Data Path vs Control Path for Timing of Radio Data

Richard Tse, Microsemi
Jouni Korhonen, Broadcom
Bomin Li, Comcores

April 25-27, 2016

History from 2/16 Plenary

- Definition of a data packet type with both seqnum and timestamp was rejected
  - This packet type supports radio timescales (e.g. CPRI frequency) that are different from the Ethernet network timescale (e.g. IEEE 1588)
  - Use of more pkt_types was not desired
- A control packet sub-type was defined with both seqnum and timestamp
  - This control packet also periodically provides the relationship between the radio timescale and the Ethernet network timescale using seqnum and timestamp

Goals of this Presentation

- Show the operation of the data path and the control path options
- List the benefits and the issues of the two options
- Confirm the use of the control path option or switch to the data path option

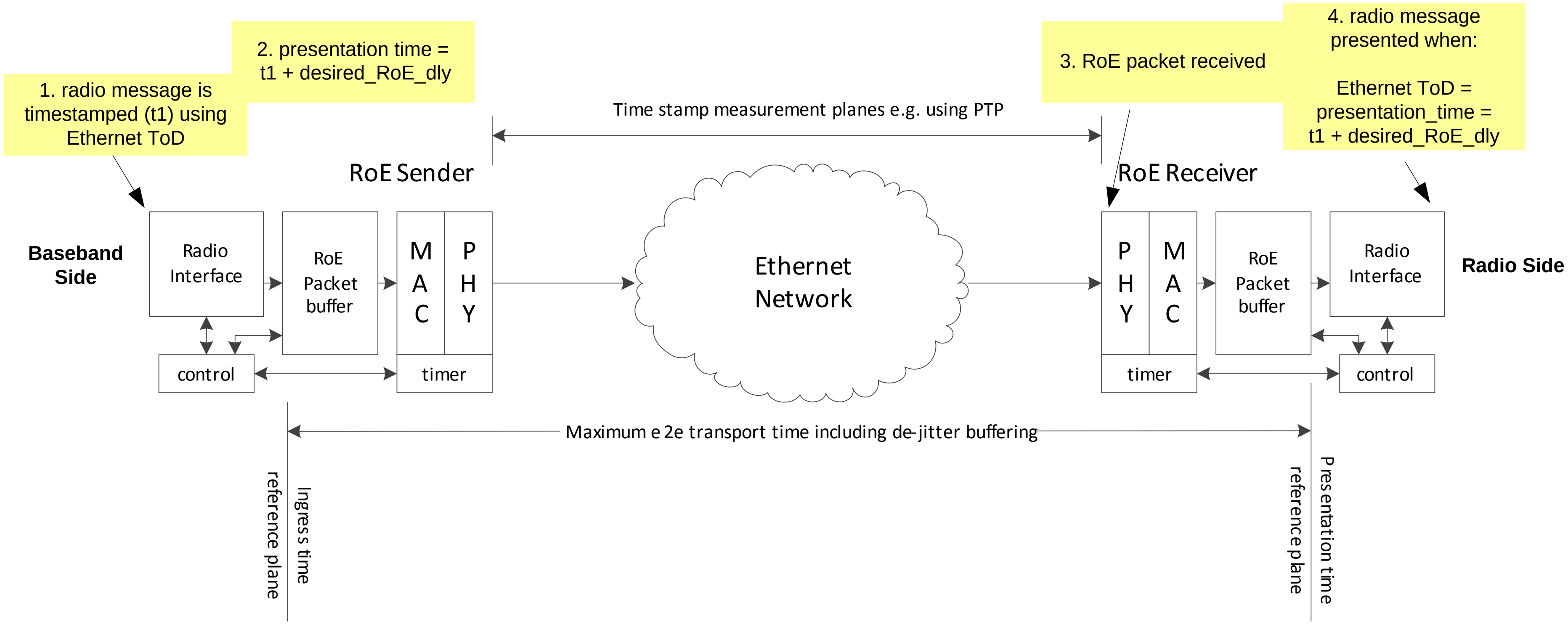
Definition

- Timescale:
  - A linear measure of time (e.g. the definition of 1 second)
  - Domains with different timescales have "1 second intervals" that are different from each other. For example:
    - 1s in domain A's timescale = 1s + 1ns in domain B's timescale

Example 1: Data Path Option

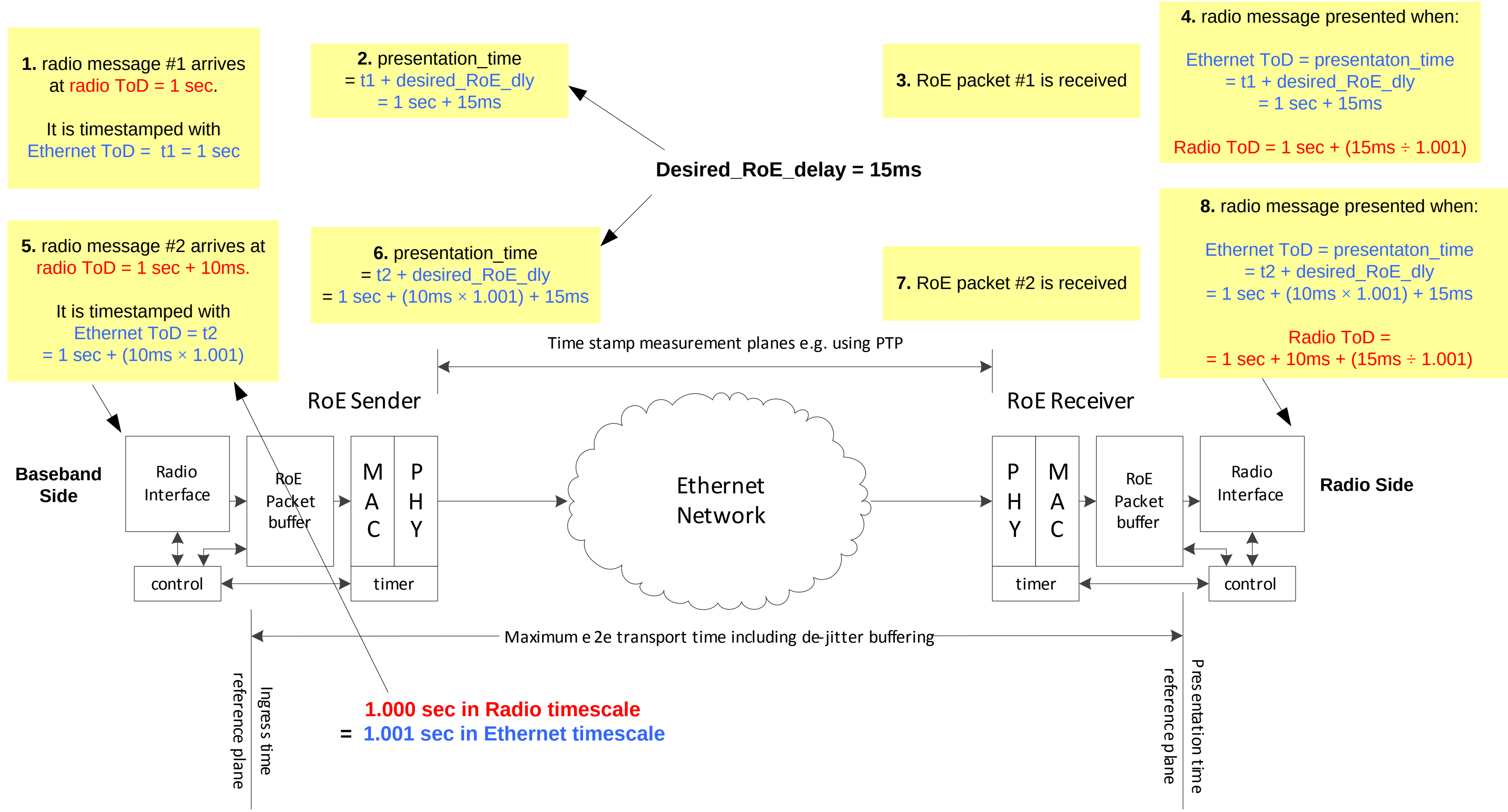
- Data path packets all have timestamps
  - For simplicity, timestamp field is not limited to 999,999,999.75ns in this example
  - Seqnum is used only for reordering or detection of missing packets
- Desired RoE network delay is set to 15ms
- The radio and the Ethernet network (PTP) have different timescales
  - 1.000 sec for the radio = 1.001 sec for PTP
  - This timescale offset is HUGE and is used for example purposes only
- Radio timescale values are shown in red
- Ethernet timescale values are shown in blue

Reminder: Basics of Data Path Timestamping



- All timestamping is done in the domain of the Ethernet timescale (PTP, for this example)

Example 1: Data Path Timestamping with Frequency Transparency



- The radio's timescale is preserved at destination
- The difference in timescales only affects the network delay
  - Network delay and timescale offsets are expected to be small so net error is small (e.g. 200µs x 50ppb = 0.01ns)

Benefits: Data Path Option

- Presentation time generation is easy
  - Just add the desired network delay to the timestamp
- Presentation time usage is easy
  - Just wait for the Ethernet ToD to equal the presentation time
- Radio client frequency preservation is easy
  - Radio client frequency is naturally preserved if its data is presented at the specified presentation time
- Effect of different radio and Ethernet timescales is negligible
  - Very small effect on the overall delay of every packet
- If timestamps are on every packet, seqnum function is simplified
  - Just used for reordering and missing packet detection

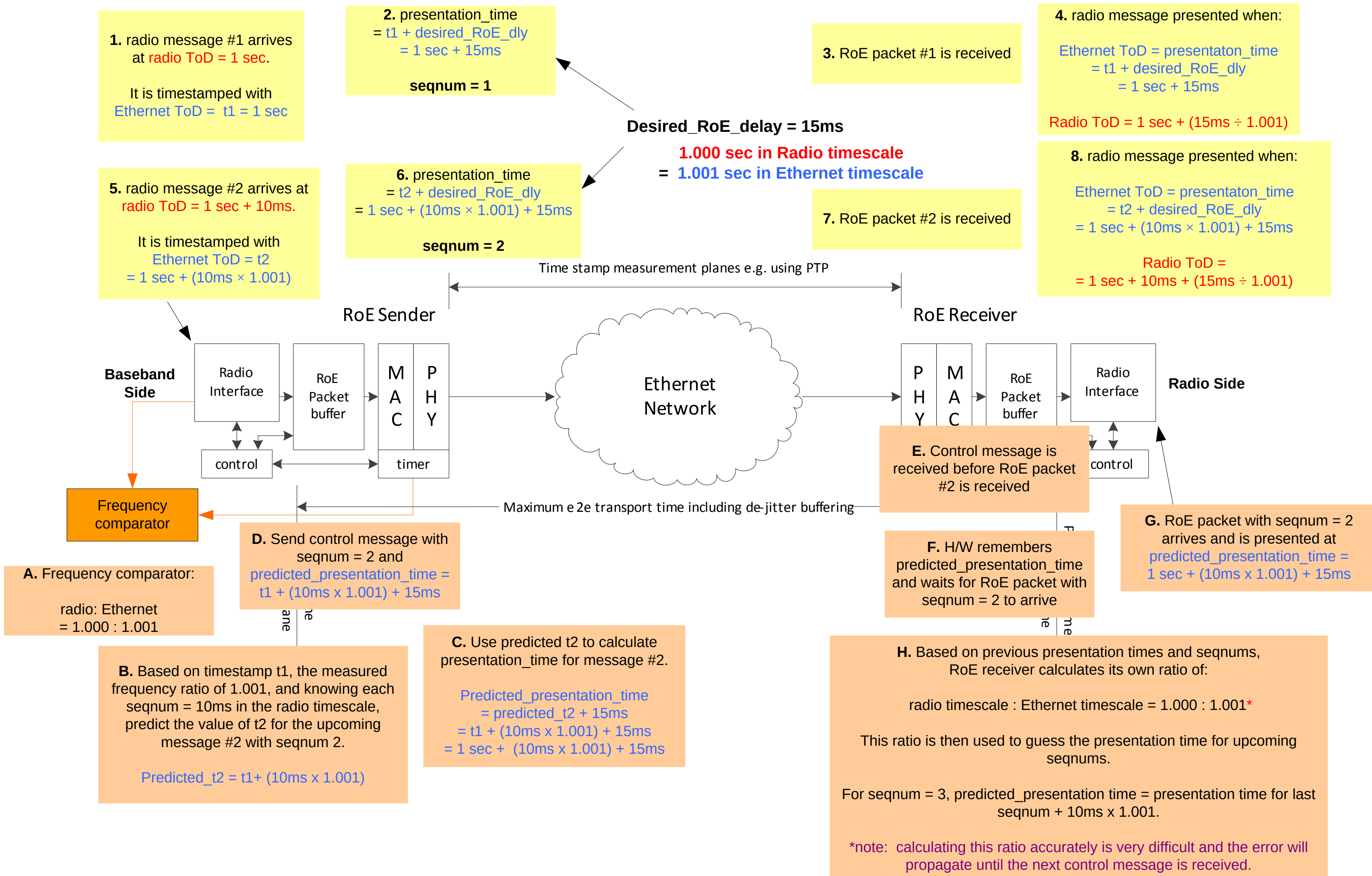
Issues: Data Path Option

- More pkt_types are consumed if we have packets with just the seqnum and packets with both seqnum and timestamp
- Bandwidth efficiency is reduced if seqnum and timestamp both exist on *every* data packet

Example 2: Control Path

- Control packets are used to communicate relationship between timestamp and seqnum
  - Simple incrementing seqnum is used for this example, where each increment is equivalent to 10ms of radio time
  - For simplicity, timestamp field is not limited to 999,999,999.75ns in this example
- Desired RoE network delay is set to 15ms
- The radio and the Ethernet network (PTP) have different timescales
  - 1.000 sec for the radio = 1.001 sec for PTP
  - This timescale offset is HUGE and is used for example purposes only
- For reference and for comparison purposes, the data path timestamp operations from last the example are shown again
- Radio timescale values are shown in red
- Ethernet timescale values are shown in blue

Example 2: Control Path with Frequency Transparency



Benefits: Control Path Option

- No additional pkt_type is used
- Bandwidth usage should be less

- Is there a less complicated way to do this with control packets?

Issues: Control Path Option

- More control packet bandwidth is required
- Control S/W must be tightly integrated with the data path
- Prediction of future events or processing of past events is required
  - Floating point math is necessary to maintain accuracy
  - Accurate prediction is difficult and the error grows linearly with:
    - the time between control packets
    - the time between the prediction and the actual event
  - Delay from post-processing of timing events may degrade timing performance
  - IEEE 1914.1 mechanisms will not produce continuous radio data, thus prediction of future events and processing of past events are not possible

Issues: Control Path Option

- Low latency and low delay variance is required for control packets
  - Control packets must get to the destination *and* be processed before the corresponding data message arrives
    - Network latency must be small
    - Processing delay must be small

    OR
  - If post-processing is done, control packets must at least arrive regularly so the clock regeneration PLL can get regular updates

Conclusions and Proposals

- **Conclusion:**
  - Data Path option has better performance, a simpler implementation, and fewer system restrictions
  - Control Path model is already complicated with many caveats. This will lead to a difficult implementation.

- **Proposals:**
  - Use the data path instead of the control path for these timing operations
  - Define a pkt_type with both timestamp and seqnum