

# **Antenna Interface 2 (AIF2) Training Part-1 -- Overview**

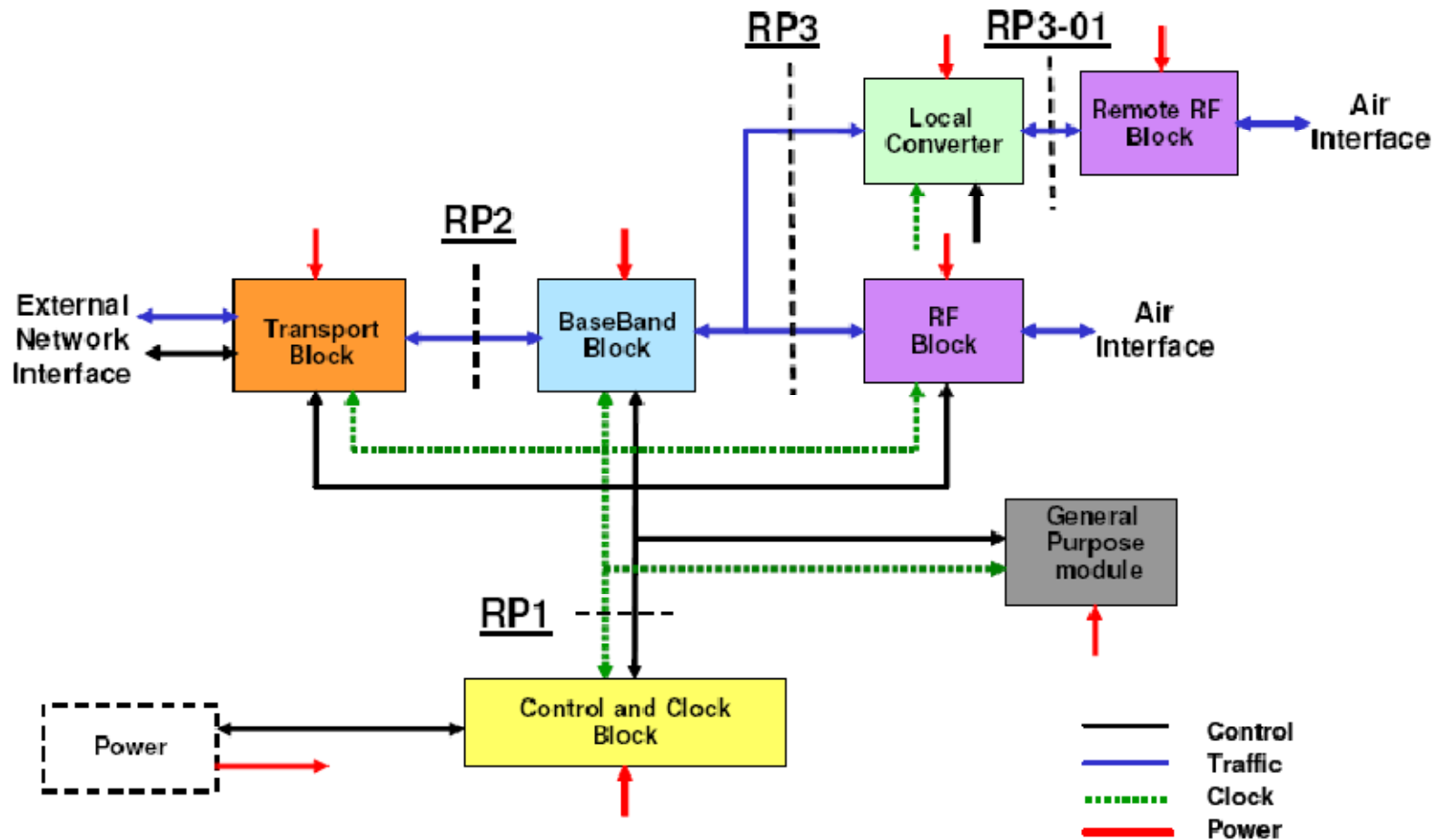
**Brighton Feng**  
**2012-5-28**

# Agenda

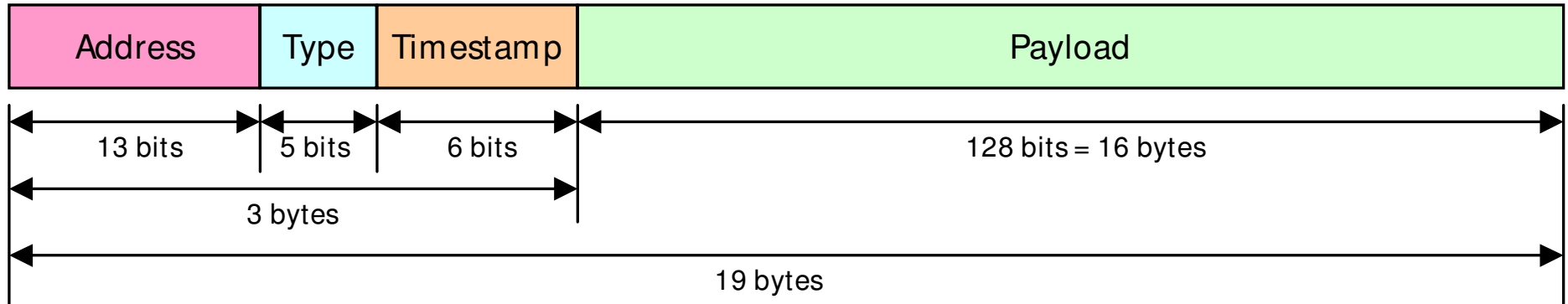
- **OBSAI and CPRI Overview**
- **AlF2 interconnection topology**
- **AlF2 block diagram and data flow overview**

# Protocol Overview

- **OBSAI** (Open Base Station Architecture Initiative)
  - RP3 antenna interface supports 768Mbps (1x), 1.536Gbps (2x), 3.072Gbps (4x), 6.144Gbps (8x) link rates

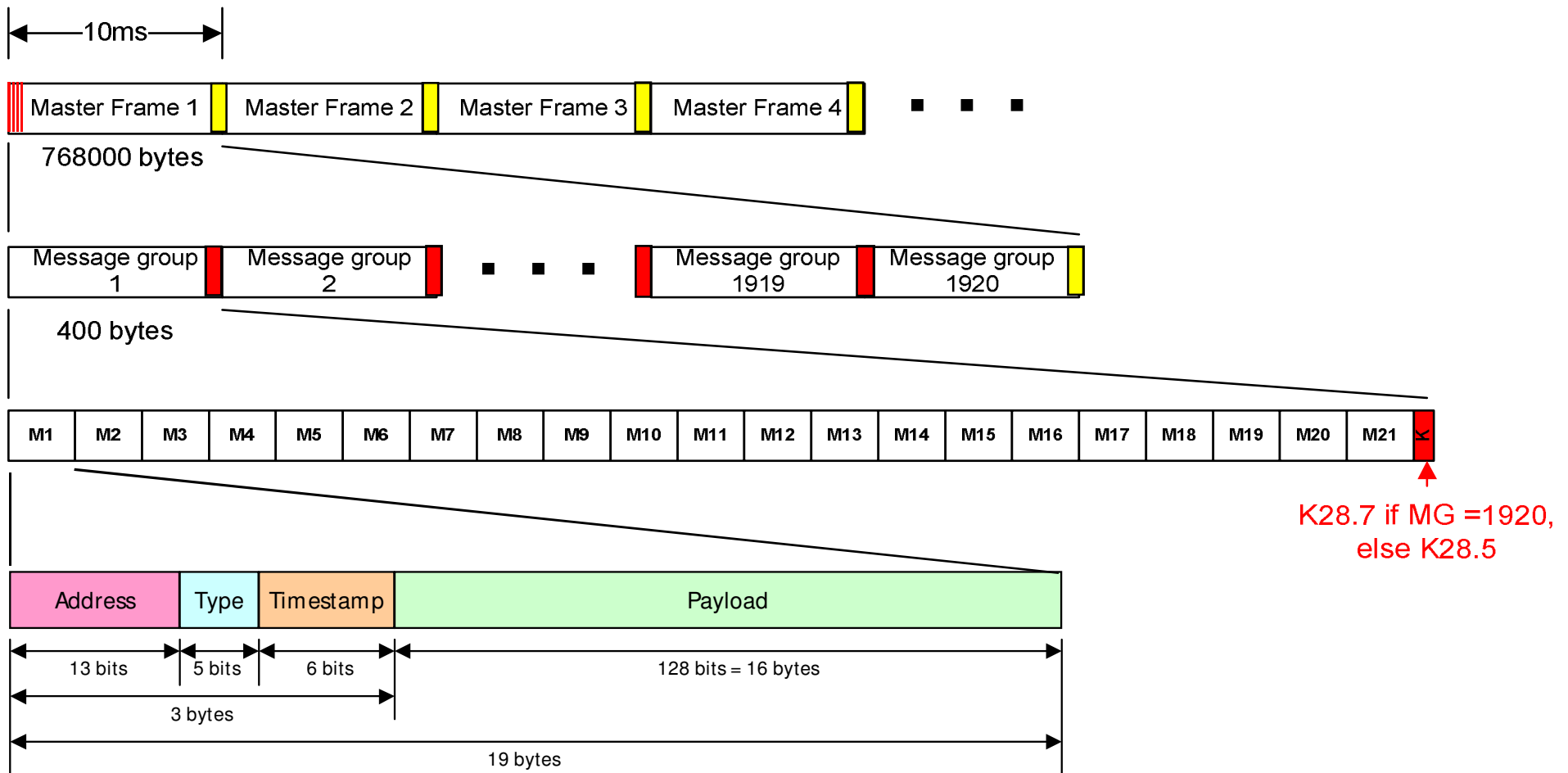


# OBSAI RP3 Message Format



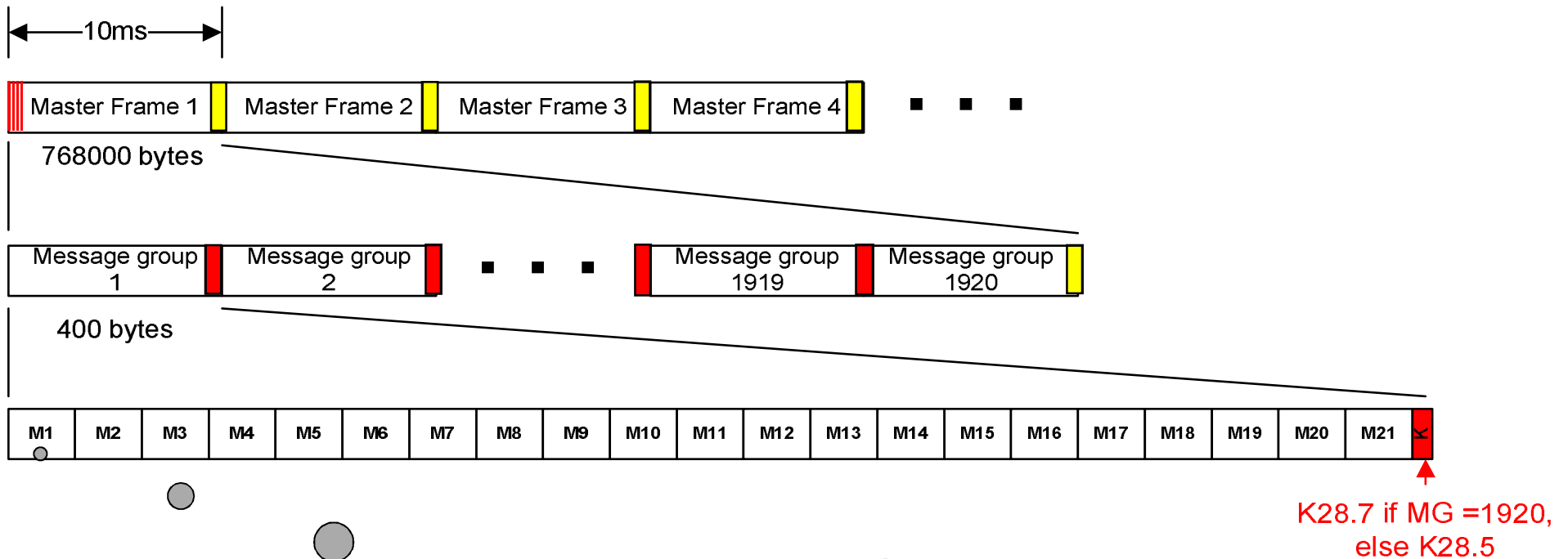
- **OBSAI RP3 protocol is message based:**
  - providing the mapping of different types of packets to the payload.
  - responsible for the end-to-end delivery of the messages, which is simply routing of messages.
  - responsible for framing of messages and message (link) synchronization
- **OBSAI protocol identifies different antenna stream according to the message header (different type or address); while CPRI protocol identifies different antenna streams according to time slot in the frame (Time Division Multiplex).**

# OBSAI RP3 1x Frame Structure



- **1x link rate = 10 bits/byte \* (19 bytes \* 21 messages + K28.x) \* 1920 message groups \* 100 frames = 768Mbps**

# OBSAI RP3 1x Frame Structure

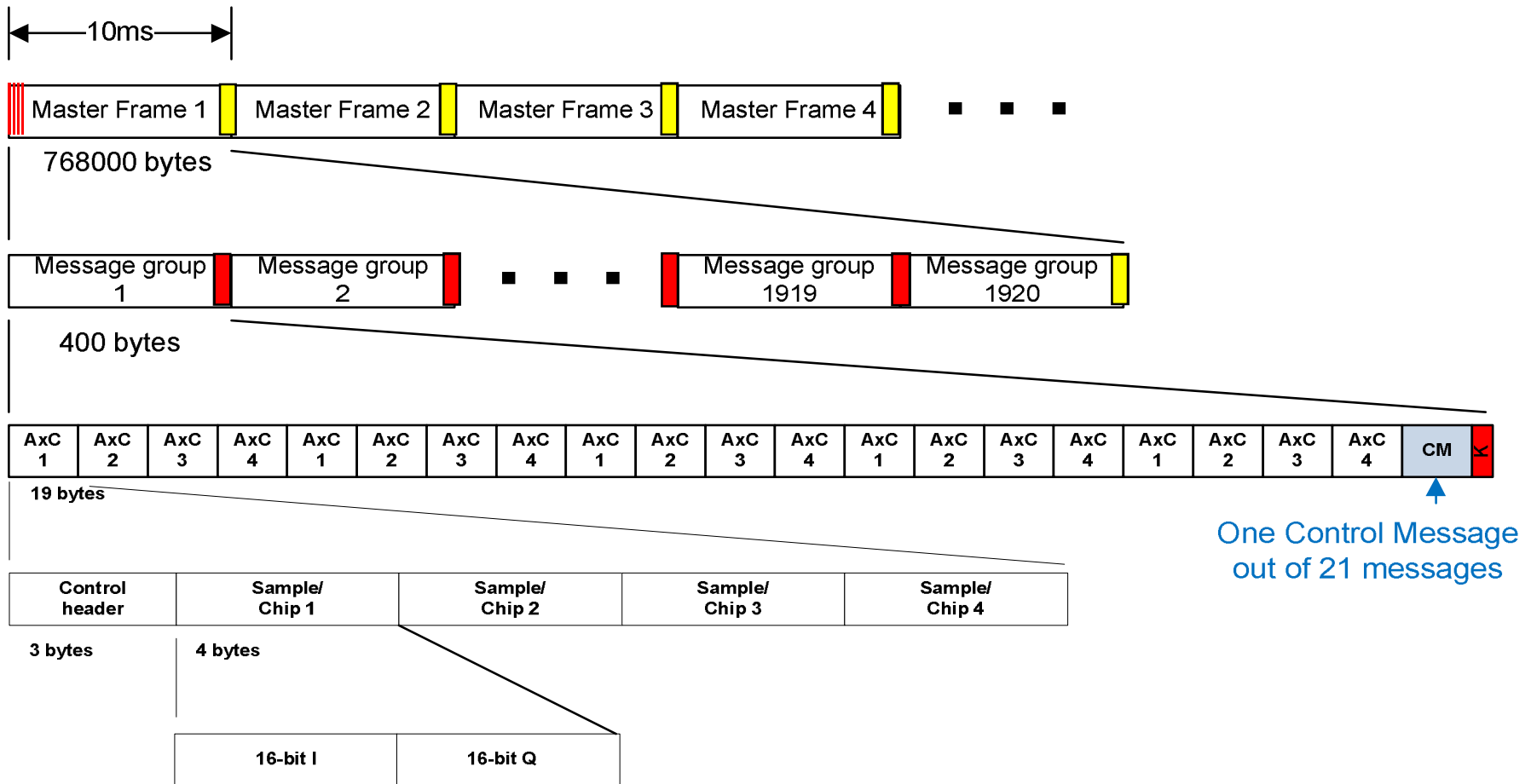


Message numbers/group increases with link rate:

21 for 1x; 42 for 2x;

84 for 4x; 168 for 8x

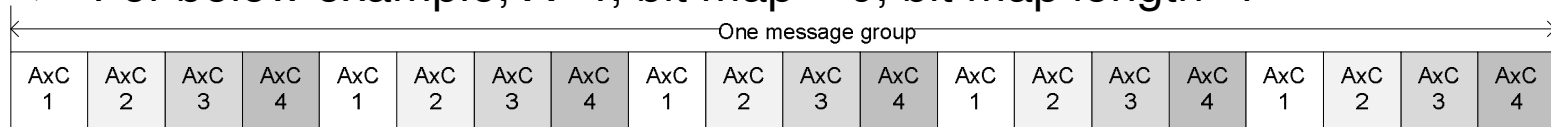
# 16-bit I/Q data packing



# Dual Bit Map (DBM)

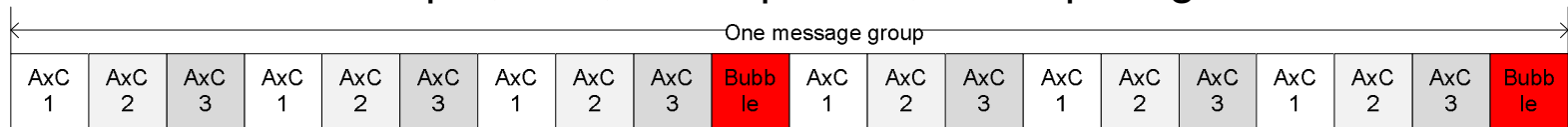
- A link may carrier just multiple of AxC number, for example WCDMA, LTE, TD-SCDMA.

- DBM is not really necessary for these cases
- For below example, X=4, bit map = 0, bit map length=1



- For some radio standards, such as 15MHz LTE, Wimax and GSM, the link speed is not just multiple of antenna data speed.

- DBM rules should be used to implement a “rate matching”
- For example, if the link speed/antenna data speed =  $10/3 = 3.33333...$
- For below example, X=3, bit map= 001, bit map length =3

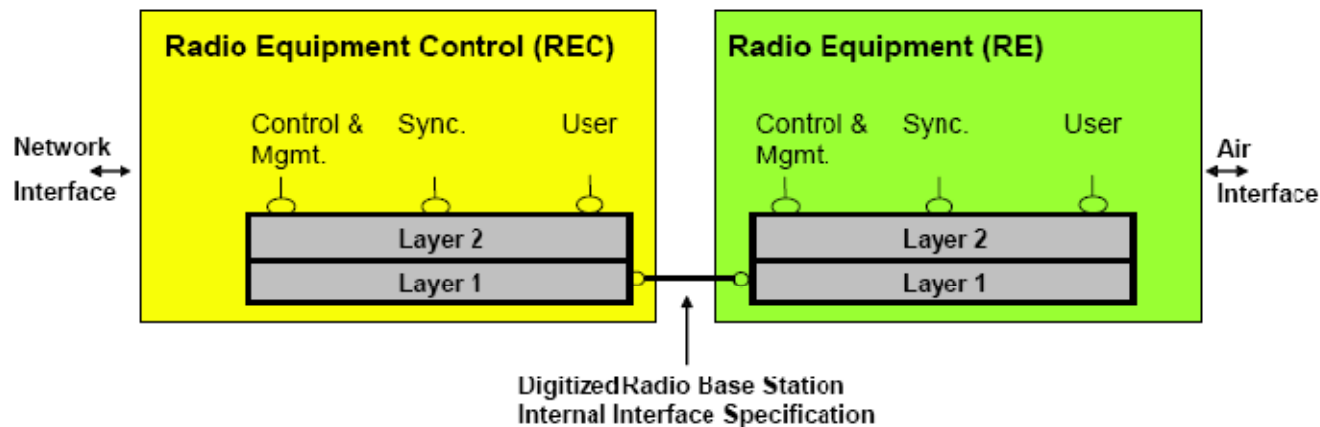


- DBM is defined by OBSAI specification, CPRI specifcatin does not define it. But AIF2 implements it for both OBSAI and CPRI.

# Protocol Overview

## ➤ CPRI (Common Public Radio Interface)

- 614.4Mbps (1x), 1.2288Gbps (2x), 2.4576Gbps (4x) , 3.072Gbps (5x) , 4.9152Gbps (8x) link rates supported
- Focus on Radio Interface only, counterpart of RP3 of OBSAI



- AIF2 supports both CPRI and OBSAI RP3 (only one mode can be used at a time).
- AIF2 Timer Module supports OBSAI RP1 clocking

# CPRI Protocol Stack

## Application Layer:

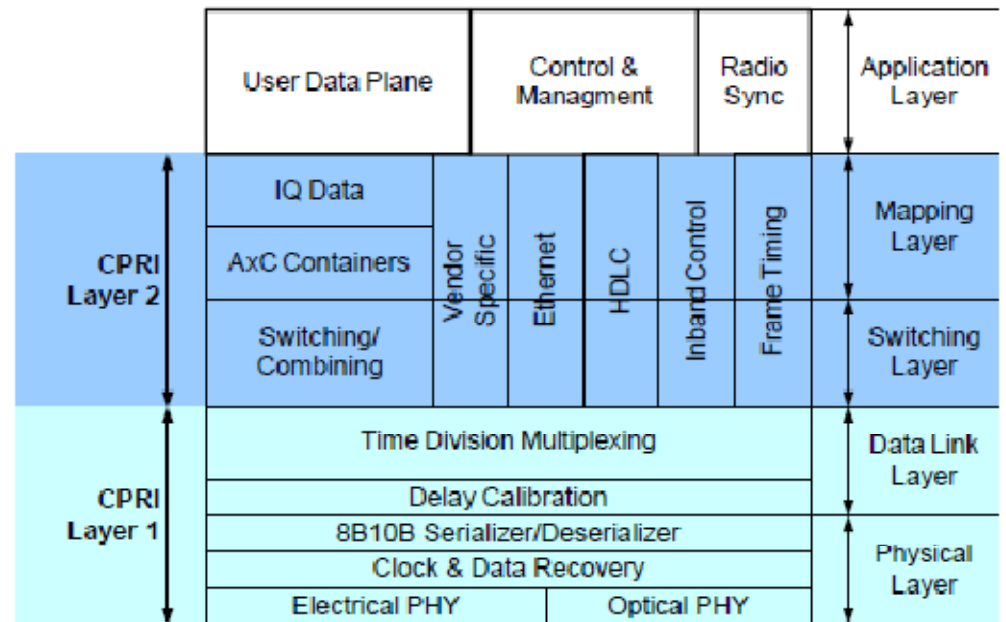
- User Data Plane, Radio data transported as IQ samples
- Radio Synchronization, Air interface reference frequency and frame timing
- Control and Management (C&M)
  - L1 Inband Protocol: To maintain the CPRI link
  - Slow C&M: Low bandwidth OAM&P channel
  - Fast C&M: Higher bandwidth OAM&P channel

## Layer 2:

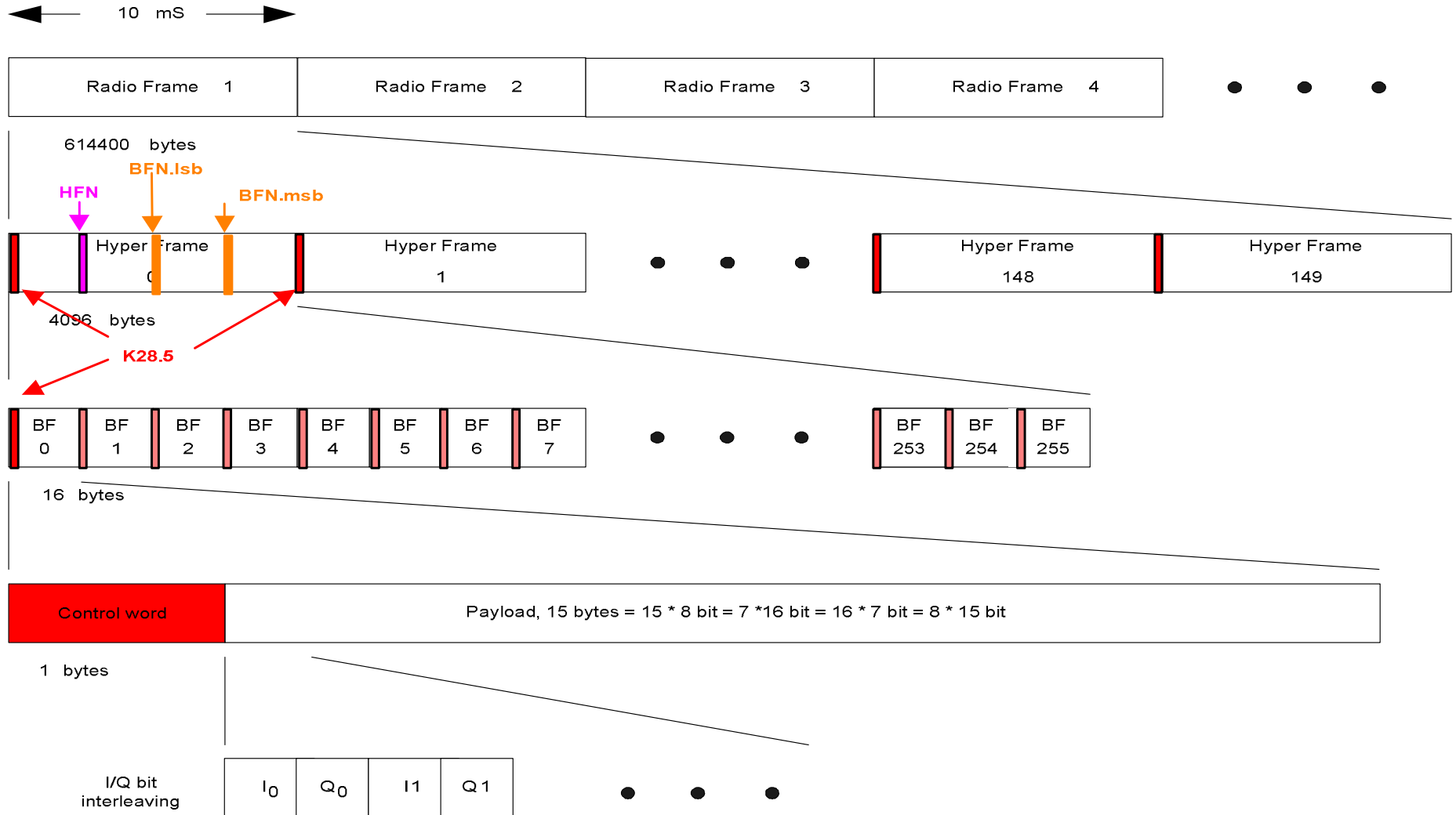
- Media access control
- Flow control
- Data protection of the control and management information flow

## Layer 1:

- Electrical characteristics
- Optical characteristics
- Time division multiplexing of the different data flows
- Low level signaling

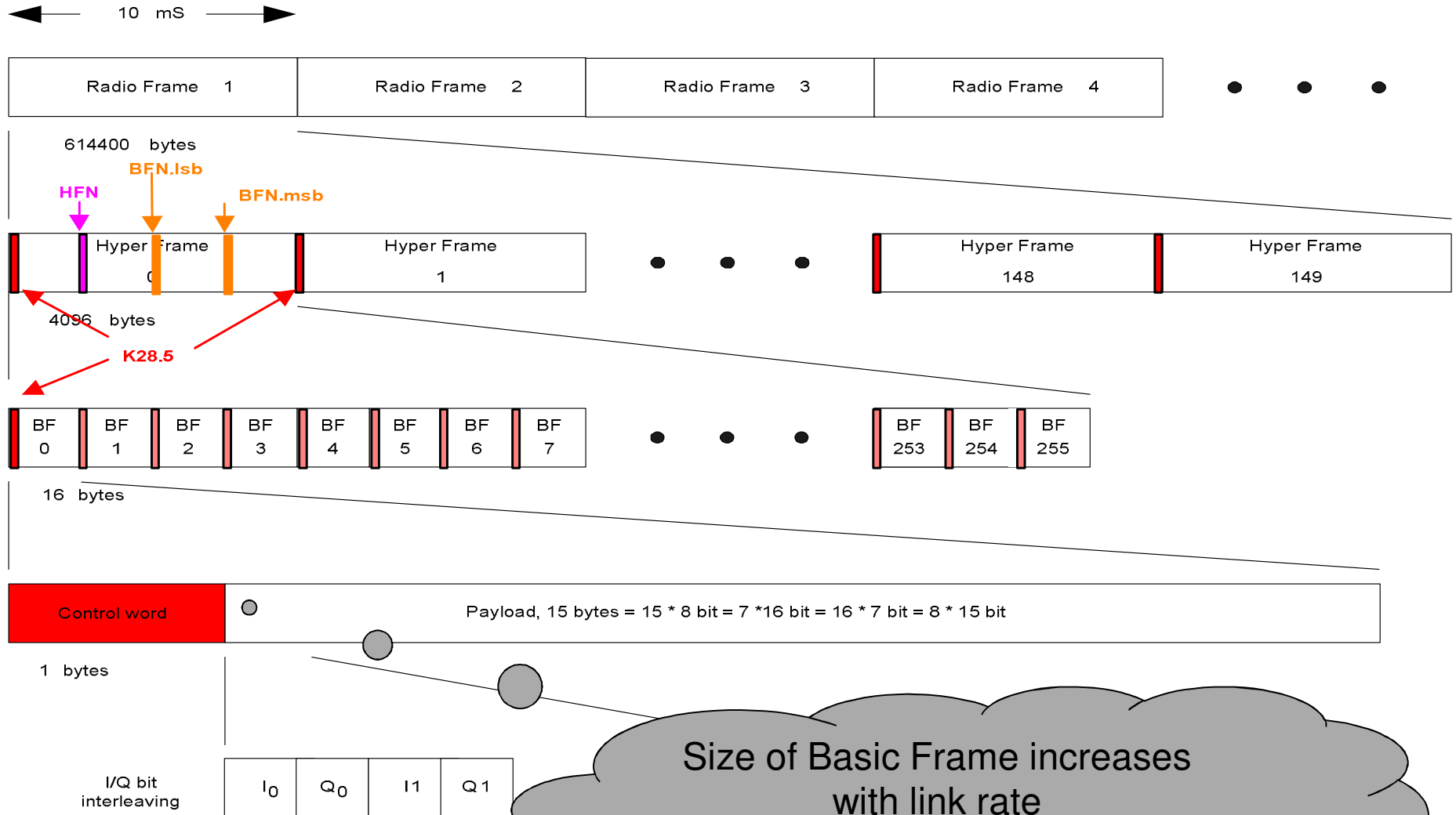


# CPRI 1x Frame Structure



- **1x link rate = 10 bits/byte \* (1+15) bytes \* 256 basic frame \* 150 Hyper frame \* 100 radio frames = 614.4Mbps**

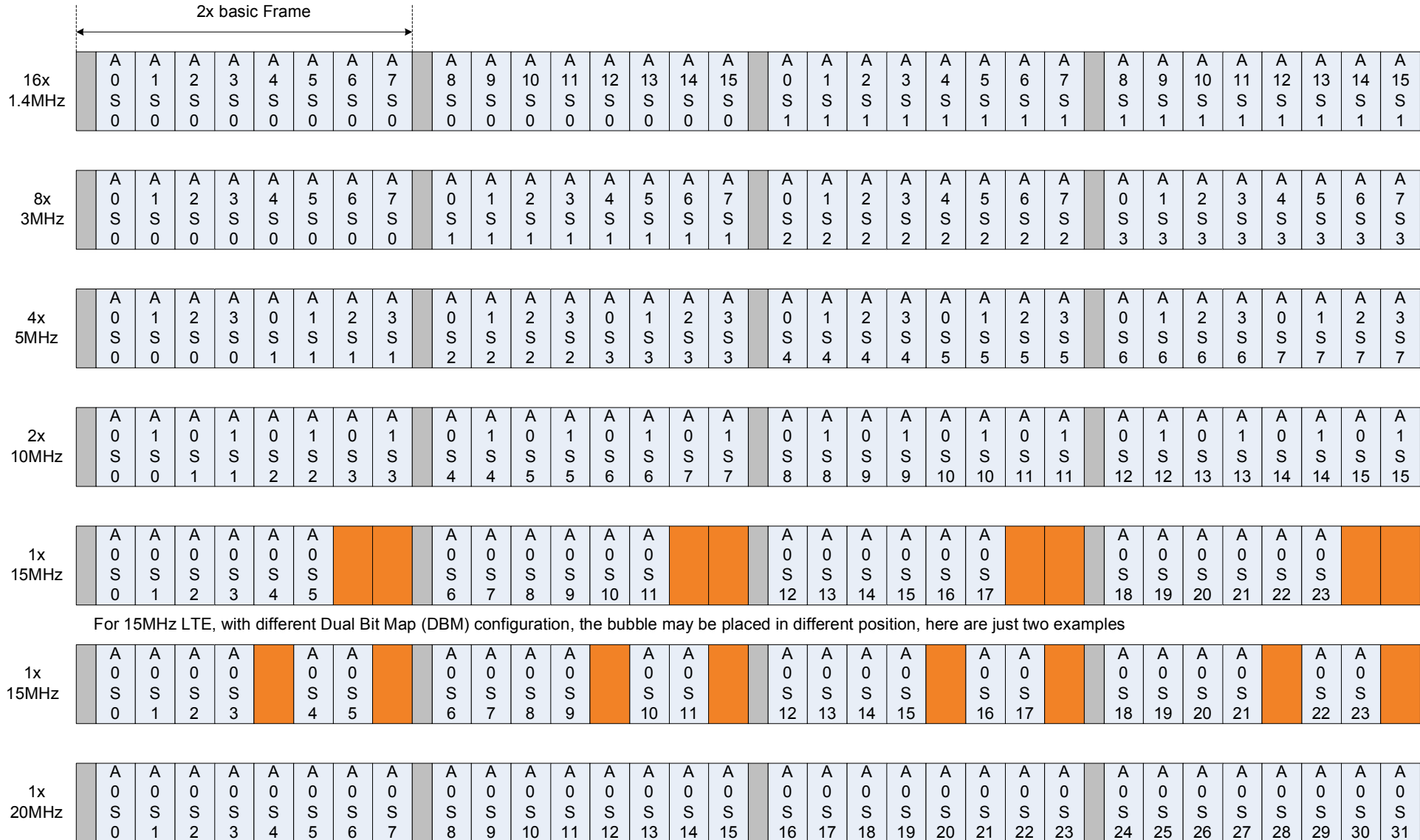
# CPRI 1x Frame Structure



Size of Basic Frame increases with link rate

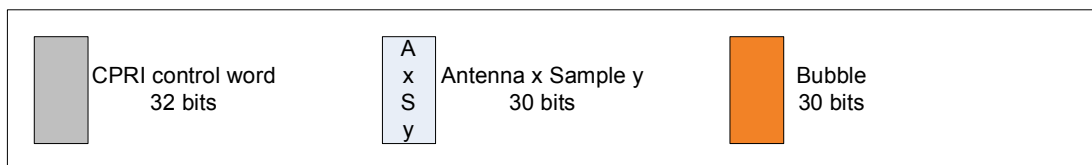
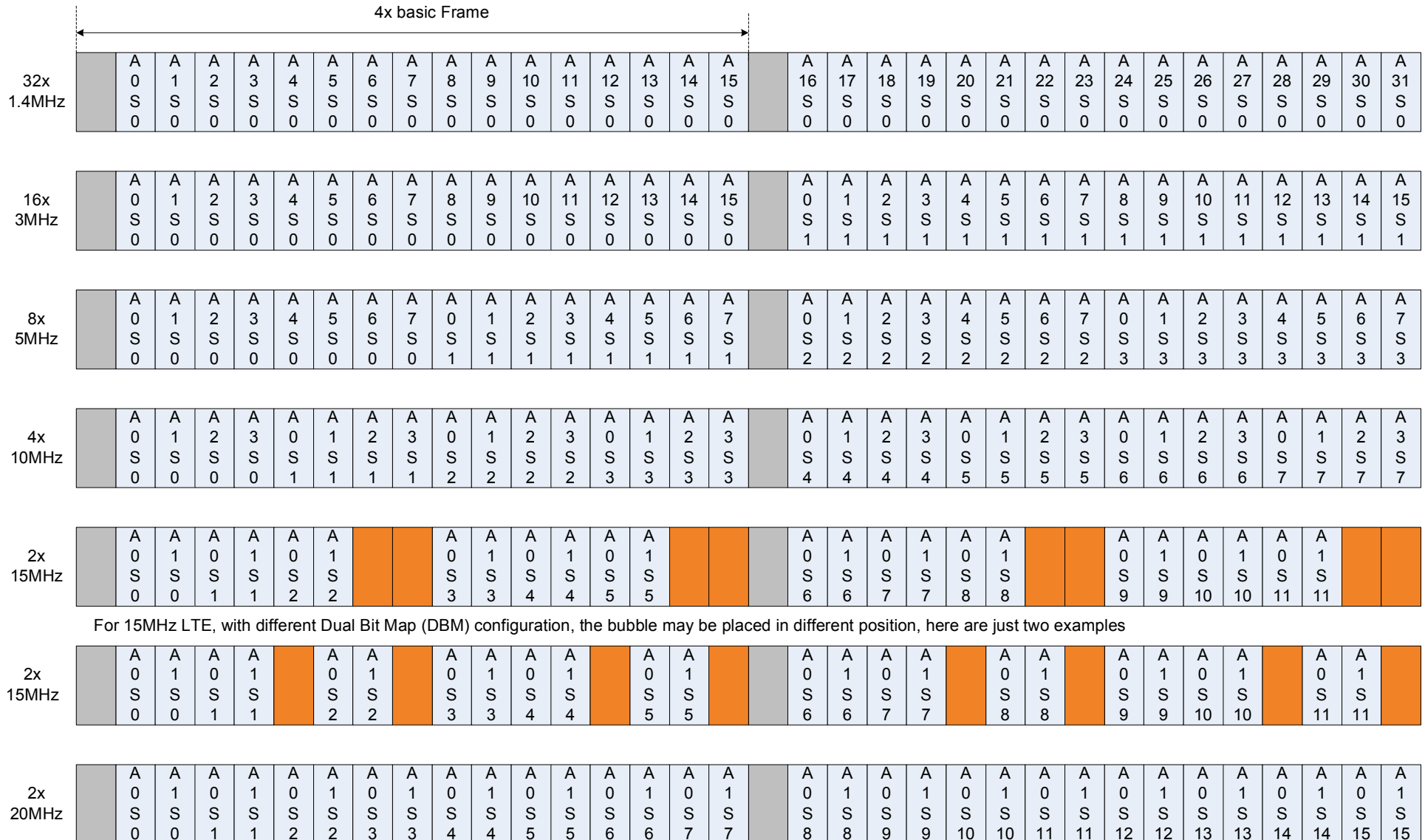
16 bytes for 1x; 32 bytes for 2x, 64 bytes for 4x; 128 bytes for 8x

# LTE Sample Packing in CPRI 2x link



- UMTS is similar as 3MHz LTE case

# LTE Sample Packing in CPRI 4x link



•UMTS is similar as 3MHz LTE case

# LTE Sample Packing in CPRI 8x link

8x basic Frame

64x  
1.4MHz

|  |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
|--|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|
|  | A | A | A | A | A | A | A | A | A | A | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A |
|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |   |
|  | S | S | S | S | S | S | S | S | S | S | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  |   |
|  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0 |

32x  
3MHz

|  |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
|--|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|
|  | A | A | A | A | A | A | A | A | A | A | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A  | A |
|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |   |
|  | S | S | S | S | S | S | S | S | S | S | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S  | S |
|  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0 |

16x  
5MHz

|  |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |   |
|--|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|---|
|  | A | A | A | A | A | A | A | A | A | A | A  | A  | A  | A  | A  | A  | A | A | A | A | A | A | A | A | A | A | A  | A  | A  | A  | A  | A  | A |
|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |   |
|  | S | S | S | S | S | S | S | S | S | S | S  | S  | S  | S  | S  | S  | S | S | S | S | S | S | S | S | S | S | S  | S  | S  | S  | S  | S  | S |
|  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1  | 1  | 1  | 1  | 1  | 1 |

8x  
10MHz

|  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|--|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A |
|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |   |
|  | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S |
|  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

4x  
15MHz

|  |   |   |   |   |  |  |   |   |   |   |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |   |   |   |   |   |  |  |
|--|---|---|---|---|--|--|---|---|---|---|---|---|---|---|--|---|---|---|---|---|--|---|---|---|---|---|---|---|---|---|--|--|
|  | A | A | A | A |  |  | A | A | A | A | A | A | A |   |  | A | A | A | A |   |  | A | A | A | A | A | A | A | A |   |  |  |
|  | 0 | 1 | 2 | 3 |  |  | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |  |   | 0 | 1 | 2 | 3 |  |   | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |  |  |
|  | S | S | S | S |  |  | S | S | S | S | S | S | S | S |  |   | S | S | S | S |  |   | S | S | S | S | S | S | S | S |  |  |
|  | 0 | 0 | 0 | 0 |  |  | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |  |   | 3 | 3 | 3 | 3 |  |   | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 |  |  |

For 15MHz LTE, with different Dual Bit Map (DBM) configuration, the bubble may be placed in different position, here are just two examples

4x  
15MHz

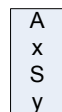
|  |   |   |   |   |   |   |   |   |  |  |   |   |   |   |  |  |   |   |   |   |   |   |   |   |  |  |   |   |   |   |  |  |
|--|---|---|---|---|---|---|---|---|--|--|---|---|---|---|--|--|---|---|---|---|---|---|---|---|--|--|---|---|---|---|--|--|
|  | A | A | A | A | A | A | A | A |  |  | A | A | A | A |  |  | A | A | A | A | A | A | A | A |  |  | A | A | A | A |  |  |
|  | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |  |  | 0 | 1 | 2 | 3 |  |  | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |  |  | 0 | 1 | 2 | 3 |  |  |
|  | S | S | S | S | S | S | S | S |  |  | S | S | S | S |  |  | S | S | S | S | S | S | S | S |  |  | S | S | S | S |  |  |
|  | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |  |  | 2 | 2 | 2 | 2 |  |  | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 |  |  | 5 | 5 | 5 | 5 |  |  |

4x  
20MHz

|  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|--|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A |
|  | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |   |
|  | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S |
|  | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 |   |



CPRI control word  
64 bits



Antenna x Sample y  
30 bits



Bubble  
30 bits

•UMTS is similar as 3MHz LTE case




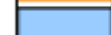




# Control Data Mapping

|              | Xs= 0 | 1   | 2   |     |
|--------------|-------|-----|-----|-----|
| Ns=0         | 0     | 64  |     |     |
| 1            | 1     | 65  |     |     |
| 2            | 2     | 66  |     | p   |
| 3            | 3     | 67  |     |     |
| 4            | 4     |     |     |     |
| 5            |       |     |     |     |
| 6            |       |     |     |     |
| 7            |       |     |     |     |
| 8            |       |     |     |     |
| 9            |       |     |     |     |
| 10           |       |     |     |     |
| 11           |       |     |     |     |
| 12           |       |     |     |     |
| 13           |       |     |     |     |
| 14           | 14    |     |     |     |
| 15           | 15    | 79  | 143 | 207 |
| 16           | 16    | 80  | 144 | 208 |
| 17           | 17    |     |     |     |
| 18           |       |     |     |     |
|              |       |     |     |     |
|              |       |     |     |     |
| Pointer p -> |       |     |     |     |
|              |       |     |     |     |
|              |       |     |     |     |
| 61           | 61    |     |     |     |
| 62           | 62    | 126 | 190 | 254 |
| 63           | 63    | 127 | 191 | 255 |

index X of control word  
within hyperframe:

$$X = Ns + 64 * Xs$$

(some indices X are inserted  
as examples)

|   |   |
|---|---|
|  | Comma Byte (K28.5)  |
|  | Synchronization and timing (HFN, BFN)                     |
|  | Slow C&M link (HDLC)                                      |
|  | L1 inband protocol (Version, startup, reset, LOS, LOF...) |
|  | Reserved  |
|  | Vendor specific   |
|  | Fast C&M link (Ethernet)                                  |
|  | pointer to start of fast C&M                              |

Notes:

1. Ethernet based fast C&M is supported by AIF2.  
HDLC based slow C&M is not supported by AIF2,
2. CPRI Protocol negotiation is not supported by AIF2. Data scrambling is not supported

# OBSAI RP3 vs CPRI

|   |           | OBSAI RP3                             | CPRI   |
|---|-----------|---------------------------------------|--|
| <b>Link Speed</b>                         | <b>1x</b> | 768Mbps                               | 614.4Mbps,   |
|   | <b>2x</b> | 1.536Gbps                             | 1.2288Gbps,  |
|   | <b>4x</b> | 3.072Gbps                             | 2.4576Gbps   |
|   | <b>8x</b> | 6.144Gbps                             | 4.9152Gbps   |
| <b>Data precision</b>                     |           | 8 bits, 16 bits                       | 7 bits, 8 bits, 15 bits, 16 bits                     |
| <b>WCDMA Streams Supported by 4x link</b> |           | 16 (8/16 bits precision)              | 15 (8/16 bits precision)<br>16 (7/15 bits precision) |
| <b>Packet Efficiency</b>                  |           | $(16/19) * (399/400) * (20/21) = 0.8$ | $(15/16) = 0.9375$                                   |

OBSAI offers more flexibility but more overhead and higher link rates

# Supporting Radio Standards

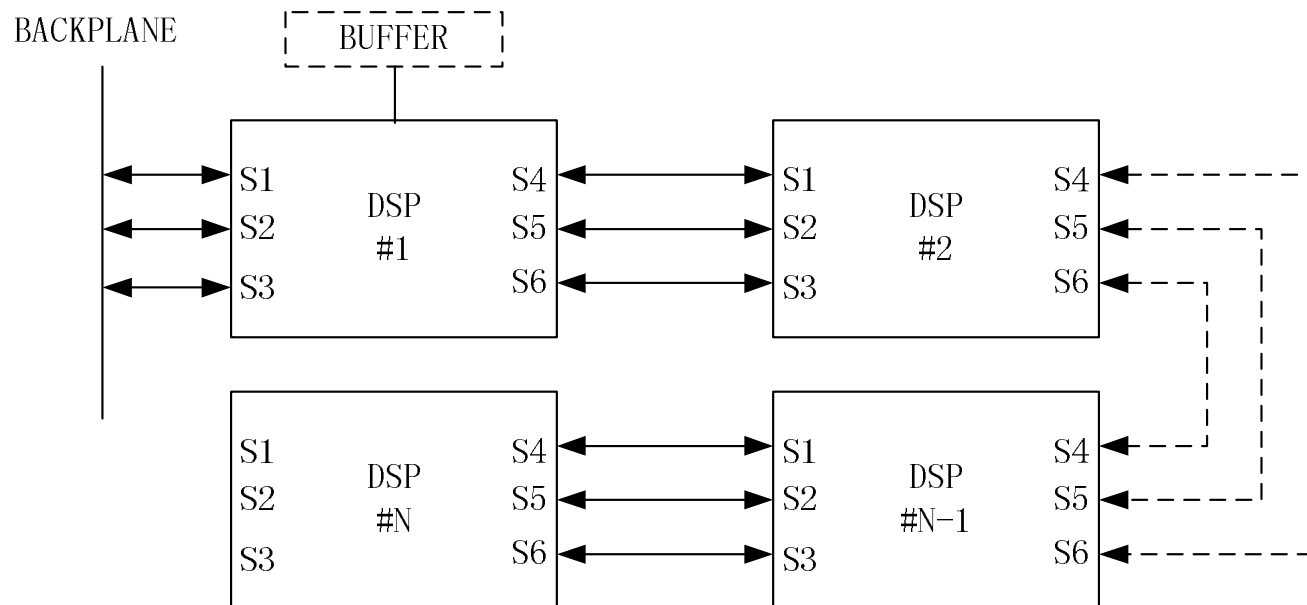
| Radio Standards | Sample Rate | AxC per Link (Typical case) |    |    |
|-----------------|-------------|-----------------------------|----|----|
|                 |             | 2x                          | 4x | 8x |
| TD-SCDMA        | 1.28MHz     | 24                          | 48 | 96 |
| WCDMA           | 3.84MHz     | 8                           | 16 | 32 |
| LTE 5MHz        | 7.68MHz     | 4                           | 8  | 16 |
| LTE 10MHz       | 15.36MHz    | 2                           | 4  | 8  |
| LTE 20MHz       | 30.72MHz    | 1                           | 2  | 4  |

- WCDMA is CPRI and OBSAI originally designed for.
- Sample rate of TD-SCDMA and most LTE bandwidth is multiple of WCDMA, so they fit into OBSAI and CPRI very well (Do not require DBM).
- 15MHz LTE, GSM and Wimax sample rate is not multiple of WCDMA, DBM (Dual Bit Map) is required for rate matching.

# Agenda

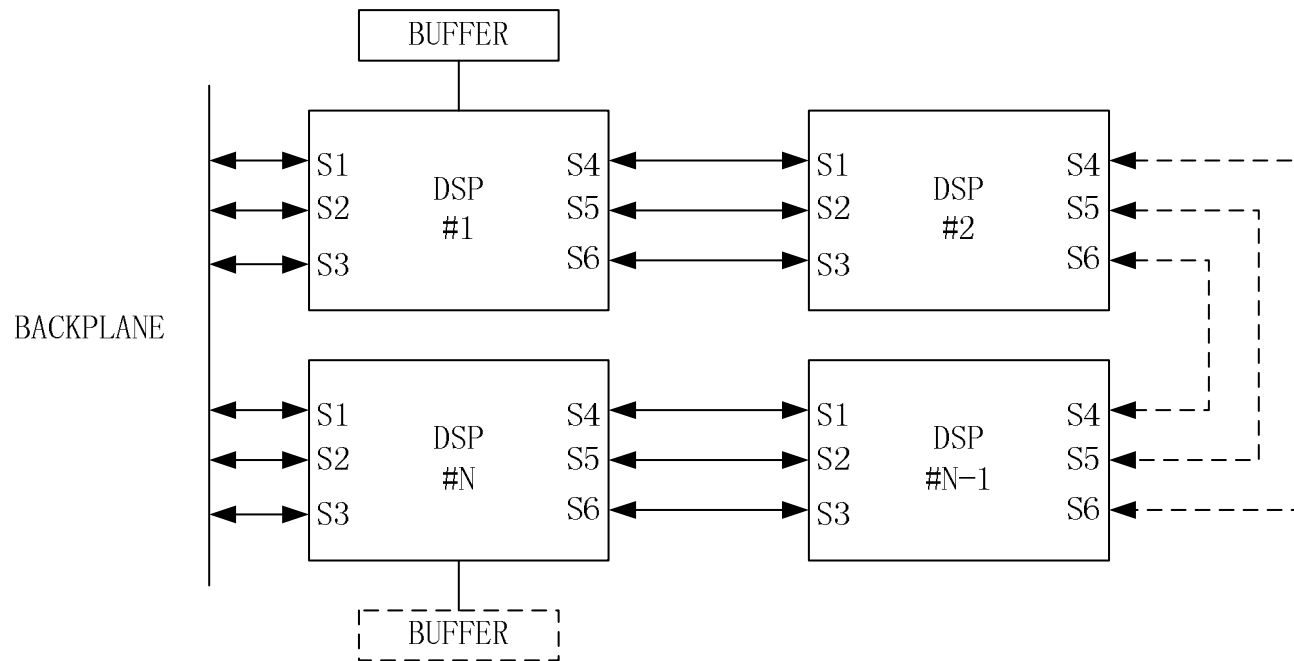
- OBSAI and CPRI Overview
- **AlF2 interconnection topology**
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# AIF: Daisy Chain Topology



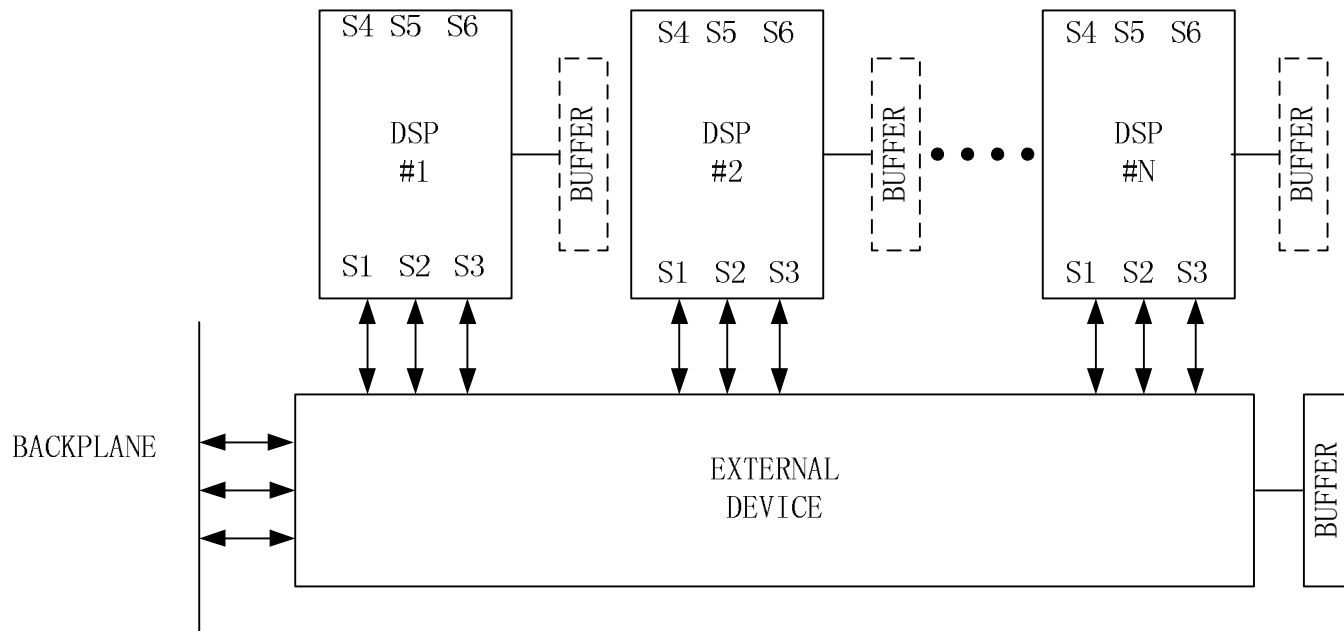
- **Antenna streams automatically forwarded by AIF hardware**
- **Delayed streams may be buffered in the memory of a DSP.**

# AIF: U-Daisy Chain Topology



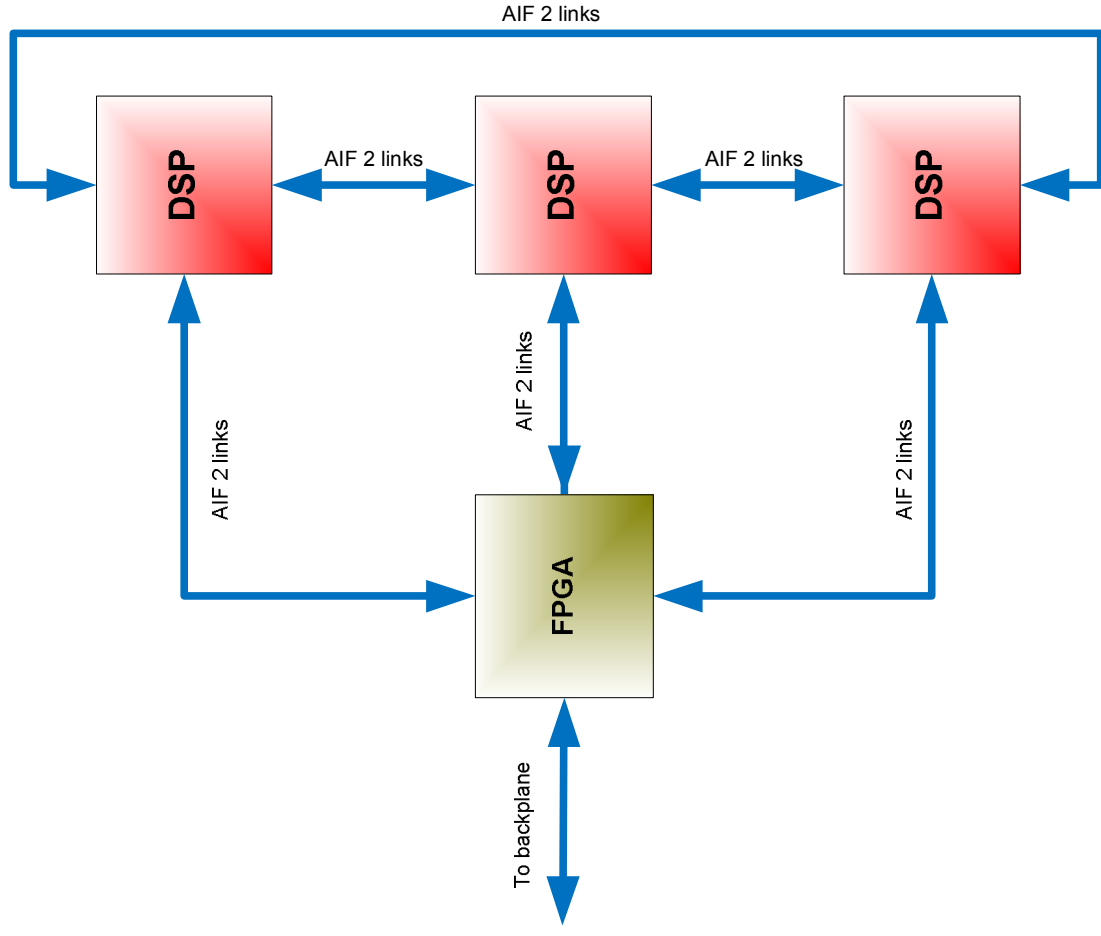
- Similar as “Daisy Chain” for redundant connections

# AIF: Star Topology



- **External device aggregates, formats data, drives the backplane**
- **Delayed streams: Faraday memory or external device memory**

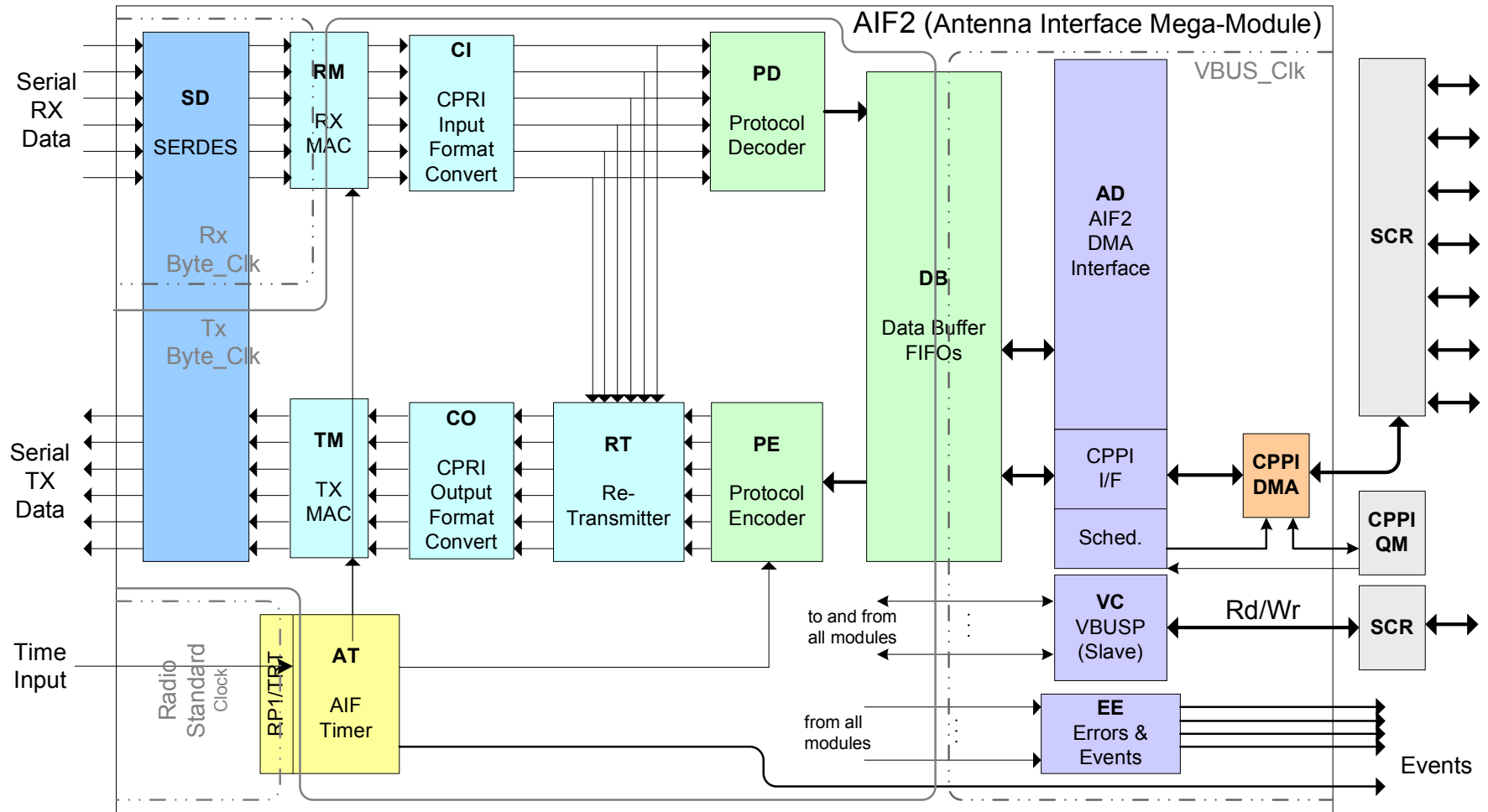
# AIF: a combined topology



# Agenda

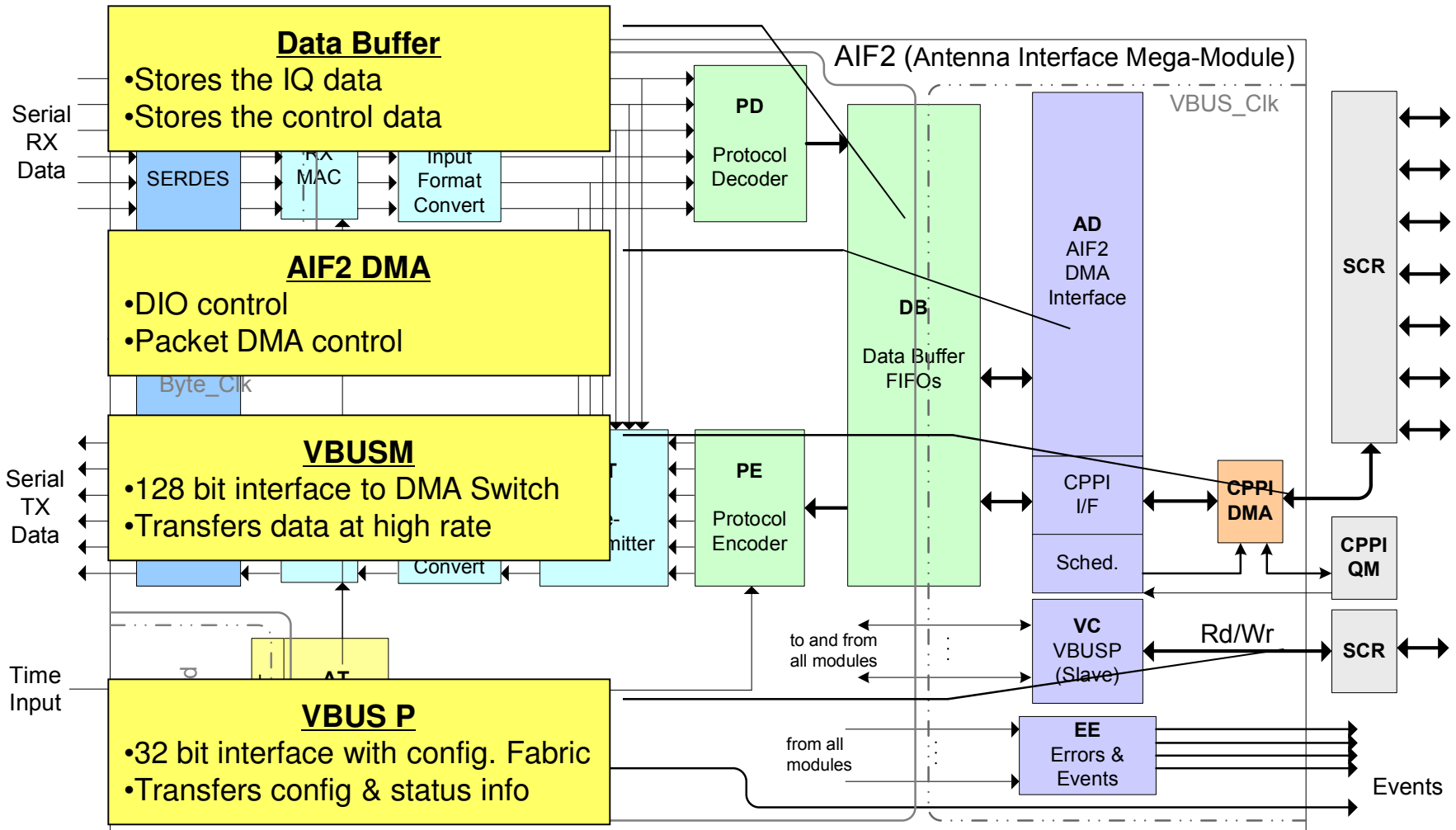
- OBSAI and CPRI Overview
- AIF2 interconnection topology
- **AIF2 block diagram and data flow overview**

# AIF2 Module Architecture

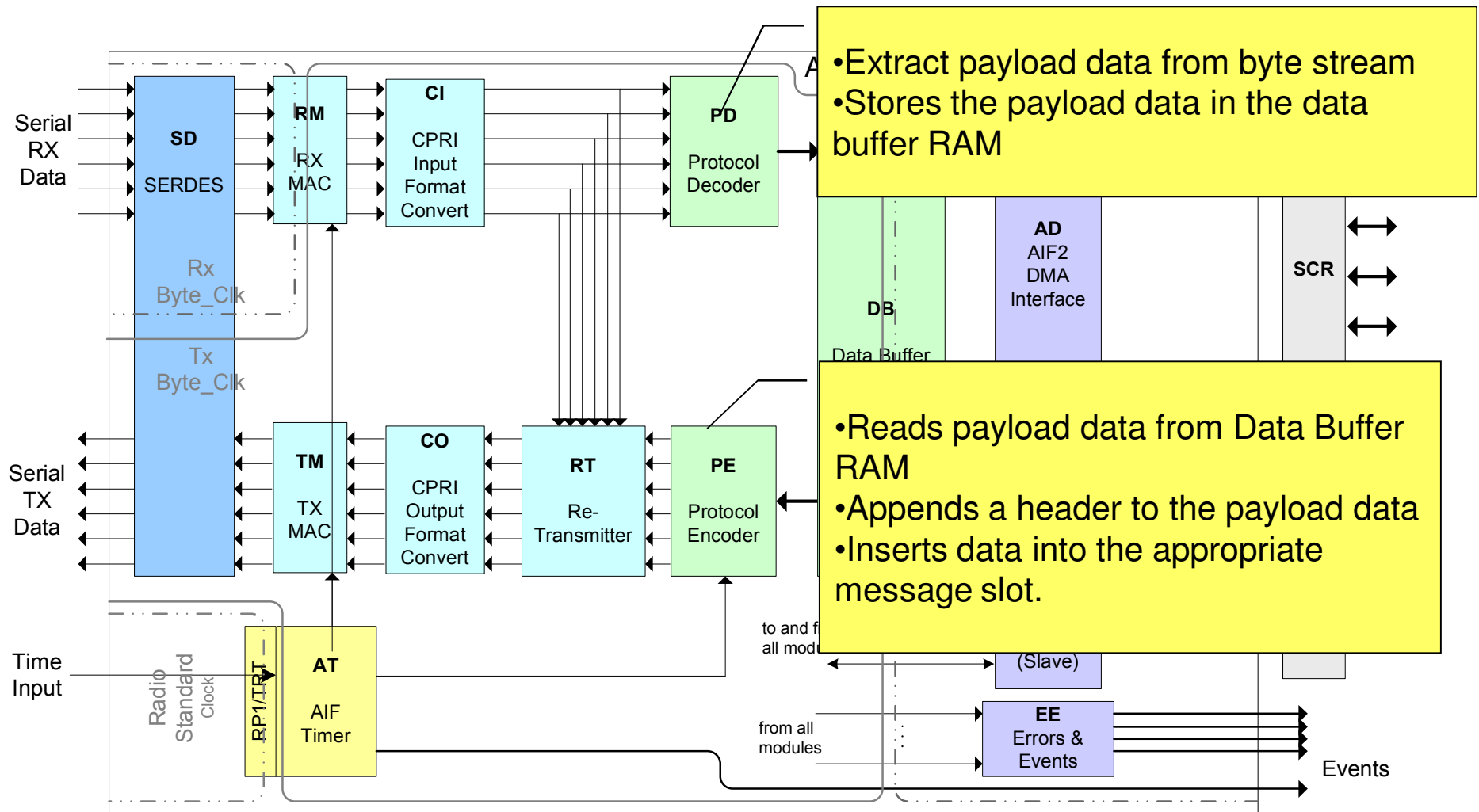


- **PHY layer {SD, RM, CI, RT, CO, TM, AT}**
- **Protocol layer {PD, PE}**
- **DMA layer {AD , DB, DMA}**

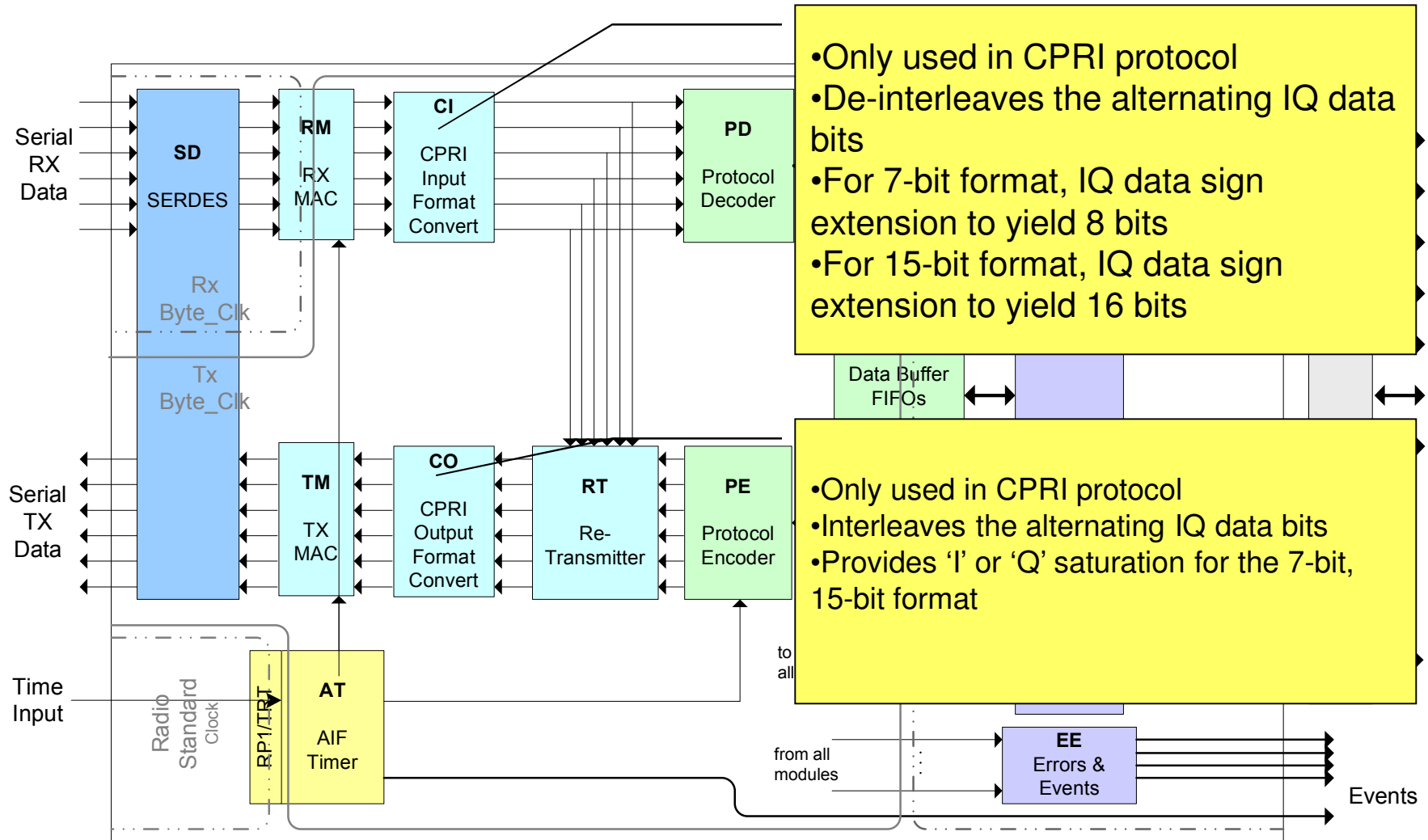
# AIF: Internal Interface Modules



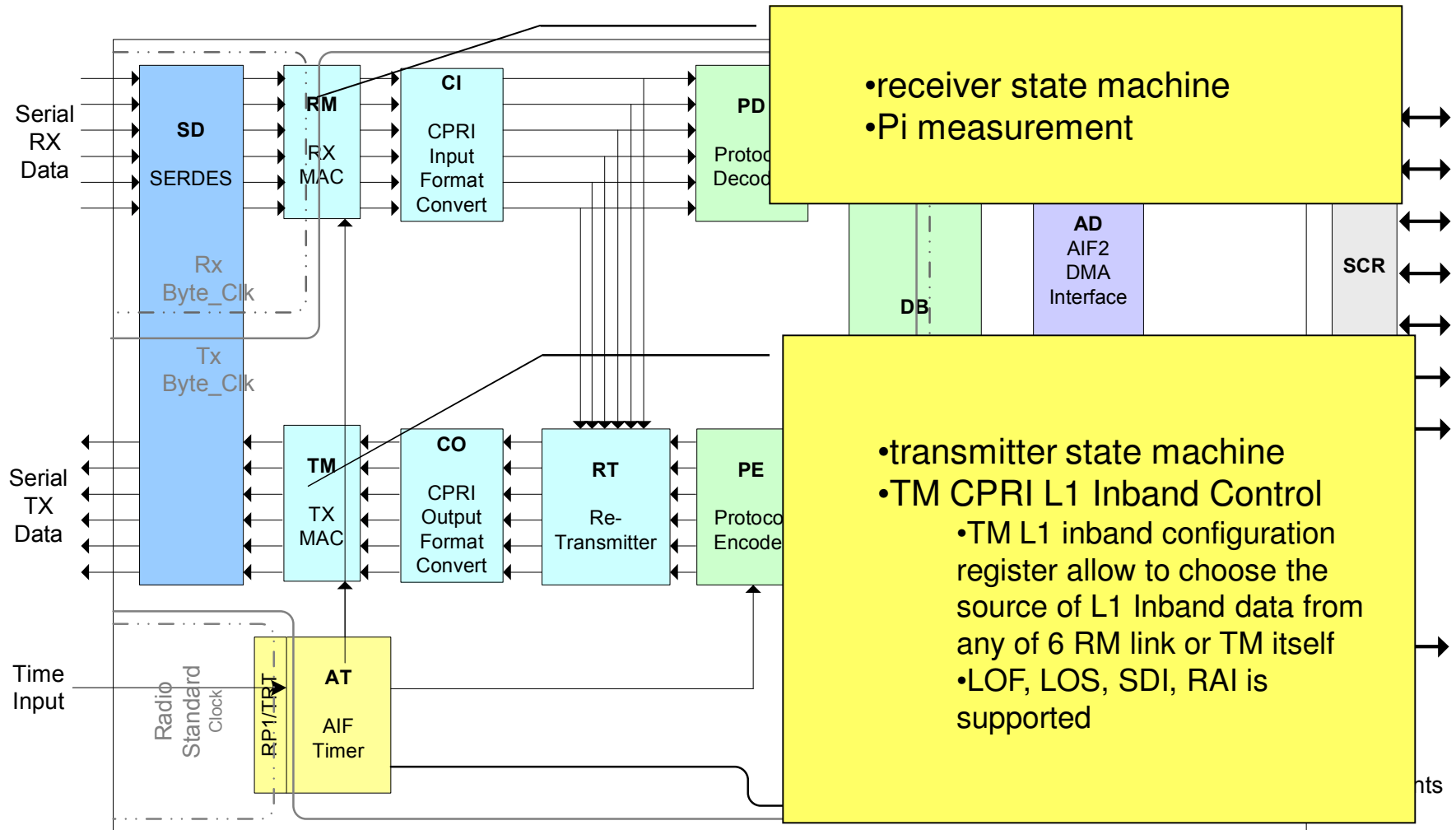
# AIF: Protocol Decoder/ Encoder



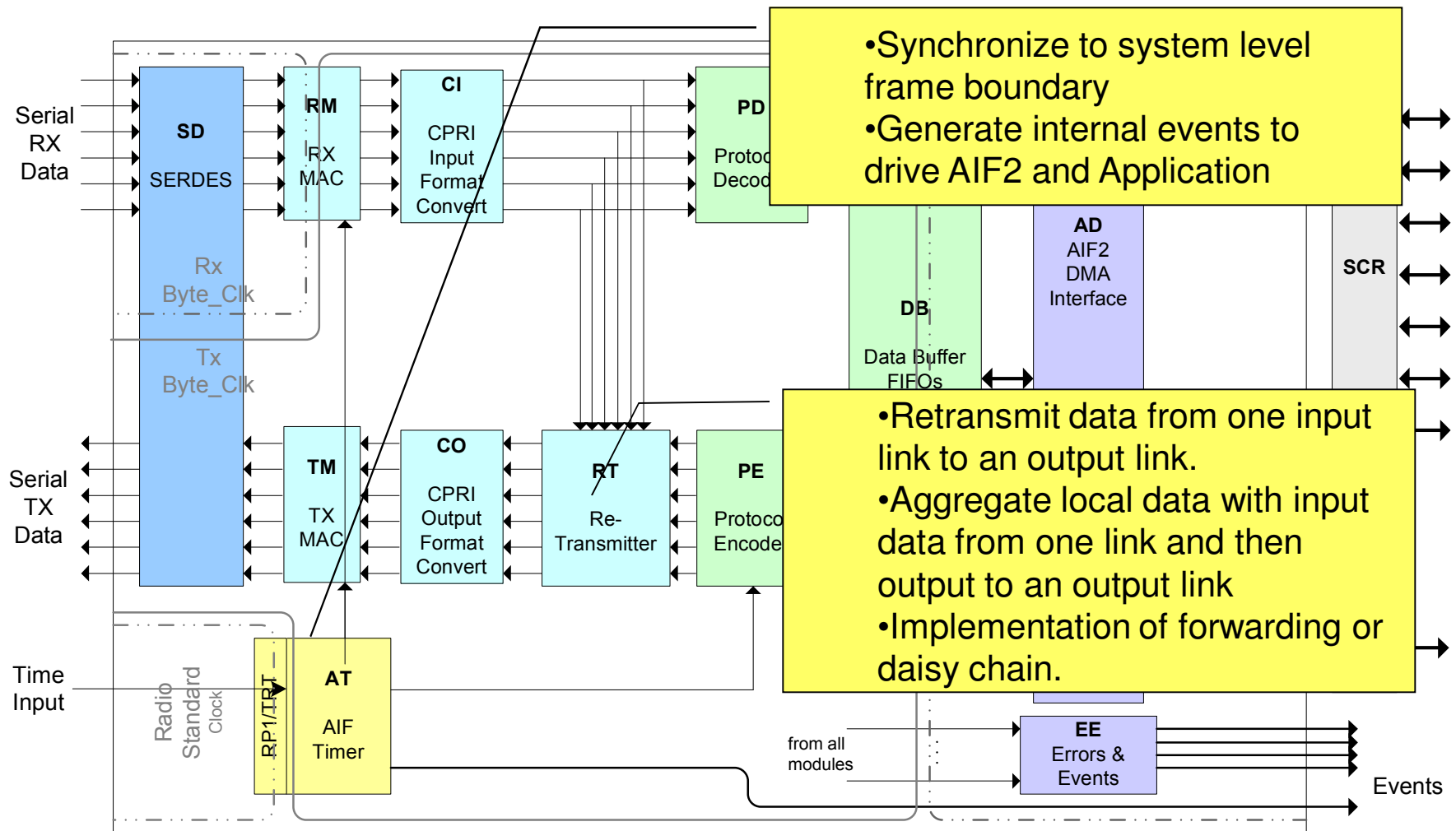
# AIF: CPRI Protocol Translators



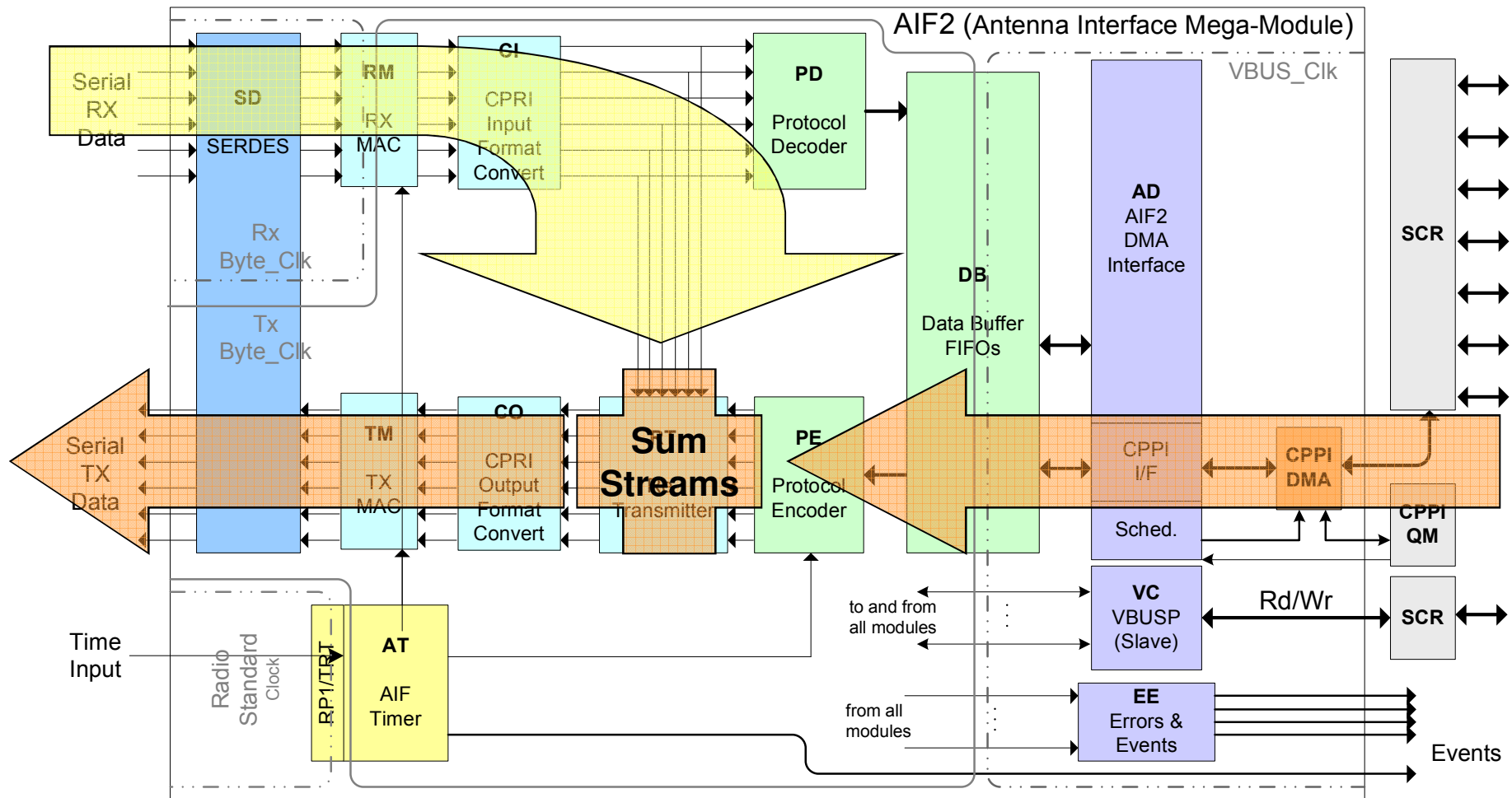
# AIF: RX/TX MACs



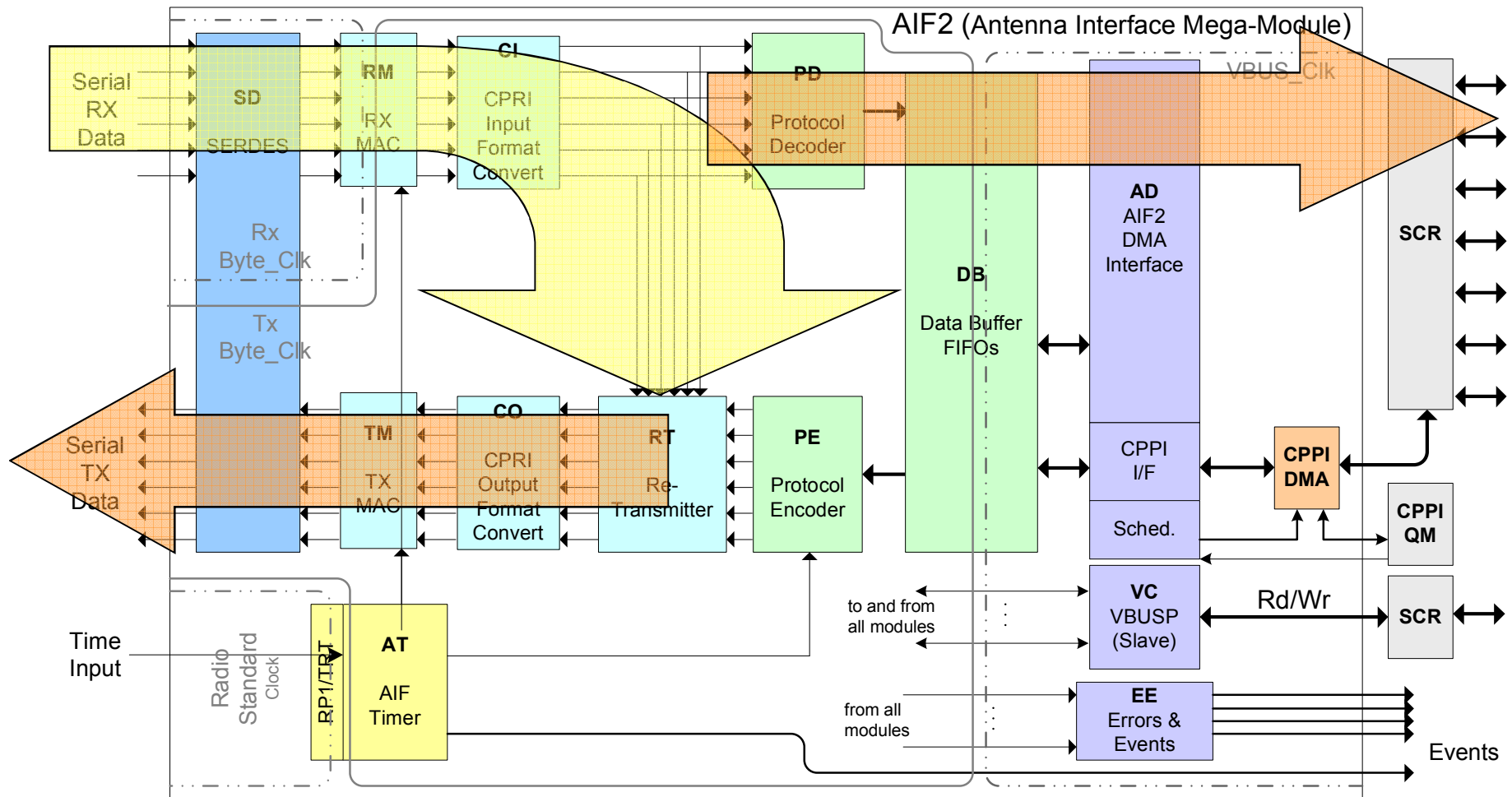
# AIF: AT and RT



# AIF: Daisy Chain Downlink Data Flow



# AIF: Daisy Chain Uplink Data Flow



# What modules need to be configured

- **Configure AT to generate events to drive other AIF2 modules and application.**
- **Configure PD, PE to allocate bandwidth between antenna streams, and split stream data into packets.**
- **Configure AD/DB to transfer data to/from DSP memory.**
- **CI, CO, RT, TM, RM, SD are relative simple for configuration.**

# Q&A

# Ten multiple choice questions from Part-1

**1. Choose all TRUE statements about the relationship or difference between CPRI and OBSAI:**

- A. CPRI and OBSAI can be supported at the same time, that is, we can have one AIF2 link transfer data with CPRI format and another link transfer data with OBSAI format.
- B. OBSAI offers more flexibility with the cost of more overhead; CPRI is simple from implementation's point of view
- C. OBSAI protocol is message based, CPRI protocol is TDM (Time Division Multiplex) based.
- D. Typical data width of CPRI format is 7 or 15 bits, while typical data width for OBSAI format is 8 or 16 bits.

**2. K28.5 identifies:**

- A. OBSAI master frame boundary
- B. CPRI Hyper frame boundary
- C. CPRI Basic frame boundary

**3. How many Hyper frames in one CPRI Radio Frame**

- A. 256
- B. 150
- C. 140
- D. 10

# Ten multiple choice questions from Part-1

**4. CPRI 8x link rate is**

- A. 2.4576 Gbps
- B. 3.072 Gbps
- C. 4.9152 Gbps
- D. 6.144 Gbps

**5. The sample rate of WCDMA antenna stream is:**

- A. 3 times of TD-SCDMA
- B. Same as 3MHz LTE
- C. Same as 5MHz LTE

**6. CPRI 4x link can carry:**

- A. 4 LTE 20MHz antenna streams
- B. 2 LTE 20MHz antenna streams
- C. 2 LTE 15MHz antenna streams
- D. 16 WCDMA antenna streams

# Ten multiple choice questions from Part-1

7. **DBM (Dual Bit Map) is really necessary for what Radio standards?**
- A. GSM
  - B. WCDMA
  - C. LTE 15MHz
  - D. LTE 20MHz
8. **How many links are implemented with AIF2**
- A. 2
  - B. 4
  - C. 6
9. **Choose the TRUE statement about the CPRI implementation in AIF2:**
- A. Ethernet based fast C&M and HDLC based slow C&M are supported by AIF2 CPRI mode.
  - B. CPRI Protocol negotiation is not supported by AIF2.
10. **Choose all TRUE statements about the functions of AIF2 modules:**
- A. AT is the heart drives the whole AIF2
  - B. PD, PE allocate bandwidth between antenna streams, and split stream data into packets.
  - C. AD, DB transfer data to/from DSP memory
  - D. CI, CO are used for both CPRI and OBSAI.
  - E. RT is the key module implement the daisy chain or forwarding feature of AIF2