Introducing the Specifications of the MEF

MEF 22.1.1: Mobile Backhaul Phase 2 Amendment 1 - Small Cells

MEF Reference Presentations

- **Intention**
  - These MEF reference presentations are intended to give general overviews of the MEF work and have been approved by the MEF Marketing Committee
  - Further details on the topic are to be found in related specifications, technical overviews, white papers in the MEF public site Information Center:
    http://metroethernetforum.org/InformationCenter

Topics

- Approved MEF Specifications
- Introduction
- Small Cell Background
- MEF On-Going Work
- Small Cell Radio Coordination
- MEF 22.1.1 amendment
- Summary

Approved MEF Specifications*

Specification	Description
MEF 2	Requirements and Framework for Ethernet Service Protection
MEF 3	Circuit Emulation Service Definitions, Framework and Requirements in Metro Ethernet Networks
MEF 4	Metro Ethernet Network Architecture Framework Part 1: Generic Framework
MEF 6.1	Metro Ethernet Services Definitions Phase 2
MEF 7.1	EMS-NMS Information Model Phase 2
MEF 8	Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks
MEF 9	Abstract Test Suite for Ethernet Services at the UNI
MEF 10.2	Ethernet Services Attributes Phase 2
MEF 11	User Network Interface (UNI) Requirements and Framework
MEF 12.1	Metro Ethernet Network Architecture Framework Part 2: Ethernet Services Layer
MEF 13	User Network Interface (UNI) Type 1 Implementation Agreement
MEF 14	Abstract Test Suite for Traffic Management Phase 1
MEF 15	Requirements for Management of Metro Ethernet Phase 1 Network Elements
MEF 16	Ethernet Local Management Interface

*Current at time of publication. See MEF web site for official current list, minor updates and superseded work (such as MEF 1 and MEF 5)

Approved MEF Specifications

Specification	Description
MEF 17	Service OAM Framework and Requirements
MEF 18	Abstract Test Suite for Circuit Emulation Services
MEF 19	Abstract Test Suite for UNI Type 1
MEF 20	User Network Interface (UNI) Type 2 Implementation Agreement
MEF 21	Abstract Test Suite for UNI Type 2 Part 1: Link OAM
MEF 22.1	Mobile Backhaul Implementation Agreement Phase 2
MEF 22.1.1	**Amendment to MEF 22.1 – Small Cell Backhaul**
MEF 23.1	Class of Service Implementation Agreement Phase 2
MEF 24	Abstract Test Suite for UNI Type 2 Part 2: E-LMI
MEF 25	Abstract Test Suite for UNI Type 2 Part 3: Service OAM
MEF 26.1	External Network Network Interface (ENNI) – Phase 2
MEF 27	Abstract Test Suite For UNI Type 2 Part 5: Enhanced UNI Attributes & Part 6: L2CP Handling
MEF 28	External Network Network Interface (ENNI) Support for UNI Tunnel Access and Virtual UNI
MEF 29	Ethernet Services Constructs

Approved MEF Specifications

Specification	Description
MEF 30	Service OAM Fault Management Implementation Agreement
MEF 31	Service OAM Fault Management Definition of Managed Objects
MEF 32	Requirements for Service Protection Across External Interfaces
MEF 33	Ethernet Access Services Definition
MEF 34	Abstract Test Suite for Ethernet Access Services
MEF 35	Service OAM Performance Monitoring Implementation Agreement
MEF 36	Service OAM SNMP MIB for Performance Monitoring
MEF 37	Abstract Test Suite for ENNI
MEF 38	Service OAM Fault Management YANG Modules Technical Specification
MEF 39	Service OAM Performance Monitoring YANG Modules Technical Specifications
MEF 40	UNI and EVC Definition of Managed Objects Technical Specification
MEF 41	Generic Token Bucket Algorithm Technical Specification
MEF 42	ENNI and OVC Definition of Managed Objects Technical Specification
MEF 43	Virtual NID (vNID) Functionality for E-Access Services Technical Specification
MEF 44	Virtual NID (vNID) Definition of Managed Objects Technical Specification
MEF 45	Multi-CEN L2CP Technical Specification

Approved MEF Specifications

Specification	Description
MEF 46	Latching Loopback Protocol and Functionality Technical Specification
MEF 47	Carrier Ethernet Services for Cloud Implementation Agreement
MEF 48	Service Activation Testing Technical Specification
MEF 49	Service Activation Testing Control Protocol and PDU Formats Technical Specification
MEF 50	Carrier Ethernet Service Lifecycle Process Model Guidelines Document

This Overview Presentation

- **Purpose:**
  - This presentation is an introduction to MEF 22.1.1
- **Scope of the Amendment**
  - Mobile backhaul and midhaul, for macro and small cells, for mobile technologies
- **Audience**
  - Equipment manufacturers building devices that will carry mobile backhaul traffic over Carrier Ethernet
  - Useful for mobile backhaul service providers architecting their systems for Carrier Ethernet
  - For wire-line service providers architecting their systems for the inclusion of mobile backhaul traffic over Carrier Ethernet

MEF 22.1.1 and Relationship to other SDOs

Other SDOs

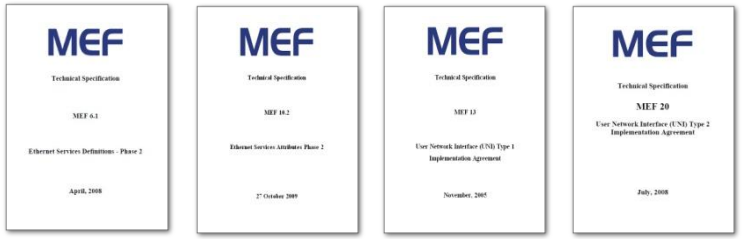
International Telecommunication Union

3GPP A GLOBAL INITIATIVE

SMALL CELL FORUM
HOME | ENTERPRISE | URBAN | RURAL

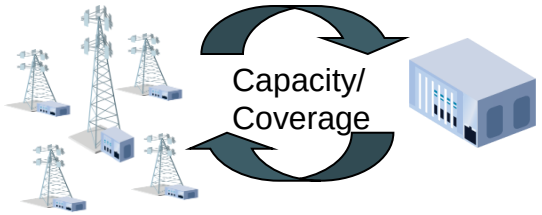
ngmn
the engine of broadband wireless innovation

MEF 6.1 | MEF 10.2 | MEF 13 | MEF 23.1



MEFs own work as the foundation

Industry trends



Standardized reference points

Service Requirements (Service Types, CoS, Eth OAM, etc)

Synchronization Recommendations

Small Cells Amendment

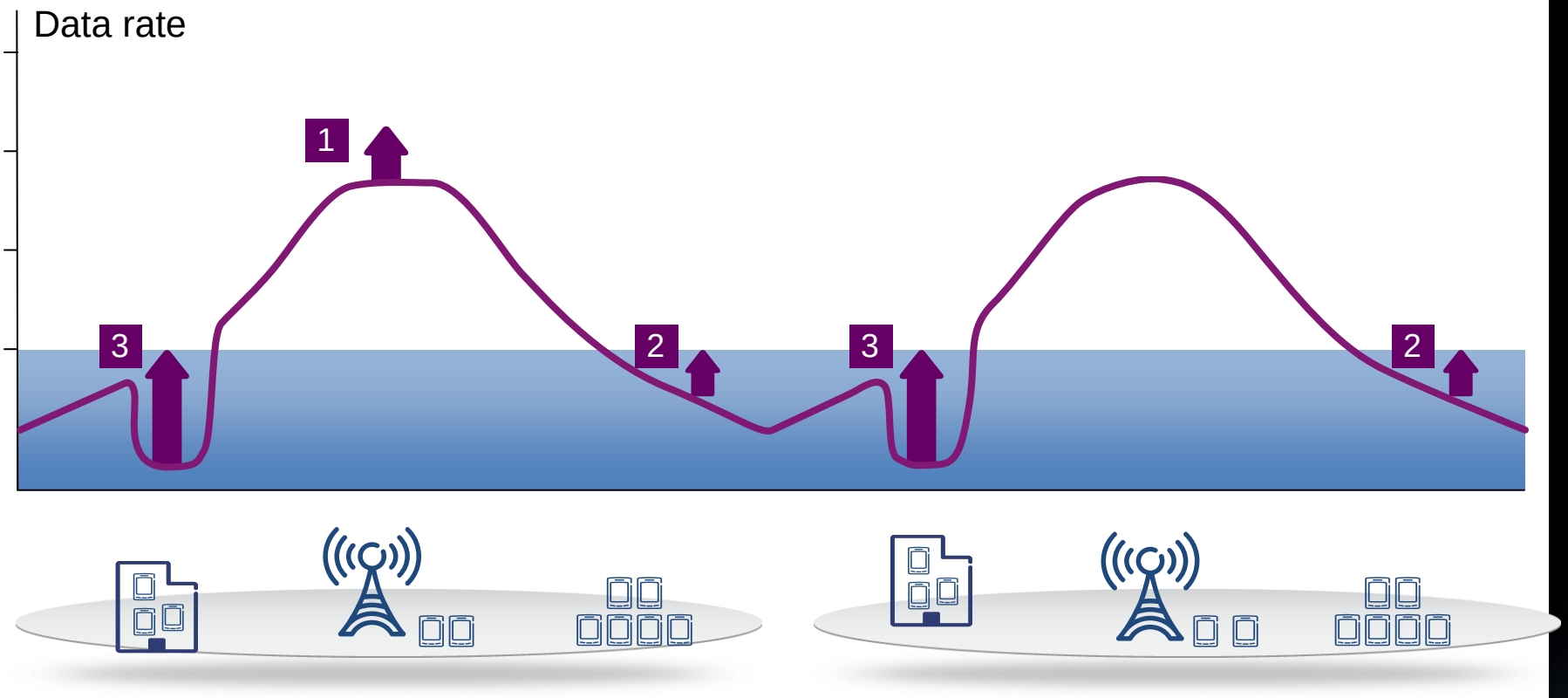
MEF Mobile Backhaul: Work in Progress

- **MEF-22.2**
  - Mobile backhaul across multiple service providers' networks using ENNI/OVC based services
  - Alignment with MEF 6.2 & MEF 10.3

- **MEF-22.2.1**
  - Time/Phase Synchronization support

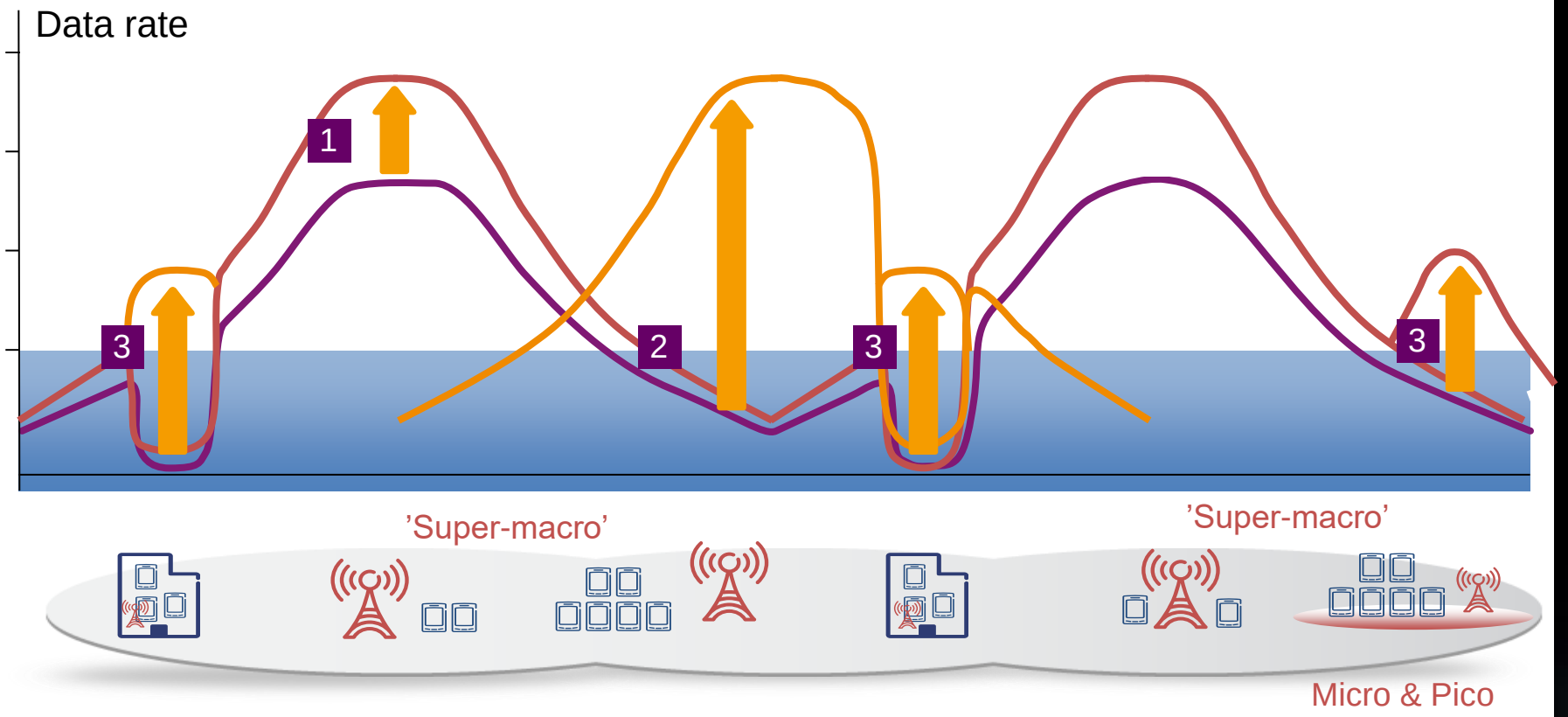
Small Cell Background

End User Experience Challenges



1. Increase overall cell site performance
2. Increase cell edge data rates
3. Increase indoor data rates

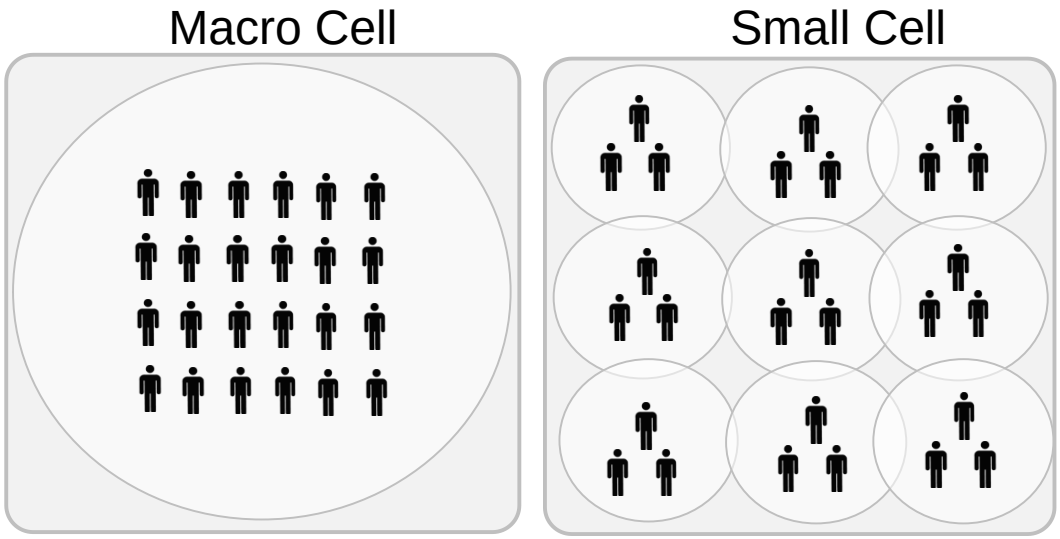
Increase Capacity & Coverage



1. "Super-macro" – advanced antennas, spectrum aggregation
2. Macro densification
3. Small cells – Micro & Pico

Increasing Network Capacity with Small Cells

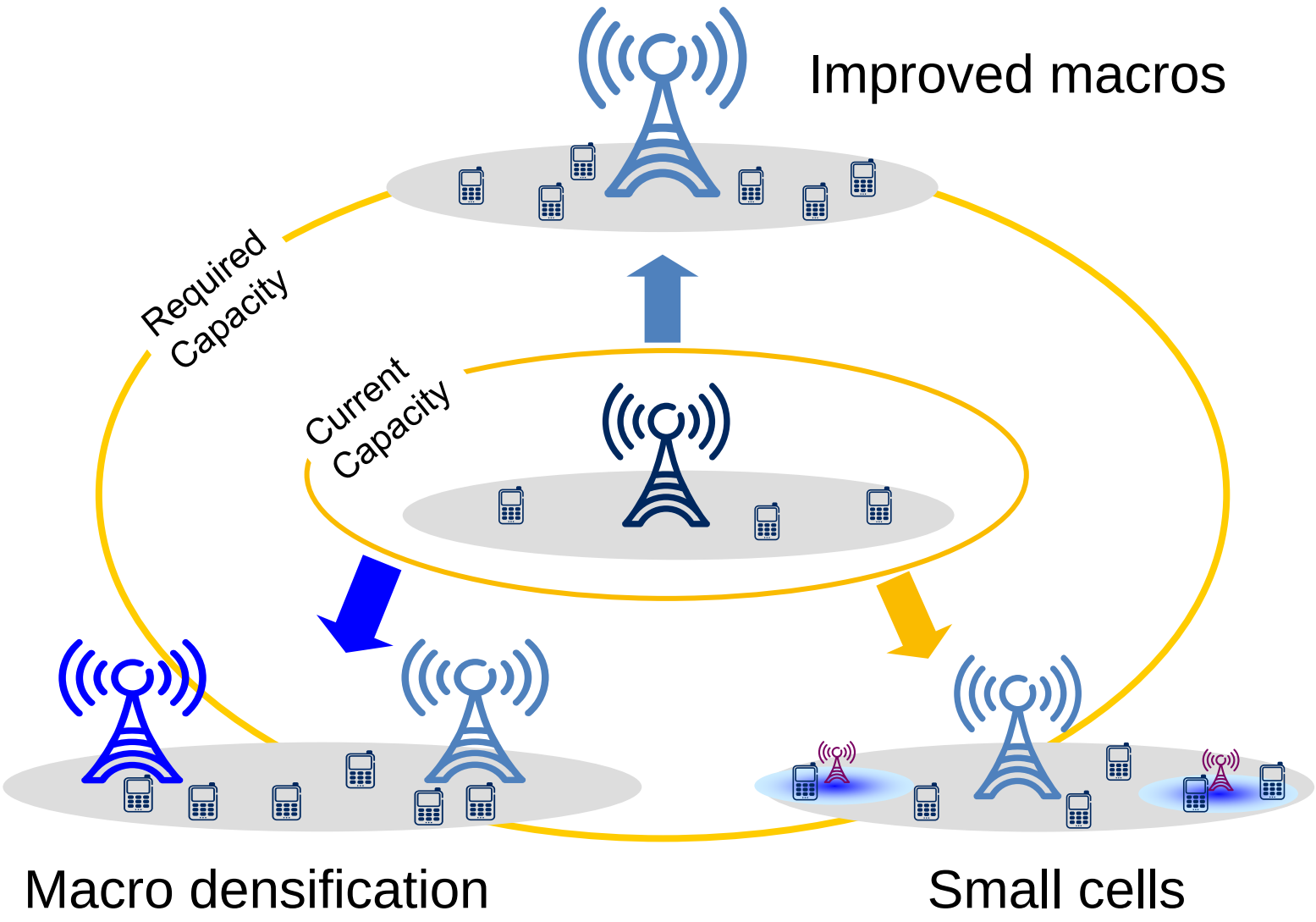
Network Transformation



Target capacity per cell	100 to 300 Mbps	25 to 100 Mbps
Cell density relative to macrocell	1	5 to 25
Total capacity	100 to 300 Mbps	125 Mbps to 2.5 Gbps
Indoor coverage	Poor	Good
Impact of SON / coordination	Low	High

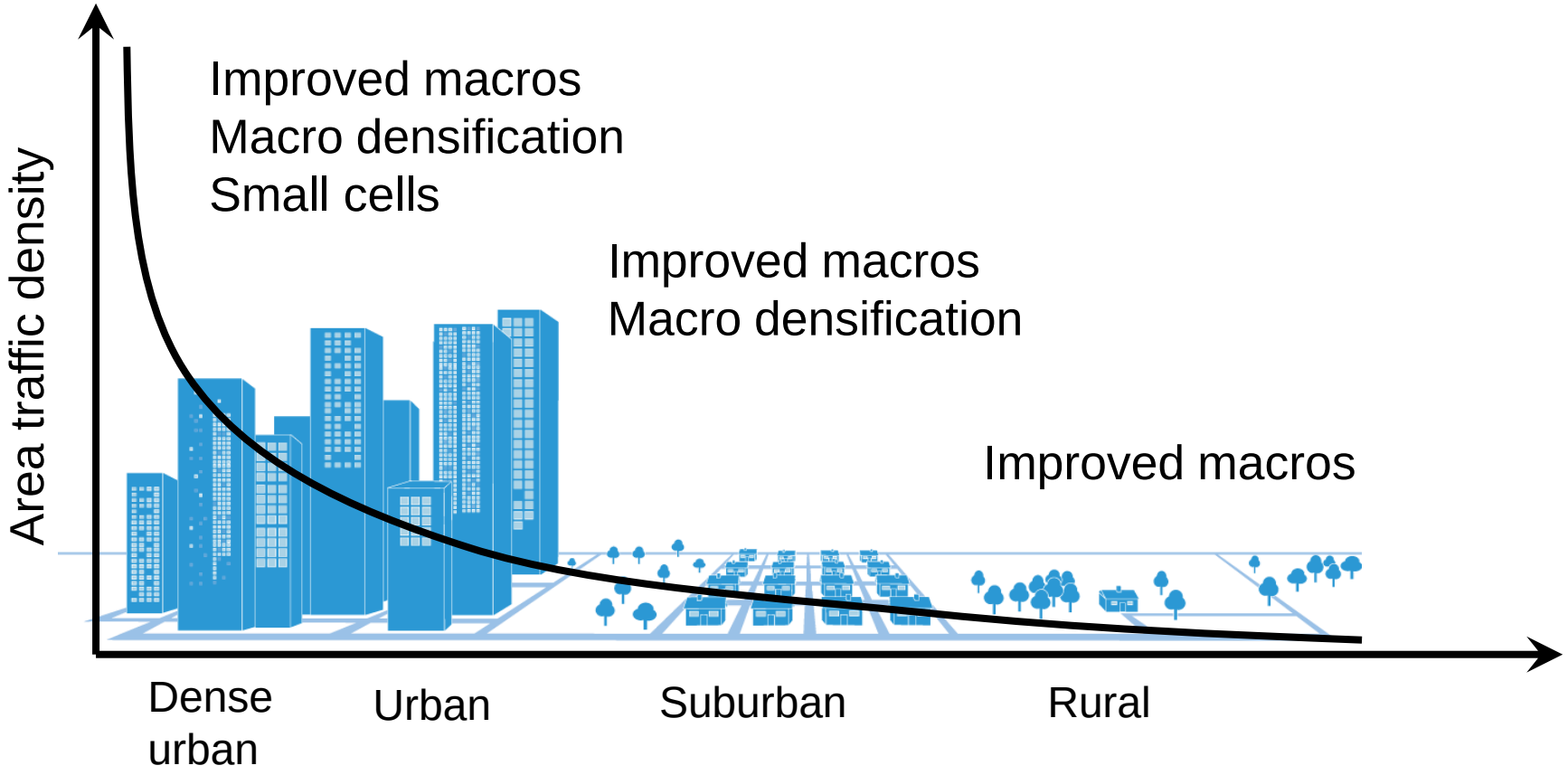
Small cells are best to meet the demand challenge

Heterogeneous Network



Heterogeneous Network Deployment

Small Cells advantage is greater in Metropolitan Areas
but also in other areas to increase coverage and/or capacity



Small Cell Coordination

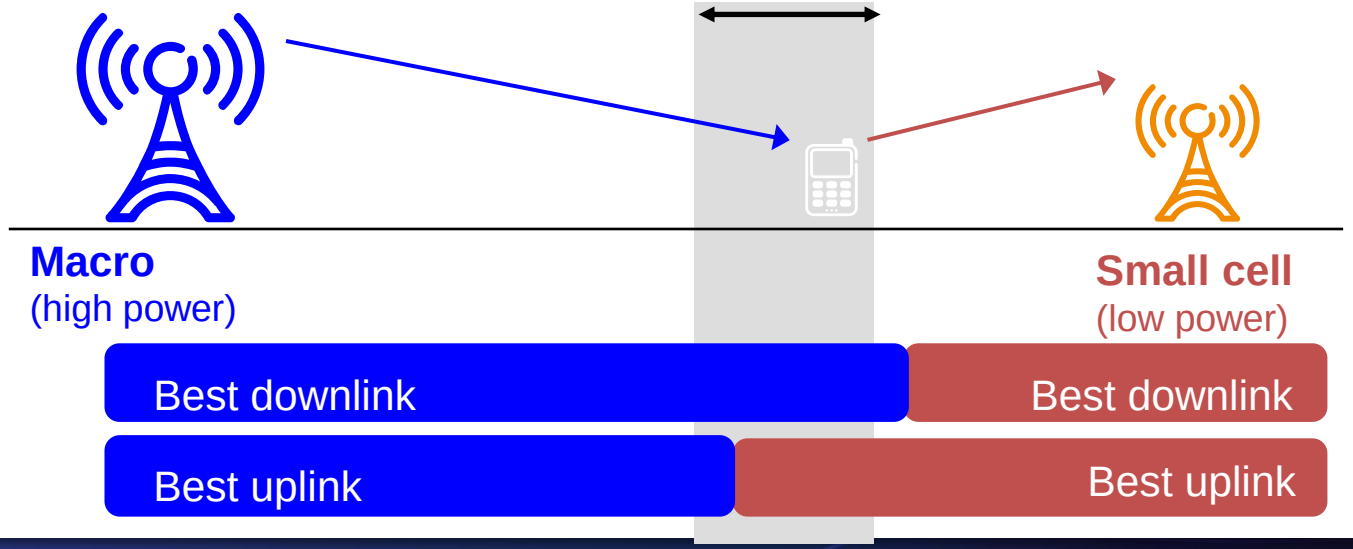
Small Cells & Radio Coordination

- **To improve uplink coverage**
  - i.e. cell edge throughput
- **To increase capacity**
  - Capacity improves as coverage improves
- **Offload congested macro cells**
- **Why is Radio coordination needed?**
  - Interference coordination between macro and small cells will Boost coverage and capacity

Small cells improves coverage and capacity

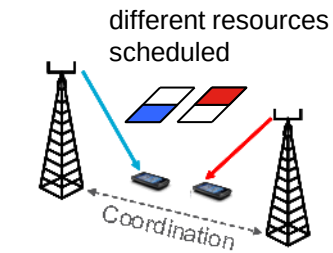
What is Coordination?

- **Multiple schemes and possibilities, often used in combination**
  - Coordinated scheduling
  - Coordinated beamforming (null forming)
  - Dynamic point selection
  - Joint transmission/reception

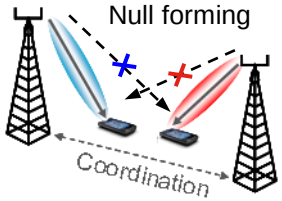


What is CoMP?

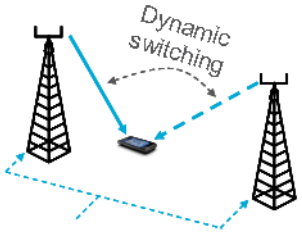
- **Coordinated MultiPoint**
- **Multiple schemes and possibilities, often used in combination**
  - Coordinated scheduling
  - Coordinated beamforming (null forming)
  - Dynamic point selection
  - Joint transmission/reception
  - …



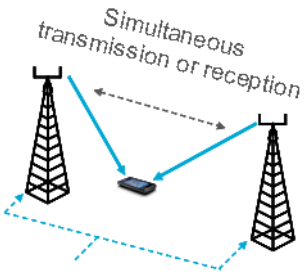
Coordinated Scheduling



Coordinated Beamforming



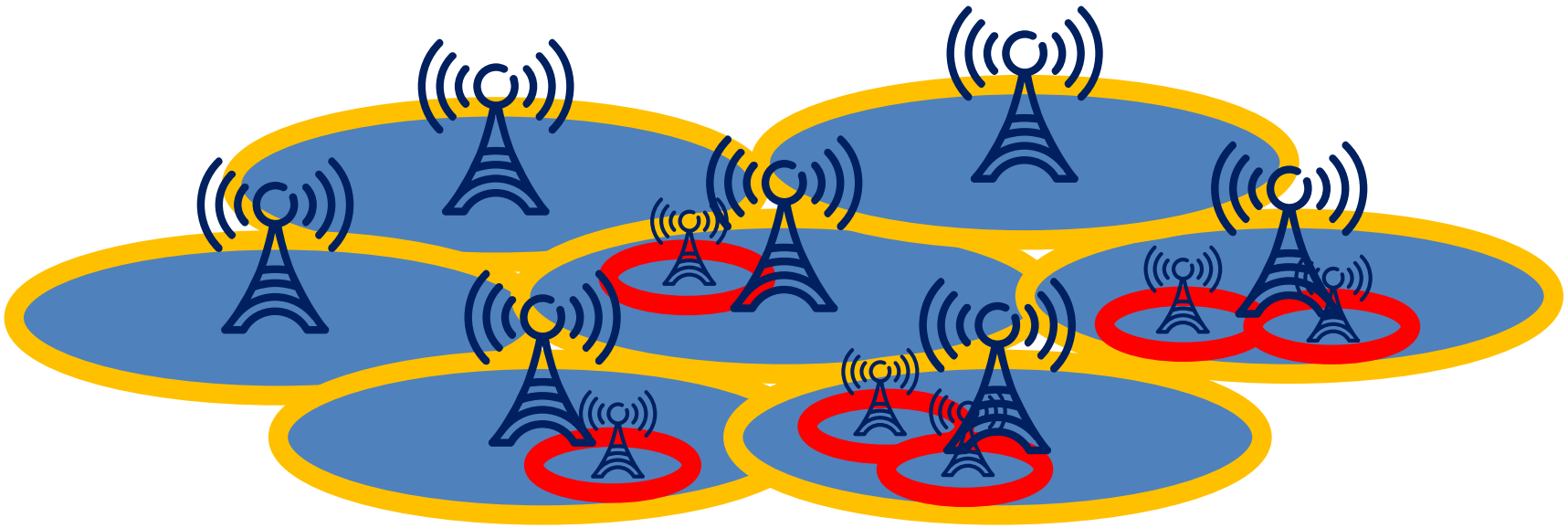
Dynamic Point Selection



Joint Transmission or Reception

Where are the CoMP gains?

The majority of the uplink/downlink bandwidth gain is on the cell edge between the small cell and the macro it shares a footprint with



No CoMP Gain

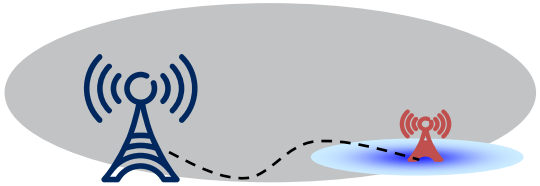
CoMP Bandwidth Gain: Uplink ~30-50%, Downlink ~15%

CoMP Bandwidth Gain: Uplink ~50-100%, Downlink ~30%

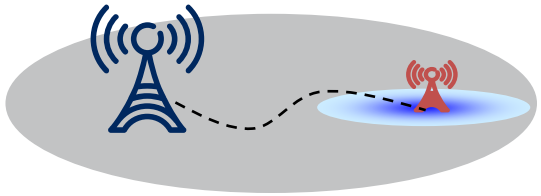
Different Degrees of Macro Cell Coordination

- **No coordination**
  - Example: uncoordinated deployment with femto cell in a macro network

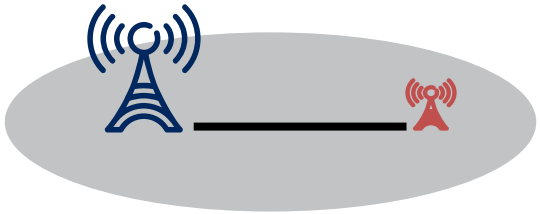
- **Moderate coordination**
  - Example: Coordinated deployment of pico cell in a macro network using range expansion or eICIC (enhanced Inter-Cell Interference Coordination)



- **Tight coordination**
  - Example: Coordinated deployment of pico cell in a macro network using features such as coordinated scheduling

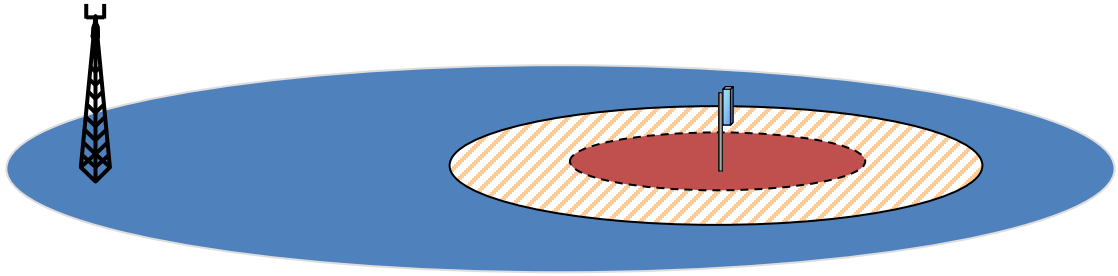


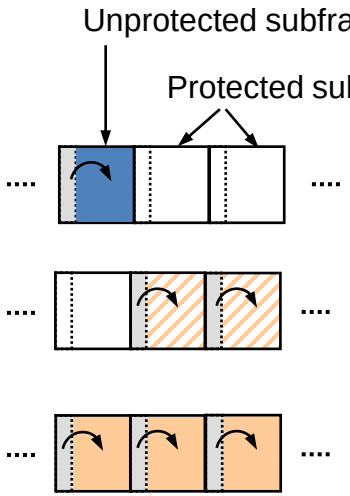
- **Very tight coordination**
  - Example: DU/RU radio network using features such as joint scheduling (air interface) over CPRI (Common Public Radio Interface)



eICIC - Moderate Coordination

- Macro cell avoids scheduling in “protected” subframes
  - Capacity loss in macro layer and pico layer
  - Reduced interference from macro cell in “protected” subframes
- Advanced Rx in Ue required for range expansion
- Cell size: Dense urban environment
- Time alignment: +/- 5us required between macro and small cell
- Latency: No special demands
- Bandwidth Needs: Low





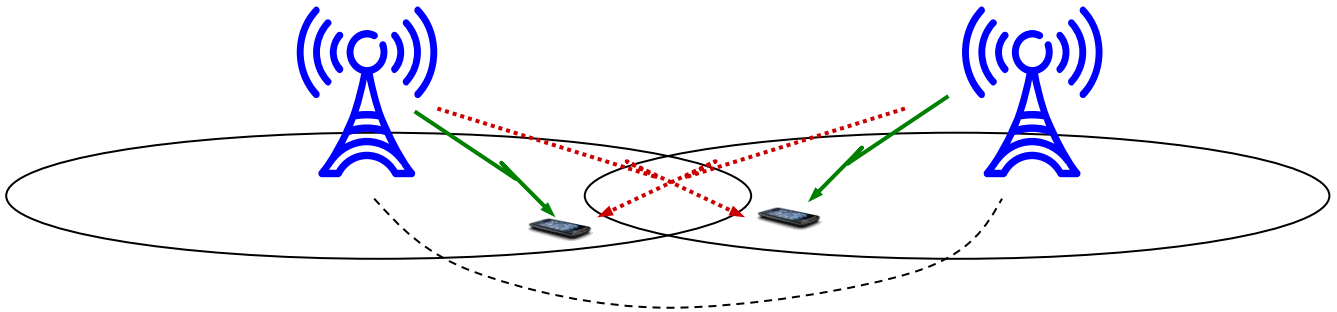
UEs in macro cell scheduled in non-protected subframes only

UEs in range expansion zone scheduled in protected subframes only

UEs in inner part of pico cell scheduled in any subframe

Time alignment is needed

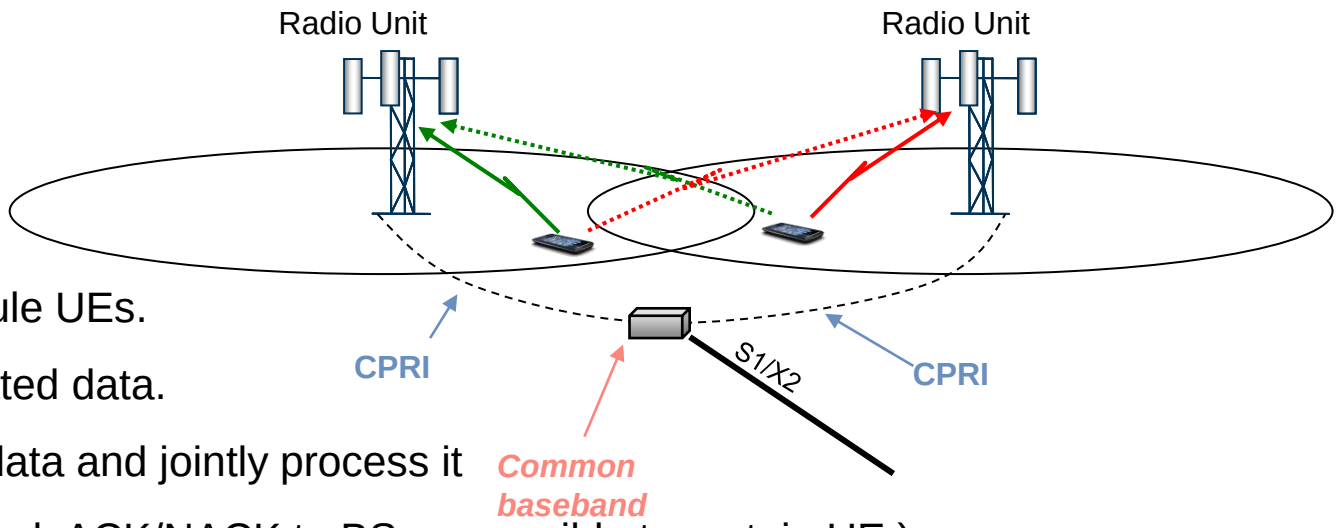
DL Coordination Scheduling - Tight Coordination



- Down Link
- Share information.
- Based on received information, perform coordinated scheduling
- Cell size: Dense urban environment
- Time alignment: +/-1.5us required between macro and small cell
- Latency: 1..10ms – the lower the latency, the better the cell edge gain
- Bandwidth: Up to 20Mbps, per coordinated cell pair

Time alignment and low latency is needed

UL Joint Reception - Very Tight Coordination



- Up Link - Schedule UEs.
- Receive transmitted data.
- Share received data and jointly process it

(Communicate back ACK/NACK to BS responsible to certain UE.)

- Cell size: Dense urban environment
- Time alignment: +/-1.5us required between cells
- Latency: <0.5ms one way
- Bandwidth: 1Gbps per antenna,

internal RBS interface

TIME ALIGNMENT, HIGH BW & VERY LOW LATENCY => BASEBAND INTERNAL ONLY

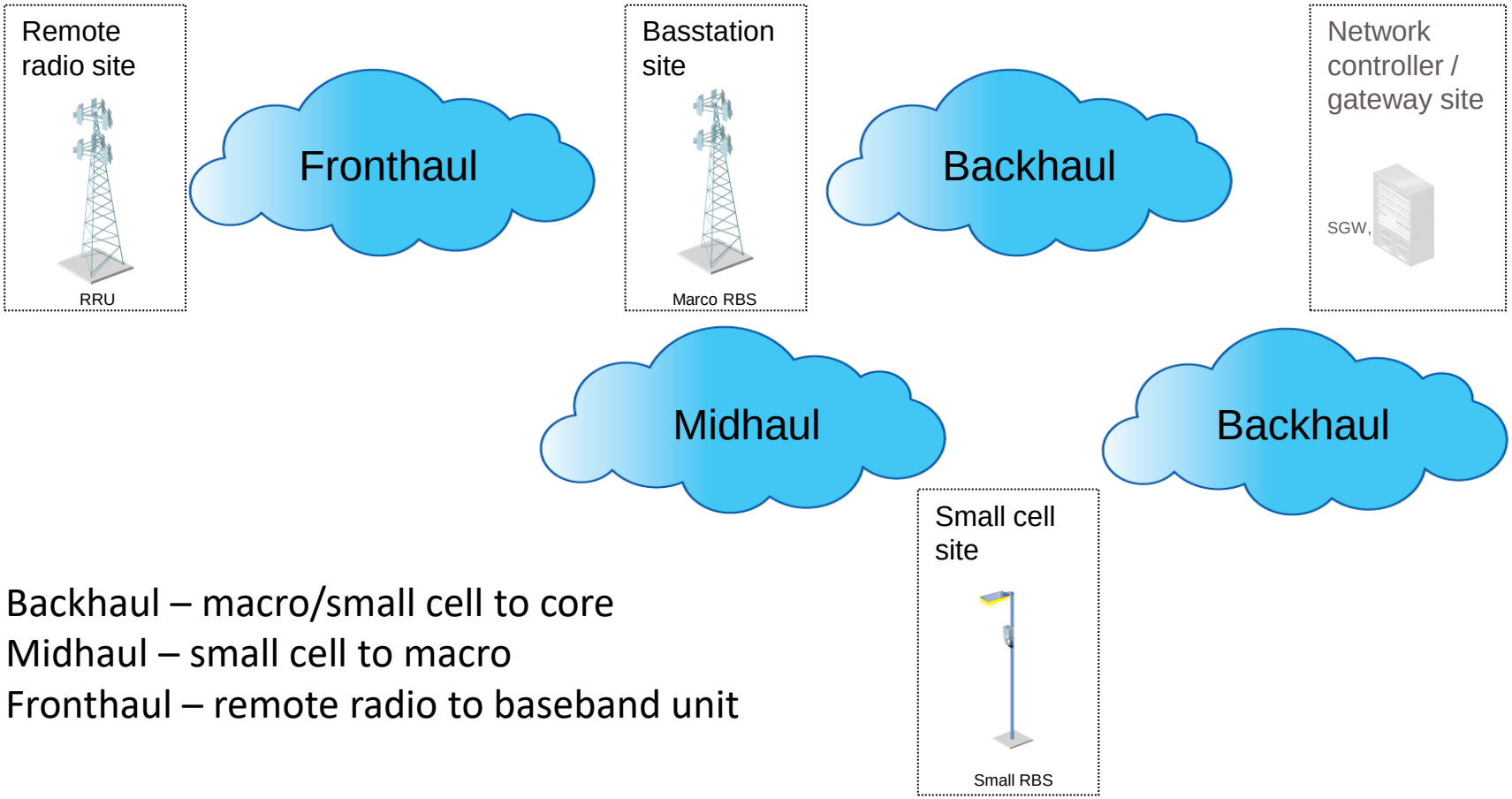
Time alignment, high bandwidth &very low latency is needed

MEF 22.1.1 - Small Cells

Introduction to the Amendment

- The MEF 22.1.1 amendment makes the following changes to MEF 22.1:
  1. Backhaul, Midhaul and Fronthaul are defined
  2. Small Cells, along with heterogeneous networks and radio coordination, are introduced
  3. New variations of existing use cases
  4. new use case 3 is defined for the midhaul case
  5. CPOs for small cells with tight radio coordination are described
  6. CPOs for small cells with split bearer are described
  7. A new Appendix defines the Aggregation Node
  8. A new Appendix summarizes LTE radio coordination

MEF 22.1.1 – New Terminology

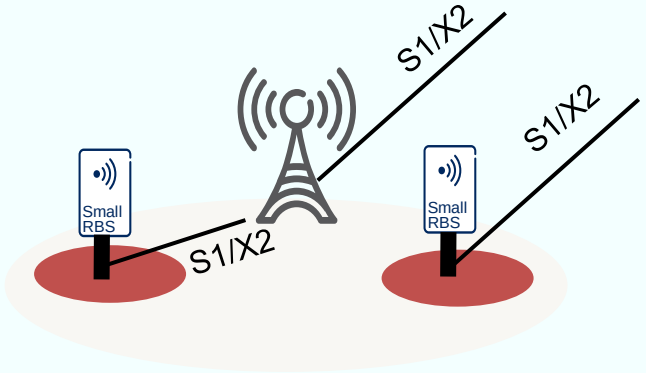


Backhaul – macro/small cell to core
Midhaul – small cell to macro
Fronthaul – remote radio to baseband unit

Small Cell alternatives

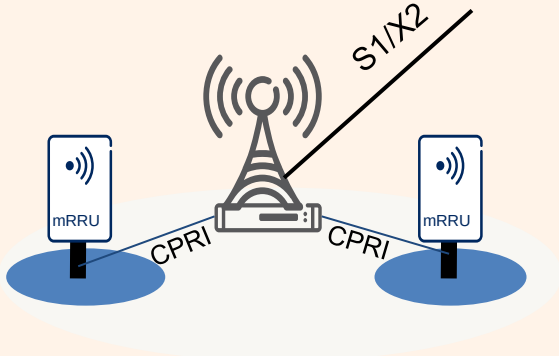
Distributed Baseband Architecture

- Backhaul – macro or small cell BS to core
- Midhaul – small cell to macro



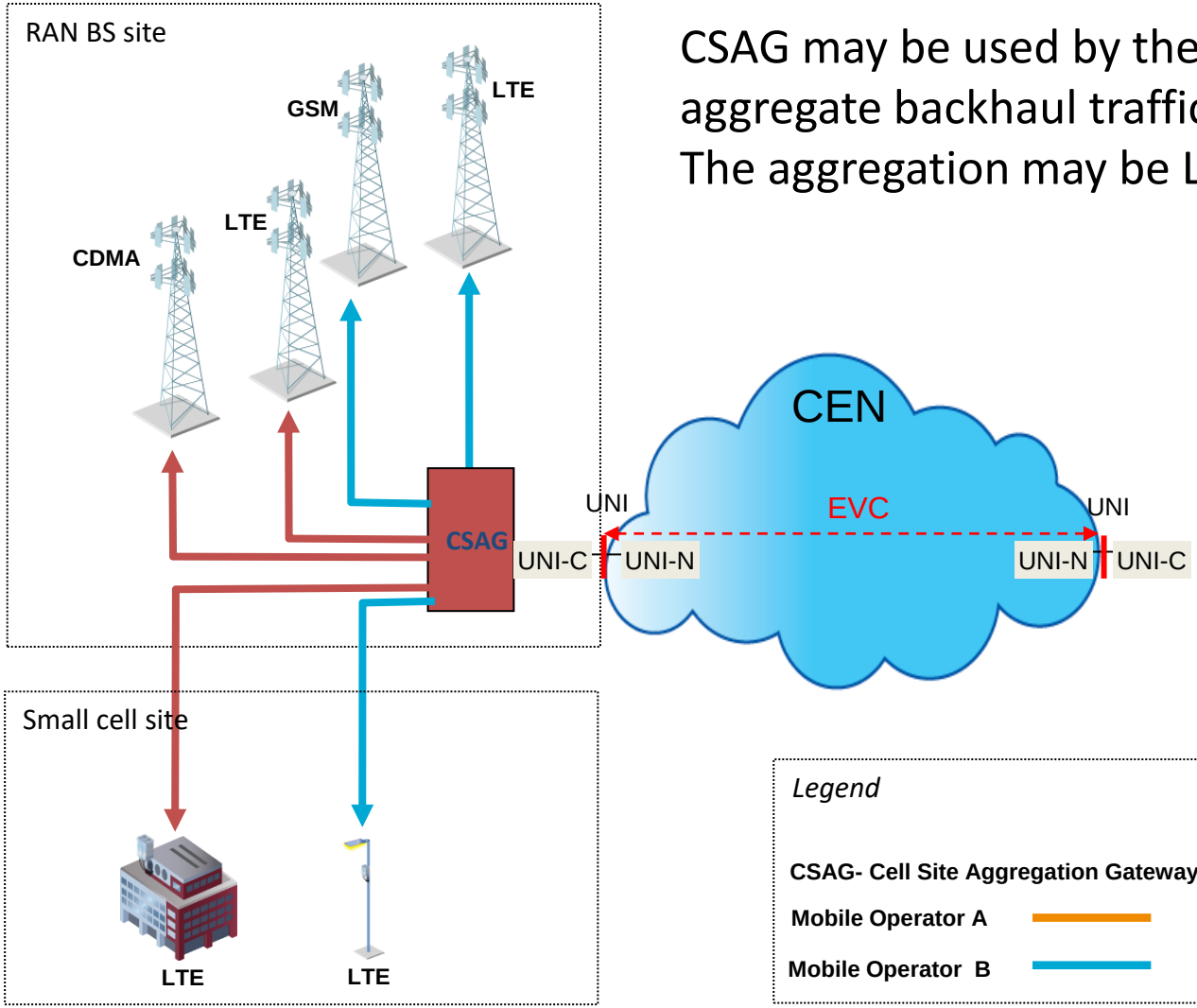
Common Baseband Architecture

– Backhaul – macro BS to core
– Fronthaul - CPRI interconnect between remote radio units and baseband unit



Small cells are operator-controlled, low-powered radio access nodes, which typically have a range from 10 metres to several hundred metres. They may be a complete basestation (distributed as on the left) or just the radio/antenna (common as on the right)

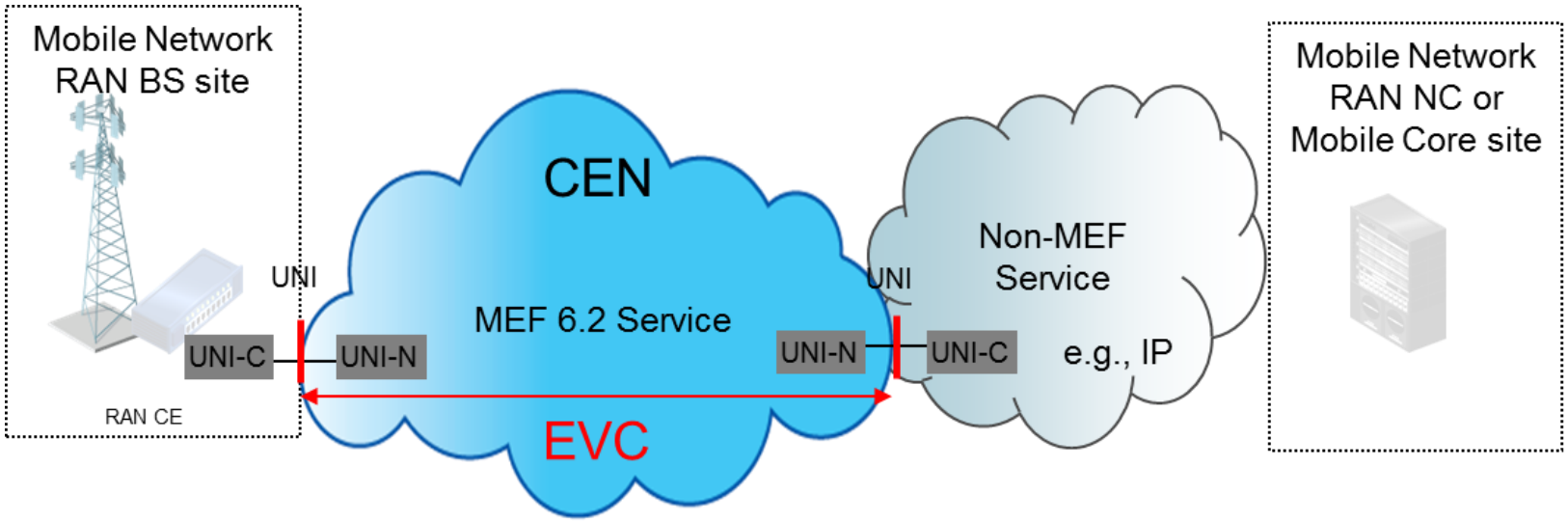
Generalized BS aggregation

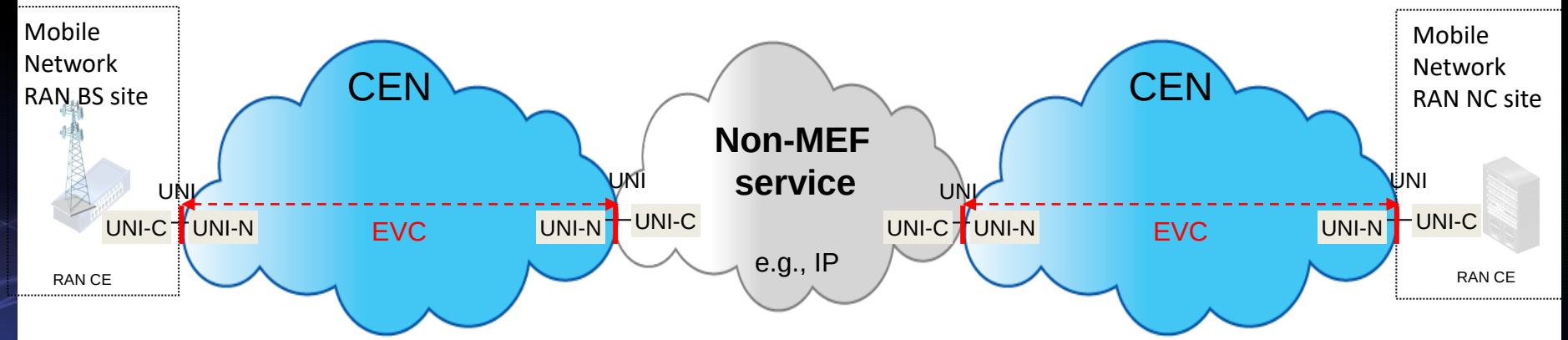


CSAG may be used by the mobile operator to aggregate backhaul traffic before the MEF UNI. The aggregation may be L2 or L3

CEN and non-CEN hybrid

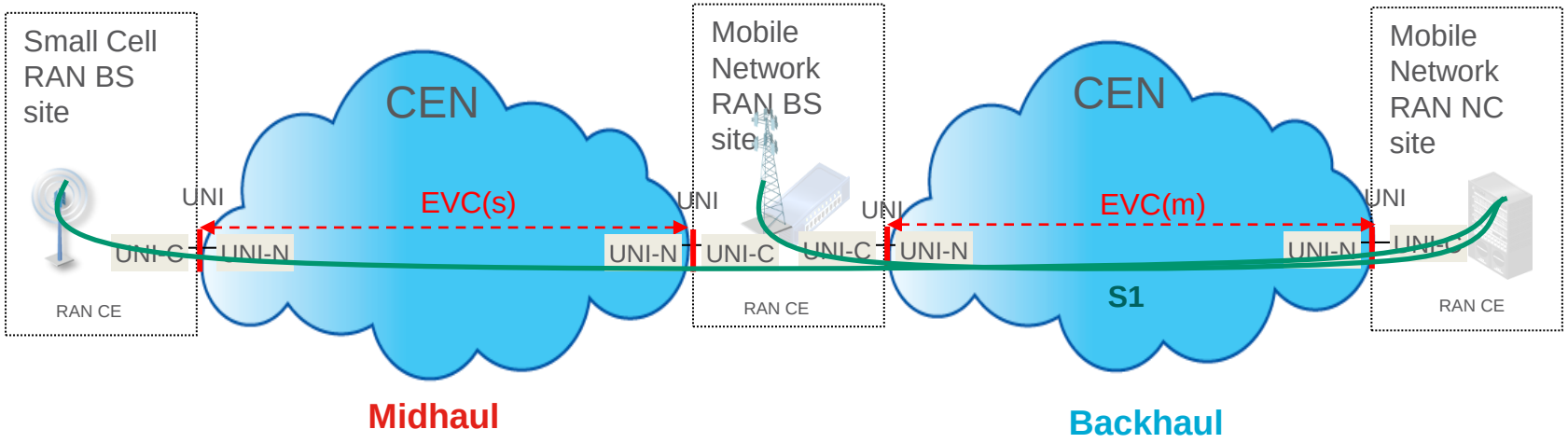
MEF MBH can be part of a multi-technology end-to-end backhaul



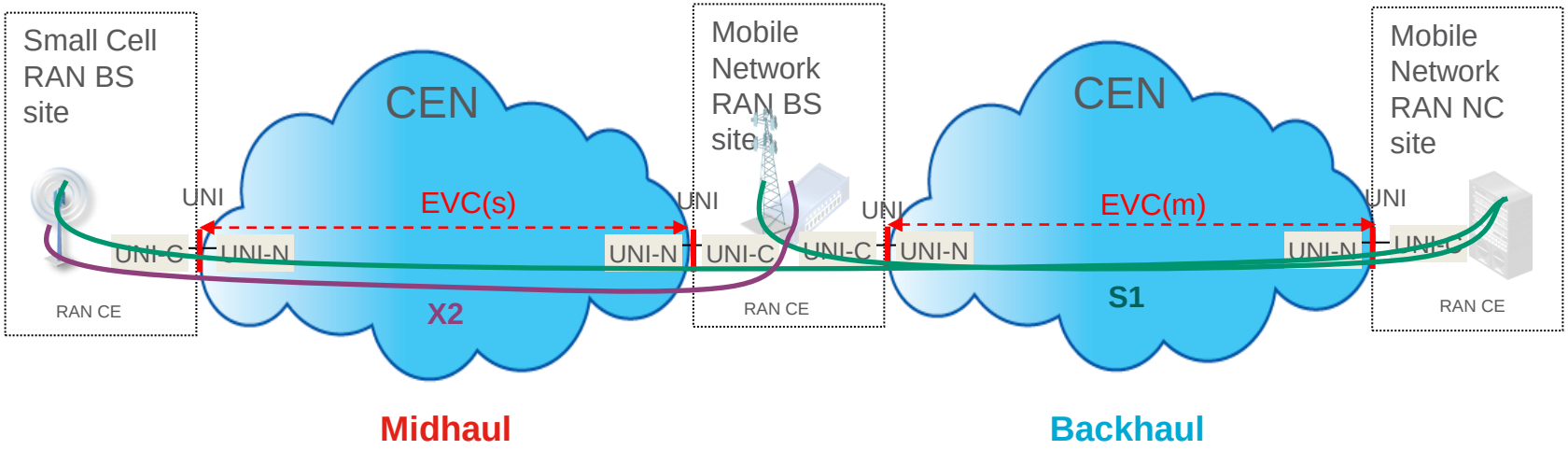


Backhaul with Small Cell Extension Use Cases

LTE S1 Backhaul:

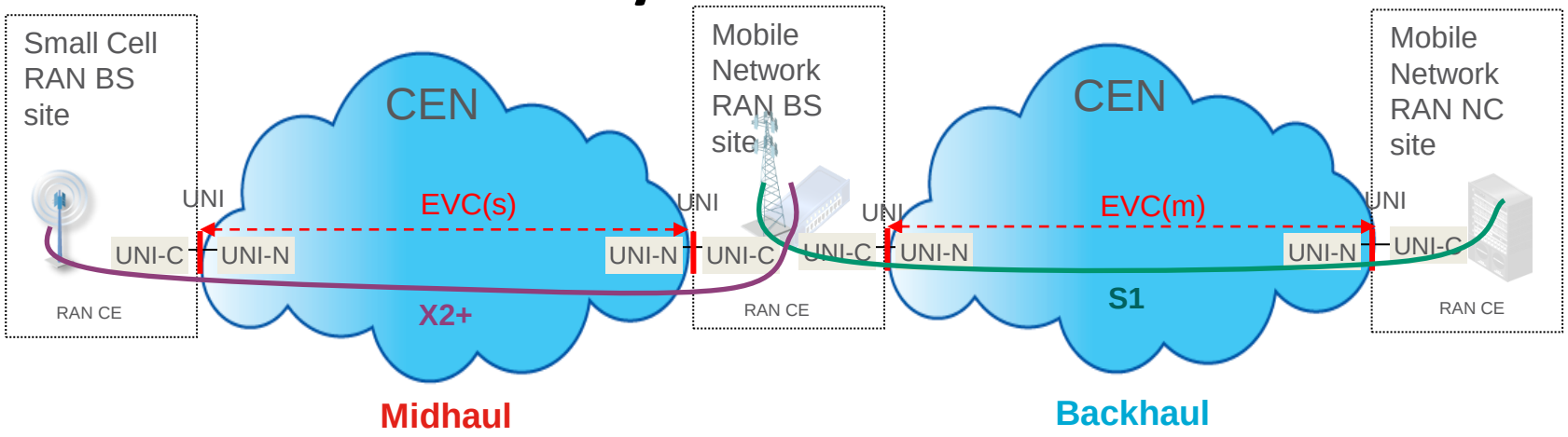


LTE S1 & X2 Backhaul:

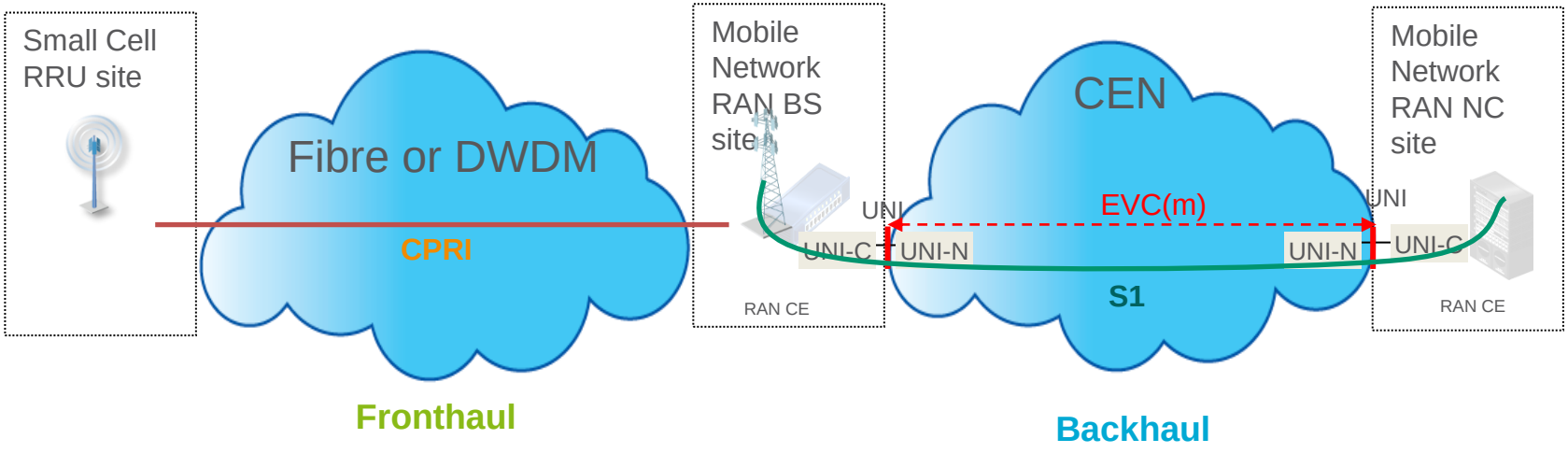


Backhaul with Small Cell Extension Use Cases (2)

LTE-A Dual Connectivity :



CPRI & Backhaul:



Transport Requirements

- **Backhaul**
  - **Macro – Core (eNB – EPC)**
  - **Packet based**
- **Fronthaul**
  - **Baseband – Radio Unit (Main-Remote)**
  - **Dedicated Fibre**
- **Midhaul**
  - **Macro – small cell (eNB-eNB)**
  - **Options**
    - **Same as backhaul**
    - **Support tight coordination**
    - **Support X2+**

Latency ~20ms

Latency ~50us

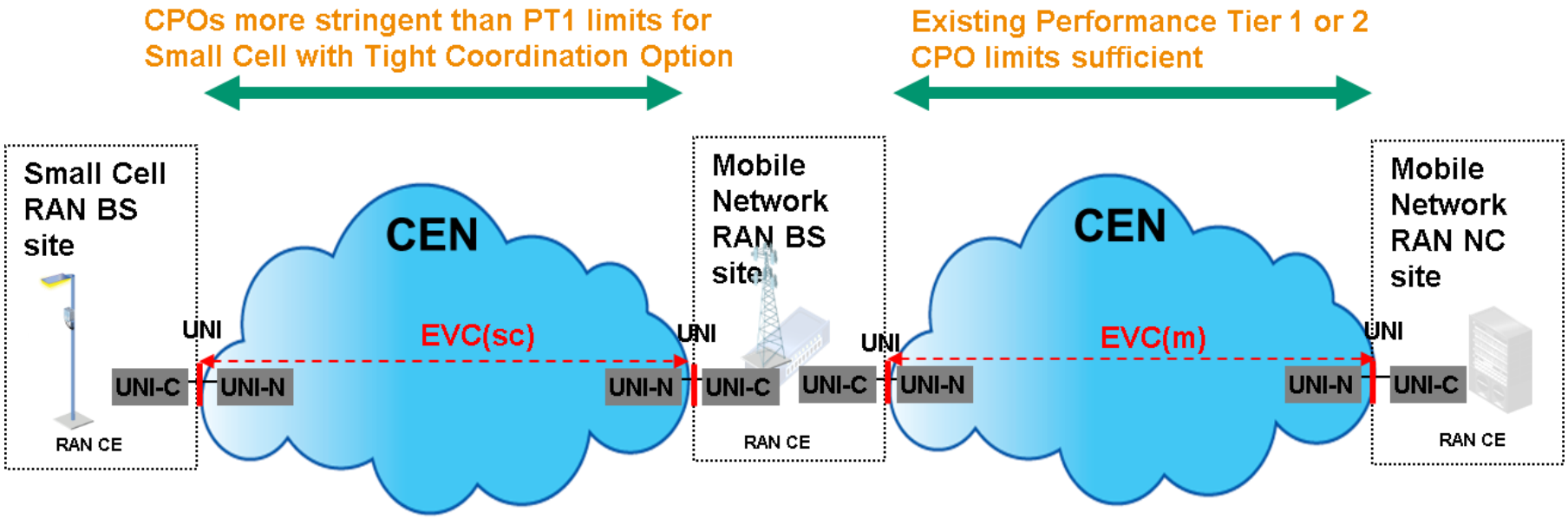
Latency ~20ms

Latency ~1ms

Latency ~50ms

New CPO for tight coordination

Constrained PT1 : FD of 1ms (CoS Name H) – 10ms (CoS Name L)



E2E budget example for S1: 1+5+1+20=27ms for CoS Name M

Summary

- **The need for greater capacity, indoor penetration and spectral-reuse is driving the requirement for small cell solutions**
- **Small cell networks present their own unique deployment and backhaul challenges**
- **MEF-22.1.1 will cover Small cell with tight coordination backhaul and is backwards compatible with MEF-22.1**