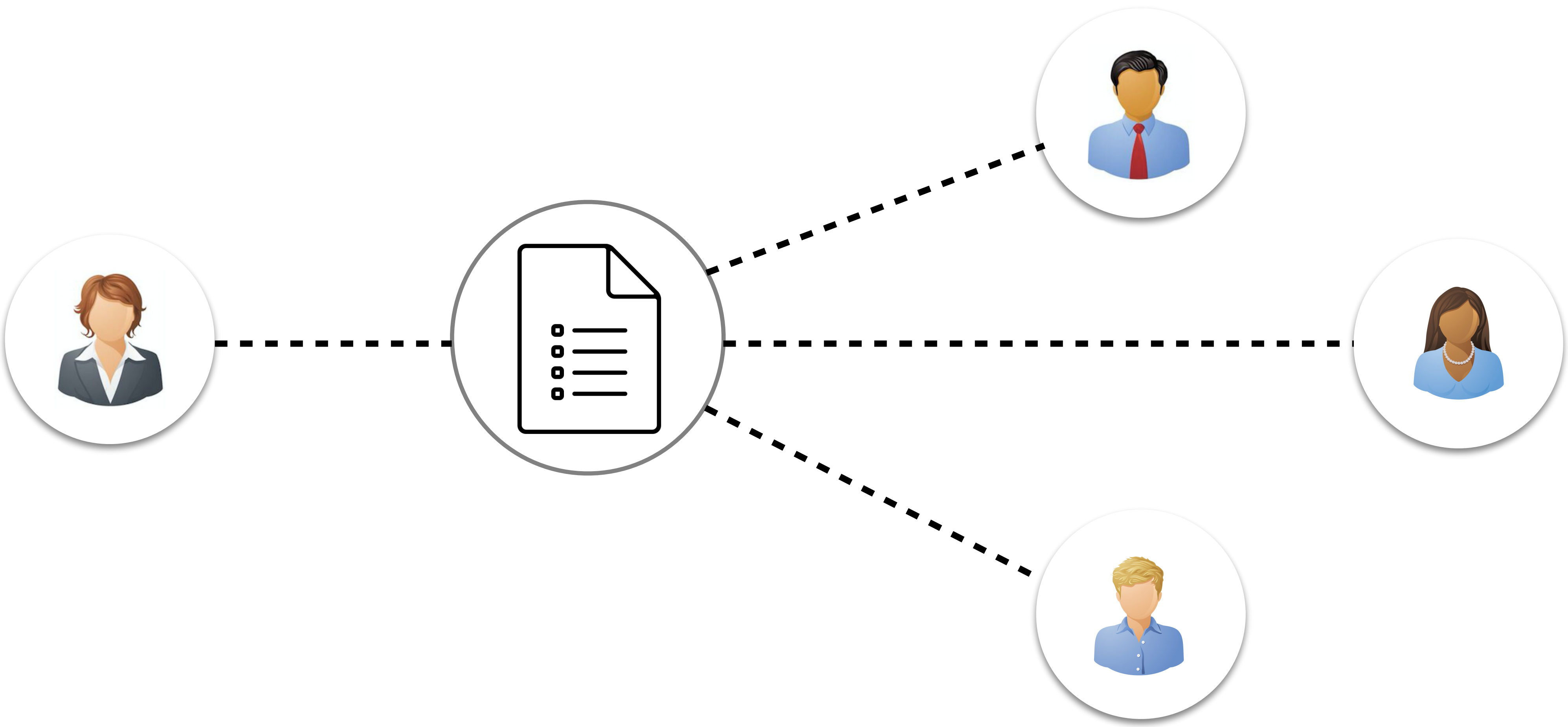
UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

Erhan Leblebici, Anthony Anjorin, Andy Schürr

ON COMBINING TRIPLE GRAPH GRAMMARS AND LINEAR OPTIMISATION TECHNIQUES

A Real-World Example: Overview

dSPACE



Robin Oppermann:
A Configurable, Model-Driven Approach to Optimal Scheduling using Triple Graph Grammars and Linear Progamming.
Ongoing Master's Thesis, Paderborn University in collaboration with dSpace

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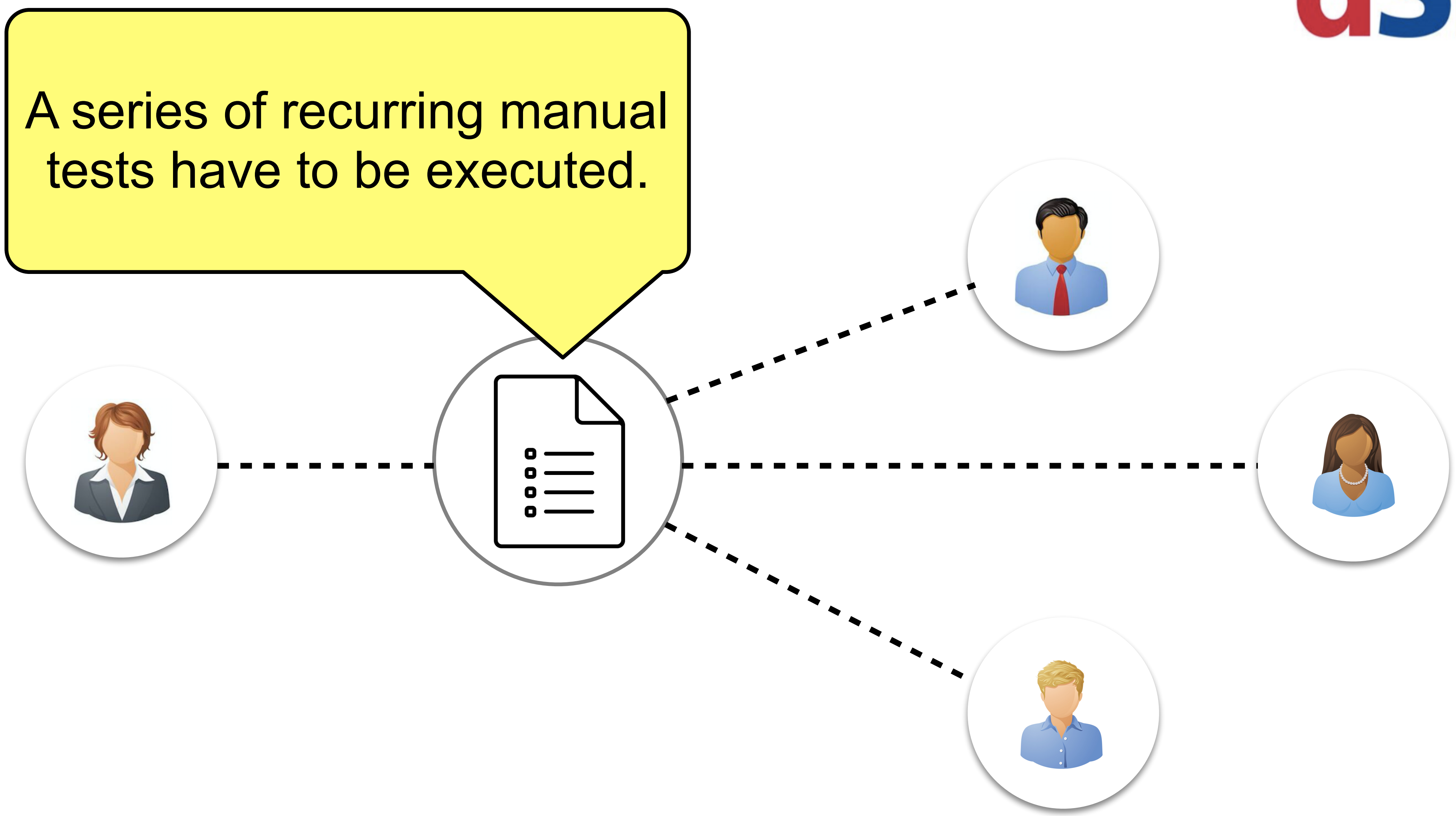

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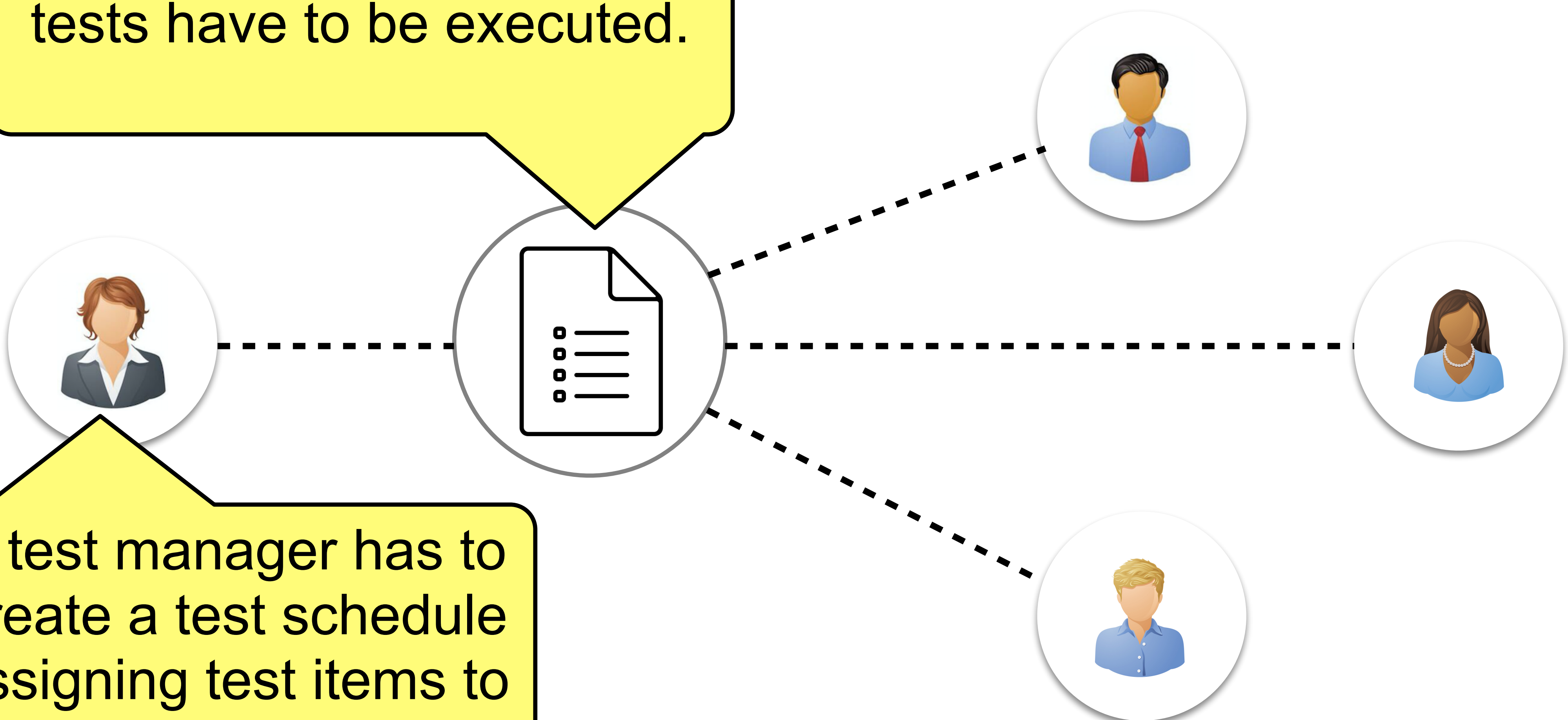
A series of recurring manual tests have to be executed.



A test manager has to create a test schedule assigning test items to developers.

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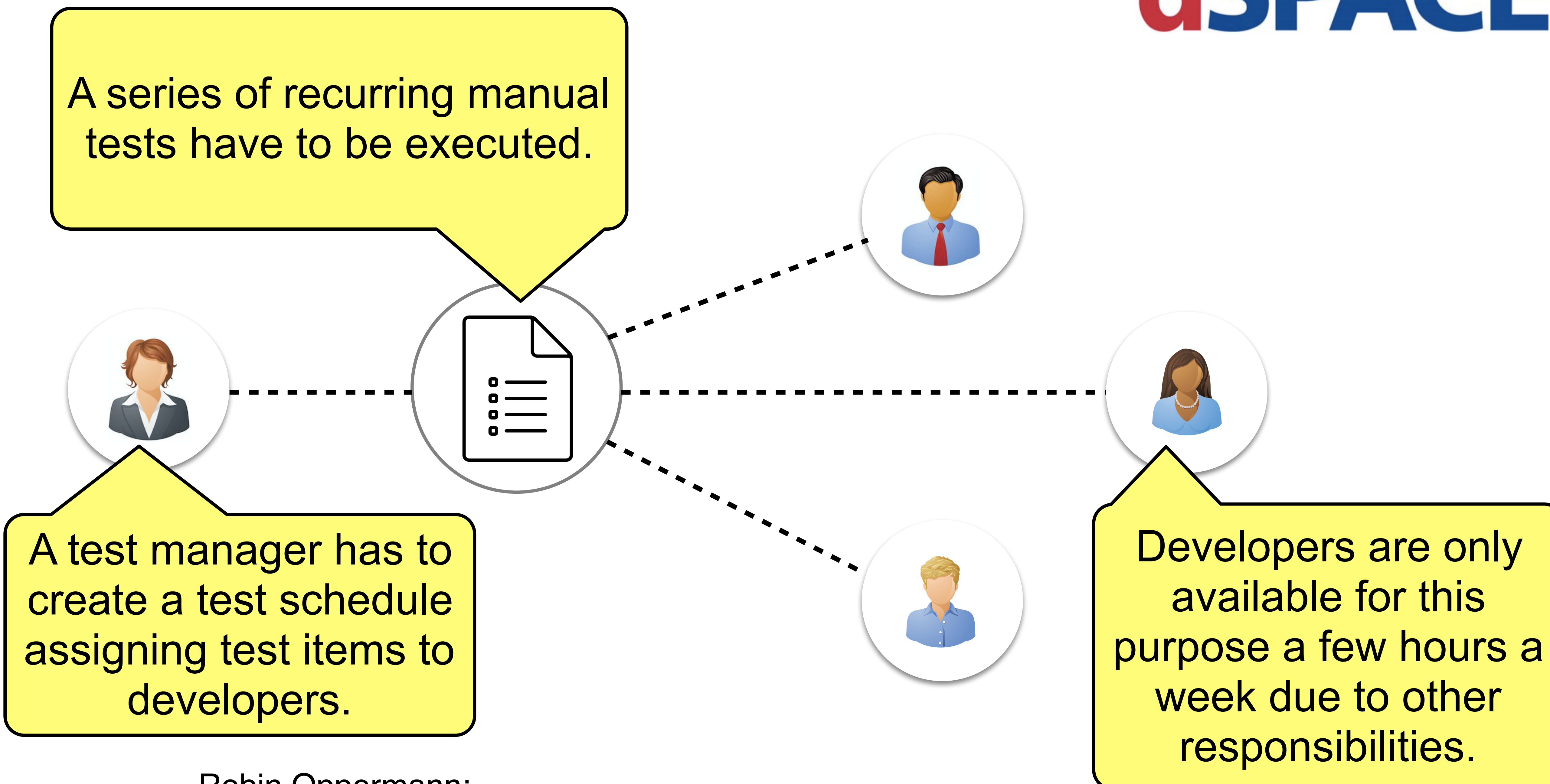

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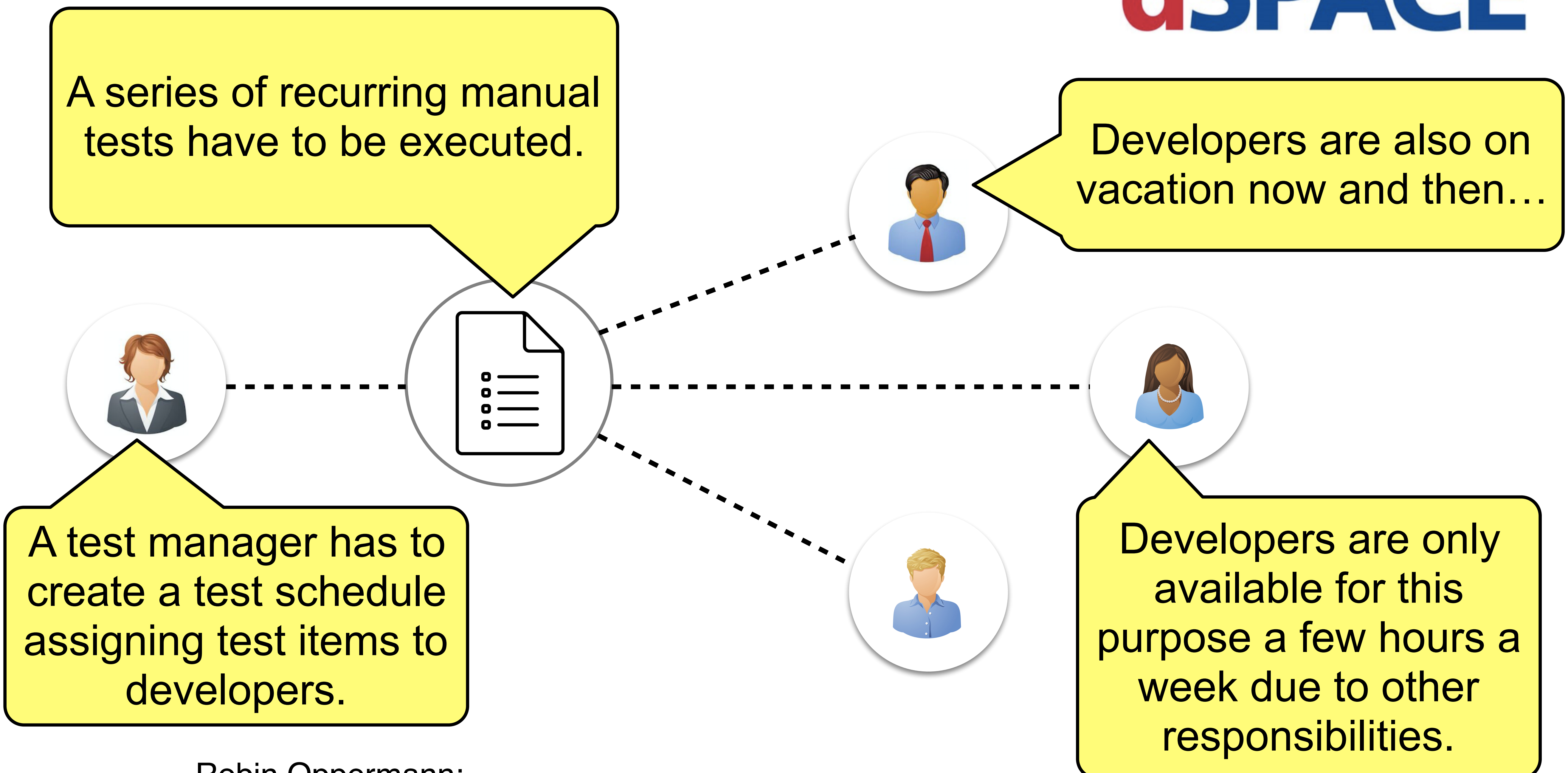

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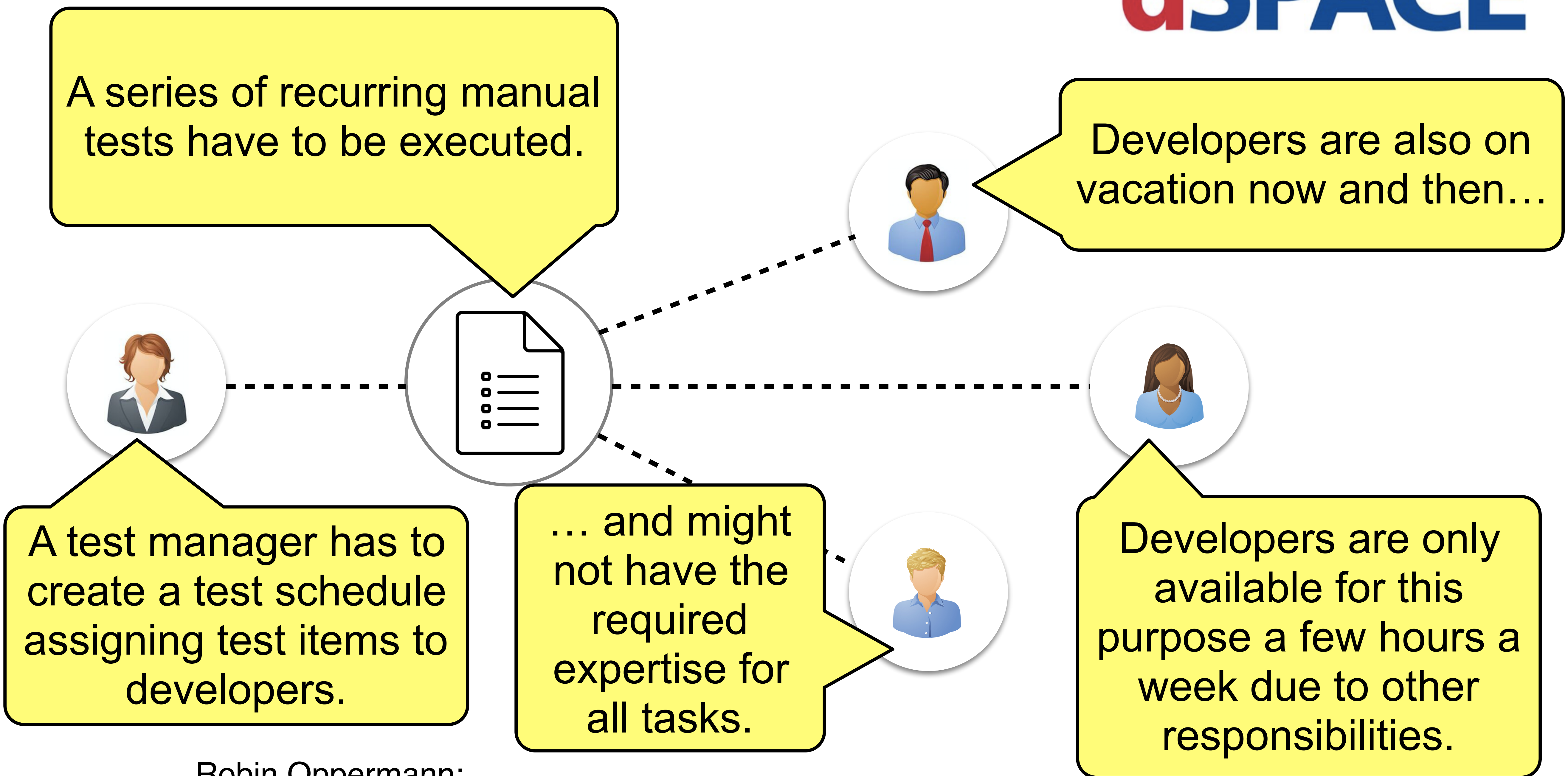

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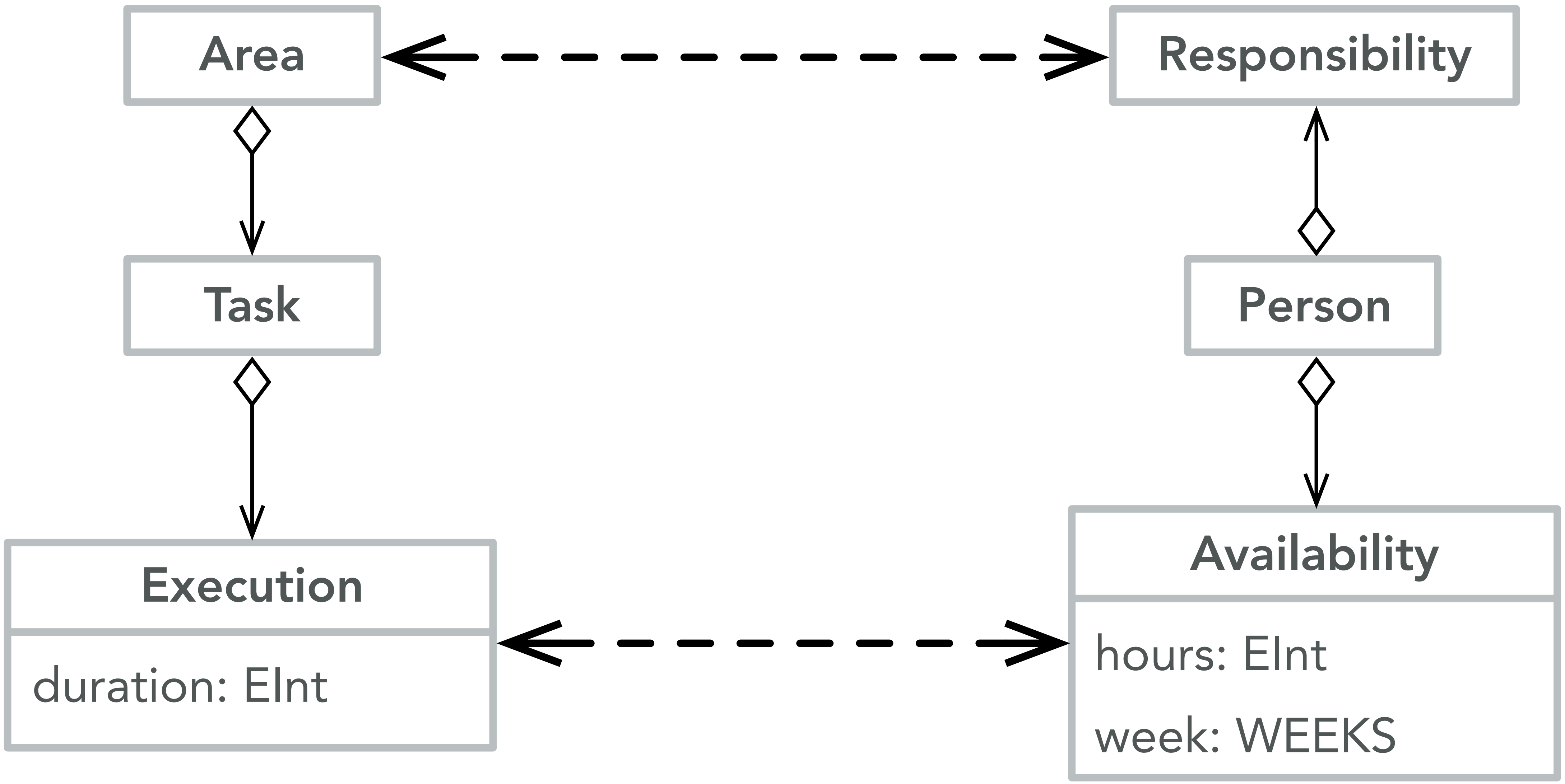
A Real-World Example: Metamodels



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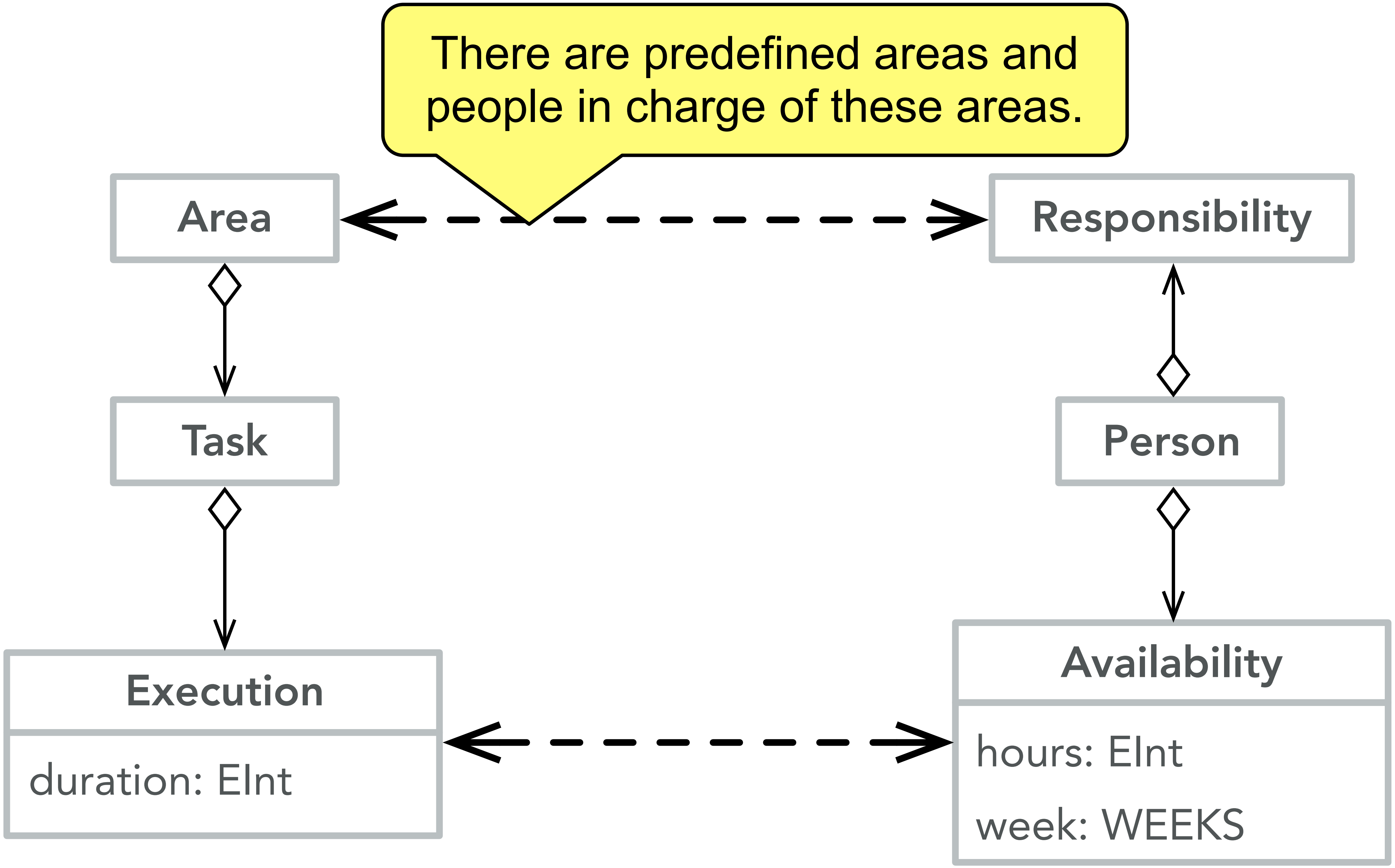

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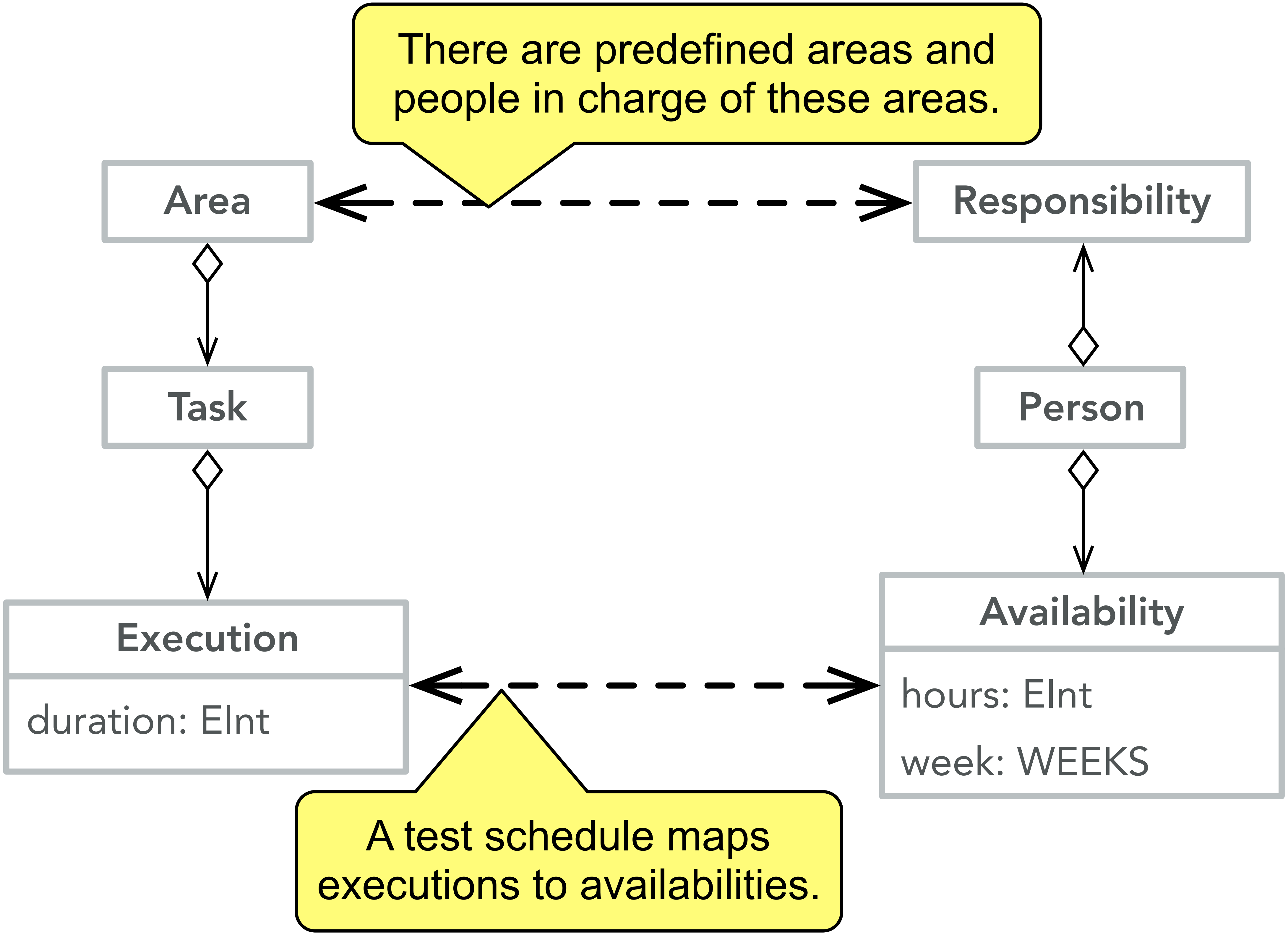

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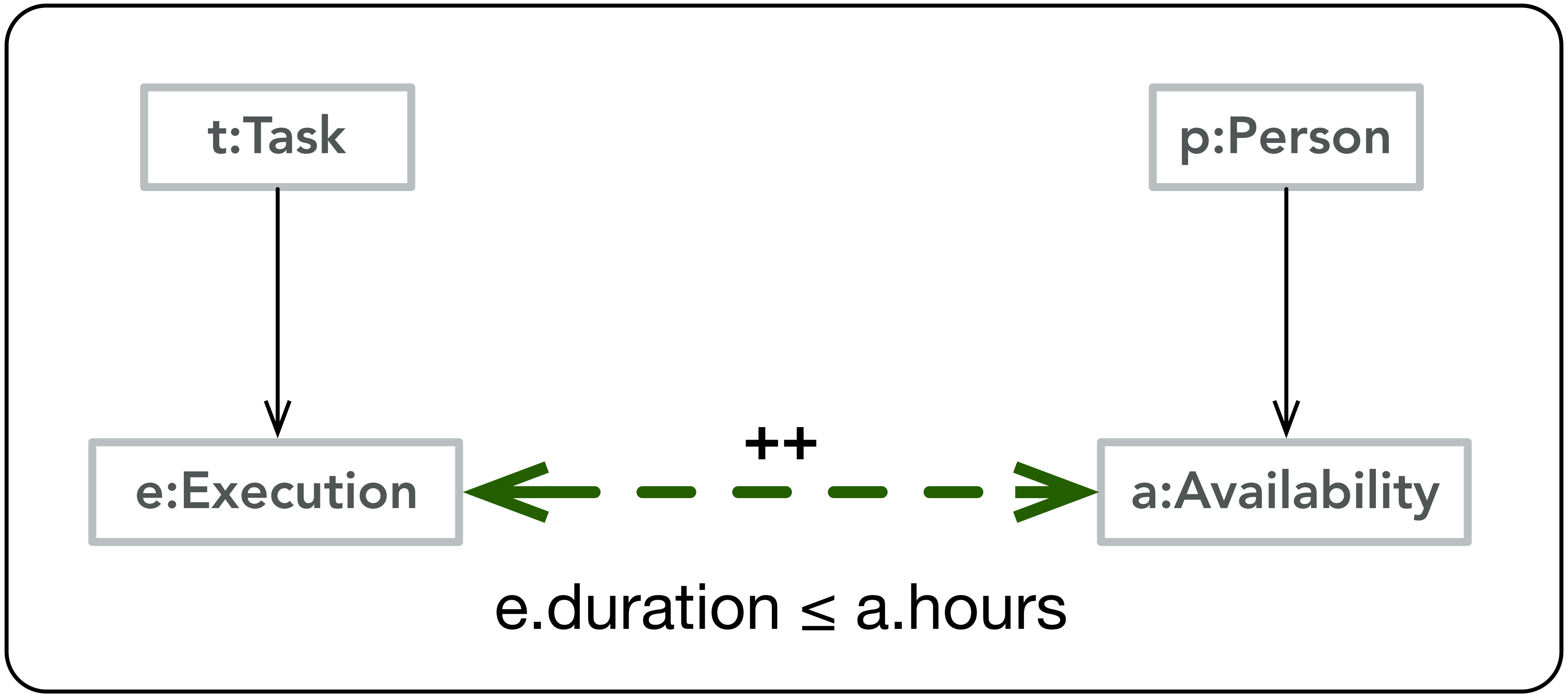

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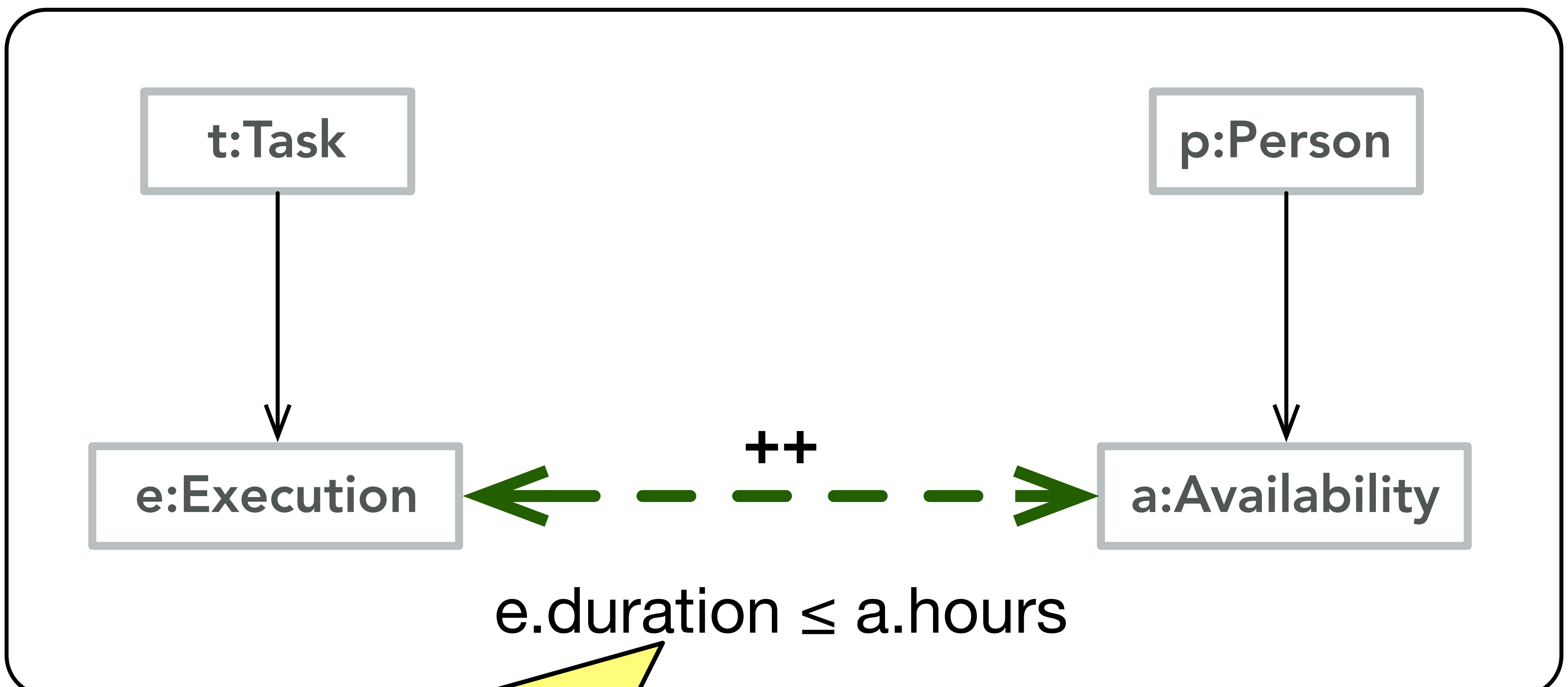

In general, anyone can do anything as long as they have the time for it…

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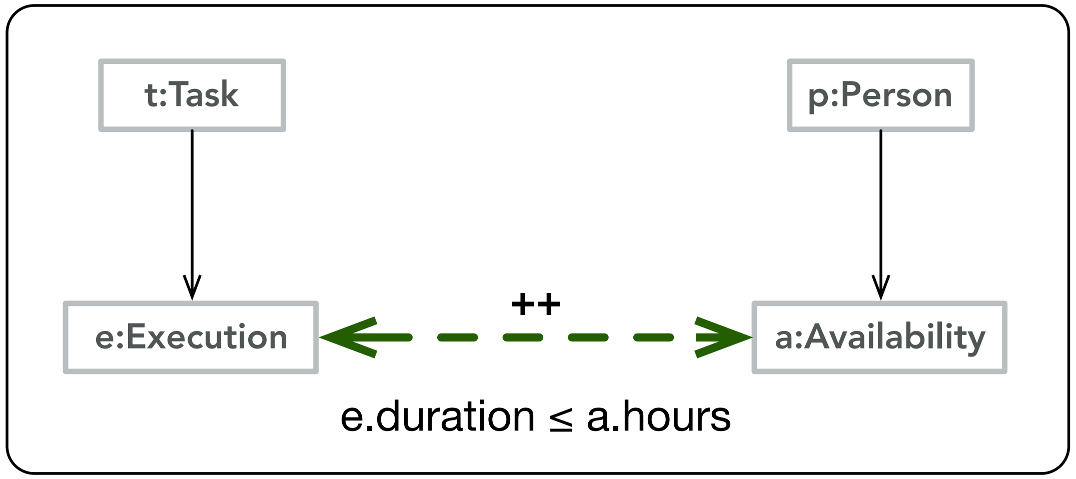

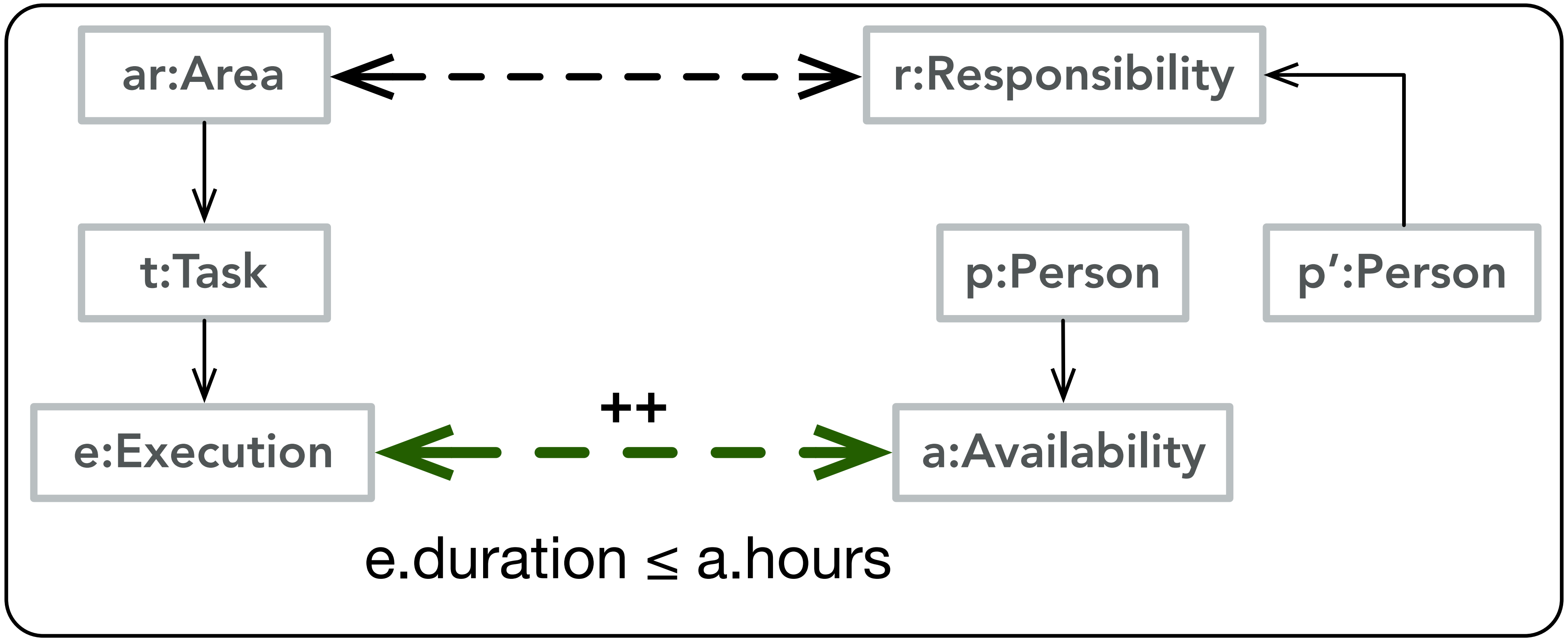

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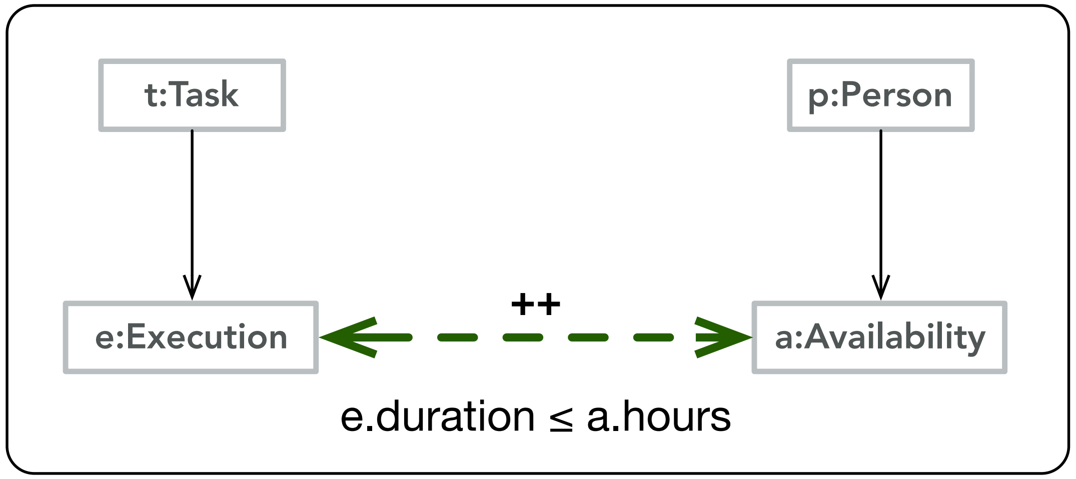

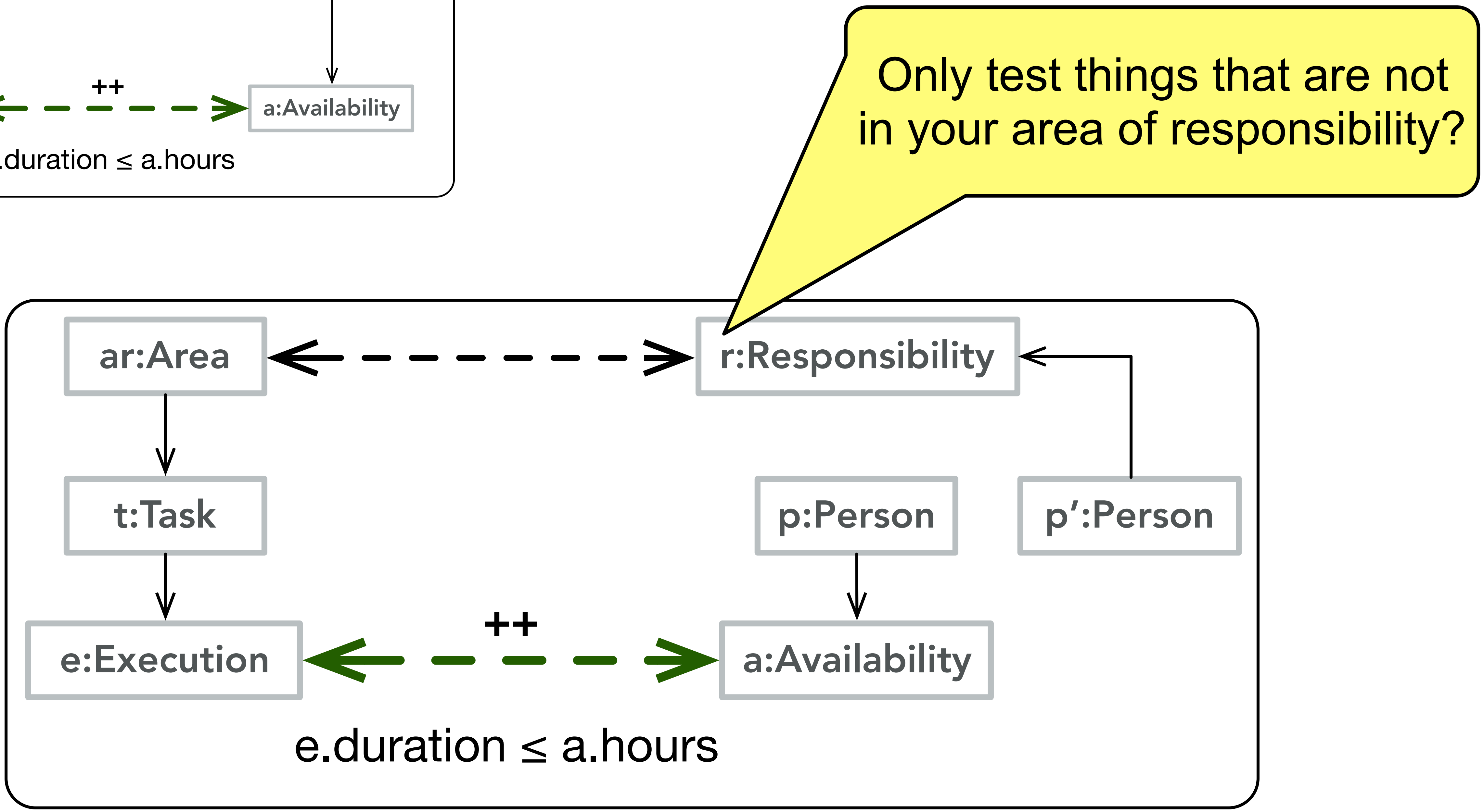

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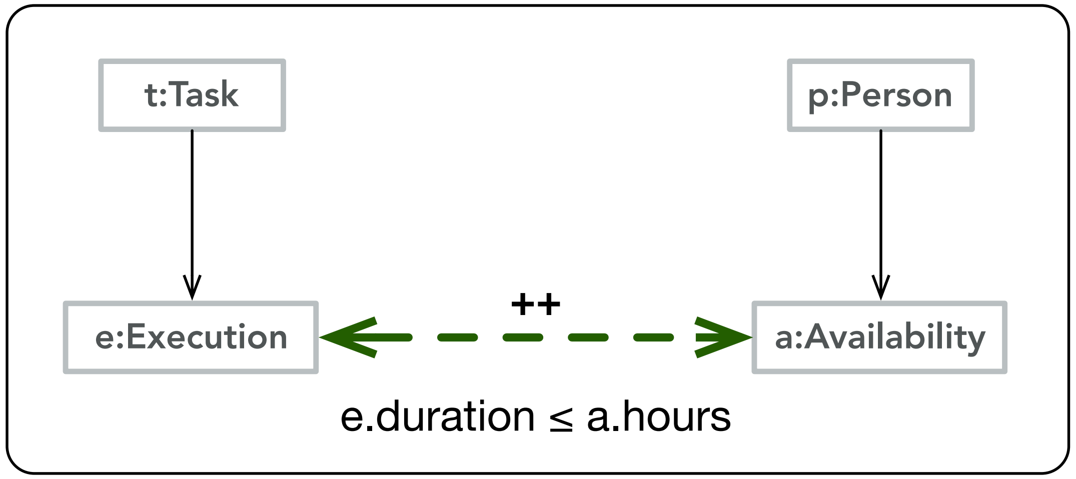

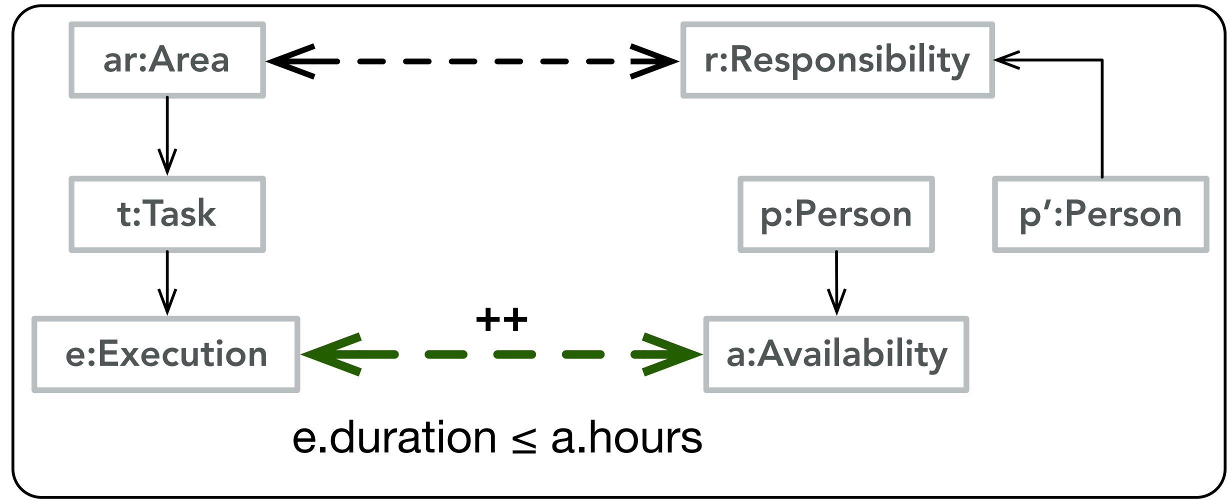

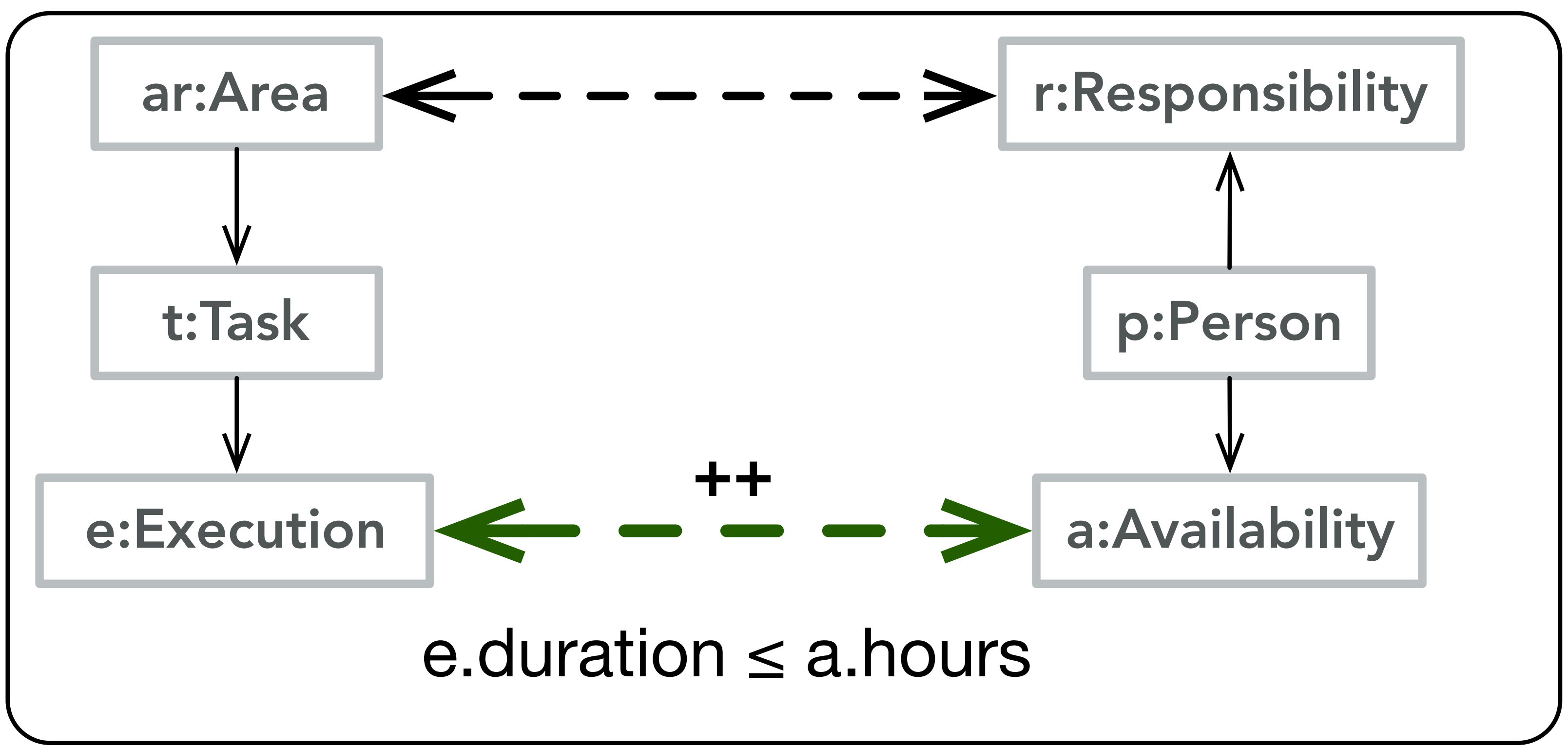

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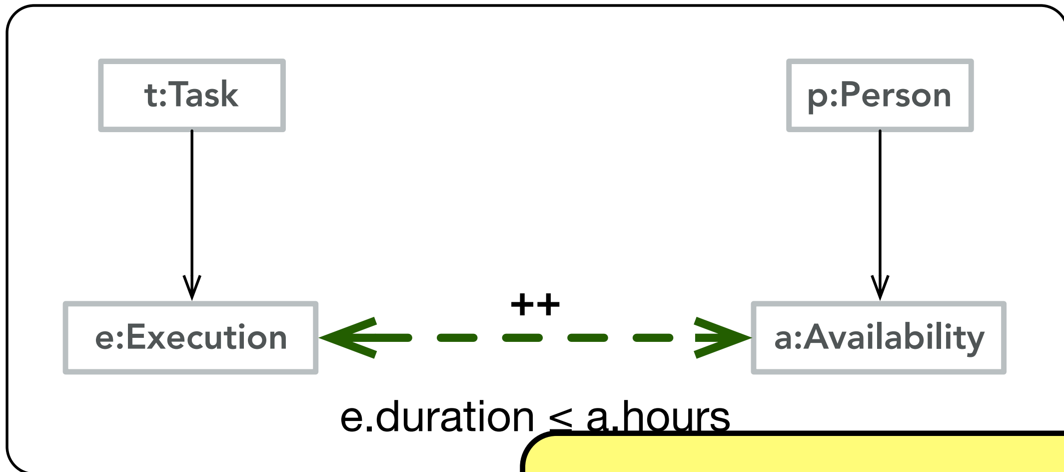
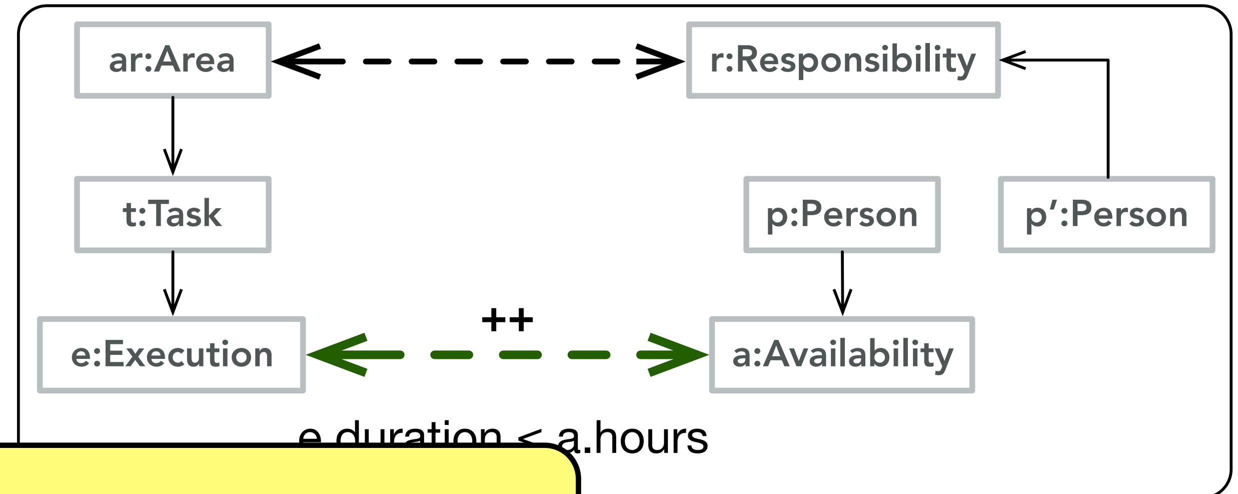
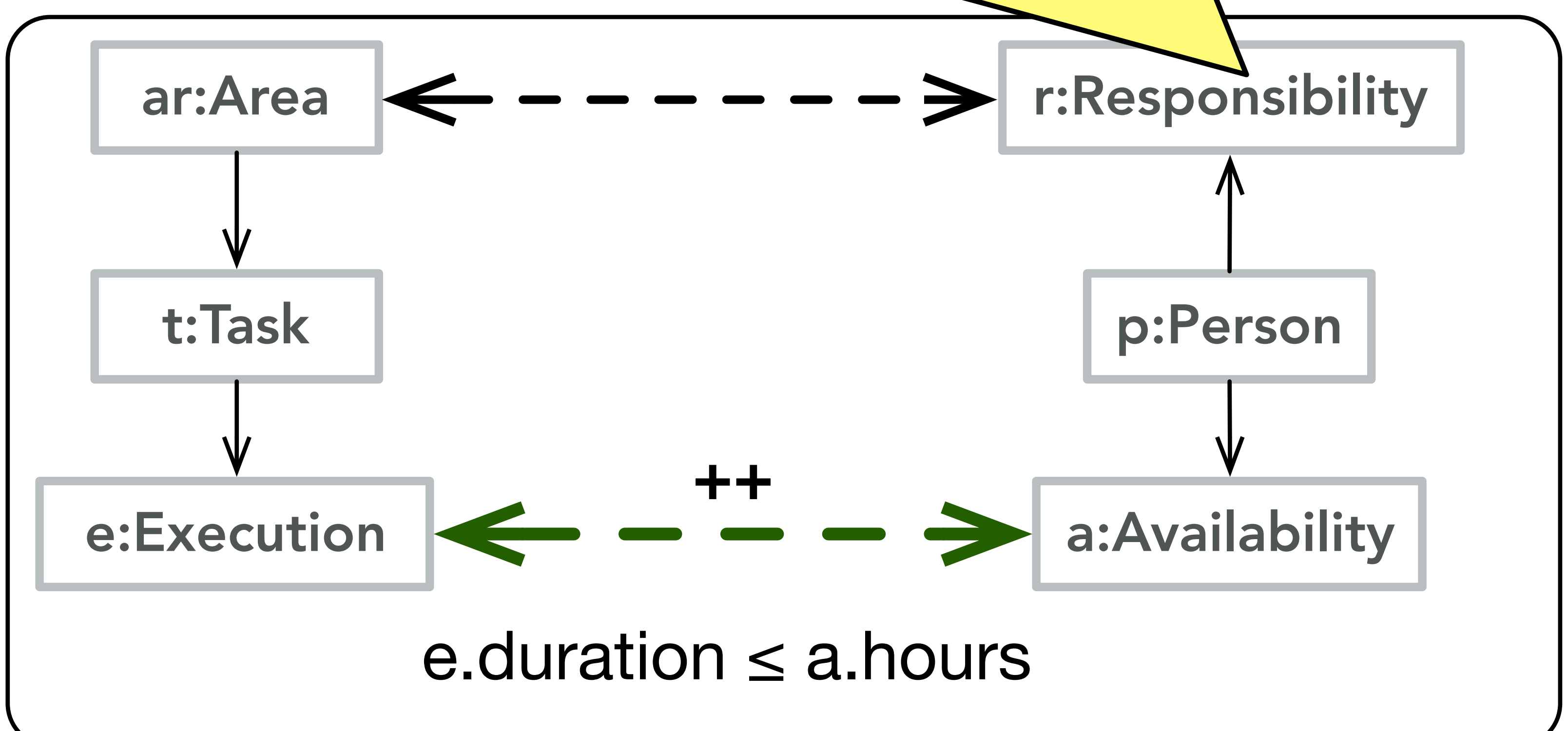




Or perhaps being an expert makes you the best tester possible?



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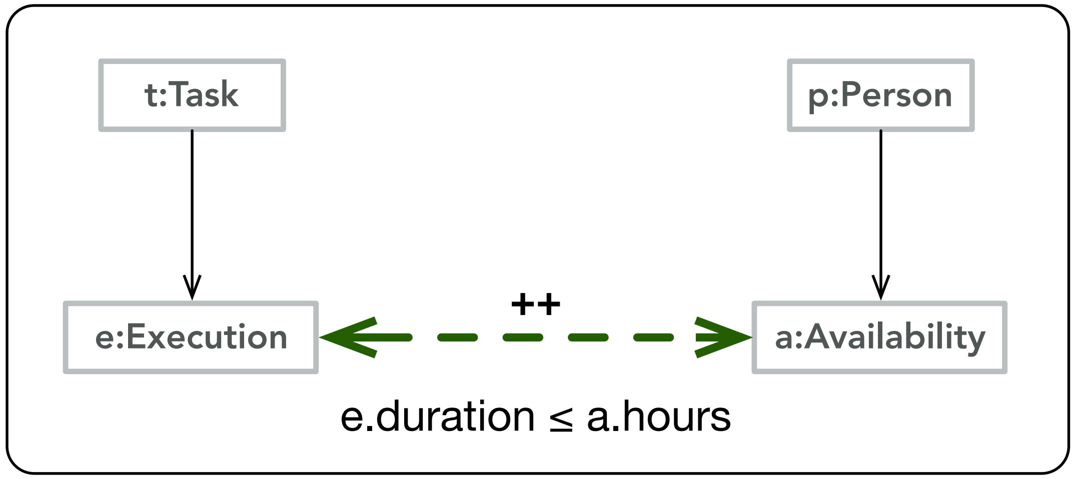

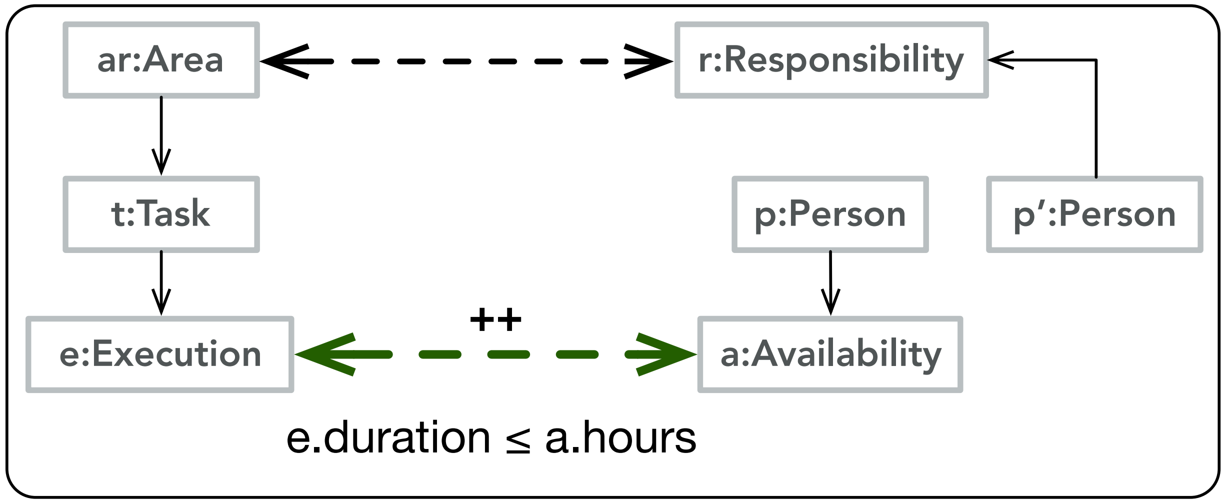

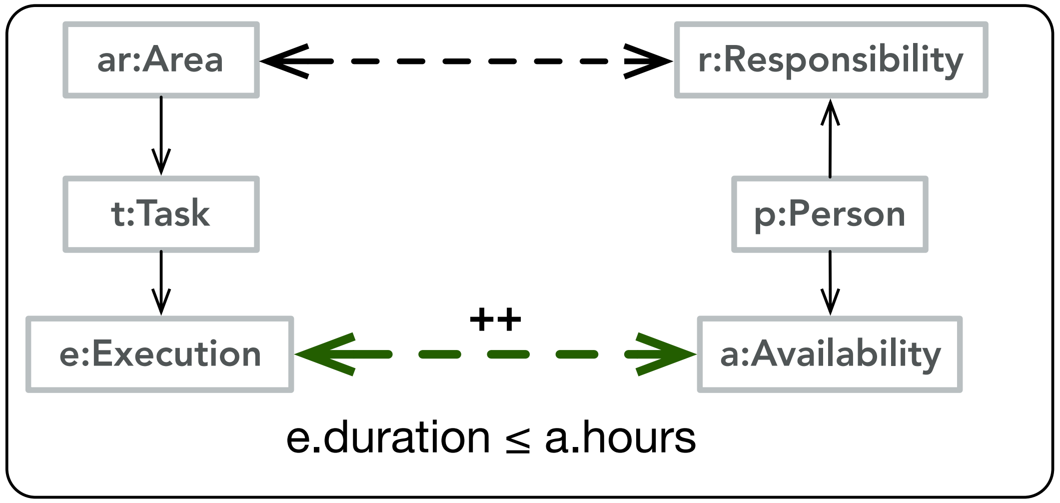

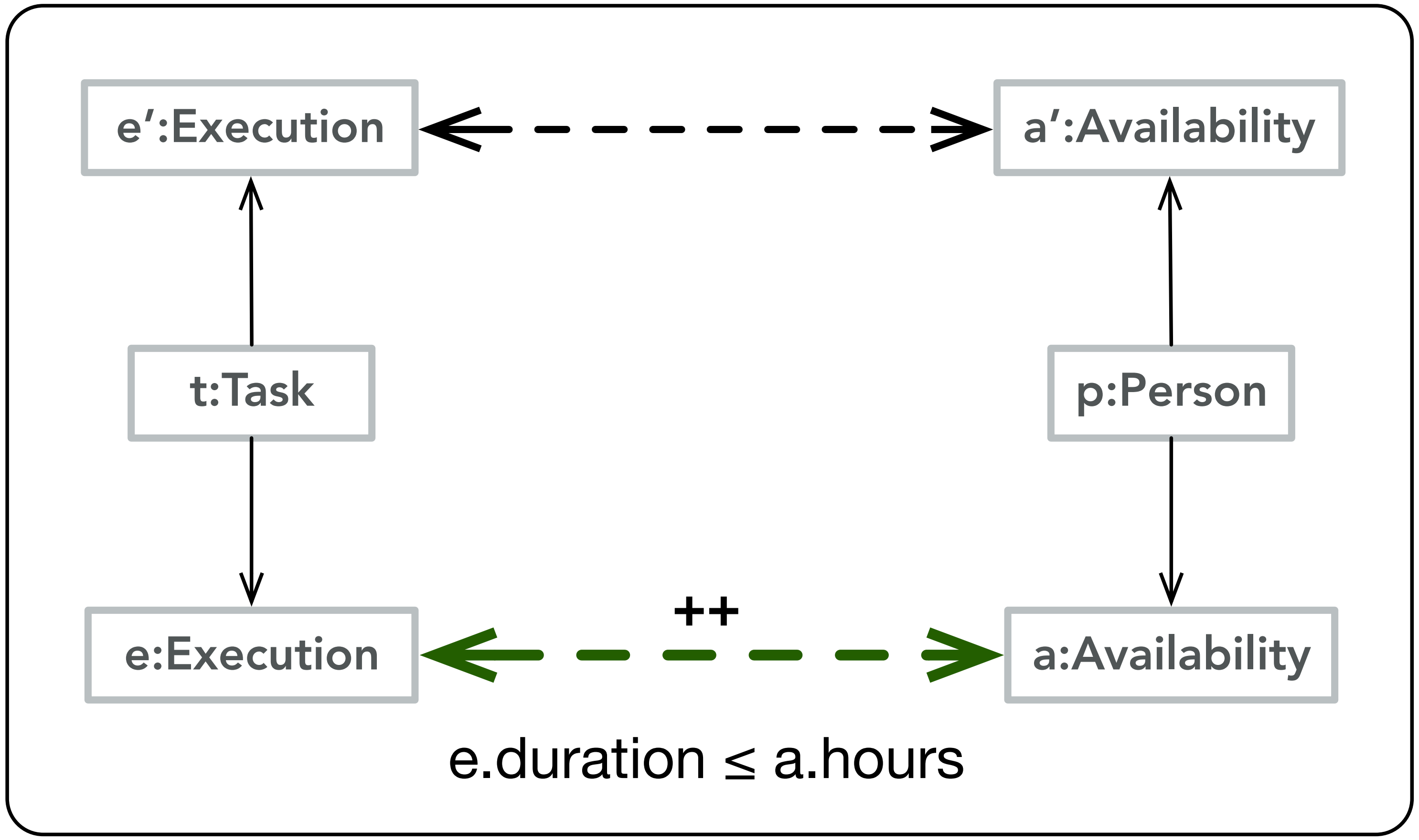

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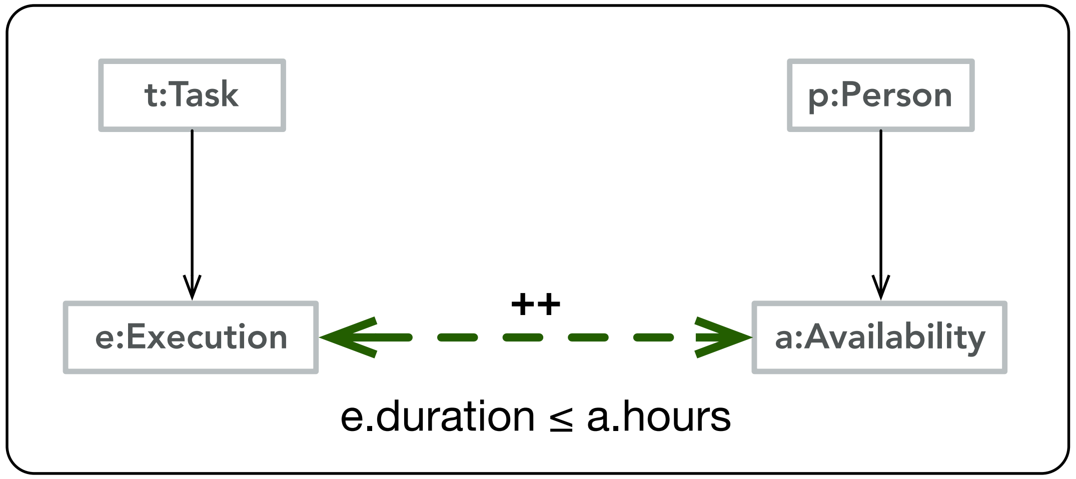
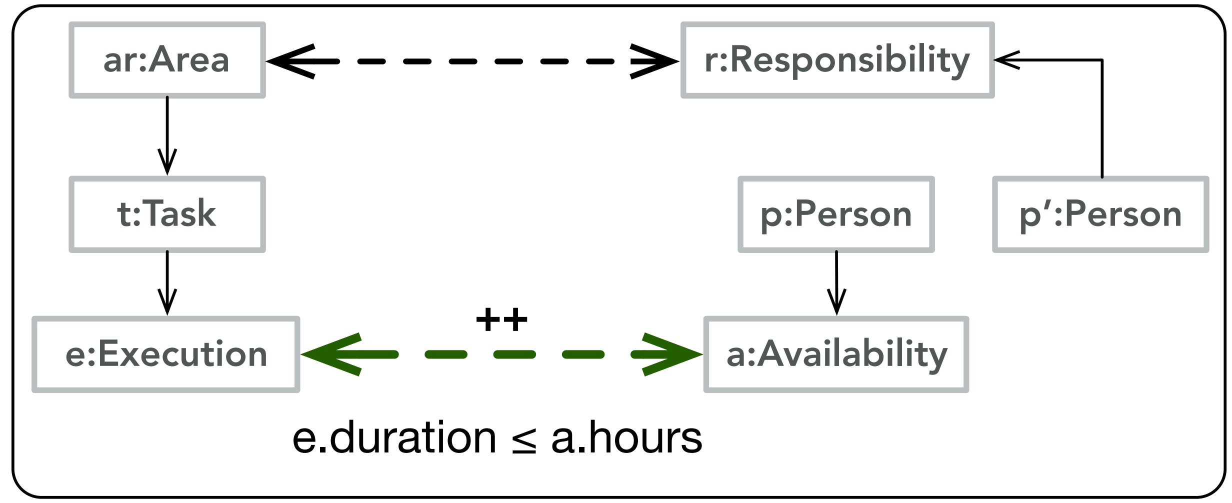
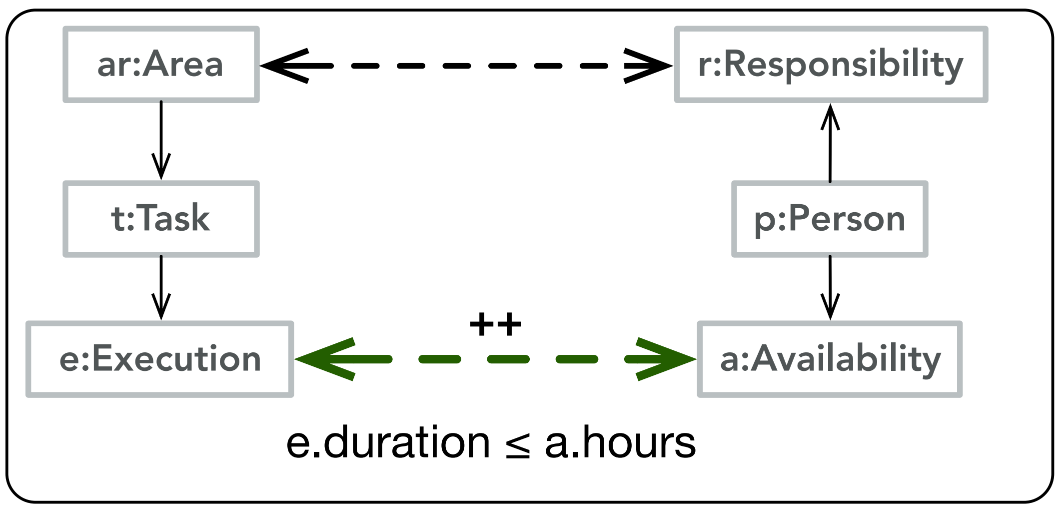
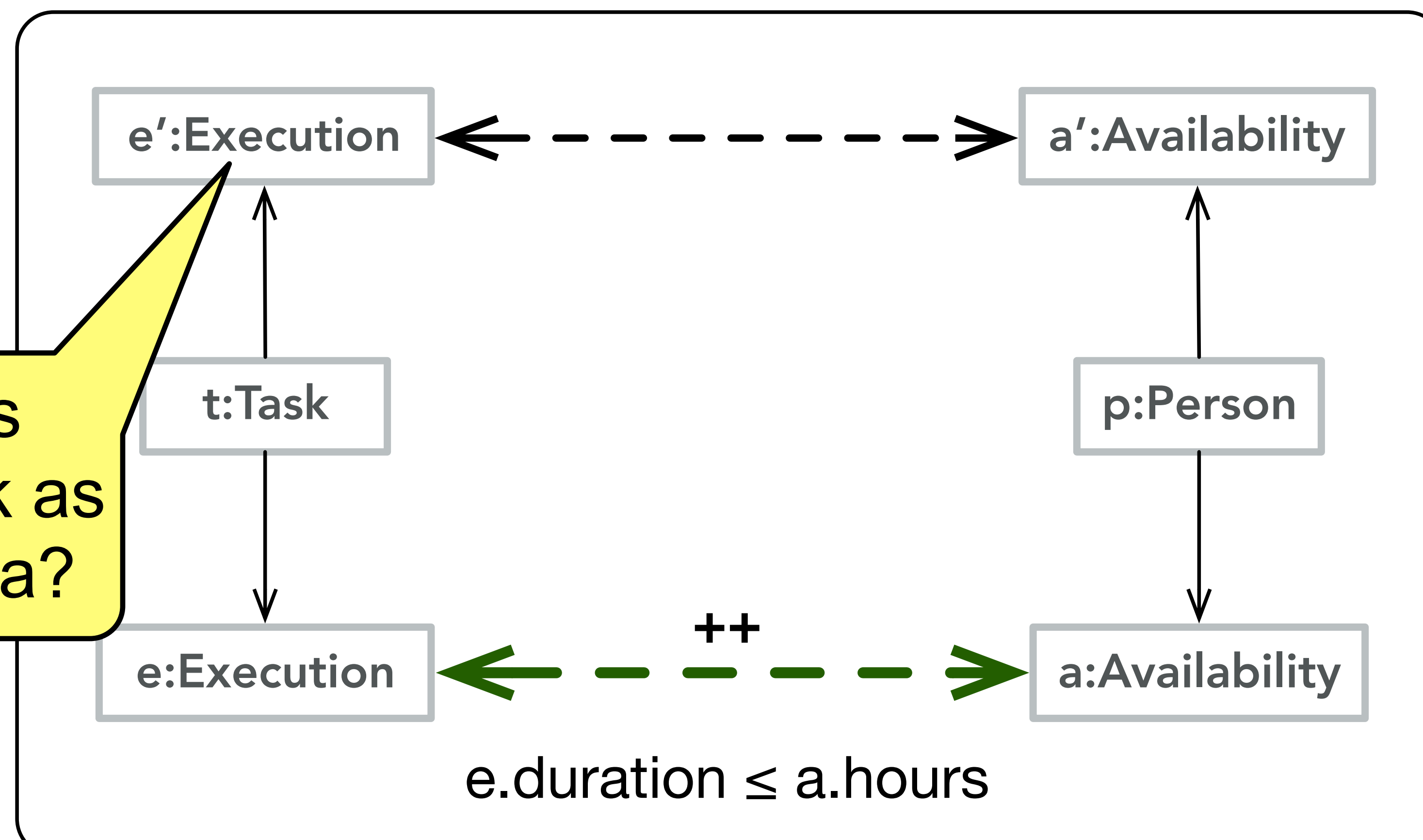


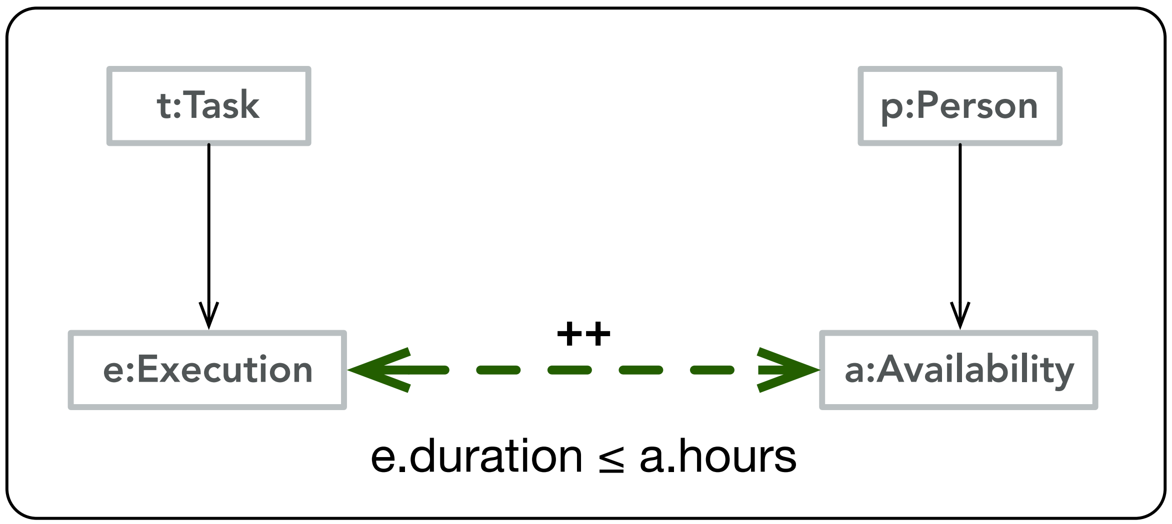


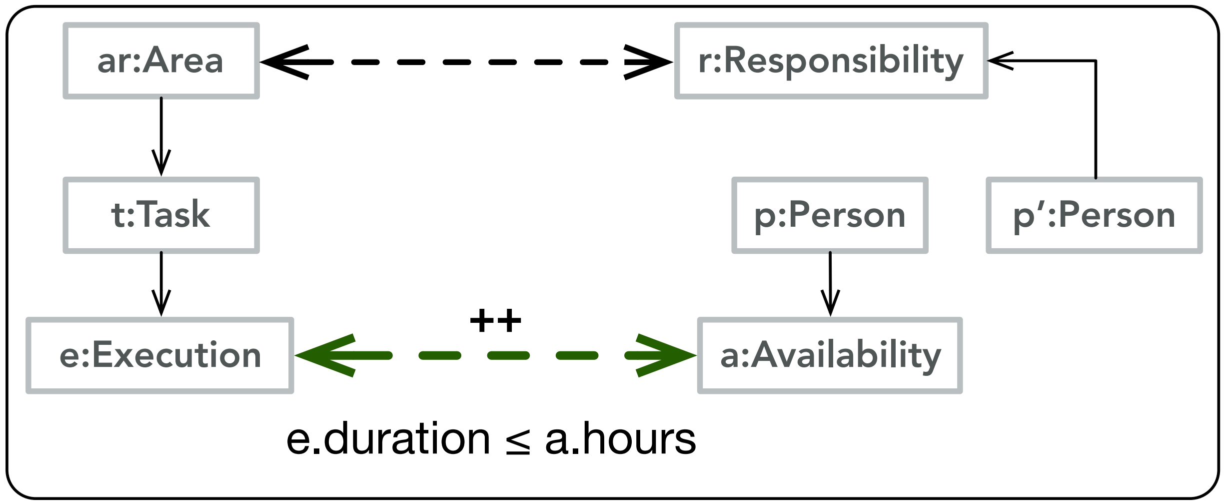


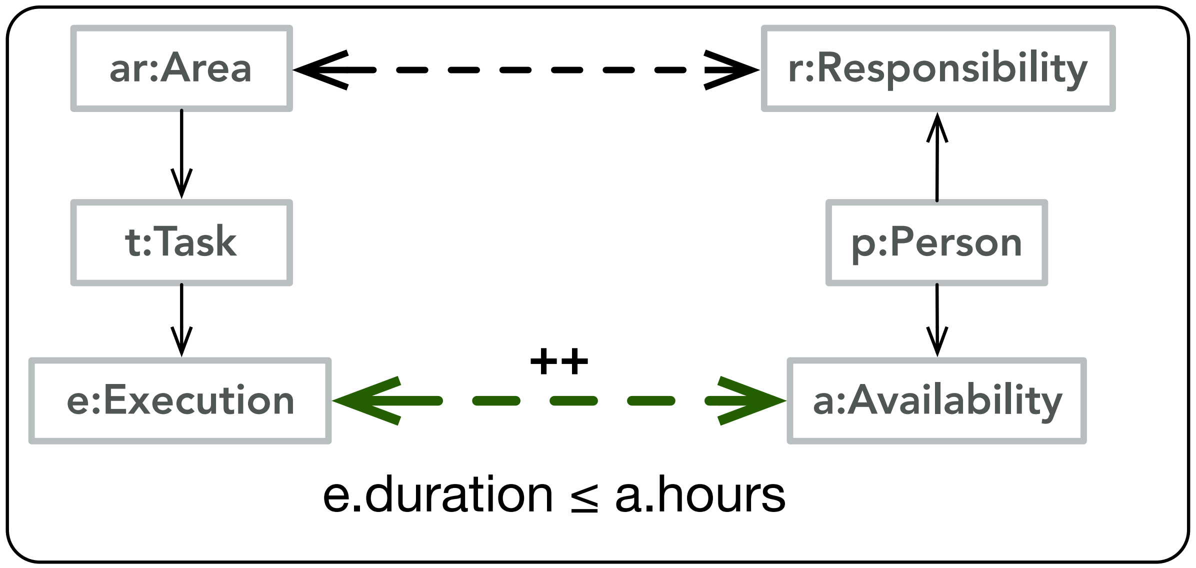


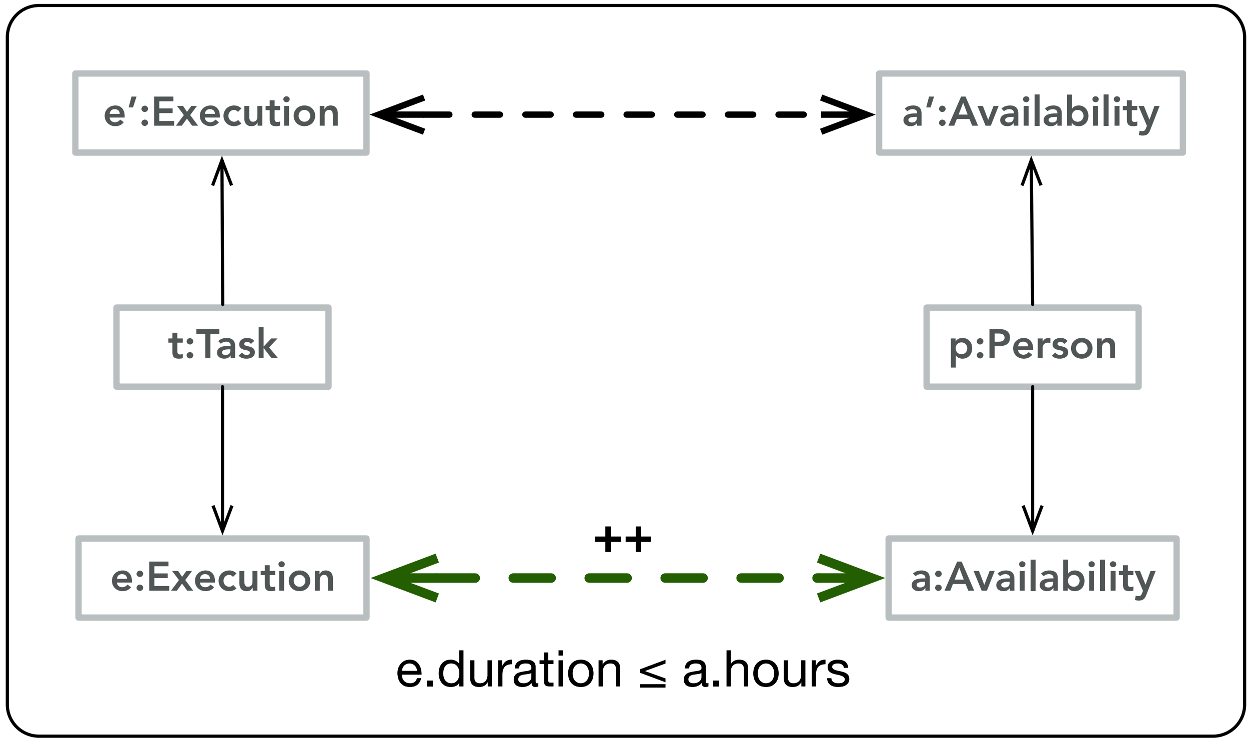
Should the same person test as many executions of the same task as possible? Or is this a terrible idea?

A Real-World Example: Allocation Rules









Similar Application Domains

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1. **Allocation Engineering:**
    - Tasks to resources
    - Programs to ECUs
    - Functions to nodes in a network
    - …

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    - Suggest traceability links
    - Check manually created traceability links
    - Flag “suspect links” after changes

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   - Tasks to resources
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   - …

2. **Traceability Maintenance:**
   - Suggest traceability links
   - Check manually created traceability links
   - Flag “suspect links” after changes

3. **Model Synchronisation:**
   - Start with existing, independently created models
   - Identify inconsistencies

Our Approach

2016: Erhan Leblebici:
Towards a Graph Grammar-Based Approach to Inter-Model Consistency Checks with Traceability Support.
Bx@ETAPS 2016: 35-39

2017: Erhan Leblebici, Anthony Anjorin, Andy Schürr:
Inter-model Consistency Checking Using Triple Graph Grammars and Linear Optimization Techniques.
FASE 2017: 191-207

2018: Erhan Leblebici:
Inter-Model Consistency Checking and Restoration with Triple Graph Grammars.
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Consistency Management via a Combination of Triple Graph Grammars and Integer Linear Programming.
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Basic idea of how to perform consistency checking with TGGs

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Full details, implementation, and evaluation in eMoflon

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Remaining formal proofs, industrial case with Siemens

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Inter-Model Consistency Checki[ng] ... Triple Graph Grammars.
PhD Thesis, Darmstadt University ...

Generalisation of the approach to other consistency management tasks (work in progress)

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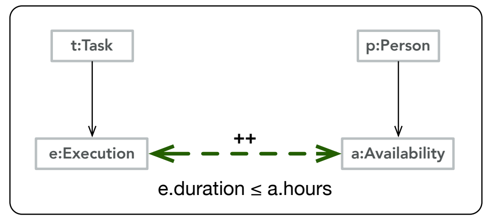
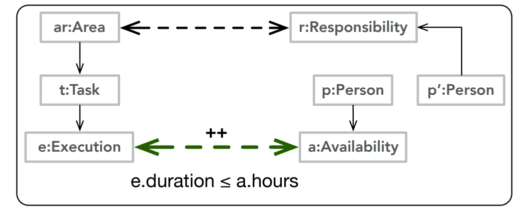
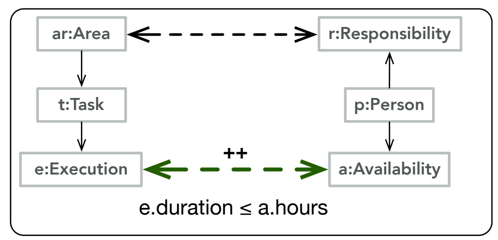
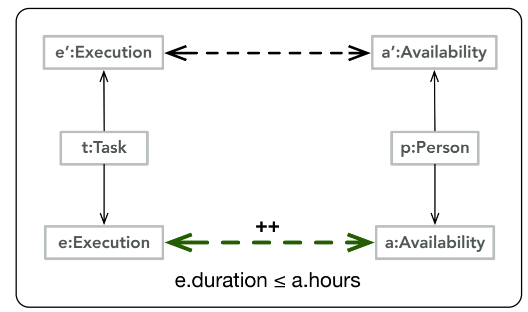
Step 1: Collect all Candidates



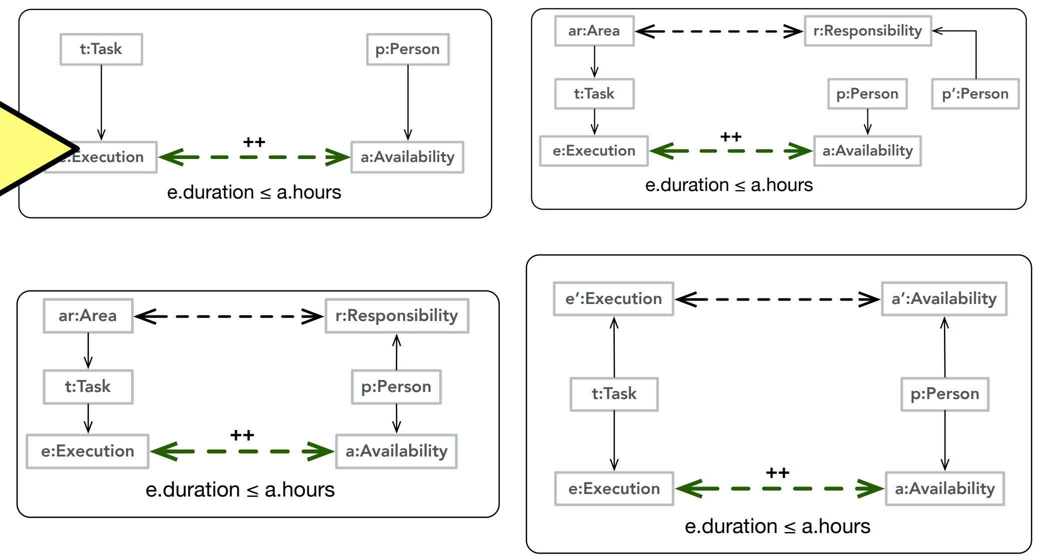






Step 1: Collect all Candidates

Use allocation rules (derived from a TGG) to create *all possible* correspondence links.



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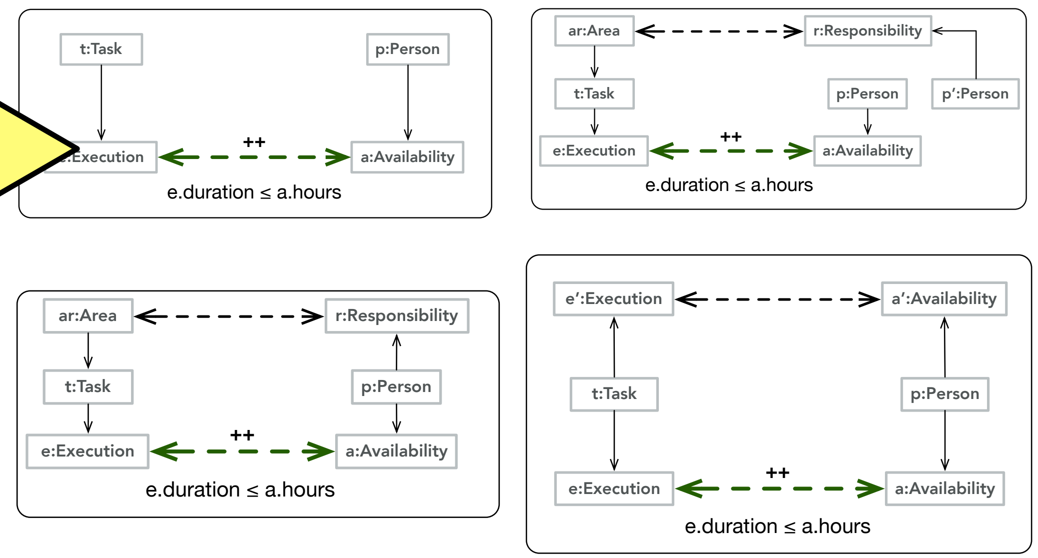

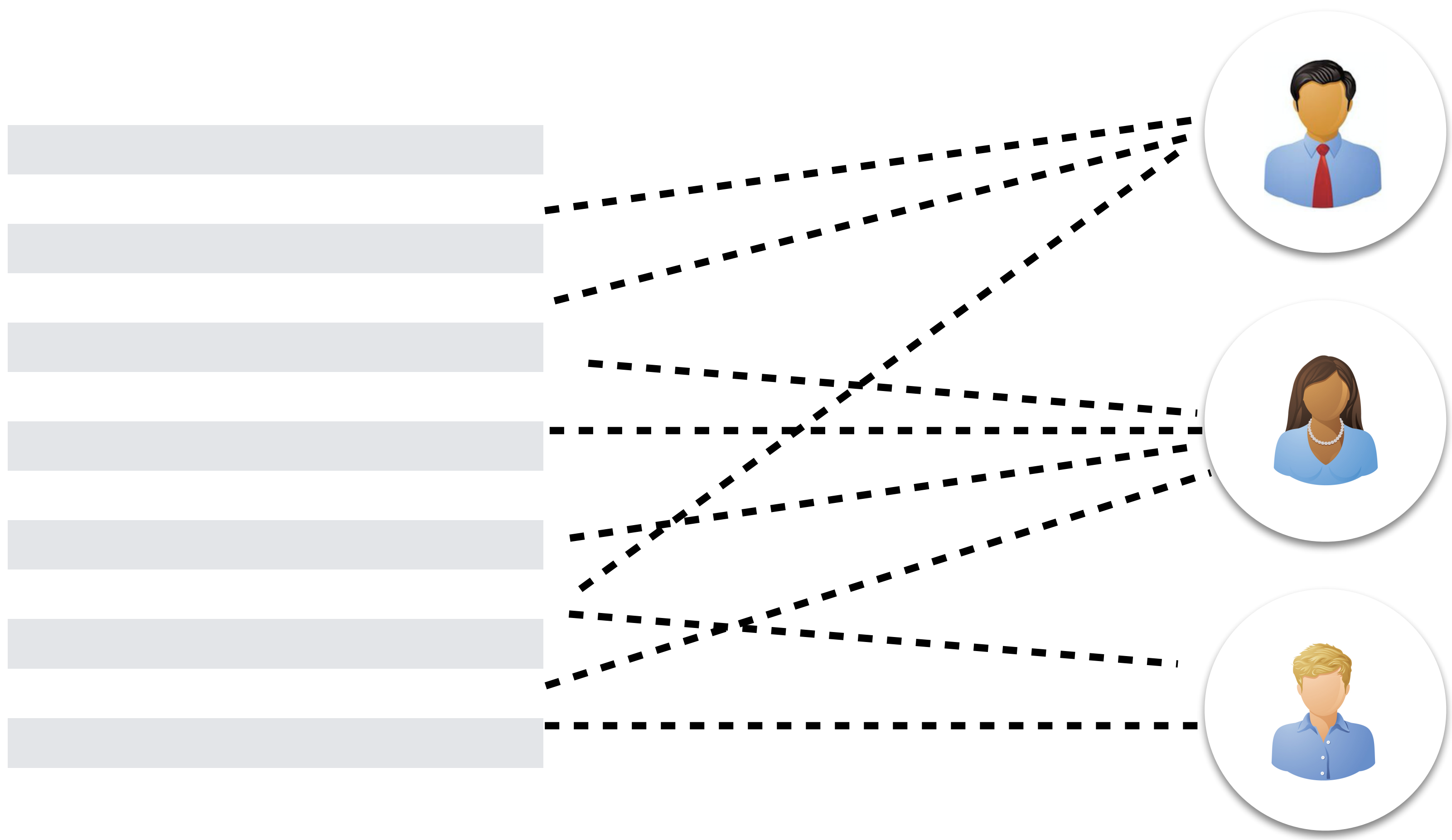

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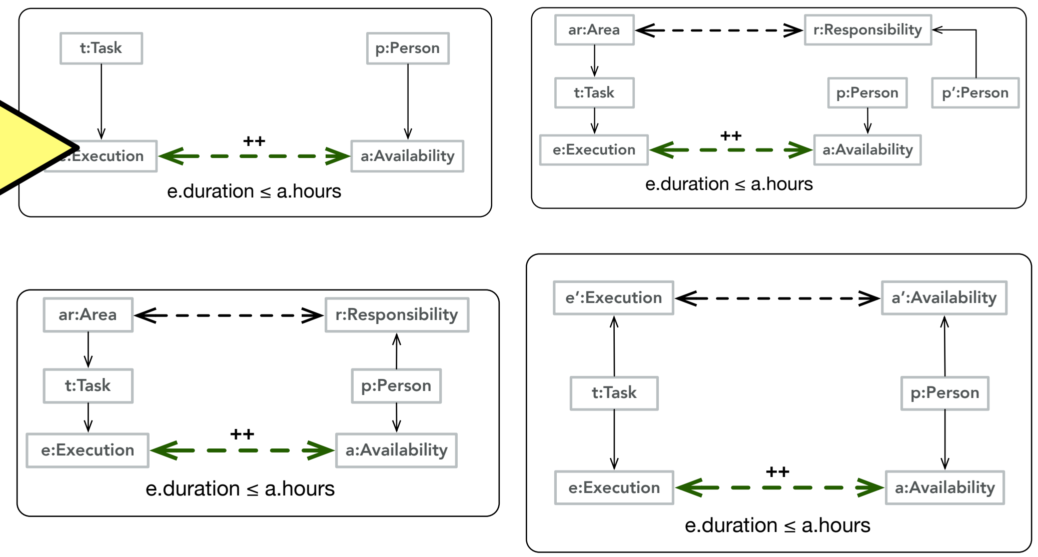
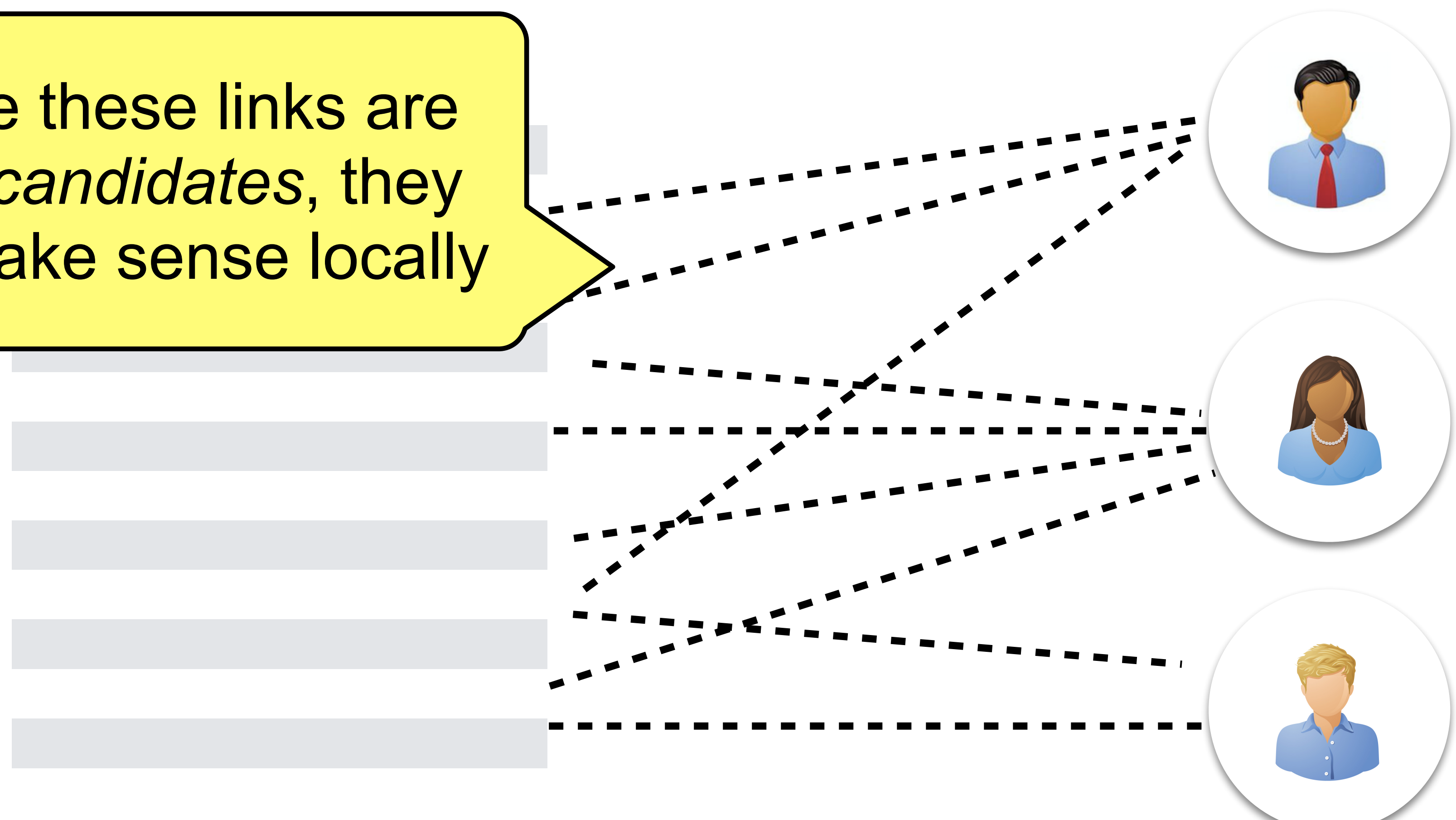


While these links are only *candidates*, they still make sense locally



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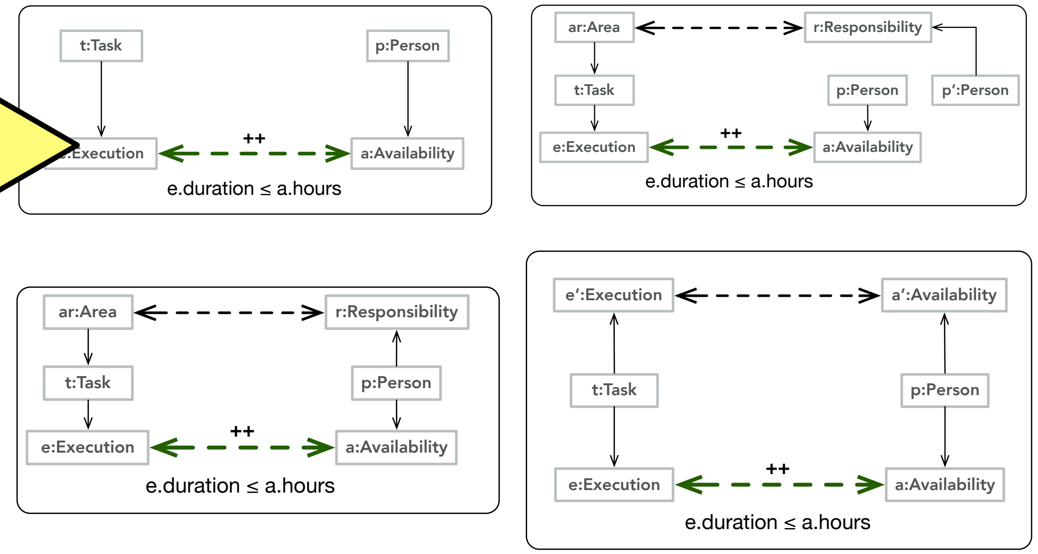

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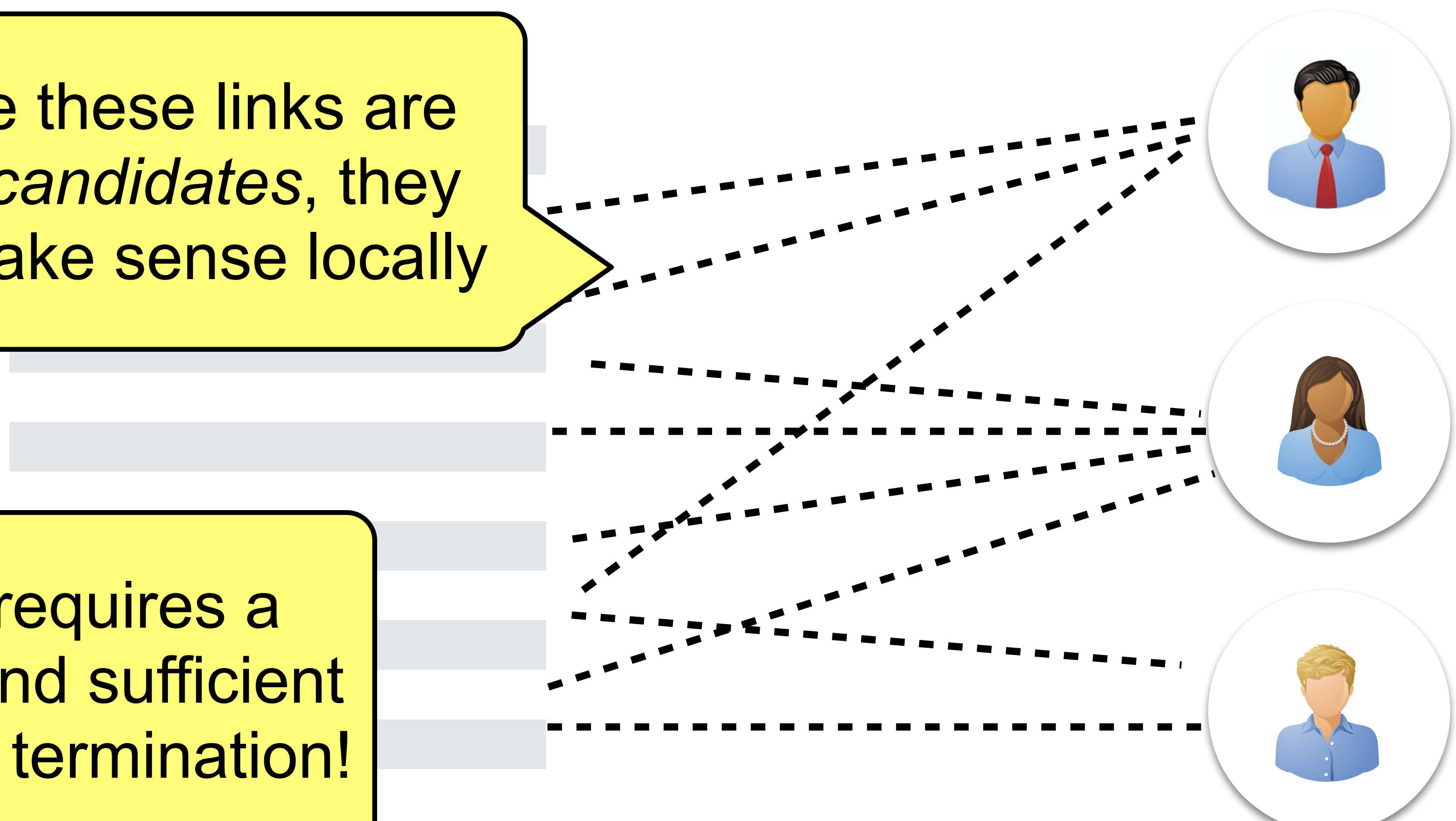

This step requires a necessary and sufficient condition for termination!

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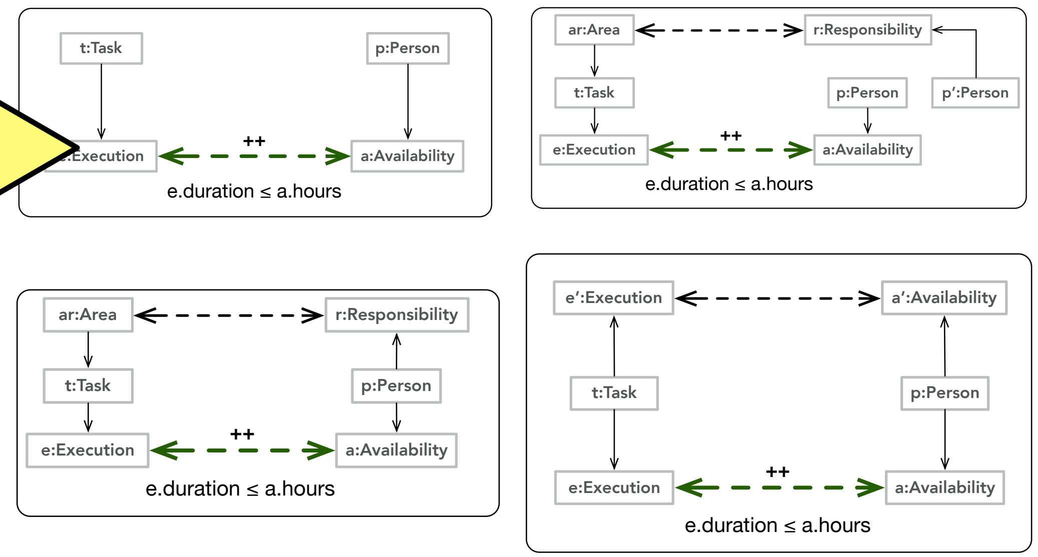
This step exploits an incremental graph pattern matcher

Use allocation rules (derived from a TGG) to create *all possible* correspondence links.



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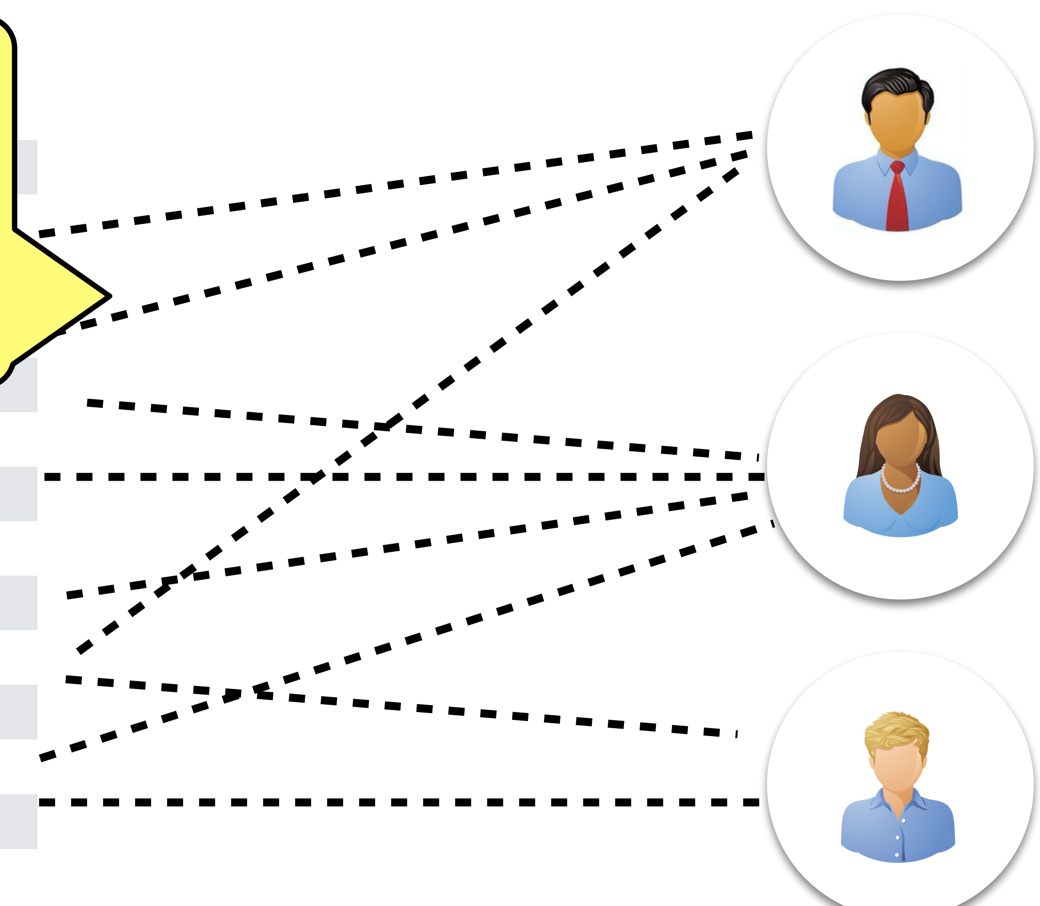

This step requires a necessary and sufficient condition for termination!

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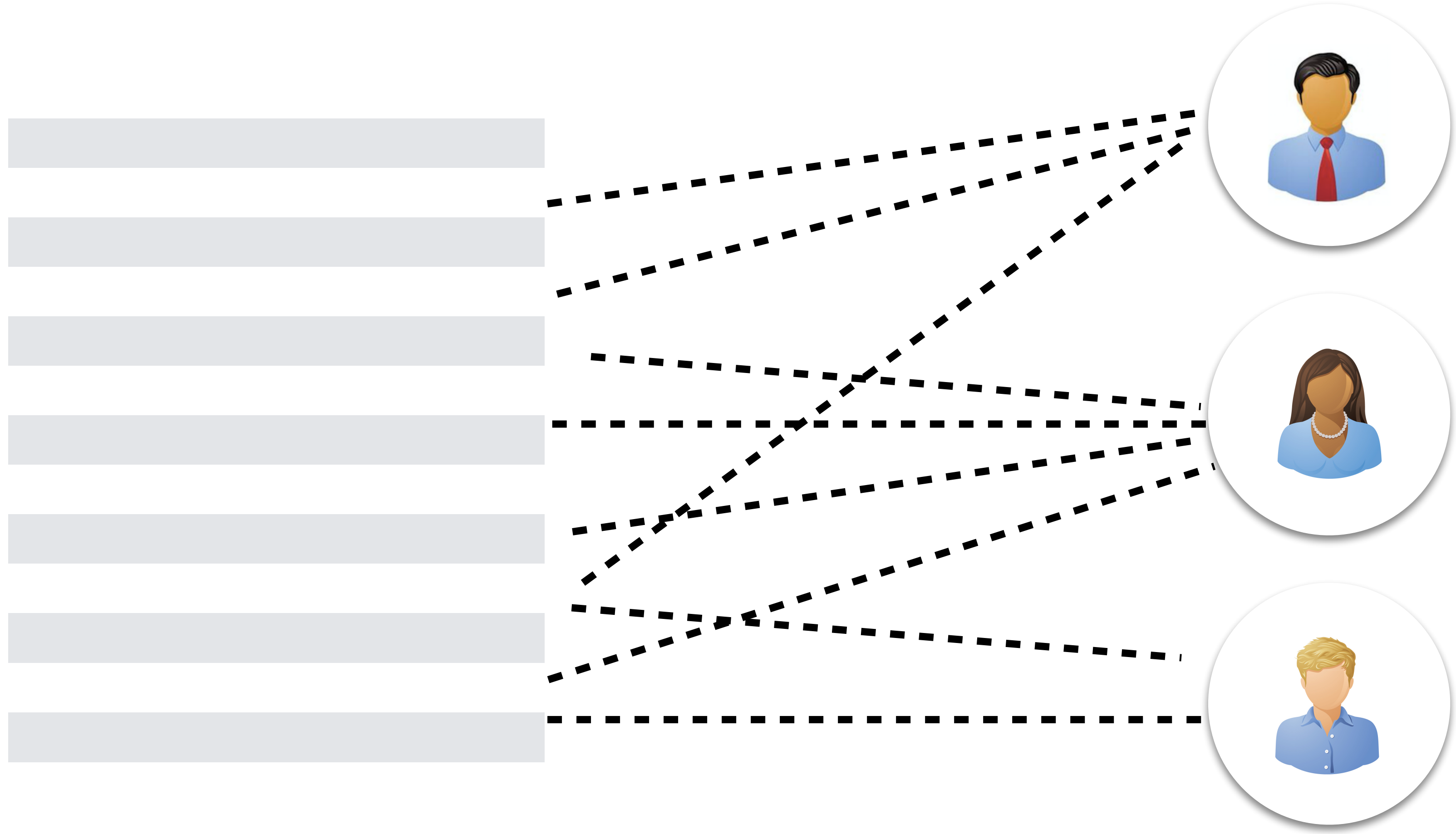

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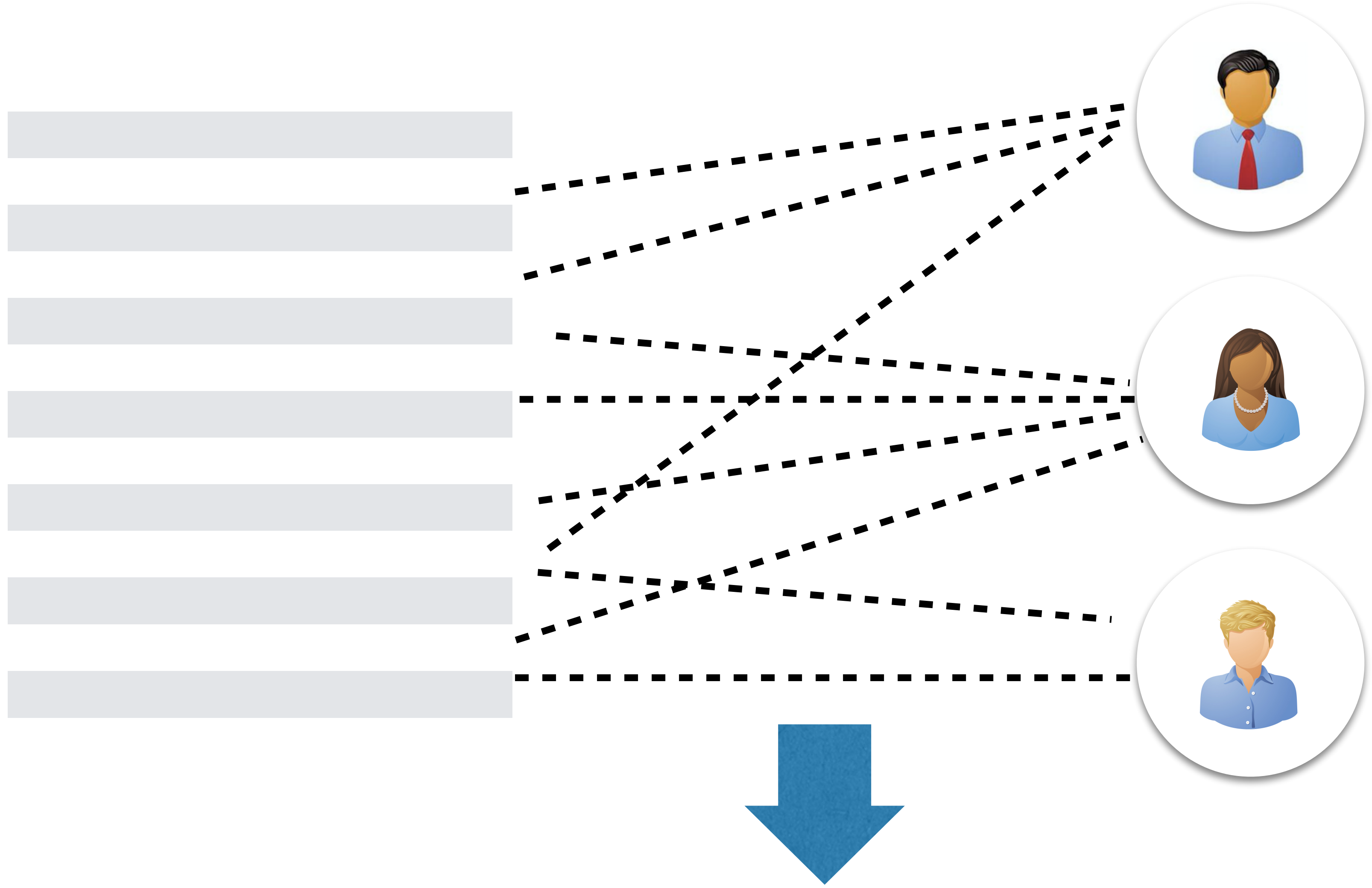

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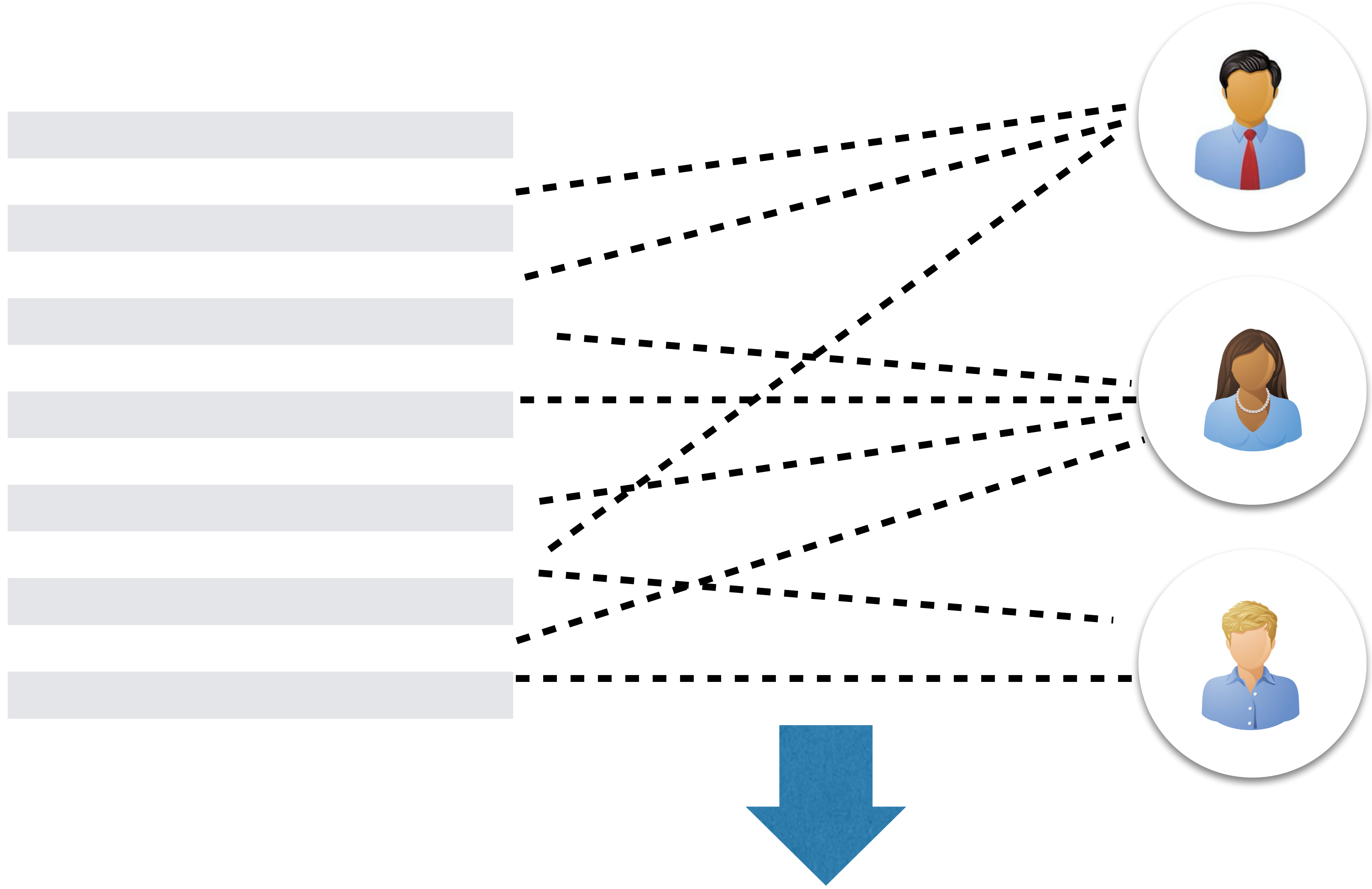

$$\max \quad \vec{c} \cdot \vec{x}$$

$$A\vec{x} \leq \vec{b}$$

Step 2: Derive ILP

$\vec{x} \in \mathbb{Z}_2^n$

Which candidates will be part of the solution?

$$\max \quad \vec{c} \cdot \vec{x}$$

$$A\vec{x} \leq \vec{b}$$

Step 2: Derive ILP

$\overrightarrow{c} \in \mathbb{R}^n$

Domain-specific weights for each candidate

$$\max \overrightarrow{c} \cdot \overrightarrow{x}$$

$$A\overrightarrow{x} \leq \overrightarrow{b}$$

Step 2: Derive ILP

E.g., prefer assigning multiple executions of the same task to the same person

$\overrightarrow{c} \in \mathbb{R}^n$

Domain-specific weights for each candidate

$$\max \overrightarrow{c} \cdot \overrightarrow{x}$$

$$A\overrightarrow{x} \leq \overrightarrow{b}$$

Step 2: Derive ILP

$$\max \quad \vec{c} \cdot \vec{x}$$

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Constraints to ensure that the chosen solution is in the language of the TGG.

Step 2: Derive ILP

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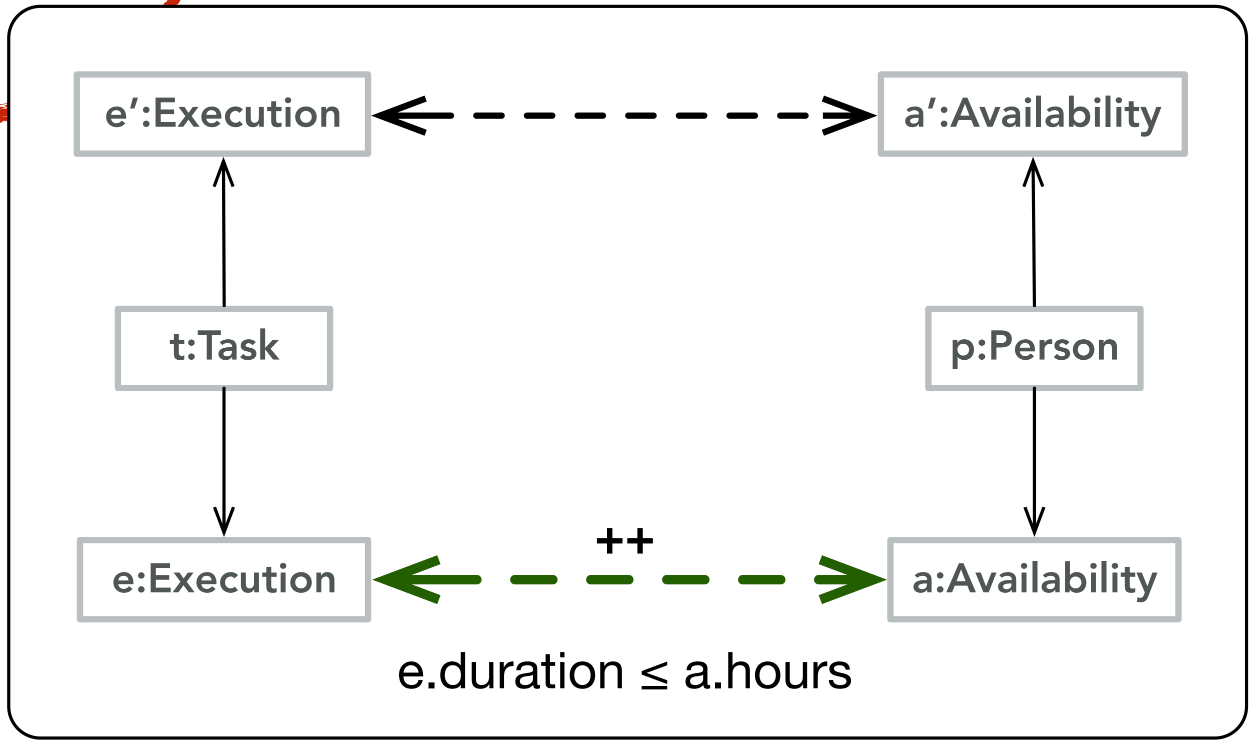

Step 2: Derive ILP

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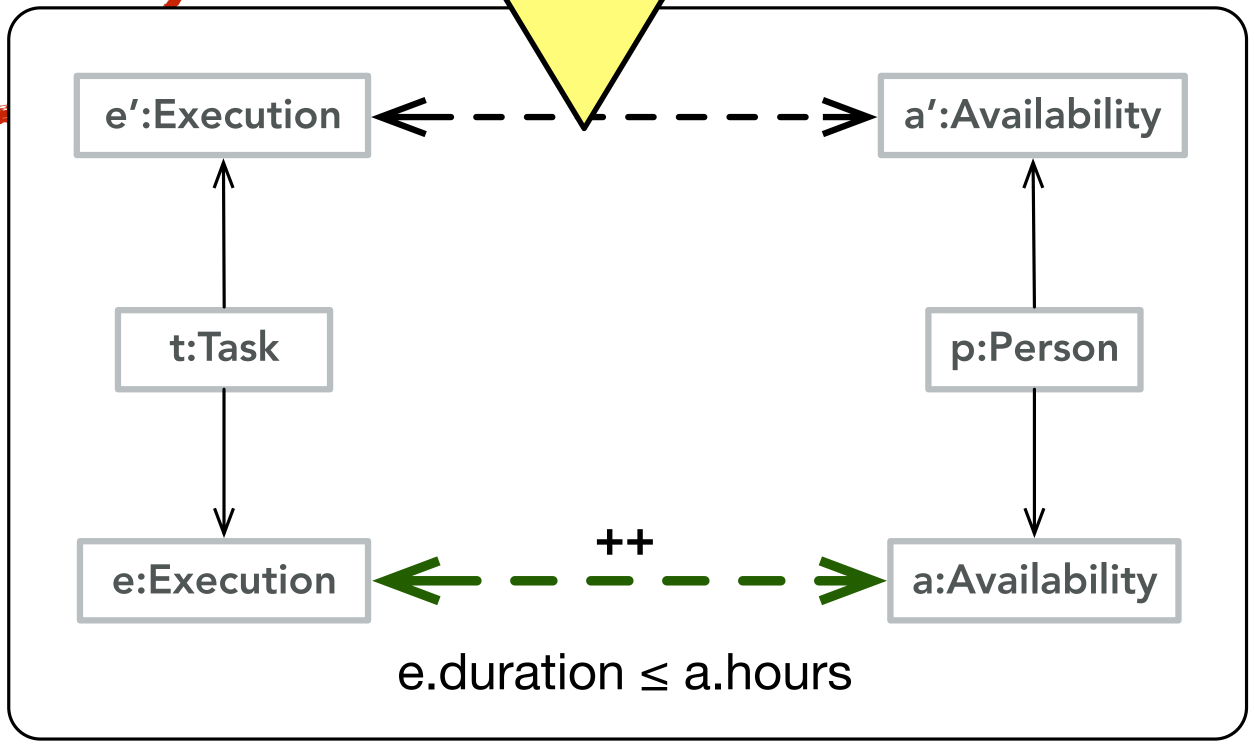
E.g, let's assume all candidates for creating this link are:

$$x_1, x_2, x_3$$



Step 2: Derive ILP

$$\max \ \vec{c} \cdot \vec{x}$$

$$A\vec{x} \leq \vec{b}$$

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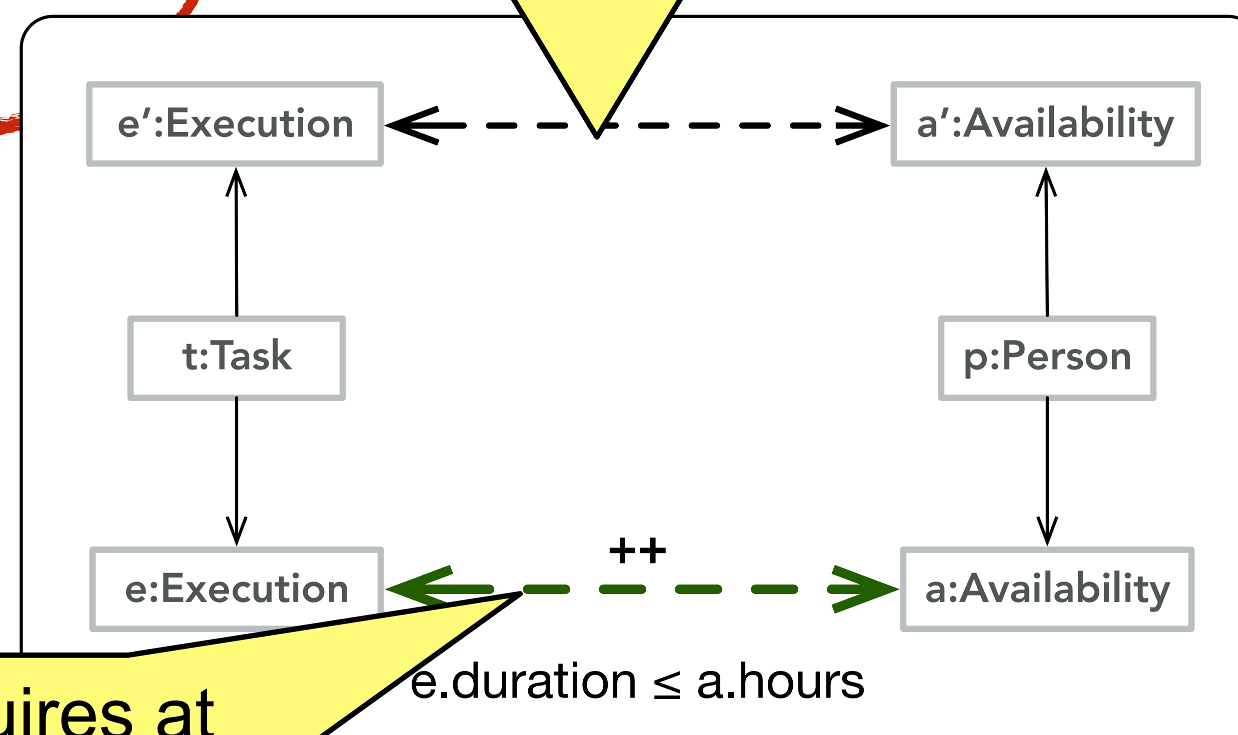

This candidate requires at least one of them to exist:

$$x_4 \Rightarrow x_1 \vee x_2 \vee x_3$$

$$x_4 \leq x_1 + x_2 + x_3$$

Step 2: Derive ILP

$$\max \quad \vec{c} \cdot \vec{x}$$

$$A\vec{x} \leq \vec{b}$$

All such inequalities are collected to form:

$$A \in \mathbb{R}^{m \times n}, b \in \mathbb{R}^{n}$$

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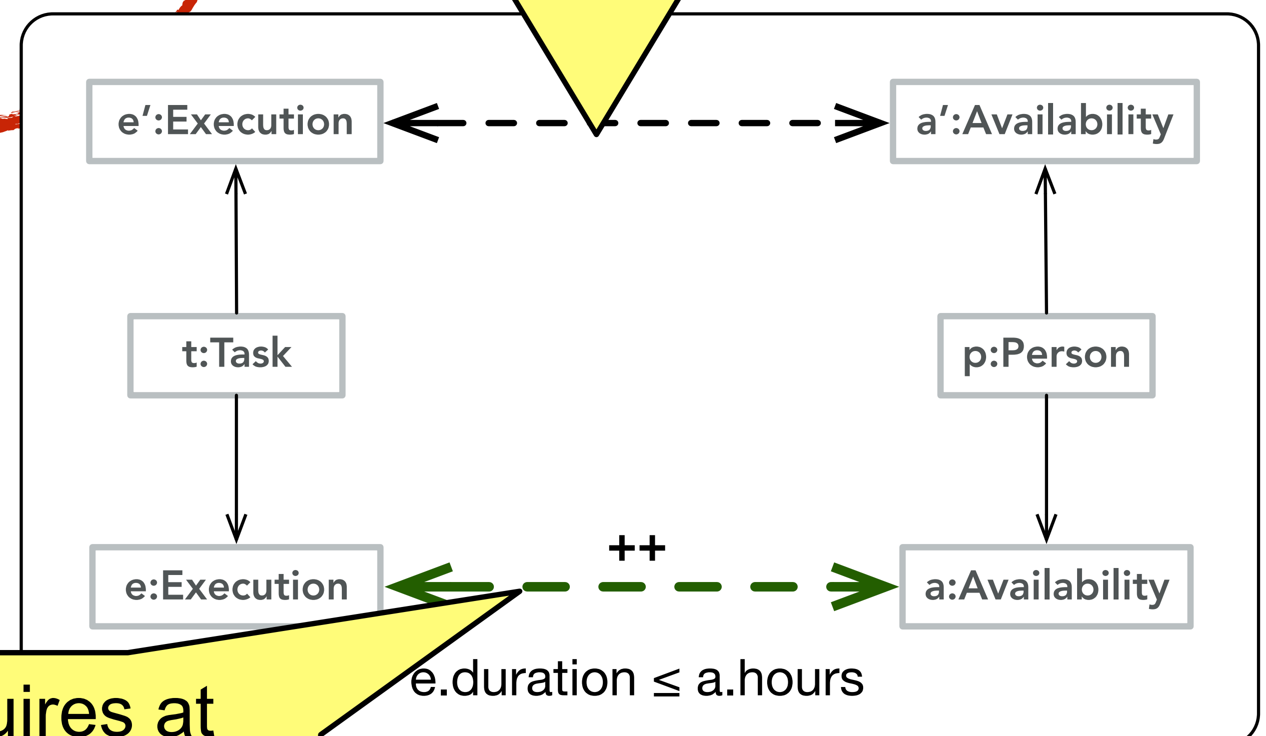

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Step 3: Solve (Optimise) ILP and Interpret Solution

$$\max \quad \vec{c} \cdot \vec{x}$$

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GUROBI
OPTIMIZATION

$$\vec{x}^*$$

Step 3: Solve (Optimise) ILP and Interpret Solution

This step exploits mature ILP solvers

$$\max \quad \vec{c} \cdot \vec{x}$$

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GUROBI
OPTIMIZATION

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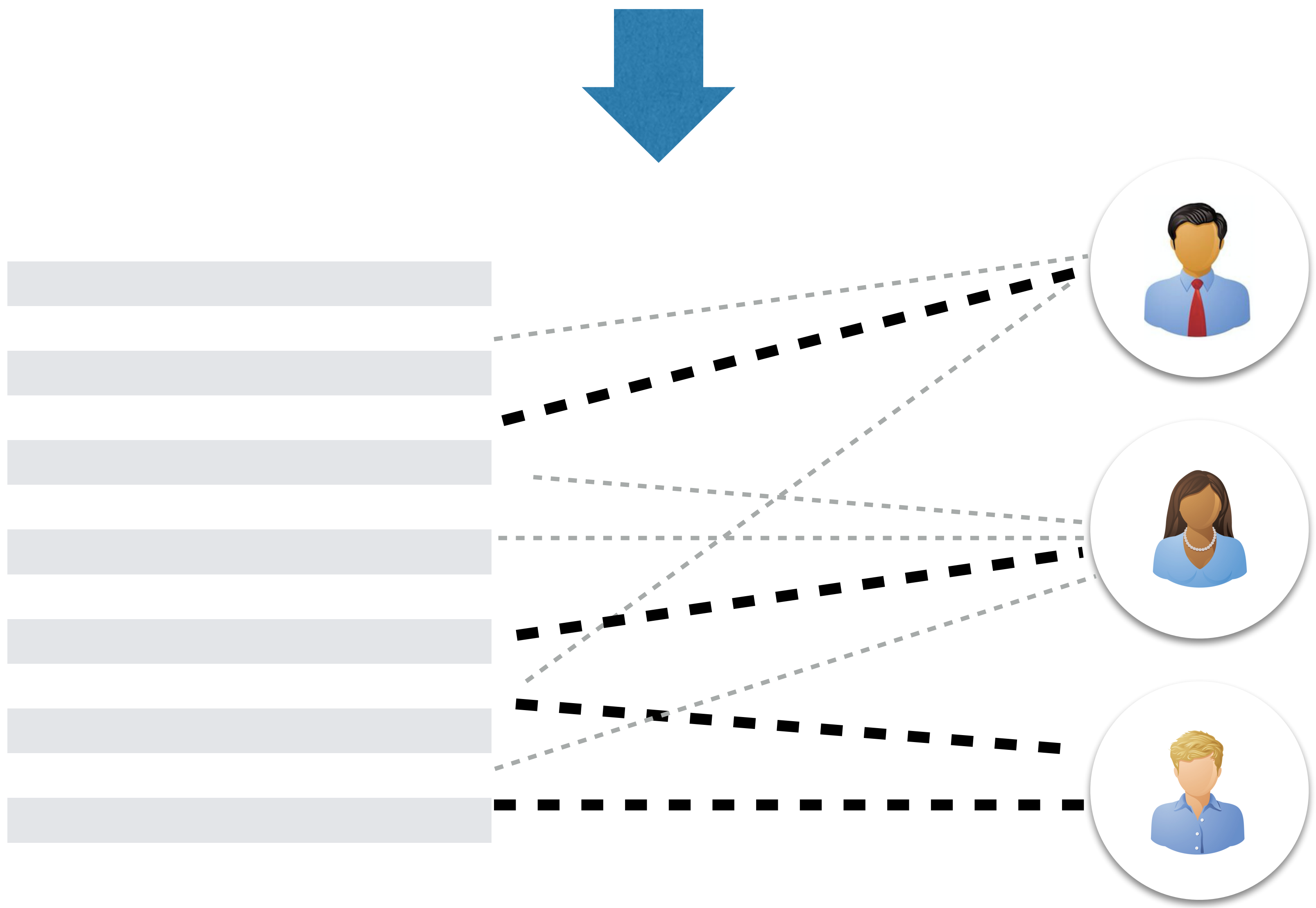

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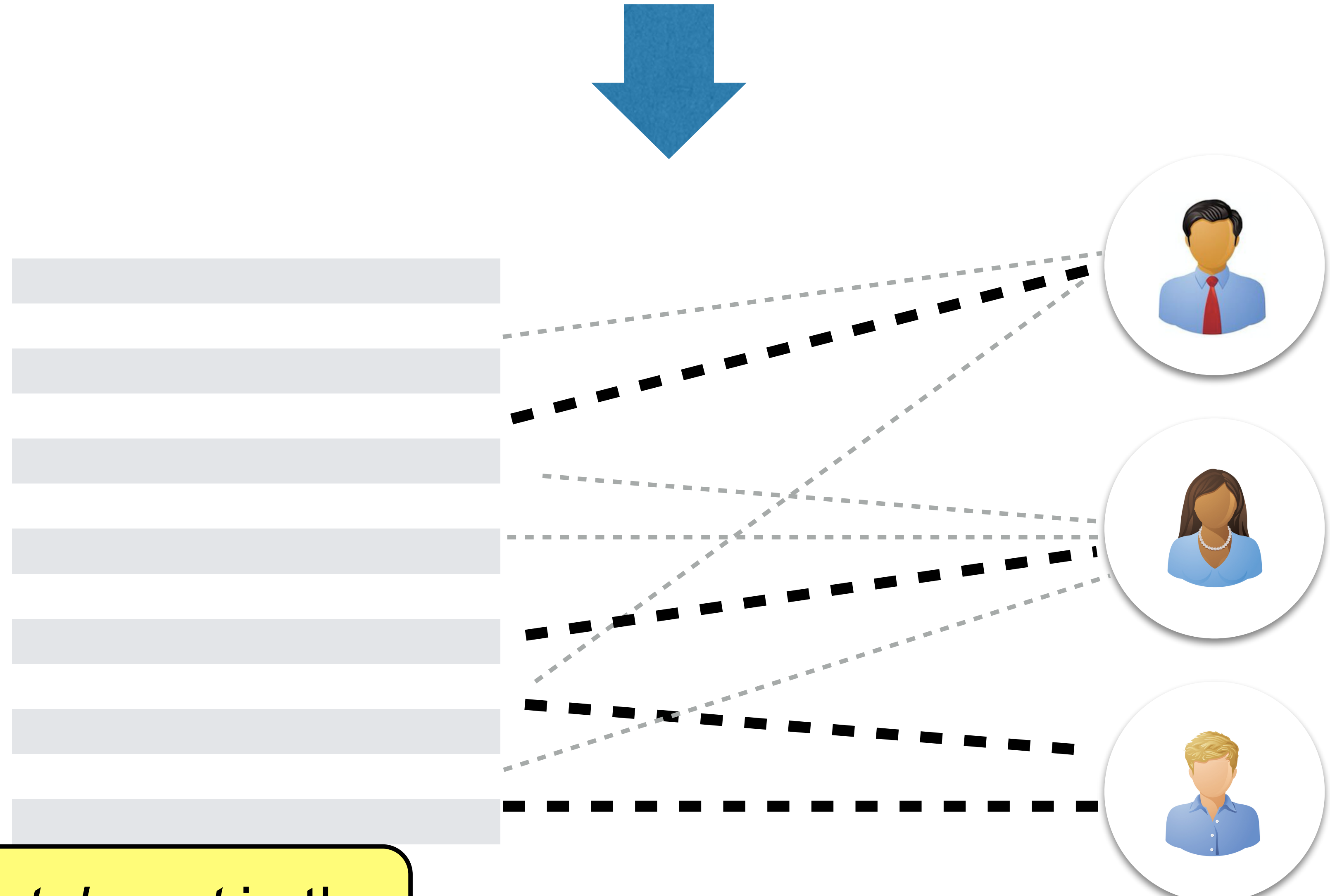

Our approach is *tolerant* in the sense that we can determine partial solutions (all variables are set to 0 in the worst case)

Ongoing and Future Work

Operation	Source	Corr	Target
CC	mark	create	mark
CO	mark	mark	mark
FWD_OPT	mark	create	create
BWD_OPT	create	create	mark

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Our initial focus (**C**onsistency **C**heck via correspondence link creation)

Ongoing and Future Work

Operation	Source	Corr	Target
CC	mark	create	mark
CO	mark	mark	mark
FWD_OPT	mark	create	create
BWD_OPT	create	create	mark

Check **O**nly:
Check existing triple for consistency

Ongoing and Future Work

Operation	Source	Corr	Target
CC	mark	create	mark
CO	mark	mark	mark
FWD_OPT	mark	create	create
BWD_OPT	create	create	mark

Normal initial (batch) fwd and bwd transformations; but now complete, tolerant, and optimal wrt. to an objective function

Ongoing and Future Work

Operation	Source	Corr	Target
CC	mark	create	mark
CO	mark	mark	mark
FWD_OPT	mark	create	create
BWD_OPT	create	create	mark

All definitions, proofs, and most parts of the implementation can be formulated generically and configured for each case using the entries in this table!

Try it out! www.emoflon.org

eMoflon