

MNA

Mobile Radio Networks

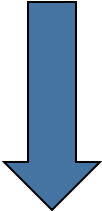
Mobile Network Architectures

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(upon prior agreement via email)

A.Y. 2019-20
Credits: 6



*Slides are provided
as supporting tool,
they are not a textbook!*

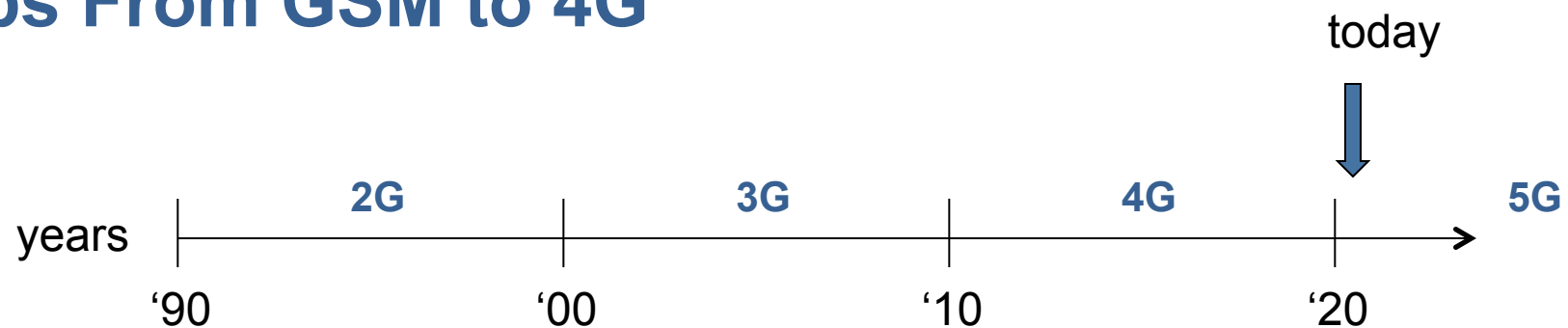
Outline

- 1. Steps From GSM to 4G**
- 2. Cellular Networks**
- 3. Network Architectures: Evolution From GSM to 4G**
- 4. Mobility Management**
- 5. Network Architectures: Evolution Towards 5G**

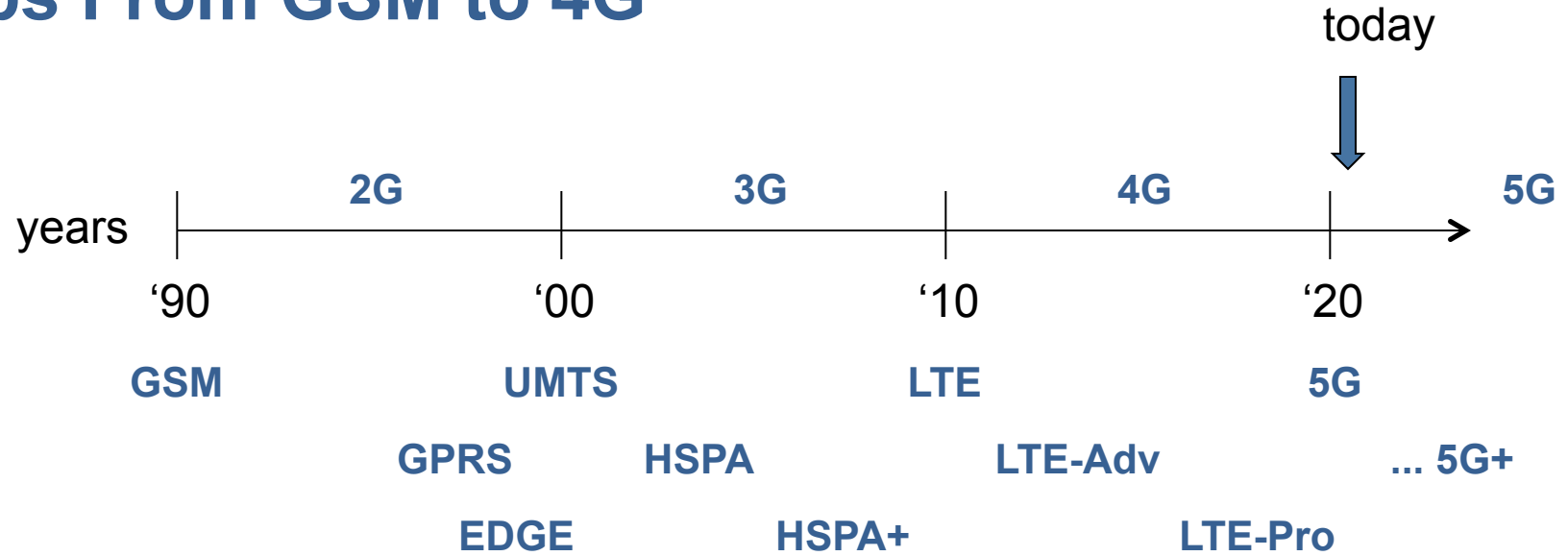
This lecture block will provide the basic concepts related to mobile radio network architectures and the way they manage mobility of users.

1. Steps From GSM to 4G

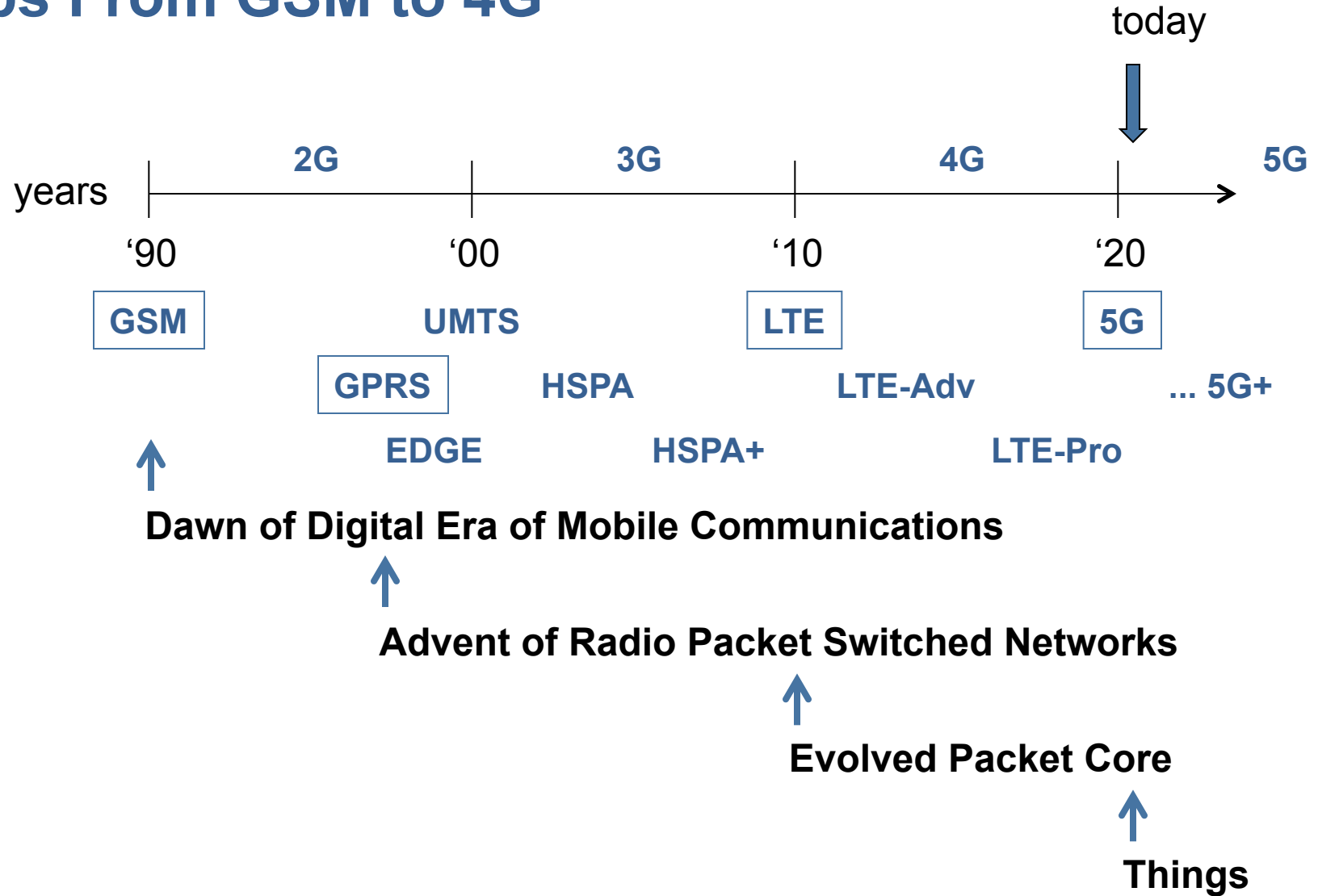
Steps From GSM to 4G



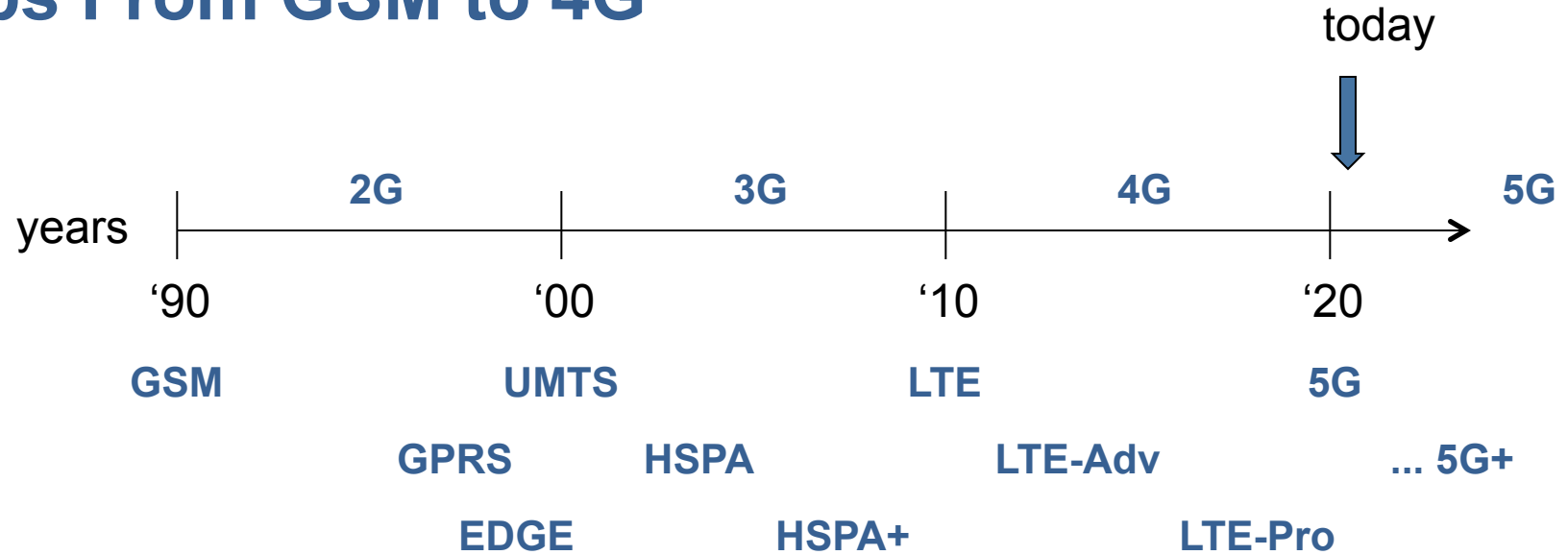
Steps From GSM to 4G



Steps From GSM to 4G



Steps From GSM to 4G



U (theoretical)	500 Kbit/s	x 100	50 Mbit/s	x 100	4 Gbit/s	x 100	> 100 Gbit/s
Latency	300 ms		100 ms		10 ms		1 ms

Steps From GSM to 4G



	GSM	Ph2	Ph2+	GPRS	EDGE
ETSI Release	GSM		96	97	98
Release year	1990	1995	1997	1997	1998



Steps From GSM to 4G



	UMTS		HSDPA	HSUPA	HSPA+
3GPP Release	99	...	5	6	7
Release year	1999		2002	2004	2006



Steps From GSM to 4G

Today



3GPP Release	8	9	10	11	12	13	14
	Launchable LTE	Bucket List Items Improvement (Regulatory, etc.)	Carrier Aggregation, CoMP, LIPA, M2M, etc... Improved Performance	Carrier Aggr. Improvement IMS, roaming, P2P, etc.	WiFi, Small Cell Impr. Signaling opt. SON, MDT, adv. Receiver MIMO Improv.	D2D, ProSe 3D/FD-MIMO Indoor Pos. Latency Reduction NB-IoT	Mission Critical Enhancem. CV2X Inter-band CA
Release year	2008	2009	2012	2013	2015	2016	2017



Steps From GSM to 4G: GSM

Modulation

GMSK

Access

FDD

F-TDMA: 8 slots/frame; 4.6 ms frame duration

Numerology

Frequency bands **900 MHz, 1800 MHz**

Ch. Bandwidth **200 KHz**

Bit Rate **271 Kbit/s**

Steps From GSM to 4G: 2.5G (Rel. 98)

Modulation

GMSK	(GSM)
8-PSK	(EDGE)
32-QAM	(Evolved EDGE)

Access

FDD
F-TDMA: 8 slots/frame; 4.6 ms frame duration

Numerology

Frequency bands	900 MHz, 1800 MHz	
Ch. Bandwidth	200 KHz	
Bit Rate	271 Kbit/s	(GSM)
	384 Kbit/s	(Evolved EDGE)

Steps From GSM to 4G: UMTS (Rel. 99)

Modulation

DS-QPSK

Access

FDD

F-CDMA: 10 slots/frame; 10 ms frame duration

Numerology

Frequency bands	2000 MHz
Ch. Bandwidth	5 MHz
Bit Rate	up to 2 Mbit/s

Steps From GSM to 4G: 3G (Rel. 7)

Modulation

DS-QPSK	(UMTS)
DS-64-QAM	(HSPA+)
DS-64-QAM	(Advanced HSPA+)

Access

FDD
F-CDMA: 10 slots/frame; 10 ms frame duration

Numerology

Frequency bands	2000 MHz	
Ch. Bandwidth	5 MHz	
Bit Rate	up to 2 Mbit/s	(UMTS)
	168 Mbit/s	(Advanced HSPA+)

Steps From GSM to 4G: LTE (Rel. 8)

Modulation

OFDM with 16-QAM

Access

FDD

OF-TDMA: 20 mini-slots/frame; 10 ms frame duration

Numerology

Frequency bands	800 MHz, 2.5 GHz	
Ch. Bandwidth	5xn MHz	n = 1, ... , 4
Bit Rate	300 Mbit/s	

Steps From GSM to 4G: 4G (Rel. 14)

Modulation

OFDM with 16-QAM	(LTE)
OFDM with 64-QAM	(LTE-Advanced)
OFDM with 256-QAM	(LTE-Pro)

Access

FDD
OF-TDMA: 20 mini-slots/frame; 10 ms frame duration

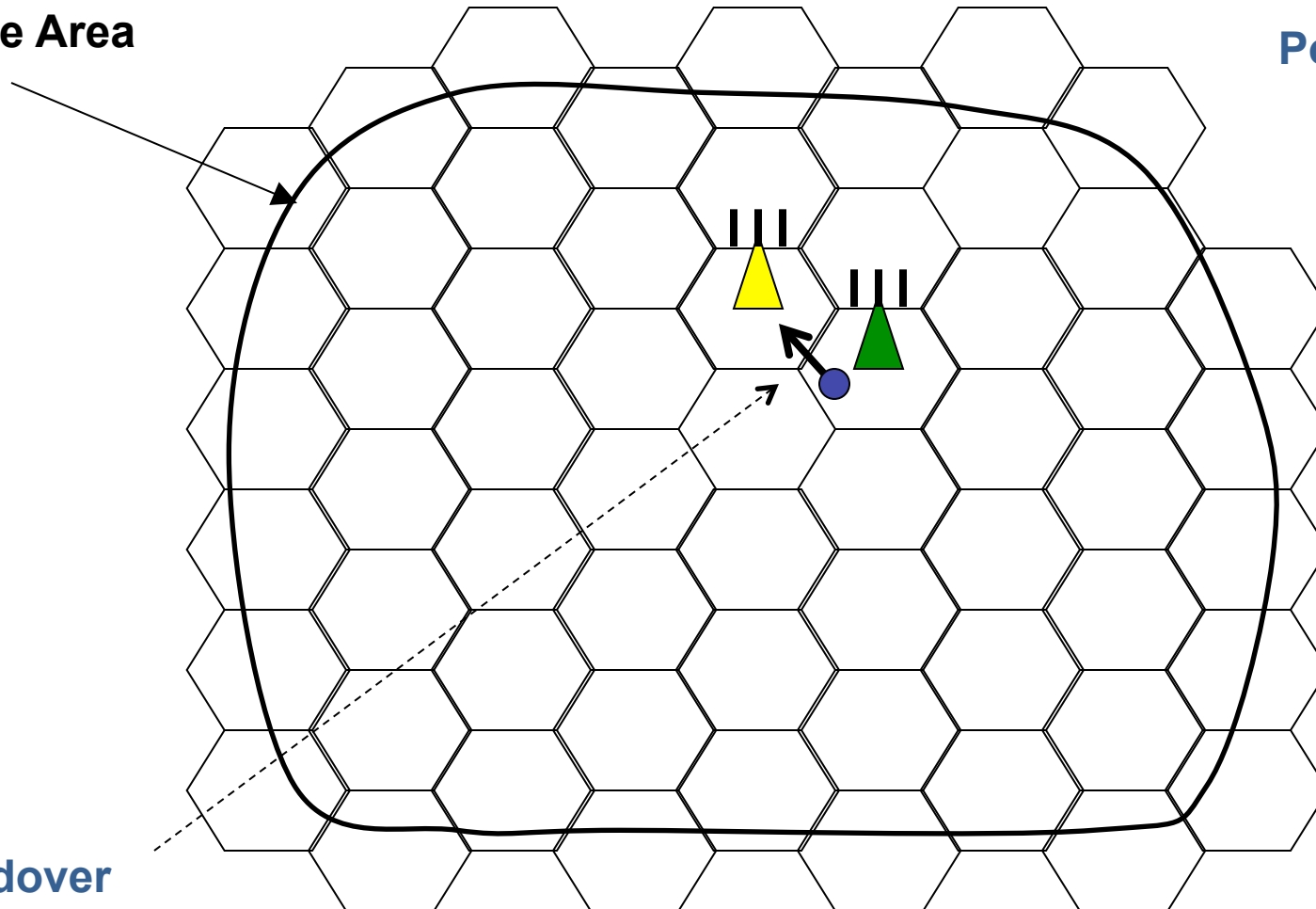
Numerology

Frequency bands	800 MHz, 2.5 GHz	
Ch. Bandwidth	5xn MHz	n = 1, ... , 20
Bit Rate	300 Mbit/s	(LTE)
	3 Gbit/s	(LTE-Pro)

2. Cellular Networks

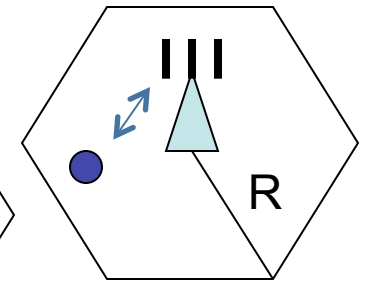
Area Coverage Networks / Cellular Networks

Service Area



Handover

Scheduling
Power Control



One base
per cell
with
omnidirect.
antenna
system

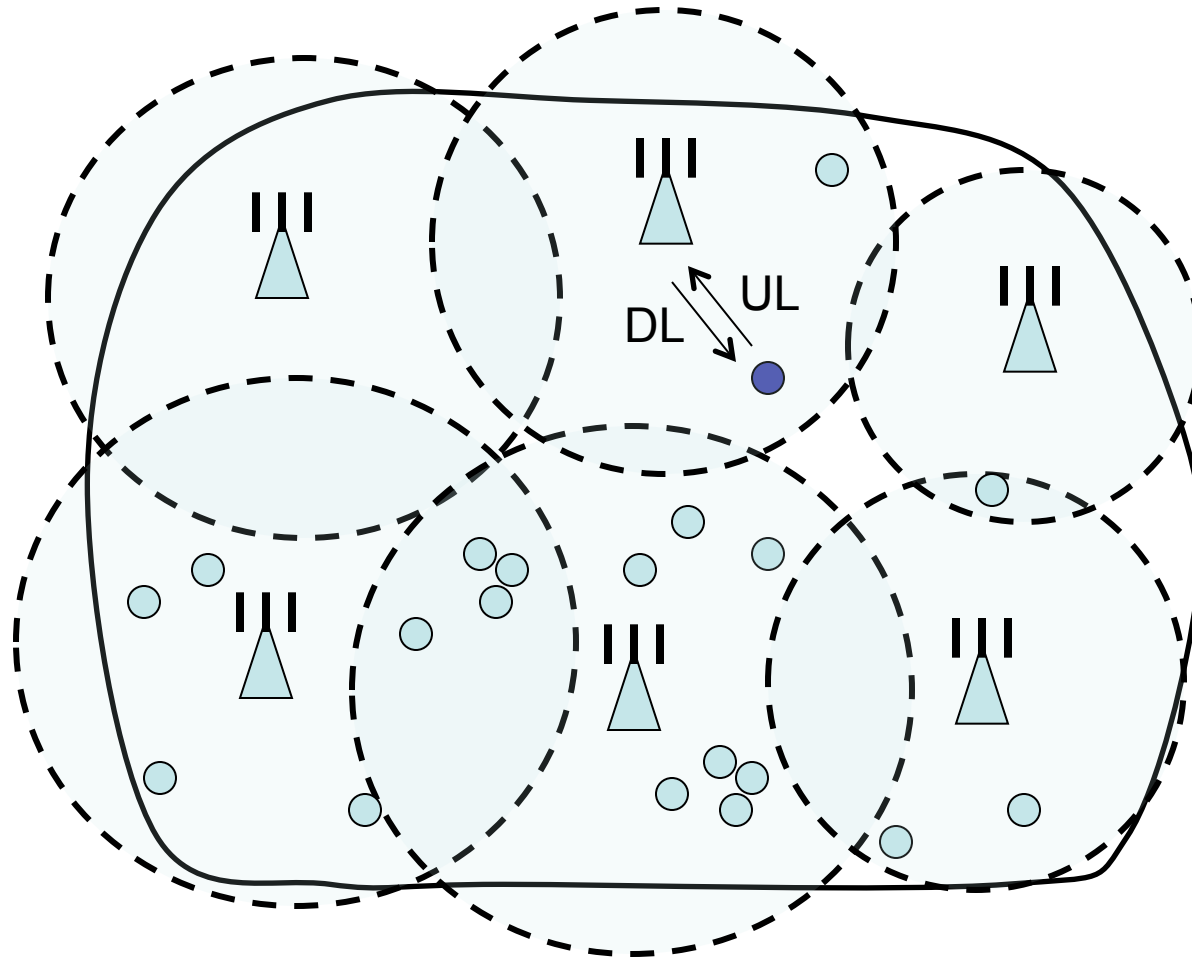
Area Coverage Networks / Cellular Networks

2G:
FDD
orthogonal

3G:
FDD
non-orth.

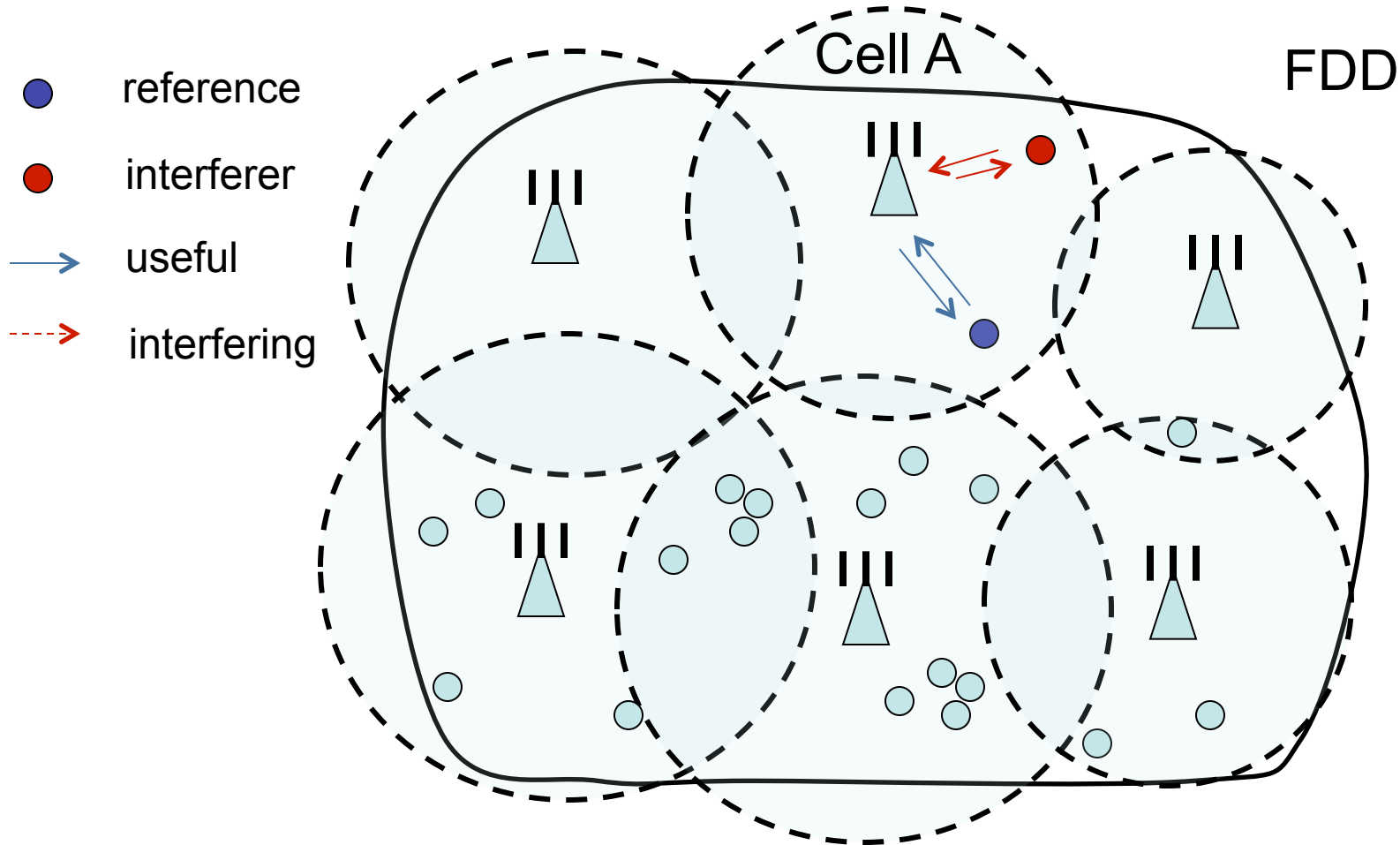
4G:
FDD
orthogonal

5G
FDD
orth./NOMA



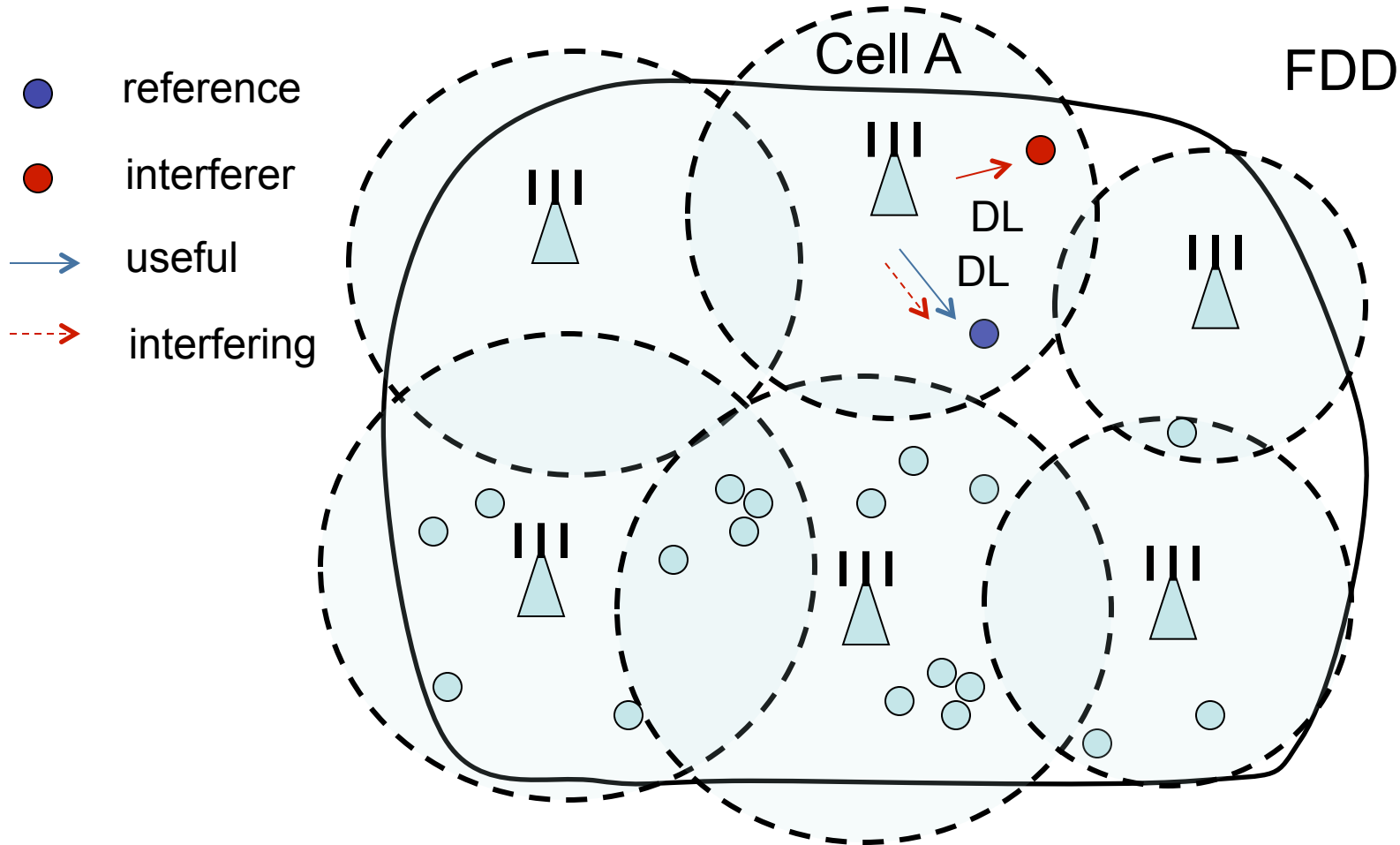
Downlink and Uplink

Area Coverage Networks / Cellular Networks



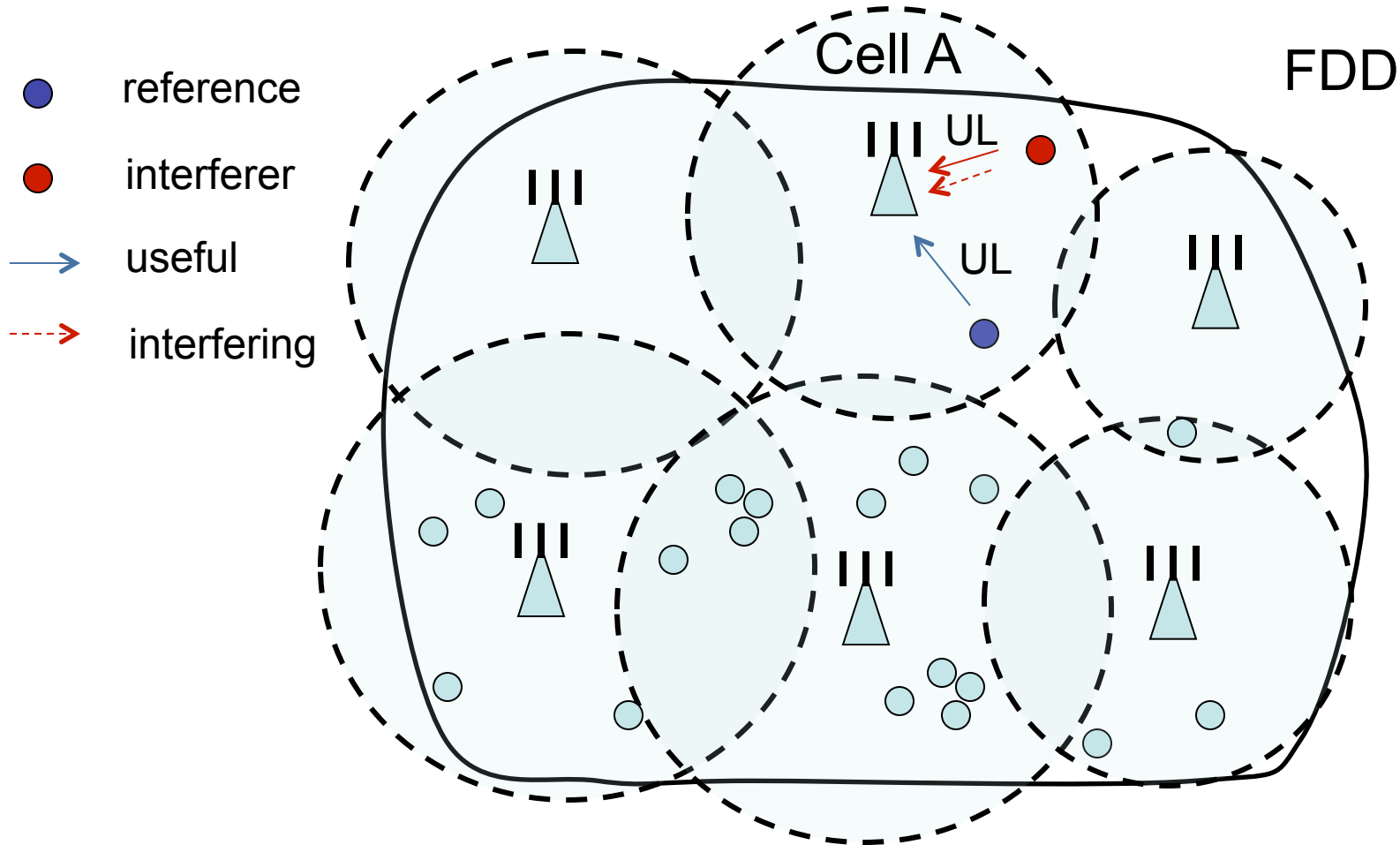
Intra-cell interference is absent if **orthogonal RUs** are used

Area Coverage Networks / Cellular Networks



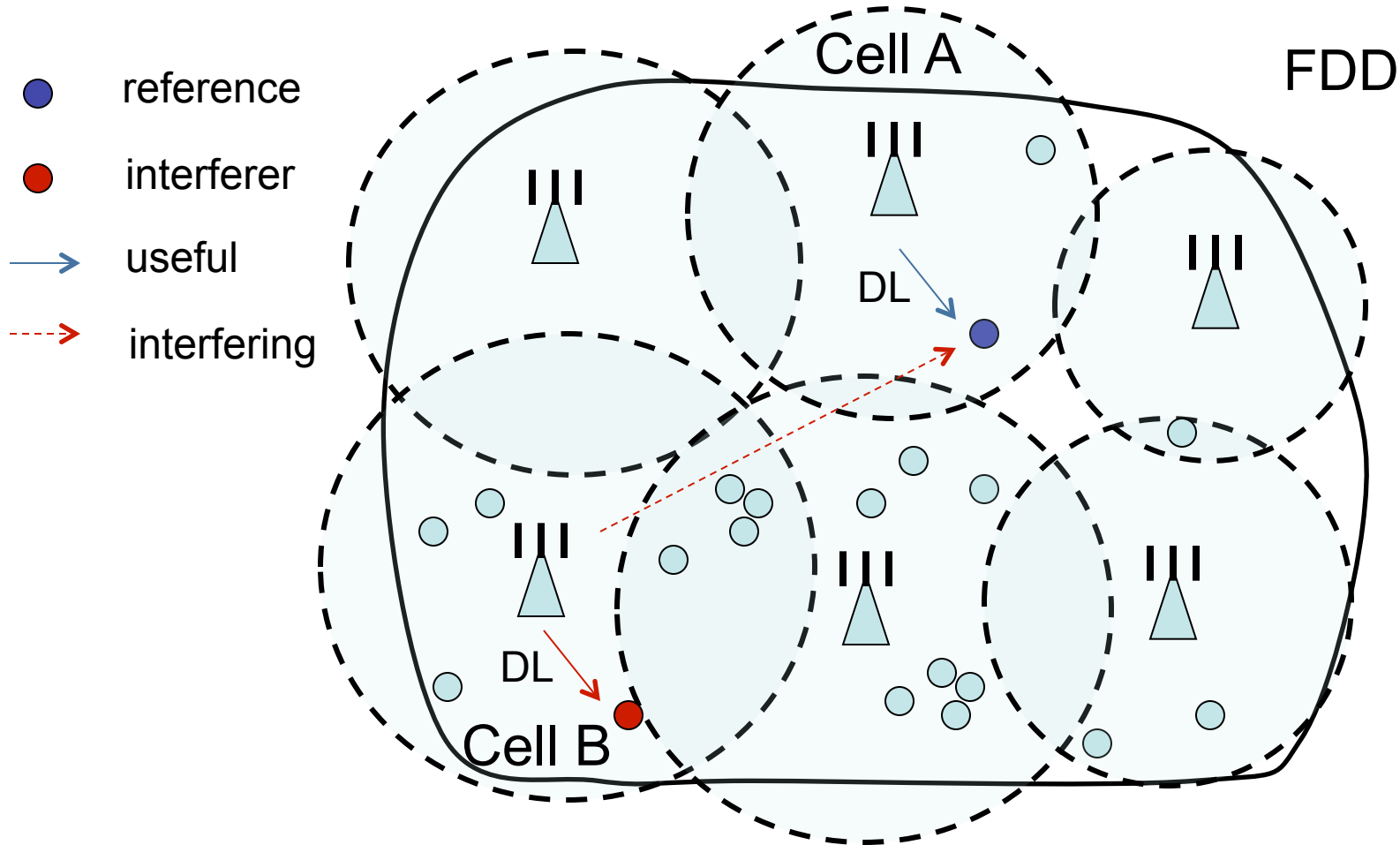
UL/UL or DL/DL intra-cell interference with non-orthogonal RUs

Area Coverage Networks / Cellular Networks



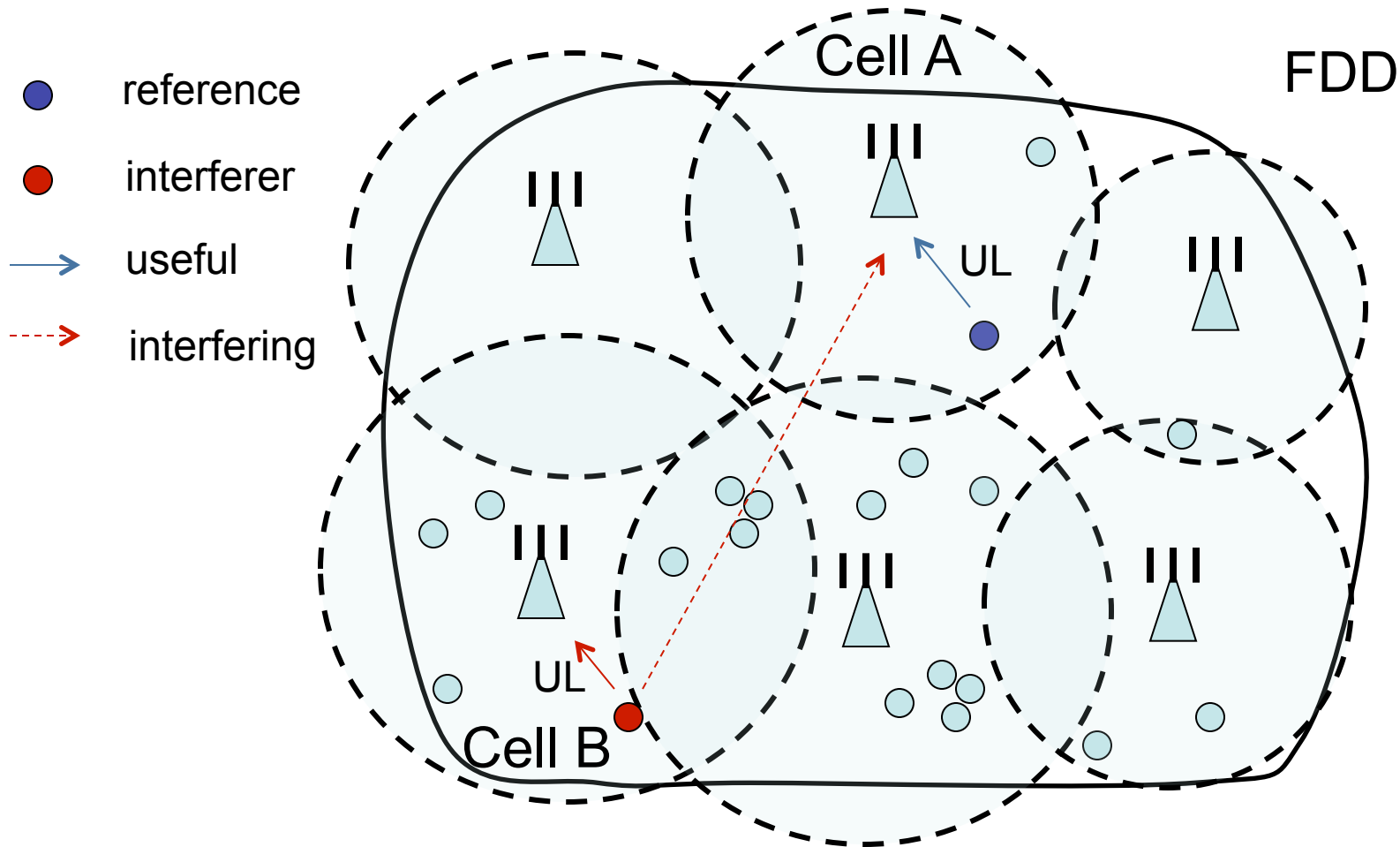
UL/UL or DL/DL intra-cell interference with non-orthogonal RUs

Area Coverage Networks / Cellular Networks



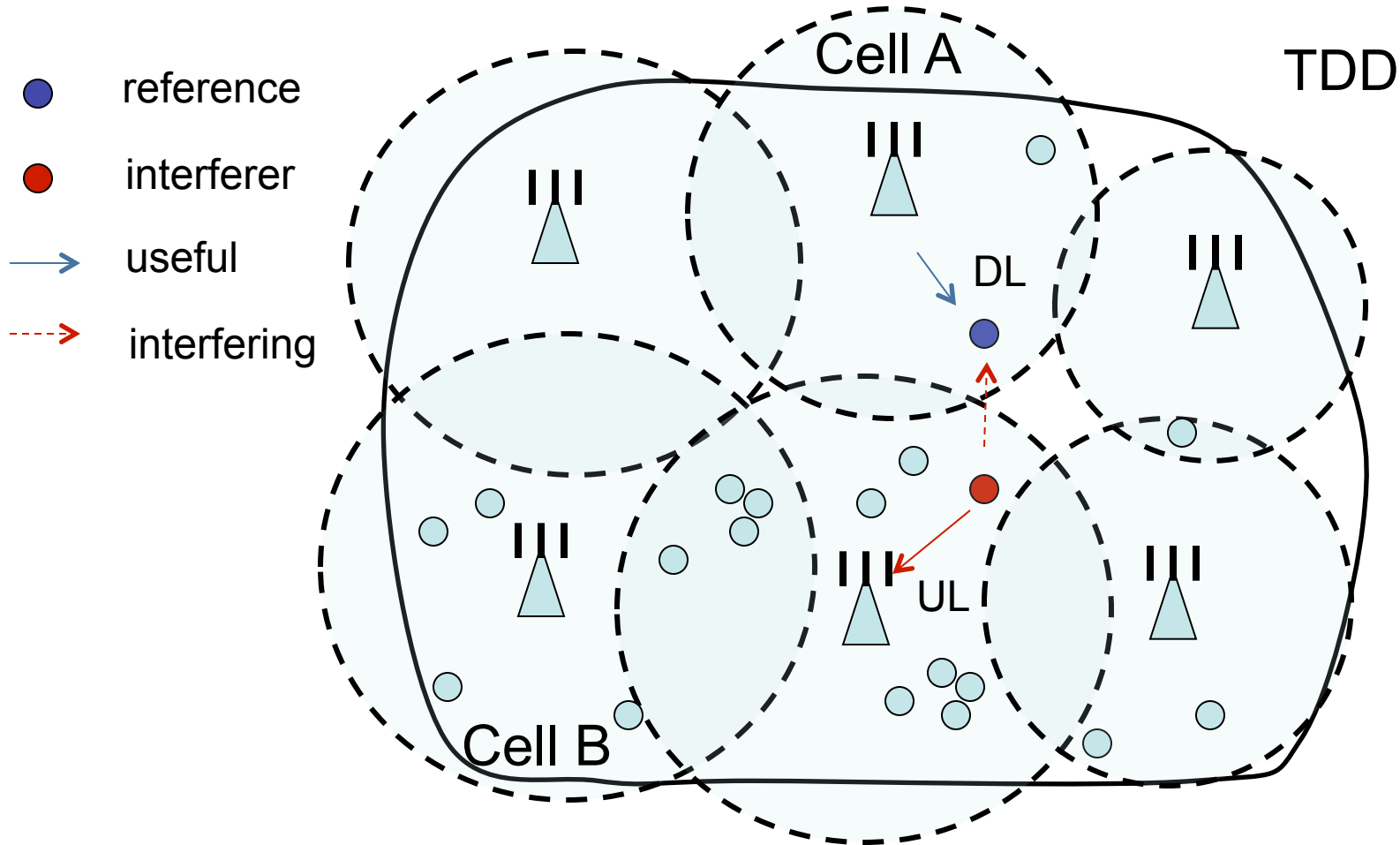
UL/UL and DL/DL inter-cell interference if **reuse** is implemented

Area Coverage Networks / Cellular Networks



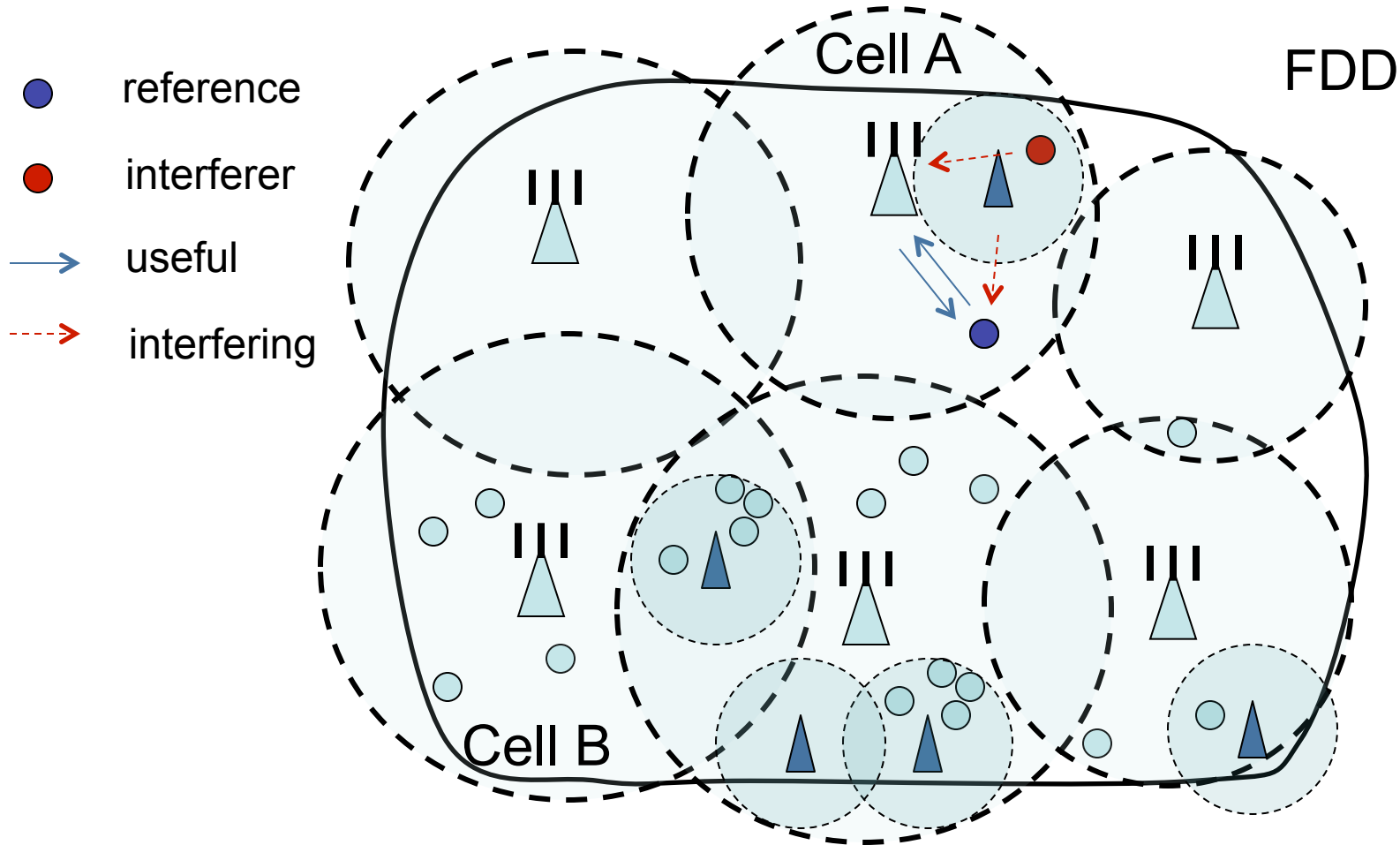
UL/UL and DL/DL inter-cell interference if **reuse** is implemented

Area Coverage Networks / Cellular Networks



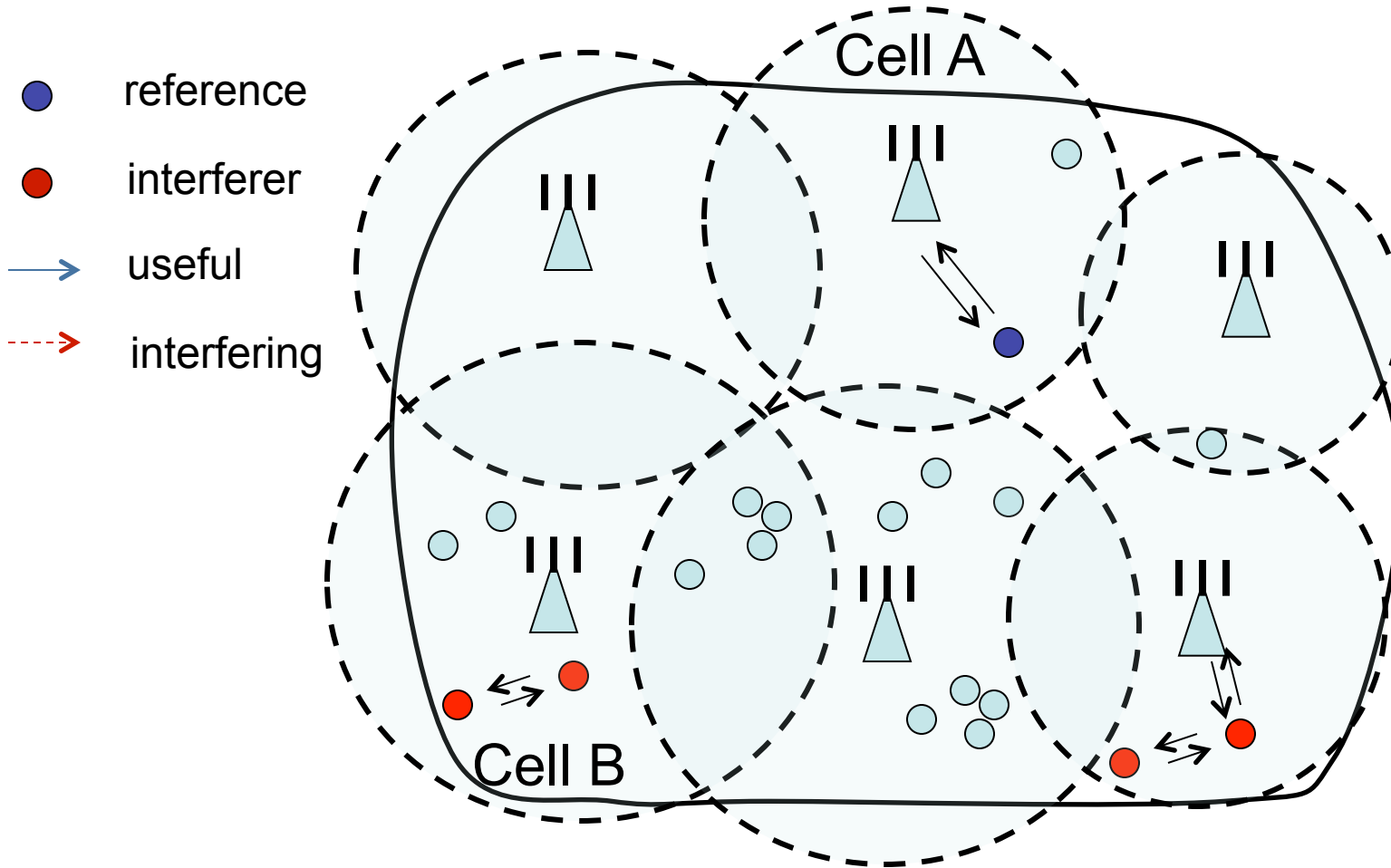
UL/DL inter-cell interference if transmissions are **not synchronised**

Area Coverage Networks / Cellular Networks



Small cells interference

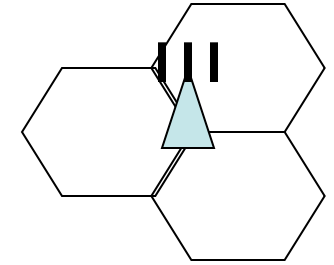
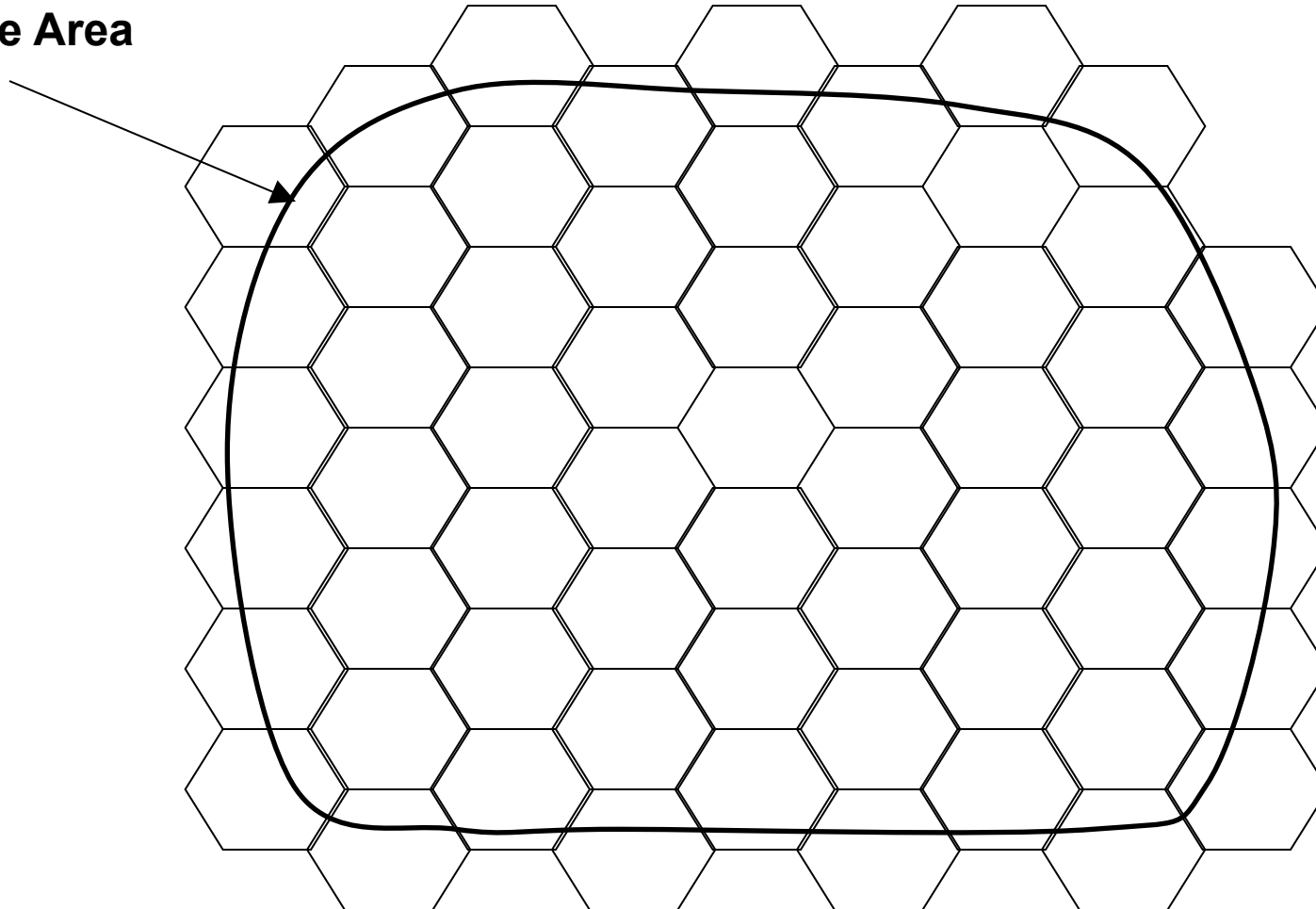
Area Coverage Networks / Cellular Networks



Device-to-Device (**D2D**)

Area Coverage Networks / Cellular Networks

Service Area



**One site
(3 bases)
every 3 cells
with
tri-sectorial
antenna
system**

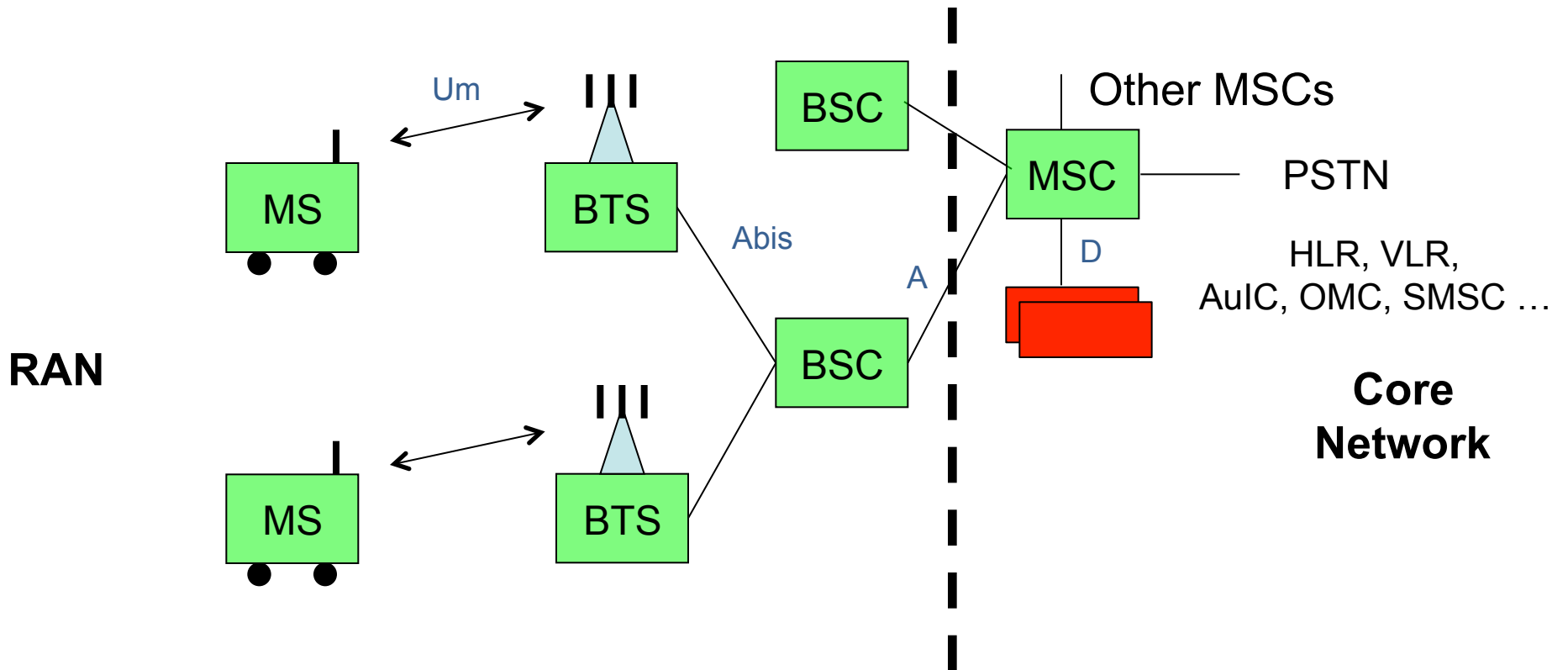
Inquiry Based Session

- **Why tri-sectorial antenna systems are better?**
 - **What are the pros and cons of having smaller cells?**
-

3. Network Architectures: Evolution From GSM to 4G

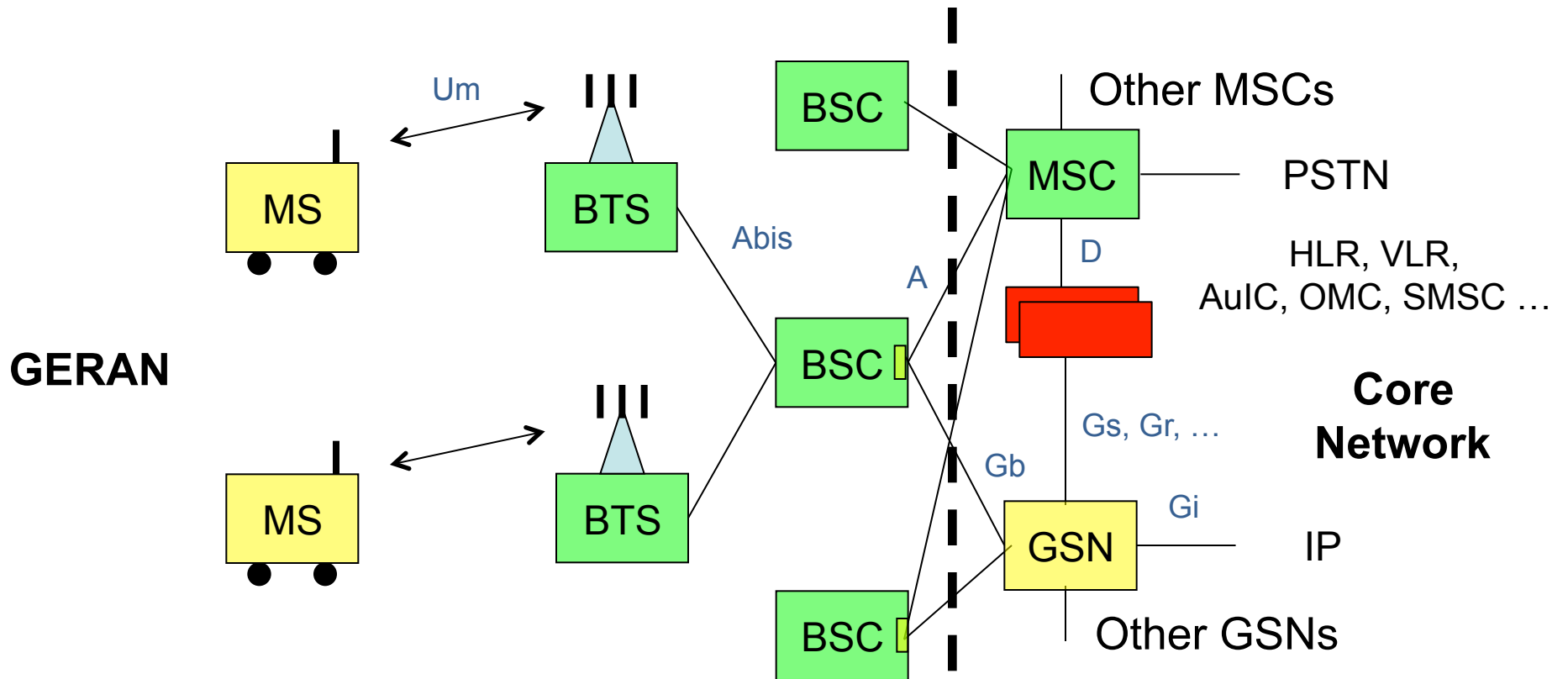
Network Architecture: 2G (GSM)

Radio Access Network

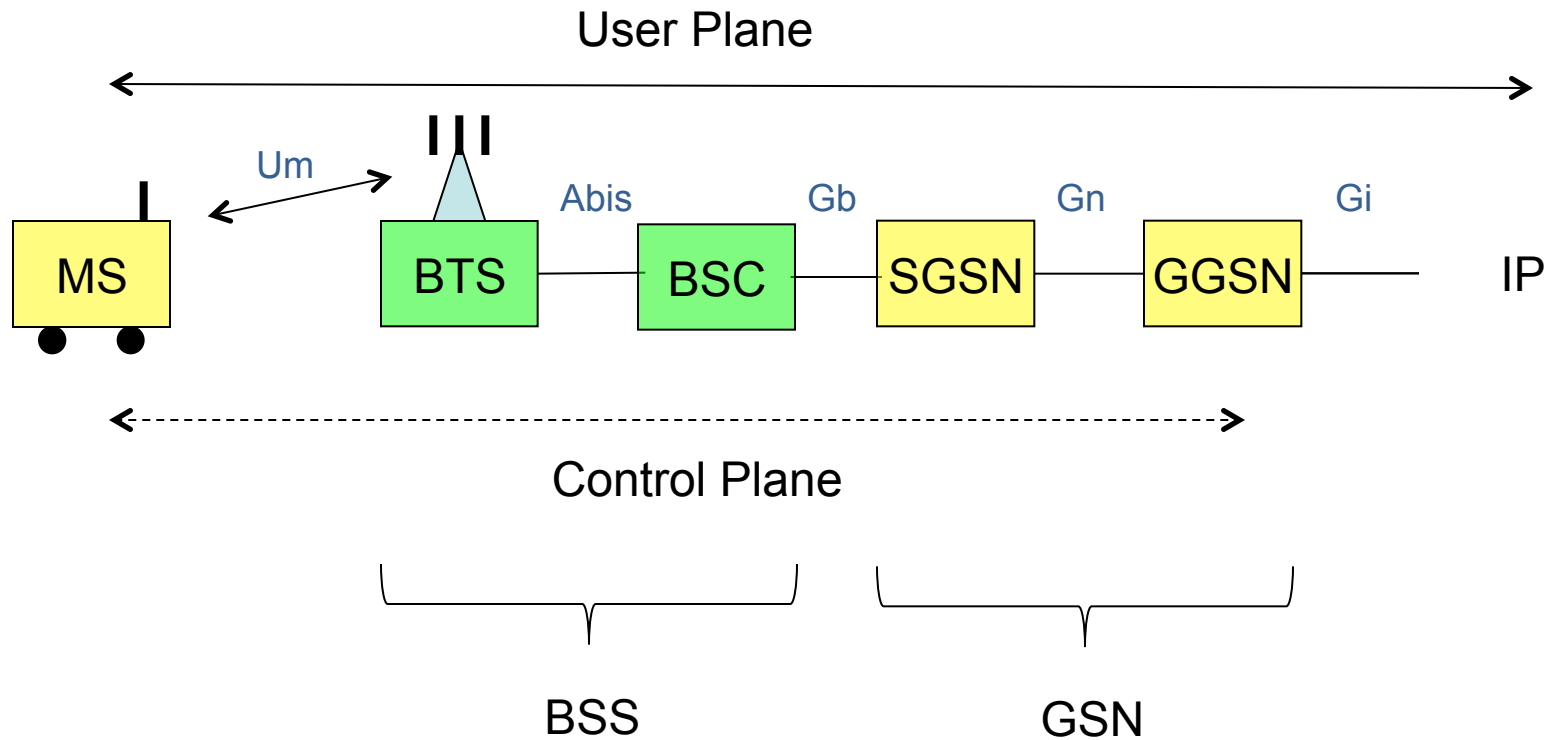


Network Architecture: 2.5G (Rel. 97)

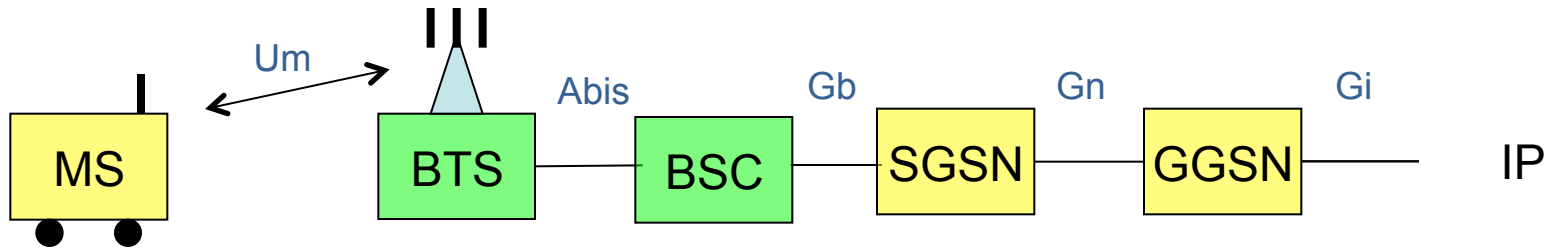
Radio Access Network



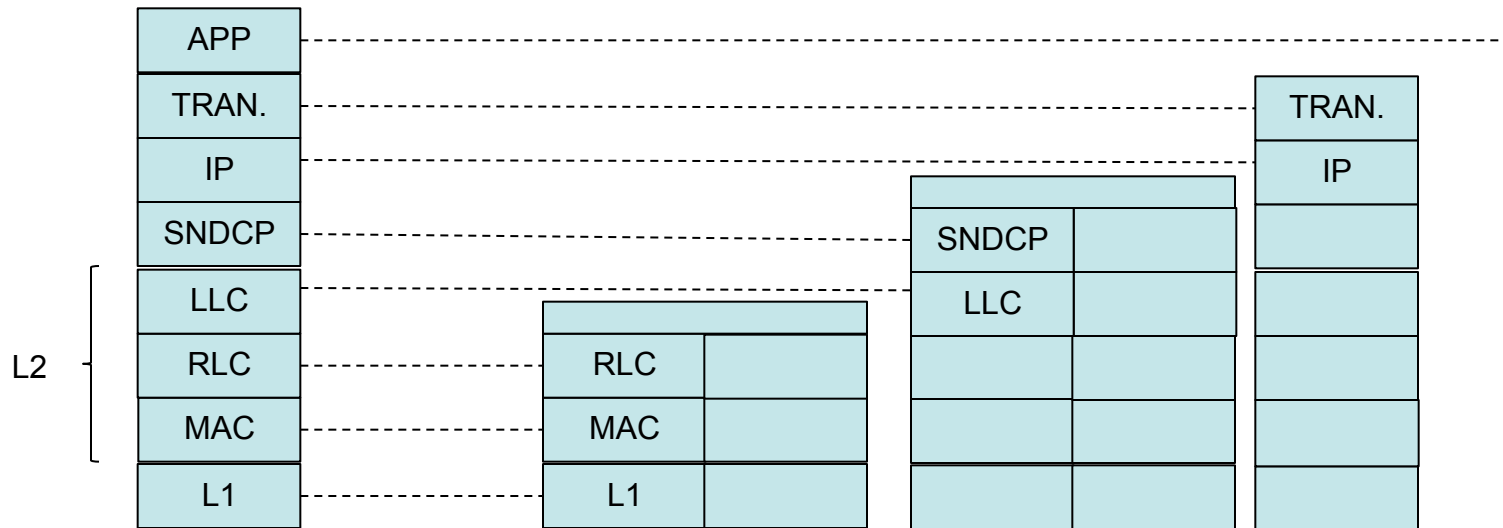
User / Control Plane (Rel. 97)



Protocol Architecture (Rel. 97)

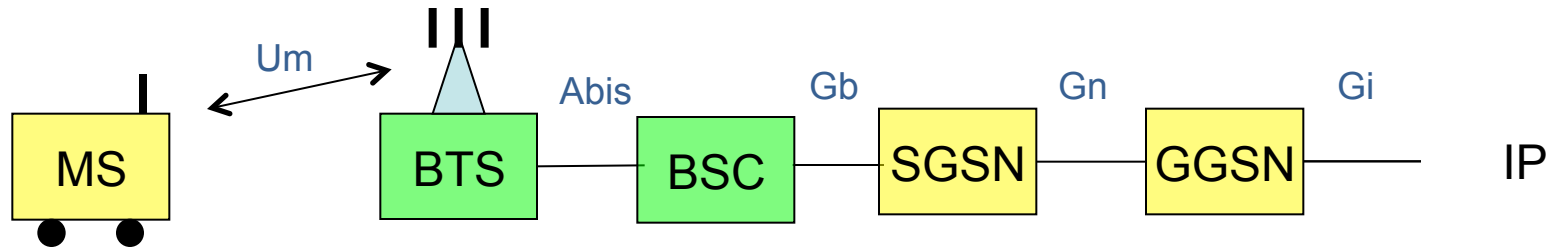


User Plane

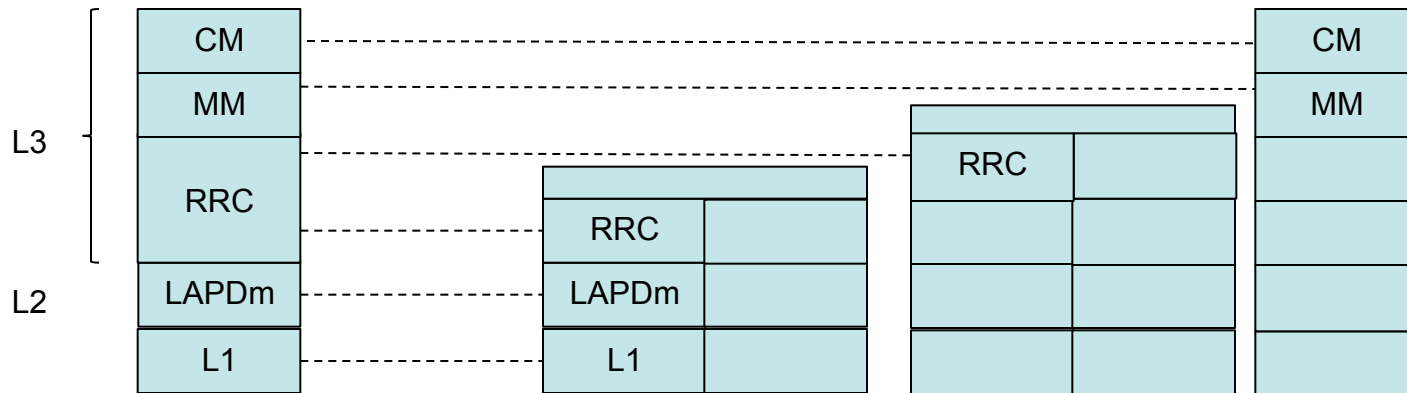


BSS

Protocol Architecture (Rel. 97)

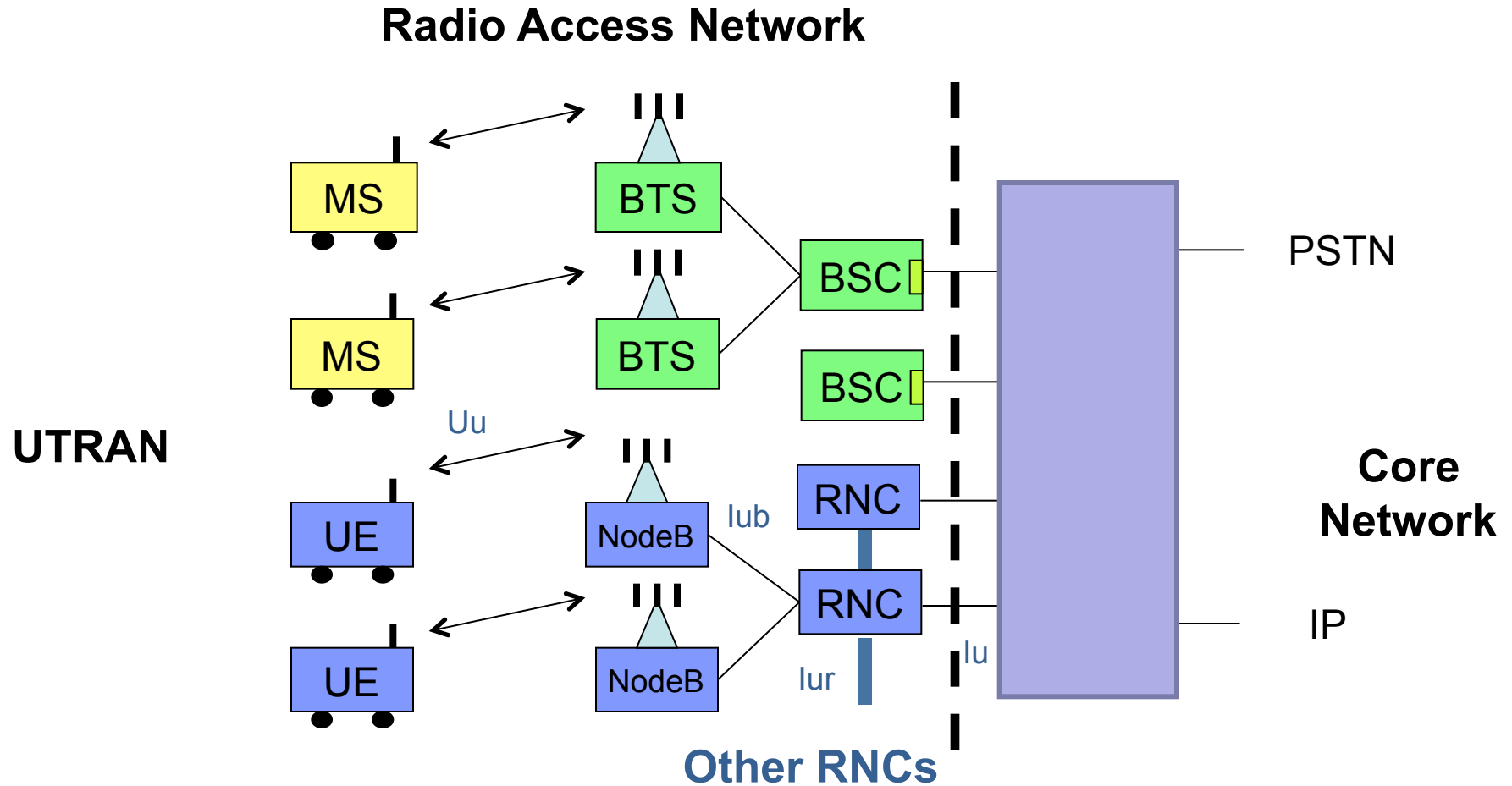


Control Plane



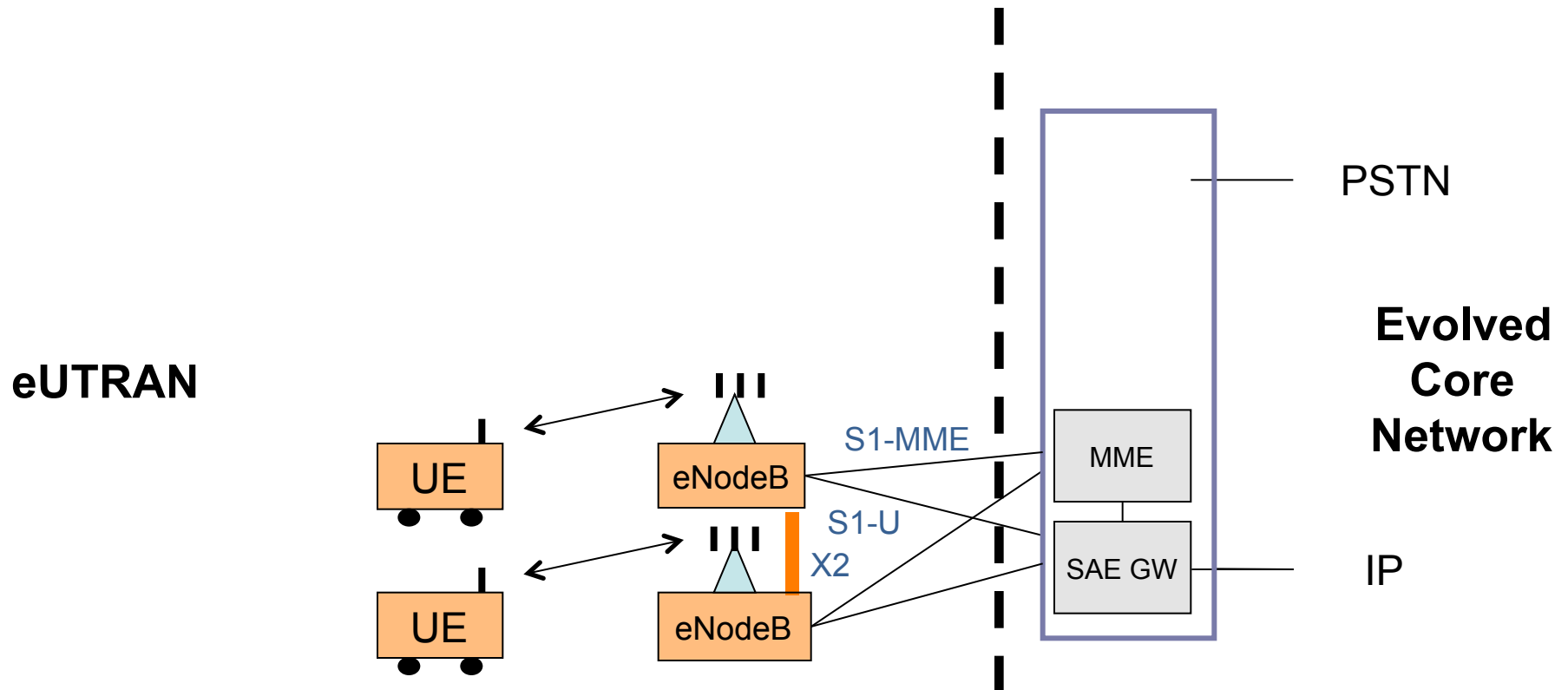
BSS

Network Architecture: UMTS (Rel. 99)

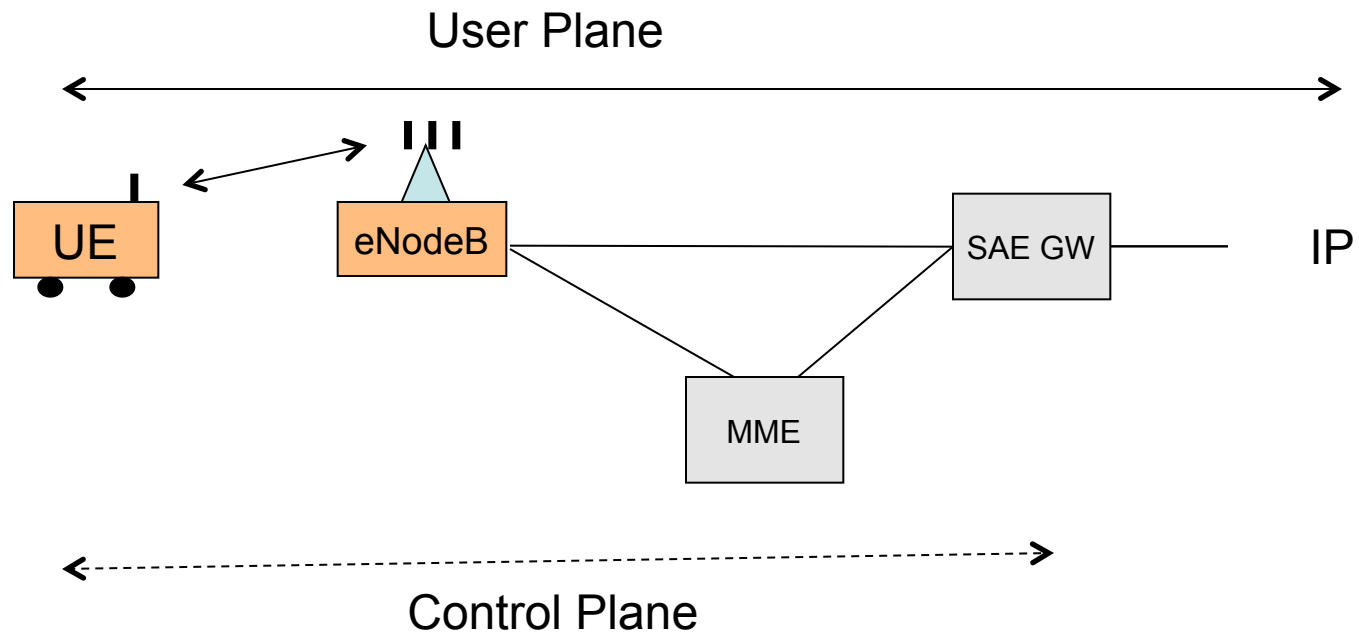


Network Architecture: LTE (Rel. 8)

Radio Access Network

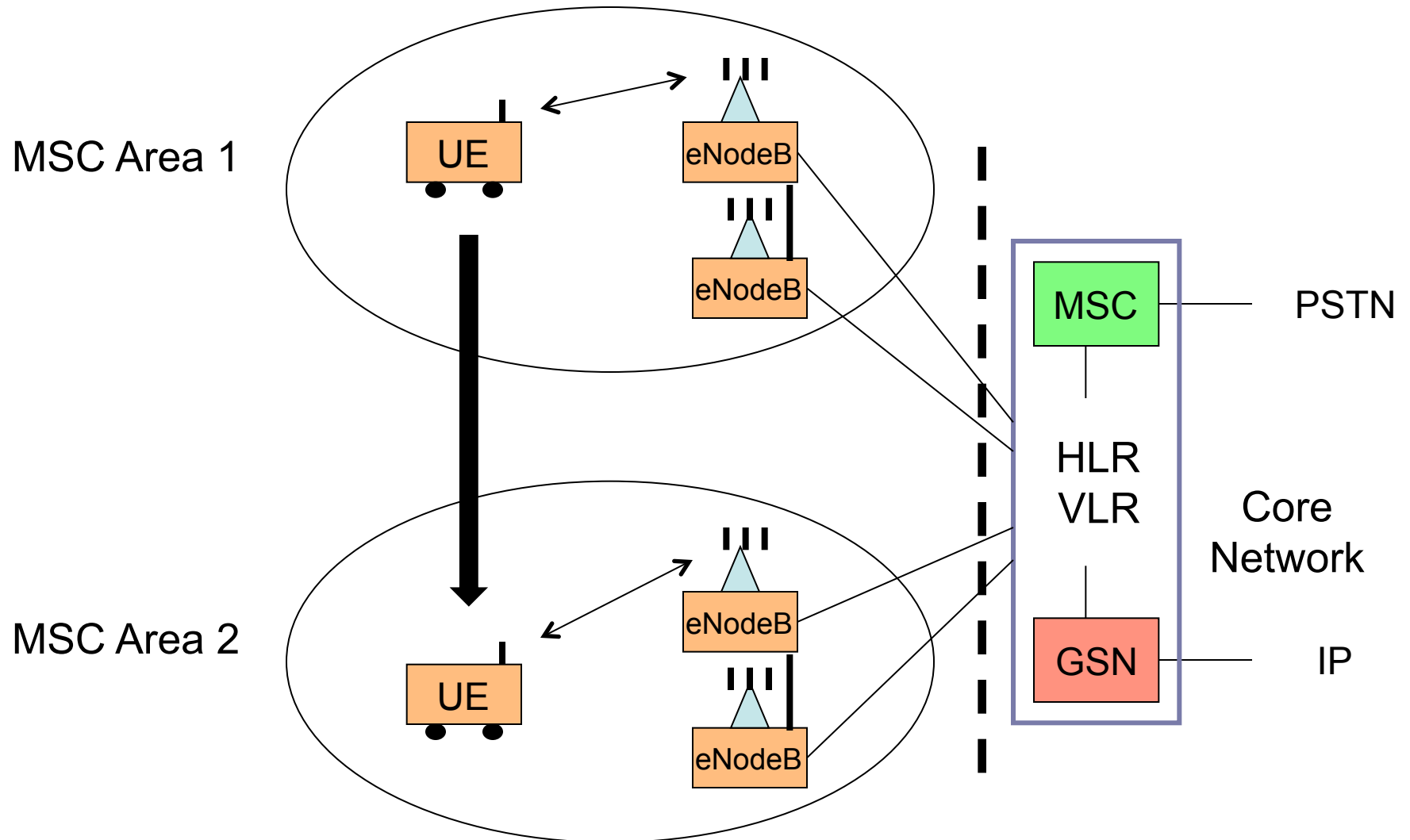


User / Control Plane (Rel. 8)

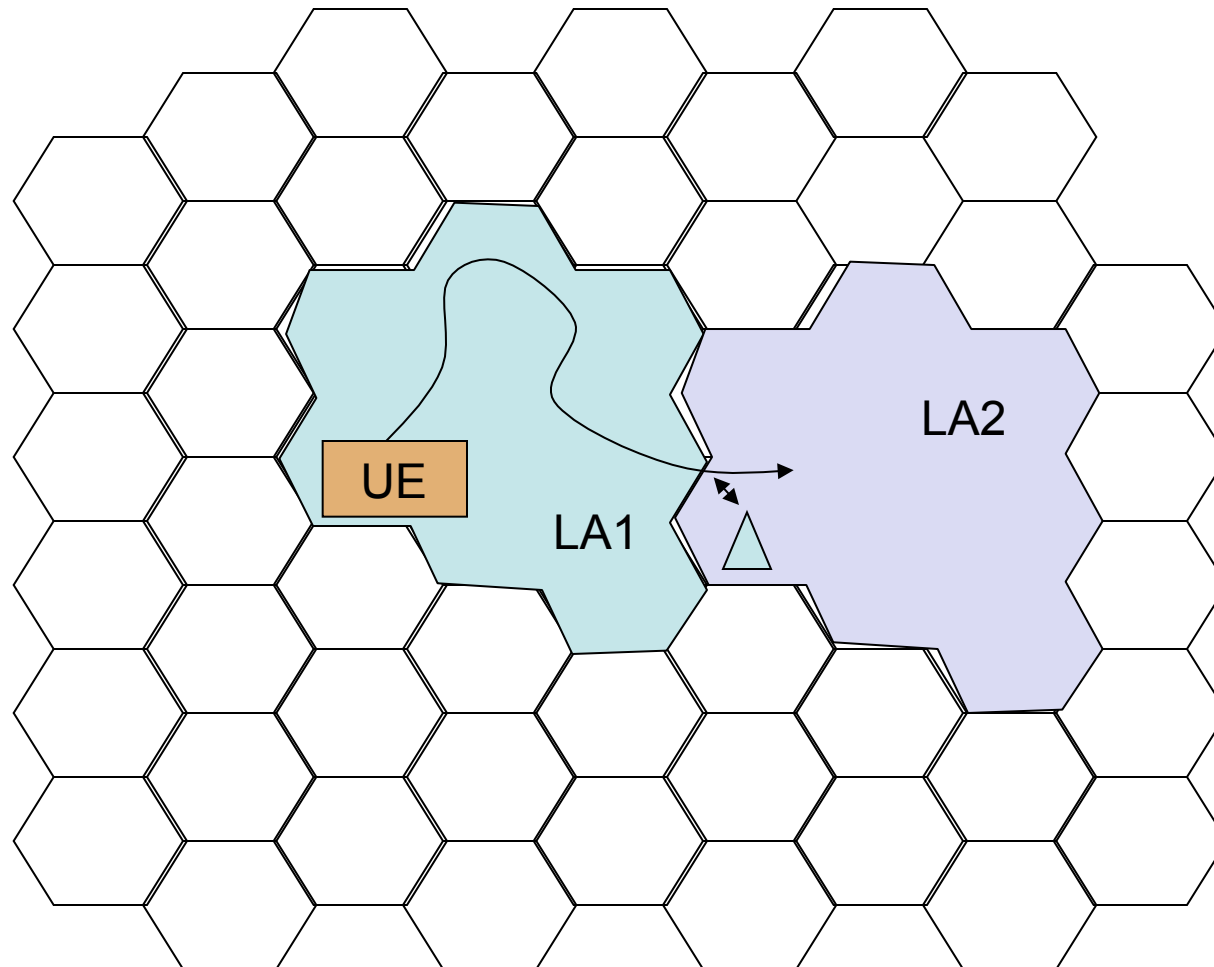


4. Mobility Management

Mobility Management (Macro Level): HLR, VLR

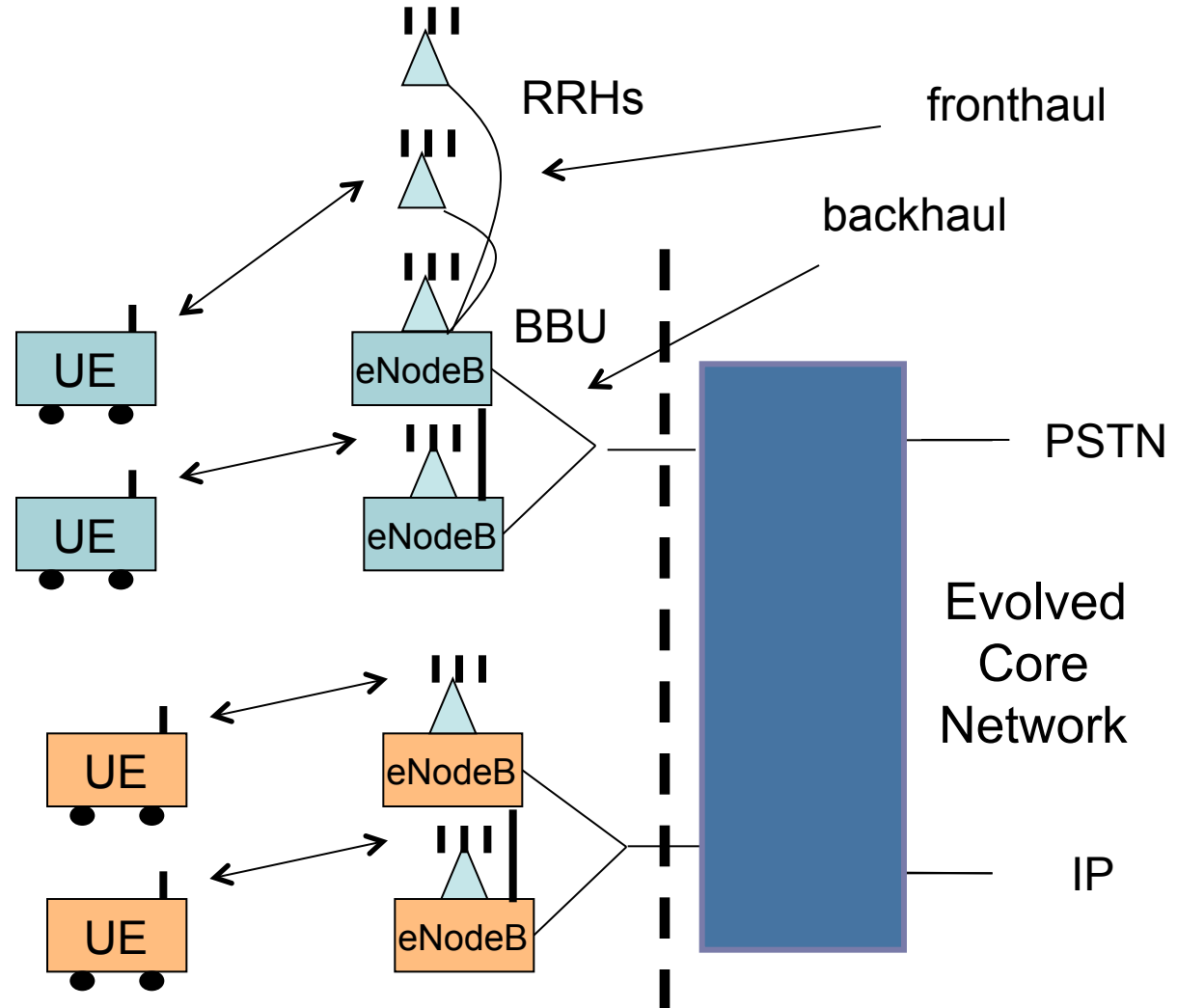


Mobility Management (Micro Level): Location Areas



5. Network Architectures: Evolution Towards 5G

Network Architecture: 5G



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Mobile Network Architectures

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