Overcoming Challenges in Functional Verification of Automotive Traffic Schedulers

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1 Automotive Traffic Schedulers

The automotive industry is going through disruptive transformations owing to recent trends in comfort, connectivity, autonomous driving, security, and infotainment

The transition from legacy domain-based to zonal architectures consolidates several cross-domain **Electronic Control Unit(ECU)** functions in a car that is now networked through a backbone consisting of Ethernet switches.

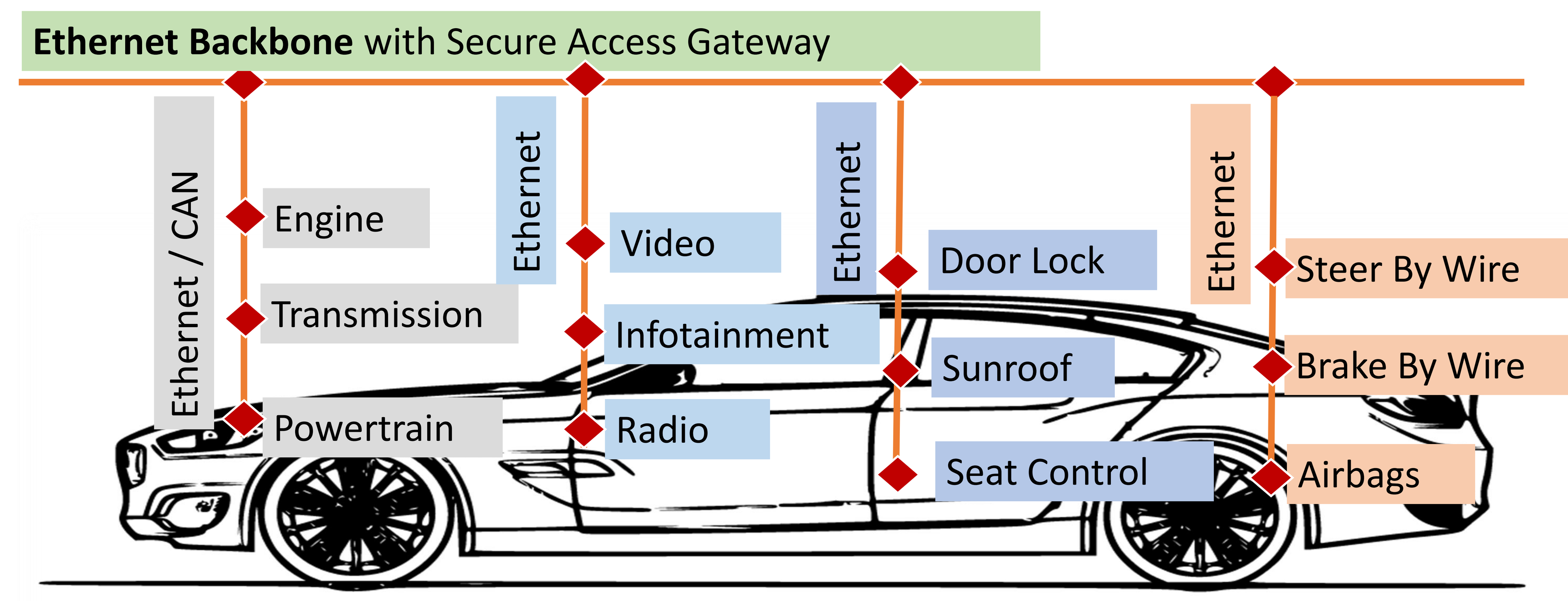
It has opened ways to move from multi-technology protocols **LIN**, **CAN**, **FlexRay**, and **MOST** to single-wiring technology for networking in a car. Consequently, new algorithms like **CBS**, **TAS**, and **ATS** have come up to schedule and shape traffic in a connected car to handle the Quality-of-Service (**QoS**) requirements of various traffic classes.

Checking the functional correctness of the new category of traffic schedulers is an entirely new verification challenge

We chose **Credit Based Shaper** (**CBS**) as a case study to resolve challenges faced in the Functional Verification of Traffic Schedulers and Shapers.

2 Automotive Ethernet

This depicts the present architecture of an An automotive vehicle with ethernet for different operations of a car.



3 Verification Challenges

New entrant due to shift to Automotive Ethernet as IVN Technology for cars
- No pre-defined flow for end-to-end validation of the scheduled traffic meeting rate constraints.

Network latencies
- To reduce end to end latency

Non availability of any Golden reference
- New and complex due to its verification challenges.

Nature of Traffic Schedulers
- Traffic categorized in Classes is scheduled over multiple queues with priority levels, allocated bandwidth as attributes.

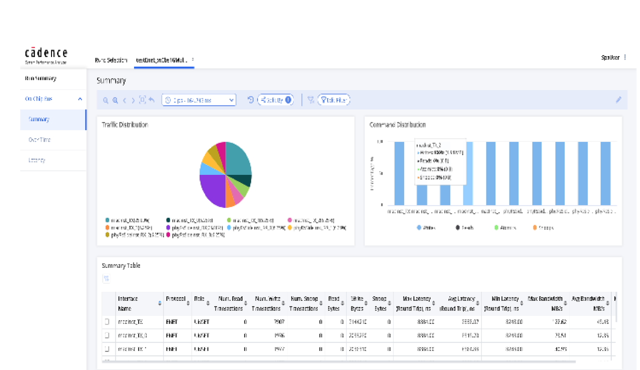
Computation Challenges
- Complex mathematical calculations for various parameters like bandwidth-over-time, credit values over time, cumulative bandwidth.

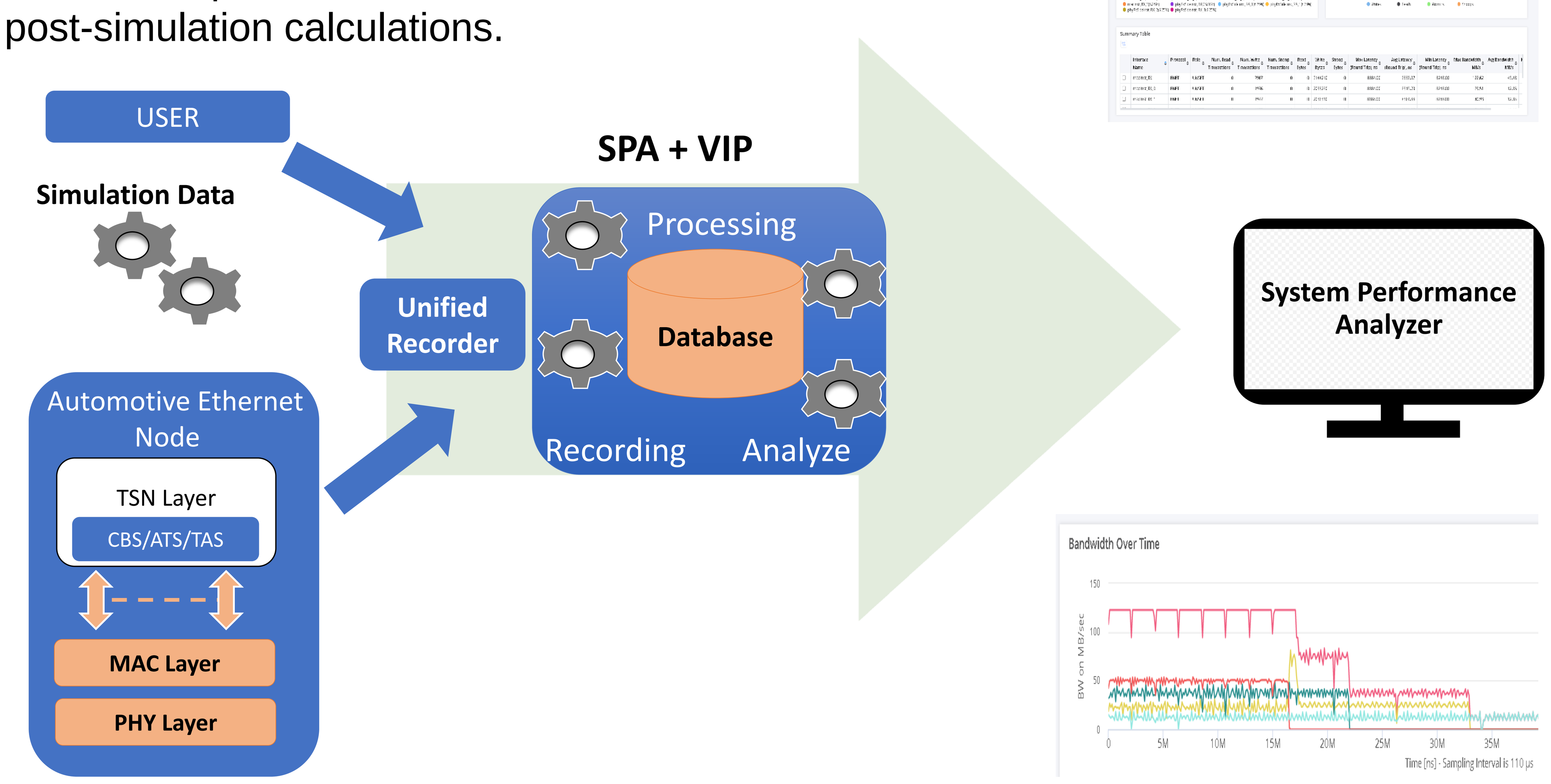
4 Overcoming Challenges

- ❑ Matching Rx with Tx
  - ❑ Measure, categorize, analyze
  - ❑ Add tags on Tx for categorization
  - ❑ Algo implementation to tally algo-specific parameters
- ❑ Cadence Proprietary **Unified Recorder (UR)** Integration
  - ❑ Record all parameters of interest
    - ❑ Start time, End time per transaction
    - ❑ Key Fields of interest in transactions
    - ❑ Algo-specific parameters
- ❑ **System Performance Analyzer(SPA)** Computation and Analysis
  - ❑ Mathematical calculations
  - ❑ Plotting of graphs and charts
  - ❑ Performance analysis in terms of bandwidth utilization, latencies

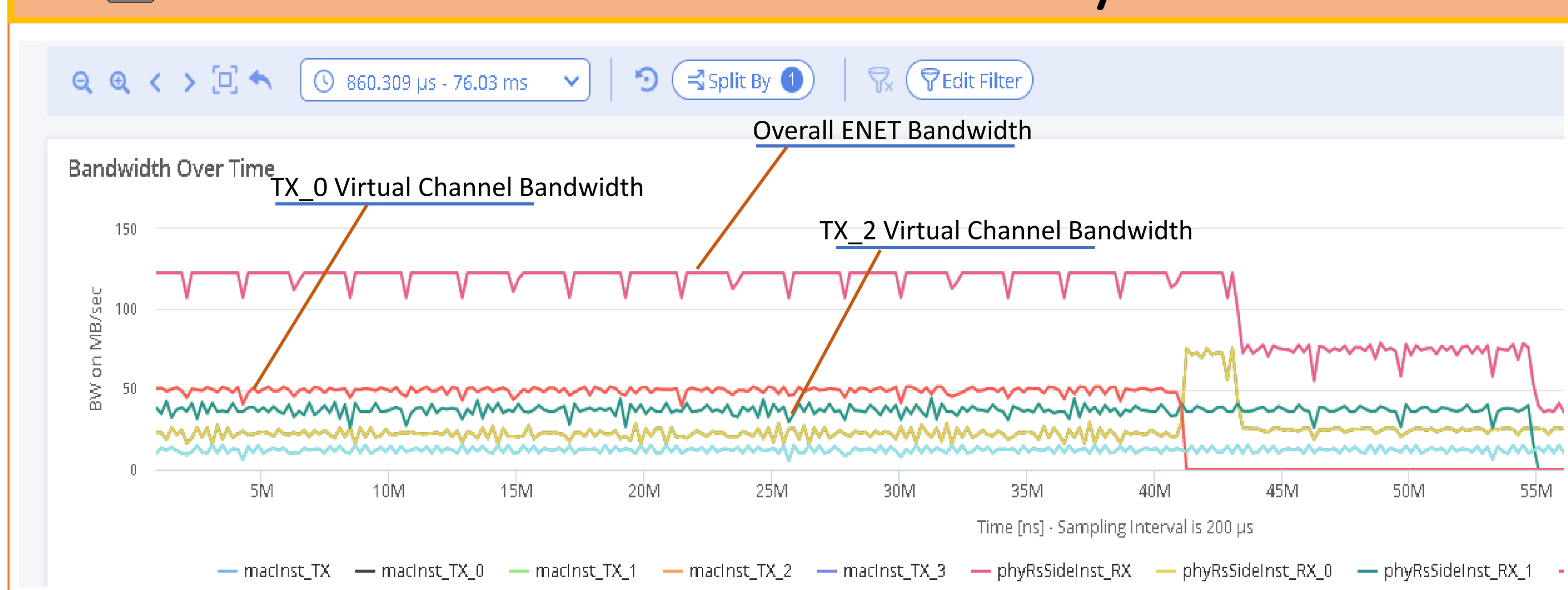
5 Set-Up And Flow

As illustrated, ethernet VIP and design are connected, and all the simulation data is sent to Cadence's proprietary **UR**, which communicates with the **SPA**, data is dumped on the server, and it will be used for post-simulation calculations.





6 Result And Summary



Summary:

- ➢ Bandwidth over time represents the different bandwidths of the queues with the overall bandwidth for computation.
- ➢ **VIP integrated with UR and SPA**
  - ❑ End-to-end functional verification solution for Traffic Schedulers
  - ❑ VIP Capabilities like stimulus generation, protocol checkers, etc.
  - ❑ Graphical visualization and analysis of QoS parameters like Bandwidth, Latency, Credits, Cumulative and per Queue and Instance-based
  - ❑ Usable at IP and SOC verification
  - ❑ Relevant for other traffic scheduler Algorithms