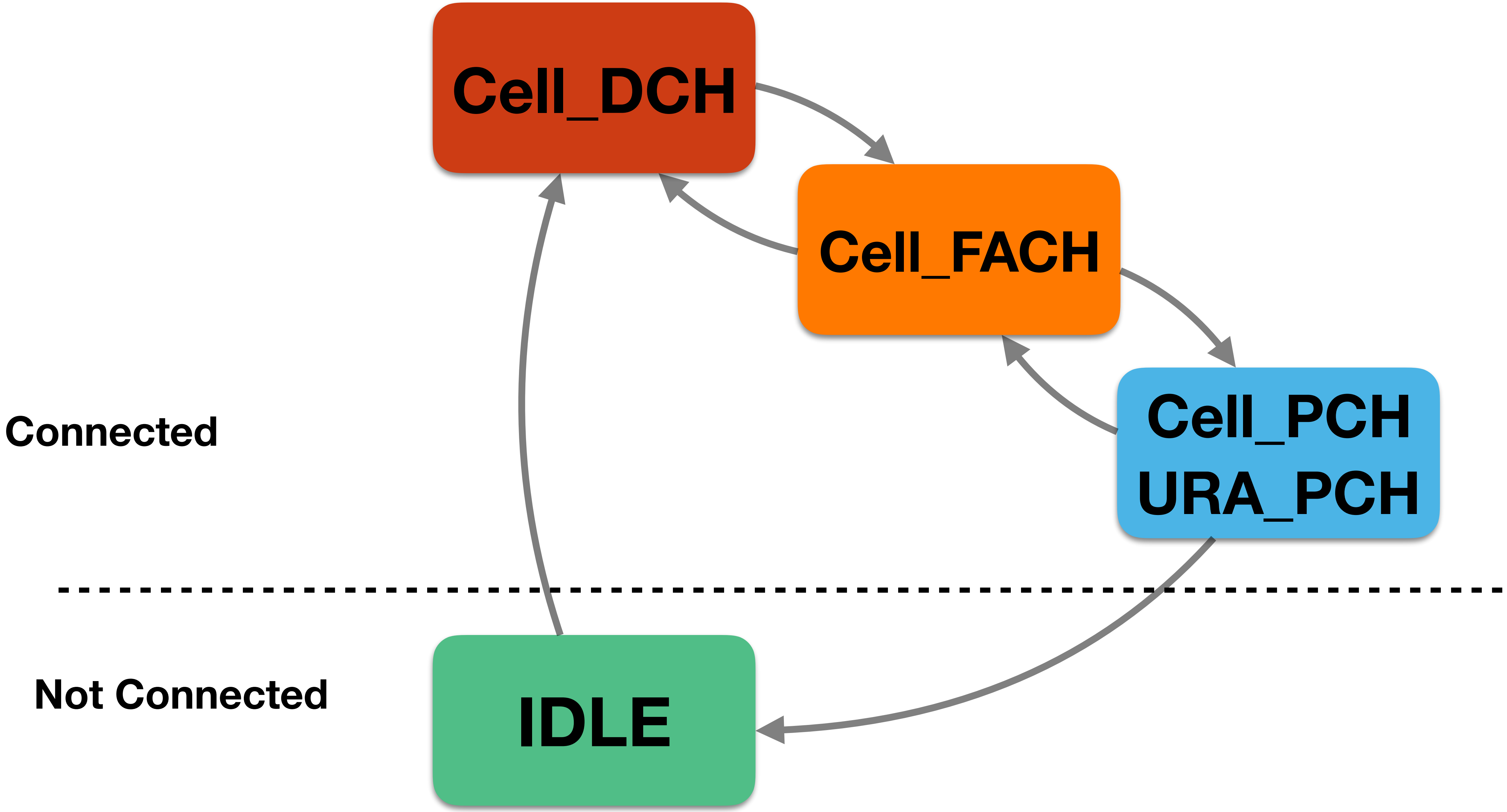
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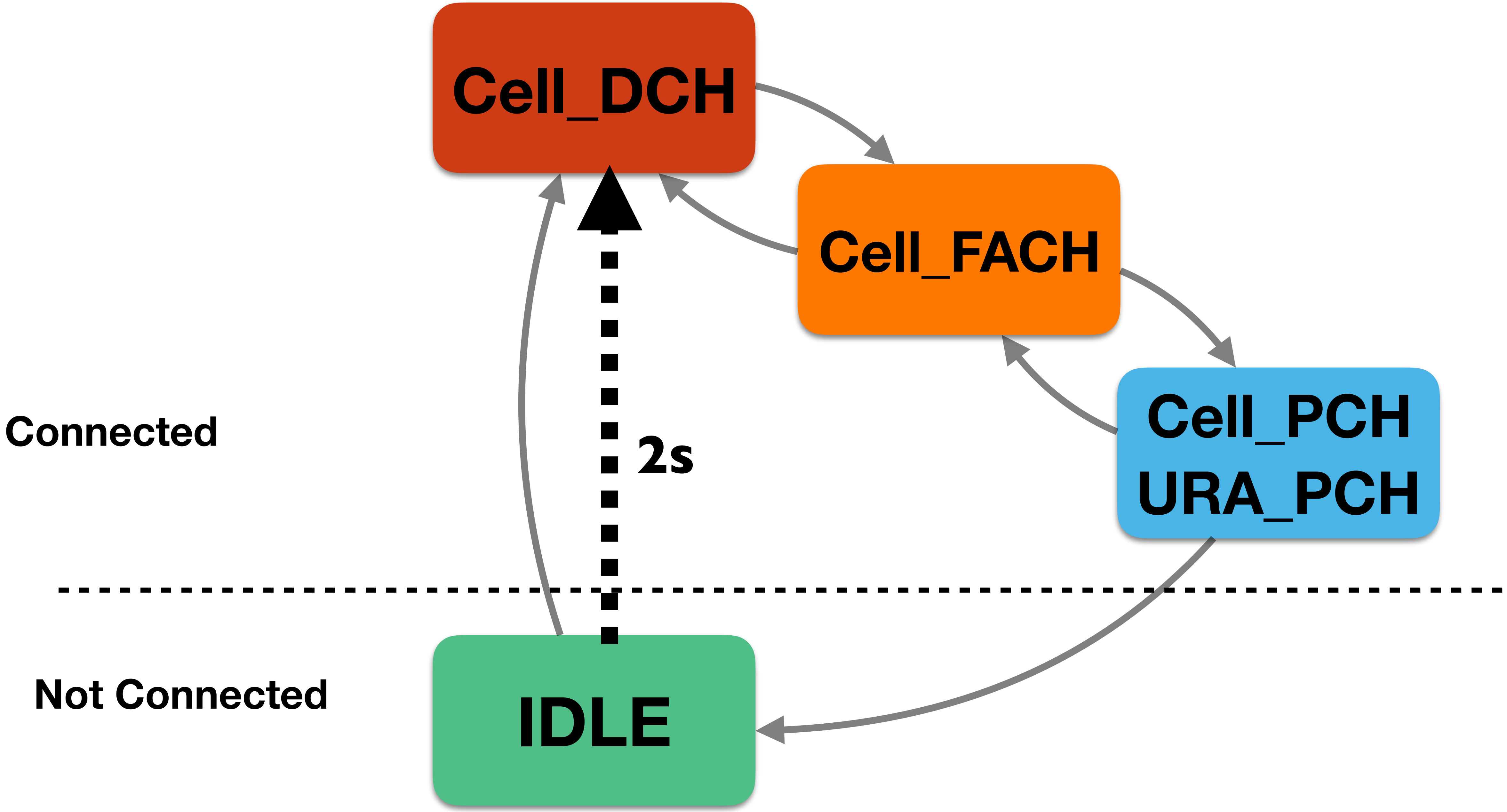
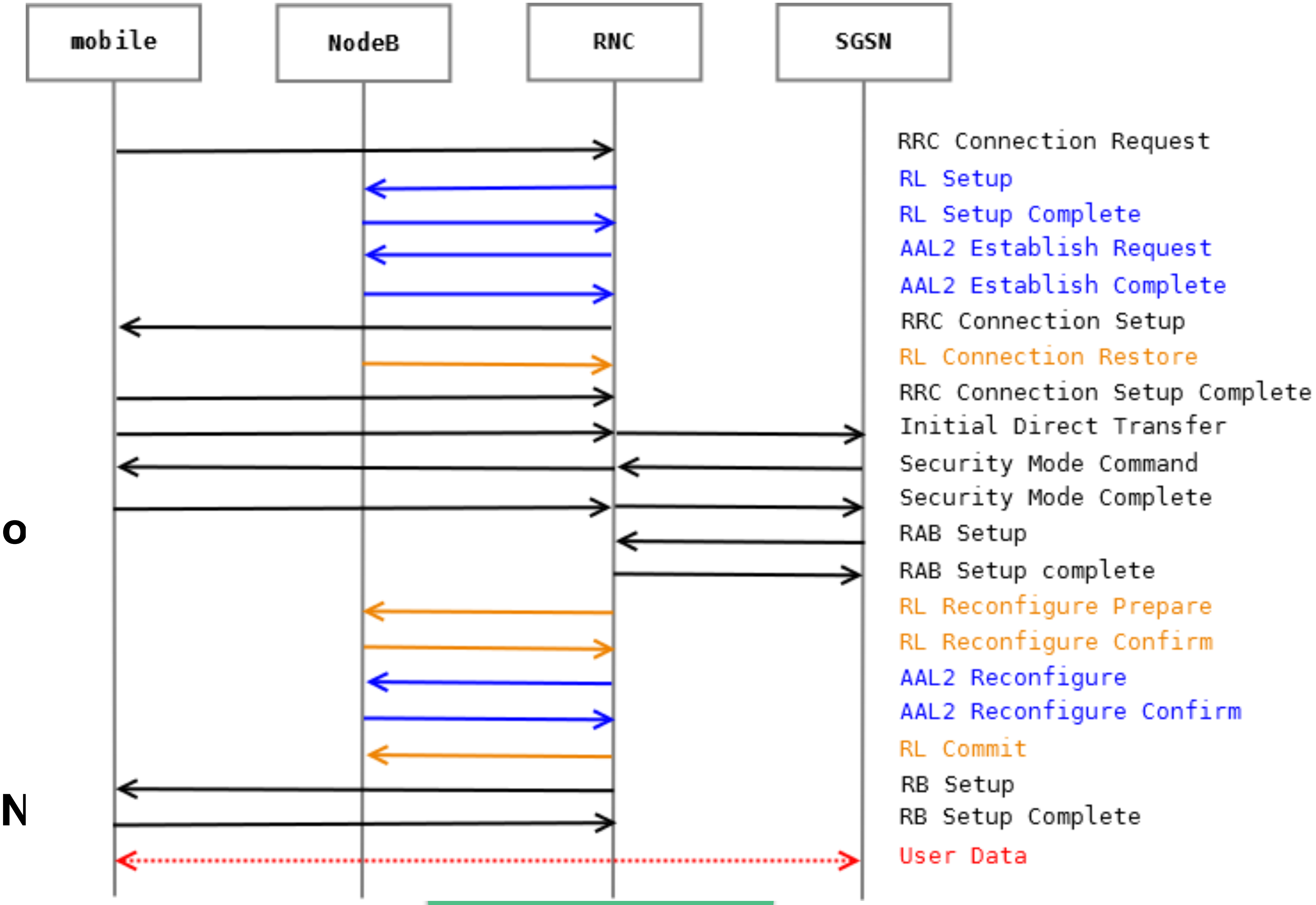

Cell_DCH
Cell_FACH
Cell_PCH
URA_PCH
2s
Connected
Not Connected
IDLE

UMTS RRC



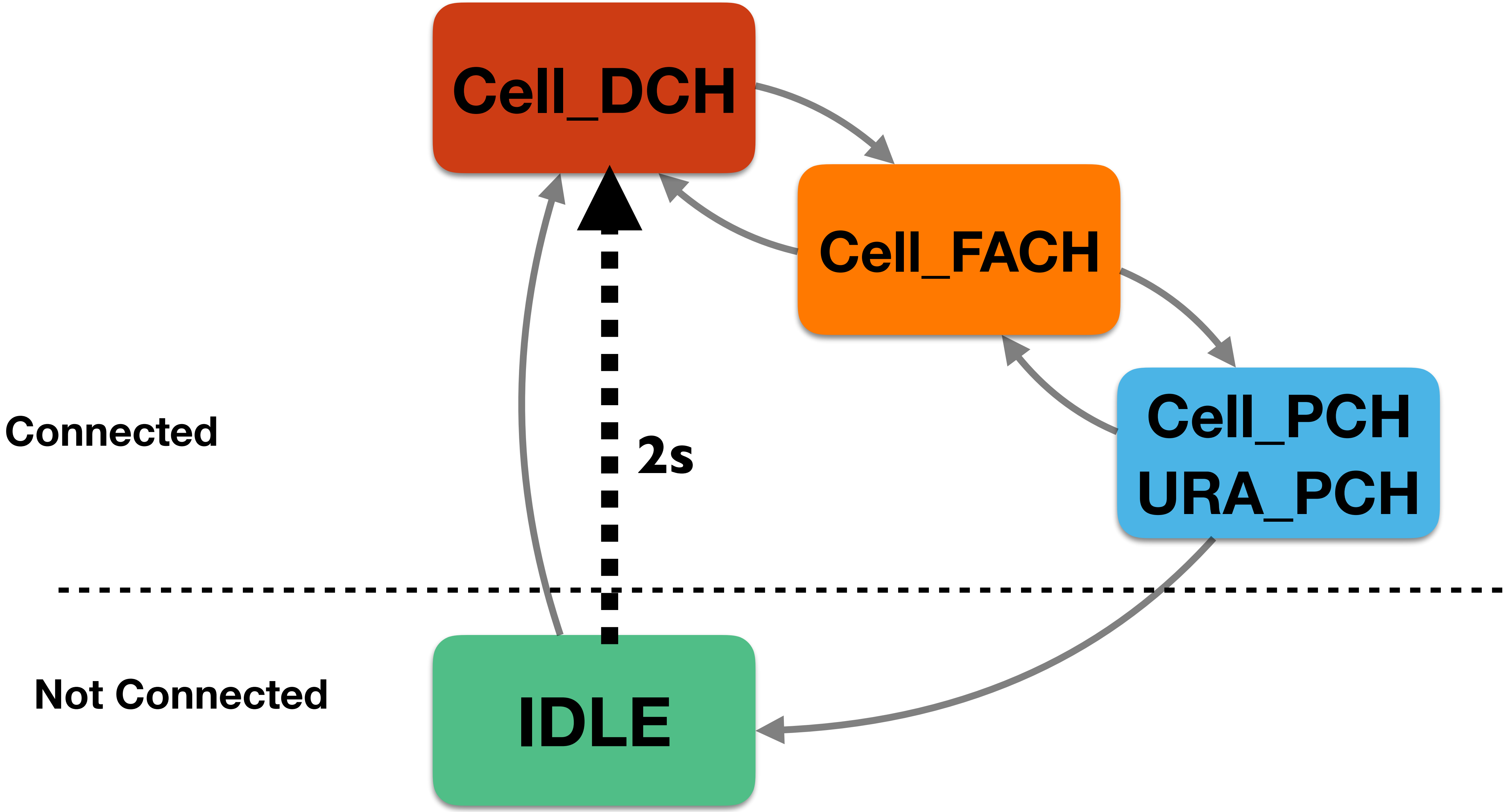
Co

N

_PCH

_PCH

UMTS RRC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Cell_PCH
URA_PCH
2s
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IDLE

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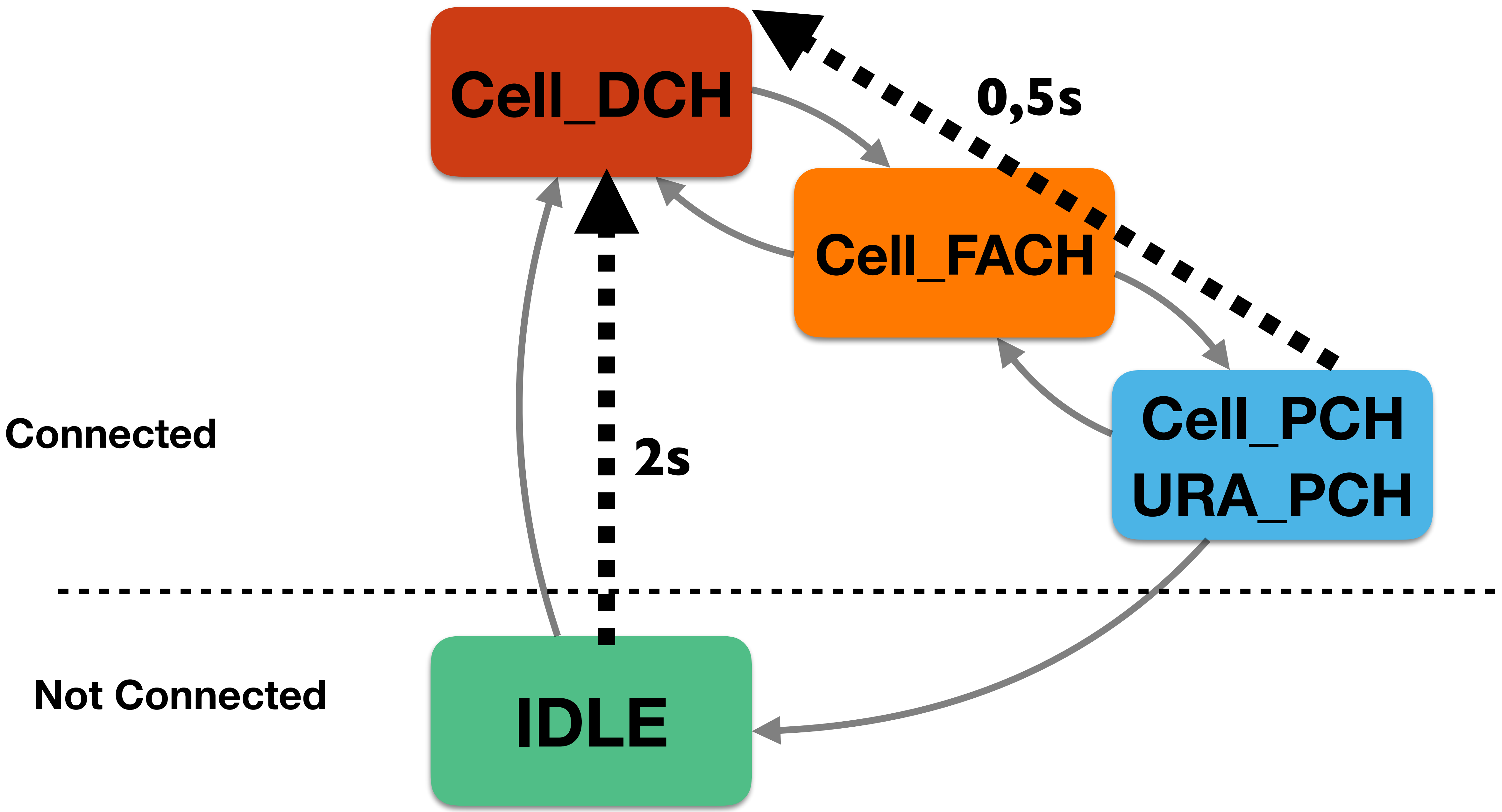
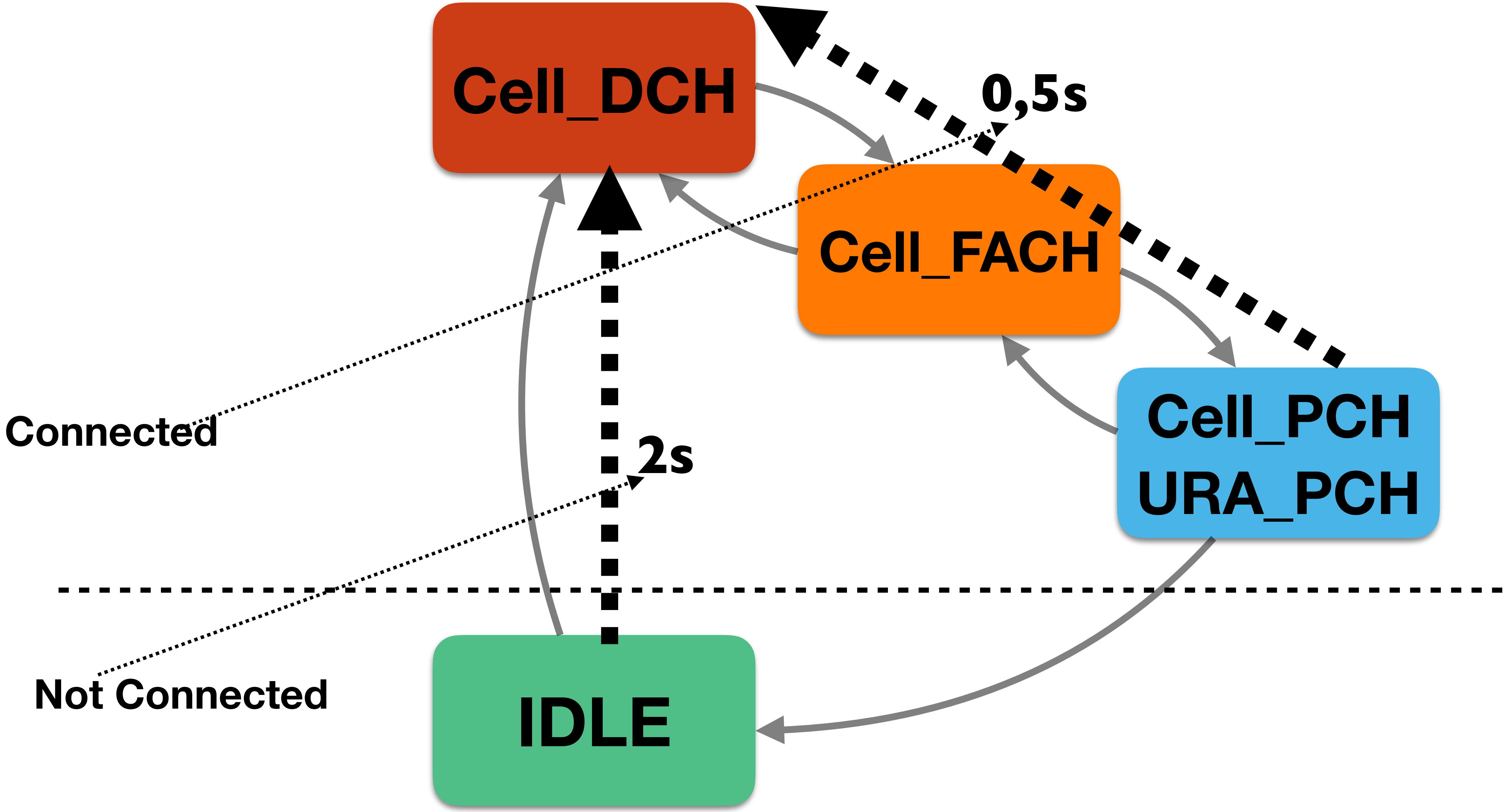
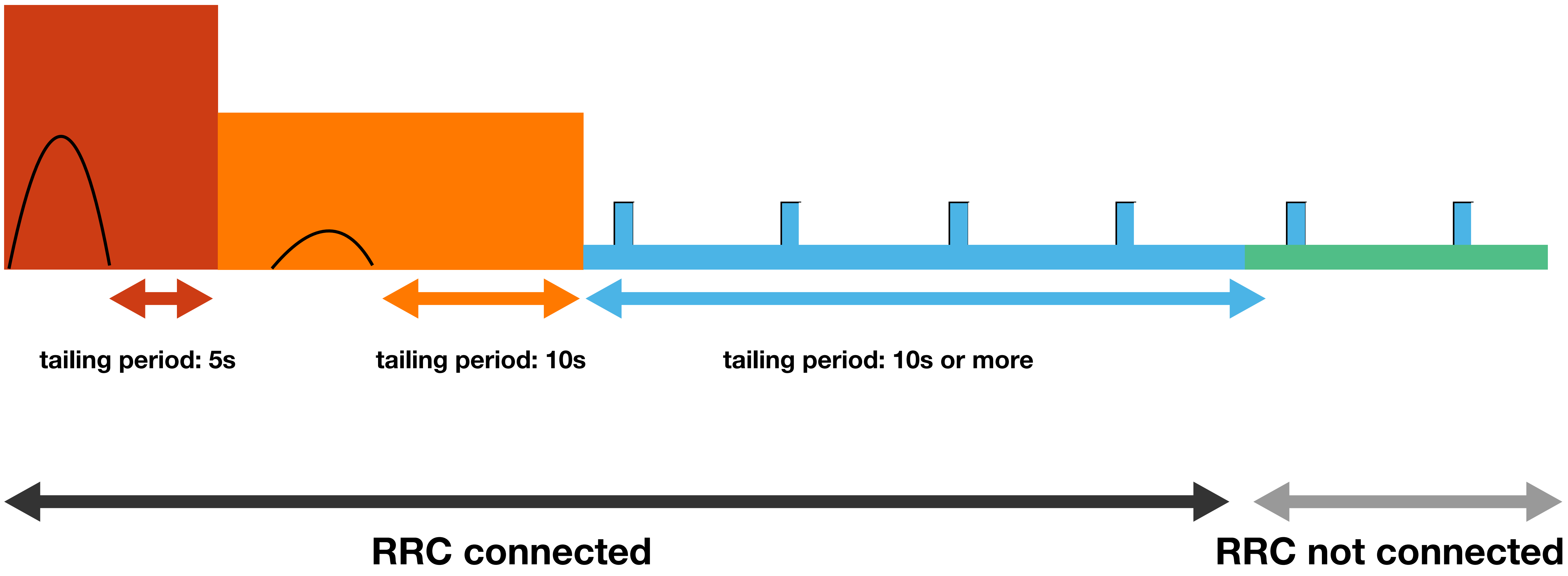

Cell_DCH
0,5s
Cell_FACH
Connected
2s
Cell_PCH
URA_PCH
Not Connected
IDLE

UMTS RRC

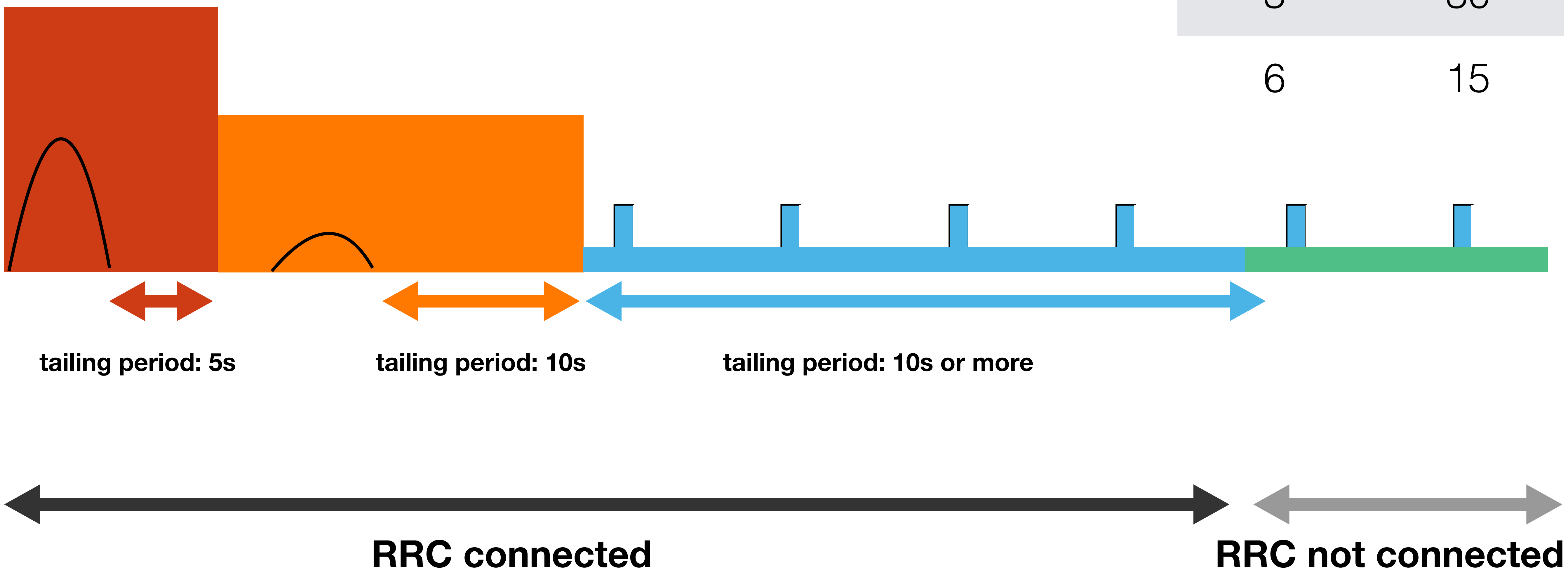

Cell_DCH
0,5s
Cell_FACH
Cell_PCH
URA_PCH
Connected
2s
Not Connected
IDLE

Tailing periods



Tailing periods

tail DCH	tail FACH
10	45
3	30
6	15



Callback for use with `ConnectivityManager.addDefaultNetworkActiveListener(ConnectivityManager.OnNetworkActiveListener)` to find out when the system default network has gone in to a high power state.

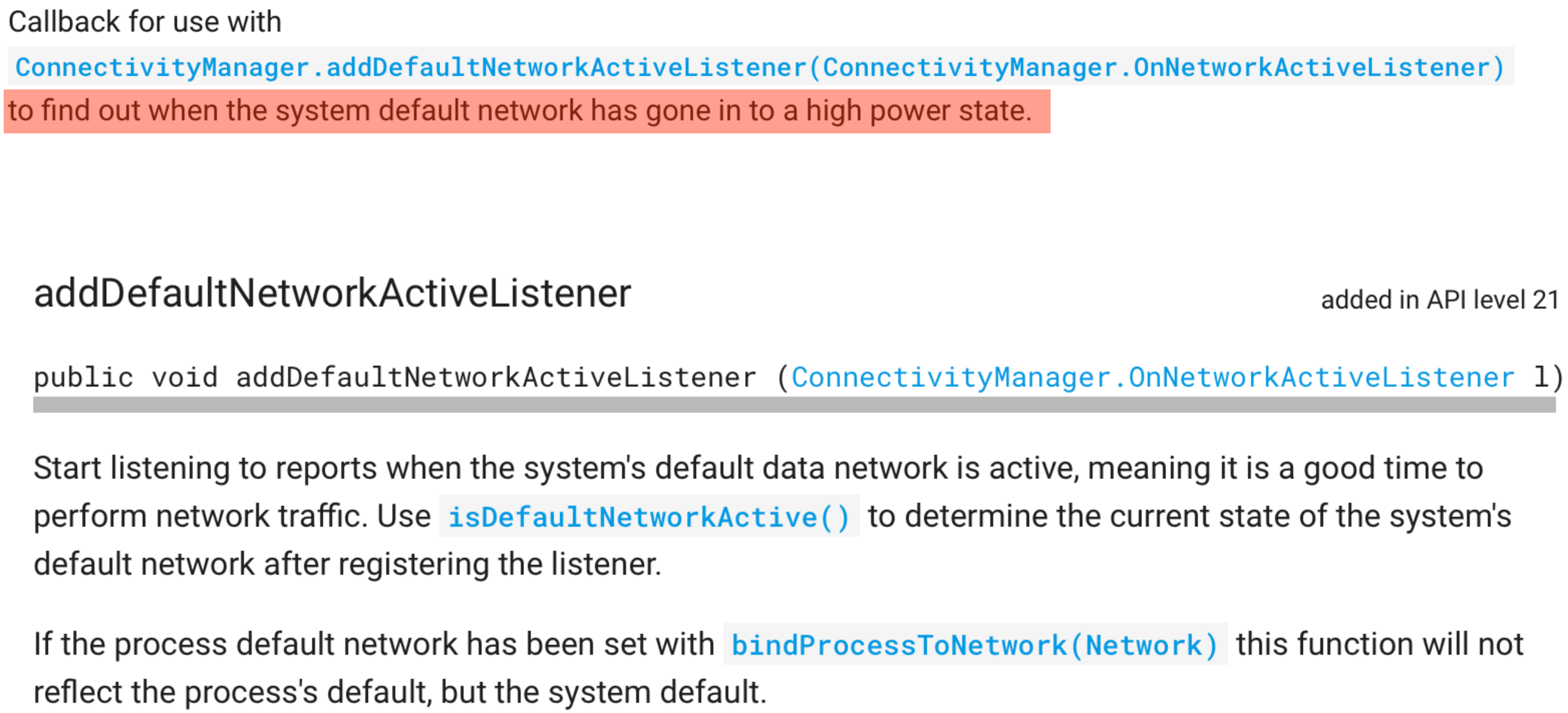
addDefaultNetworkActiveListener

added in API level 21

```
public void addDefaultNetworkActiveListener (ConnectivityManager.OnNetworkActiveListener l)
```

Start listening to reports when the system's default data network is active, meaning it is a good time to perform network traffic. Use `isDefaultNetworkActive()` to determine the current state of the system's default network after registering the listener.

If the process default network has been set with `bindProcessToNetwork(Network)` this function will not reflect the process's default, but the system default.



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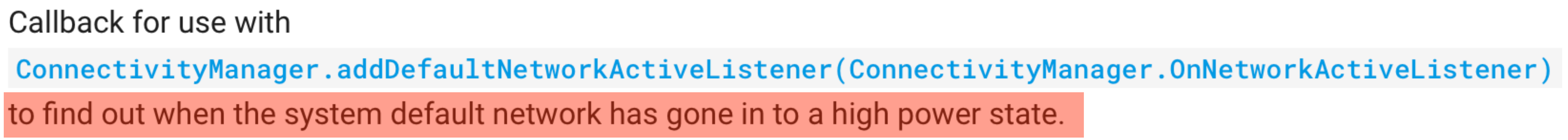

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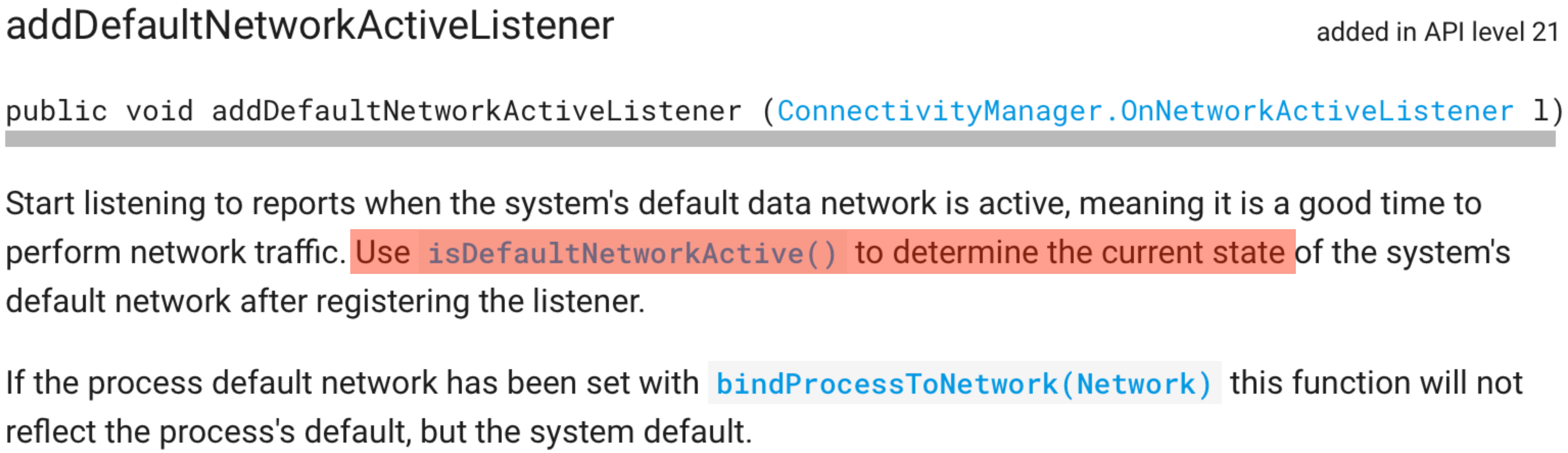

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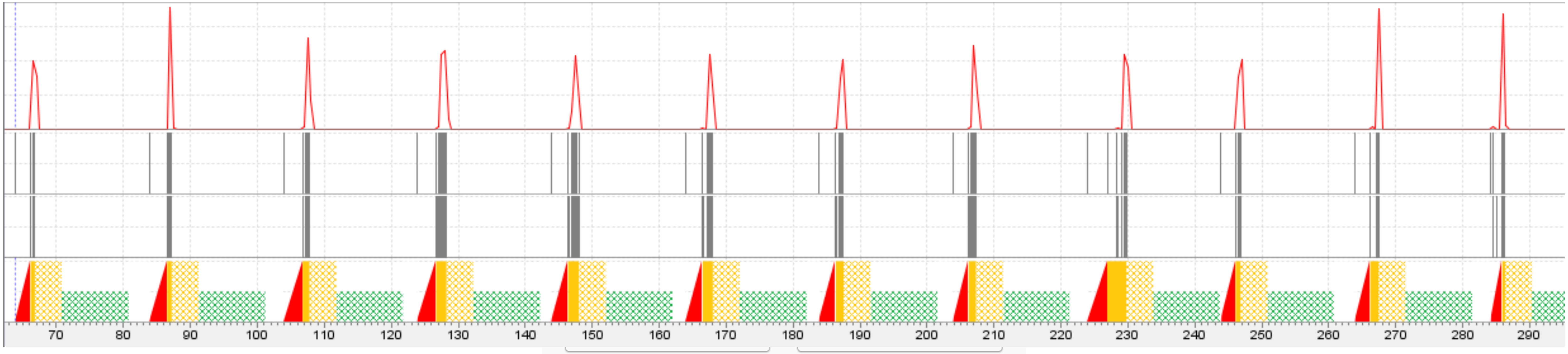
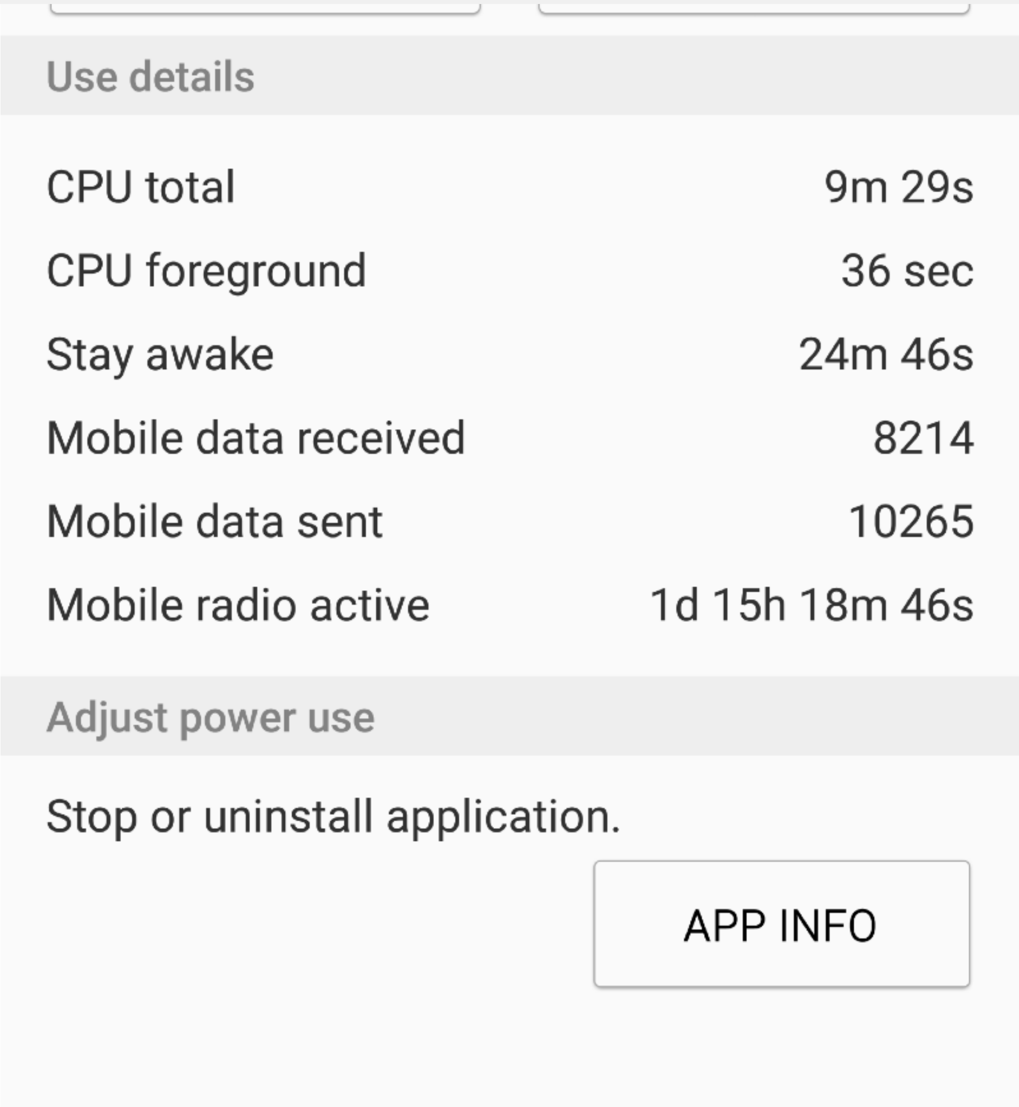




Use details

CPU total	9m 29s
CPU foreground	36 sec
Stay awake	24m 46s
Mobile data received	8214
Mobile data sent	10265
Mobile radio active	1d 15h 18m 46s

Adjust power use

Stop or uninstall application.

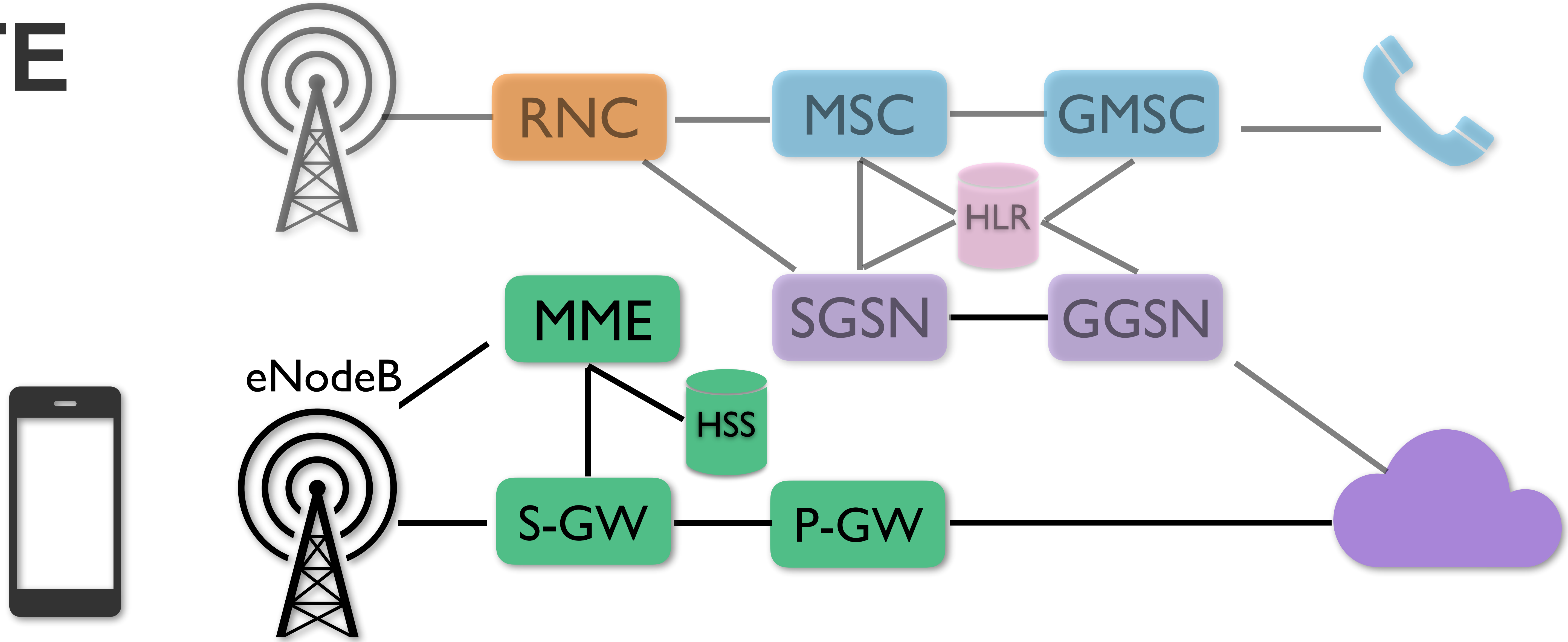
cDRX

Connected DRX

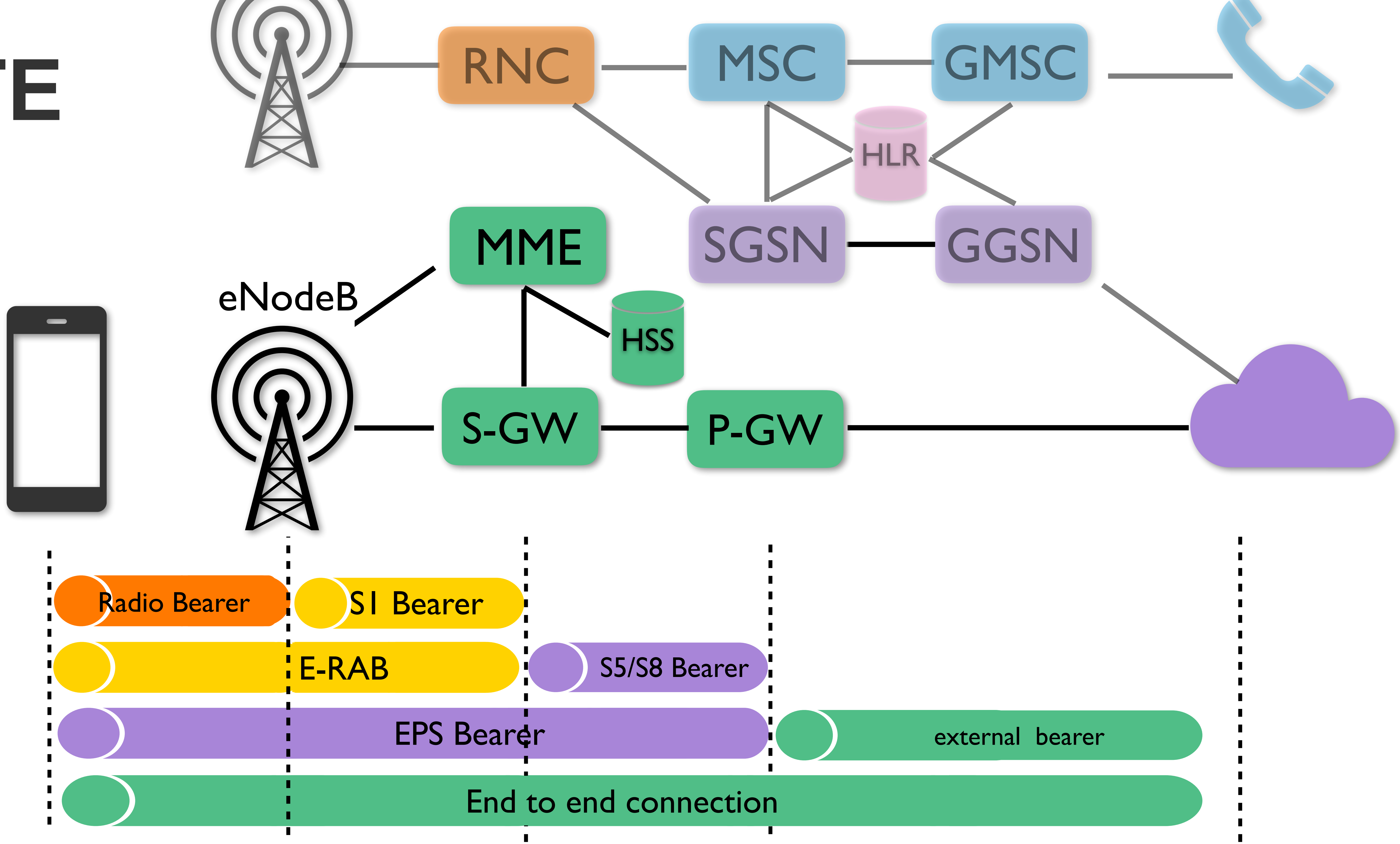
cDRX

Connected DRX

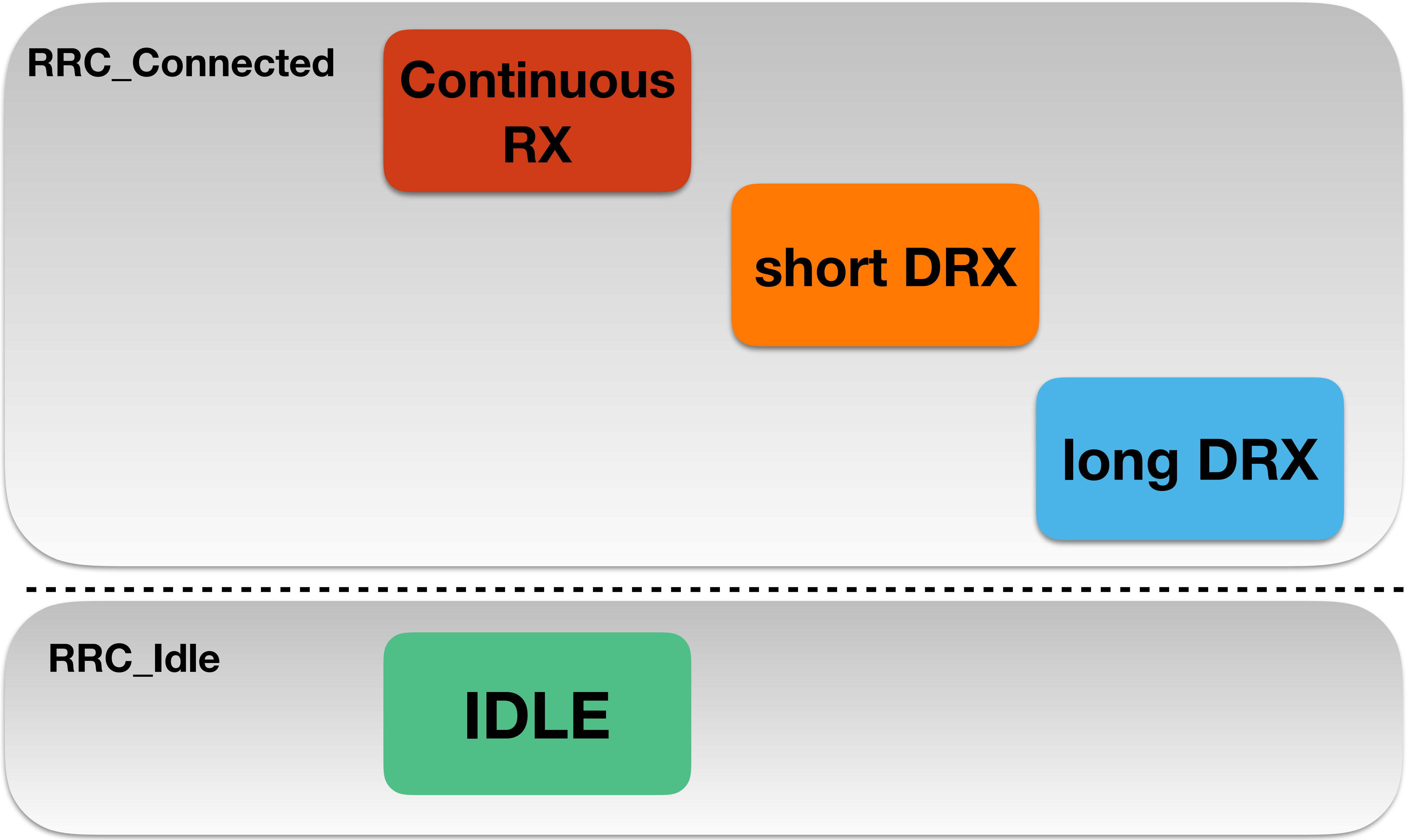
LTE



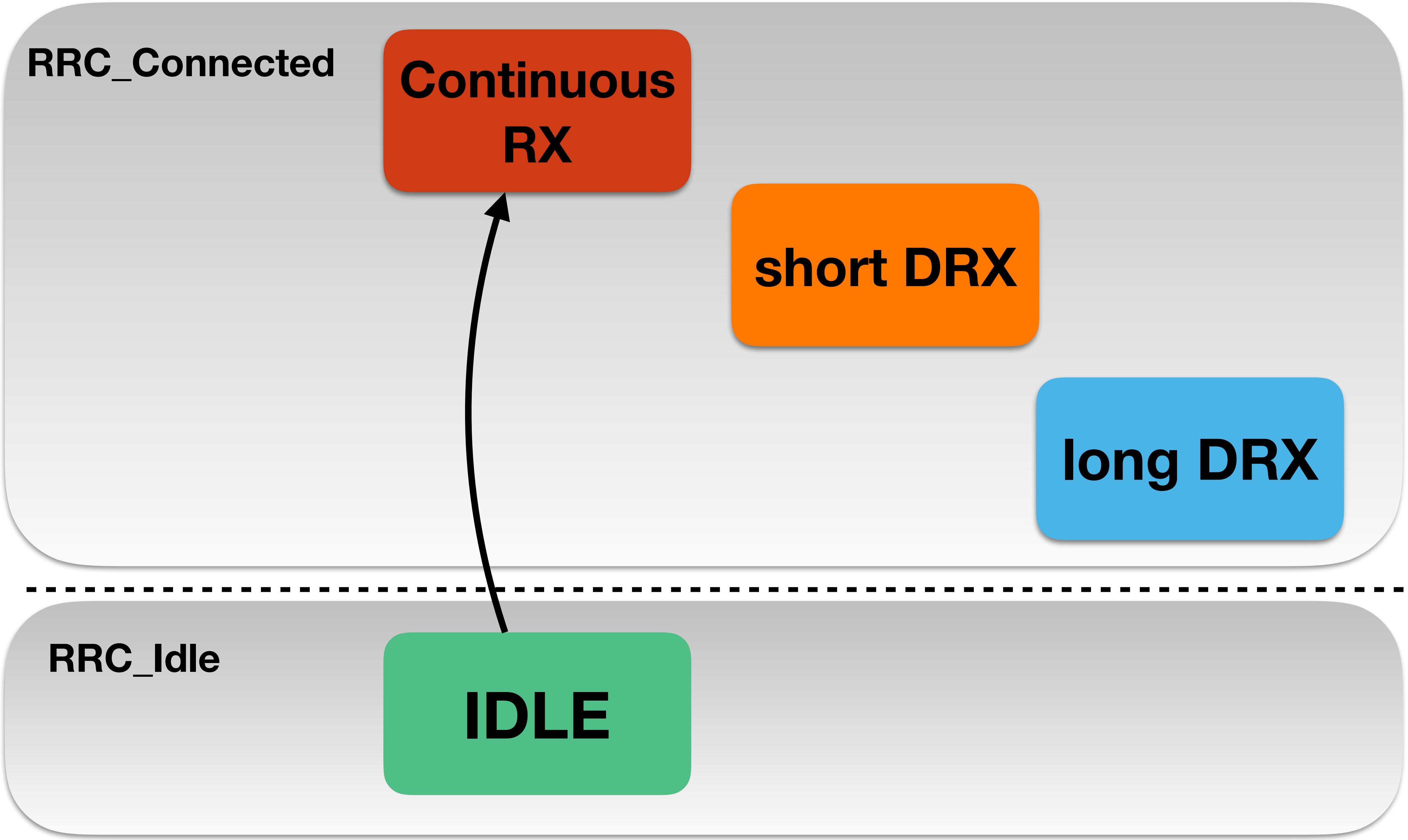
LTE


RNC
MSC
GMSC
HLR
MME
SGSN
GGSN
eNodeB
HSS
S-GW
P-GW
Radio Bearer
S1 Bearer
E-RAB
S5/S8 Bearer
EPS Bearer
external bearer
End to end connection

LTE RRC


RRC_Connected
Continuous RX
short DRX
long DRX
RRC_Idle
IDLE

LTE RRC



RRC_Connected

Continuous RX

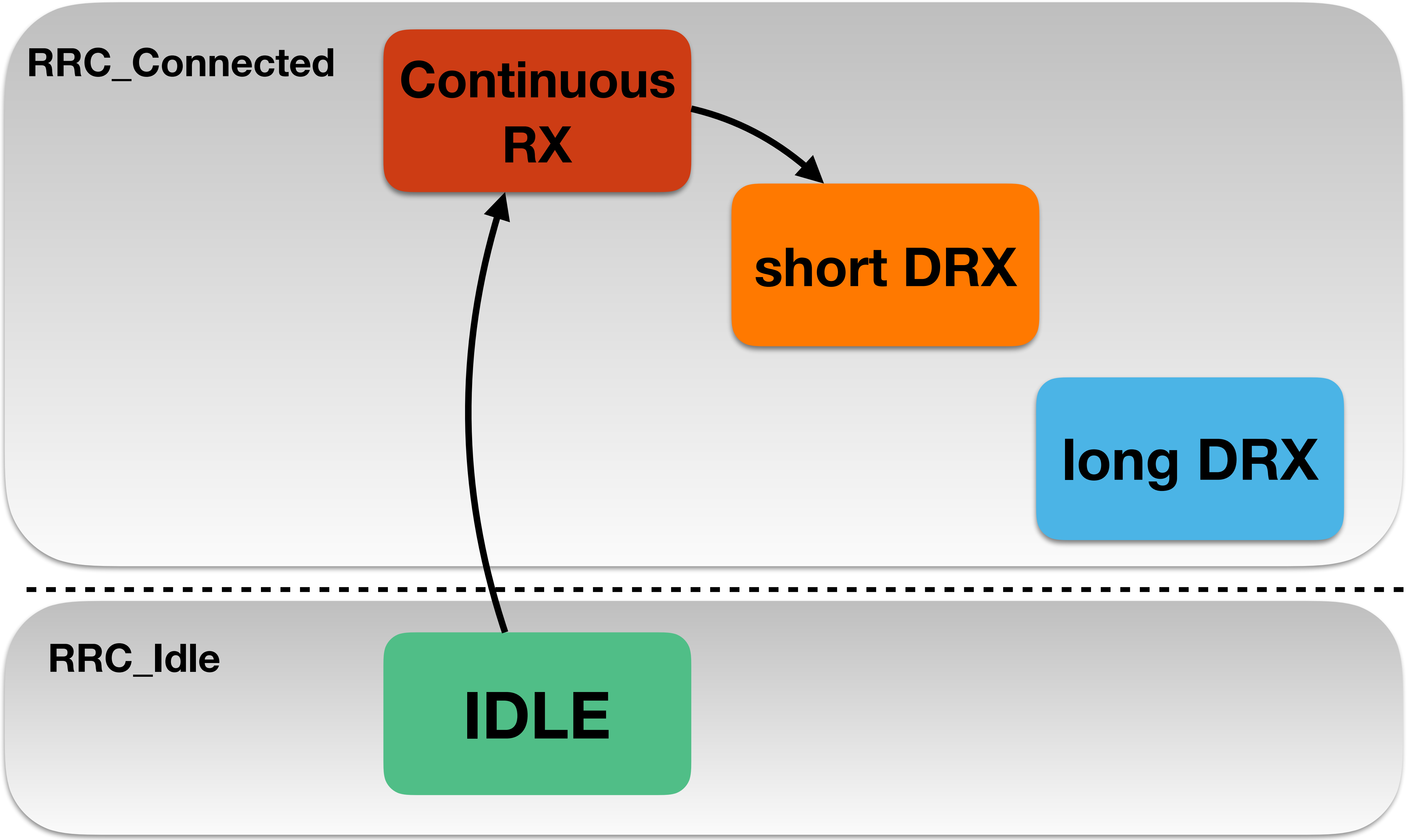
short DRX

long DRX

RRC_Idle

IDLE

LTE RRC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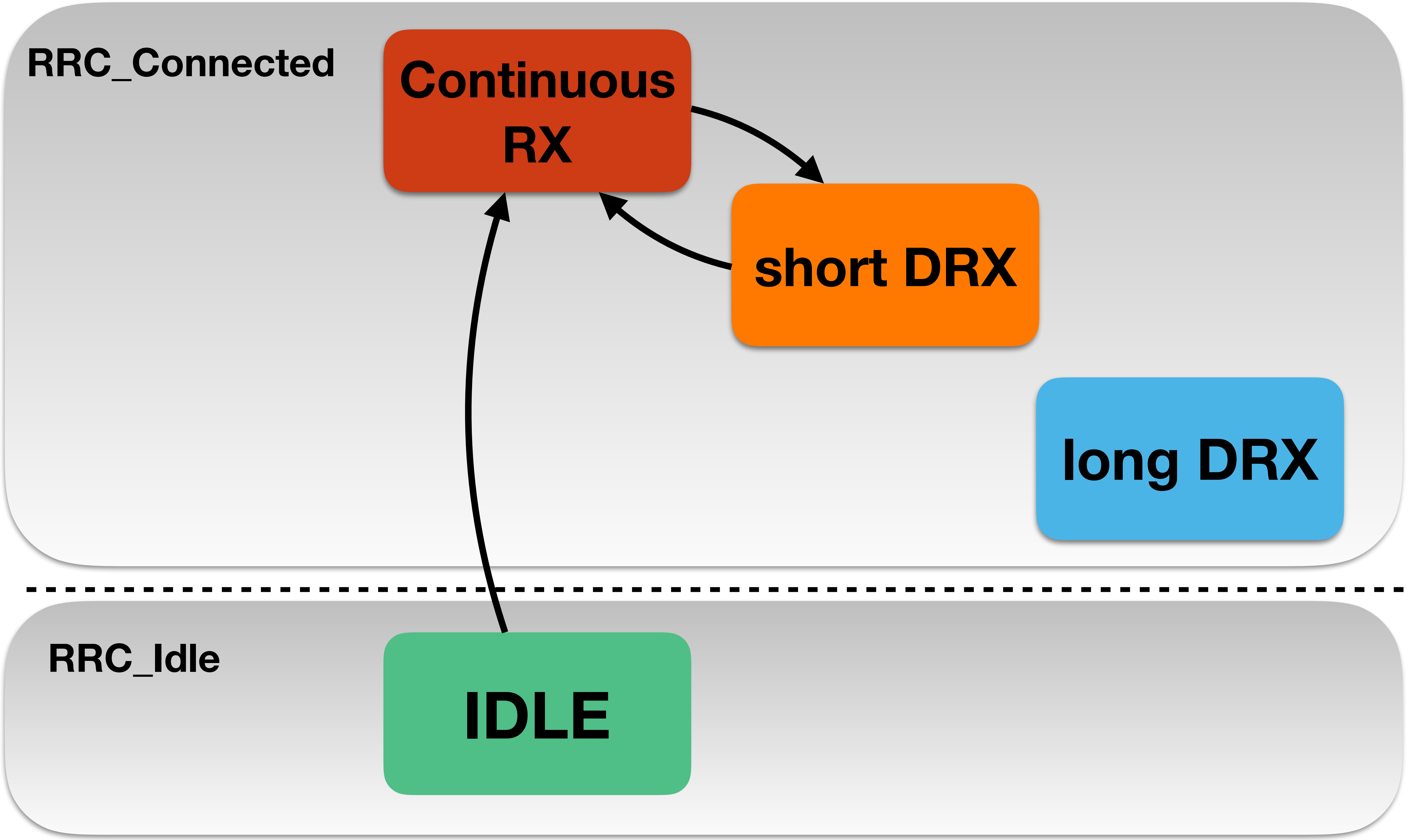
IDLE

LTE RRC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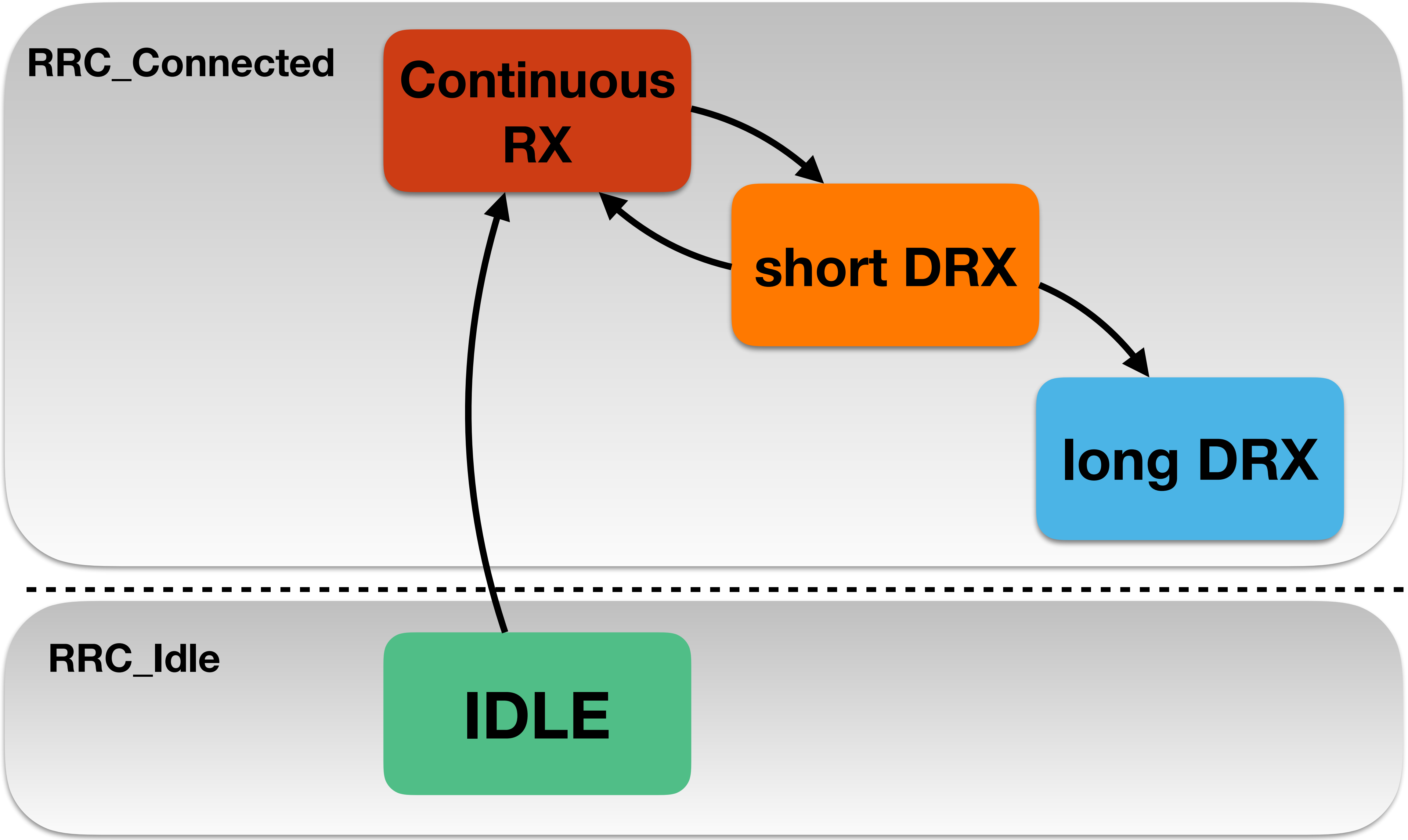
long DRX
RRC_Idle
IDLE

LTE RRC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Continuous RX
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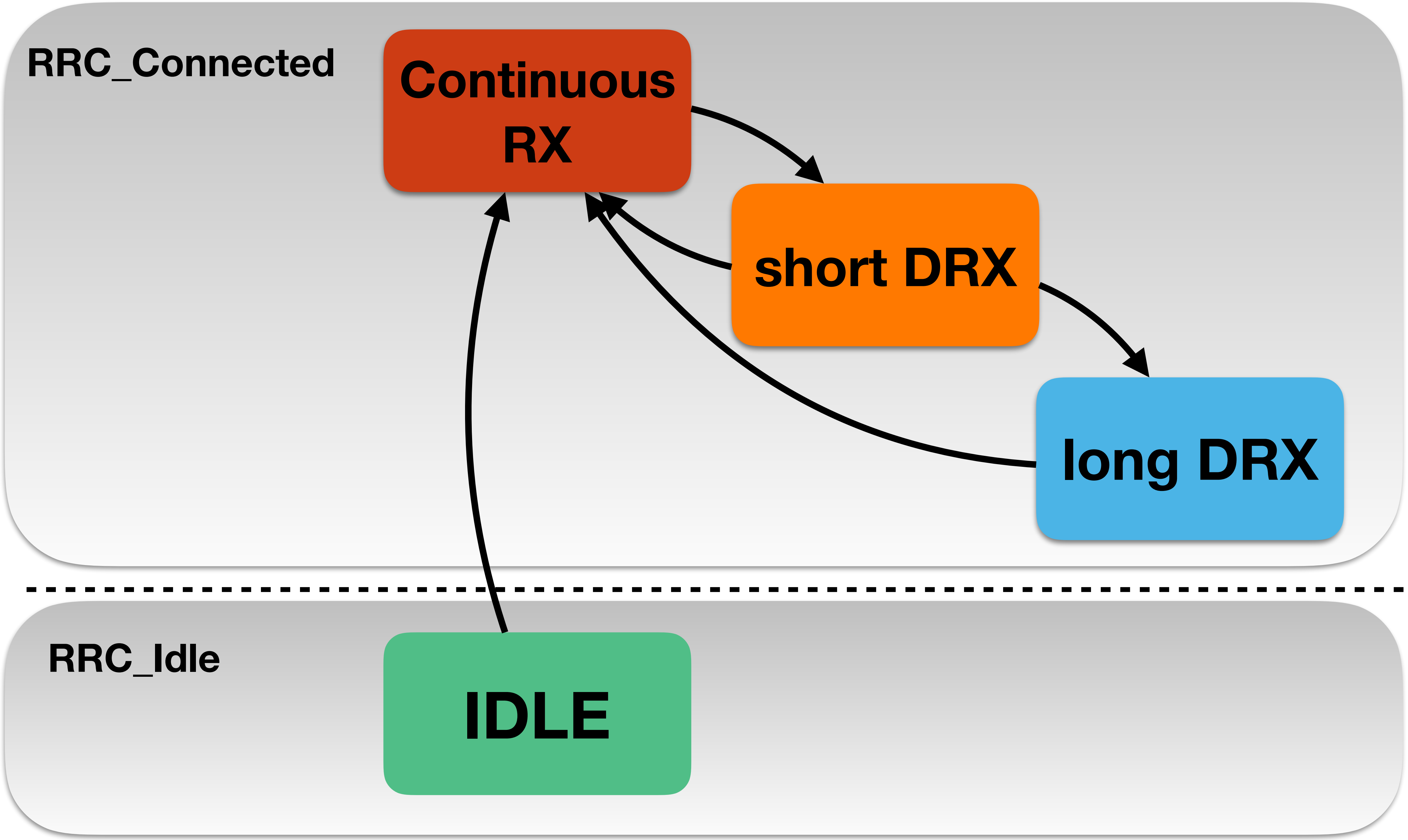
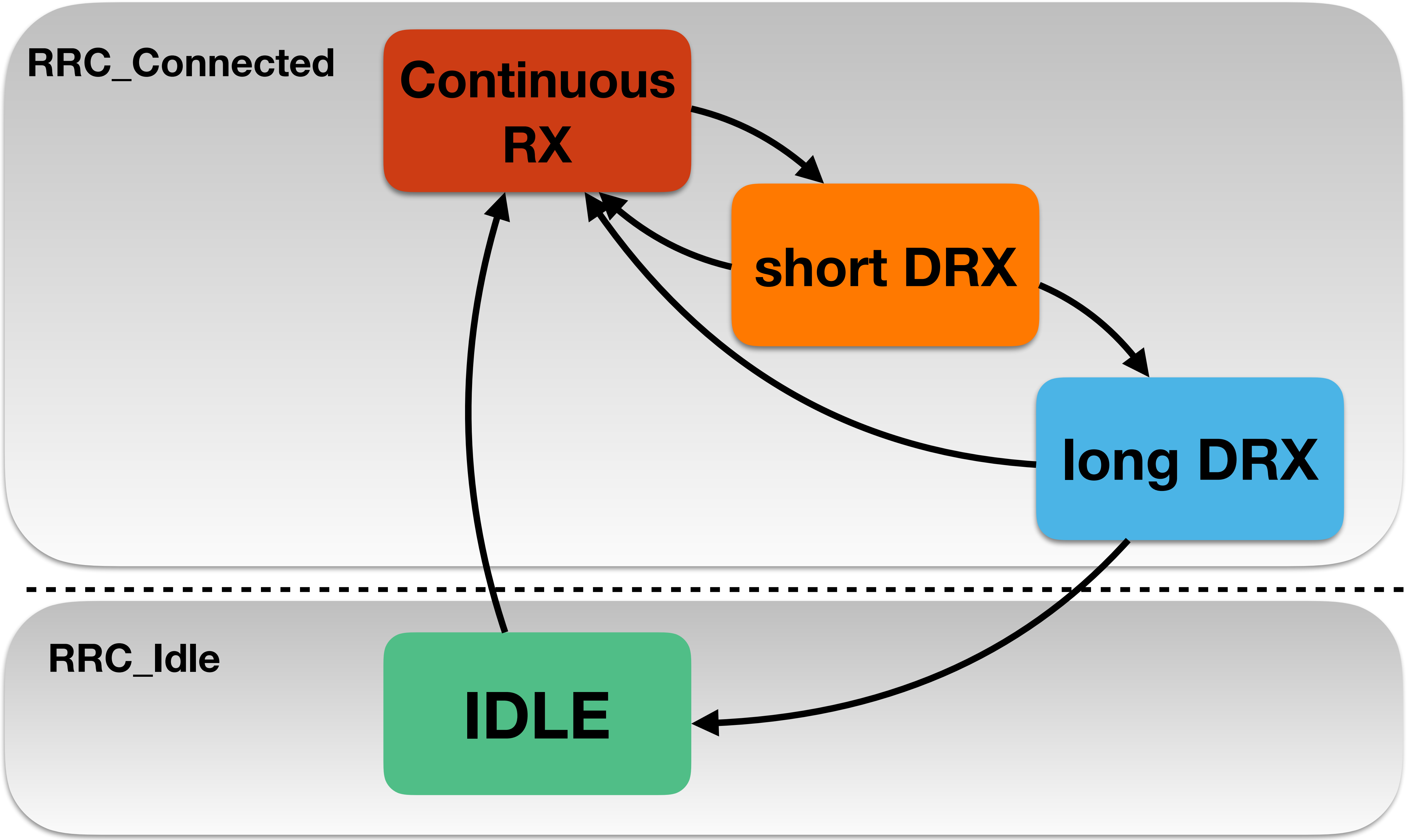
long DRX
RRC_Idle
IDLE

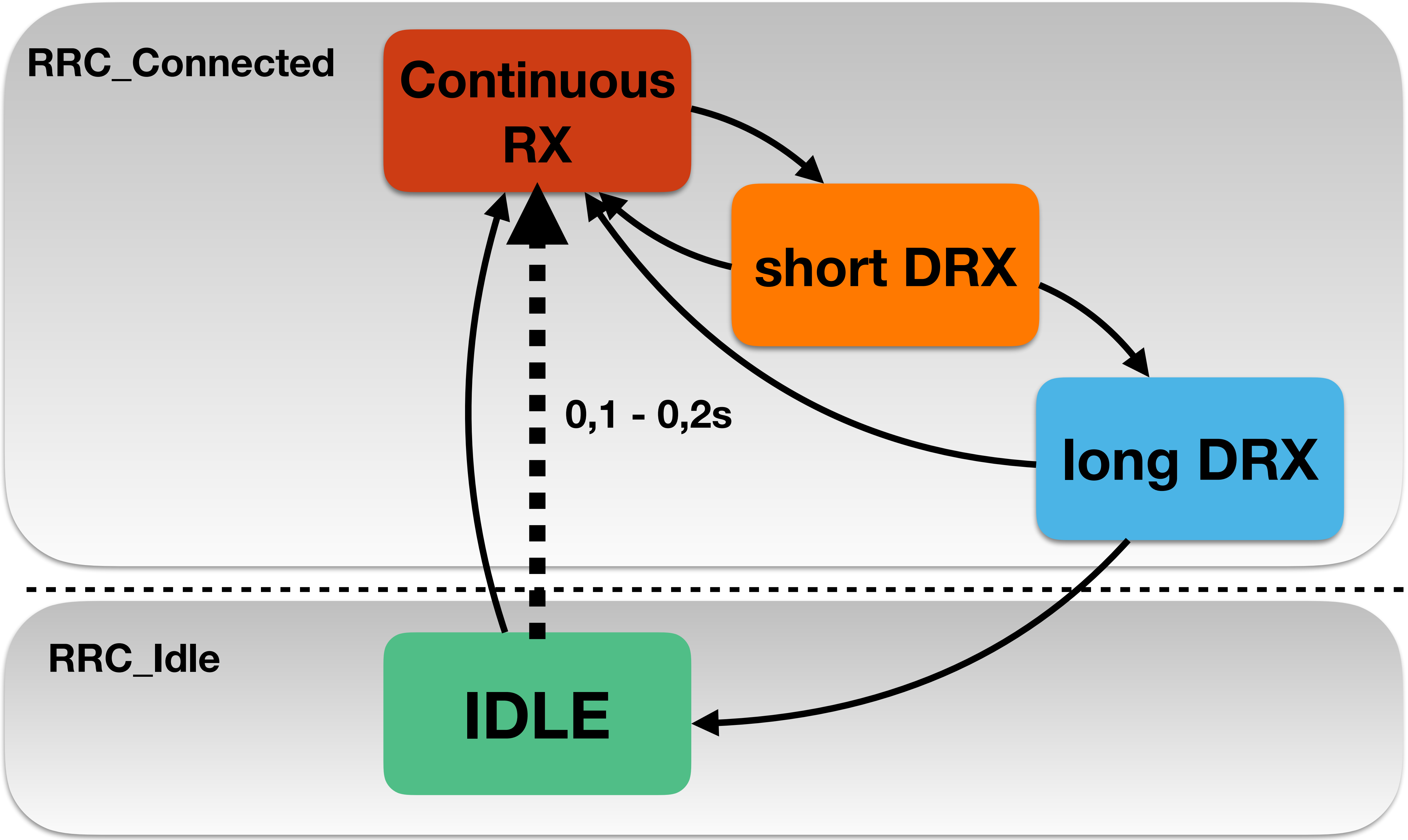
LTE RRC


RRC_Connected
Continuous RX
short DRX
long DRX
RRC_Idle
IDLE

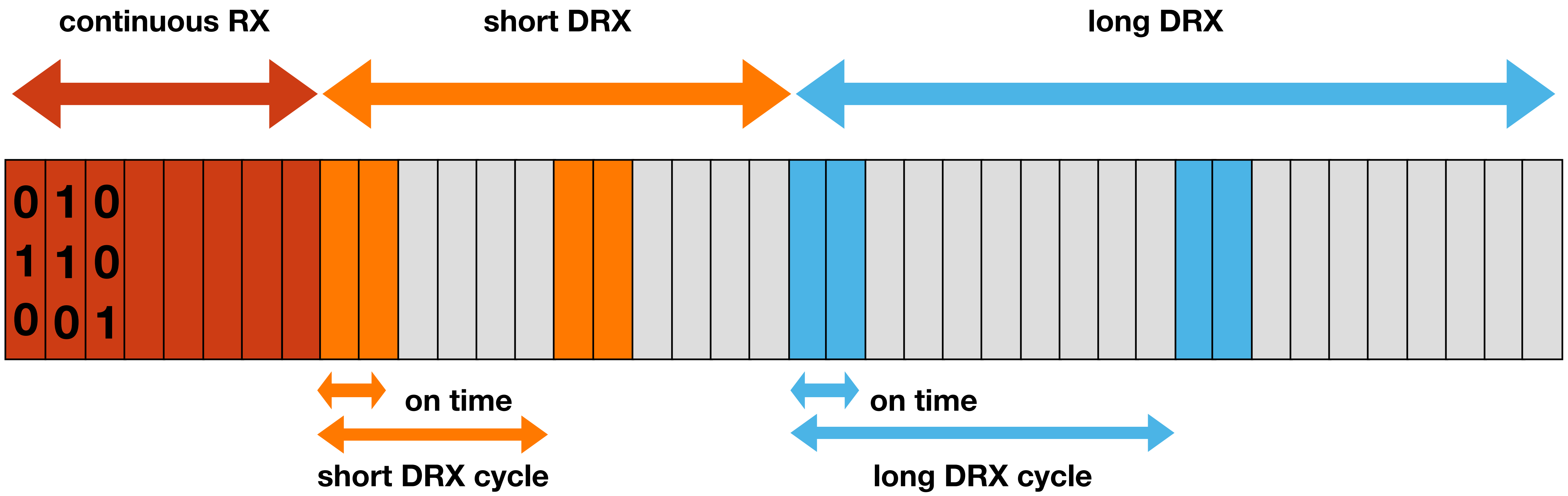
LTE RRC


RRC_Connected
Continuous RX
short DRX
long DRX
RRC_Idle
IDLE

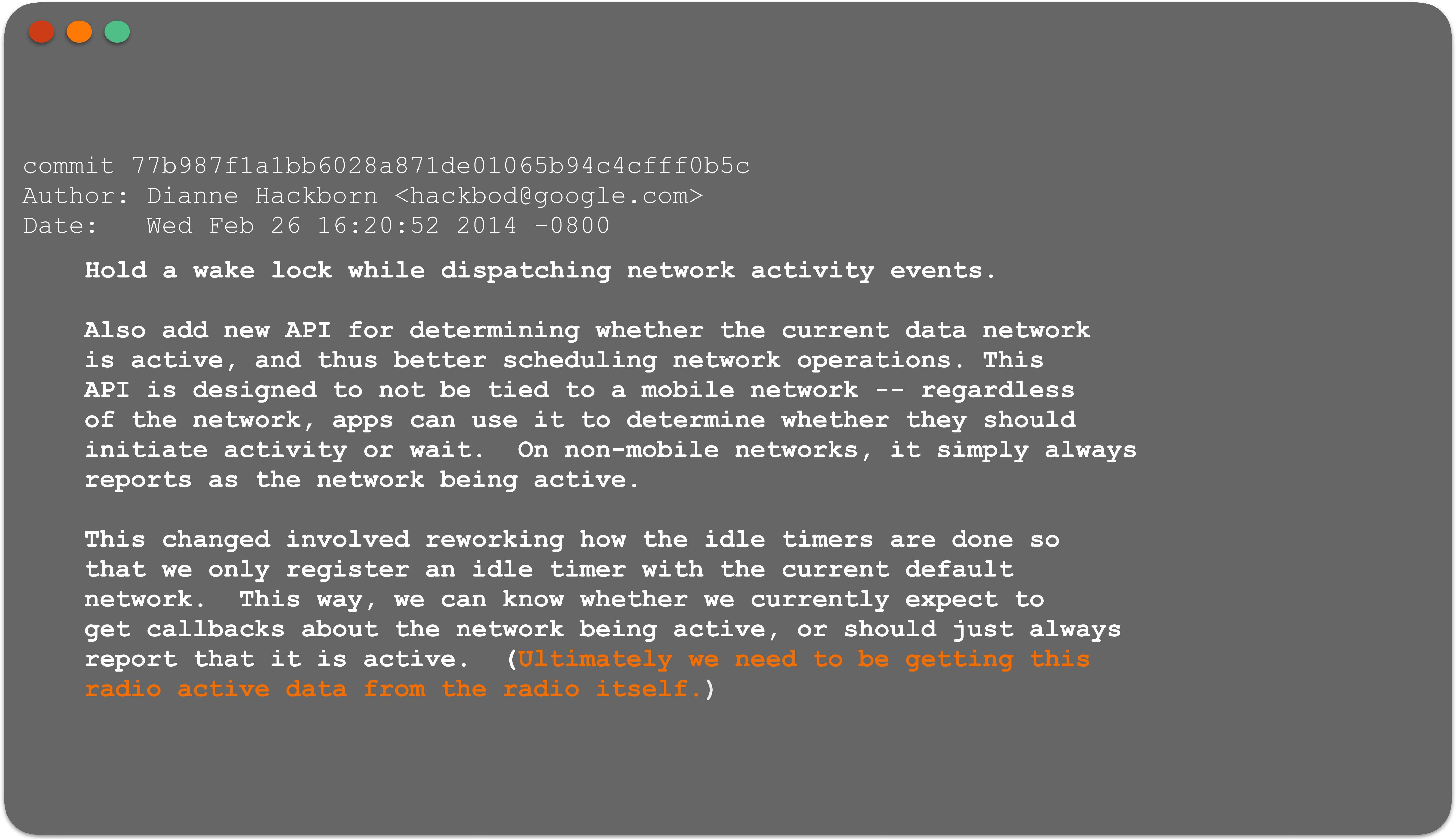
LTE RRC


RRC_Connected
Continuous RX
short DRX
long DRX
0,1 - 0,2s
RRC_Idle
IDLE

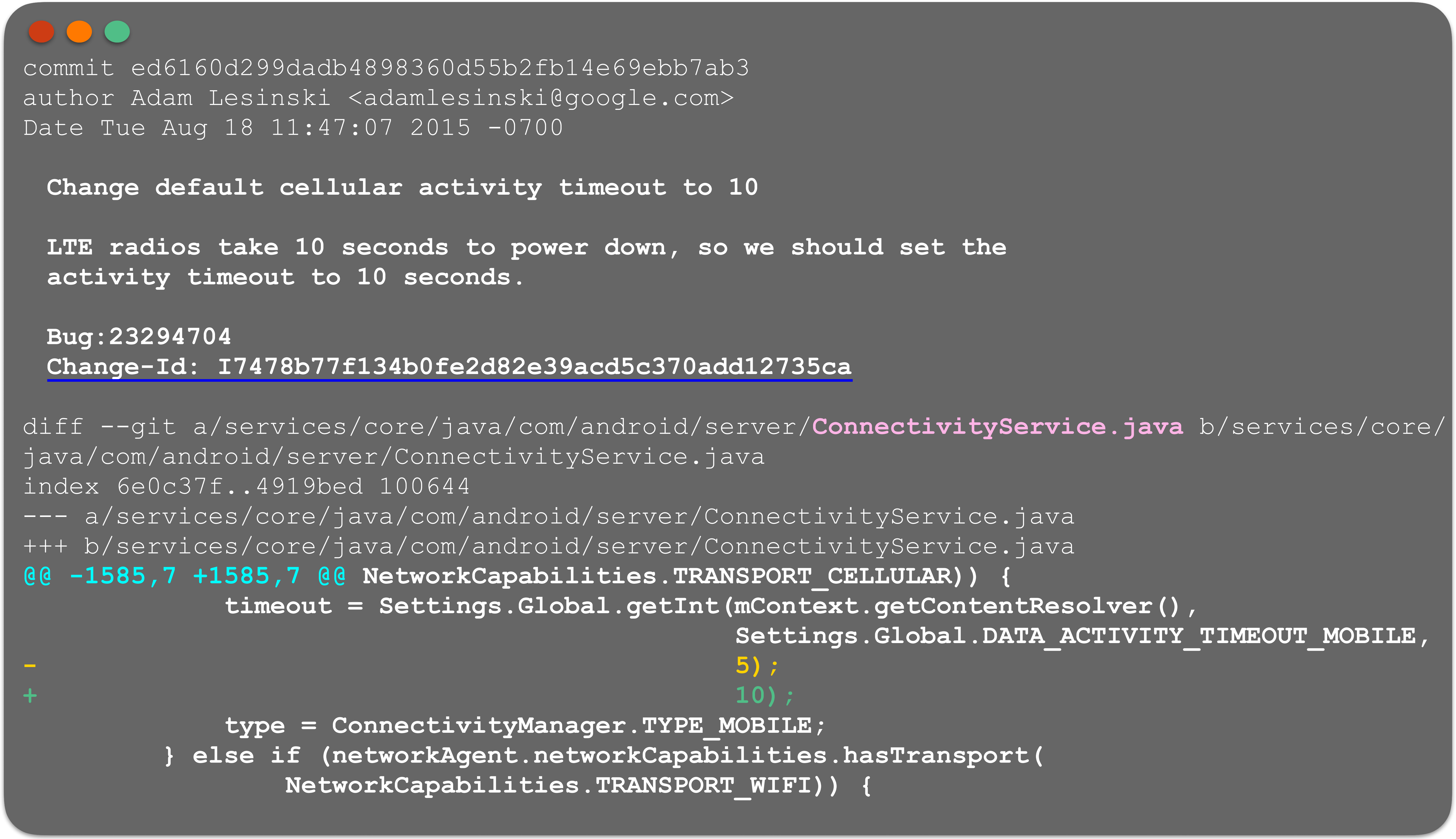
cDRX (Connected DRX)



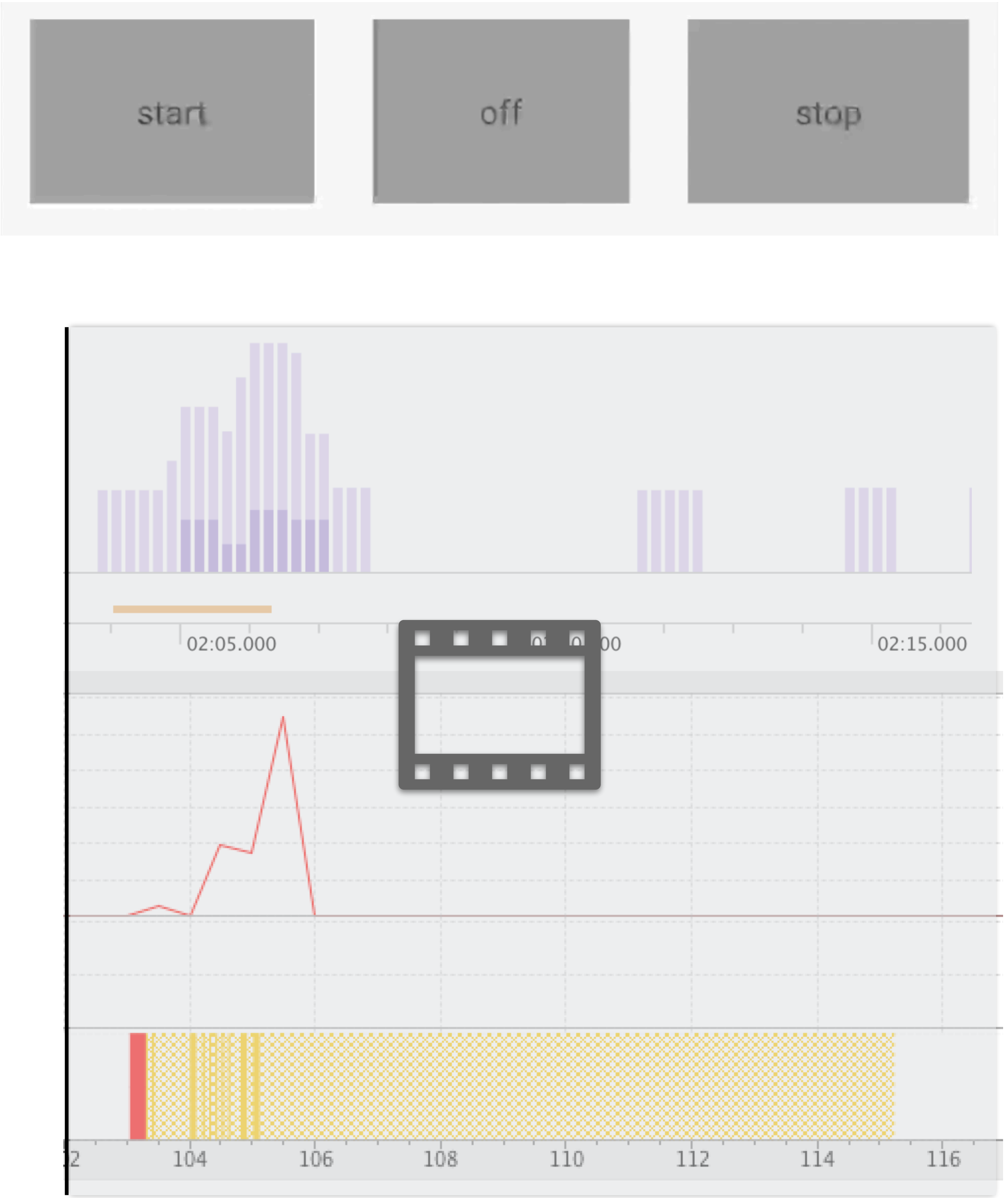
QCI	cont. rx(ms)	on time(ms)	short	long	back to idle(s)
9	200	10	20	320	15
9	100	10	80	200	10
9	200	4	X	80	30
9	always on	X	X	X	5
1	10	4	X	40	30

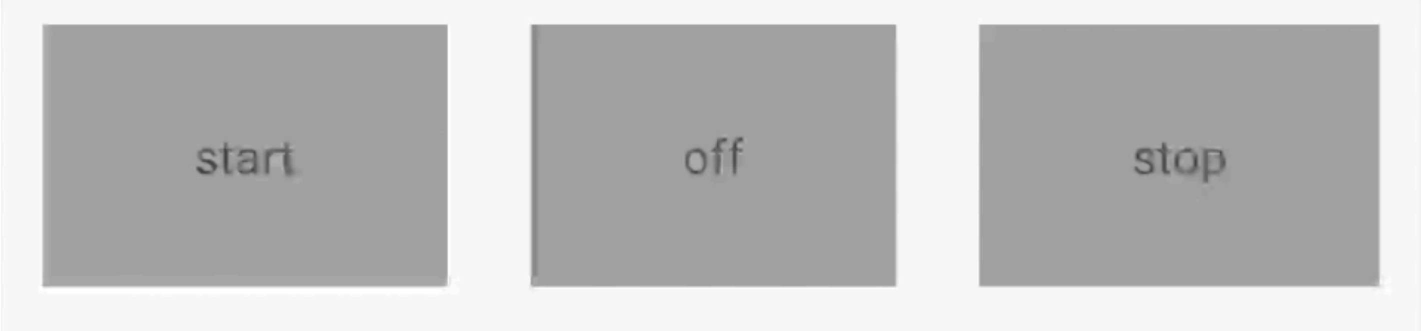


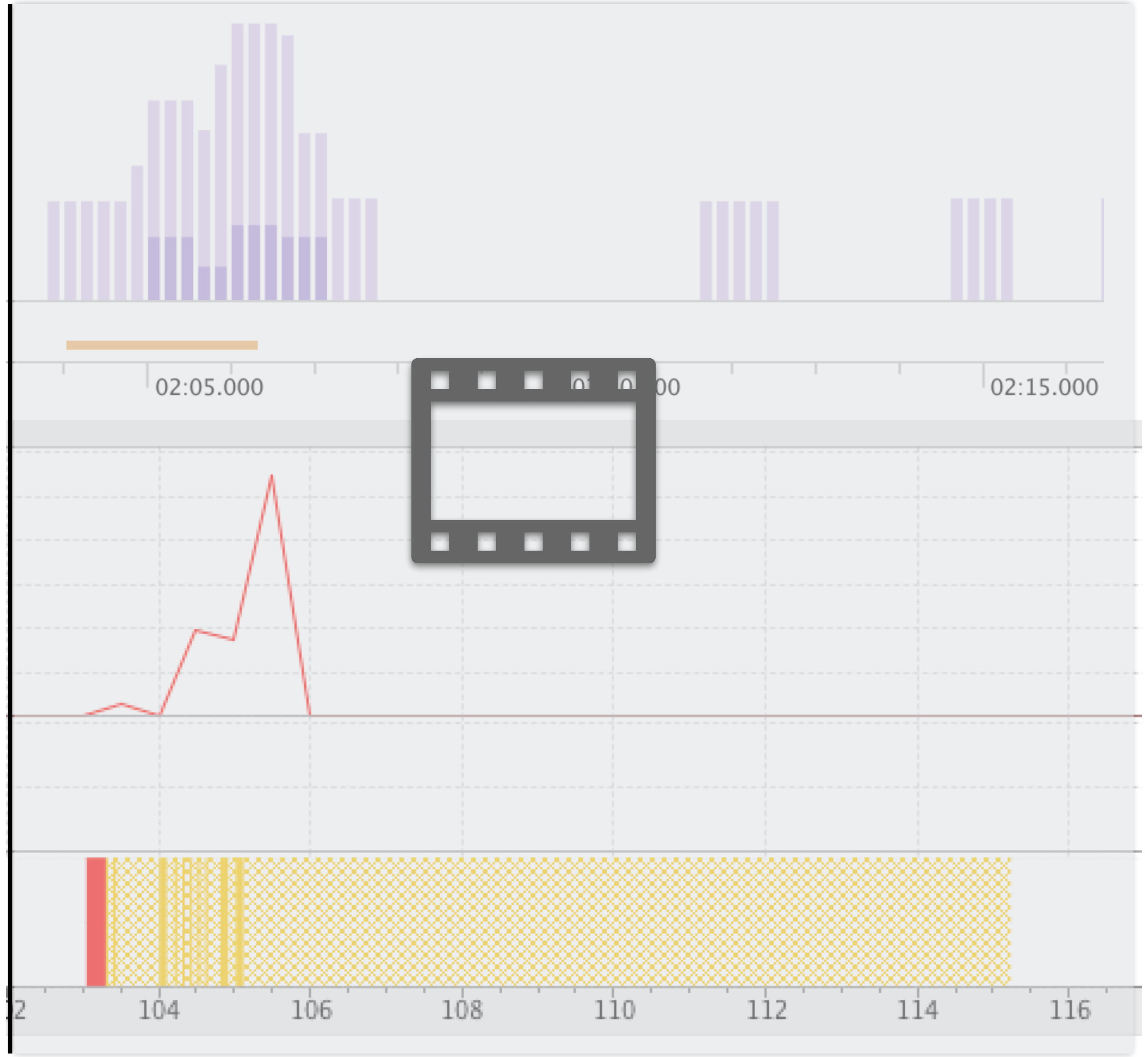
```
commit 77b987f1a1bb6028a871de01065b94c4cfff0b5c
Author: Dianne Hackborn <hackbod@google.com>
Date:   Wed Feb 26 16:20:52 2014 -0800

    Hold a wake lock while dispatching network activity events.

    Also add new API for determining whether the current data network
    is active, and thus better scheduling network operations. This
    API is designed to not be tied to a mobile network -- regardless
    of the network, apps can use it to determine whether they should
    initiate activity or wait.  On non-mobile networks, it simply always
    reports as the network being active.

    This changed involved reworking how the idle timers are done so
    that we only register an idle timer with the current default
    network.  This way, we can know whether we currently expect to
    get callbacks about the network being active, or should just always
    report that it is active.  (Ultimately we need to be getting this
    radio active data from the radio itself.)
```



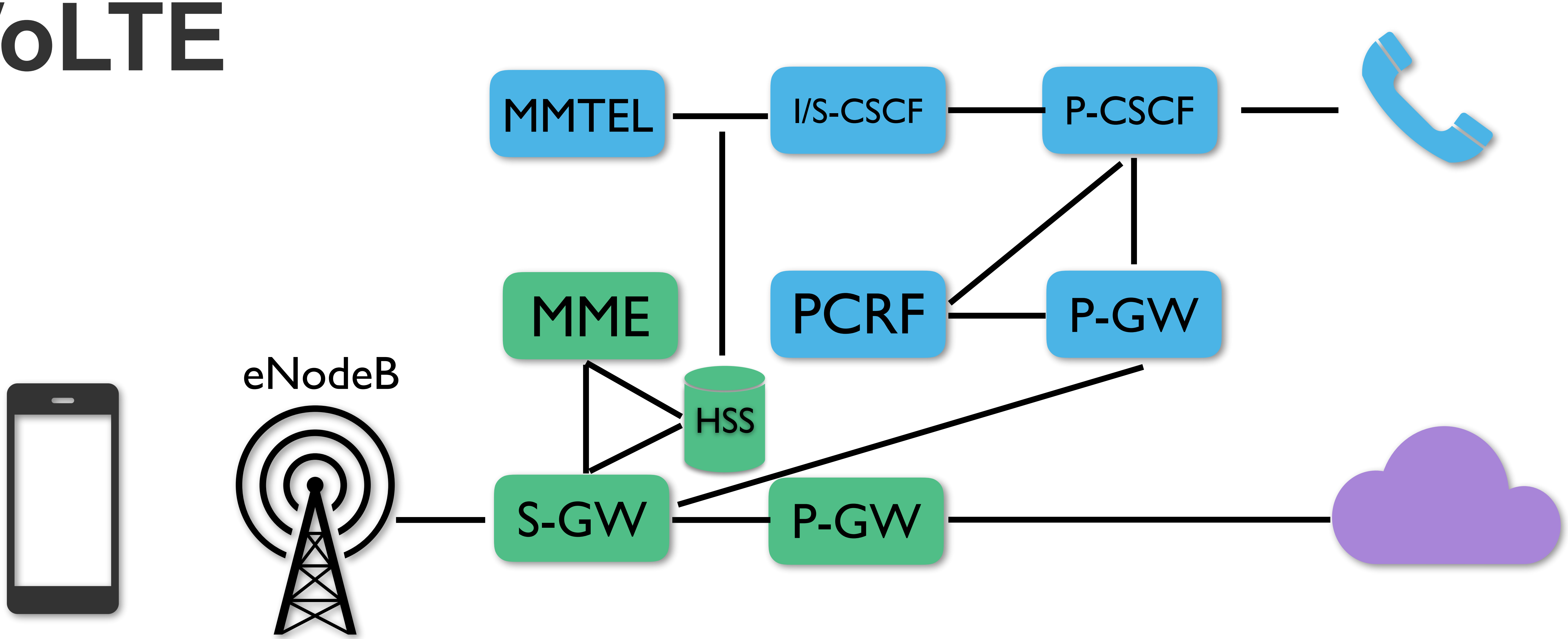
```
commit ed6160d299dadb4898360d55b2fb14e69ebb7ab3
author Adam Lesinski <adamlesinski@google.com>
Date Tue Aug 18 11:47:07 2015 -0700

  Change default cellular activity timeout to 10

  LTE radios take 10 seconds to power down, so we should set the
  activity timeout to 10 seconds.

  Bug:23294704
  Change-Id: I7478b77f134b0fe2d82e39acd5c370add12735ca

diff --git a/services/core/java/com/android/server/ConnectivityService.java b/services/core/
java/com/android/server/ConnectivityService.java
index 6e0c37f..4919bed 100644
--- a/services/core/java/com/android/server/ConnectivityService.java
+++ b/services/core/java/com/android/server/ConnectivityService.java
@@ -1585,7 +1585,7 @@ NetworkCapabilities.TRANSPORT_CELLULAR)) {
             timeout = Settings.Global.getInt(mContext.getContentResolver(),
                                              Settings.Global.DATA_ACTIVITY_TIMEOUT_MOBILE,
-                                             5);
+                                             10);
             type = ConnectivityManager.TYPE_MOBILE;
         } else if (networkAgent.networkCapabilities.hasTransport(
                 NetworkCapabilities.TRANSPORT_WIFI)) {
```


start
off
stop
02:05.000
02:15.000
104
106
108
110
112
114
116


start
off
stop


02:05.000
00
02:15.000
2
104
106
108
110
112
114
116

VoLTE



MMTEL

I/S-CSCF

P-CSCF

MME

PCRF

P-GW

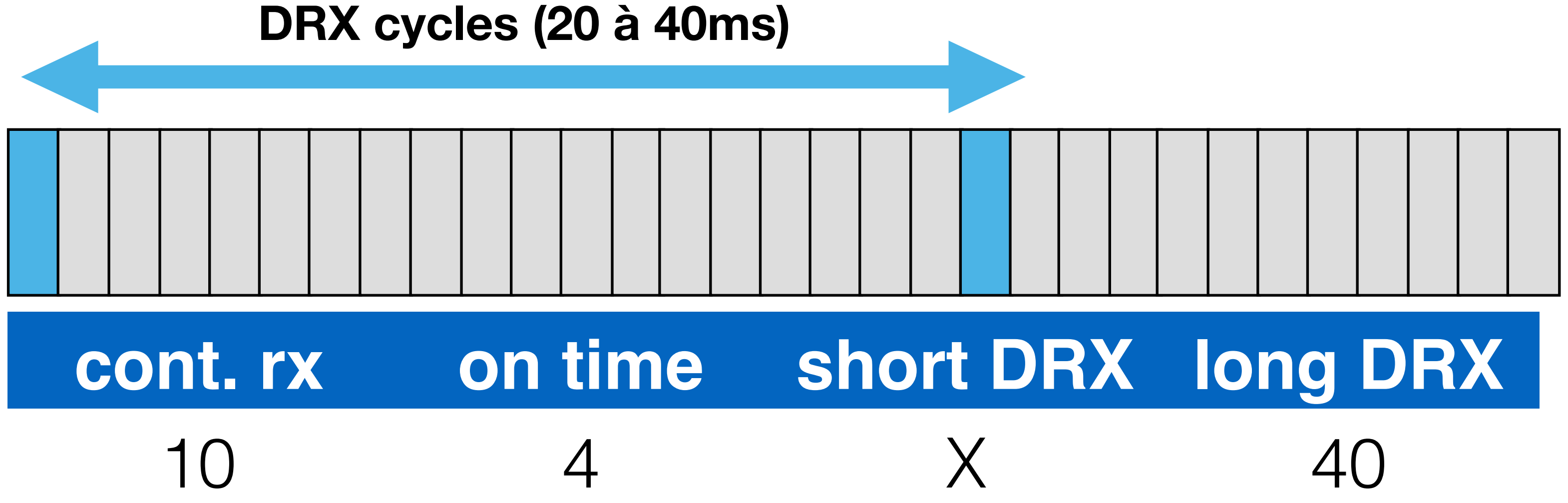
eNodeB

HSS

S-GW

P-GW

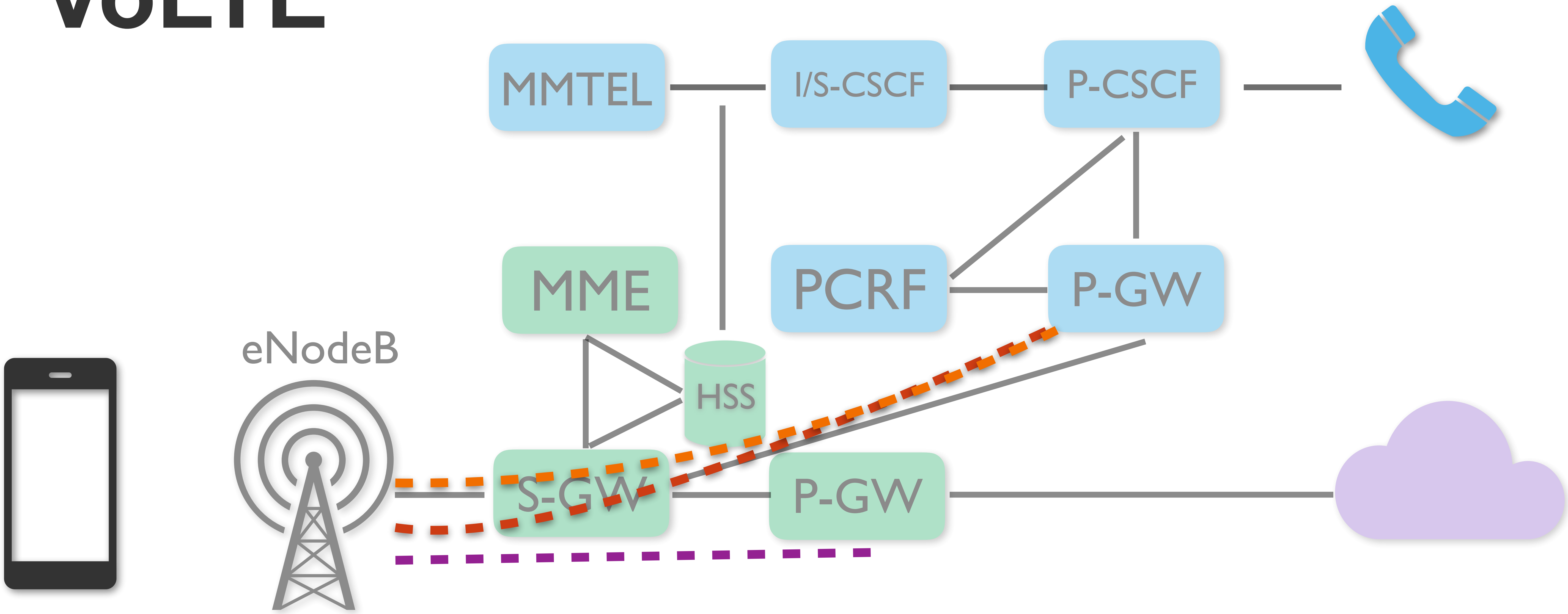
WB-AMR: ~25kbit/s
IP/UDP/RTP overhead : ~50kbit/s
sample every 20ms



DRX cycles (20 à 40ms)

cont. rx	**on time**	**short DRX**	**long DRX**
10	4	X	40

VoLTE



default bearer QCI 9: best effort, faible priorité (défaut pour internet), non GBR

default bearer QCI 5: signalisation SIP pour l’IMS, haute priorité, nonGBR

dedicated bearer QCI 1: flux RTP pour appelle VoIP IMS, (garanteed bitrate) genre 50kbits/s

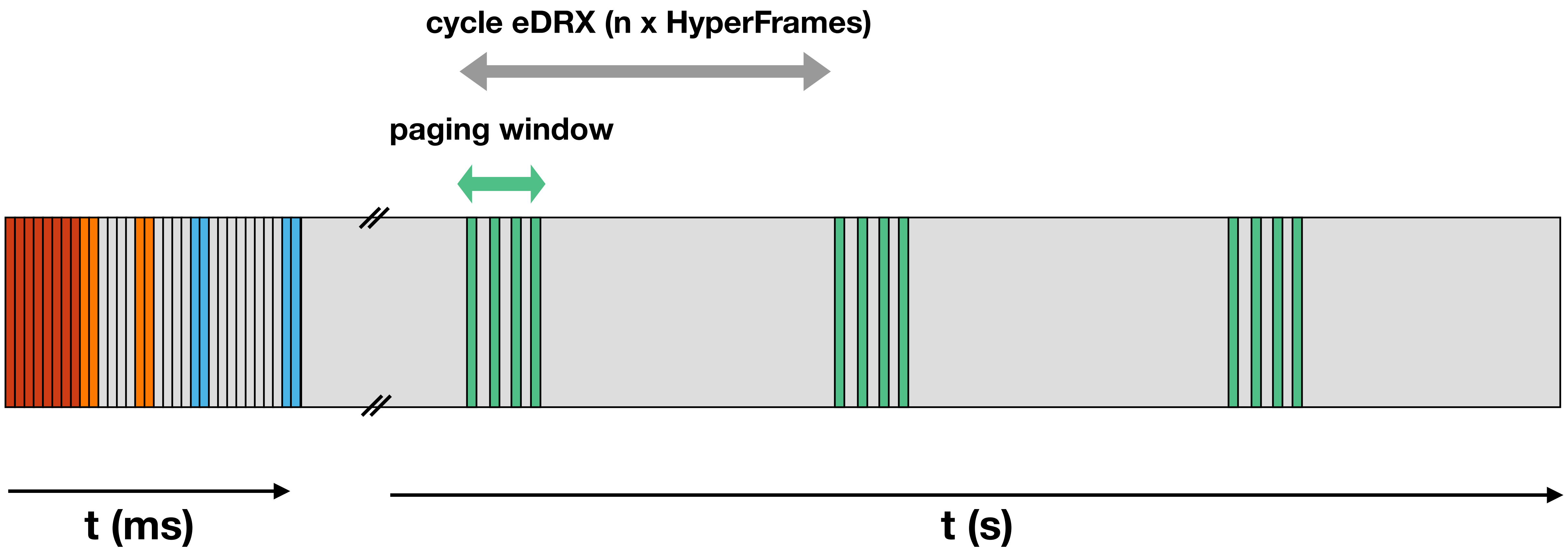
eDRX

Extended DRX

eDRX

Extended DRX

eDRX



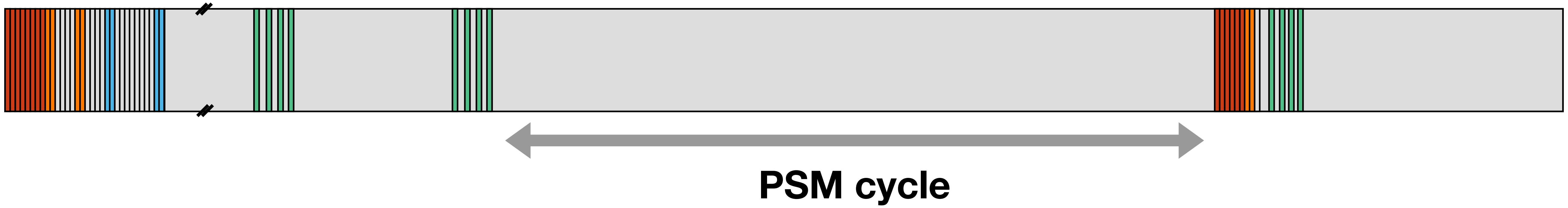
C-eDRX:

- Les cycles vont jusque 10.24 s (contre 2,56s en cDRX)

I-eDRX:

- Les cycles peuvent atteindre ~44min en LTE-M (~3hr en NB-IOT)

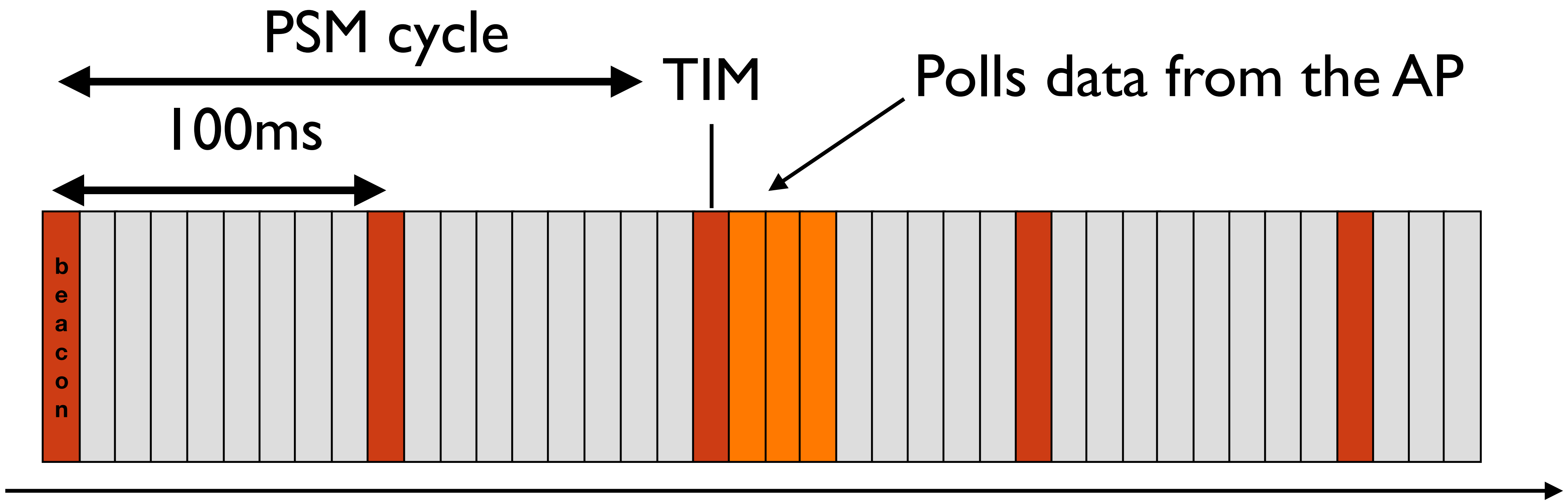
PSM (Power Saving Mode)



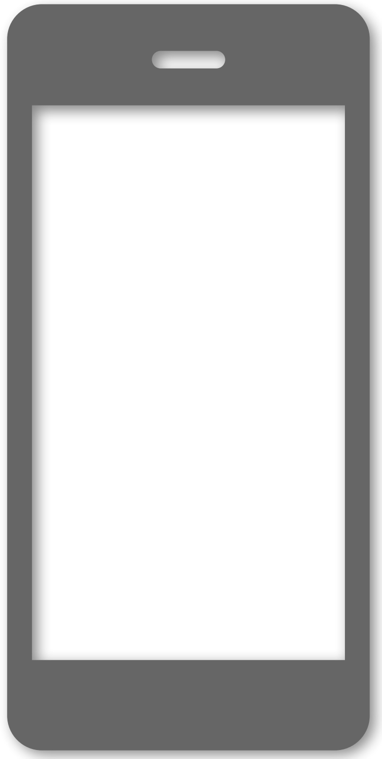
- Quasi équivalent à couper la radio mais en restant attaché au réseau
- Les cycle PSM peuvent atteindre 400 jours !
- Autonomie de batterie: 10 ans …

PSM (en Wifi)

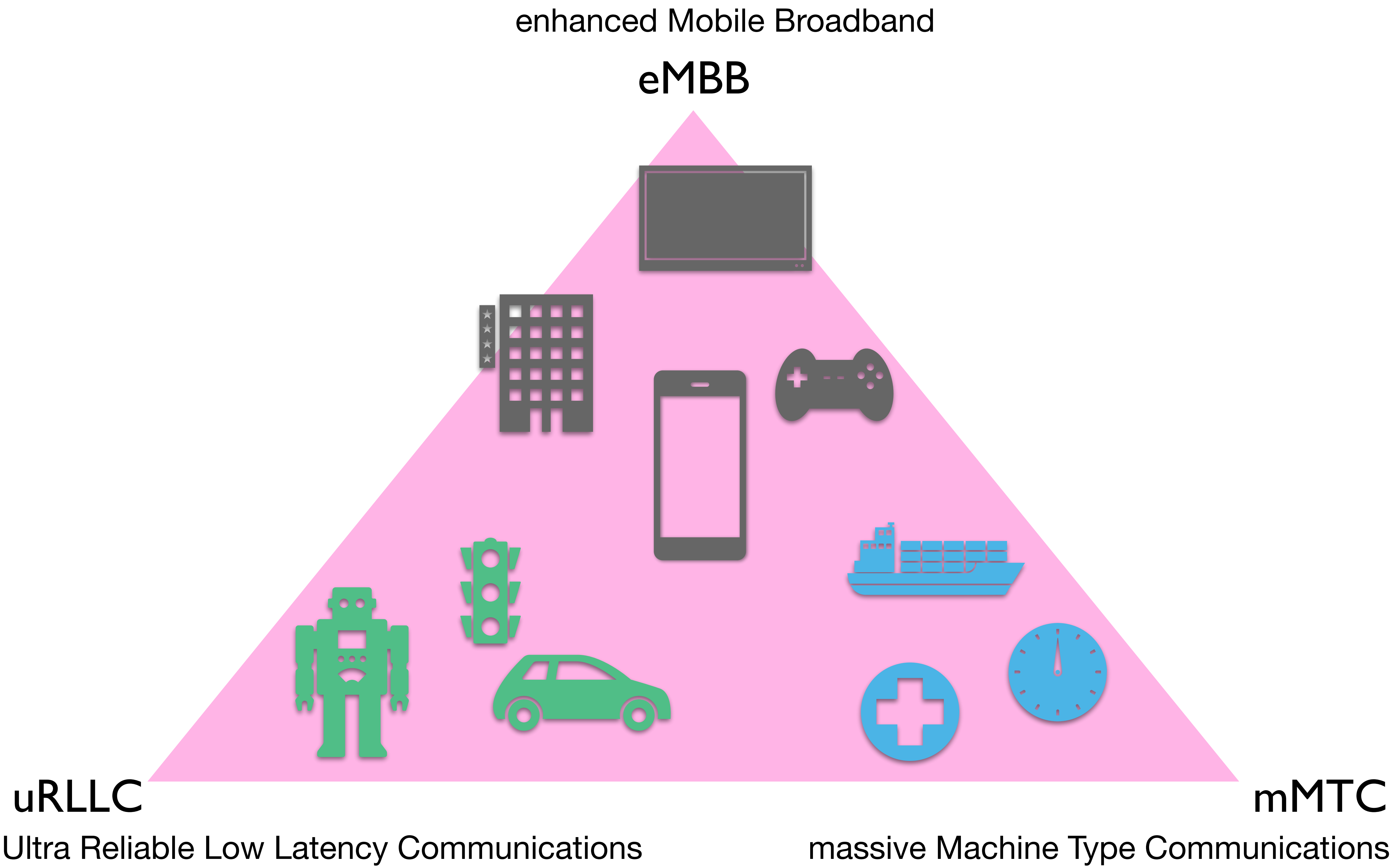
- Power Saving Mode par opposition au CAM (Constant Awake Mode)
- L'énergie nécessaire à la transmission en Wifi est beaucoup plus faible que sur le réseau mobile (Local area vs Wide area)
- Mais l'énergie requise reste importante (ex: 802.11n)



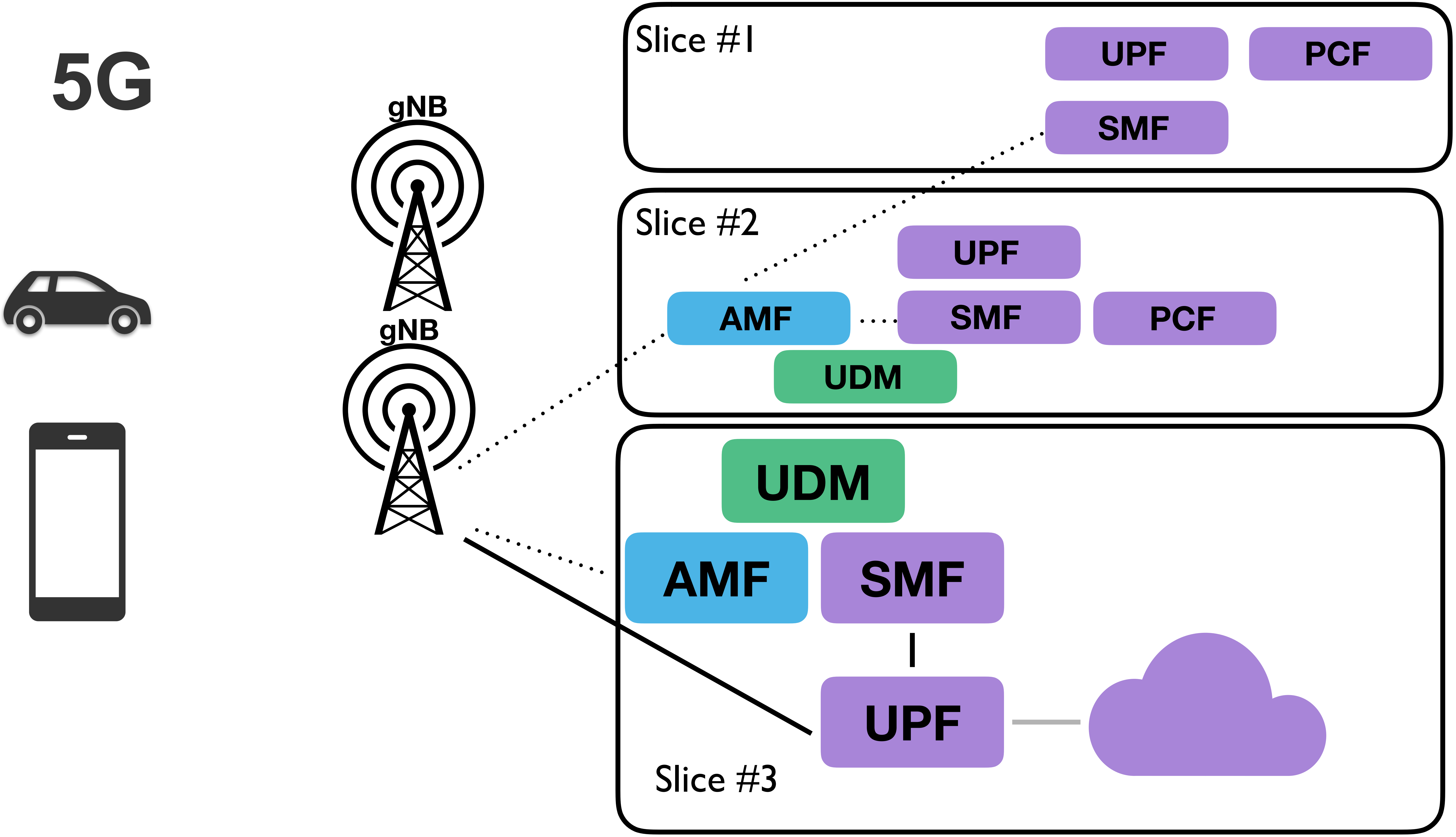
5G



5G


enhanced Mobile Broadband
eMBB
uRLLC
Ultra Reliable Low Latency Communications
mMTC
massive Machine Type Communications

5G



gNB

gNB

Slice #1

UPF

PCF

SMF

Slice #2

UPF

AMF

SMF

PCF

UDM

UDM

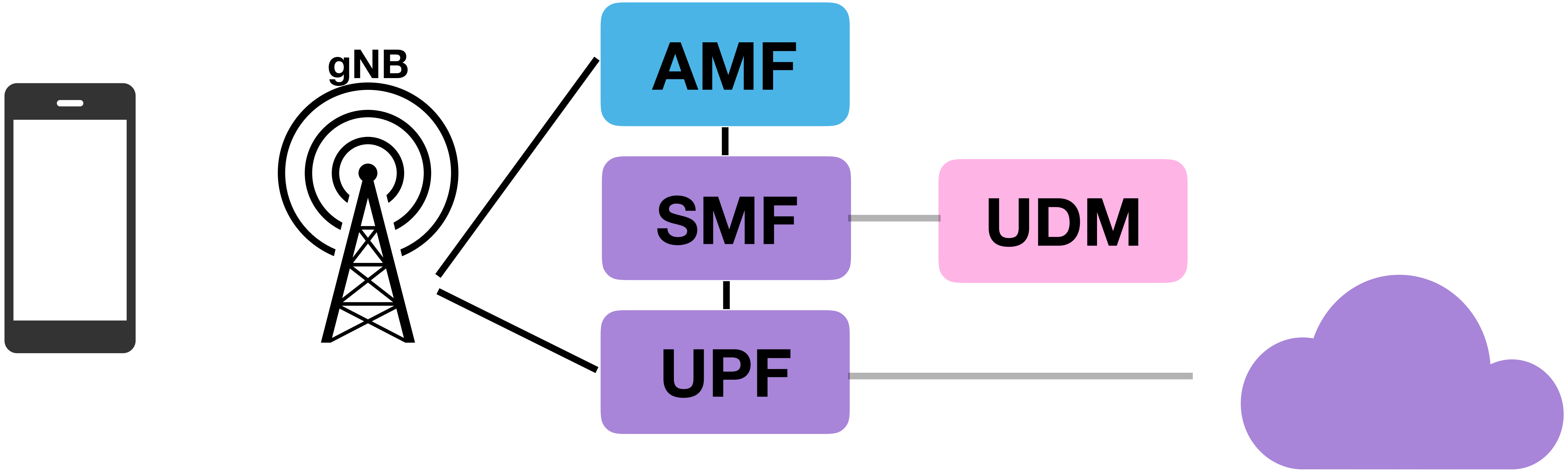
AMF

SMF

UPF

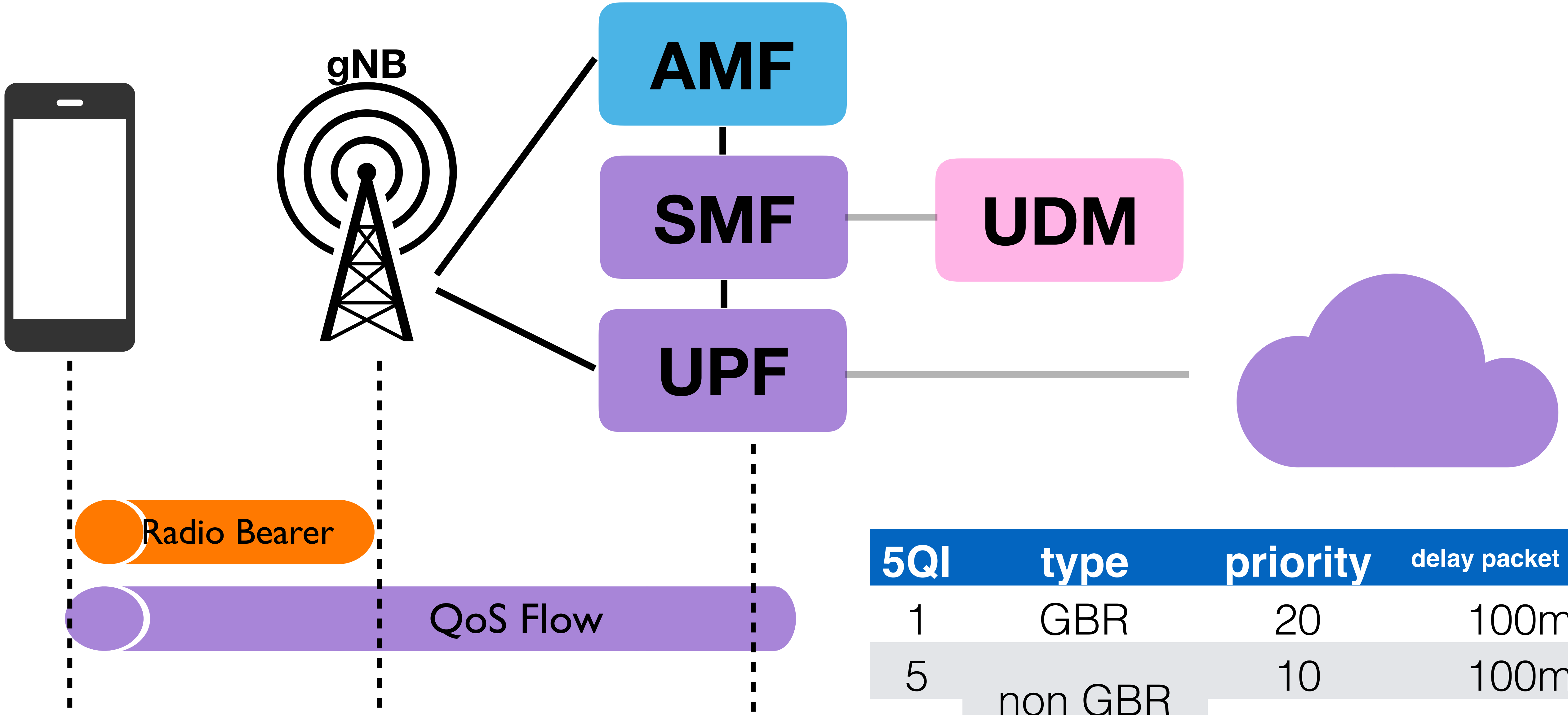
Slice #3

5G



5QI	type	priority	delay packet budget	usage
1	GBR	20	100ms	Voix
5	non GBR	10	100ms	IMS
9		90	300ms	Internet
81	**delay critical GBR**	**11**	**5ms**	**remote control**
83		**13**	**20ms**	**Intelligent transport**

5G



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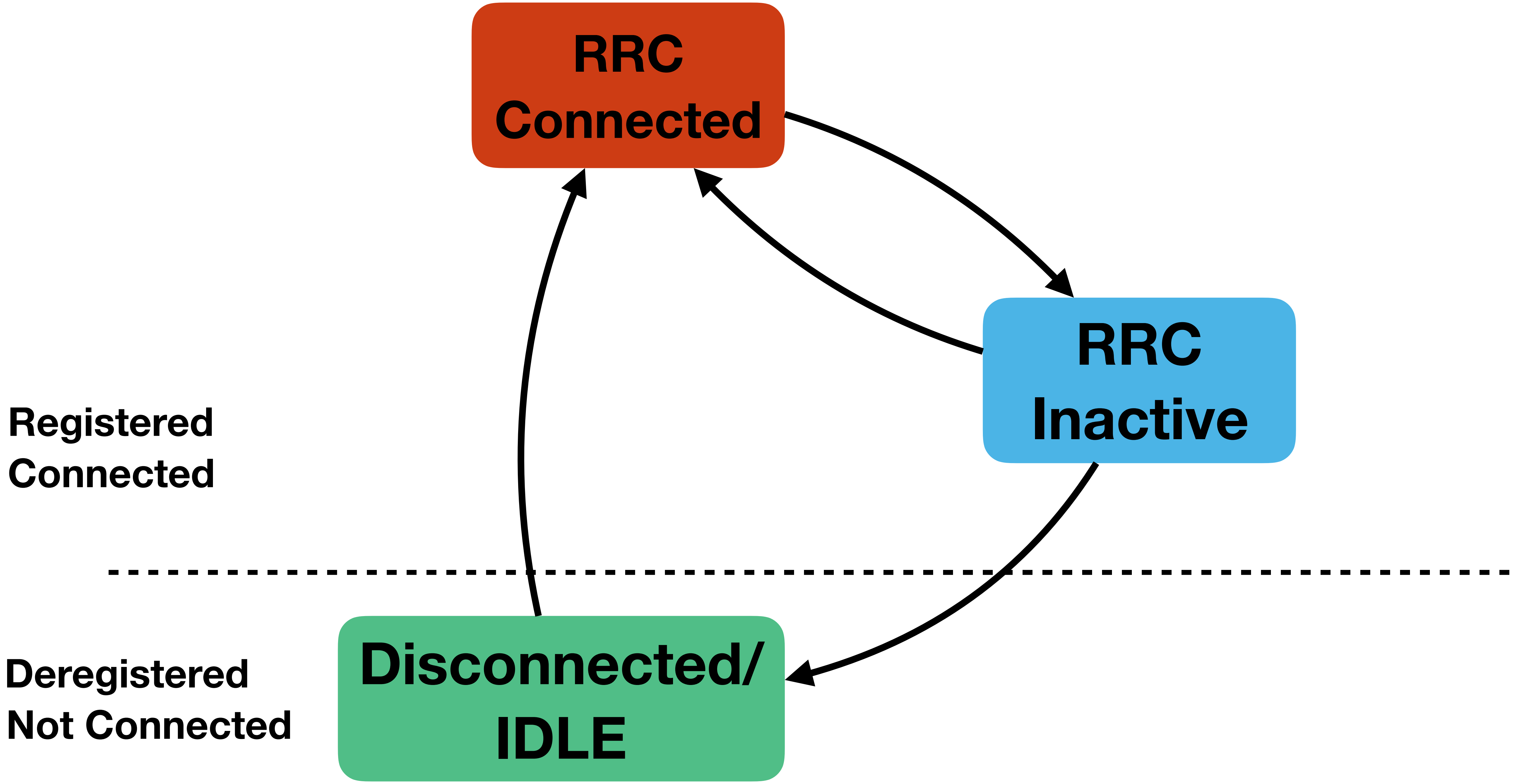
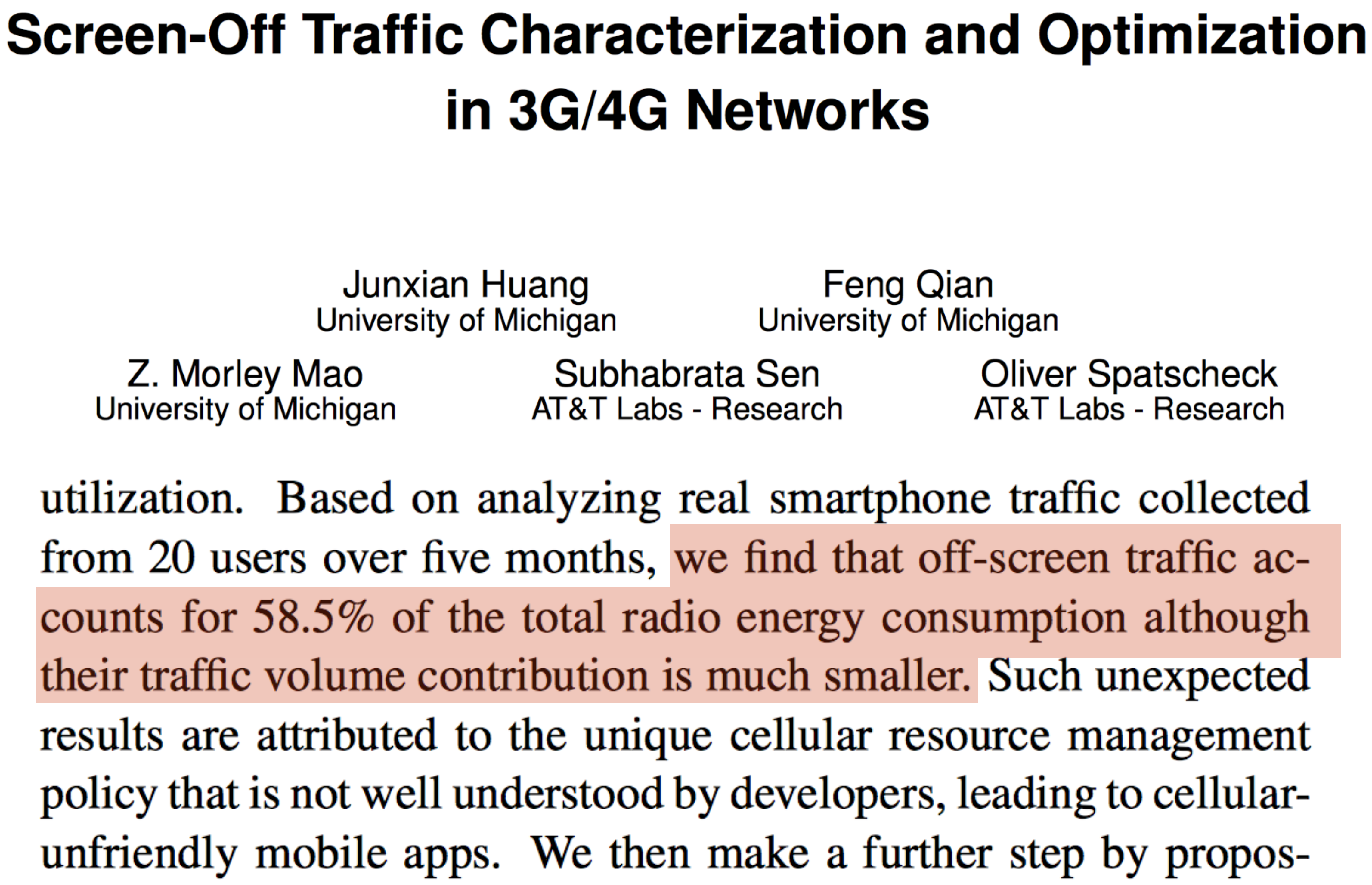
5G


RRC Connected
RRC Inactive
Registered Connected
Deregistered Not Connected
Disconnected/ IDLE

Conclusion

- Le réseau mobile accorde une attention particulière à la gestion de l'énergie.
- Un compromis entre différentes propriétés comme la latence et la consommation est nécessaire.
- Il est important (IMHO) de s'y intéresser car tout ceci n'est pas forcément visible pour un développeur.
- Une même appli peut être connectée à un large panel de réseaux ayant des propriétés très différentes



Screen-Off Traffic Characterization and Optimization in 3G/4G Networks

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University of Michigan

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Z. Morley Mao
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AT&T Labs - Research

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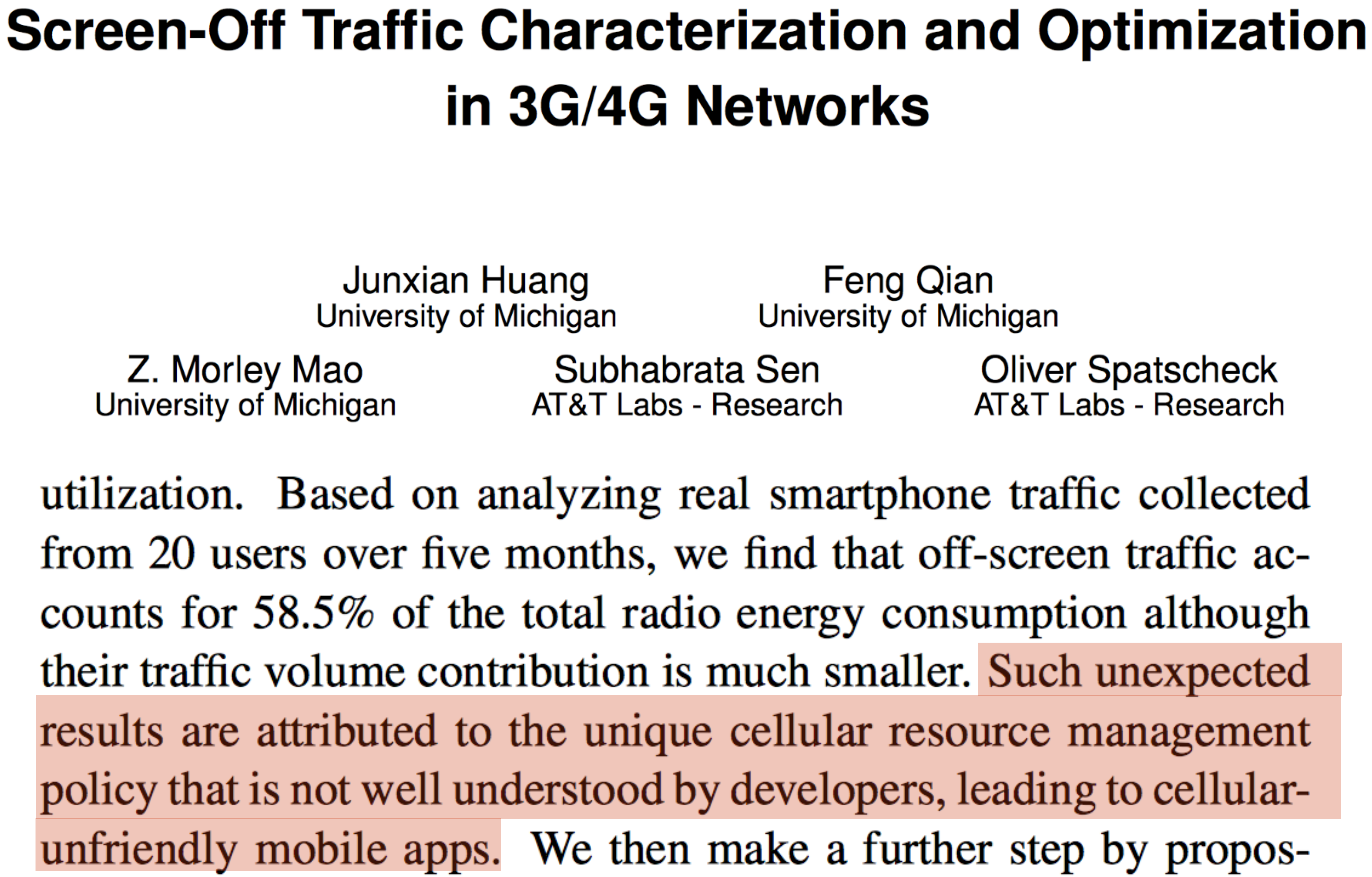
utilization. Based on analyzing real smartphone traffic collected from 20 users over five months, we find that off-screen traffic accounts for 58.5% of the total radio energy consumption although their traffic volume contribution is much smaller. Such unexpected results are attributed to the unique cellular resource management policy that is not well understood by developers, leading to cellular-unfriendly mobile apps. We then make a further step by propos-



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Thanks