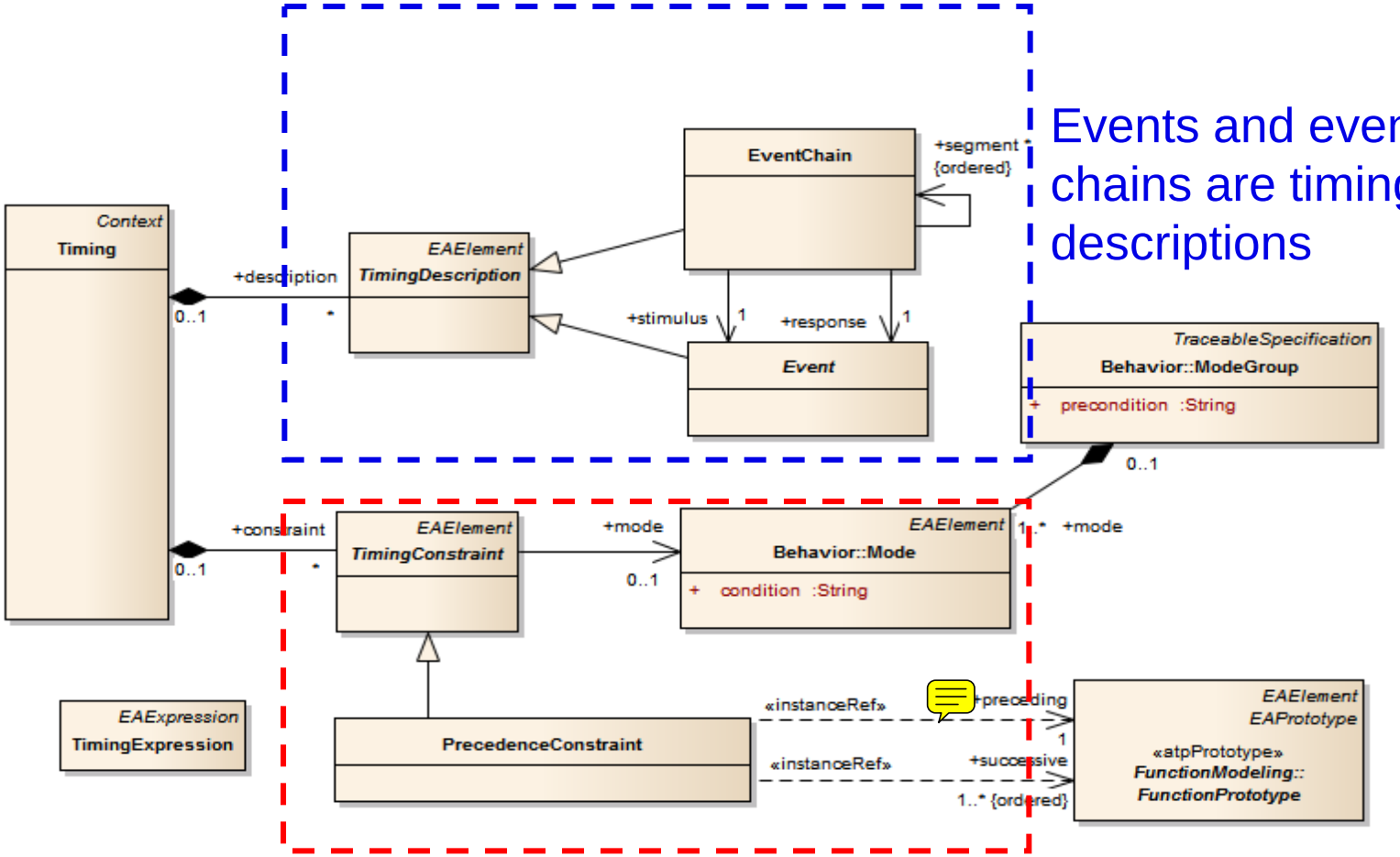
EAST-ADL support for timing

Outline, EAST-ADL support for Timing

Timing concepts are based on TIMMO2Use project results (Timing Augmented Modelling Language, version 2, TADL2)

- Timing concepts are reviewed here, essentially
  - Events
    Related to EAST-ADL and AUTOSAR structural entities
  - Event Chains
    Binds together events to establish sequences/relations between events
  - Constraints
    Puts temporal constraints on sets of events or on event chains

Meta-model overview



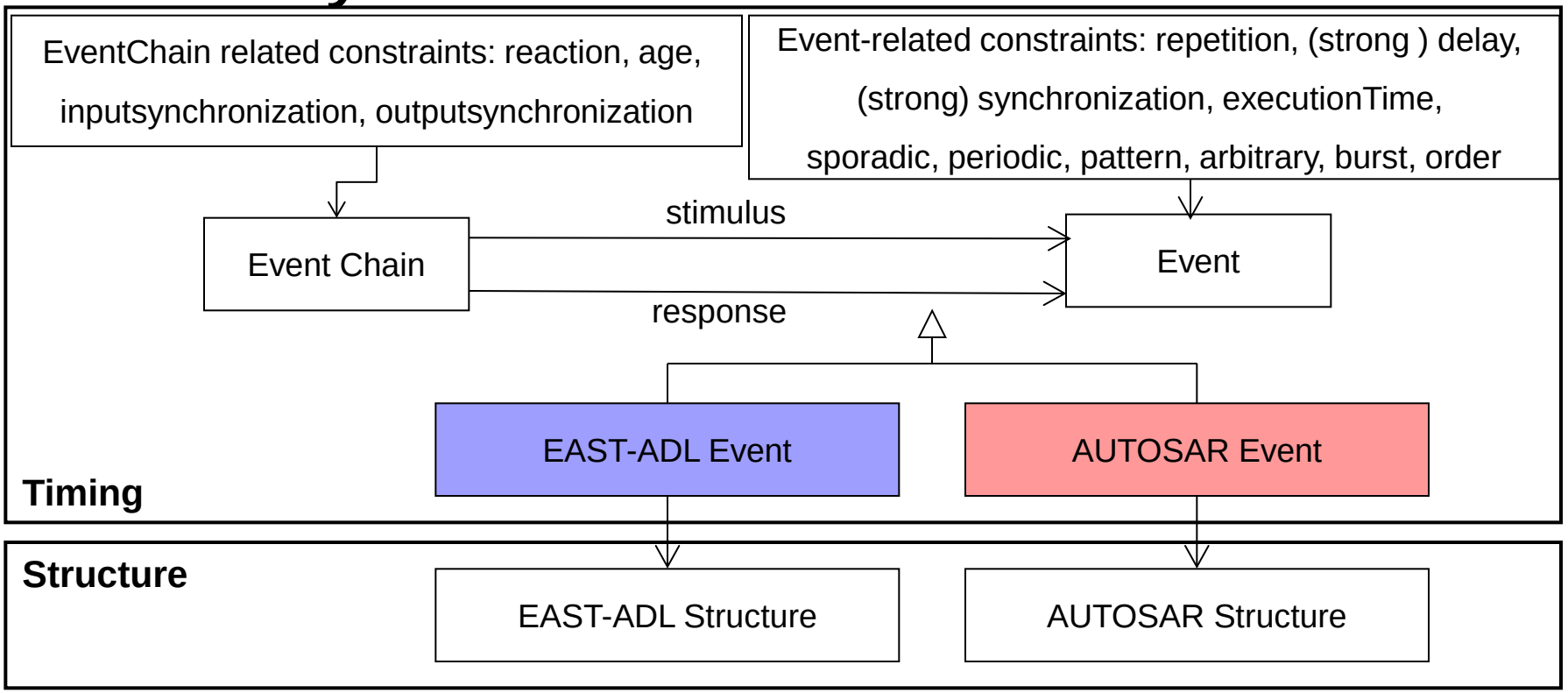
Events and event chains are timing descriptions

Timing constraints, imposed on events and event chains. The timing constraint is only valid when the specified mode is active

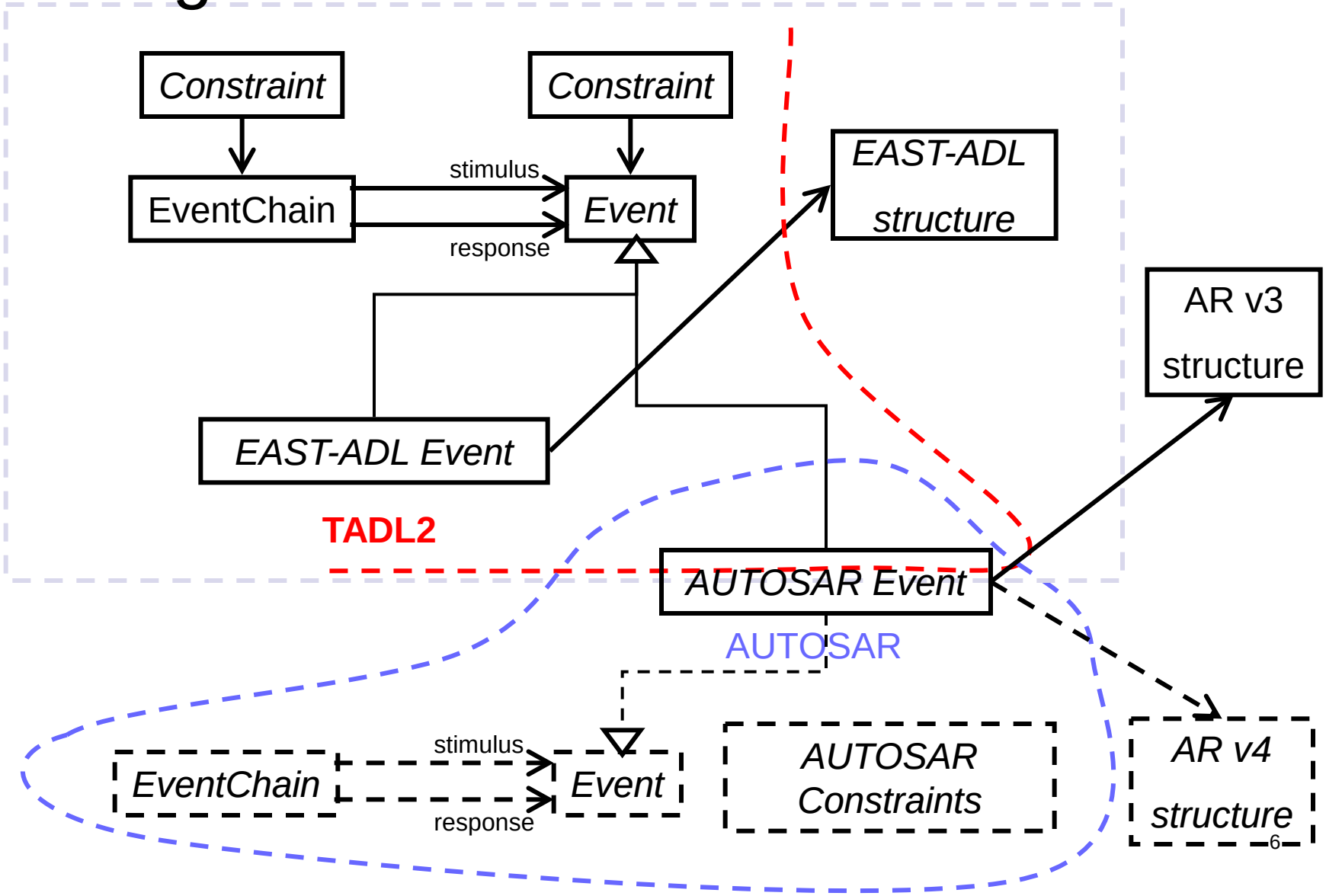
Timing Information

- **Timing Descriptions**
  - Event
  - Event Chain
- **Timing Constraints**
  - Event-chain related constraints – Requirements/constraints imposed on event chains
    - Age Constraint
    - Reaction Constraint
    - Input and Output Synchronization Constraint
  - Event related constraints
    - Requirements/constraints imposed on one event
      - Periodic Constraint
      - Sporadic Constraint
      - Pattern Constraint
      - Arbitrary Constraint
    - Requirement/constraint imposed on two events or more
      - Delay Constraint and Strong Delay Constraint
      - Synchronization Constraint and Strong Synchronization constraint
      - ExecutionTimeConstraint

Basic Syntax

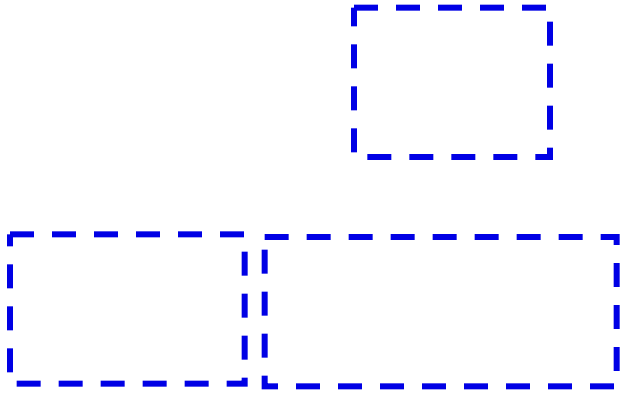


Timing in EAST-ADL and AUTOSAR



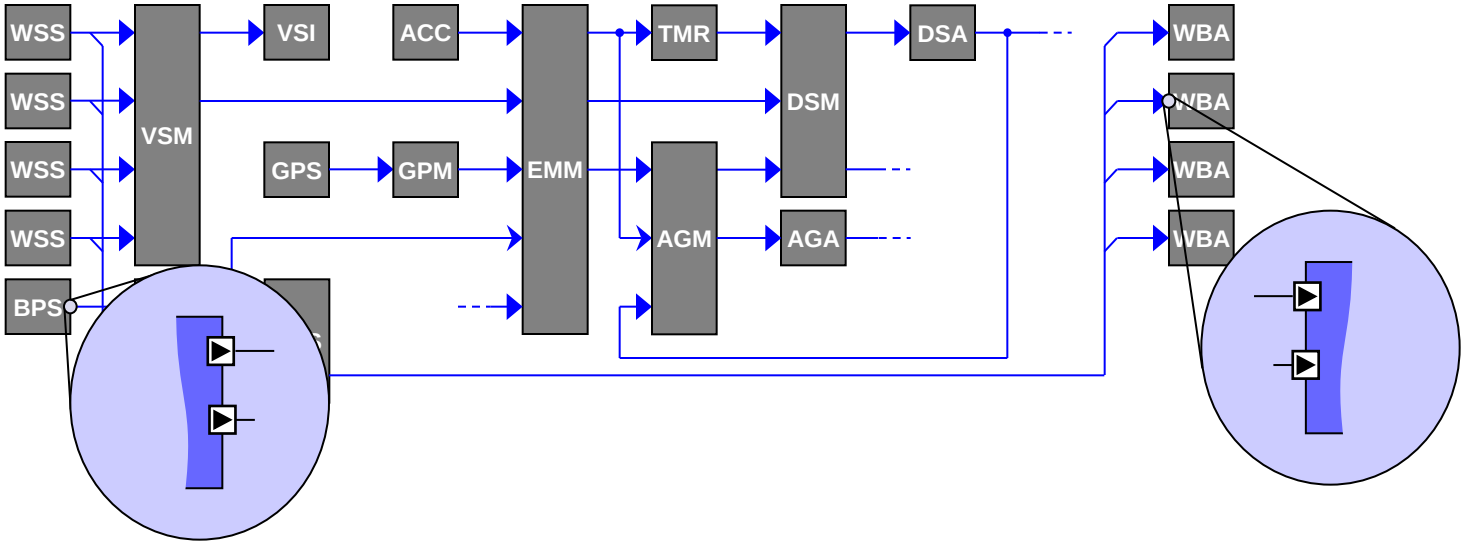
EAST-ADL Events – Functional modelling

- EventFunctionFlowPort
  - Data received or sent on port
- EventClientServerPort
  - Client request or server response sent on port
  - Client response or server request received on port
- EventFunction
  - Function instance triggered
  - Function type triggered



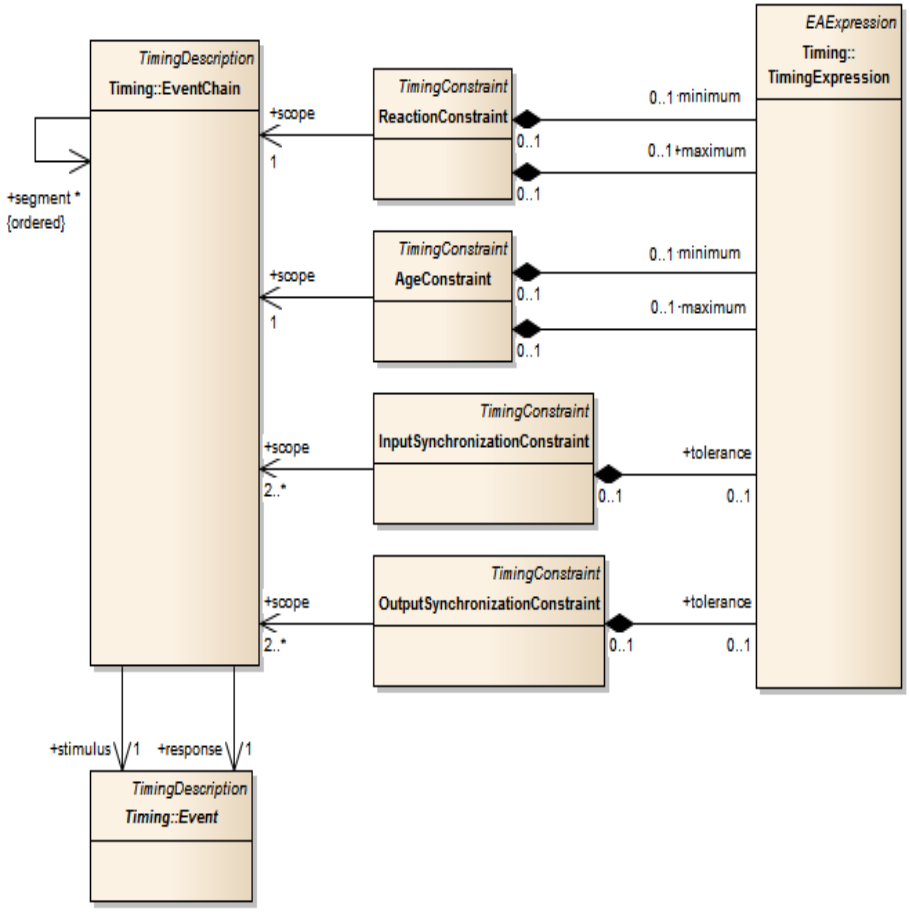
Event Chain

- Relates events with each other
- Establishes a causality between events: stimulus and response
- Can be broken into further Event Chain Segments (decomposition)
- Can be composed by existing Event Chain Segments (composition)



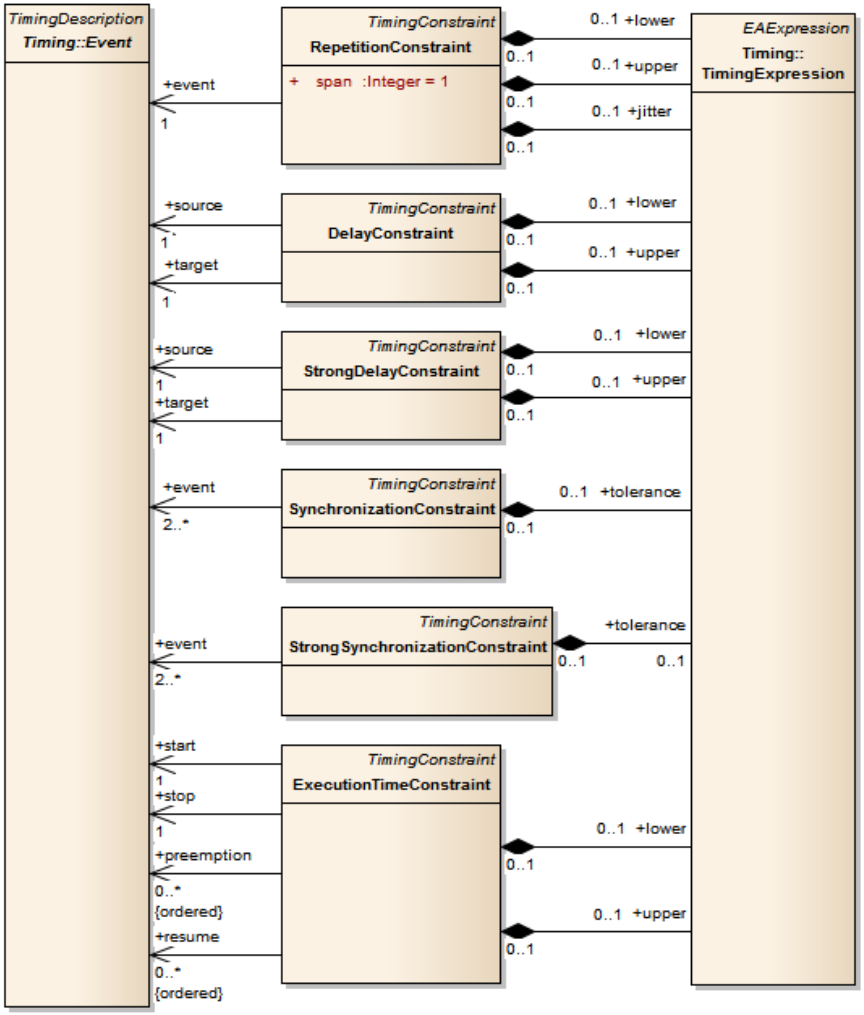
Event-chain related constraints

- Reaction constraint: defines how long after the occurrence of a stimulus a corresponding response must occur. Perspective is from the stimulus event forward
- Age constraint: defines how long before each response a corresponding stimulus must have occurred. Perspective is from the response event backward
- Input Synchronization constraint: defines how far apart the stimuli that corresponds a certain response may occur.
- Output Synchronization constraint: defines how far apart the responses that belong to a certain stimulus may occur.



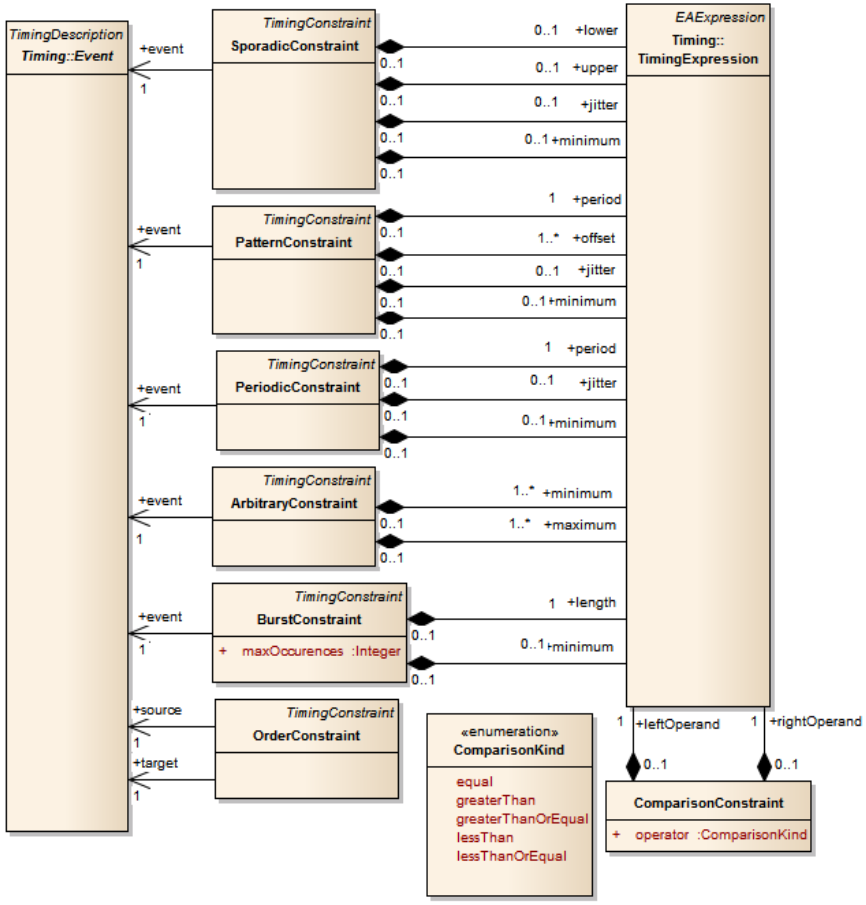
Event-related constraints (1/2)

- Repetition constraint describes the distribution of the occurrences of a single event, including the allowance for jitter (deviation from the ideal repetitive pattern).
- Delay constraint imposes limits between the occurrences of an event called source and an event called target.
- A strong delay constraint imposes limits between each indexed occurrence of an event called source and the identically indexed occurrence of an event called target. The strong delay notion requires source and target occurrences to appear in lock-step.
- Synchronization constraint describes how tightly the occurrences of a group of events follow each other.
- Strong synchronization for lock-steps
- An execution time constraint limits the time between the starting and stopping of an executable entity (function), not counting the intervals when the execution of such an executable entity (function) has been interrupted.



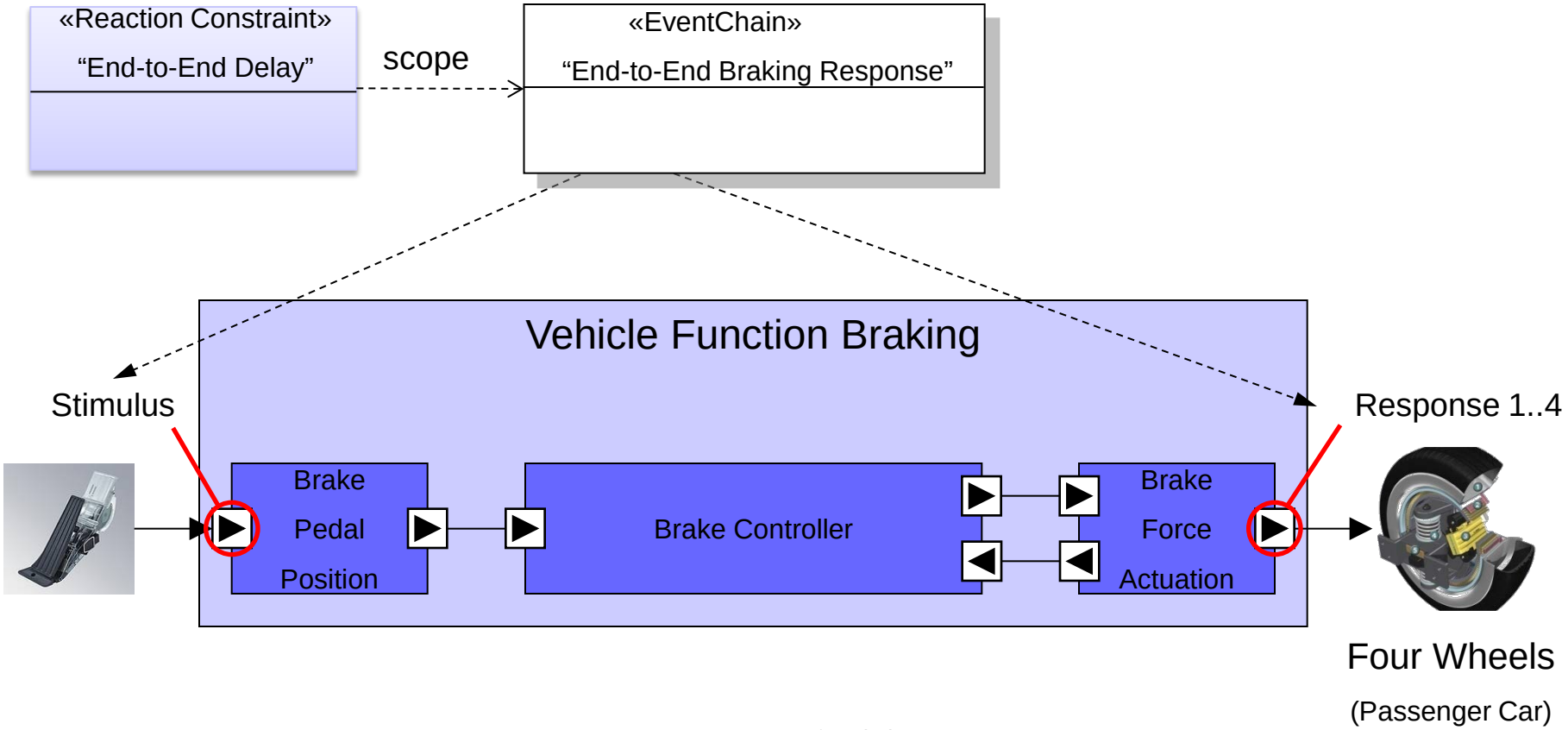
Event-related constraints (2/2)

- A sporadic constraint describes an event that occurs sporadically. The effective minimum distance between any two occurrences must be at least the value given by minimum attribute
- A pattern constraint describes an event that exhibits a known pattern relative to the occurrences of an event
- A periodic constraint describes an event that occurs periodically
- An arbitrary constraint describes an event that occurs irregularly
- A burst constraint describes an event that occurs in semi-regular bursts. It expresses the maximum number of event occurrences that may appear in any interval of a given length
- An order constraint imposes an order between the occurrences of an event called source and an event called target.
- A comparison constraint states that a certain ordering relation must exist between two timing expressions.



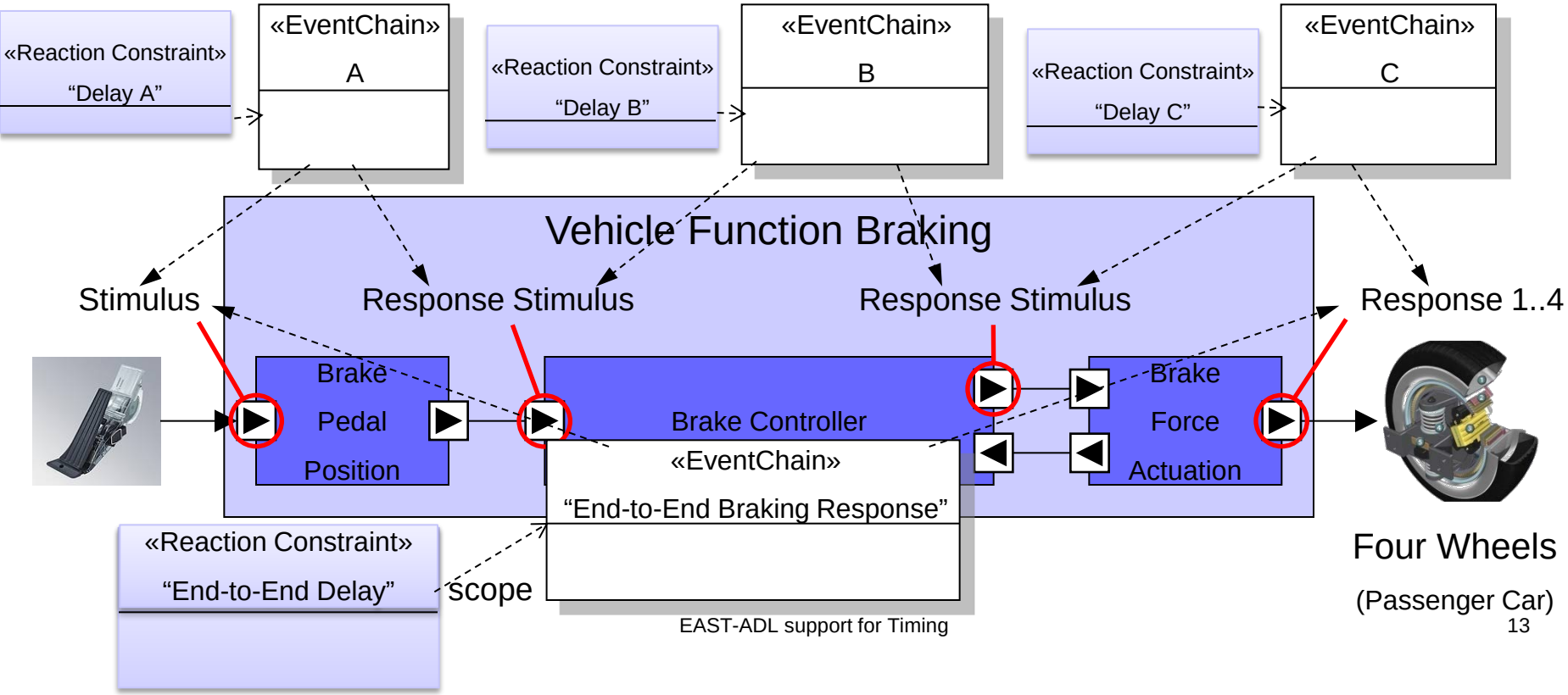
Example: Reaction Constraint

- What is the maximum and/or minimum delay from brake pedal sensor to brake actuator?



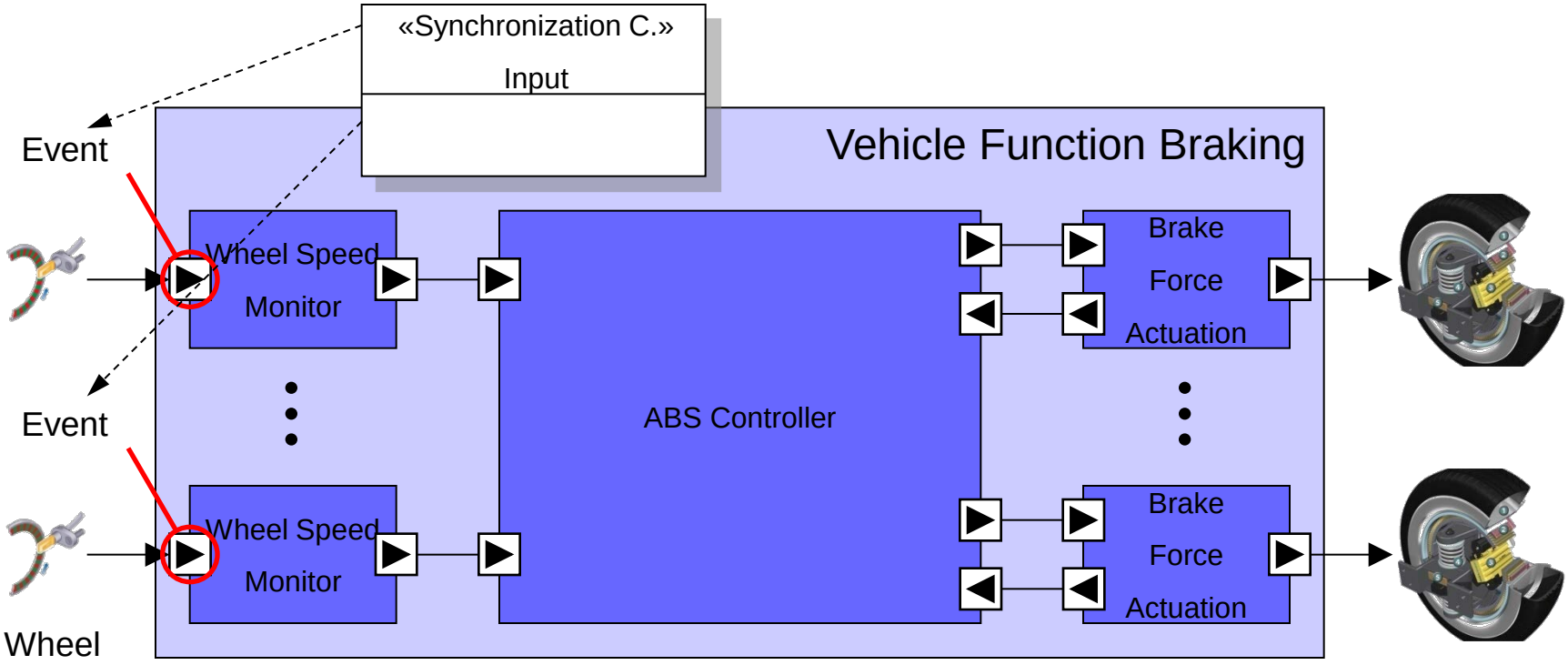
Reactions on Segments of a Chain

- One can identify a number of reaction constraints that constitutes the *segments* of a “longer” chain:
- Example:
  - The total delay (ReactionConstraint D) from Brake Pedal to Brake Actuator can be broken down into segments A, B and C.
  - D = A + B + C



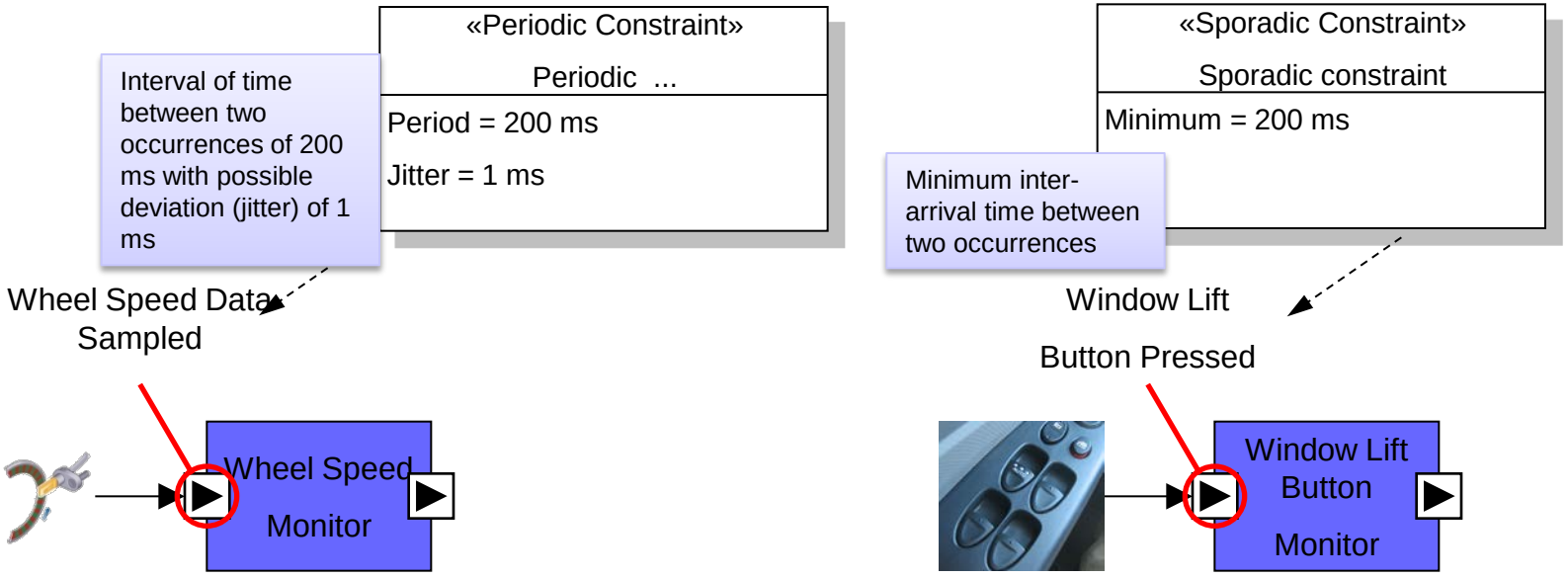
Example: Synchronization Constraint

- What is the difference between a set of stimuli, regardless of when the response will happen?
- Example:
  - What is the tolerated maximum difference between the wheel speed sensors for the ABS?



Example: Event constraints related to one event

- One can specify how often an event occurs.
- Example:
  - What is the interval between two samplings of a wheel speed sensor?
  - What is the minimum interval between two occurrences of a window lift button pressed?

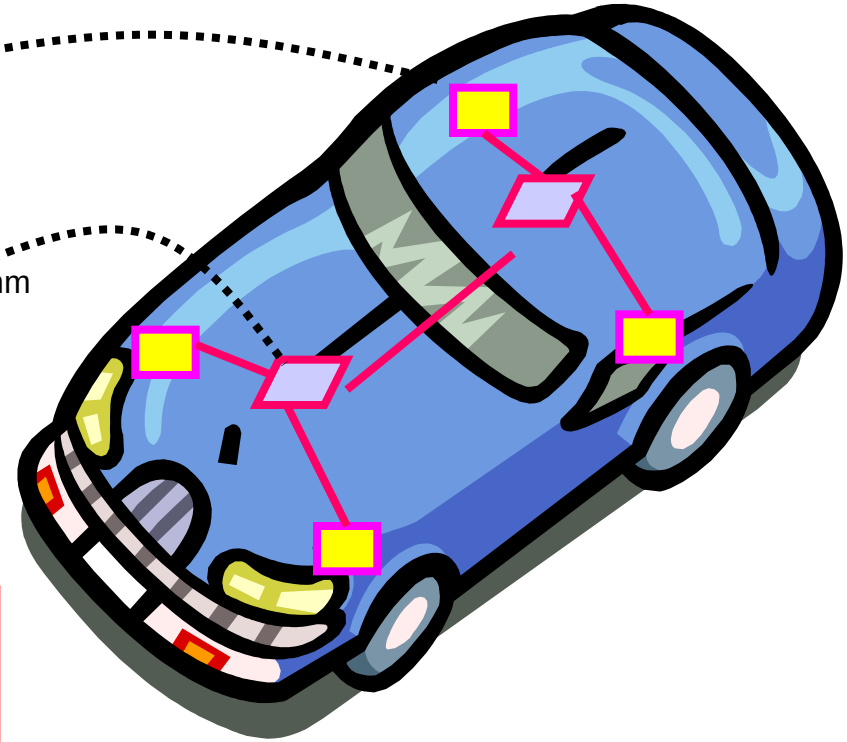


Reaction versus Age

- Both:
  - Delay between stimulus and response
- Reaction:
  - Perspective is from the stimulus event
  - Example: When brake pedal is pressed (stimulus), how long will it take before brake is active on wheel (response)?
- Age:
  - Perspective is from the response event
  - Example: When brake force on wheel is updated (response), how old is the corresponding value of the brake pedal (stimulus)?

Example: Distributed ABS

- 4 wheel control units
  - Brake actuator
  - Wheel speed sensor
  - Local control of wheel
- 2 algorithm control units
  - Distributed control algorithm
    - Front
    - Rear



Timing Modelling Challenge

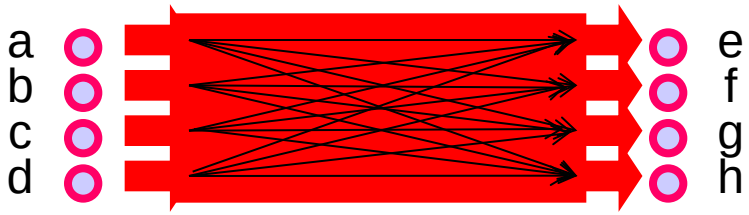
- Express maximum age constraints
  - **Age of wheel speed data when updating brake force data to each wheel**
- Build up end-to-end age constraint from age constraints of smaller EventChains

Events for End-to-End Age Constraint

- 4 Response Events
  - Update of brake force value for one wheel
  - Denote these Ea, Eb, Ec and Ed
    (front: Ea and Eb, rear: Ec and Ed)
- 4 Stimuli Events
  - Sampling of wheel speed for one wheel
  - Denote these events Ee, Ef, Eg and Eh
    (front: Ee and Ef, rear: Eg and Eh)

- 4X4 EventChains (each chain has only one stimulus and one response)
  - EventChain ECa2e
  - EventChain ECa2f
  - EventChain ECa2g
  - EventChain ECa2h
  - EventChain ECb2e….

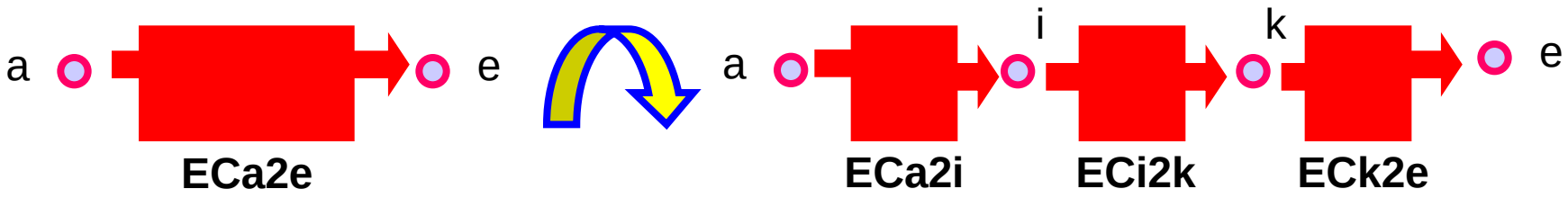
One Age Constraint



- Constraint: Max Age = 35
- For all 4 responses the maximum age from any of the 4 stimuli should be 35
- All the 16 chains subjected to the age constraint

Segments (Composition of Constraints)

- 4 Events related to Brake Control Units
  - Ei: Front control unit ready to send sensor data from front wheels to rear control unit
  - Ej: Rear control unit ready to send sensor data from rear wheels to front control unit
  - Ek: Front control unit ready to send actuator values to front wheel units
  - El: Rear control unit ready to send actuator values to rear wheel units



35 ≥ 11 + 10 + 14

Max age constraint broken down among the segments