

# **Tutorial: Rigid and Variable Embodiment**

## **Application part**

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# Our running example: A transport service company

The entities we consider are:

- the transport service company (the organization  $o$ ), with roles:
  - president/principal ( $p$ )
  - administrative assistant ( $a$ )
  - driver ( $d$ )
  - mechanic ( $m$ )
- trailer truck ( $t$ ), own by company  $o$
- transport service process of the company  $o$
- a client  $c$  of the company  $o$

# Our running example: A transport service company

Ontologically speaking, these actors are classified as follows:

- the transport service company ( $o$ ) is a **social object**;
- the president ( $p$ ), the administrative assistant ( $a$ ), the driver ( $d$ ), the mechanic ( $m$ ) and the client ( $c$ ) are **roles** in the context of  $o$ ;
- the trailer truck ( $t$ ) is a **material functional object**;
- transport service process is an **event** over a finite temporal interval.

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- transport service process is an **event** over a finite temporal interval.

Interestingly all of them can be represented through  
some form of embodiment!

# Outline

## 1. Rigid Embodiment

- I. The truck as a rigid embodiment (example)
- II. The transport service company (hands-on)
- III. Qua objects

## 2. Variable Embodiment

- I. The organisation in time (example)
- II. The transport service process (hands-on)

# Rigid Embodiment

# The Truck (example)

# The truck ( $t$ )

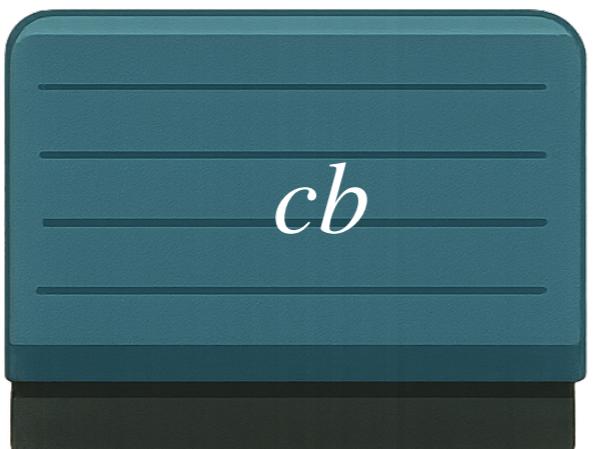


“Ladybird”

The parts of the truck are assembled according to a certain structure.

# The truck ( $t$ )

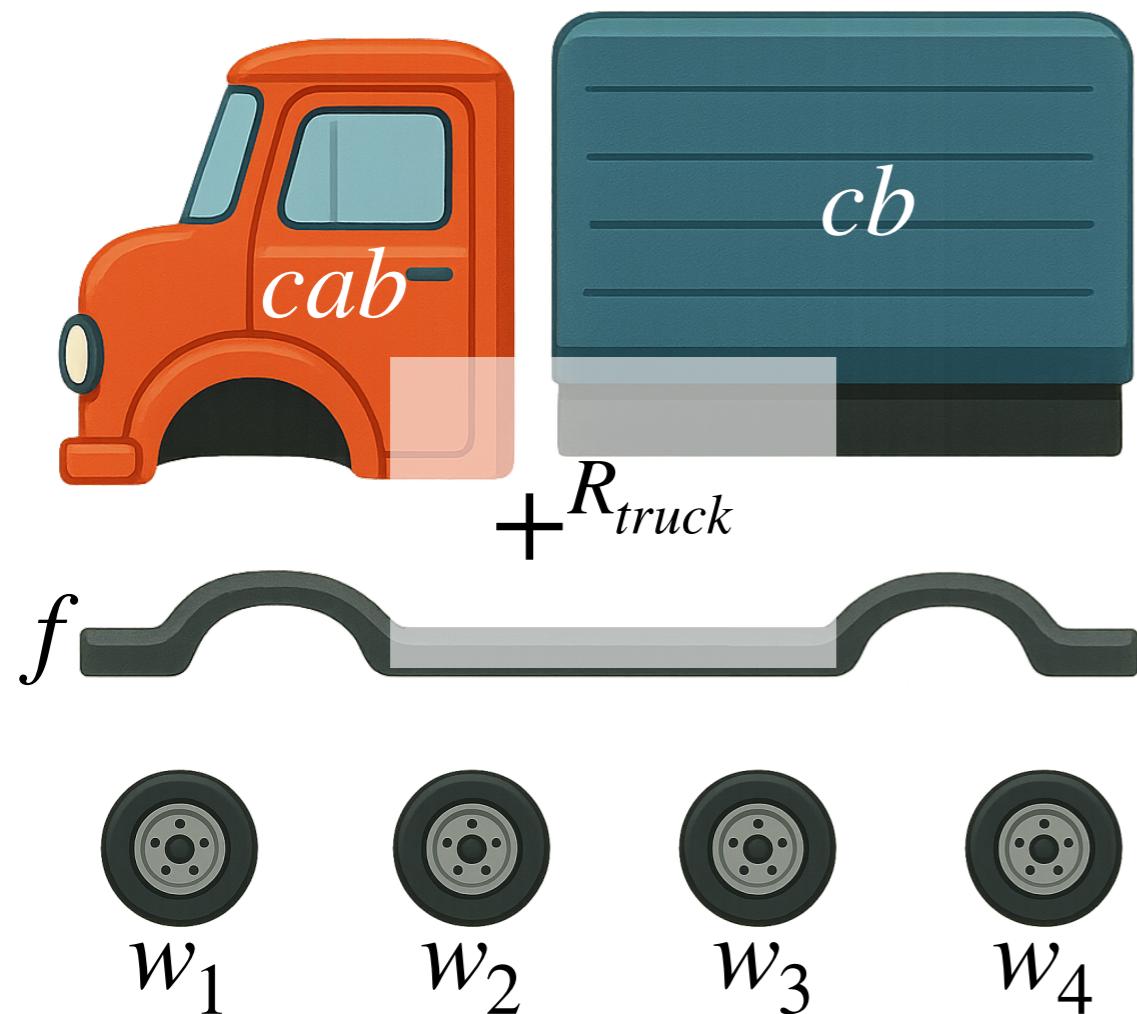
Let us simplify, and assume that the parts of a truck are:



- the cab (*cab*),
- the cargo body (*cb*),
- the frame (*f*),
- and four wheels ( $w_1, w_2, w_3, w_4$ ).

# The truck ( $t$ )

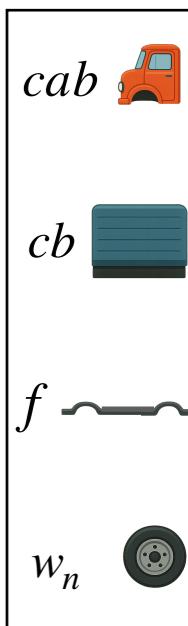
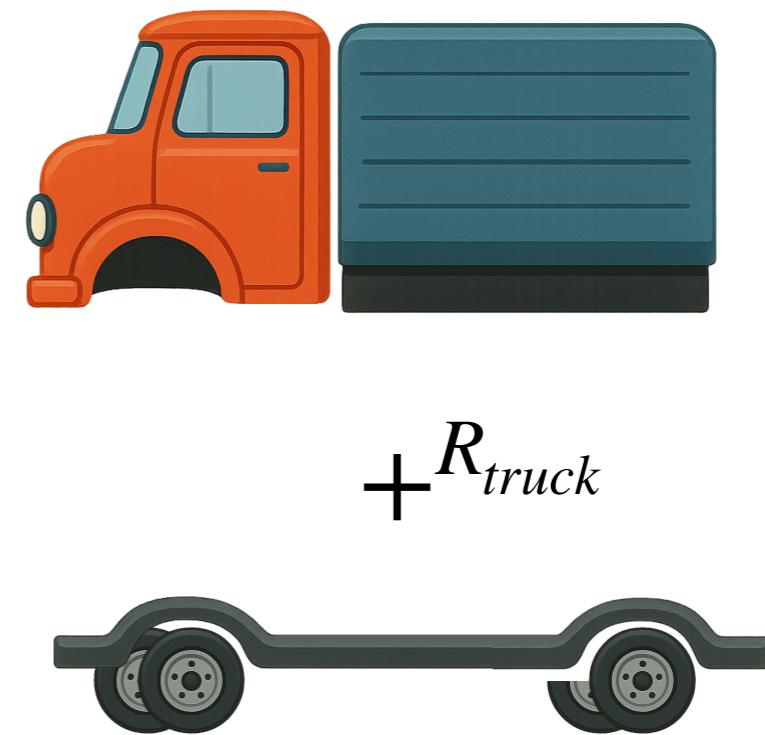
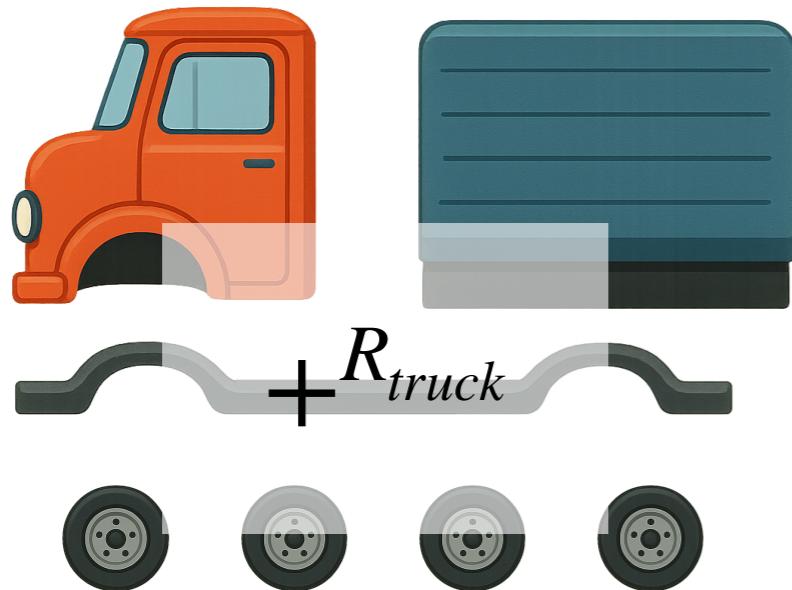
Given relation *being a truck*  $R_{truck}$  (the principle of Rigid Embodiment for trucks),  $t$  as a rigid embodiment-truck will be:



$$t = cab, cb, f, w_1, w_2, w_3, w_4 / R_{truck}$$

# The truck ( $t$ )

There exist different ways in which the truck could be assembled, but this does not change the fact that we are still talking about the same truck (principle **R3\***):

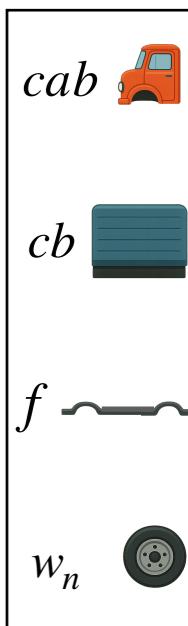
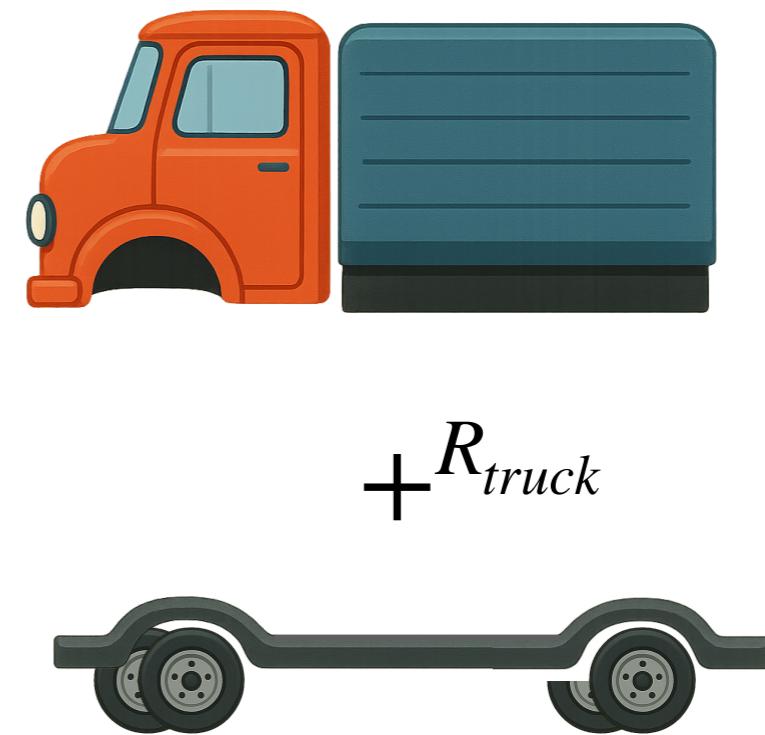
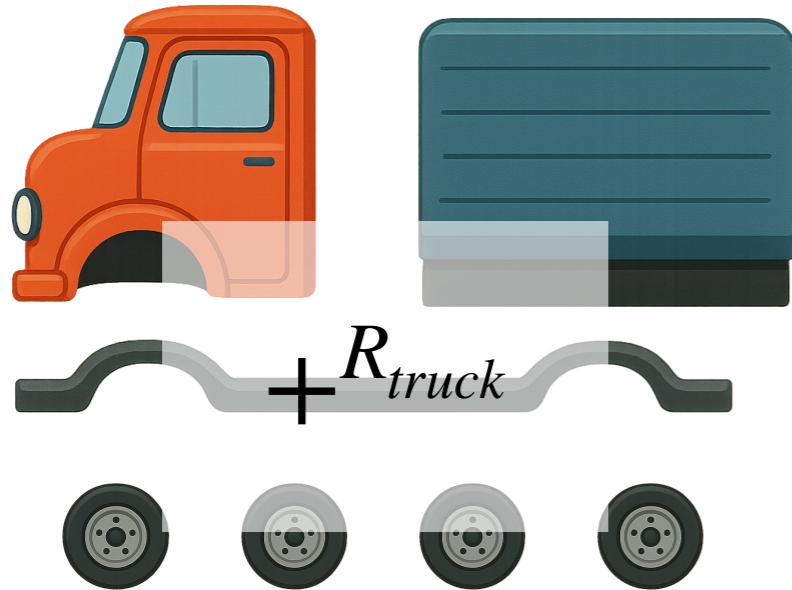


$cab, cb, f, w_1, w_2, w_3, w_4 / R_{truck}$

$(cab, cb / R'_{truck}), (f, w_1, w_2, w_3, w_4 / R''_{truck}) / R_{truck}$

# The truck ( $t$ )

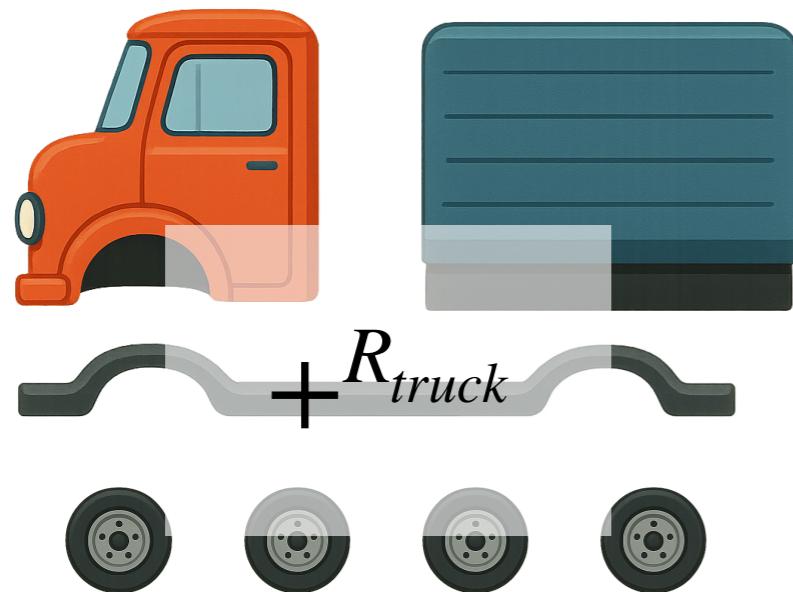
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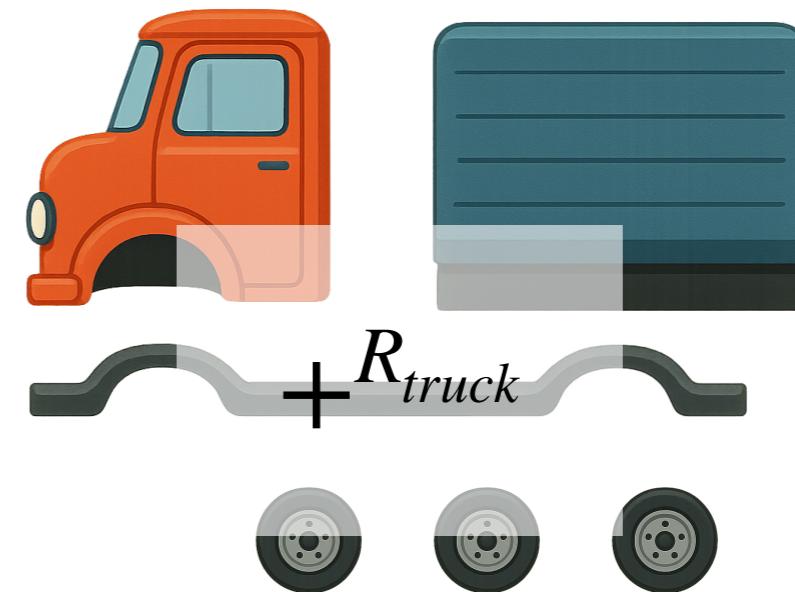
$$cab, cb, f, w_1, w_2, w_3, w_4/R_{truck} \sim (cab, cb/R'_{truck}), (f, w_1, w_2, w_3, w_4/R''_{truck})/R_{truck}$$

# The truck ( $t$ )

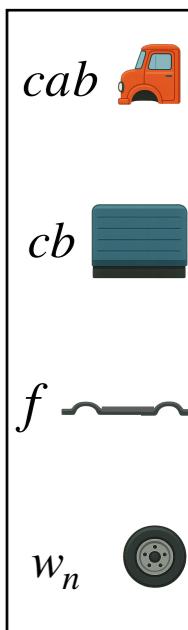
The truck is the same even if it loses one wheel. The object (VE) is the same; the rigid embodiments are however different.



$cab, cb, f, w_1, w_2, w_3, w_4/R_{truck}$

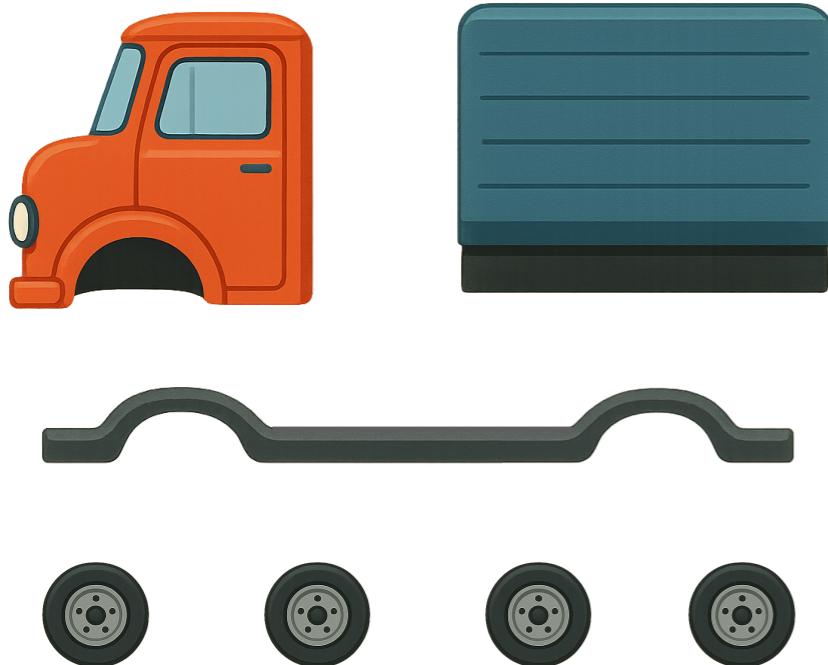


$cab, cb, f, \_, w_2, w_3, w_4/R_{truck}$



# The truck ( $t$ )

We can distinguish between immediate parts and mediate parts:

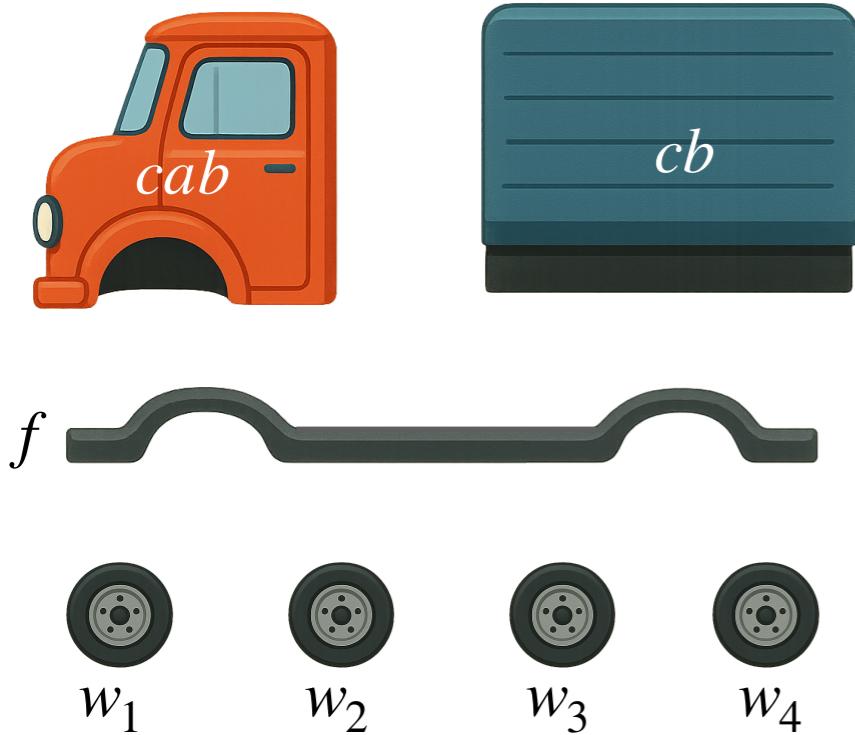


Immediate parts:  $x$  is immediate part of a RE  $r$  iff there is a rigid embodiment  $a_1, \dots, a_n/R$  equivalent to  $r$  such that  $x$  is one of  $a_1, \dots, a_n$  or  $R$ . (**R4\***)

Mediate parts:  $x$  is a (timeless) mediate part of  $r$  iff for any objects  $xx$  that include all the immediate parts of  $r$  and are closed under the relation of (timeless) immediate part, we have  $x \prec xx$ .

# The truck ( $t$ )

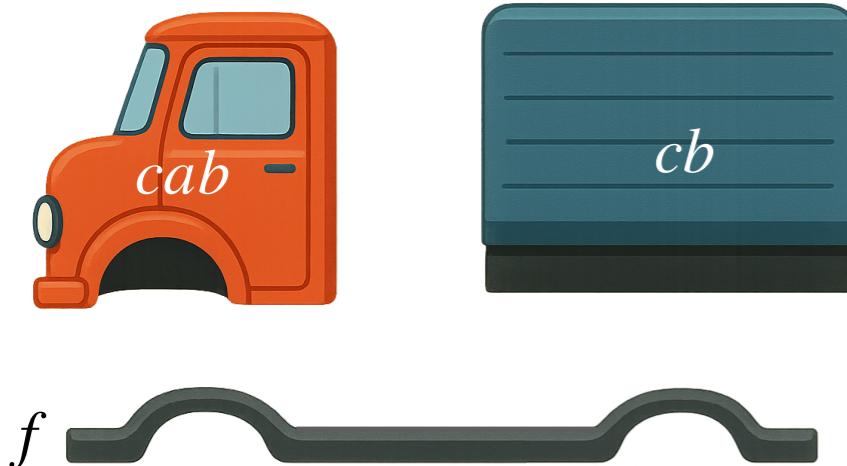
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Immediate parts: the cab, the cargo body, the frame, and four wheels.

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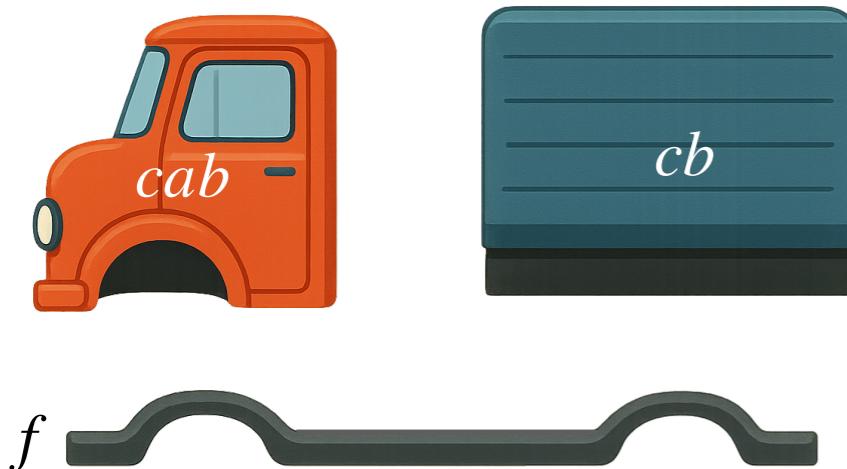
Each of them will have immediate parts as well: the door, the windscreen, the frontal light, and the remaining part of the cab.



$$cab = d, w, l, r / R_{cab}$$

# The truck ( $t$ )

We can distinguish between immediate parts and mediate parts:



Immediate parts: the cab, the cargo body, the frame, and four wheels.

Each of them will have immediate parts as well: the door, the windscreen, the frontal light, and the remaining part of the cab.



These will only be mediate parts of the truck:  $t = (d, w, l, r/R_{cab}), cb, f, w_1, w_2, w_3, w_4/R_{truck}$

# **The transport service company (hands-on)**

# The transport service company (*o*)



“TC-Freight”

The organisation has also a certain structure provided by the roles it includes.

# The transport service company ( $\sigma$ )



In our case, we have the following roles:

- the president, necessarily one
- the drivers, possibly many
- the mechanics, possibly many
- and the administrative assistants, possibly many
- registered name of the company, necessarily one

In this case, the relation, AKA the principle of embodiment, also provides information about roles.

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**Exercise:** write the relation describing the organisation, and the corresponding RE formula.

# The transport service company ( $o$ )



In our case, we have the following roles:

- the president, necessarily one ( $p$ ).
- the drivers, possibly many ( $dd$ )
- the mechanics, possibly many ( $mm$ )
- and the administrative assistants, possibly many ( $aa$ )
- registered name of the company, necessarily one ( $n$ )

In this case, the relation, AKA the principle of embodiment, also provides information about roles.

Solution:

The relation describing the roles:  $R_{org}(p, dd, mm, aa, n)$

In terms of a RE:  $p, dd, mm, aa, n / R_{org}$

# The transport service company ( $o$ )



@ $t$  :  $j$        $b$        $s$        $a$

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At a specific point in time  $t$ , we have:

- Jane is the president ( $j$ ),
- Bob is the driver ( $b$ ),
- Sara is the mechanic ( $s$ ),
- Alex is the administrative assistant ( $a$ ),
- TC-Freight ( $tc$ ) is the company's name (fixed in time).

# The transport service company ( $o$ )



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 $@t' : j \quad b, m \quad s, p \quad a$

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At another time  $t'$ , we have:

- Jane is the president ( $j$ ),
- Bob and Mary are the drivers ( $b, m$ ),
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**Exercise:** write the structure of the instantiated  $o$  and the corresponding RE formulas.

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Solution:

$R_{org}(j, b, s, a, tc);$

in terms of a RE:  $j, b, s, a, tc / R_{org}$

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Solution:

$R_{org}(j, (b, m), (s, p), a, tc);$

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- Alex is the administrative assistant ( $a$ ),
- the company's name is TC-Freight ( $tc$ ).

# Qua objects

# Qua objects (the truck)



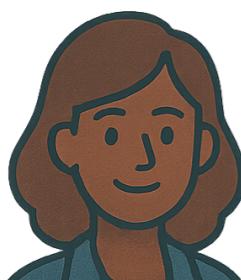
The truck is a single material functional object.

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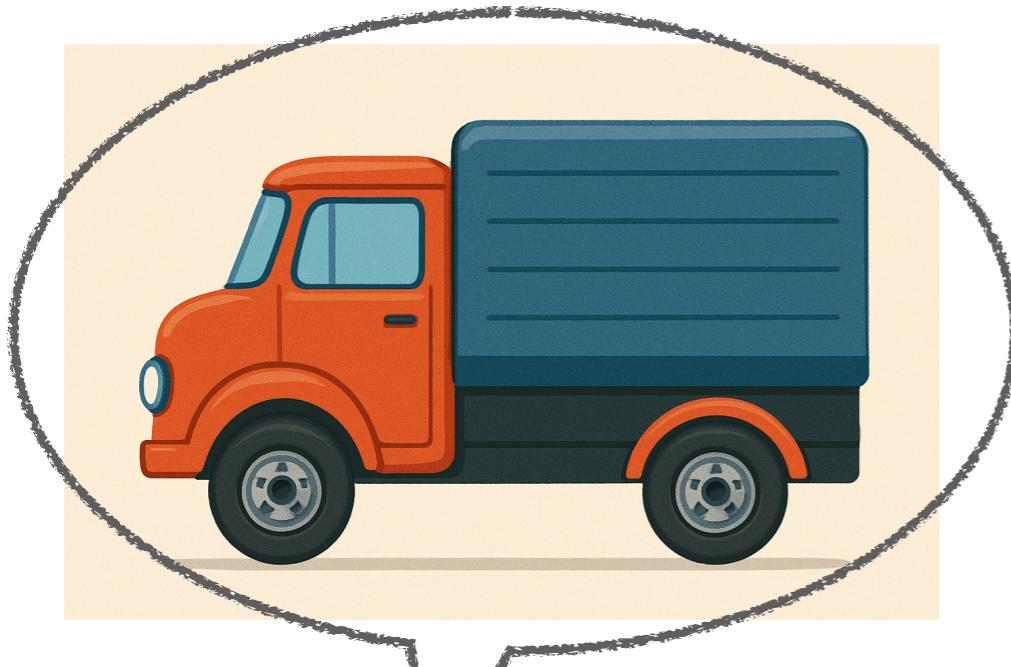


The truck is a single material functional object.

However, depending on their role, the different actors of the company will “see it” in a different way.

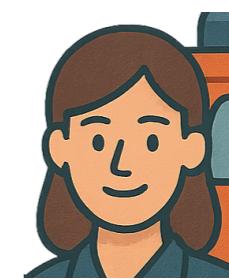
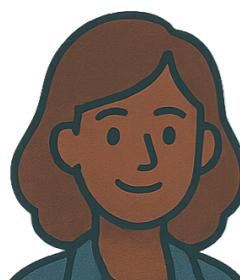


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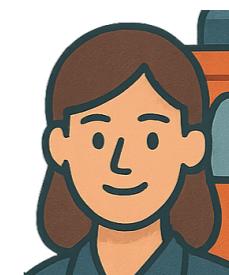
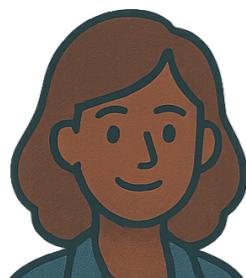
The **president** sees the truck as an economic asset for generating revenue: the focus may be on the costs

# Qua objects (the truck)



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However, depending on their role, the different actors of the company will “see it” in a different way.



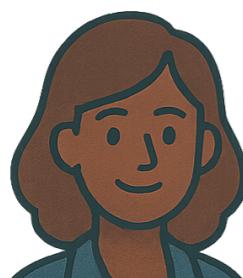
The **driver** sees it as a tool for transportation: the focus is on its functional role, reliability, and possibly comfort while driving

# Qua objects (the truck)



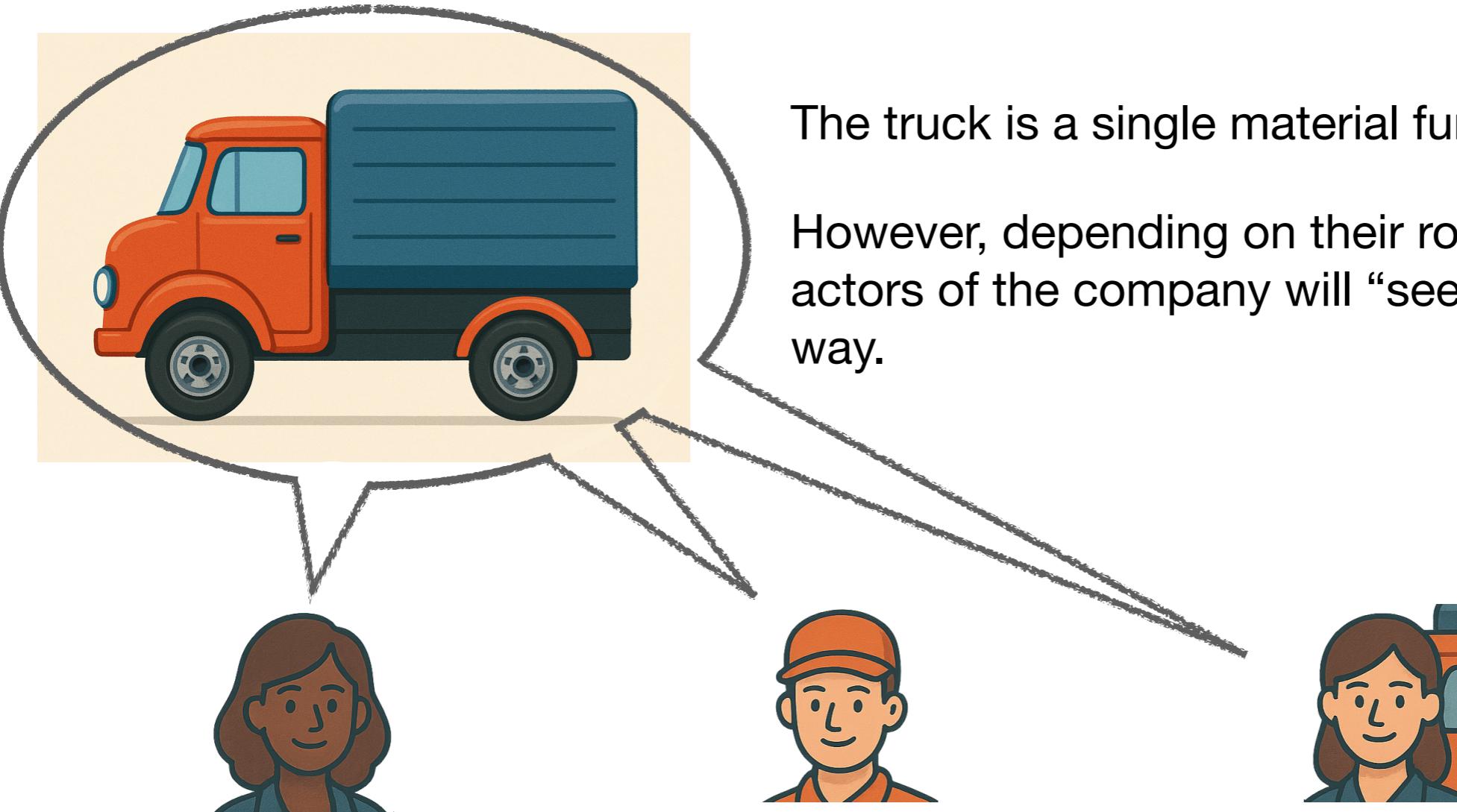
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The **mechanic** sees it as a system of components: the focus is on its maintenance and technical needs

# Qua objects (the truck)



The truck is a single material functional object. However, depending on their role, the different actors of the company will “see it” in a different way.

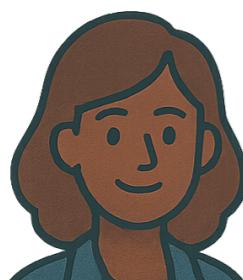
These are **qua-objects**: distinct but dependent entities that embody, in our technical sense, the same underlying object.

# Qua objects (the truck)



The truck is a single material functional object.

However, depending on their role, the different actors of the company will “see it” in a different way.



$t/P$

Truck-qua-president  
("Truck-qua-truck for  
the president")



$t/D$

Truck-qua-driver



$t/M$

Truck-qua-mechanic

# Qua objects (the truck)



The qua-object inherits some properties from the object from which it is obtained.

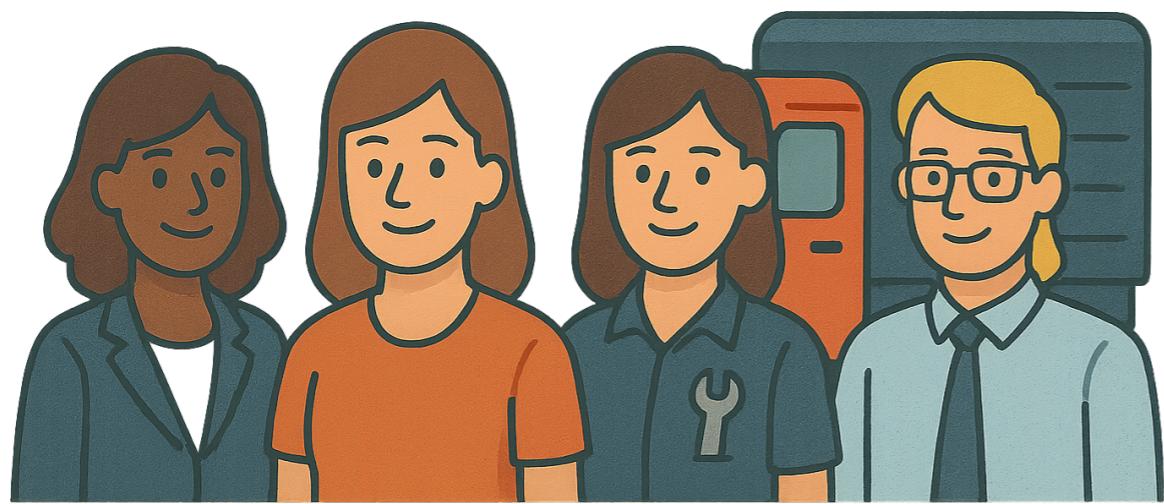
For  $t/P$ , the truck's cost and functionality;

For  $t/D$ , the truck's reliability and comfort;

For  $t/M$ , its technical condition, ease of repair, etc.

# **Variable Embodiment**

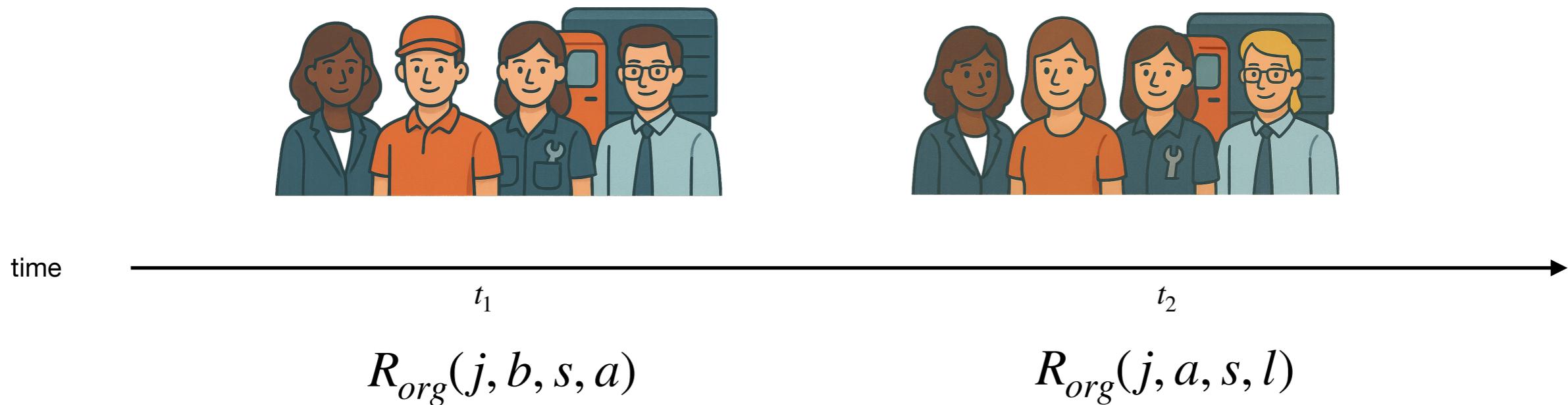
# Variable Embodiment



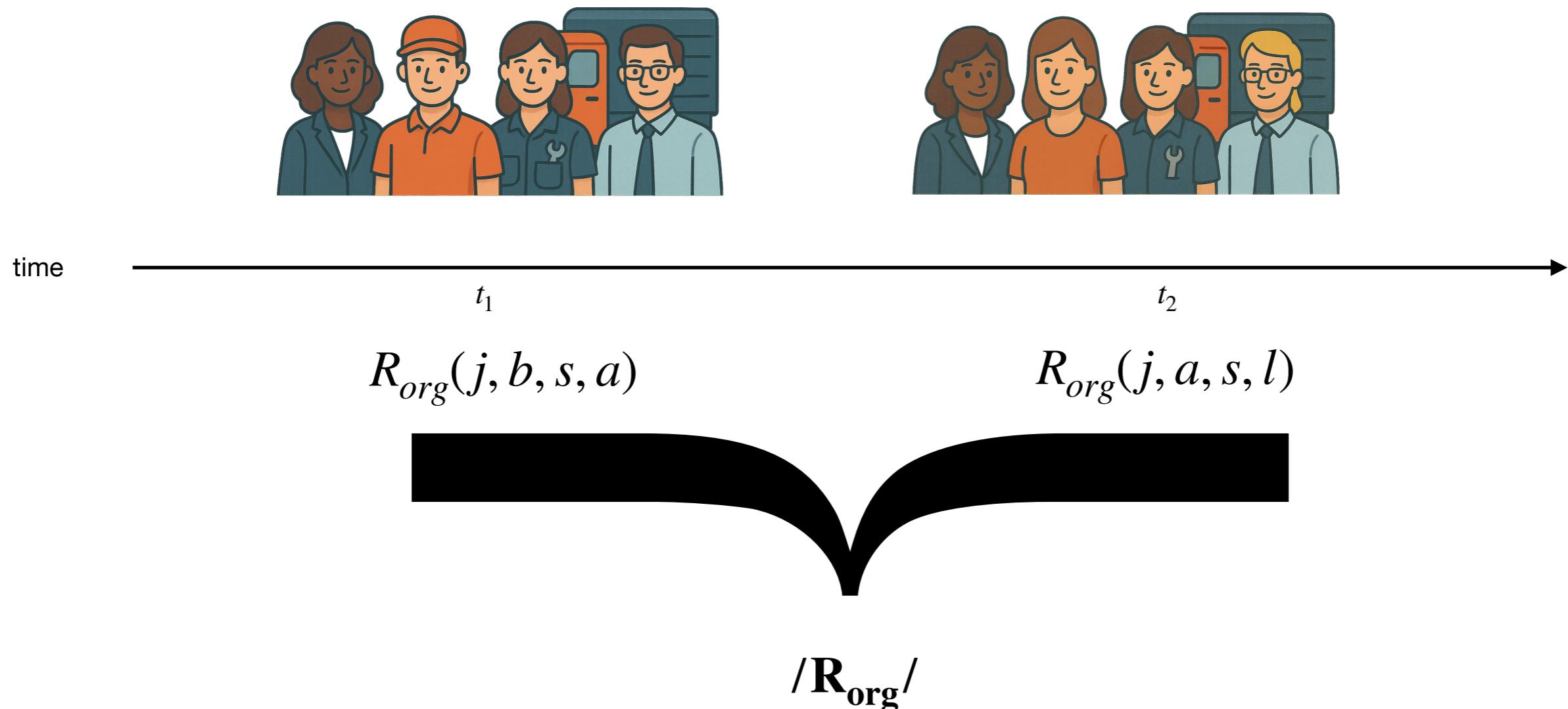
In time, both the parts of the truck and the parts of the organisation can change.

# **The organisation in time**

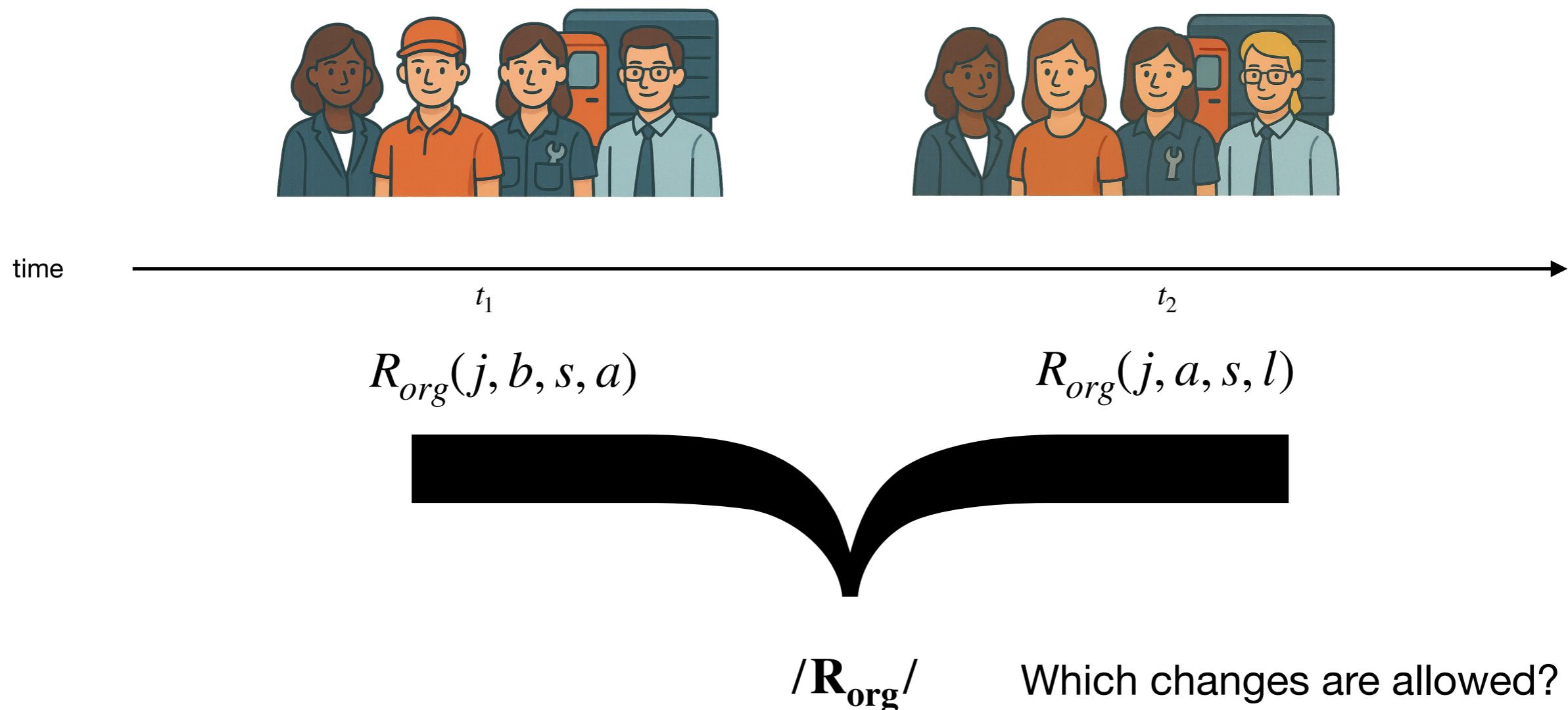
# The organisation in time



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$/R_{org}/$  can change remaining the same organisation through non-disruptive-changes (NDC):

(I) replacement:

(II) reassignment:

(III) gain or loss of players:

# The organisation in time



/R<sub>org</sub>/ can change remaining the same organisation through non-disruptive-changes (NDC):

- (I) replacement: Sara (the mechanic) leaves the company and a new one (Sally) is hired.
- (II) reassignment: Bob the mechanic and Sara the driver swap their roles: now Bob is the driver and Sara the mechanic.
- (III) gain or loss of players: Bob was once the only driver in the company; now Mary is hired and the company has two drivers.

# The organisation in time



/R<sub>org</sub>/ can change remaining the same organisation through non-disruptive-changes (NDC):

- (I) replacement: Sara (the mechanic) leaves the company and a new one (Sally) is hired.
- (II) reassignment: Bob the mechanic and Sara the driver swap their roles: now Bob is the driver and Sara the mechanic.
- (III) gain or loss of players: Bob was once the only driver in the company; now Mary is hired and the company has two drivers.

We could also consider changes at the level of the roles (not the players)...

# The organisation in time



/R<sub>org</sub>/ can change remaining the same organisation through non-disruptive-changes (NDC):

(I) replacement:

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(III) gain or loss of roles:

# The organisation in time



/R<sub>org</sub>/ can change remaining the same organisation through non-disruptive-changes (NDC):

- (I) replacement: due to market changes, the company replaces the role of mechanic with that of electro-mechanic.
- (II) reassignment: of roles' responsibilities — the president delegates the administrative assistant some extraordinary responsibilities (e.g., the right to commit to a service without asking the president).
- (III) gain or loss of roles: the company decides to outsourcing a job role - e.g. the driver.

# The organisation in time



$/R_{\text{org}}$  / can change remaining the same organisation through non-disruptive-changes (NDC):

Changes at the level of the roles are “formal” changes: changes at the level of the principle  $R$ . More extreme cases exists:

(IV) empty role:

# The organisation in time

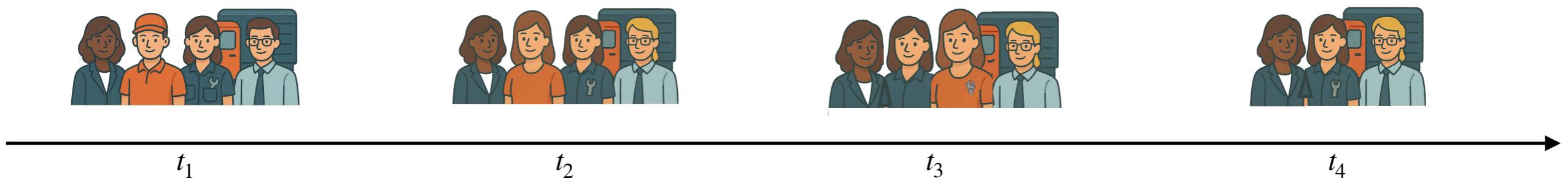


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Changes at the level of the roles are “formal” changes: changes at the level of the principle  $R$ . More extreme cases exists:

- (IV) empty role: the company keeps existing even if the mechanic position is outsourced (NB: difference btw having a role  $r$  with no player and not having role  $r$ ).

# The organisation in time



$R_{org}(j, b, s, a)$

$R_{org}(j, a, s, l)$

$R_{org}(j, s, a, l)$

$R_{org}(j, \_, s, l)$   
 $R'_{org}(j, s, l)$

$/\mathbf{R}_{\mathbf{org}}/$  is then a chain of NDC.

# **The transport service process (hands-on)**

# The transport service process



Processes as well can be modelled as variable embodiments. Accordingly, a process is a variable embodiment that is manifested by different events (or subprocesses) at the different times it exists.

# The transport service process

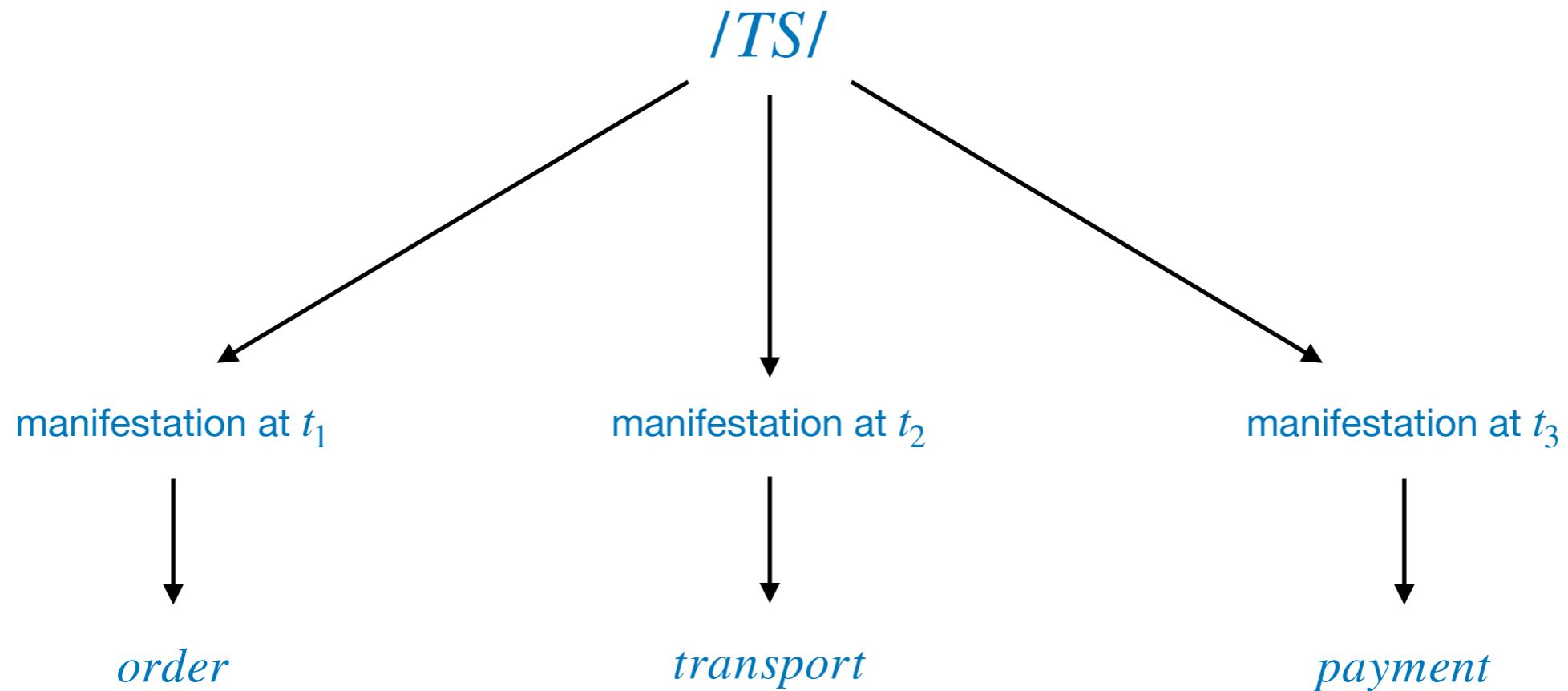


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Exercise: describe a transport service in terms of a variable embodiment (*/TS/*).

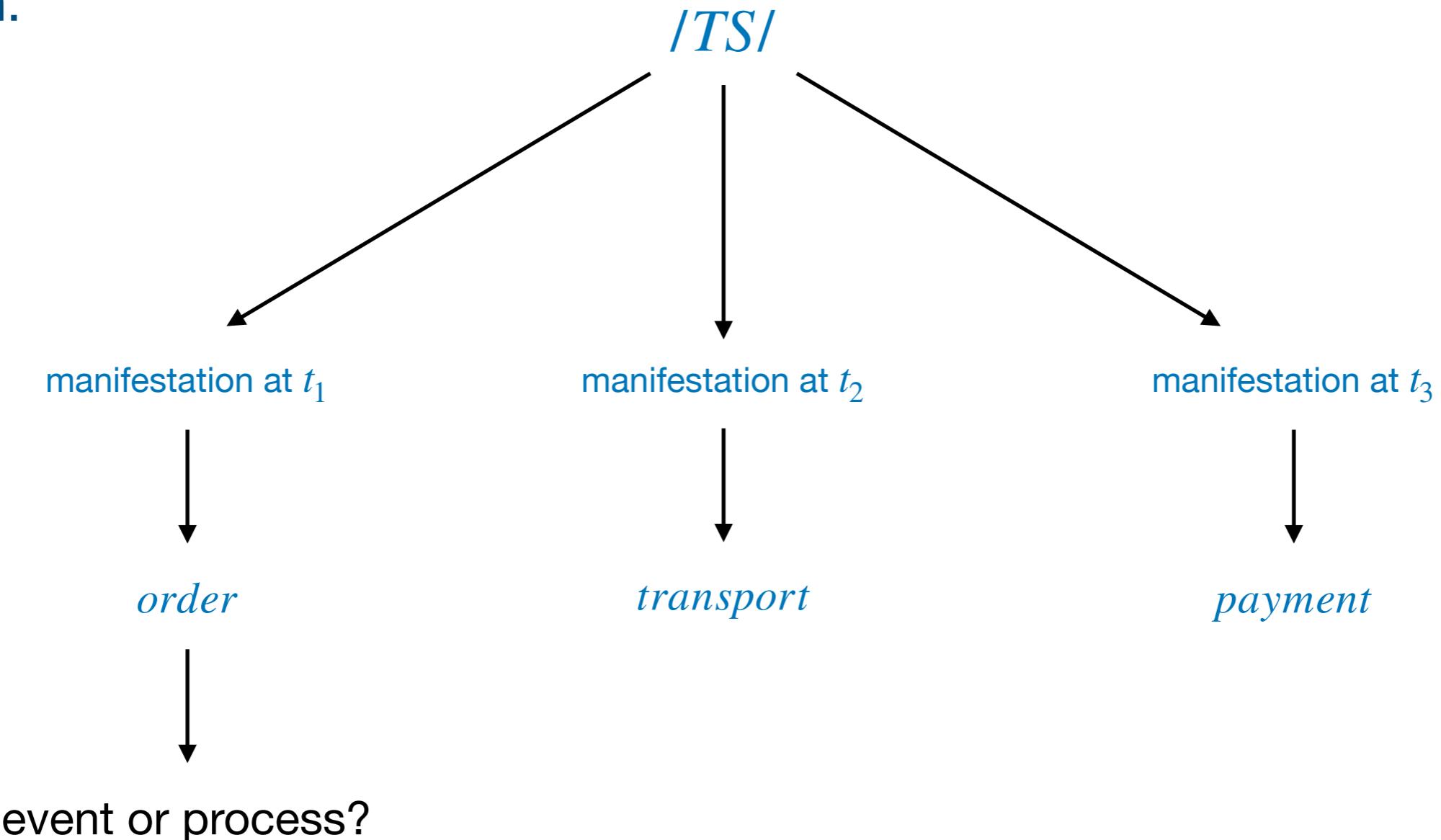
# The transport service process

Solution:



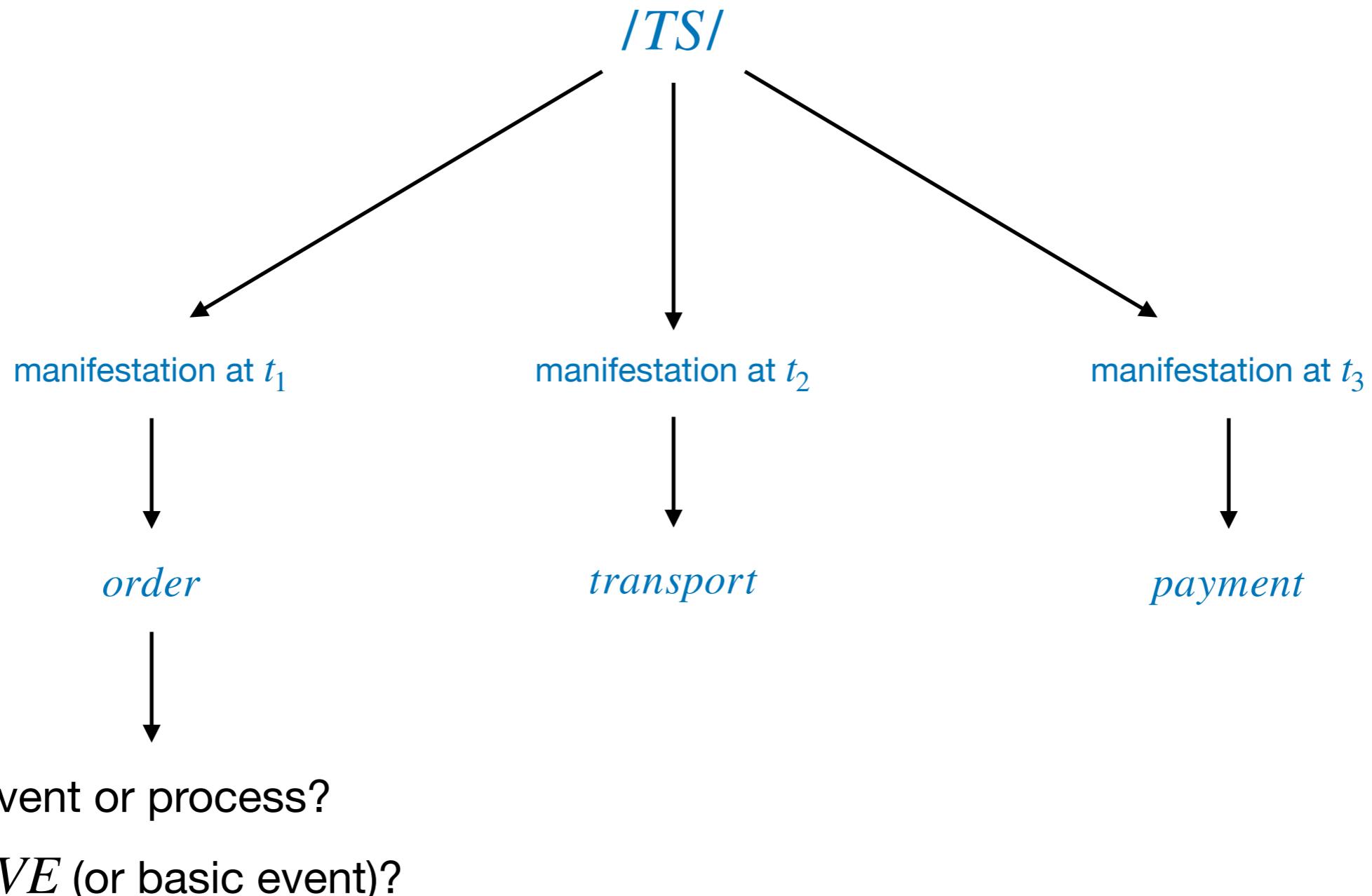
# The transport service process

Solution:



# The transport service process

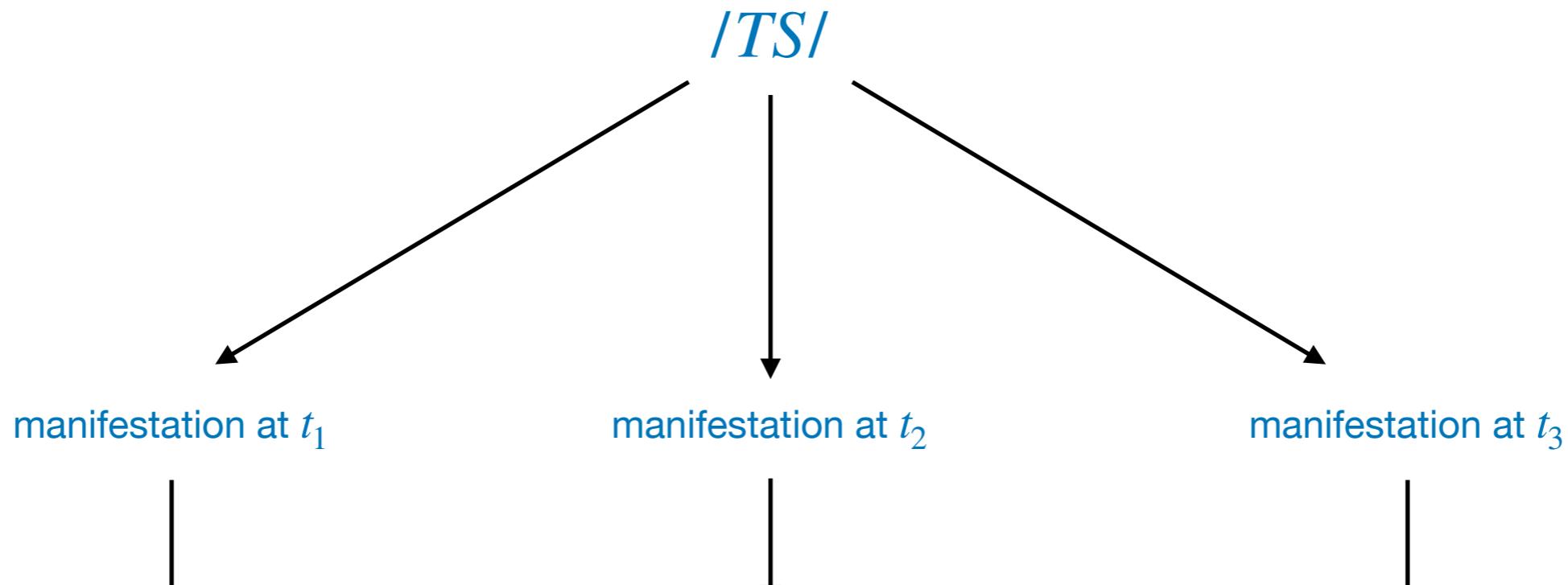
Solution:



*RE, VE (or basic event)?*

# The transport service process

Solution:



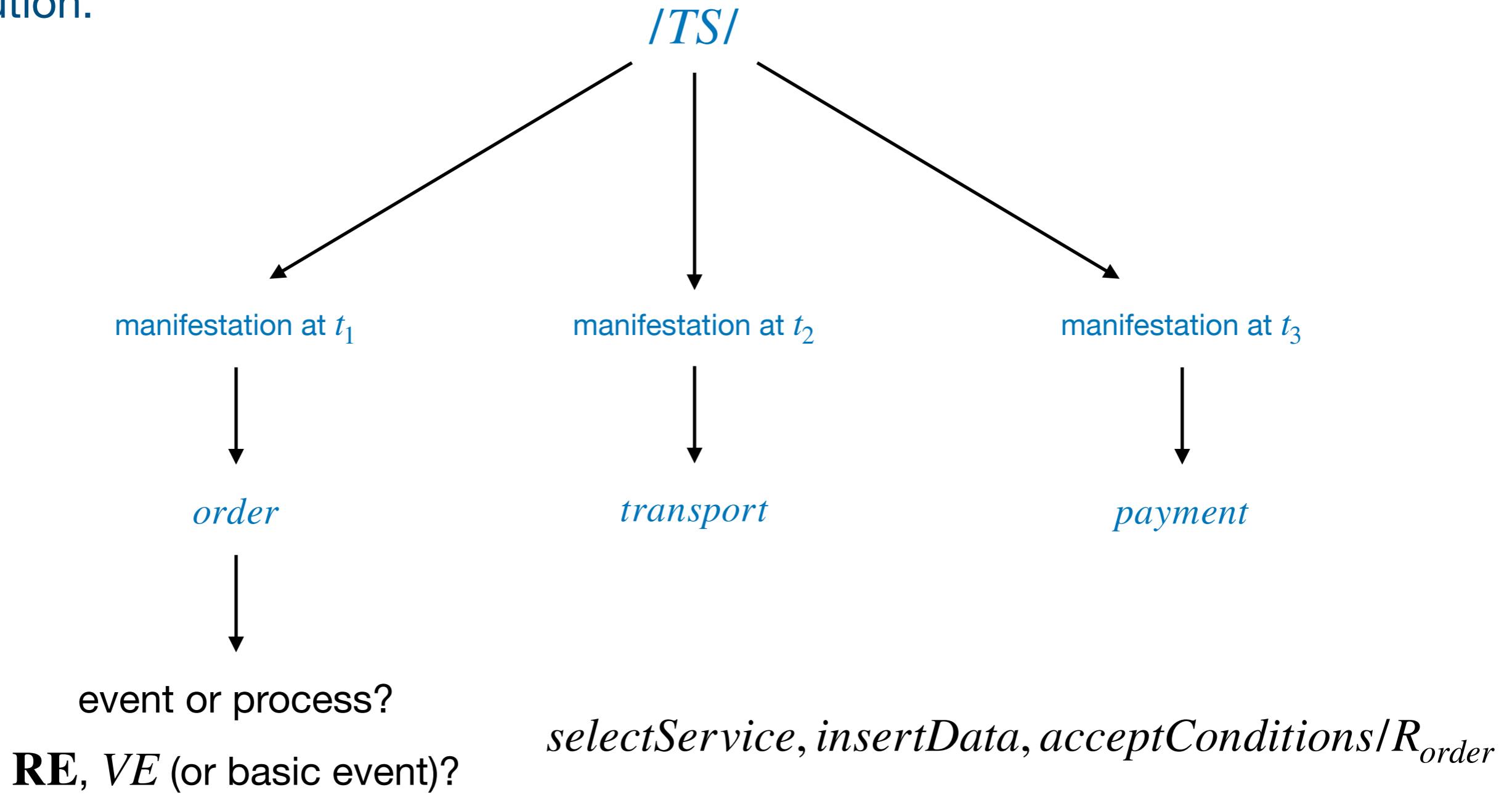
event or process?

**RE, VE (or basic event)?**

as *RE*: the parts of the *RE* are the single moments that compose the event...

# The transport service process

Solution:



# The transport service process

Solution:

