

MNA

Mobile Radio Networks

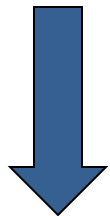
Mobile Network Architectures

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Monday 4 – 6 pm
(upon prior agreement via email)

A.Y. 2019-20
Credits: 6



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

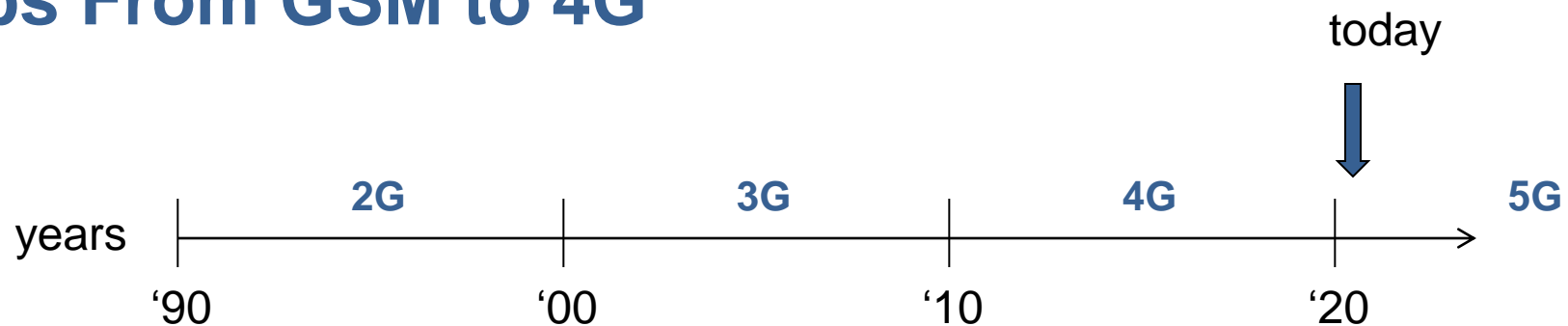
Outline

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**

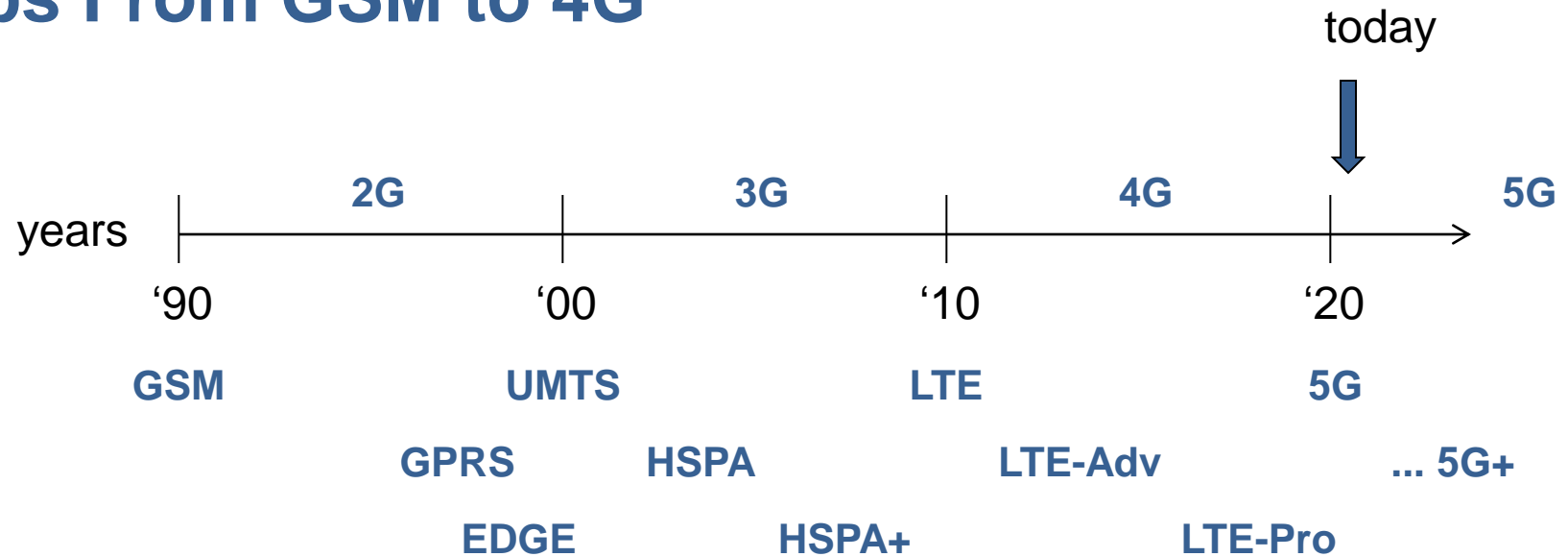
This lecture block will provide the basic concepts related to mobile radio network architectures and the way they manage mobility of users.

1. Steps From GSM to 4G

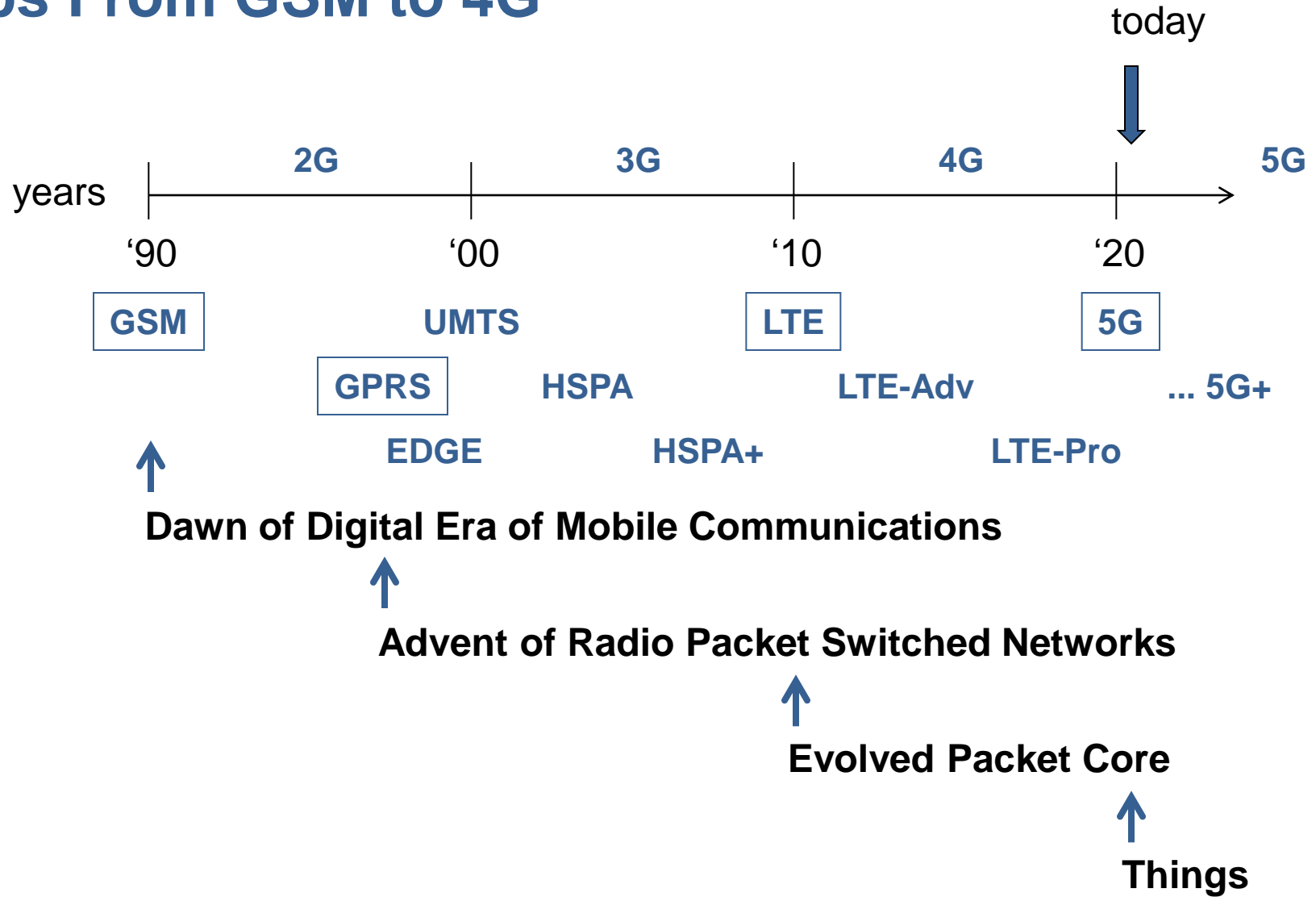
Steps From GSM to 4G



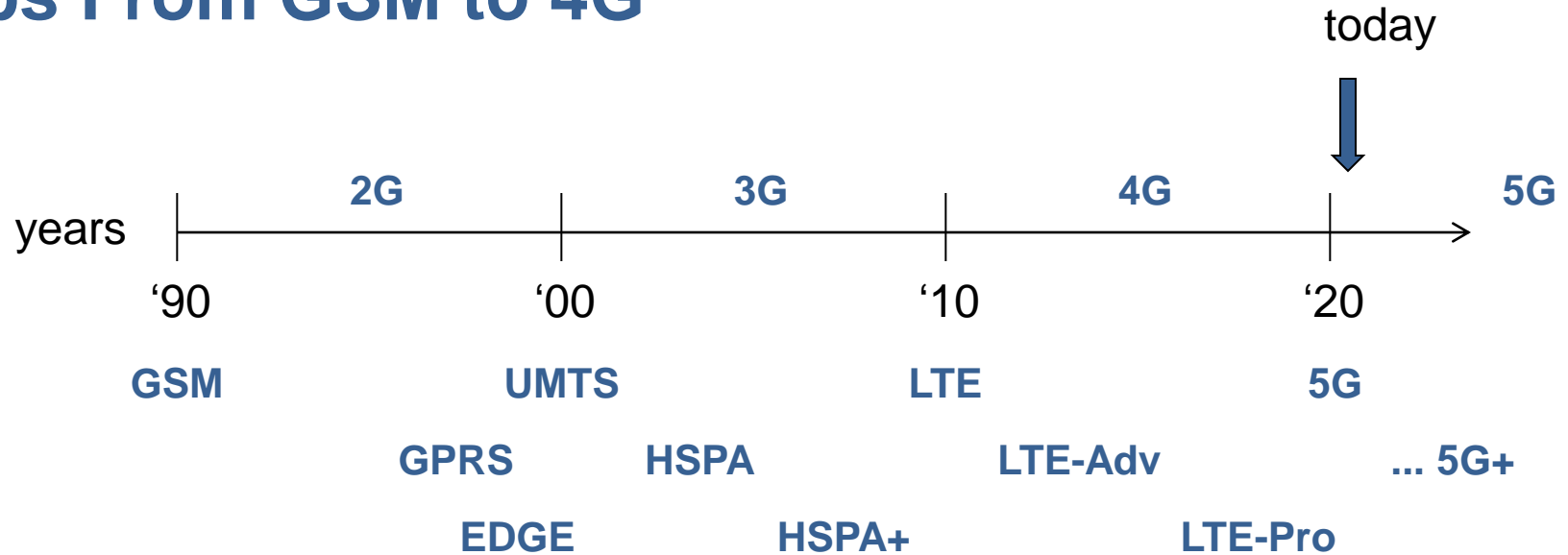
Steps From GSM to 4G



Steps From GSM to 4G



Steps From GSM to 4G

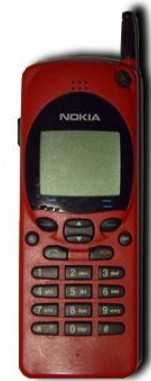


| | | | | | | | |
|-----------------|------------|-------|-----------|-------|----------|-------|--------------|
| U (theoretical) | 500 Kbit/s | x 100 | 50 Mbit/s | x 100 | 4 Gbit/s | x 100 | > 100 Gbit/s |
| Latency | 300 ms | | 100 ms | | 10 ms | | 1 ms |

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

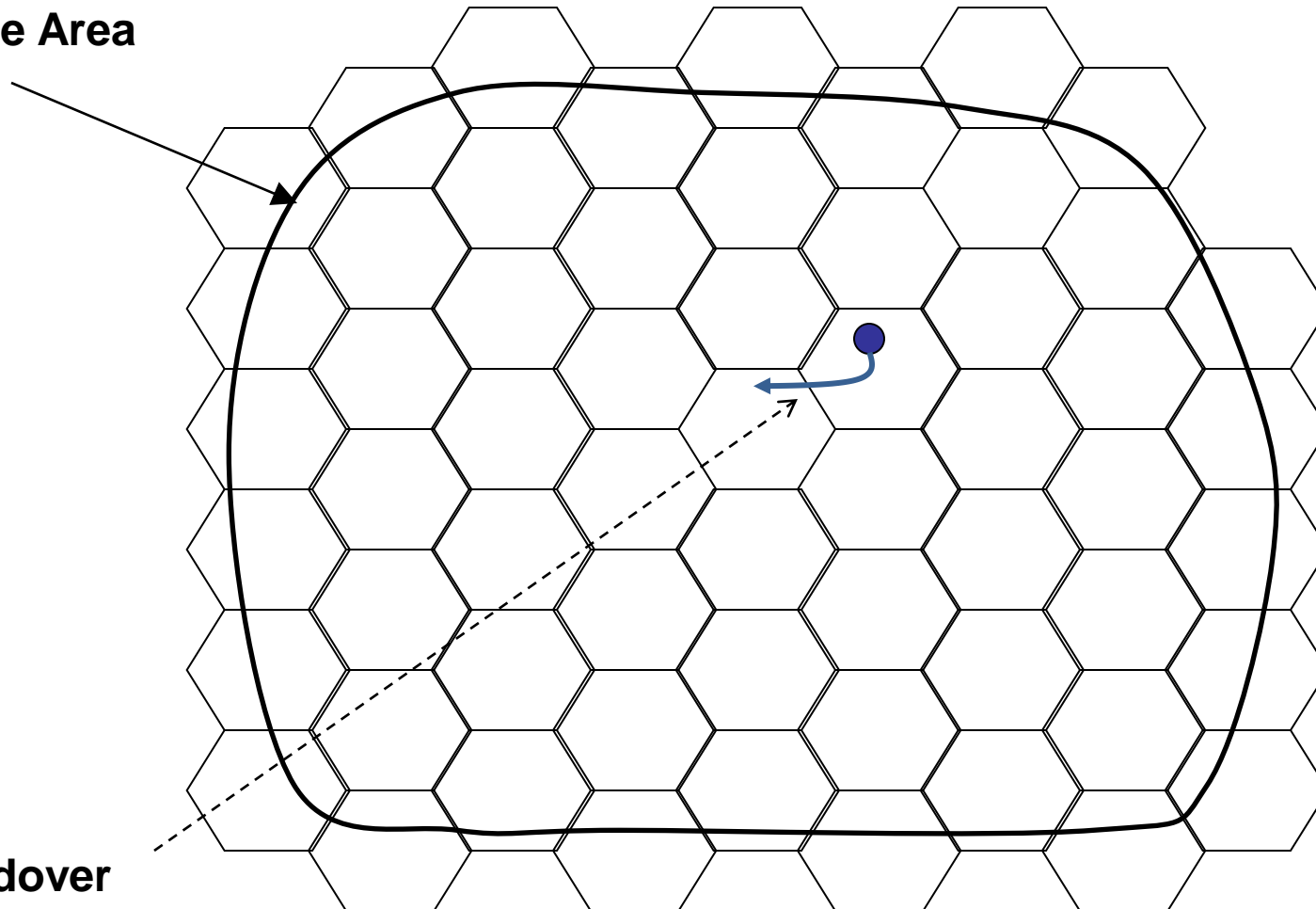
Numerology

| | | |
|-----------------|------------------|-----------------|
| 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) |

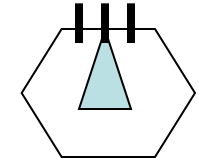
2. Cellular Networks

Area Coverage Networks / Cellular Networks

Service Area

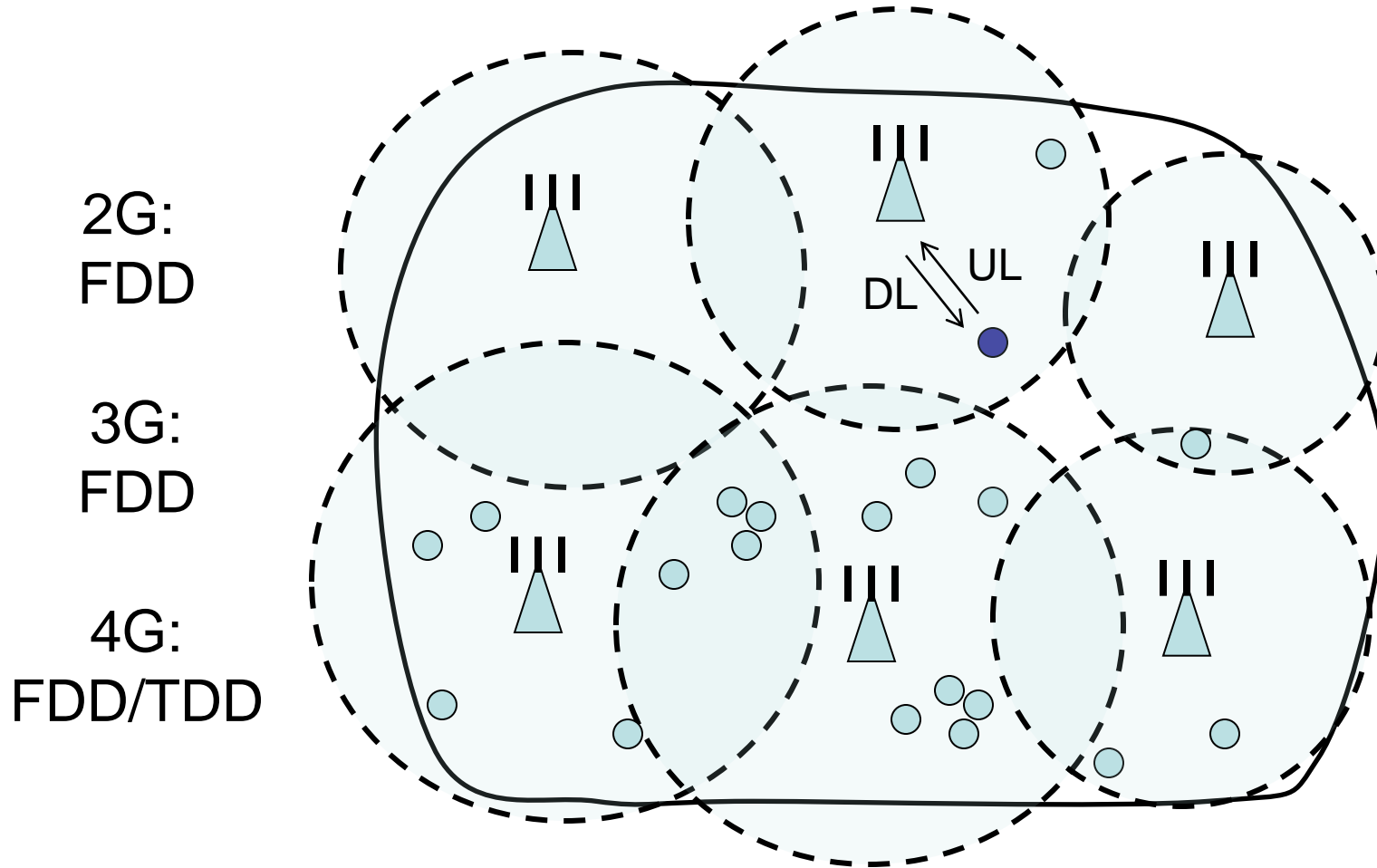


Handover



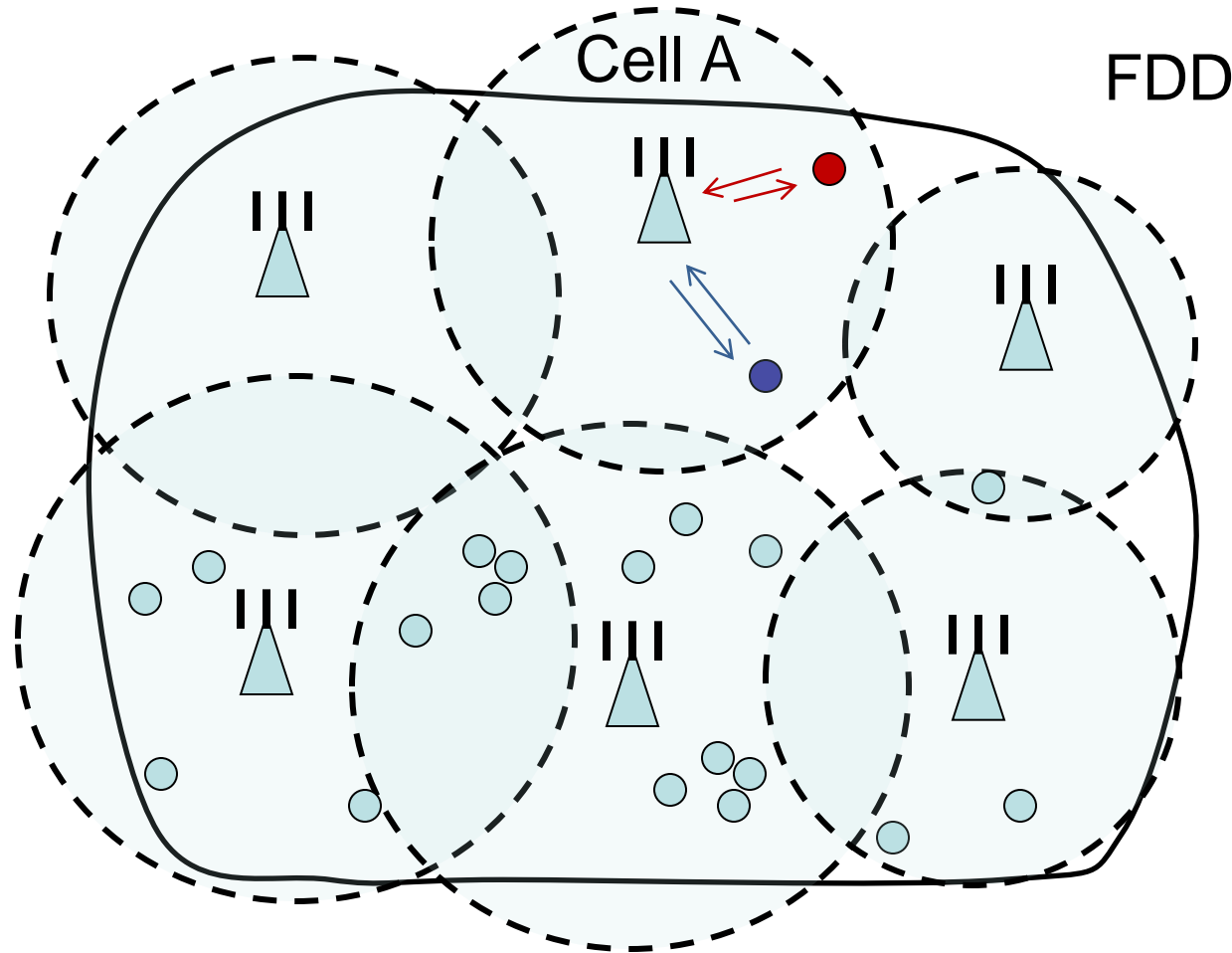
One base
per cell
with
omnidirect.
antenna
system

Area Coverage Networks / Cellular Networks



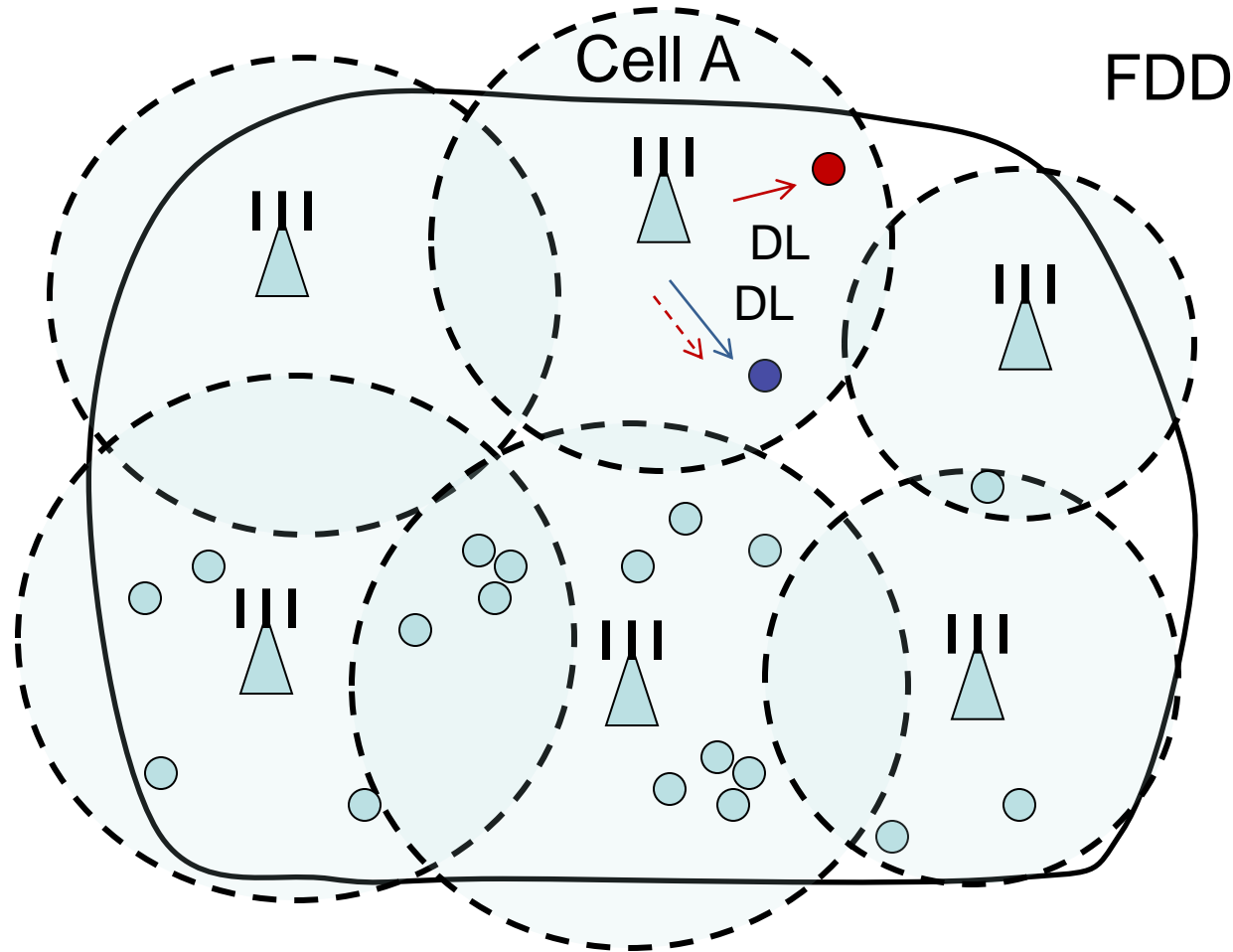
Downlink and Uplink

Area Coverage Networks / Cellular Networks



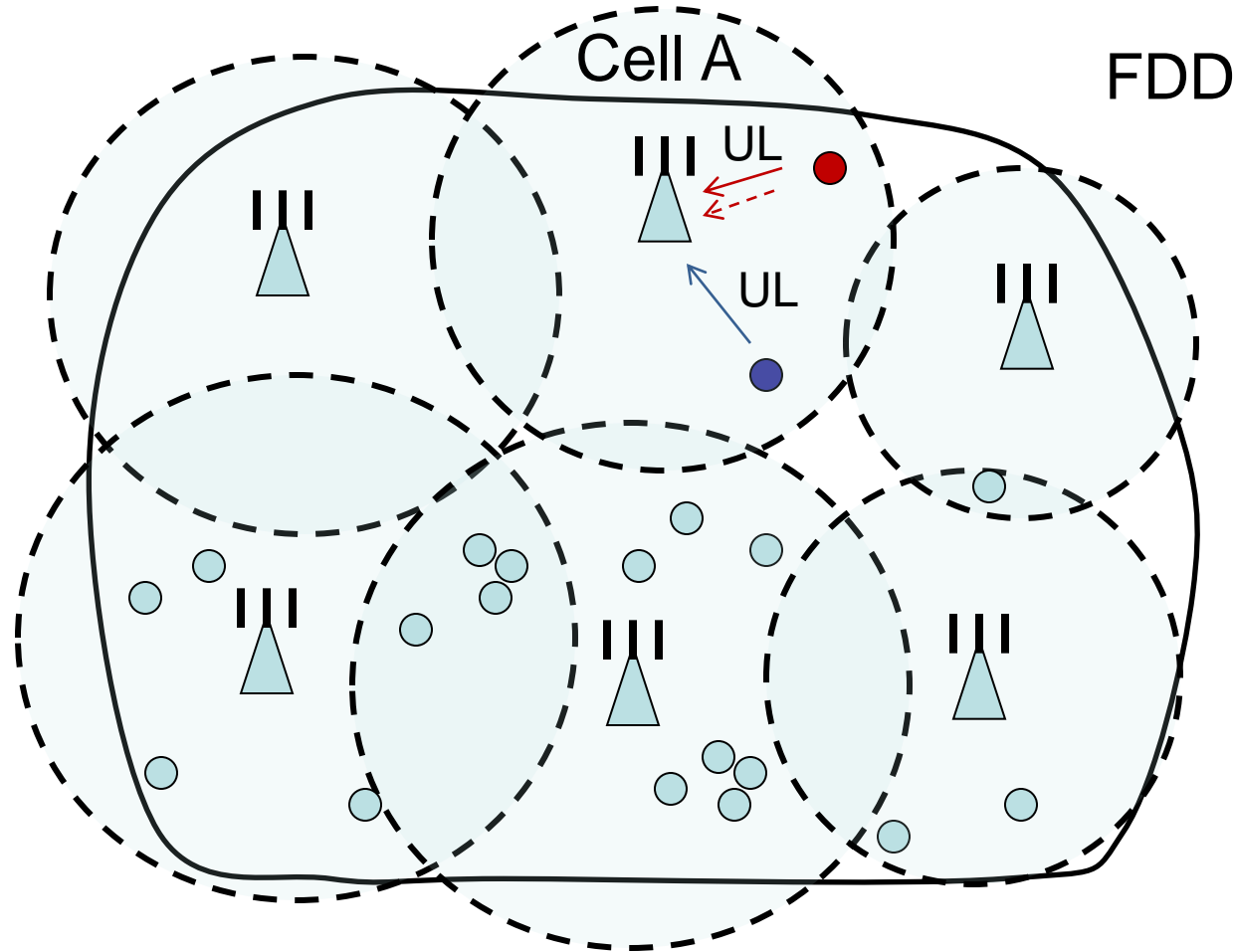
Intra-cell interference is absent if orthogonal RUs are used

Area Coverage Networks / Cellular Networks



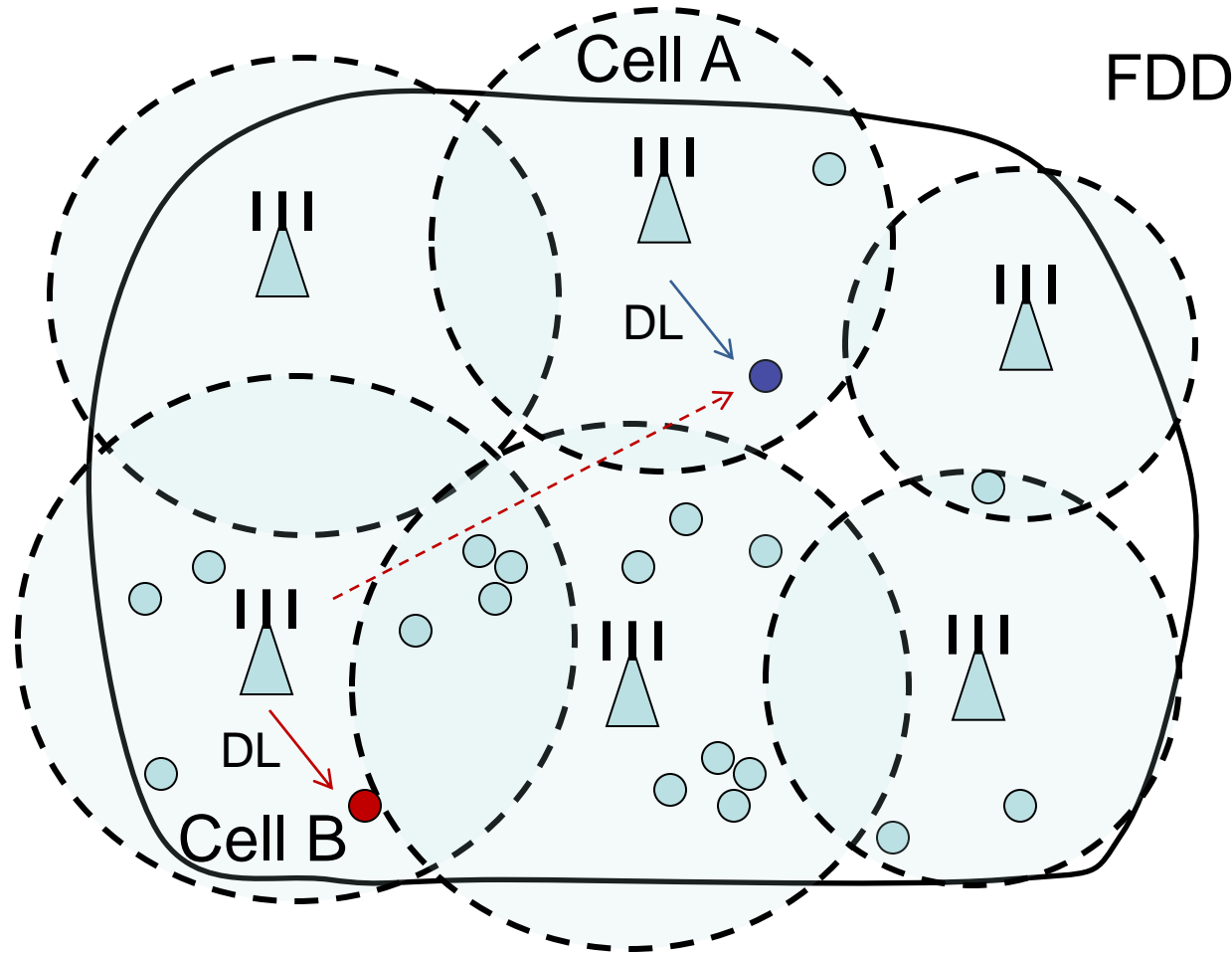
UL/UL or DL/DL intra-cell interference with non-orthogonal RUs

Area Coverage Networks / Cellular Networks



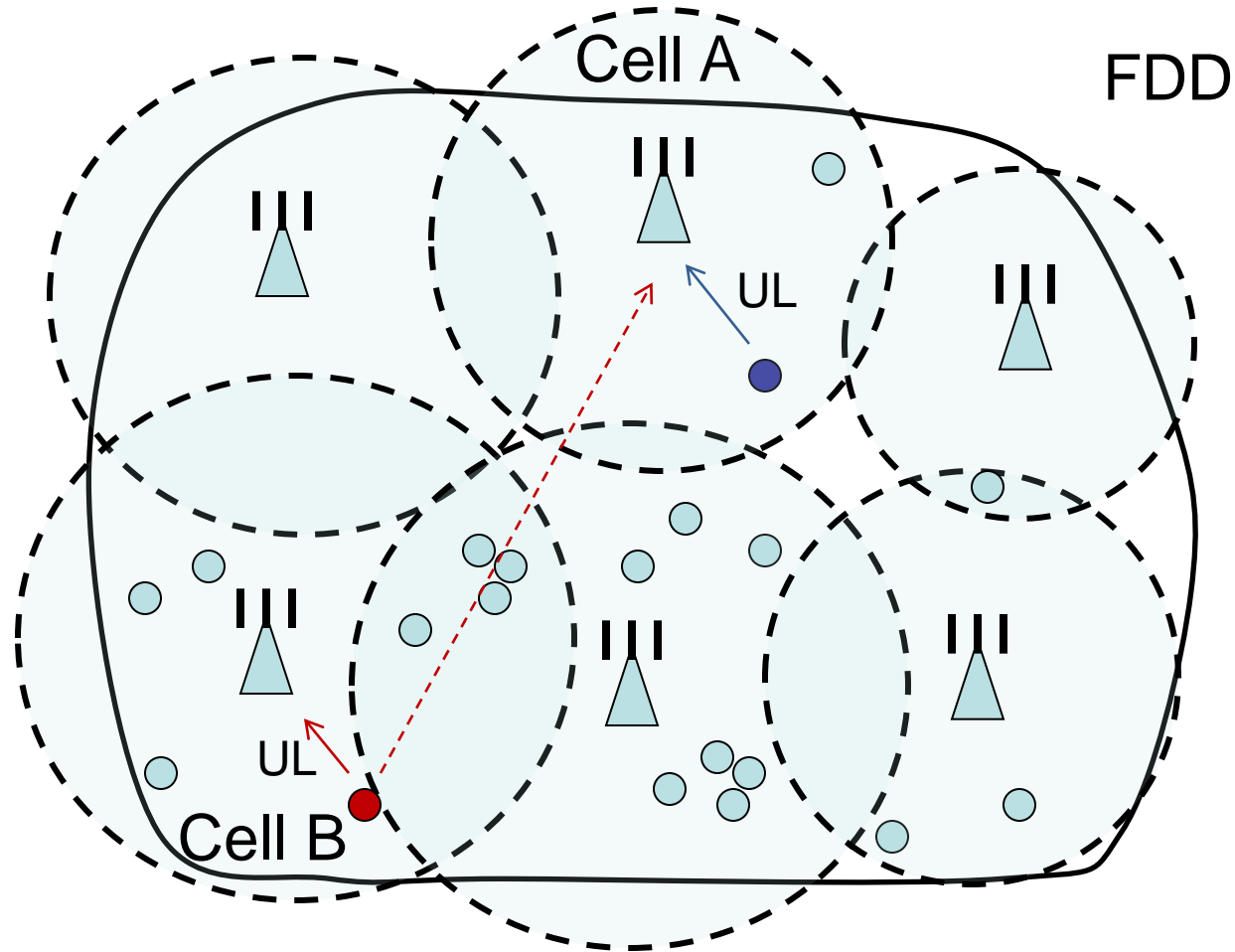
UL/UL or DL/DL intra-cell interference with non-orthogonal RUs

Area Coverage Networks / Cellular Networks



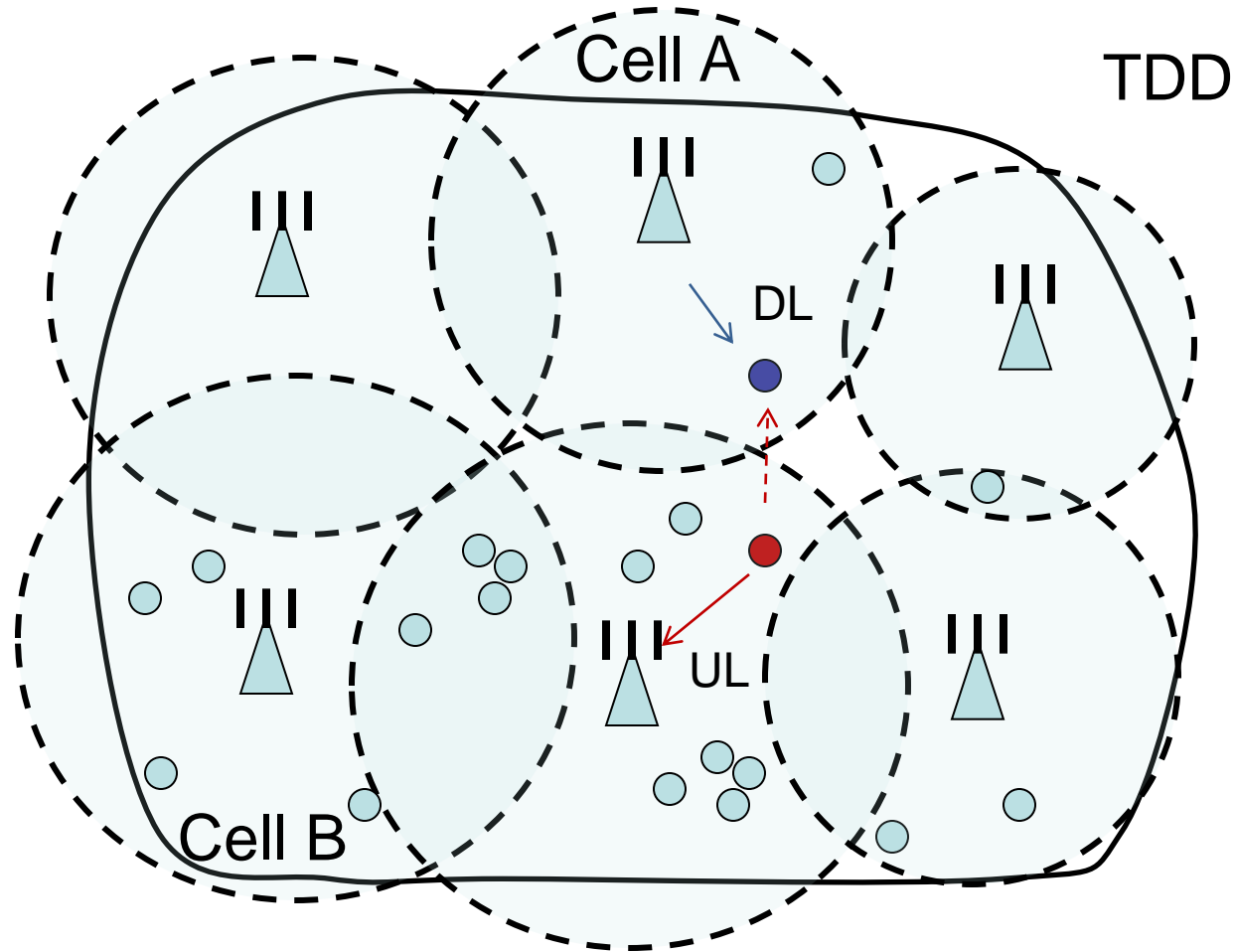
UL/UL and DL/DL inter-cell interference if reuse is implemented

Area Coverage Networks / Cellular Networks



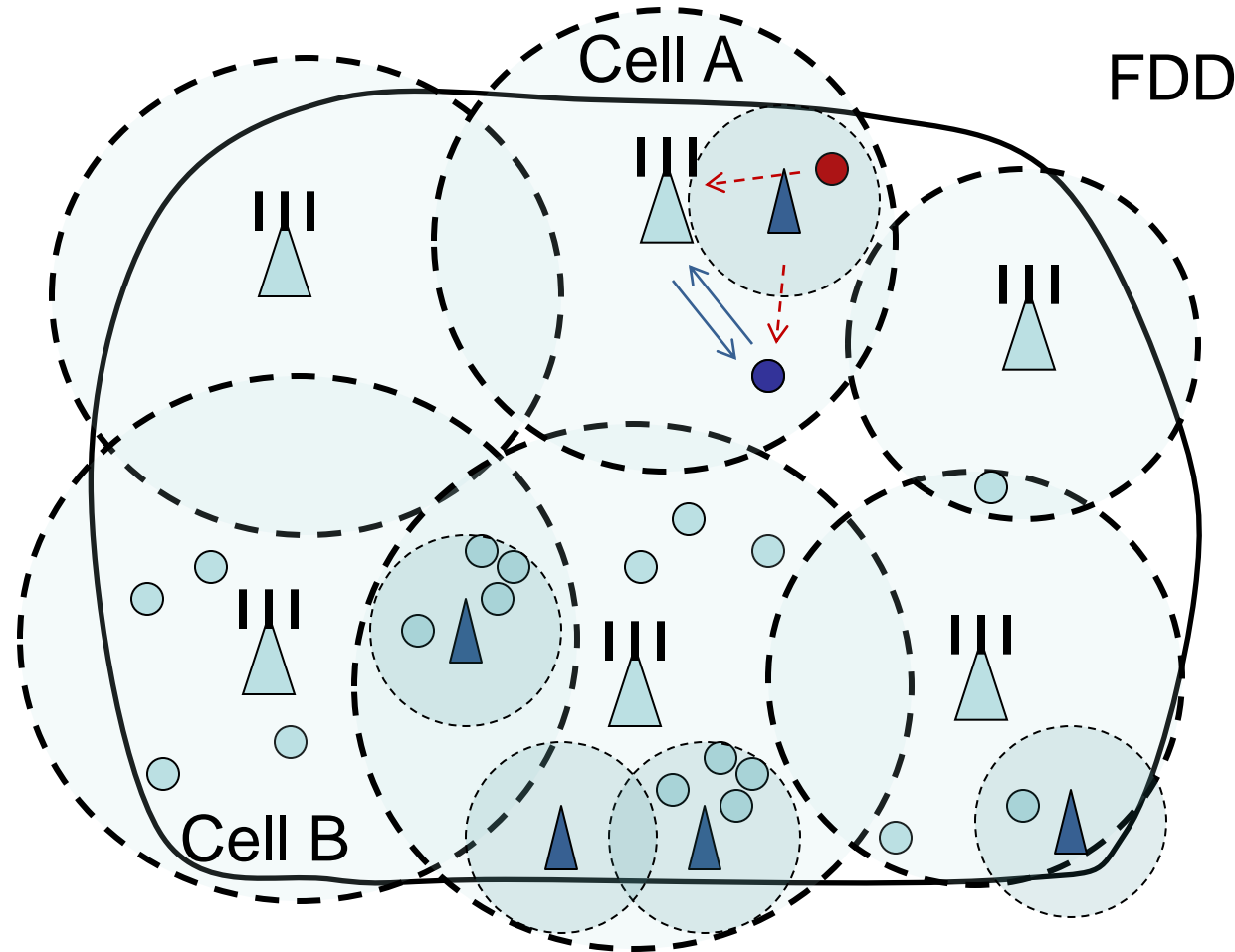
UL/UL and DL/DL inter-cell interference if reuse is implemented

Area Coverage Networks / Cellular Networks



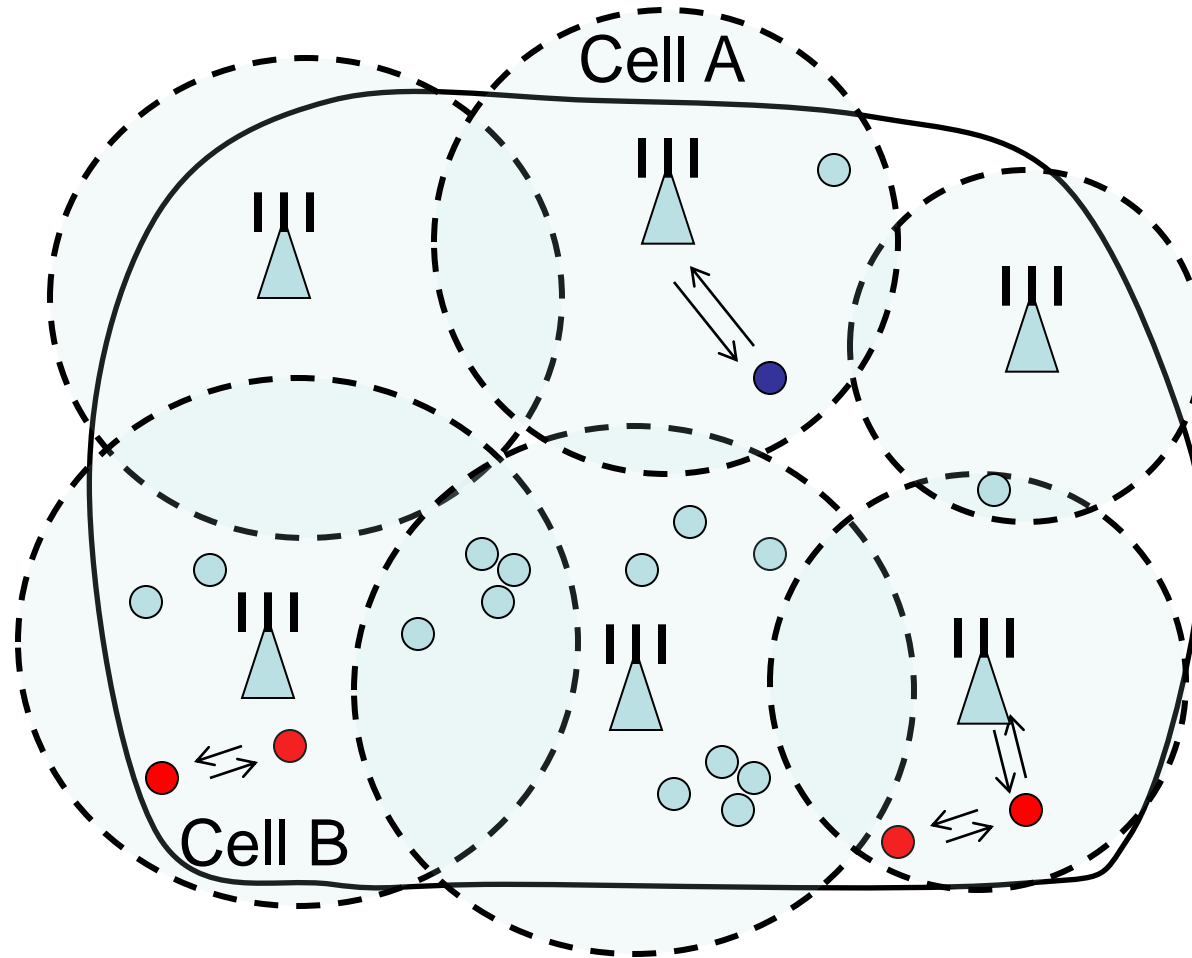
UL/DL inter-cell interference if transmissions are not synchronised

Area Coverage Networks / Cellular Networks



Small cells interference

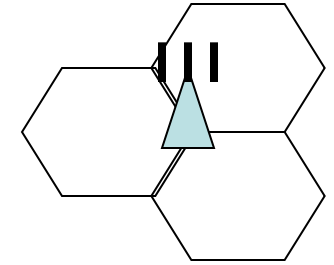
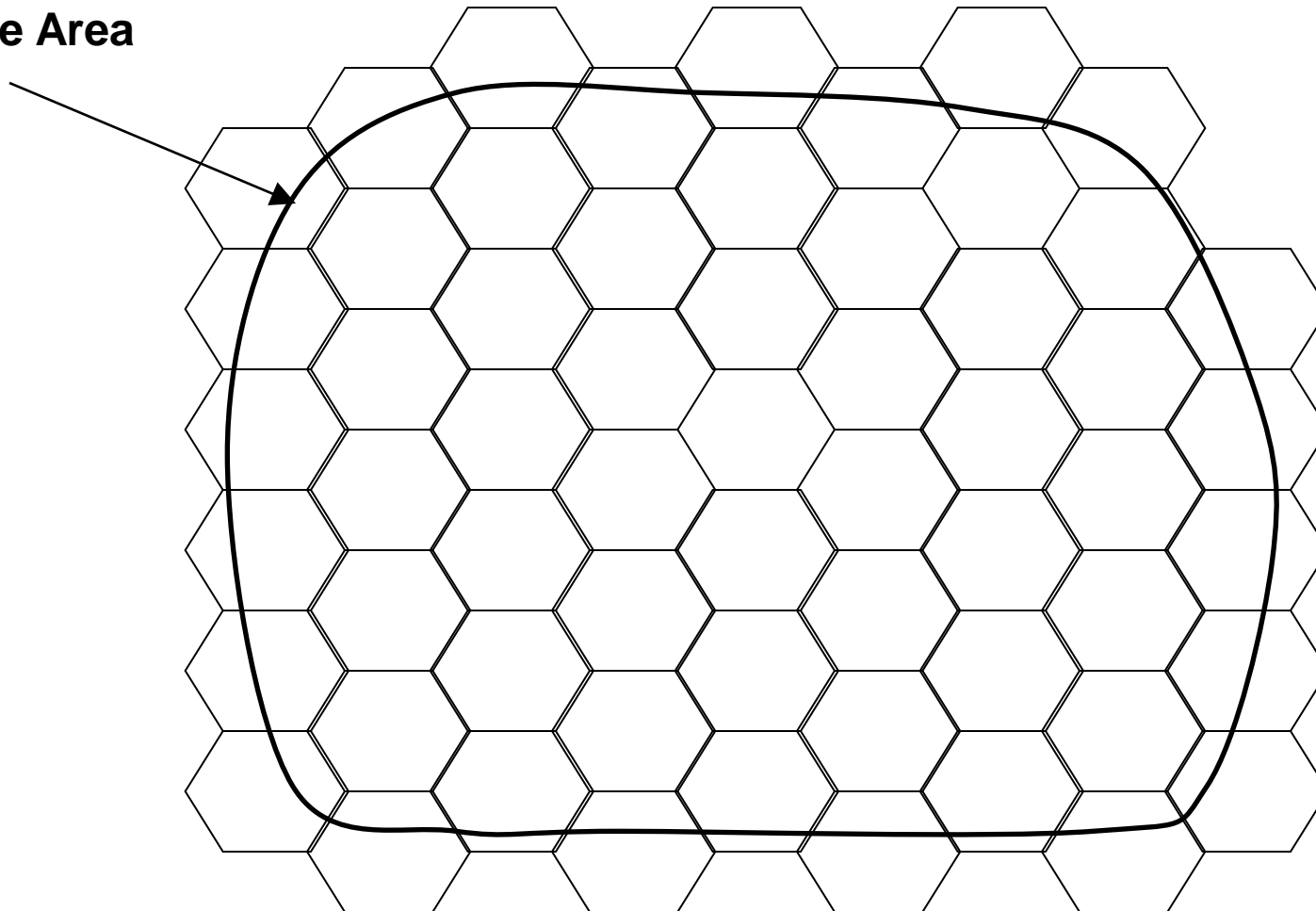
Area Coverage Networks / Cellular Networks



Device-to-Device (D2D)

Area Coverage Networks / Cellular Networks

Service Area



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

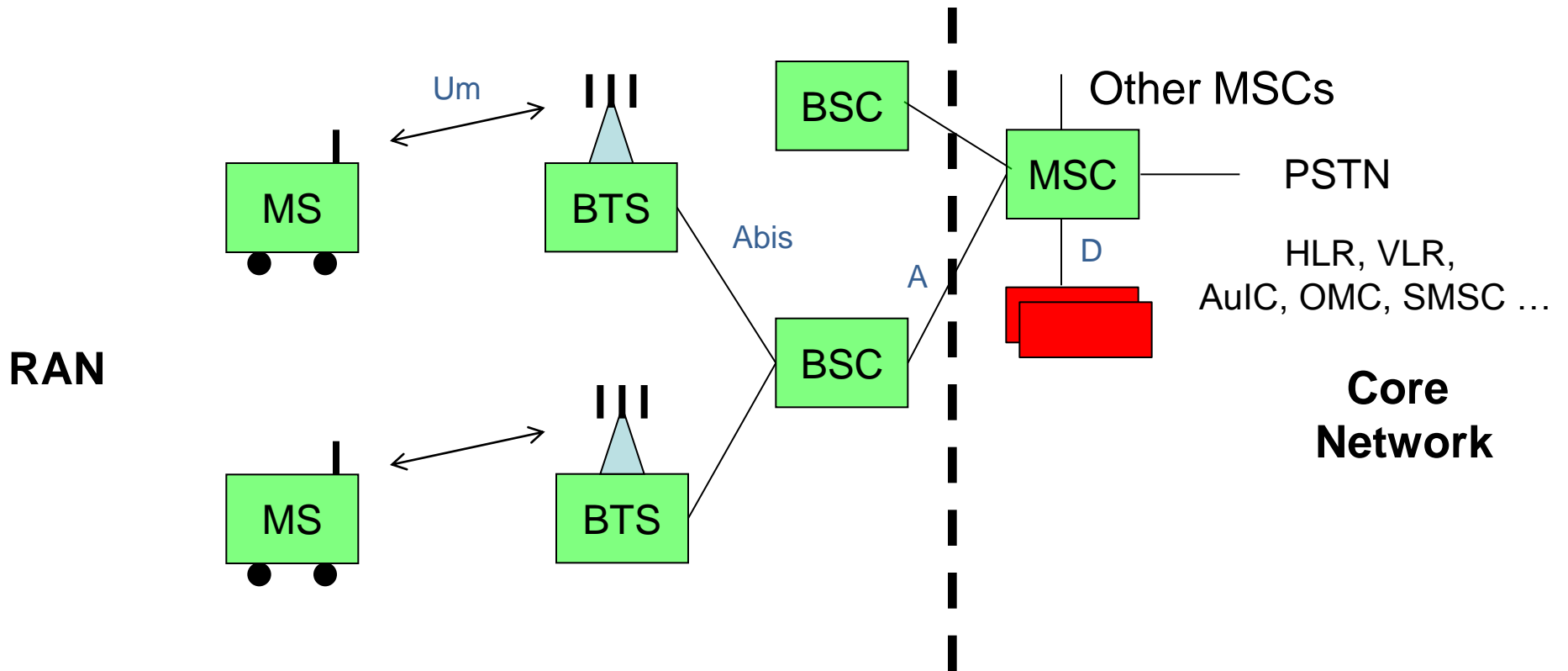
Inquiry Based Session

- **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

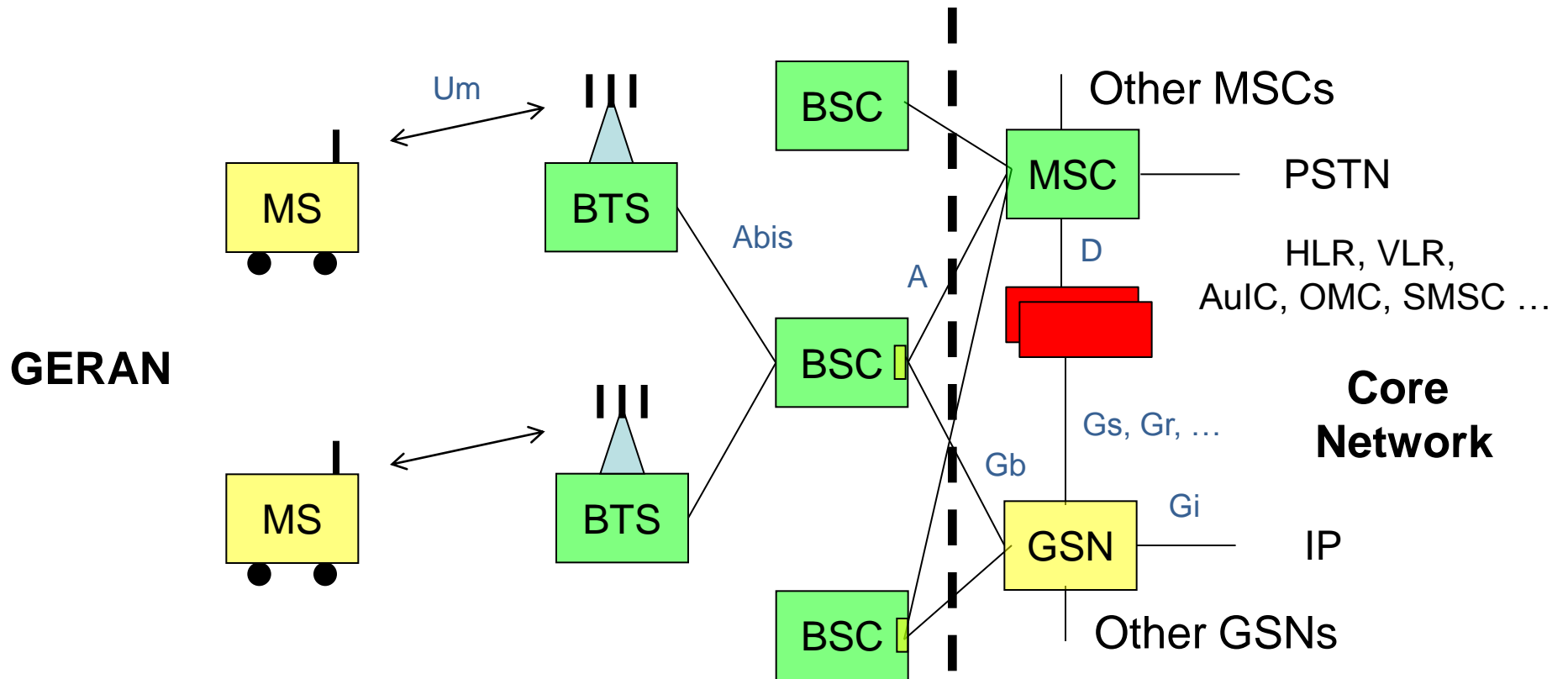
Network Architecture: 2G (GSM)

Radio Access Network

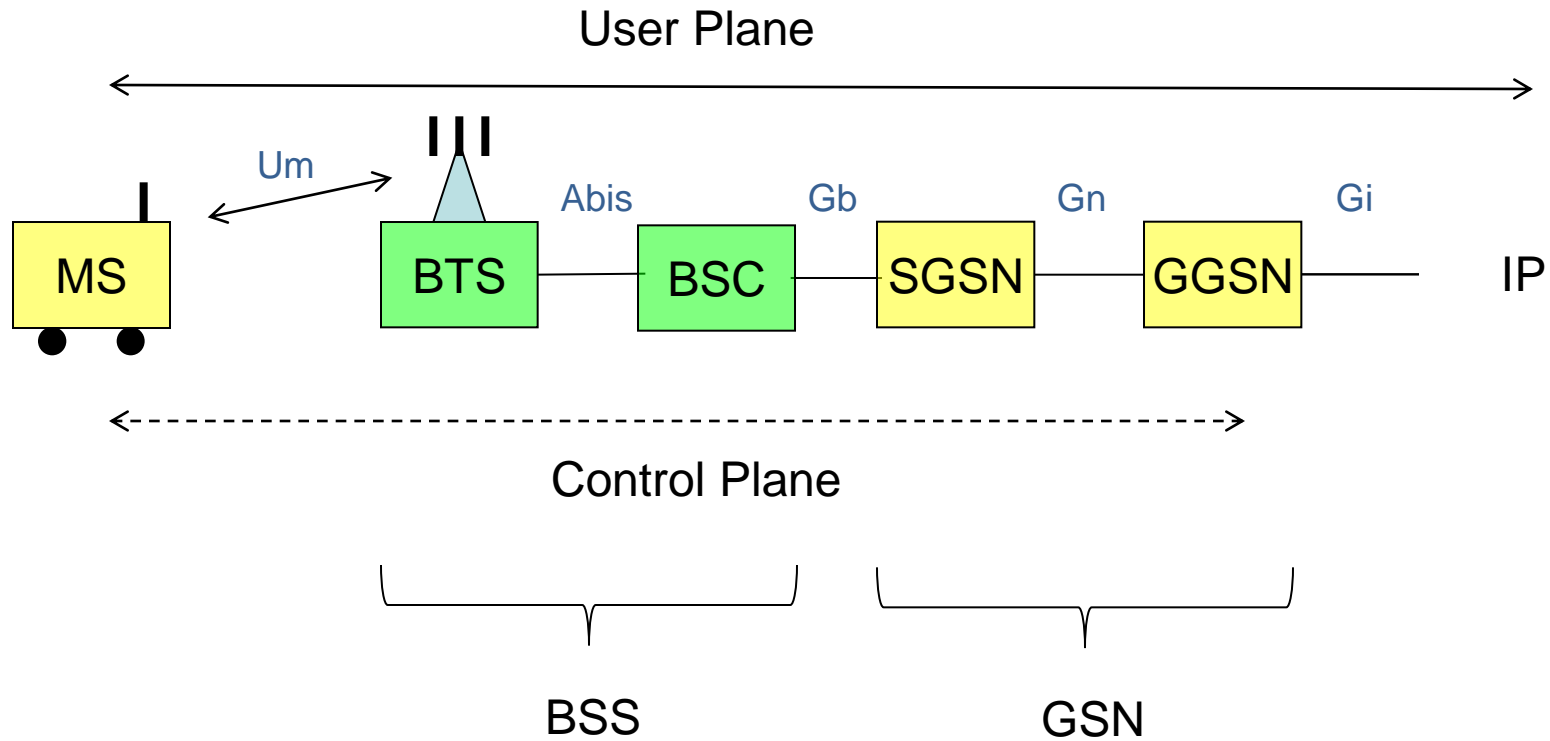


Network Architecture: 2.5G (Rel. 97)

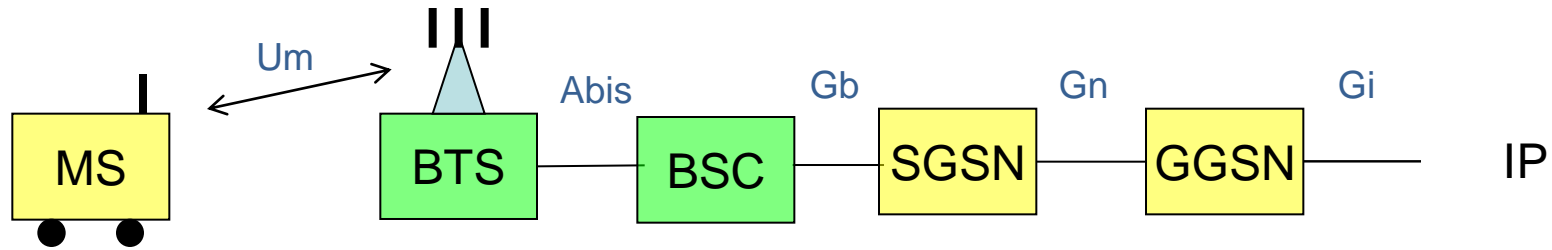
Radio Access Network



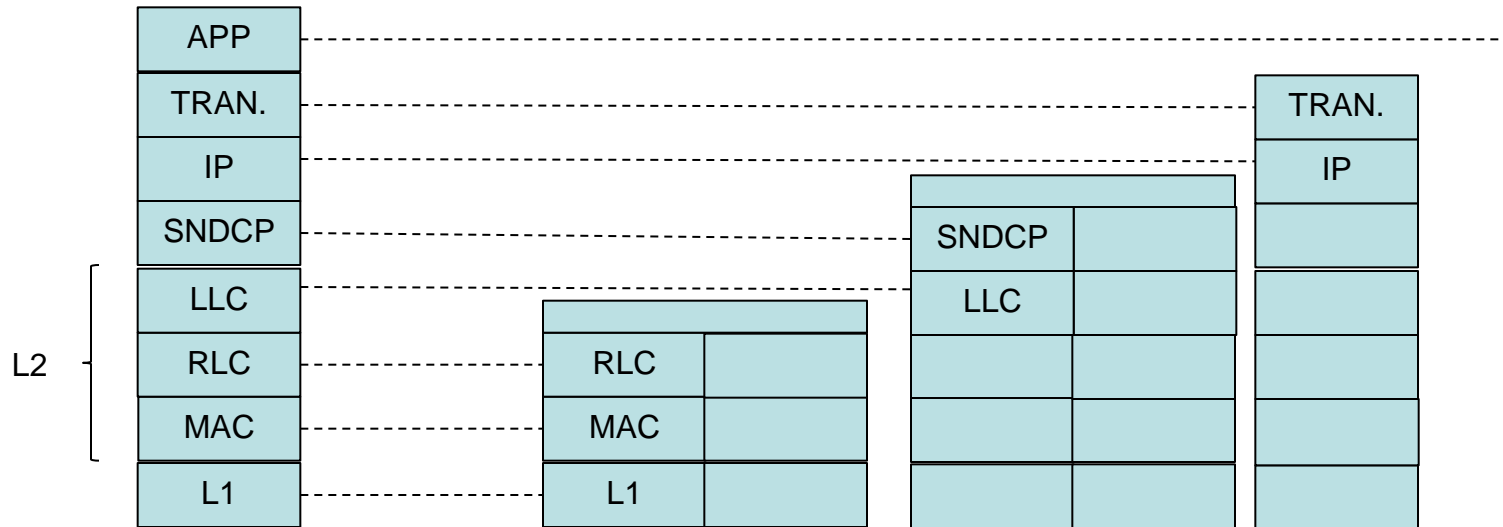
User / Control Plane (Rel. 97)



Protocol Architecture (Rel. 97)

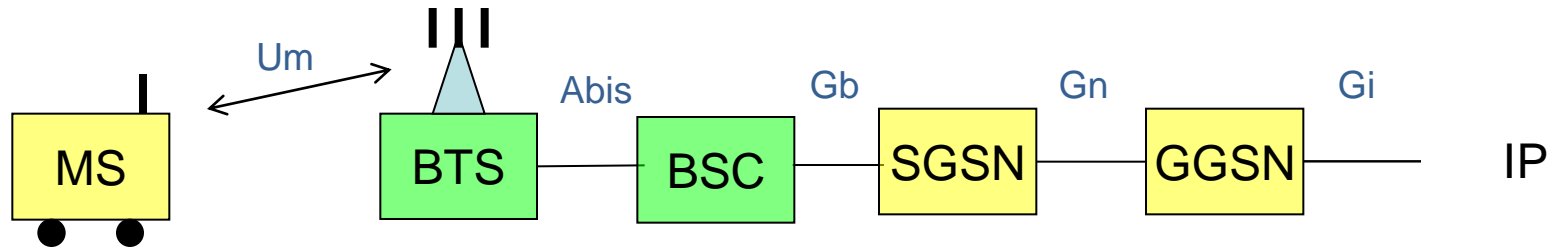


User Plane

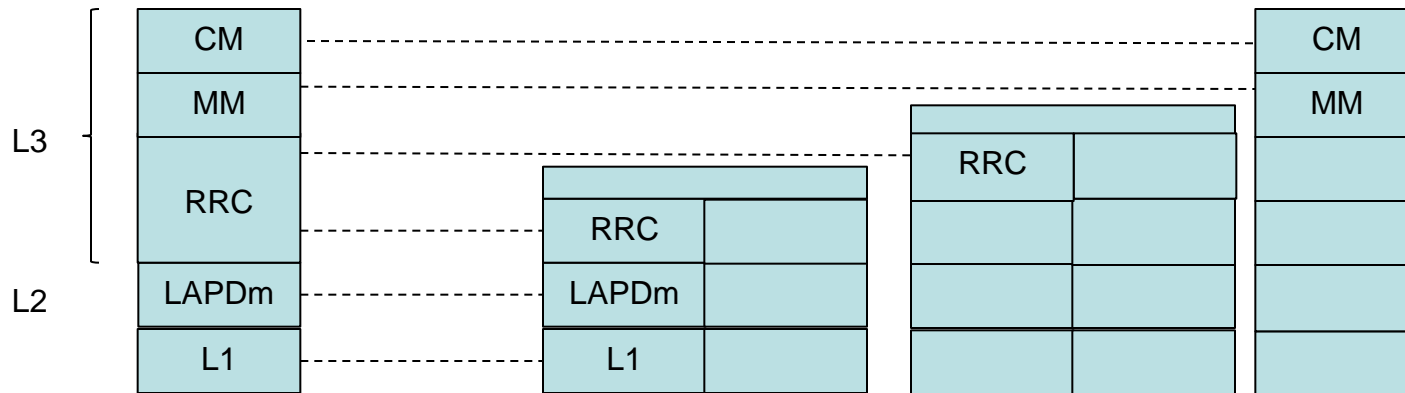


BSS

Protocol Architecture (Rel. 97)

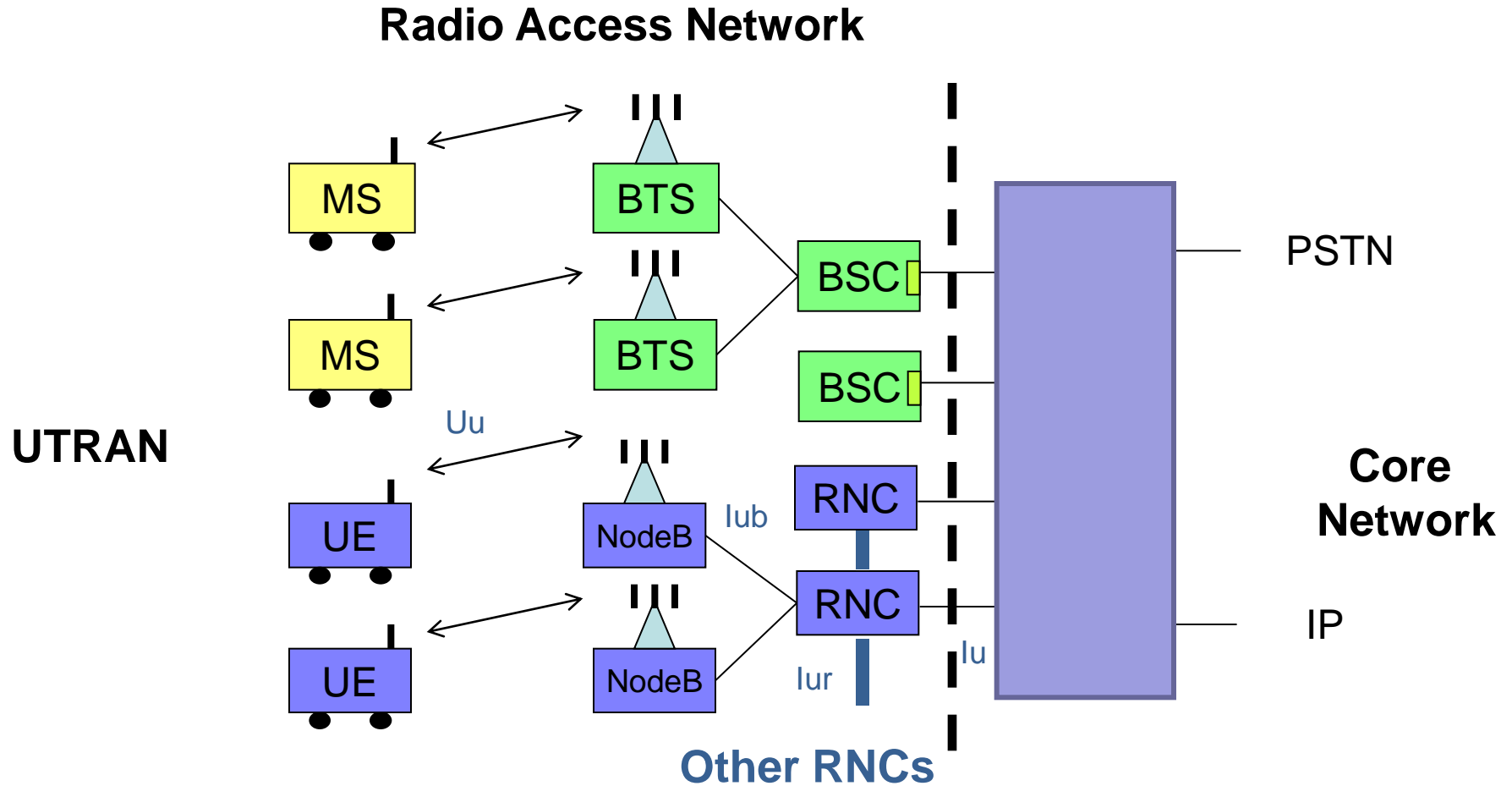


Control Plane



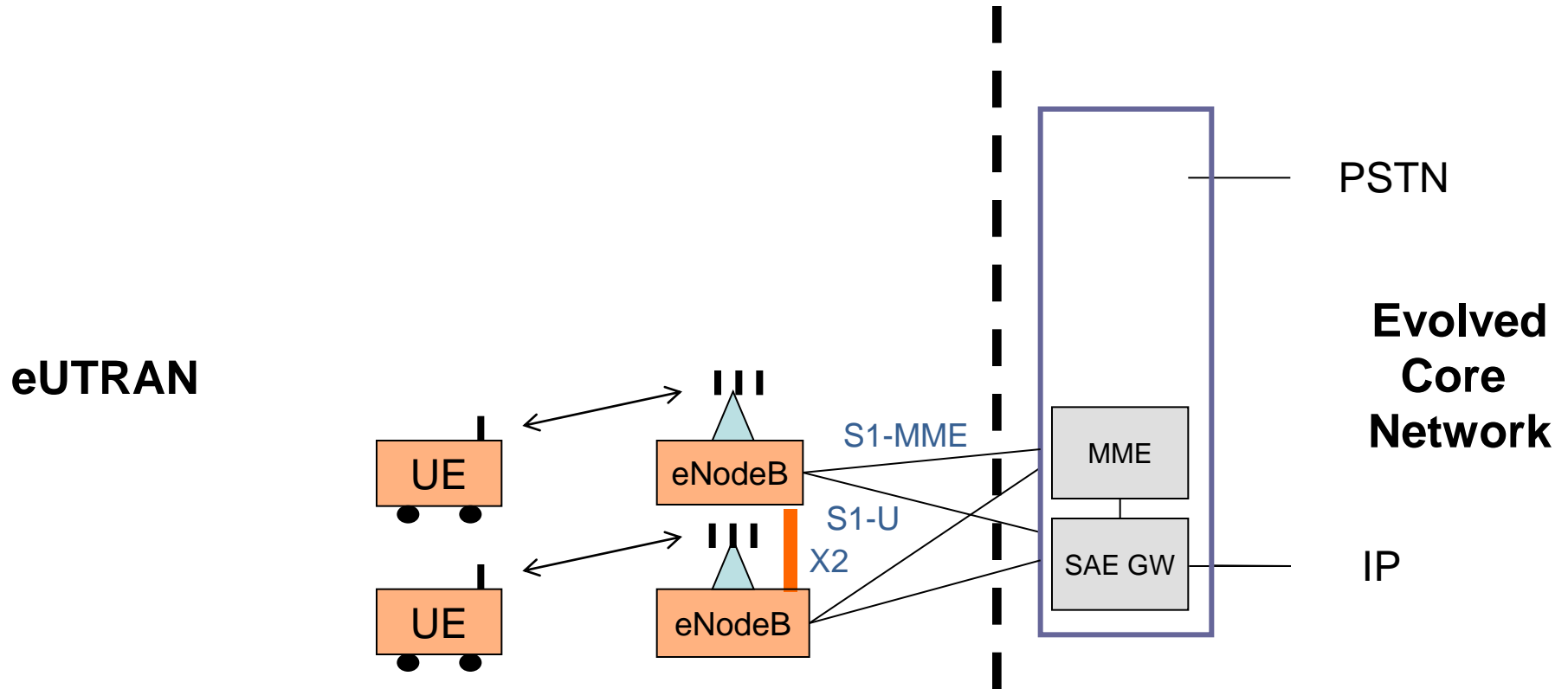
BSS

Network Architecture: UMTS (Rel. 99)

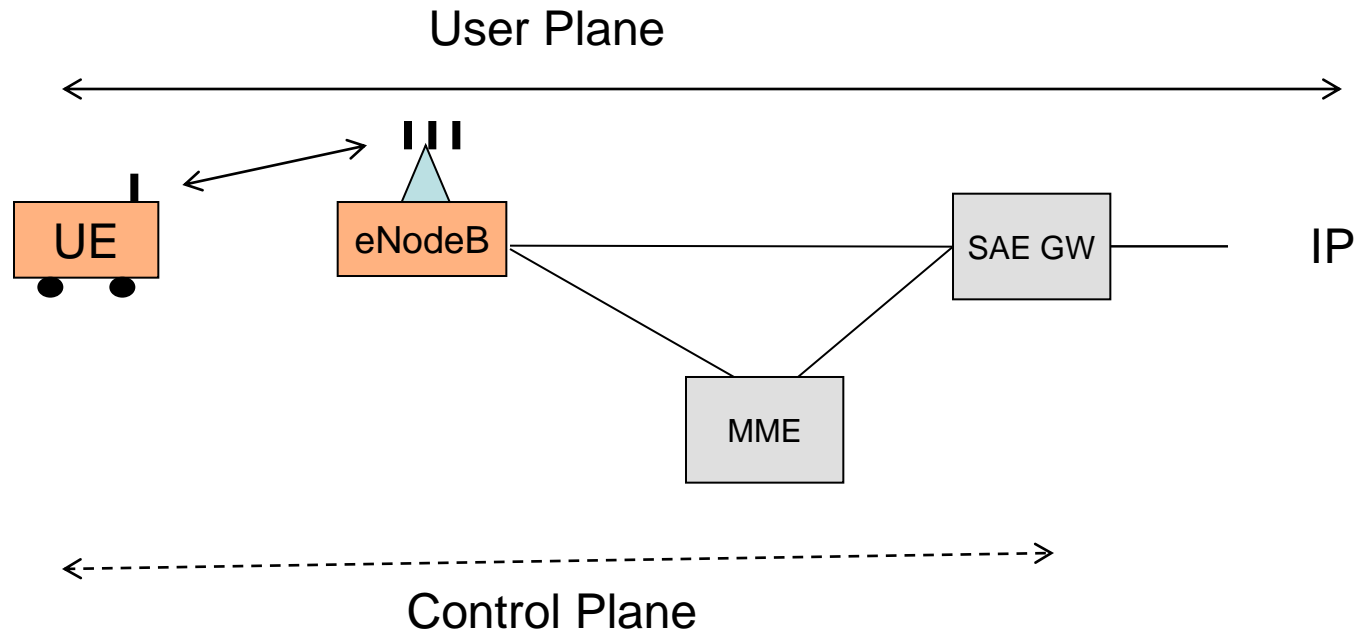


Network Architecture: LTE (Rel. 8)

Radio Access Network

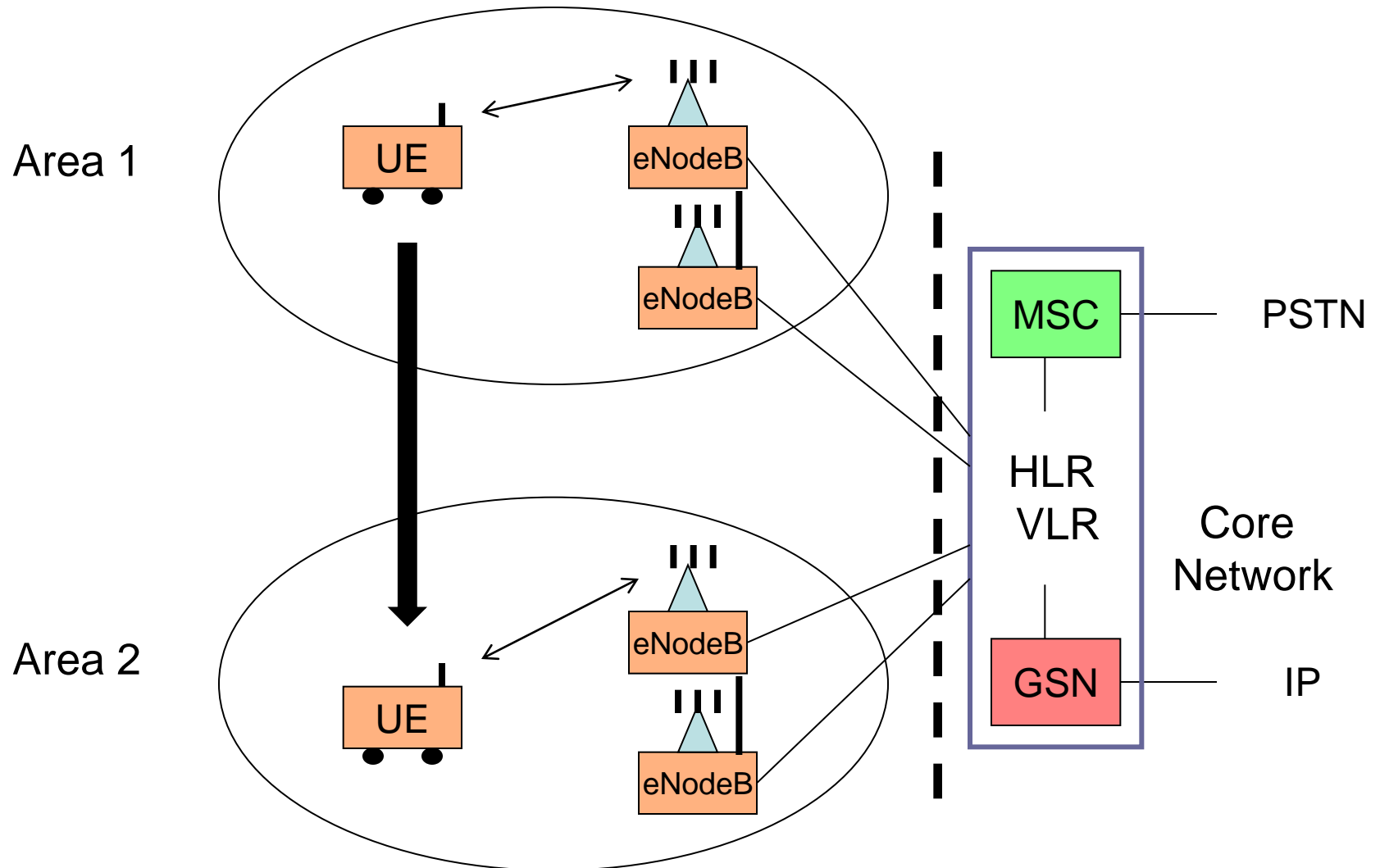


User / Control Plane (Rel. 8)

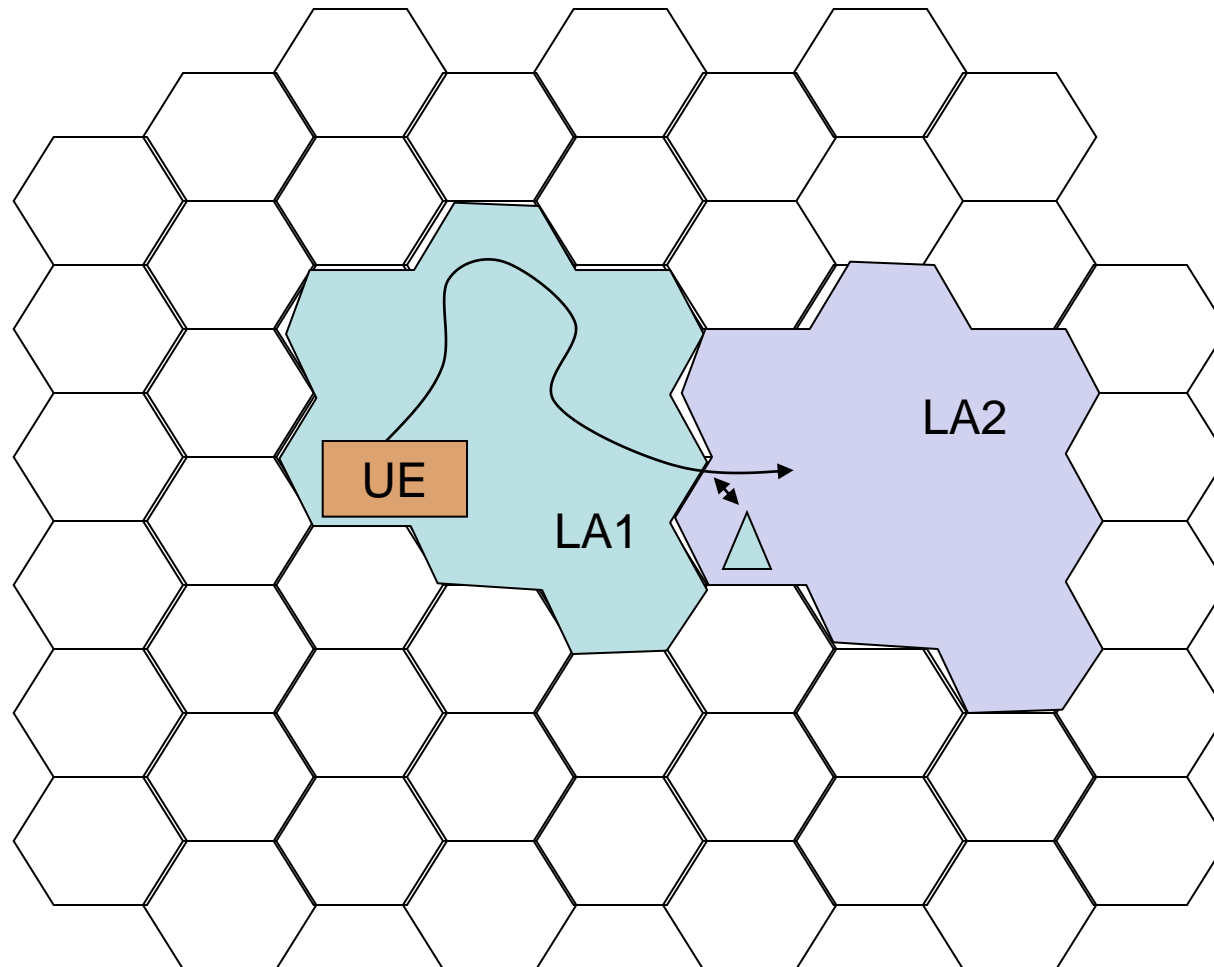


4. Mobility Management

Mobility Management (Macro Level): HLR, VLR

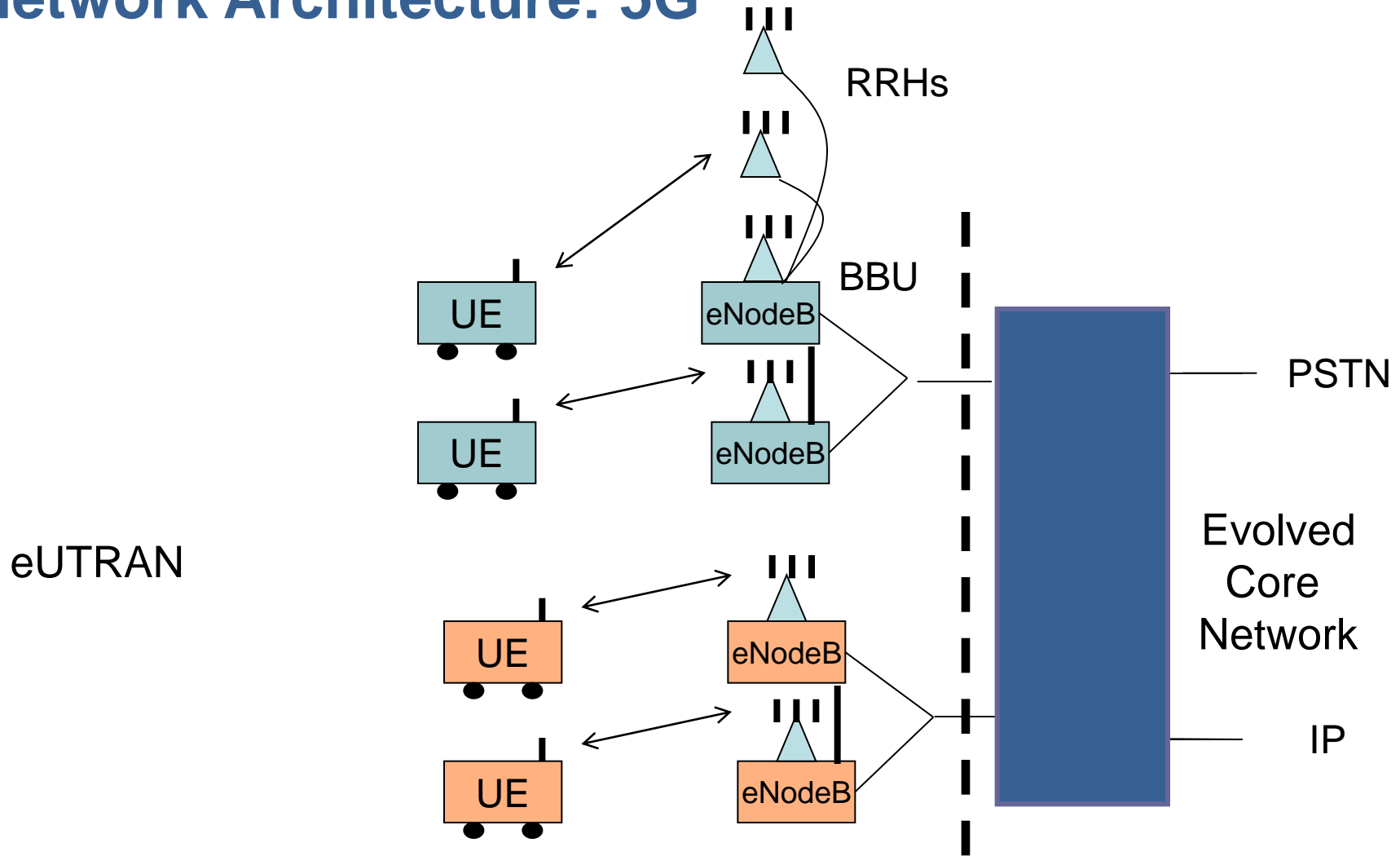


Mobility Management (Micro Level): Location Areas



5. Network Architectures: Evolution Towards 5G

Network Architecture: 5G



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Mobile Network Architectures

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