EAST-ADL support for timing

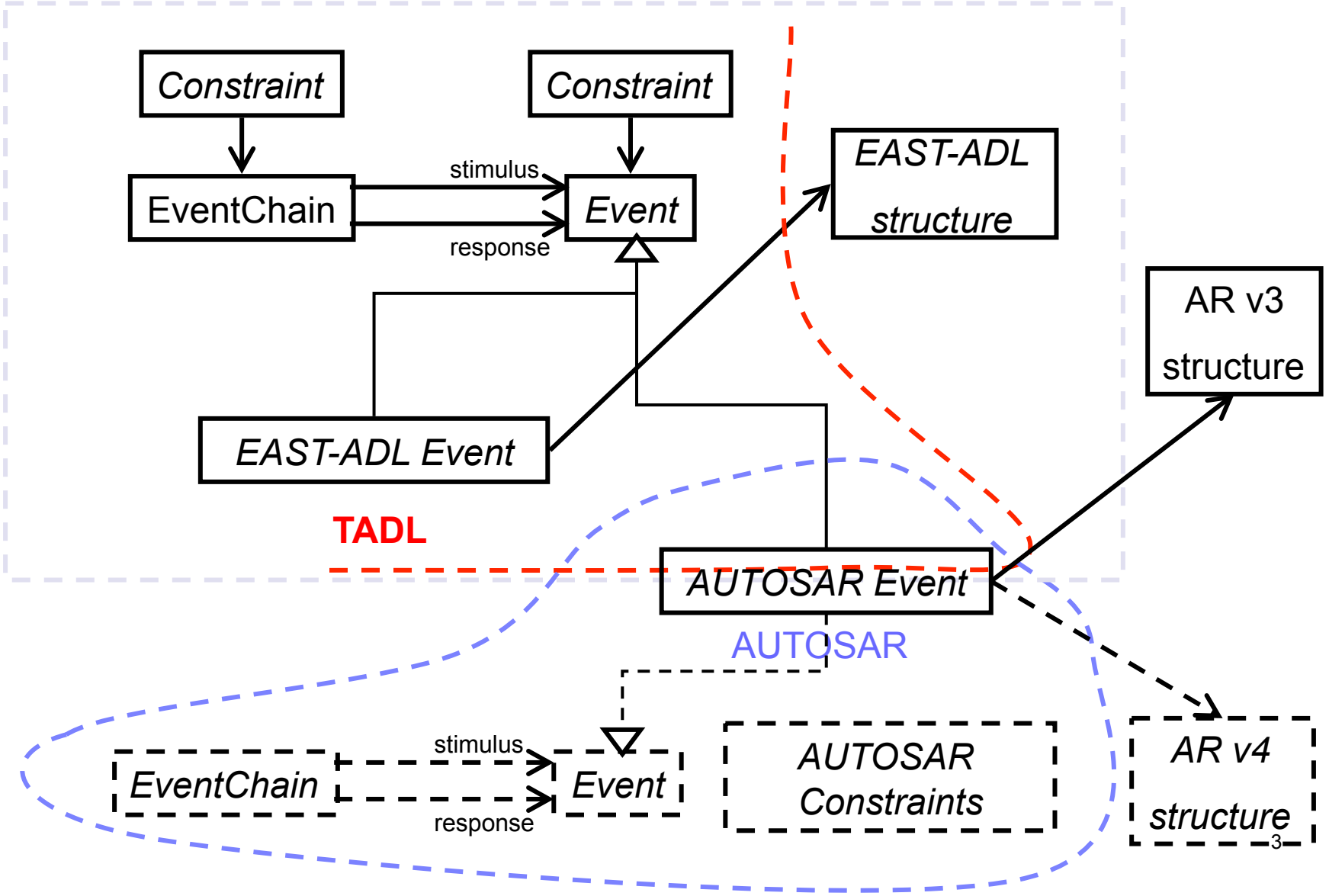
2011

Outline, EAST-ADL support for Timing

Timing concepts are based on TIMMO project results (Timing Augmented Modelling Language, TADL)

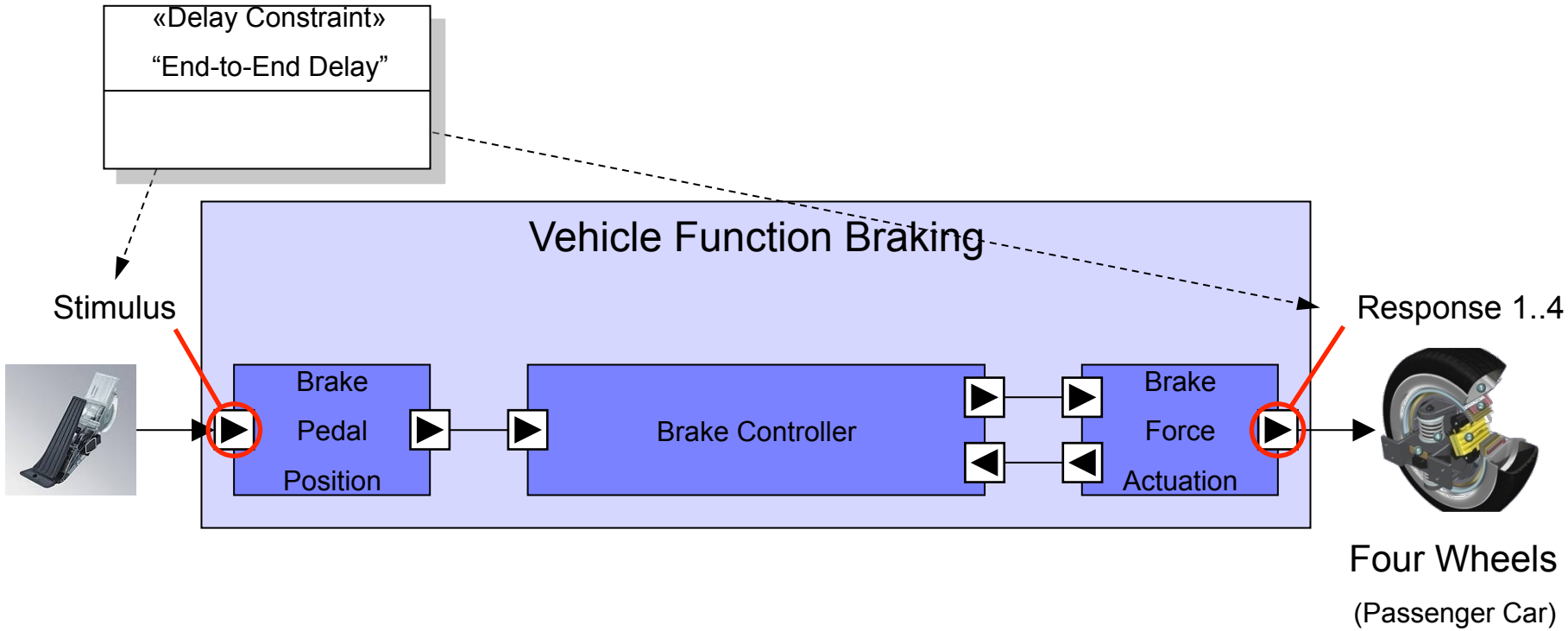
- Timing concepts are reviewed here, essentially
  - Events
    Related to EAST-ADL and AUTOSAR structural entities
  - Event Chains
    Binds together events to establish sequences/relations between events
  - Constraints
    Puts temporal constraints on sets of events or on event chains
- Ongoing Harmonization with MARTE with the purpose of allowing Timing analysis – see MAENAD analysis workbench

Metamodel Overview – Timing aspects



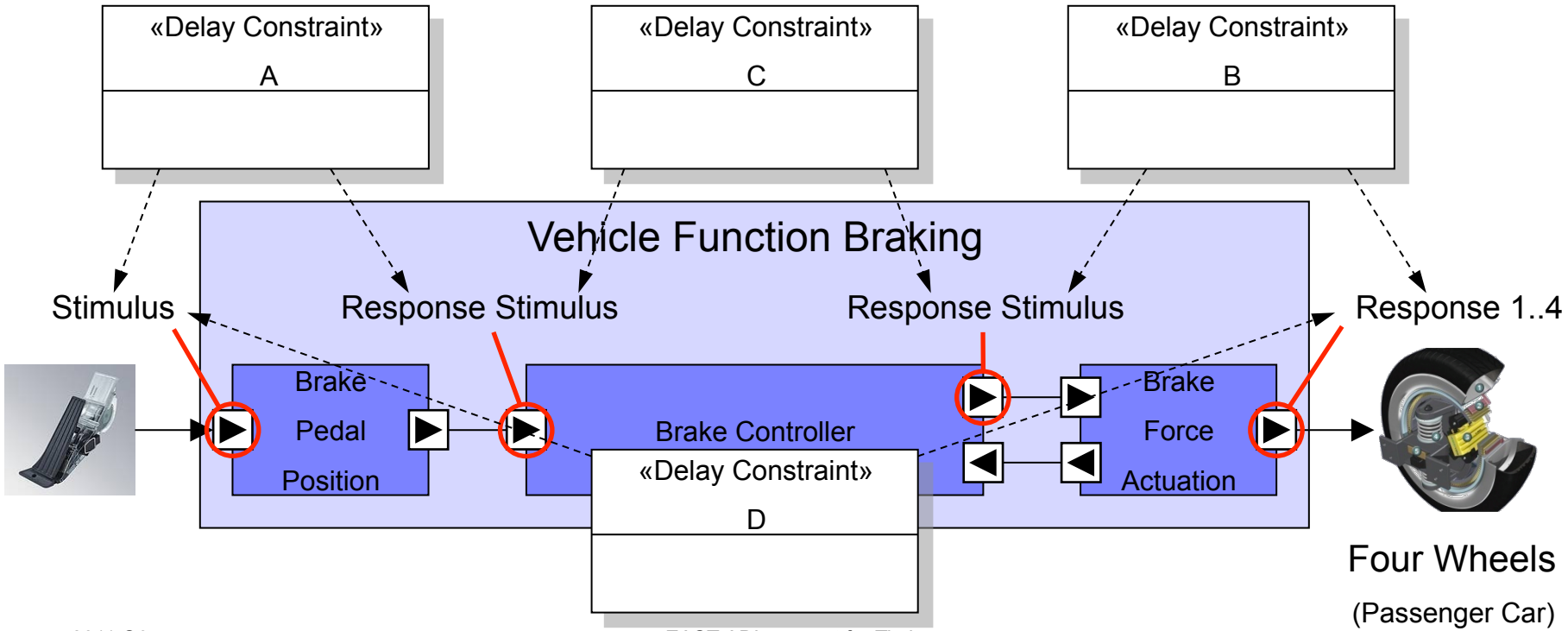
Introduction: Delay Constraint

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



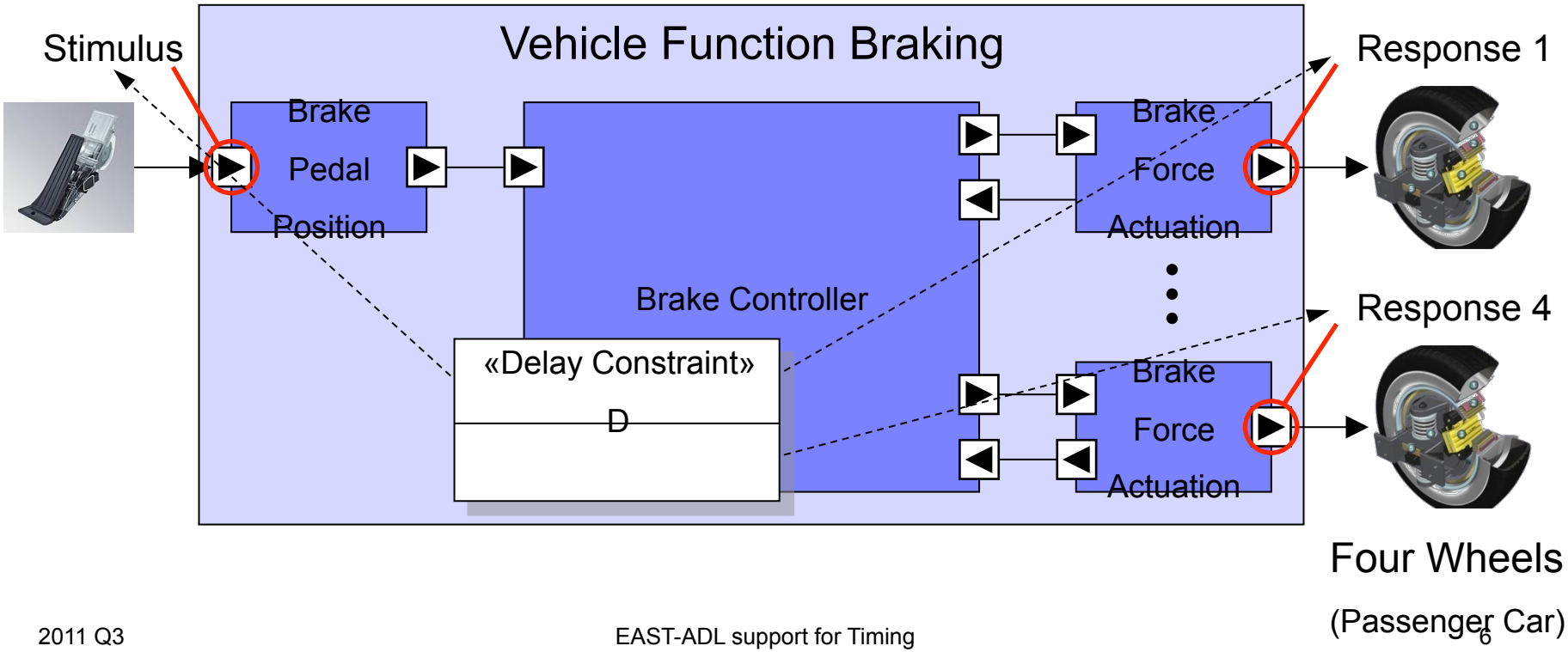
Delay Constraint Segments of a Chain

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



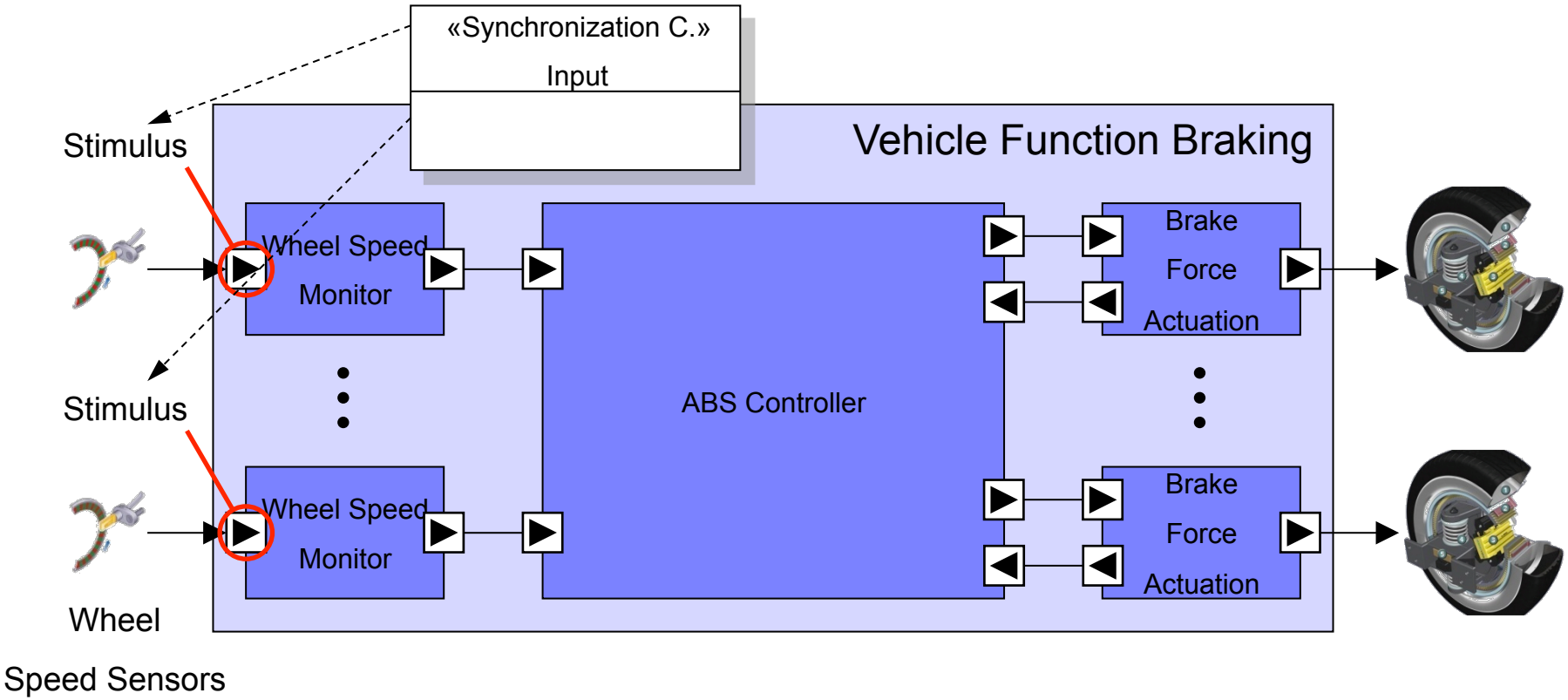
Delay Constraint Segments of a Chain

- One can have more than one stimulus and/or response for a delay constraint.
- Example:
  - What is the total delay from the Brake pedal to any of the four wheel brakes?



Input Synchronization

- 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?

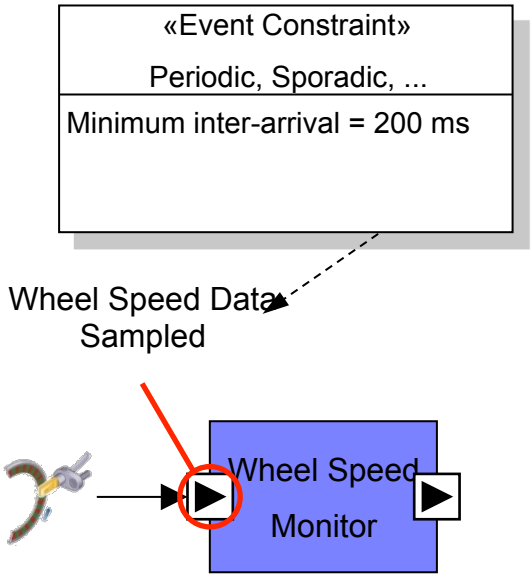


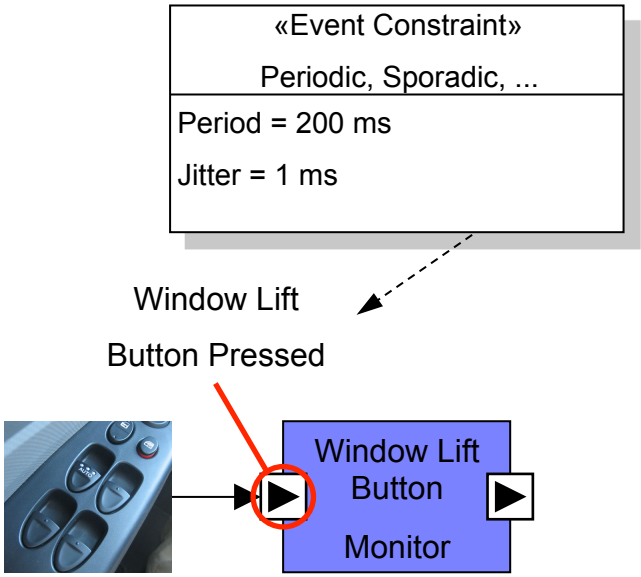
Introduction: Output Synchronization

- What is the difference between a set of responses, regardless of when the stimuli happened?
- Example:
  - What is the tolerated maximum difference between first and last door lock when locking the doors of a vehicle?

Event Constraint

- 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?

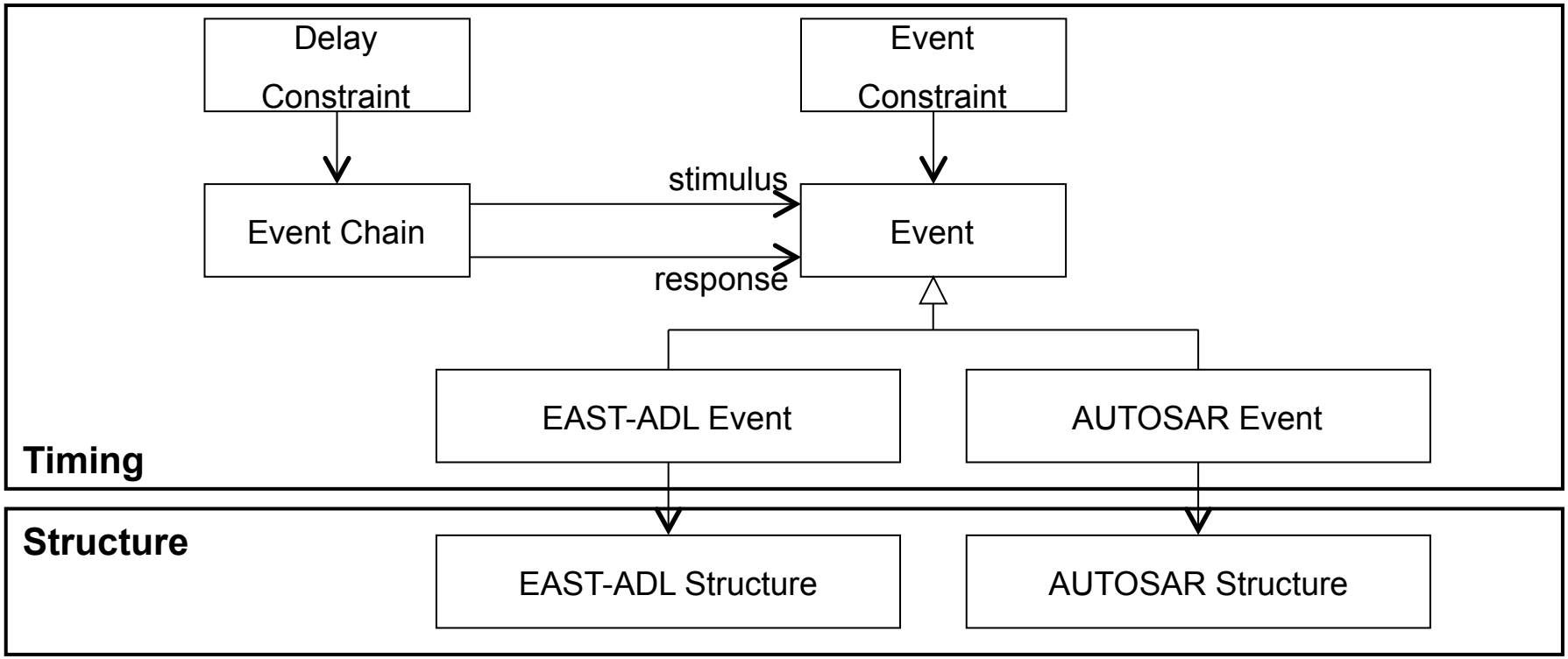




Timing Information

- **Timing Descriptions**
  - Event
  - Event Chain
- **Timing Constraints**
  - Delay Constraint – Requirements/constraints imposed on event chains
    - Age Timing Constraint
    - Reaction Constraint
    - Input and Output Synchronization Constraint
  - Event Constraint (a.k.a. Event Models, Event Repetition Constraints) – Requirements/constraints imposed on events
    - Periodic Event Constraint
    - Sporadic Event Constraint
    - Pattern Event Constraint
    - Arbitrary Event Constraint
  - Offset Constraint – Requirement/constraint imposed on two events

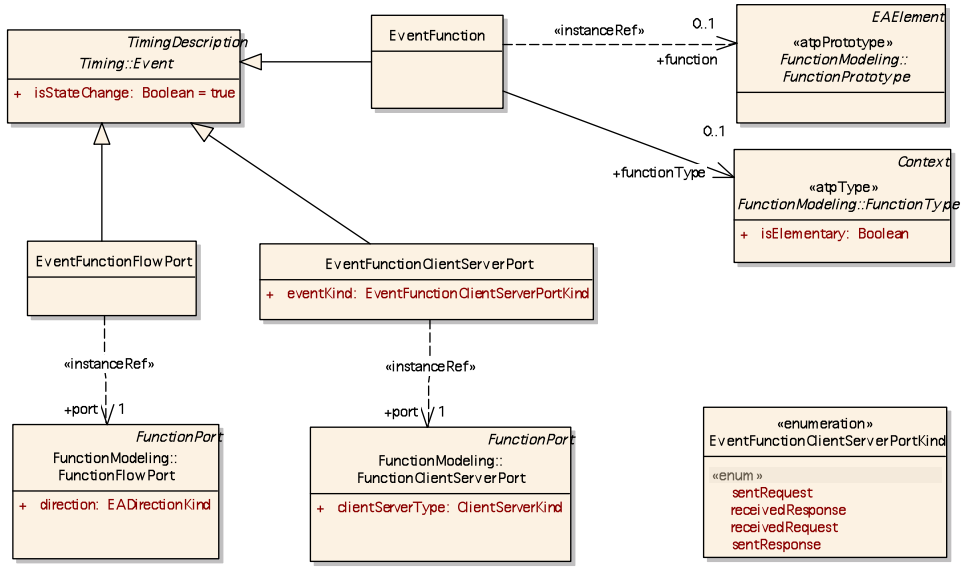
Basic Syntax



- A delay constraint is imposed on an event chain
- An event chain points to events playing the roles of stimuli and responses
- An event constraint is imposed on an event
- An event points to a system model in EAST-ADL

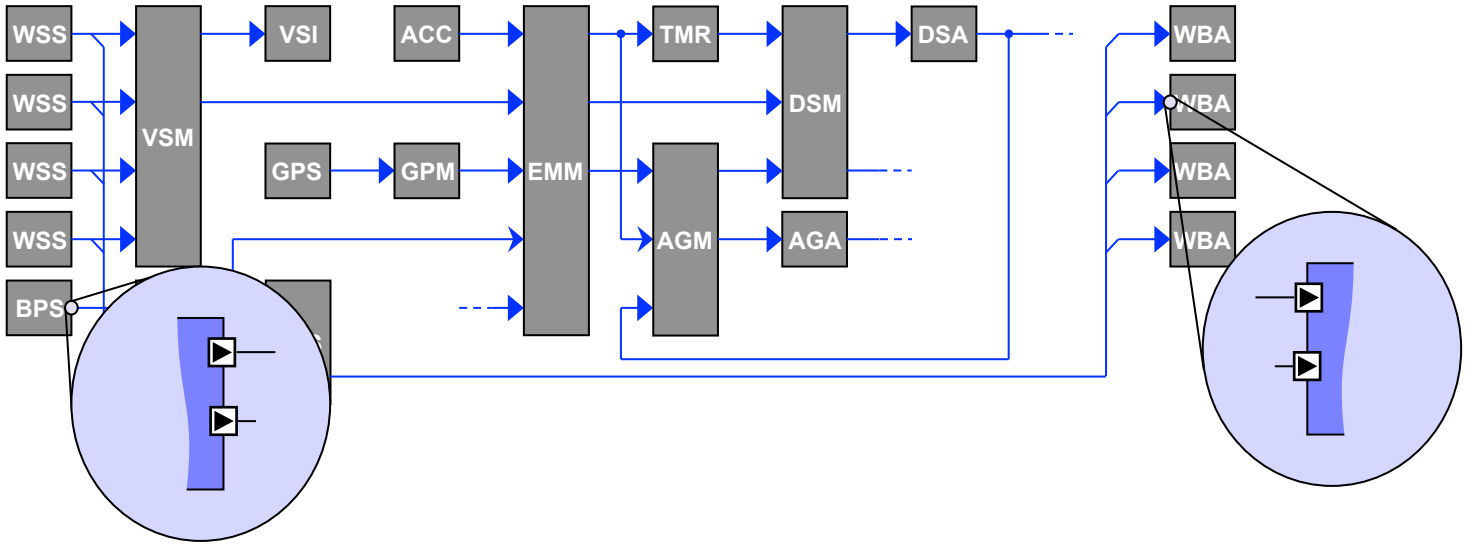
EAST-ADL Predefined Events

- 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

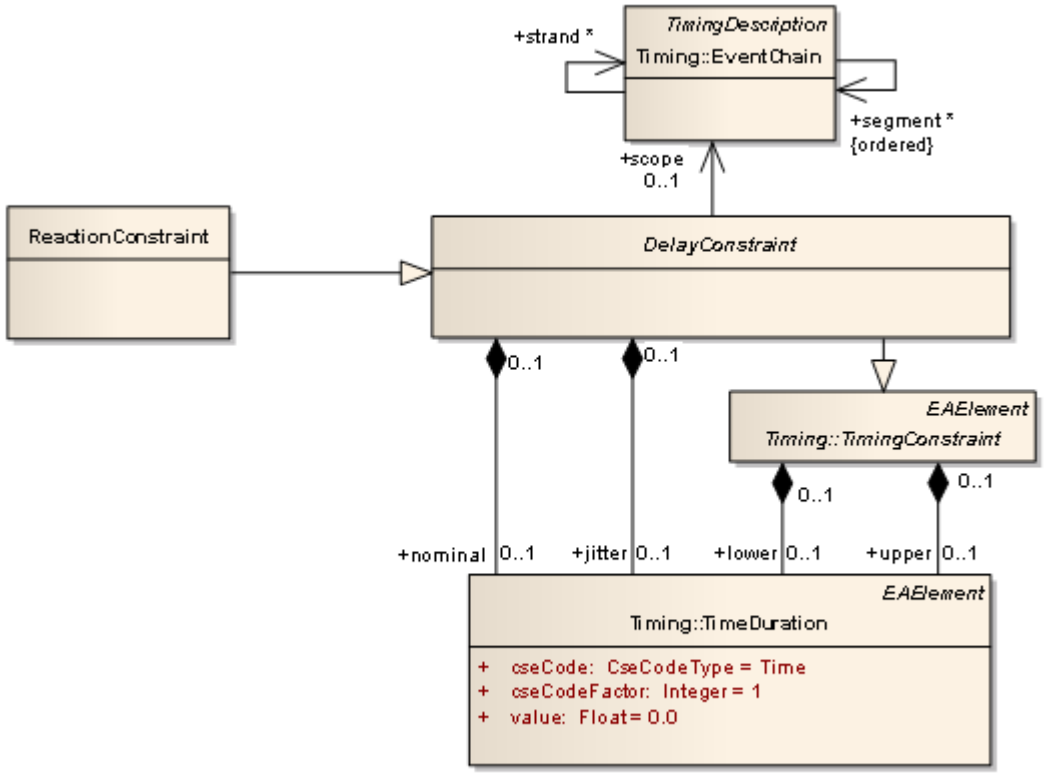


Event Chain

- 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)
- Subsumes a number of event chains, called event chain strands

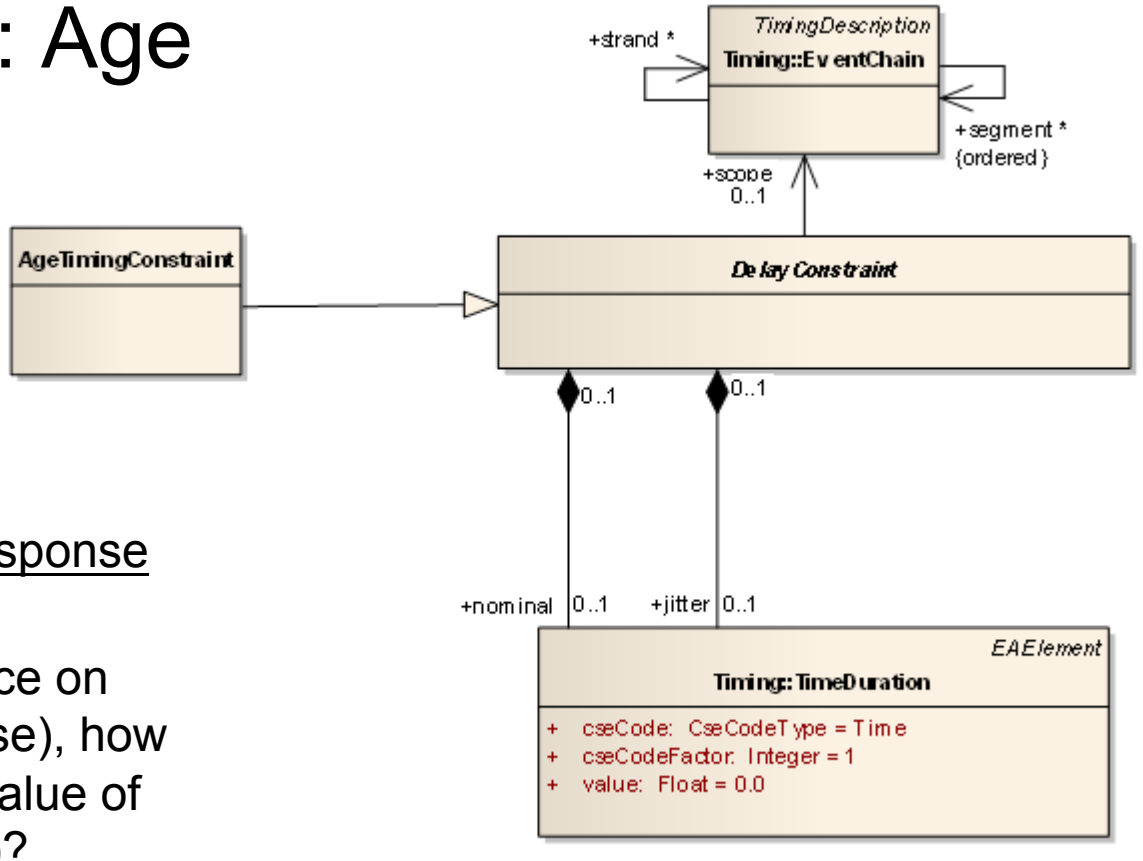


Delay Constraint: Reaction



- Perspective is from the stimulus event forward
- Example: When brake pedal is pressed (stimulus), how long will it take before brake is active on wheel (response)?

Delay Constraint: Age



- Perspective is from the response event backward
- Example: When brake force on wheel is updated (response), how old is the corresponding value of the brake pedal (stimulus)?

Delay Constraint: 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)?

Delay Constraint: Reaction versus Age ... *continued*

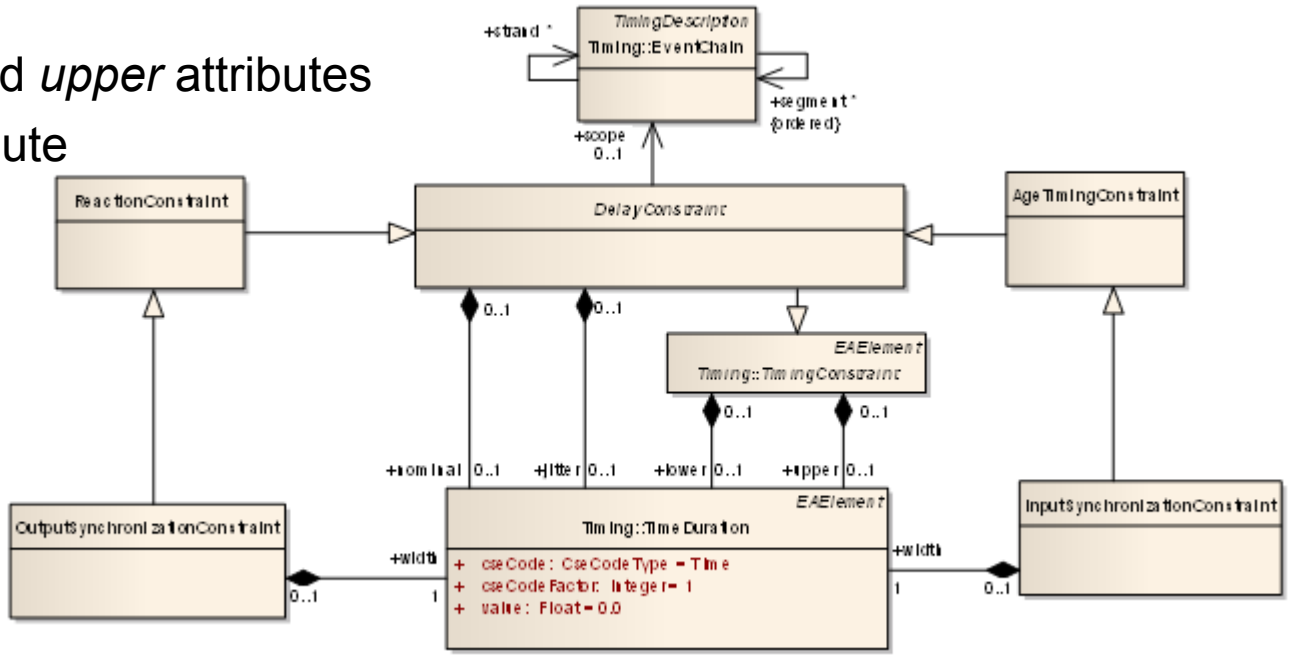
- Both:
  - Delay between stimulus and response
- But:
  - In sampled systems the difference is important to be able to
    - Compose segments to a longer chain
      - Constraint of longer chain is the sum of Segment Constraints (even in multi rate systems)
    - Uniquely identify the corresponding events and the path between them

Delay Constraint: Reaction versus Age ... Conclusion

- Age is defined for each response
  - Several Age event chains can originate from a certain stimulus, but only one can end in a certain response-
- Reaction is defined for each stimulus
- One can compose and decompose constraints of the same type
  - Age = Age + Age + ...
  - Reaction = Reaction + Reaction + ...
  - Reaction event chains can end in a certain response, but only one can originate from a certain response.

Delay Constraint: Synchronization

- Input Synchronization specializes Age
  - Inherits: *lower* and *upper* attributes
  - Adds: *width* attribute
- Output Synchronization specializes Reaction
  - Inherits: *lower* and *upper* attributes
  - Adds: *width* attribute

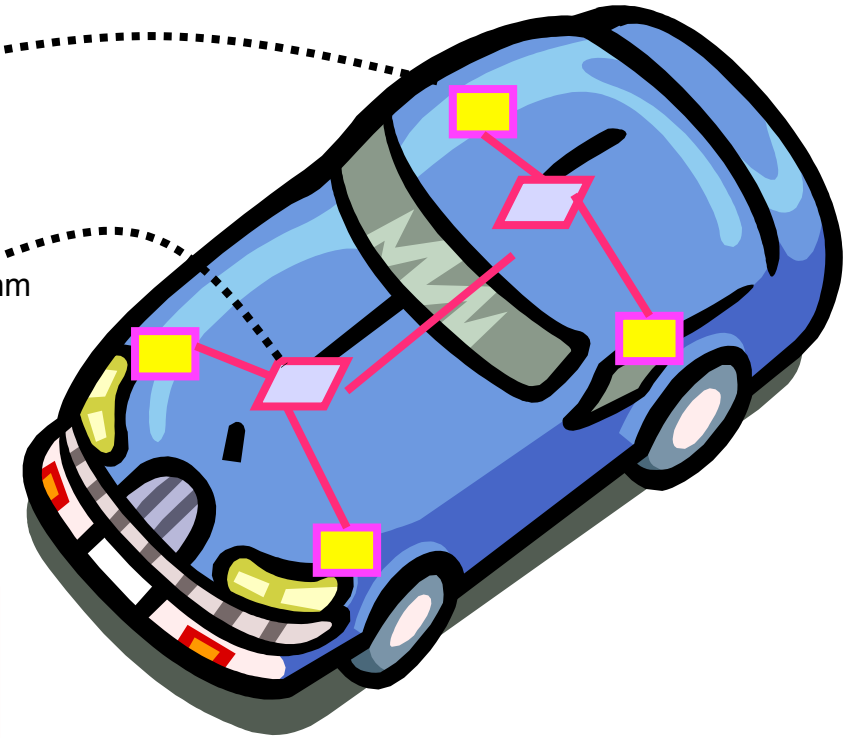


Strands and Segments: Example

- Distributed ABS
- Different possibilities for break-down / sum-up
  - Segments first
  - Strands first
- General for sum-up and break-down
  - Max Age/Reaction
    - Σ Segments $\leq$ Whole
    - Max(Strands) $\leq$ Whole
  - Min Age/Reaction
    - Σ Segments $\geq$ Whole
    - Min(Strands) $\geq$ Whole

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**
- Break down overall end-to-end age constraint into several age constraints
- Build up end-to-end age constraint from age constraints of smaller EventChains

Events for End-to-End Age Constraint

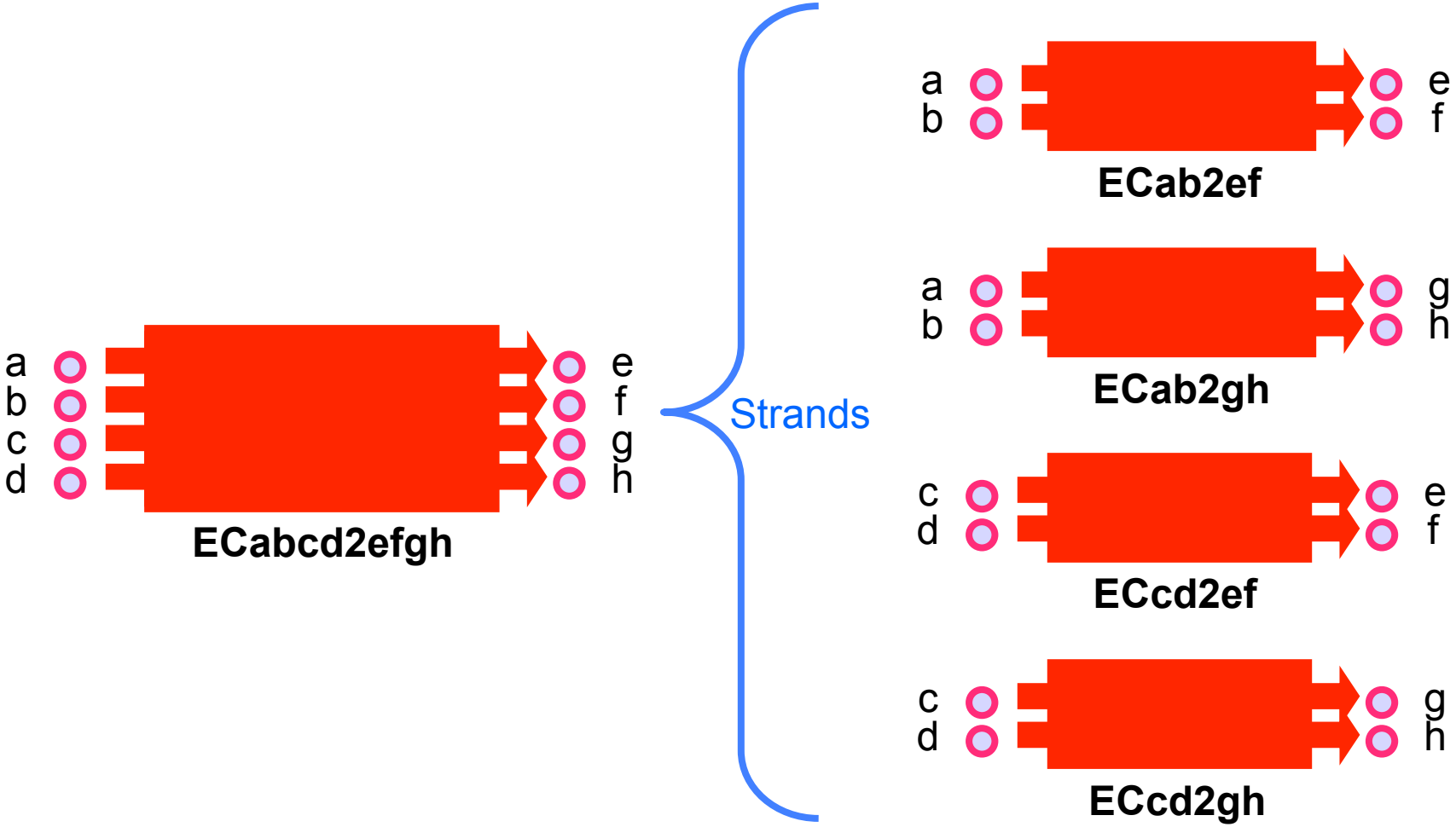
- 4 Response Events
  - Update of brake force value for one wheel
  - Denote these Ea, Eb, Ec and Ed
    (front: Ea and Eb, rear: Ec and Ed)
- 4 Stimuli Events
  - Sampling of wheel speed for one wheel
  - Denote these events Ee, Ef, Eg and Eh
    (front: Ee and Ef, rear: Eg and Eh)

- 1 EventChain
  - Having these above events as stimuli and responses respectively
  - Denote this EventChain ECabcd2efgh

One Age Constraint

- Constraint: Max Age = 35
- For all 4 responses the maximum age from any of the 4 stimuli should be 35 (independent of the path between stimulus and response)

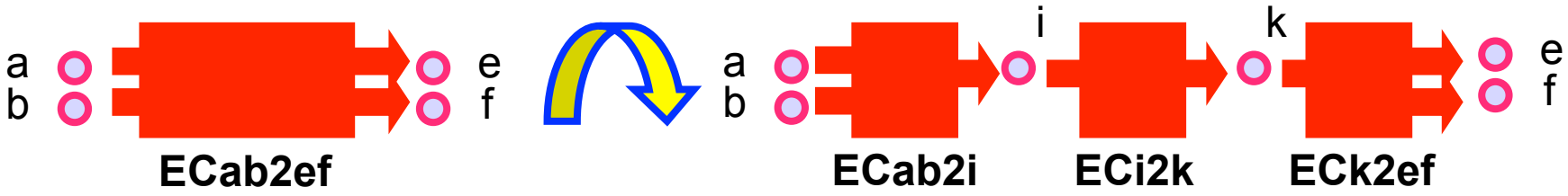
Alternative 1: Strand Break-down First



- Max Age Constraint for these 4 Event Chains: 35 each

Alternative 1: … then Segments

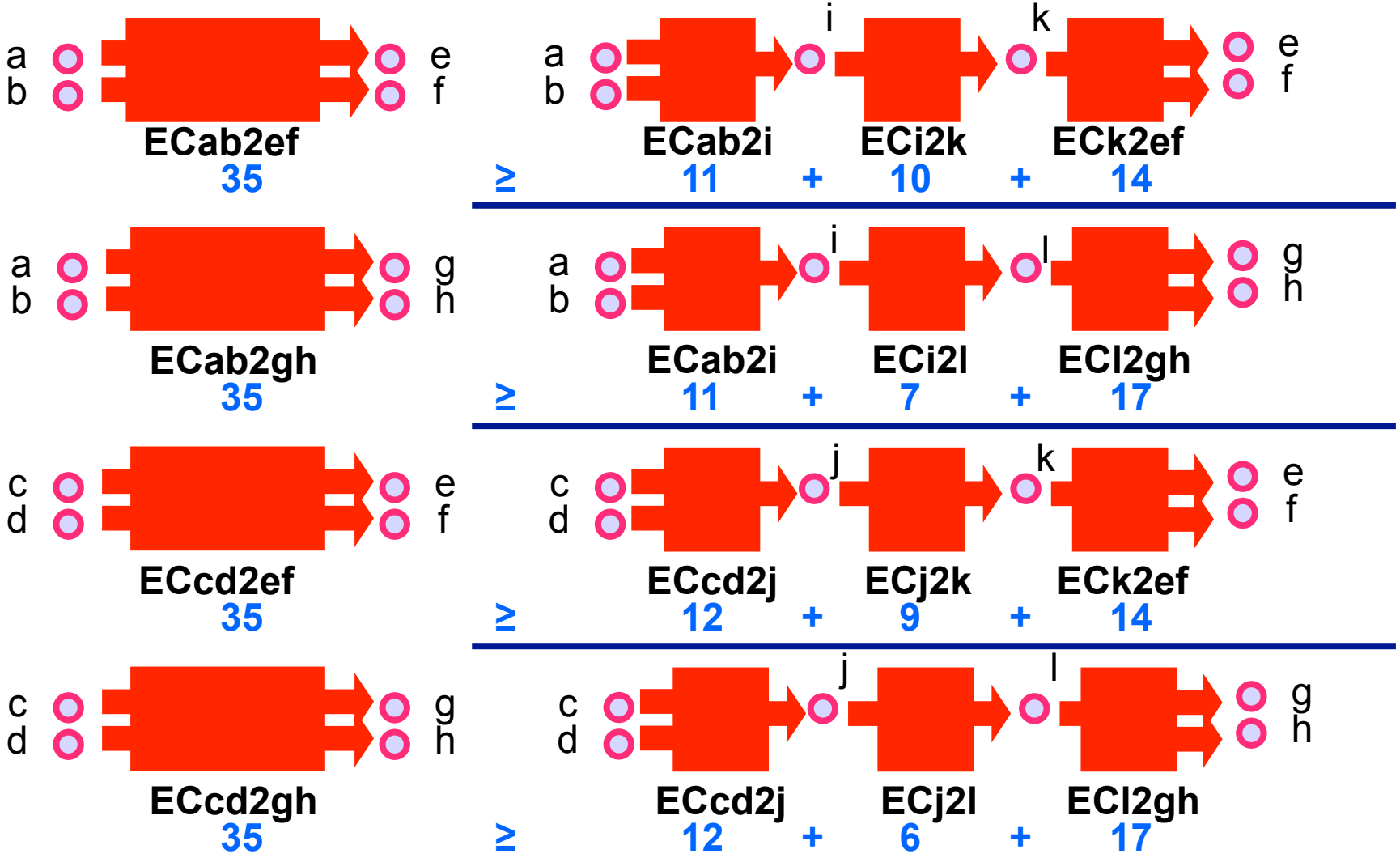
- 4 Events related to Brake Control Units
  - Ei: Front control unit ready to send sensor data from front wheels to rear control unit
  - Ej: Rear control unit ready to send sensor data from rear wheels to front control unit
  - Ek: Front control unit ready to send actuator values to front wheel units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



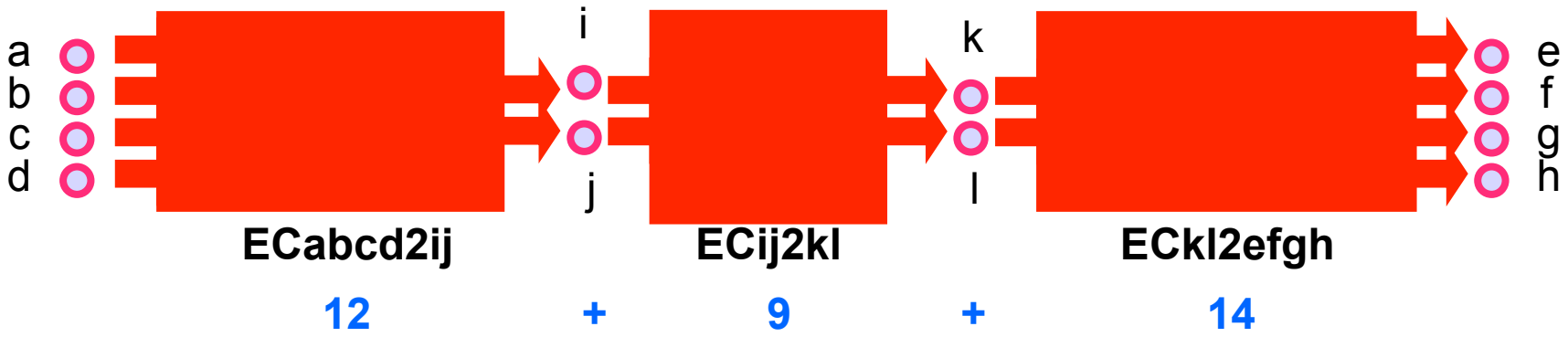
35 ≥ 11 + 10 + 14

Max age constraint broken down among the segments

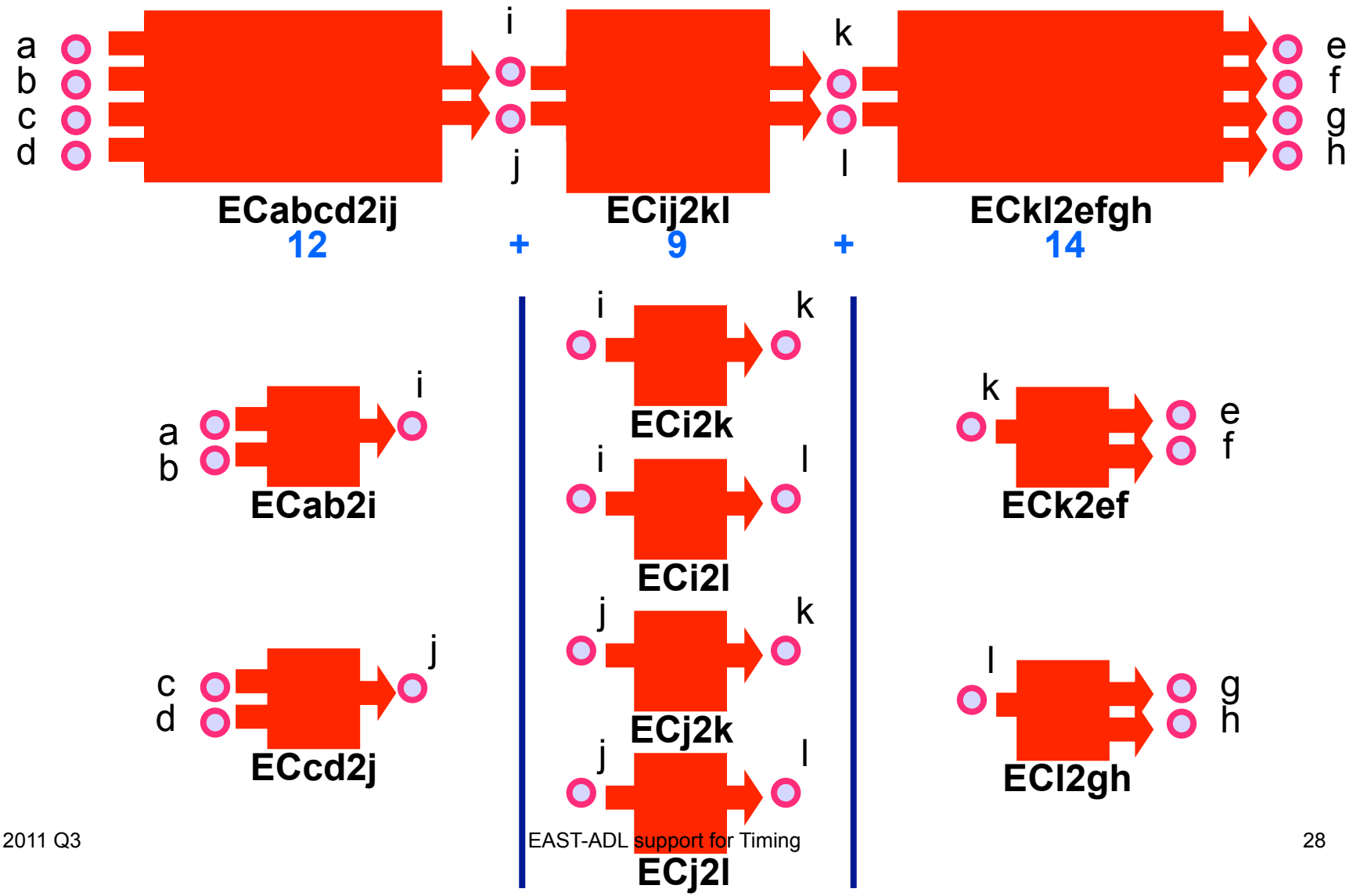
Alternative 1: … Segments for all Strands



Alternative 2: Segment Break-down First



Alternative 2: … then Strands



Break-down of Requirements

- Strands first or Segments first?
- The order makes a difference!
- In any step:
  - Max Age/Reaction
    - Σ Segments $\leq$ Whole
    - Max(Strands) $\leq$ Whole
  - Min Age/Reaction
    - Σ Segments $\geq$ Whole
    - Min(Strands) $\geq$ Whole

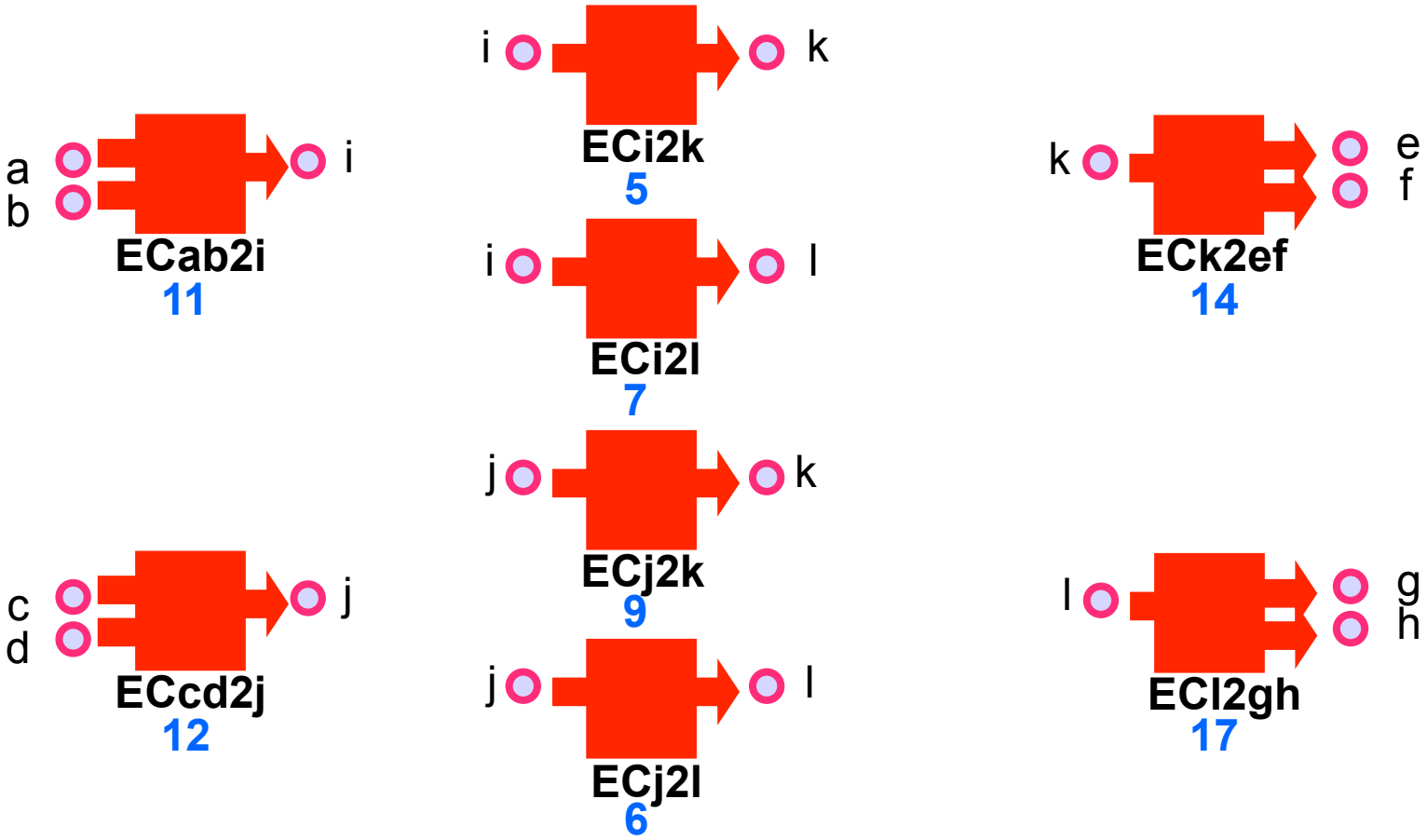
Composition of Constraints

Summing up for a “data sheet”

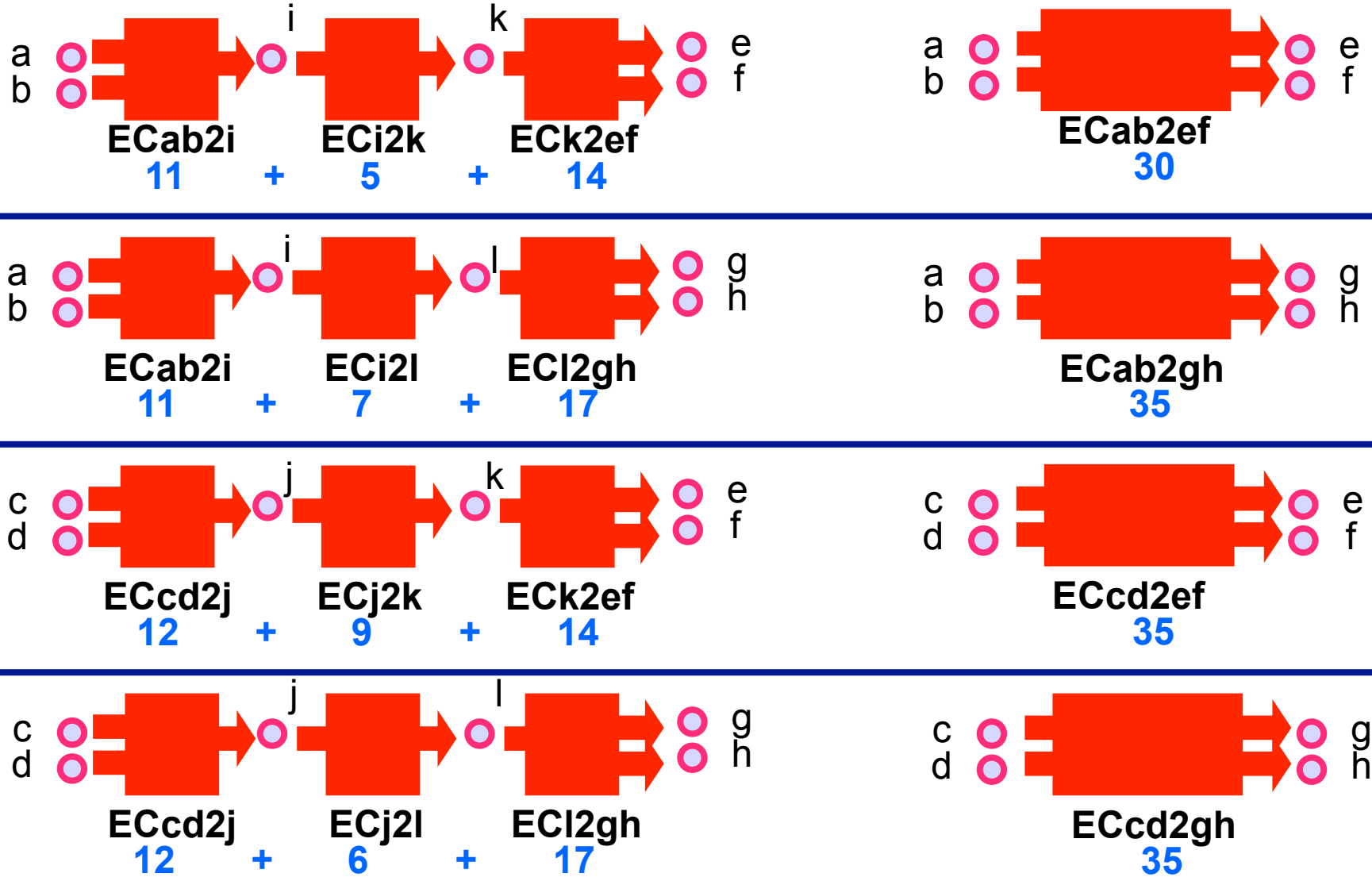
- Given constraints of smaller EventChains
  - **What are the derived constraints for larger (composed) EventChains**
- Composition by either
  - **Segments after each other**
  - **Strands besides each other**

Example Revisited

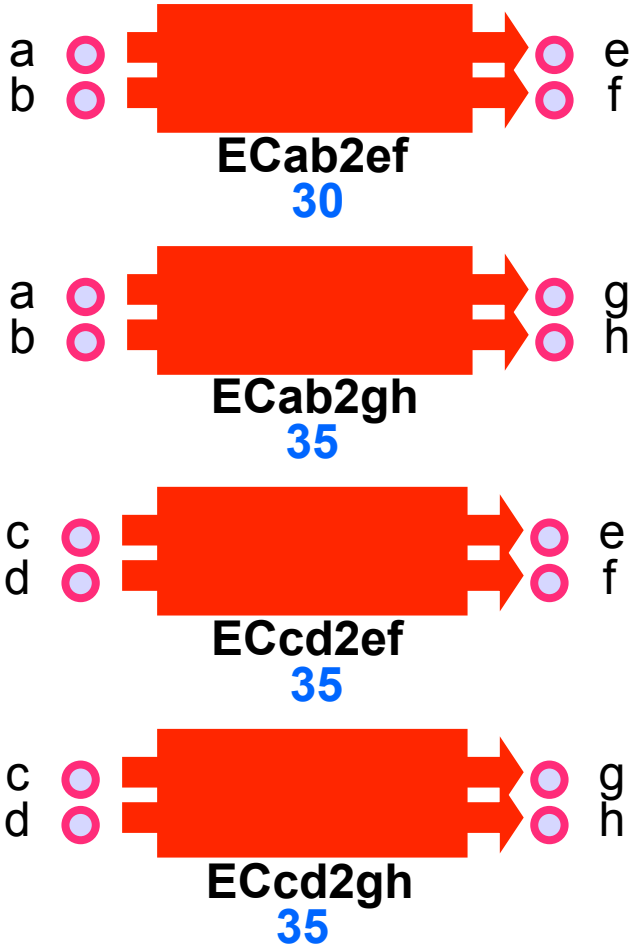
Start with 8 smaller EventChains and associated max age constraints:



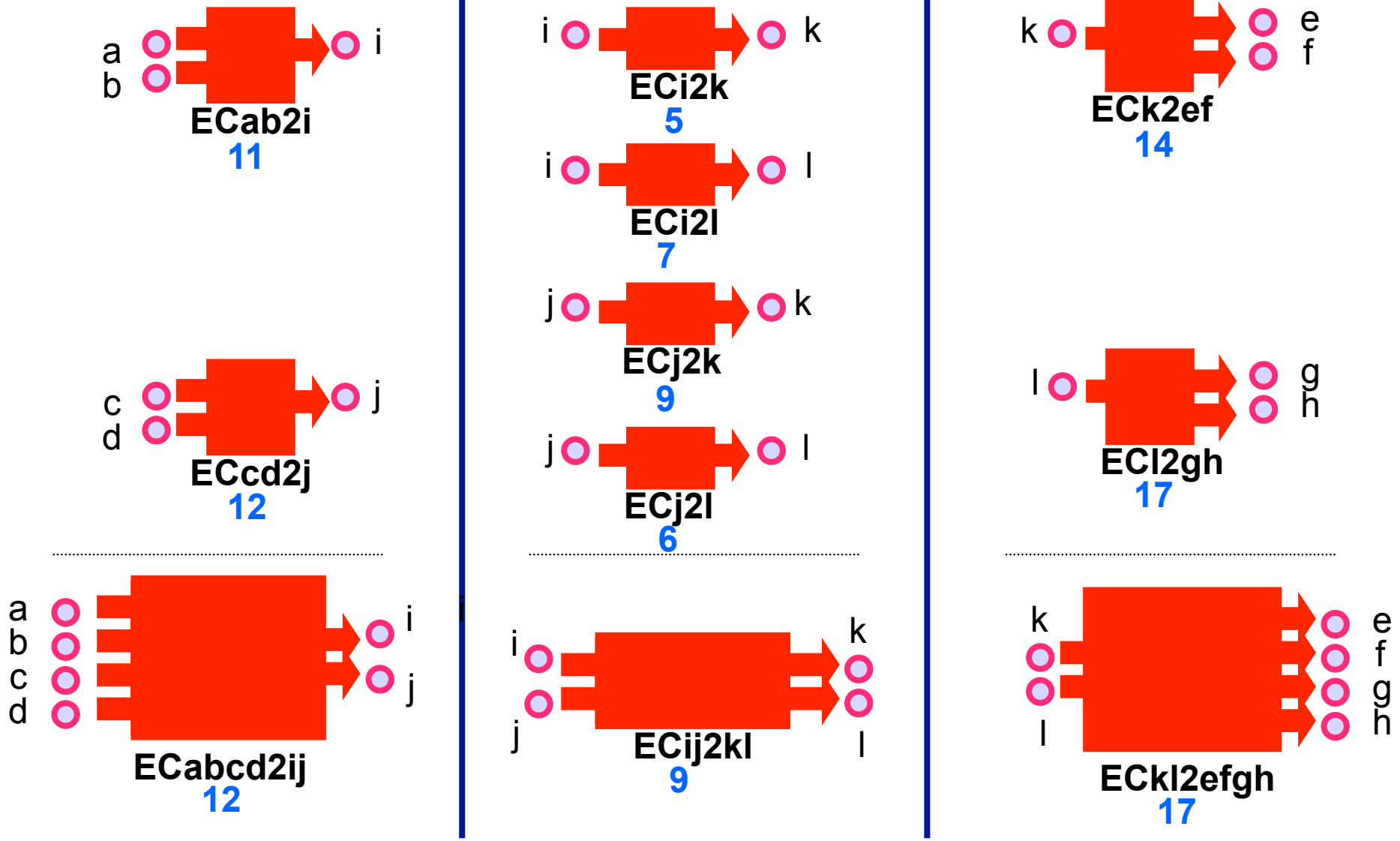
Compose: Segments First



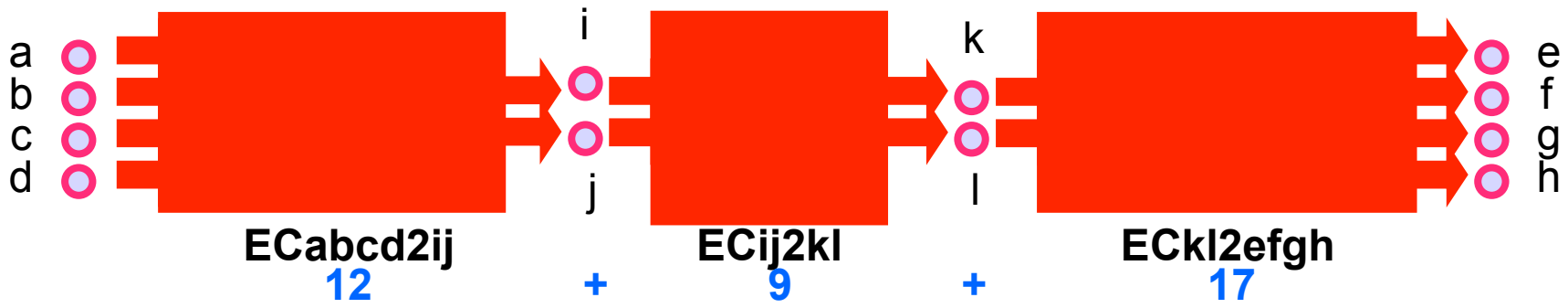
Compose: … then Strands



Compose: Strands First



Compose: … then Segments



Conclusion

The order of Composition/Decomposition makes a difference

- Strands First then Segments

  may differ from

- Segments First then Strands

What order of Composition/Decomposition to choose depends on what Constraints that are relevant to express in a certain context

Rules for Composition/Decomposition are the same

- Max Age/Reaction
  - **Σ Segments ≤ Whole**
  - **Max(Strands) ≤ Whole**
- Min Age/Reaction
  - **Σ Segments ≥ Whole**
  - **Min(Strands) ≥ Whole**

This holds as long as Age/Reaction not are mixed with one another