Karlsruhe Institute of Technology

# Remodularizing Legacy Model Transformations with Automatic Clustering Techniques

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3rd Workshop on the Analysis of Model Transformations
Monday, September 29, 2014

SOFTWARE DESIGN AND QUALITY GROUP
INSTITUTE FOR PROGRAM STRUCTURES AND DATA ORGANIZATION, FACULTY OF INFORMATICS

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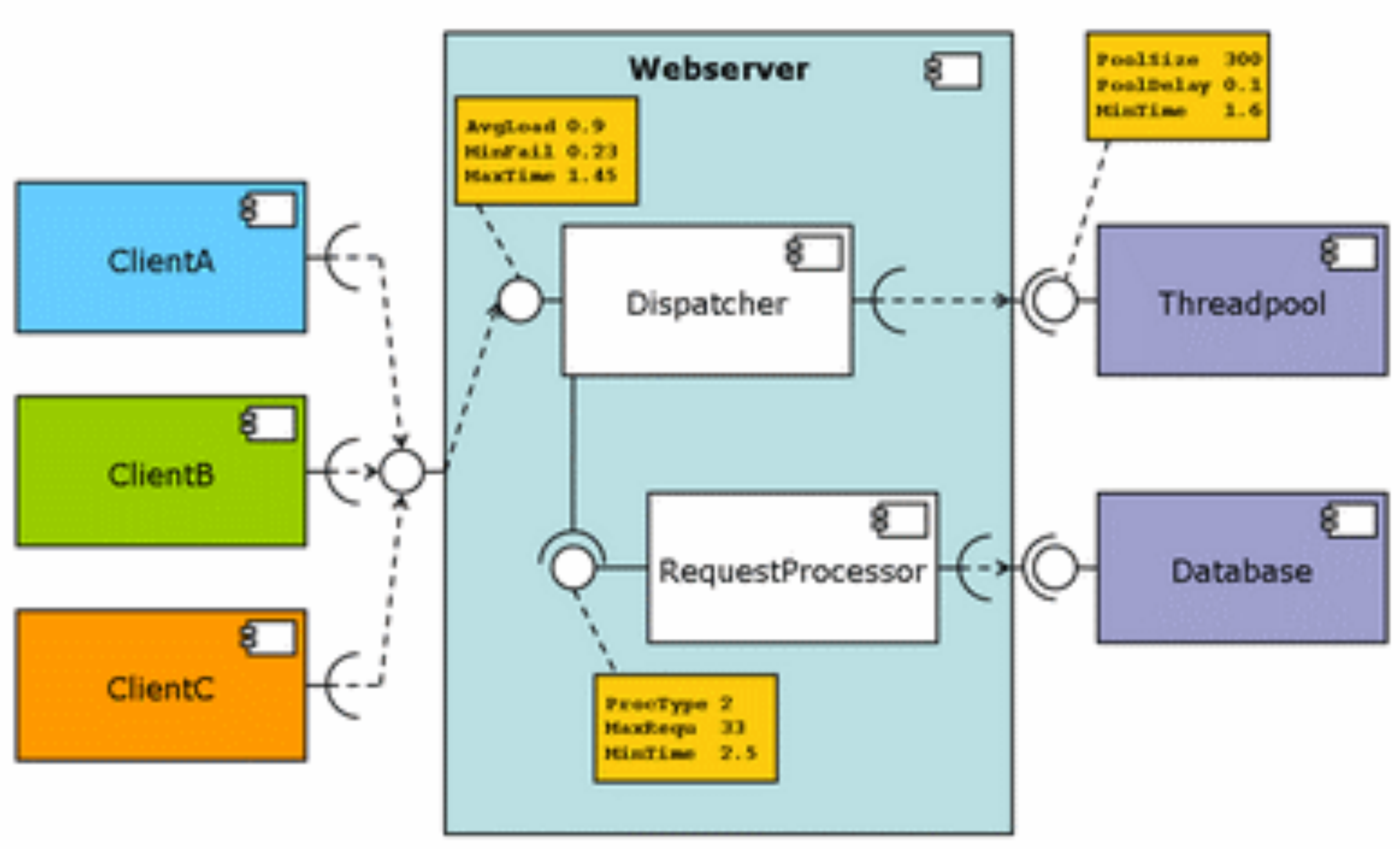
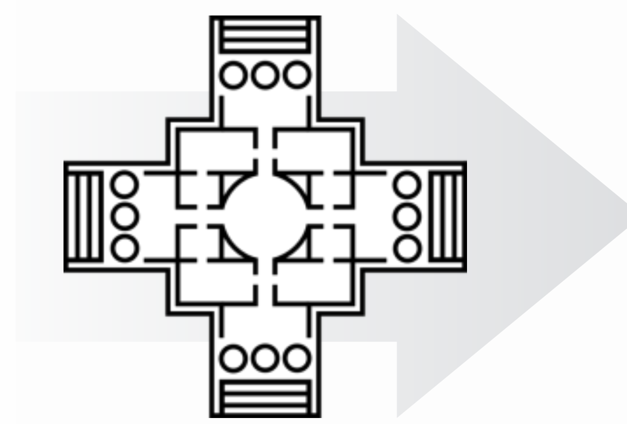
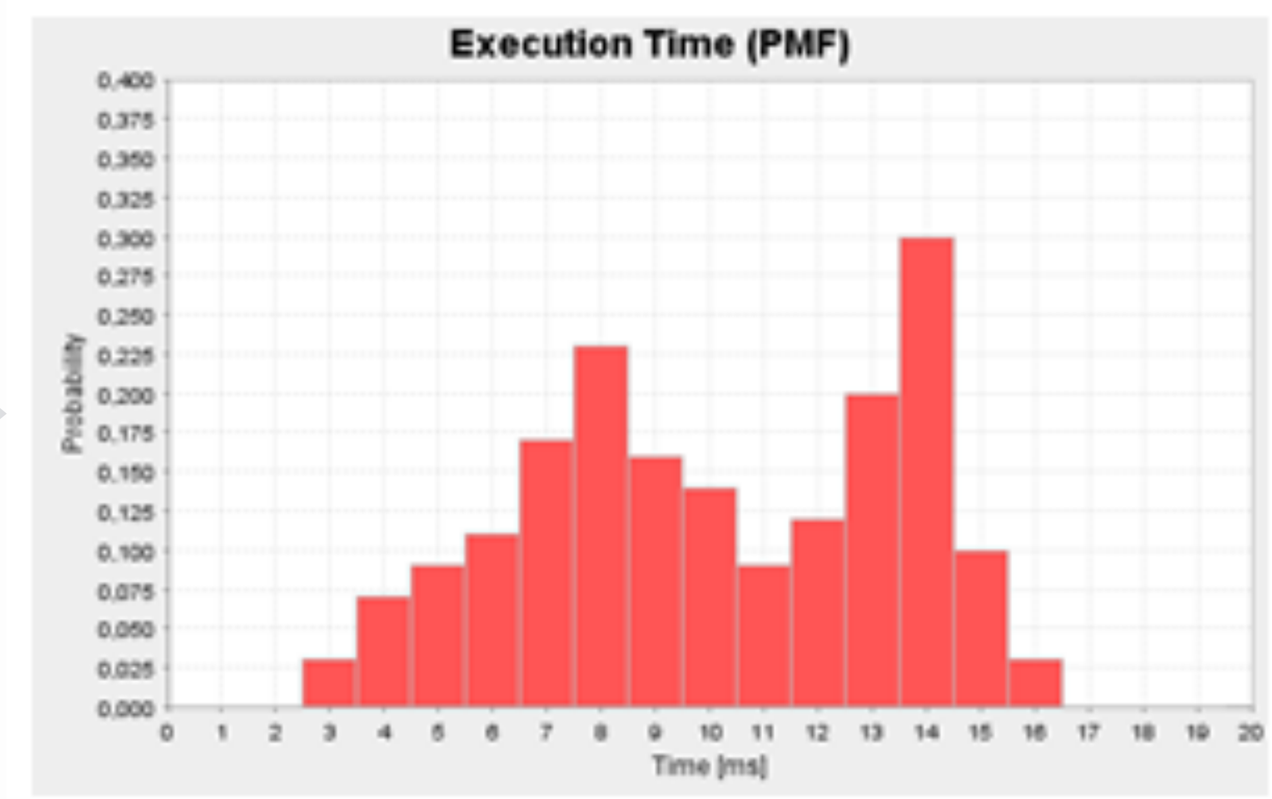
# Model-driven Software Quality Prediction






Performance model
of a component-based
software architecture

Performance data:

- Execution time
- Throughput
- Resource utilisation

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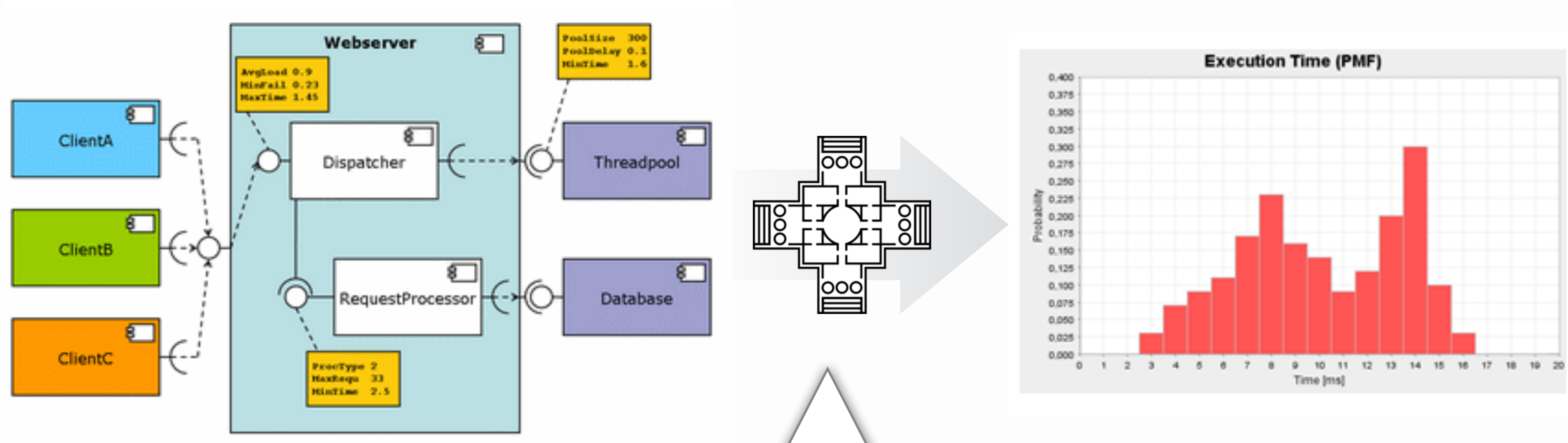


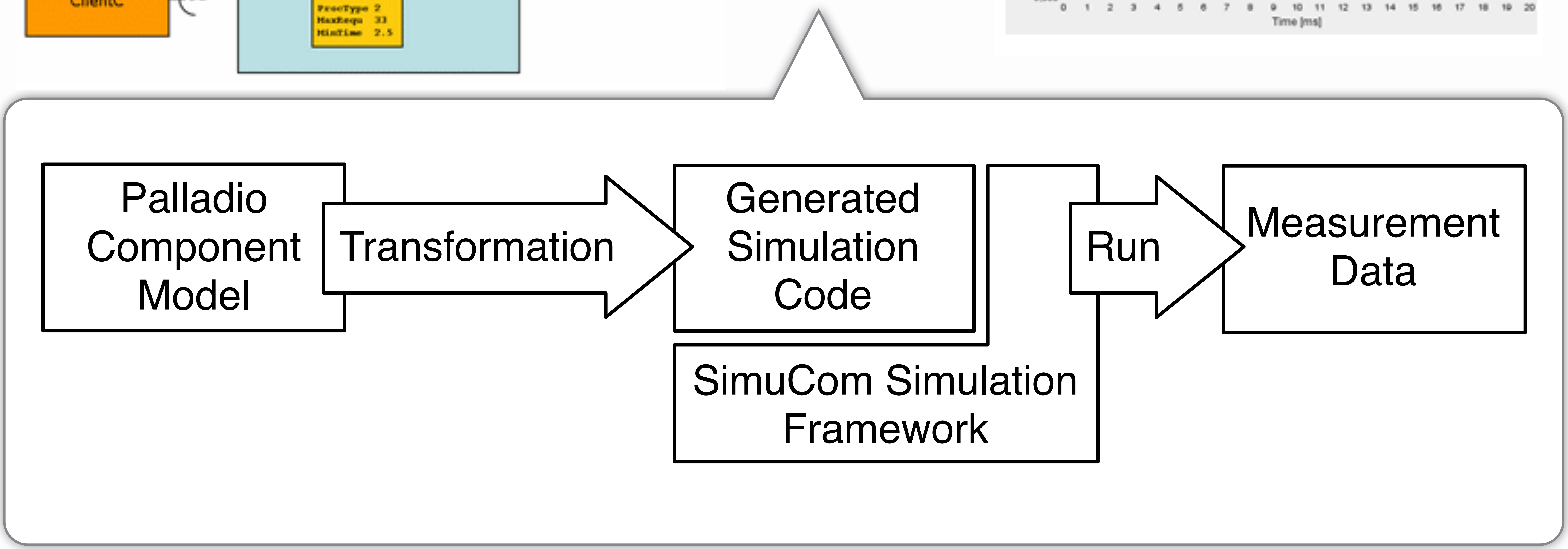

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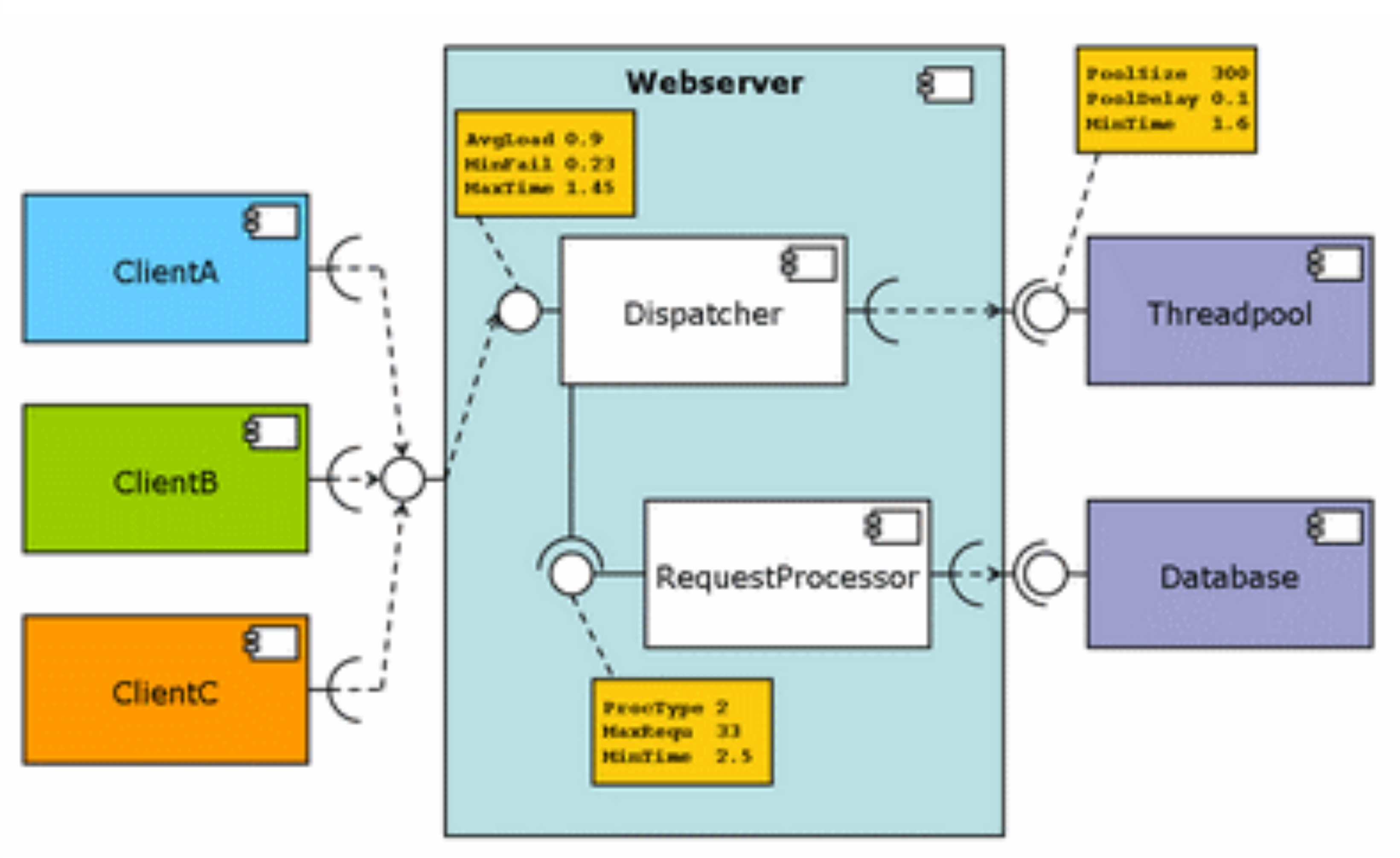


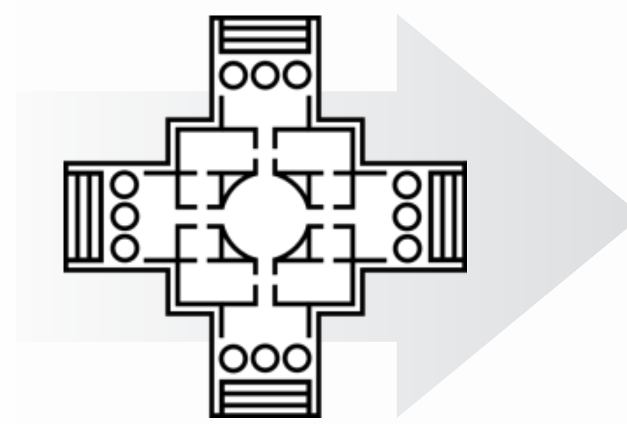

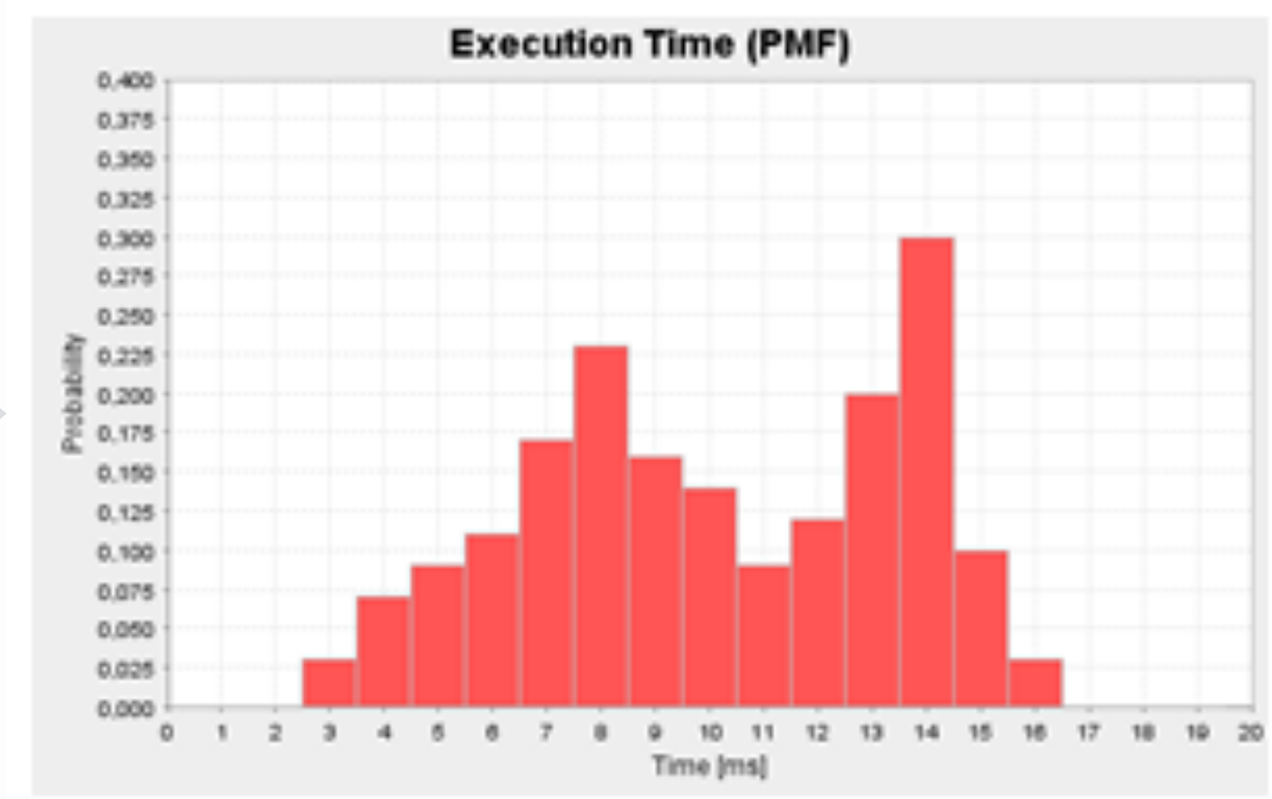


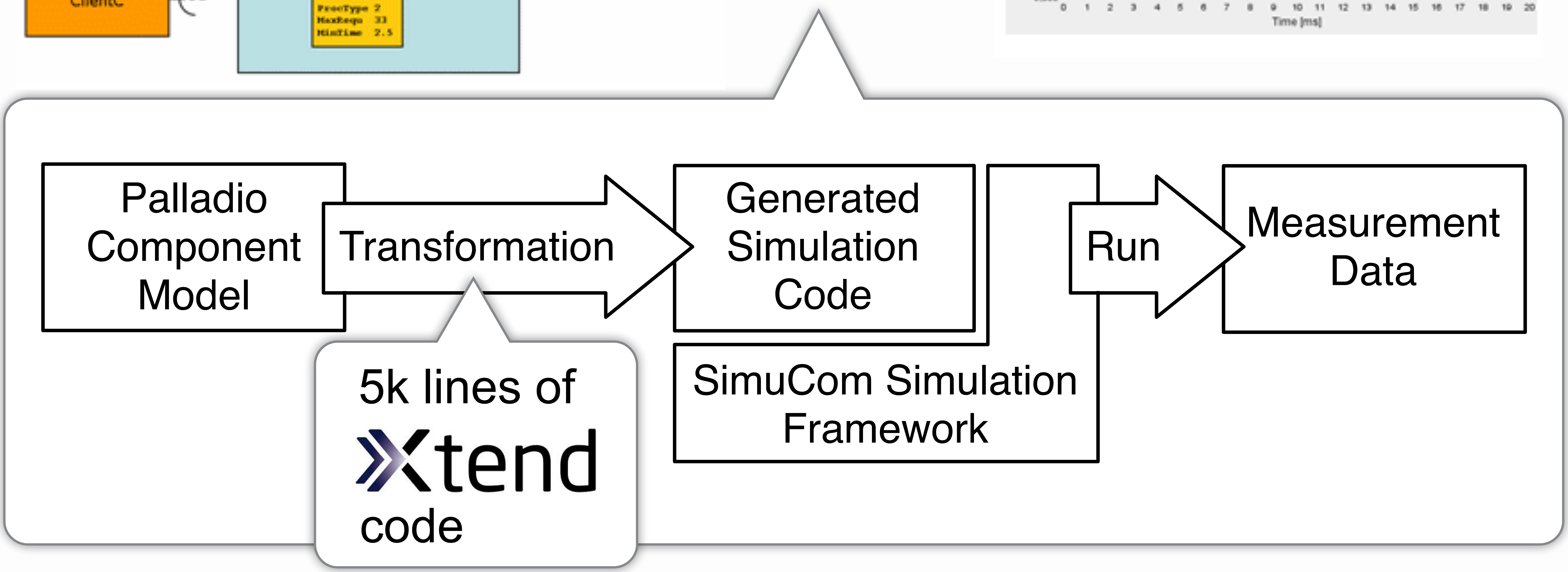

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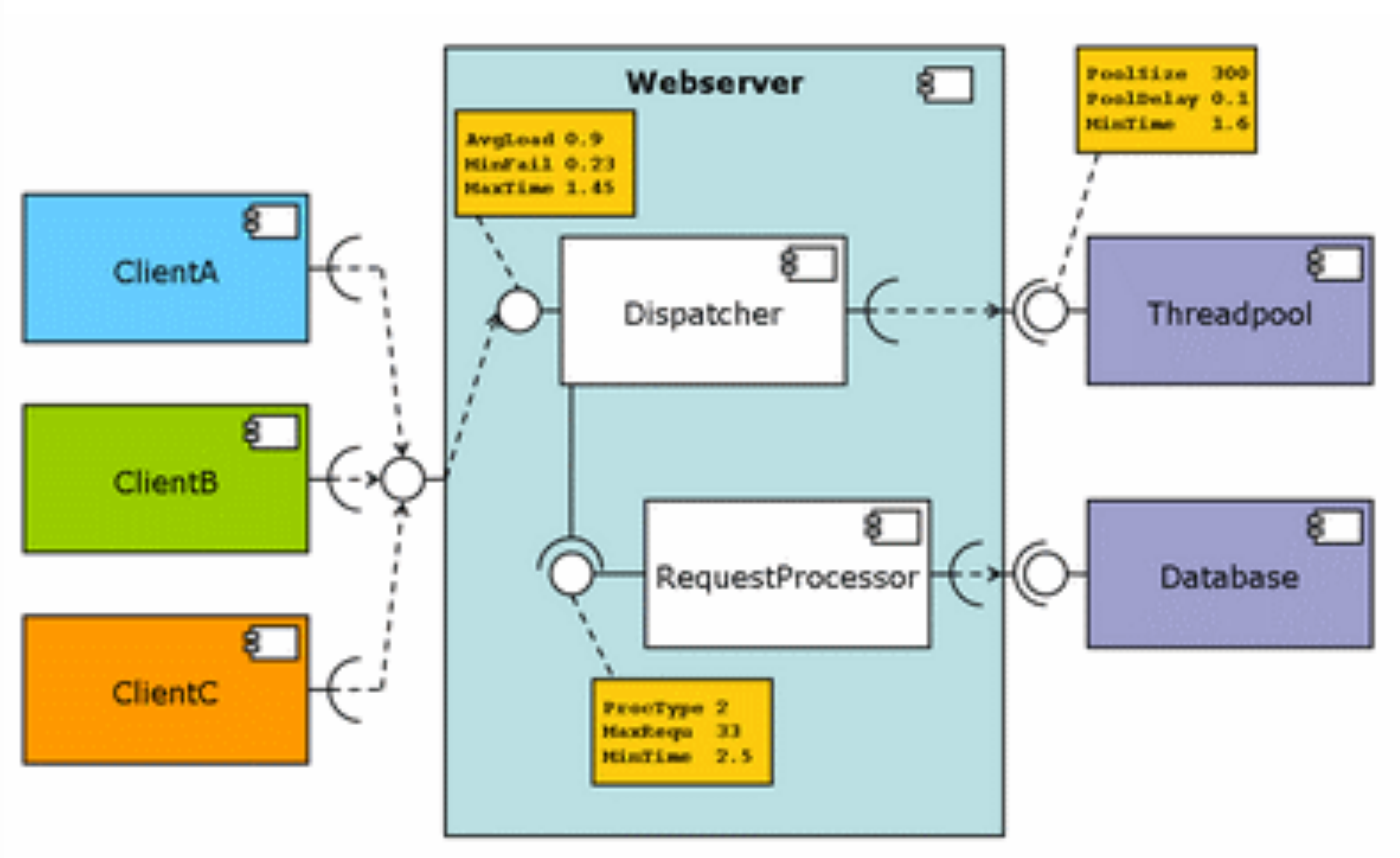


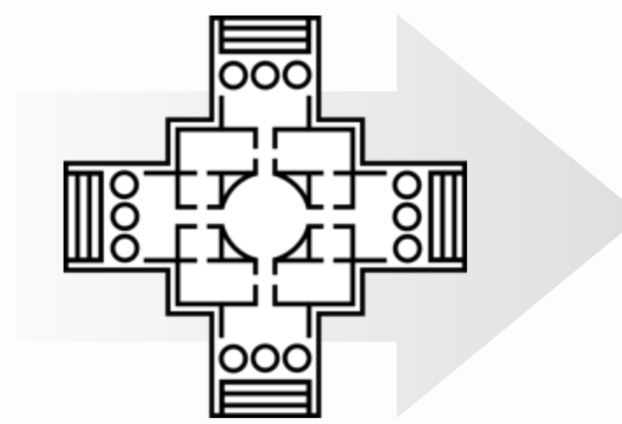

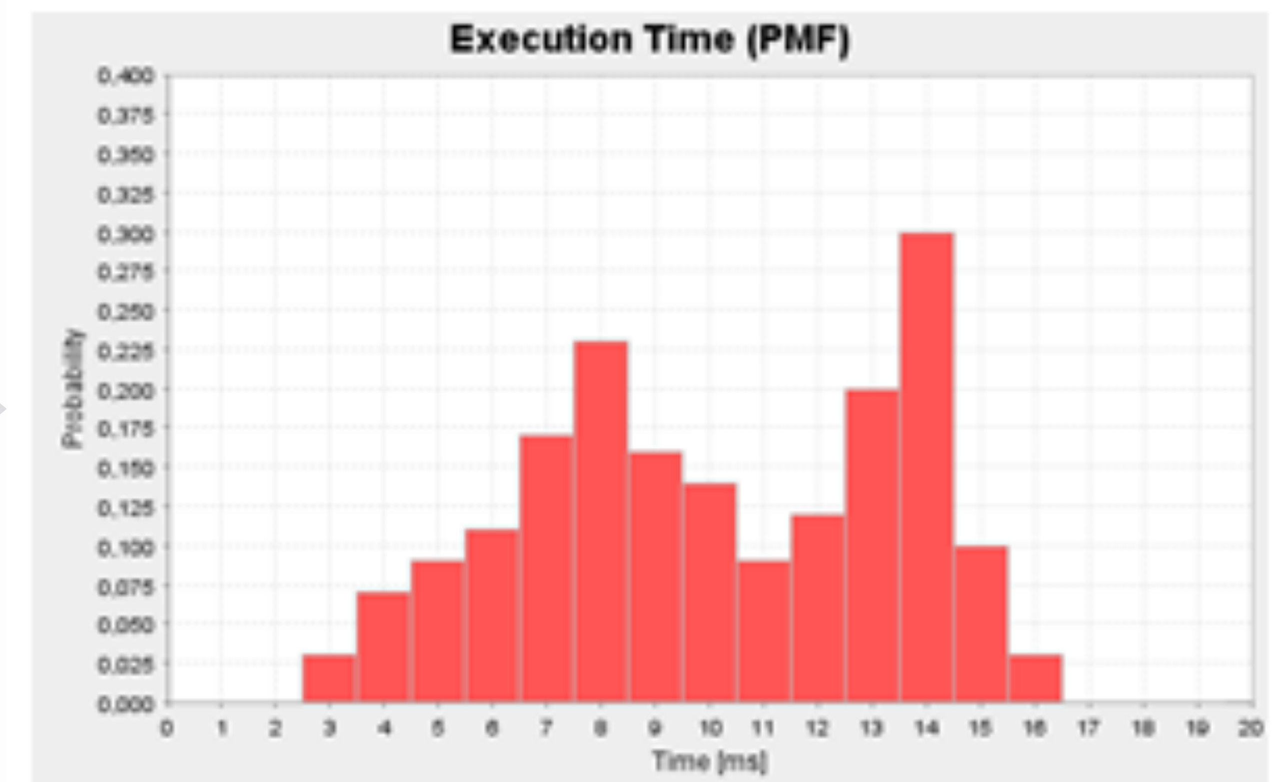


Palladio Component Model → Transformation → Queueing Petri Net Model → Simulate → Measurement Data

5k lines of **QVT-O** code

# Problem and Overall Approach

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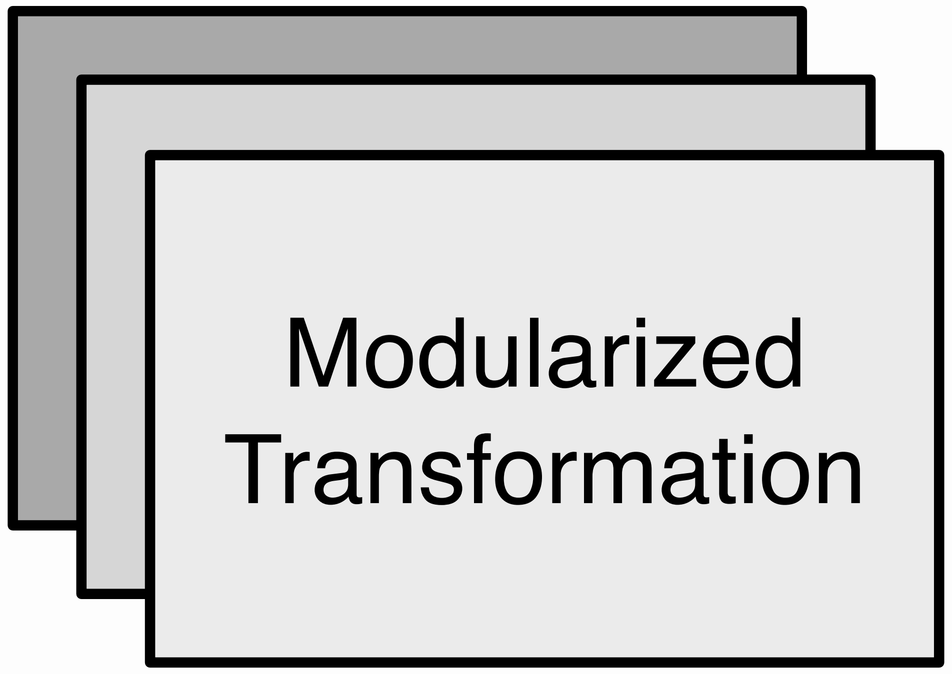

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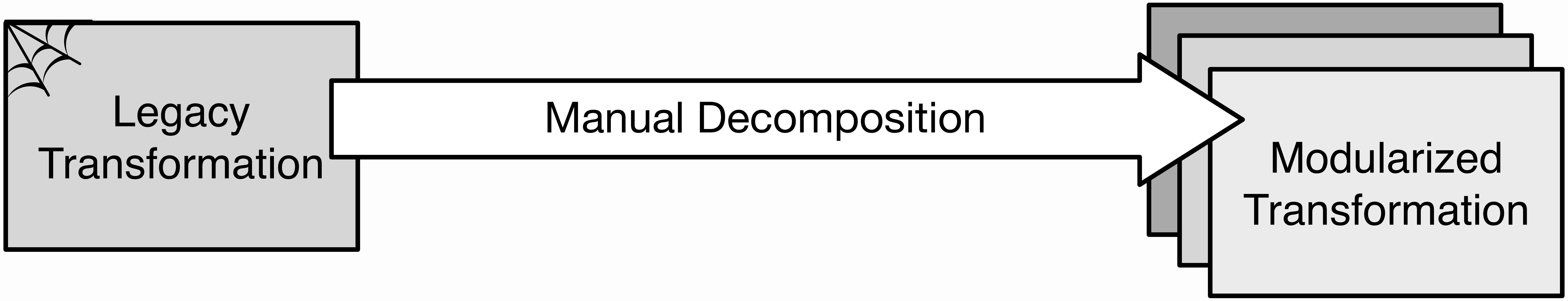

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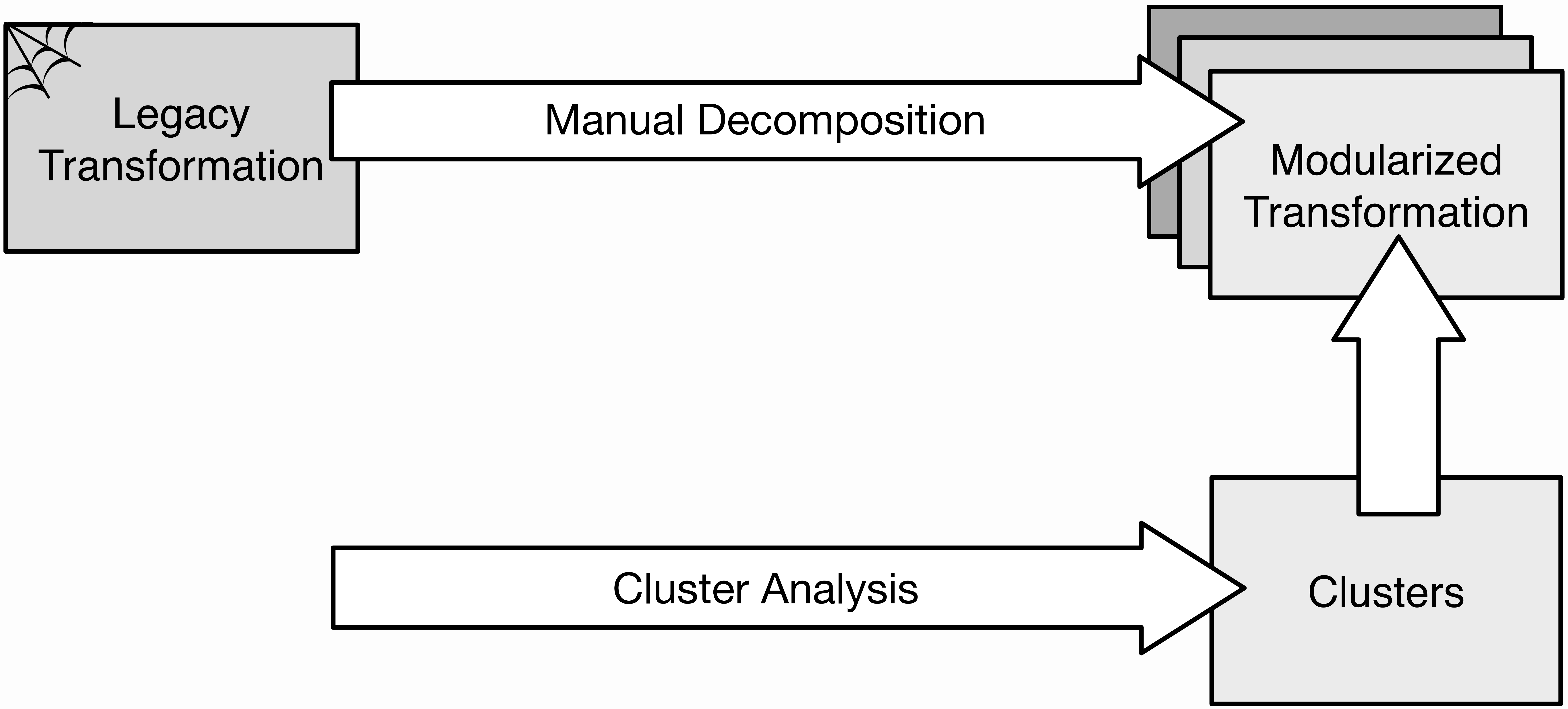

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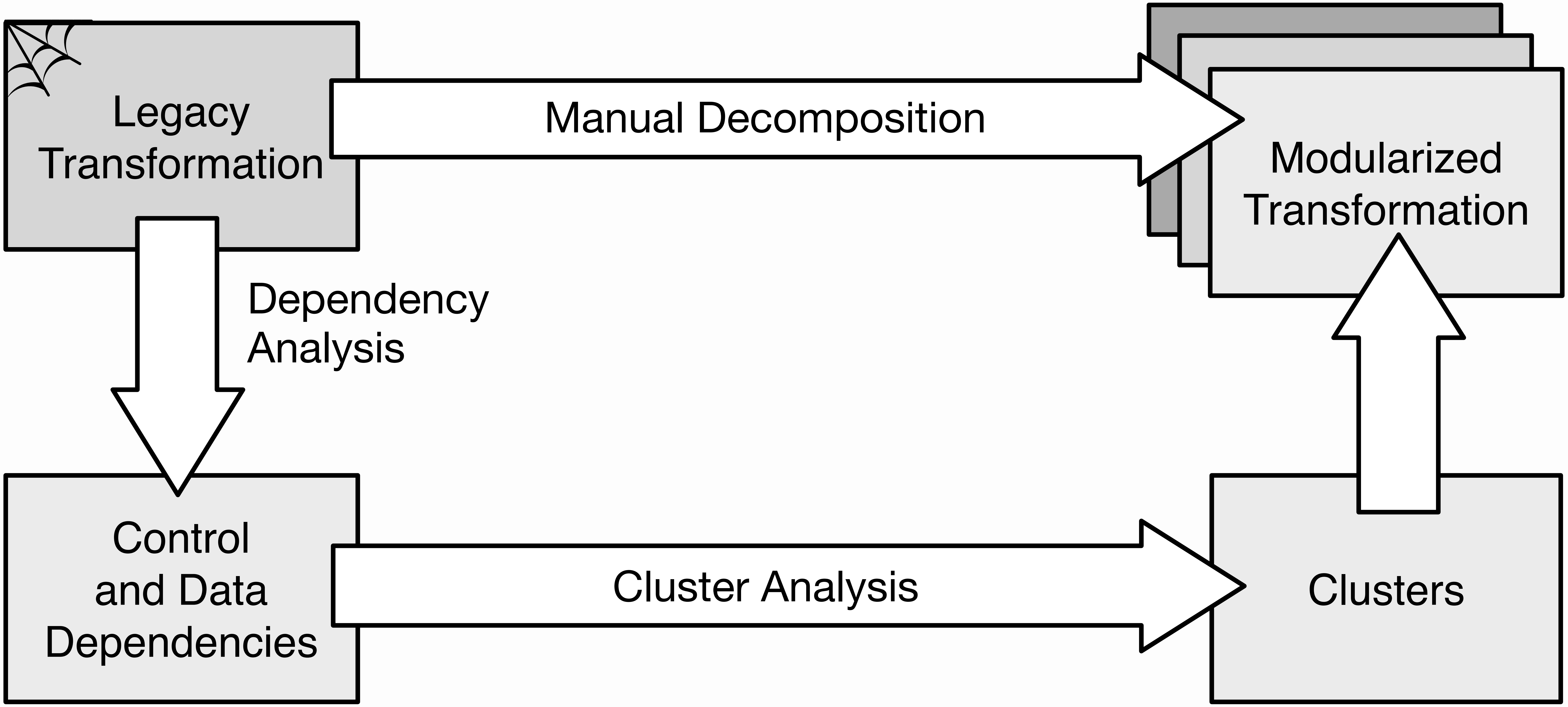

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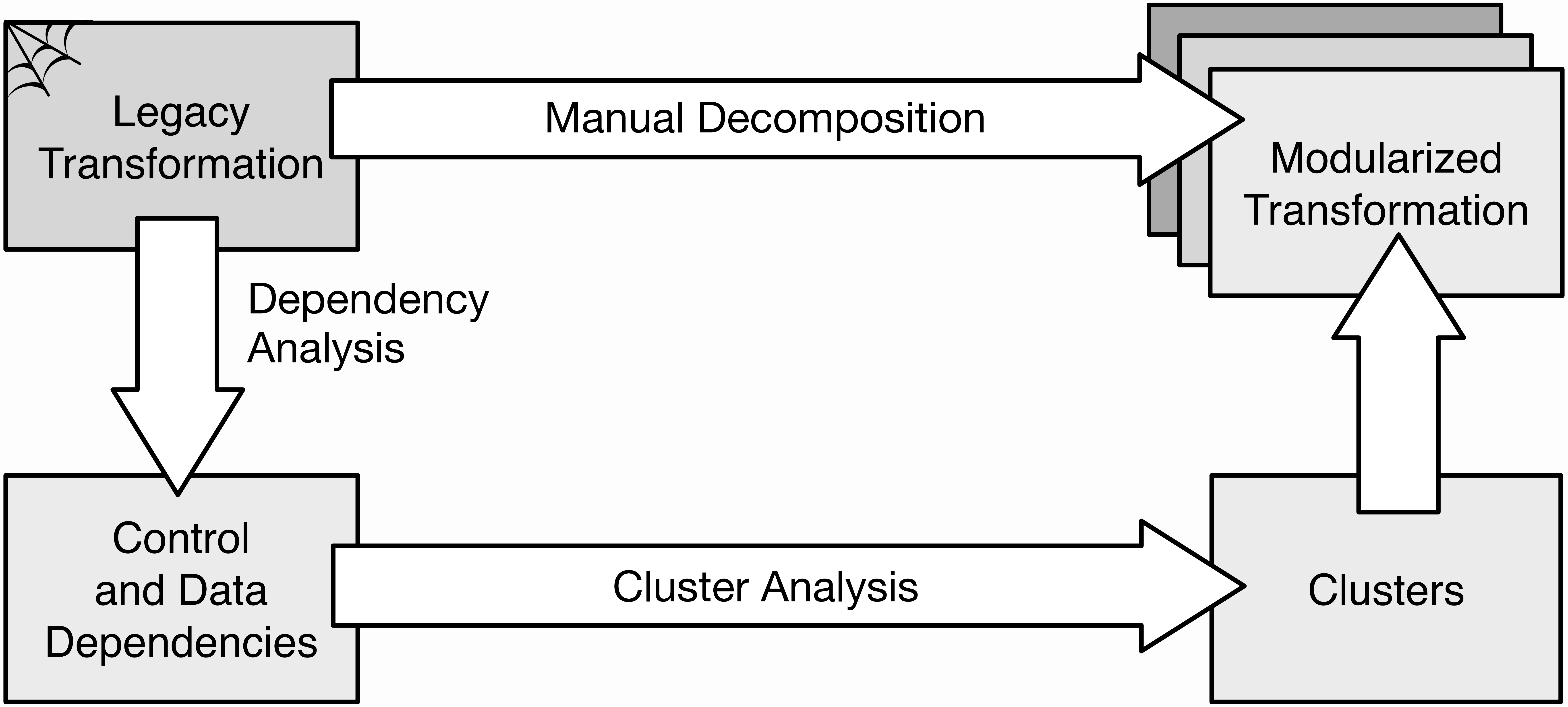


- How can we support typical transformation designs?
- What dependence information is required?

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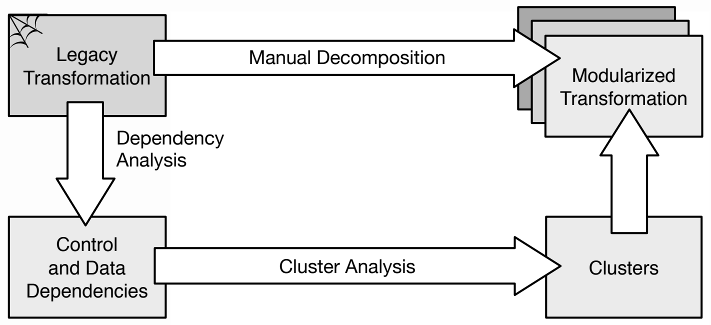


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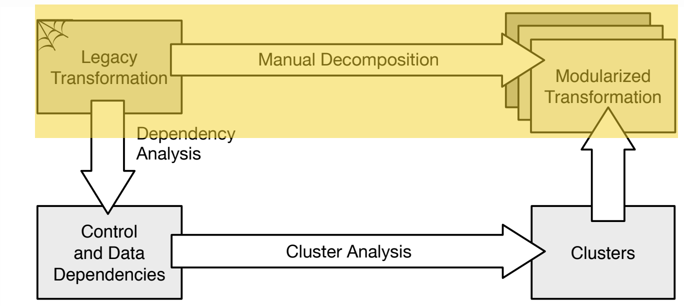


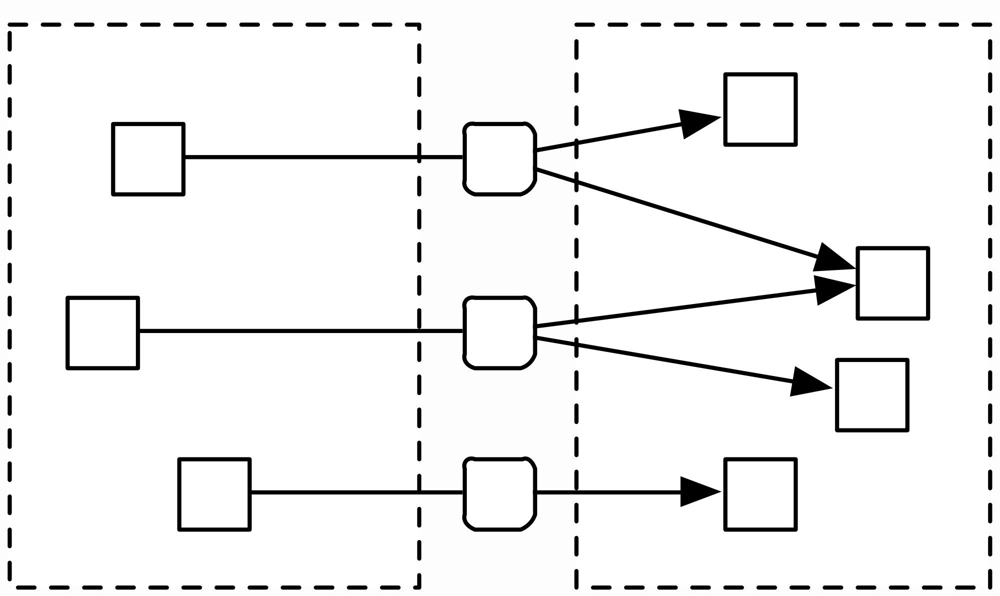

# Design Rules

What’s makes model transformations different from GPL programs?

- Data-centric operations
- Data is hierarchically structured
- Data models extrinsically defined

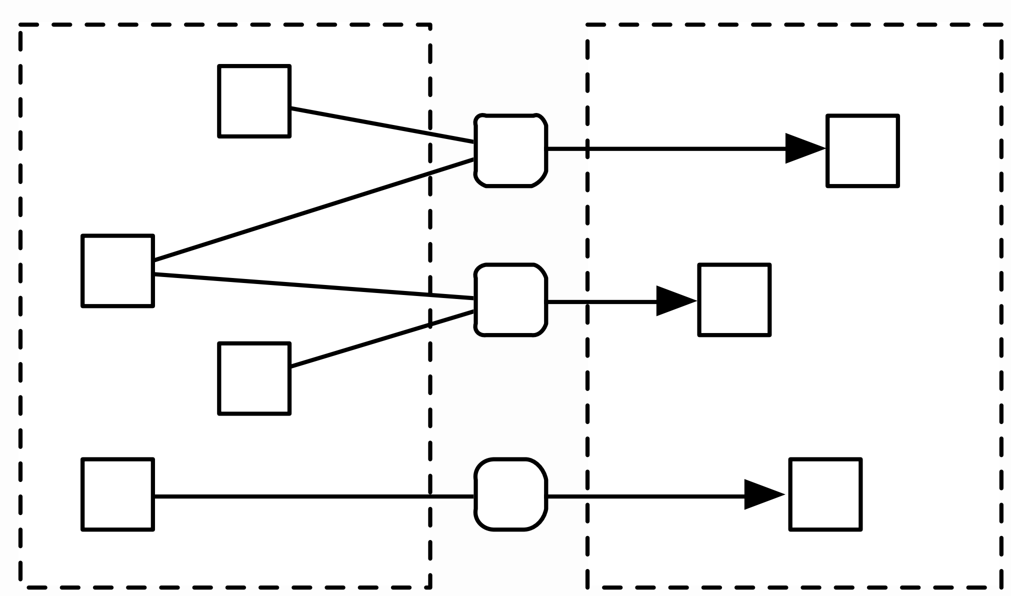
Common decompositional styles [Lawley04]:

Source-driven



one-to-many mappings

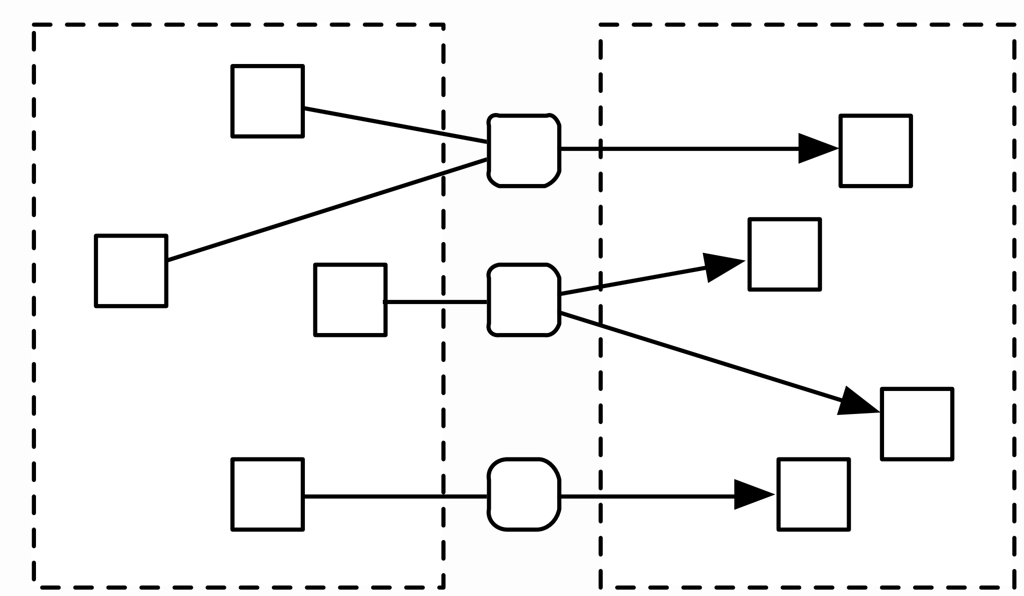
Target-driven



many-to-one mappings,

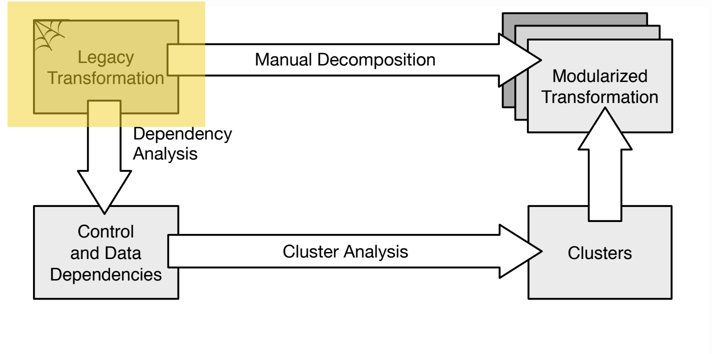
M2T templates

Aspect-driven



a mixture of both

# A Minimalistic Example Transformation



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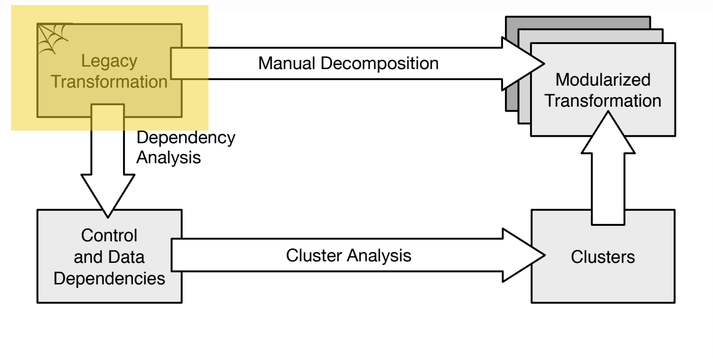
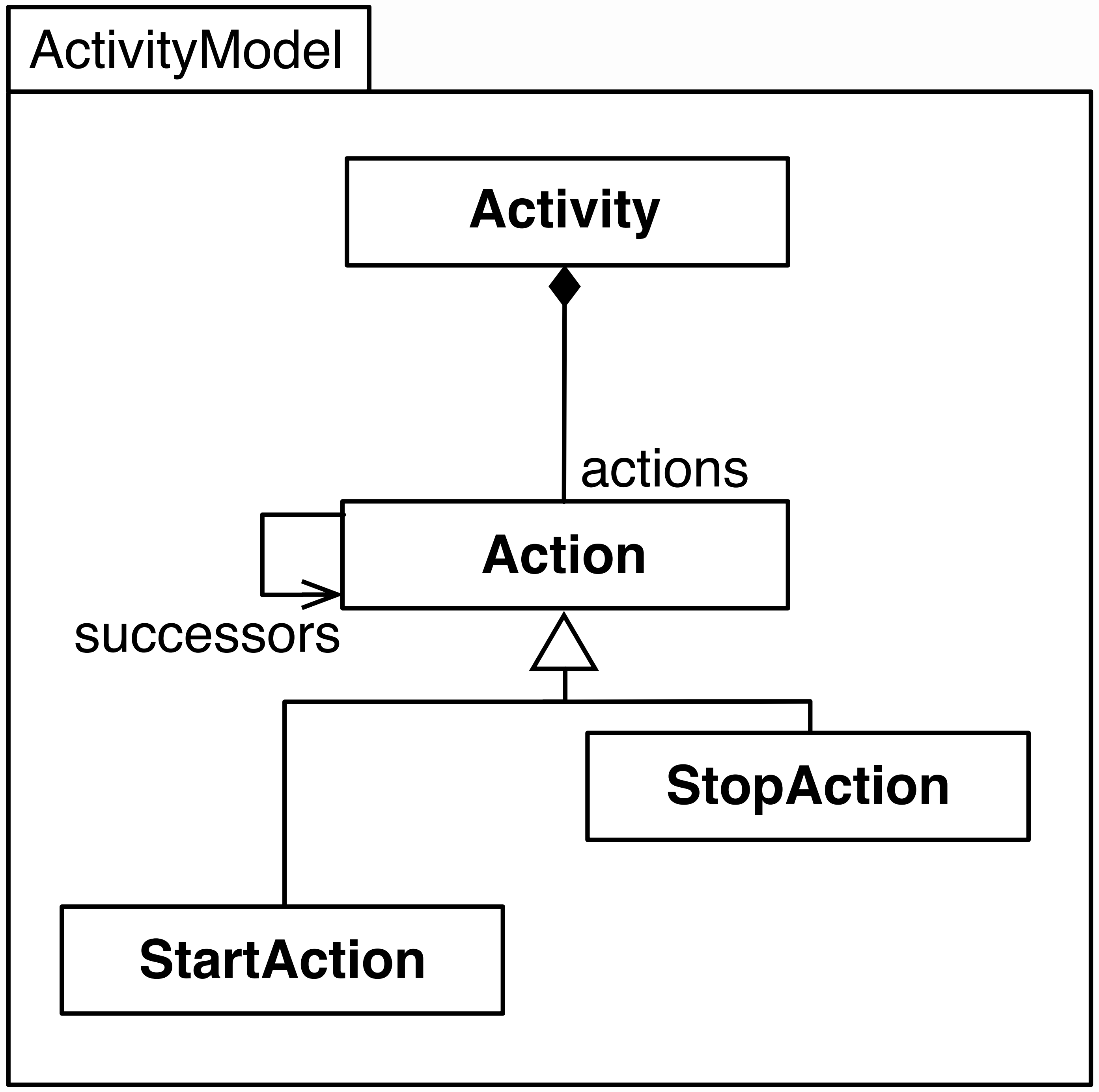



Source Model



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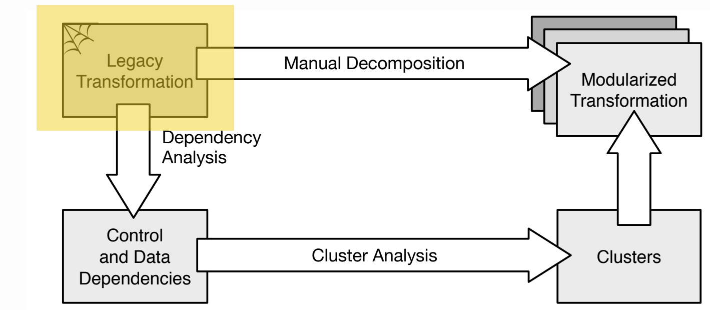


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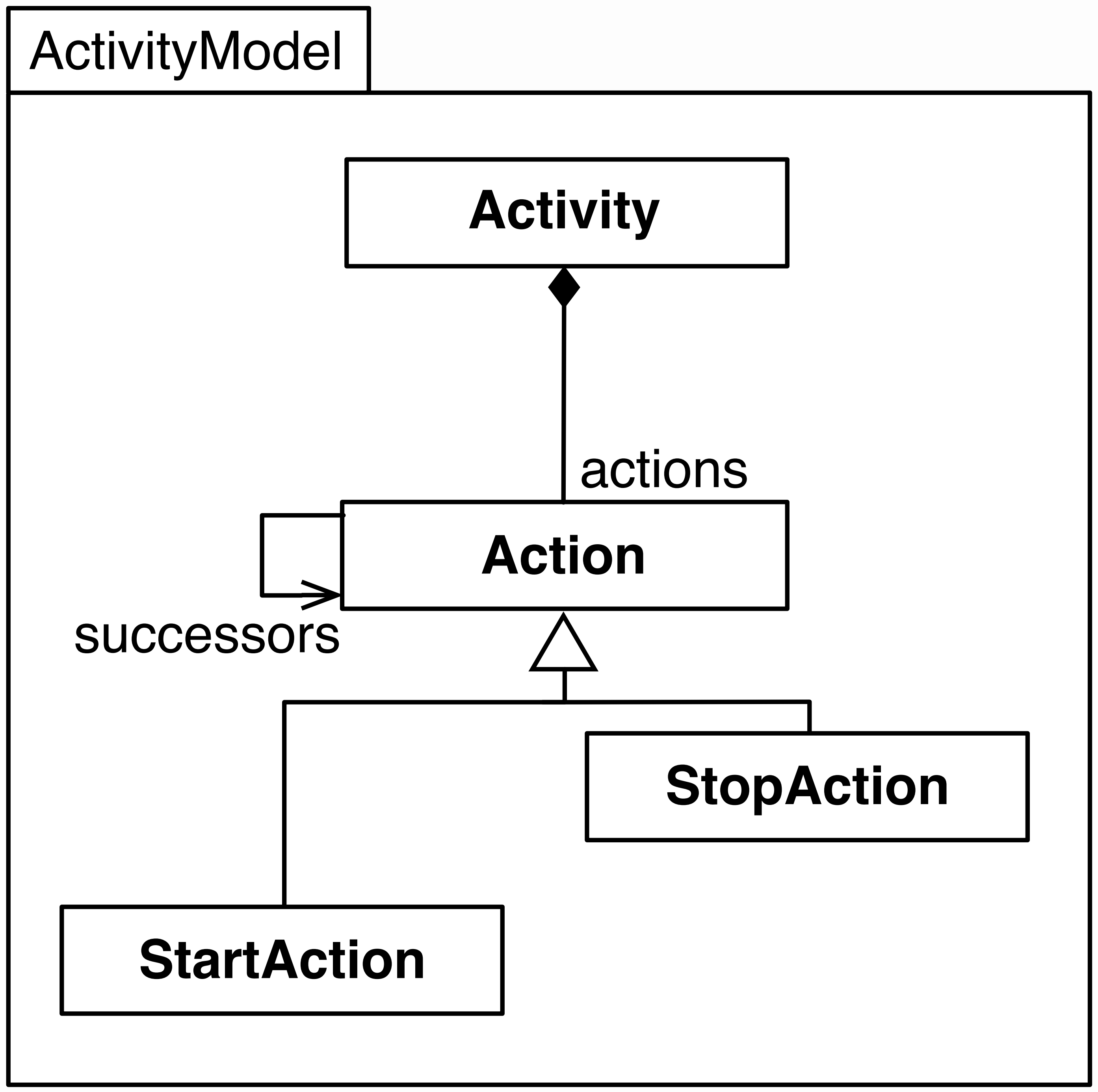
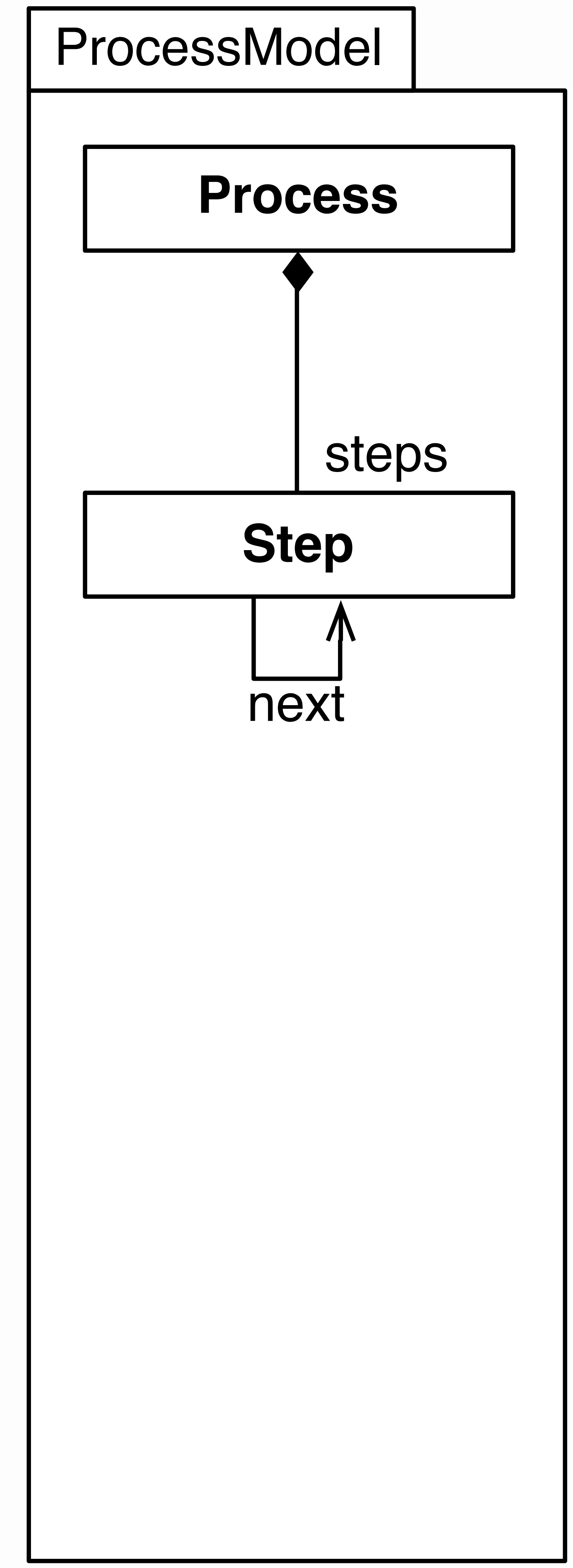



Target Model



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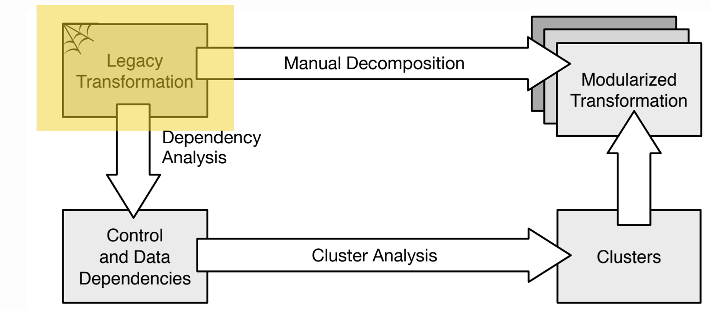


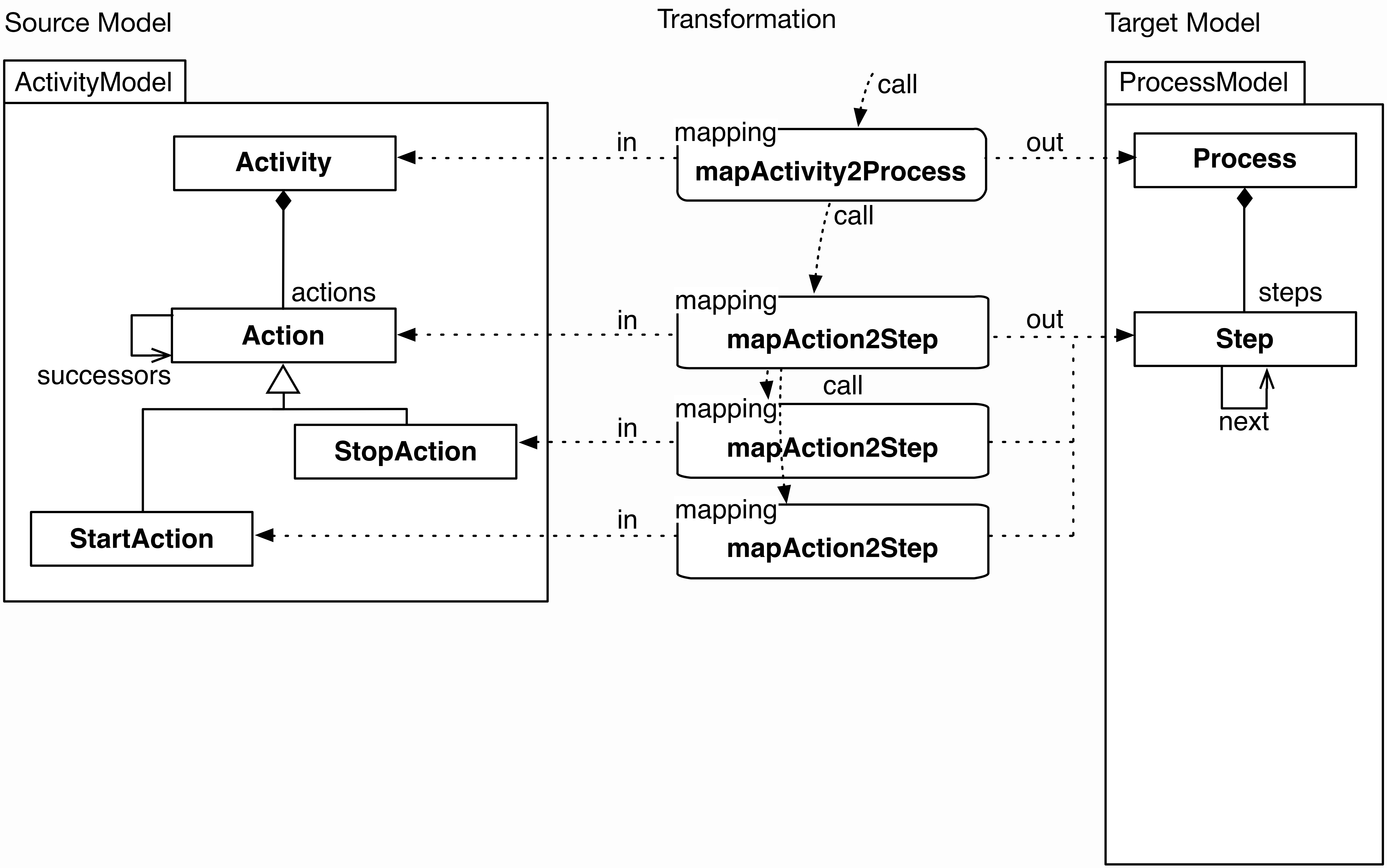

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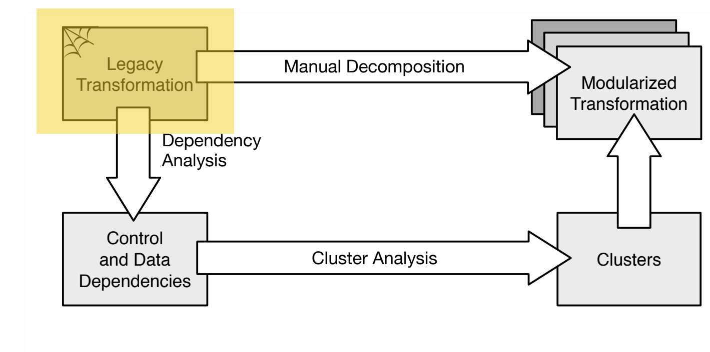


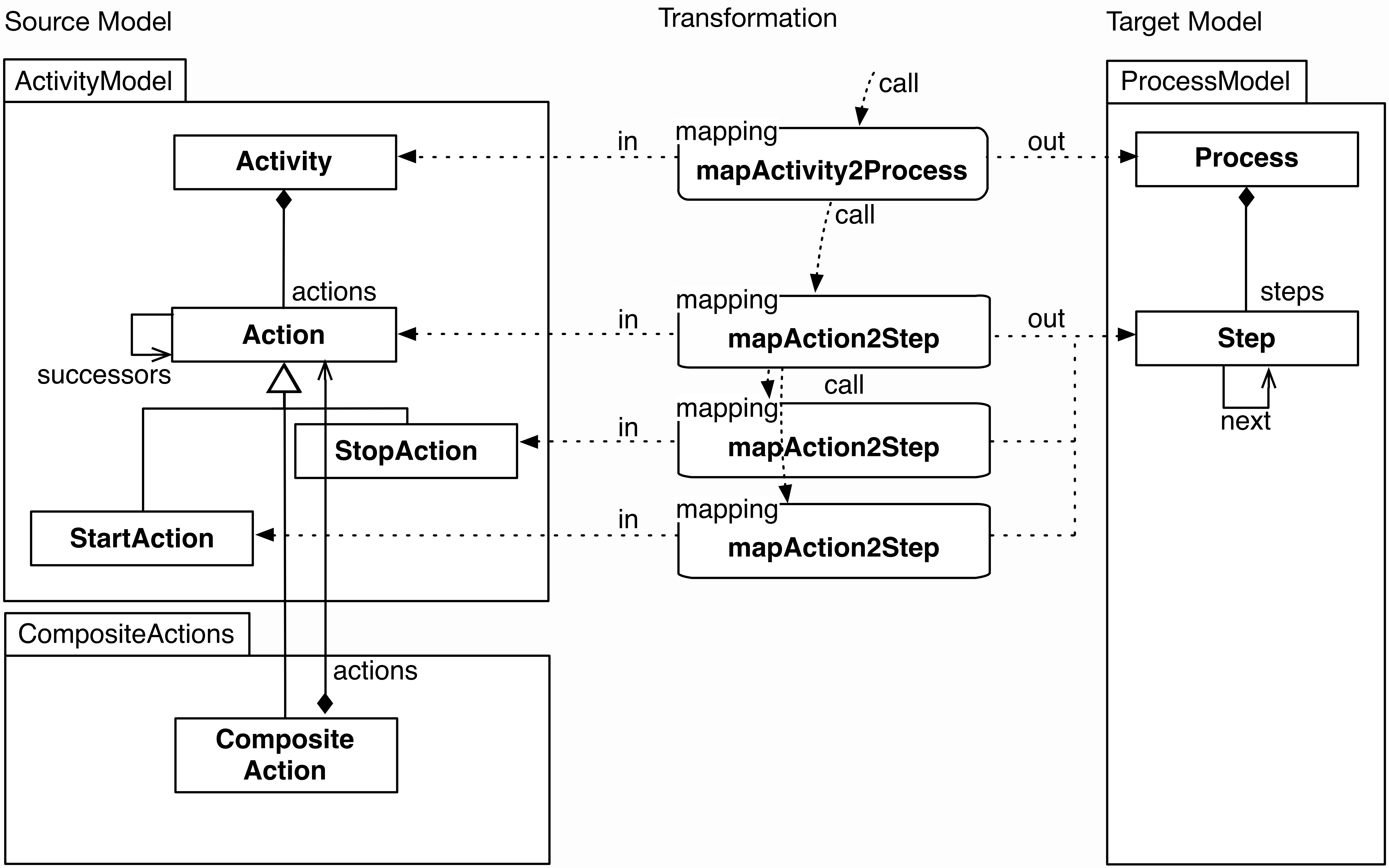

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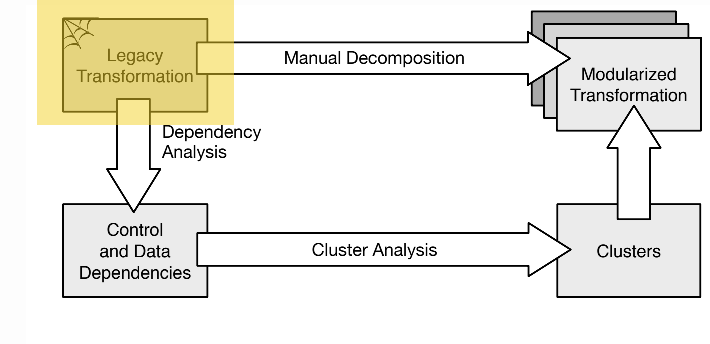


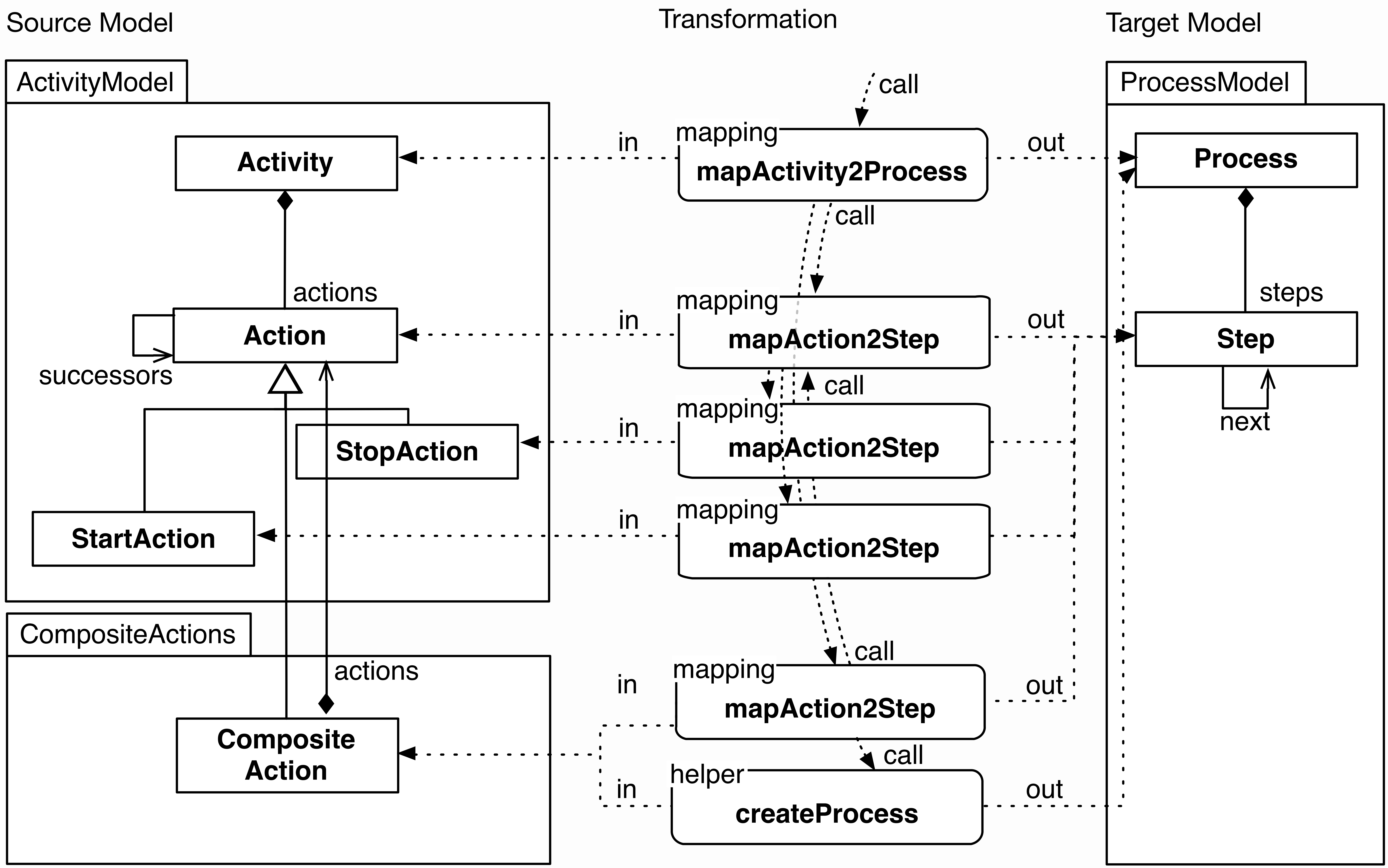

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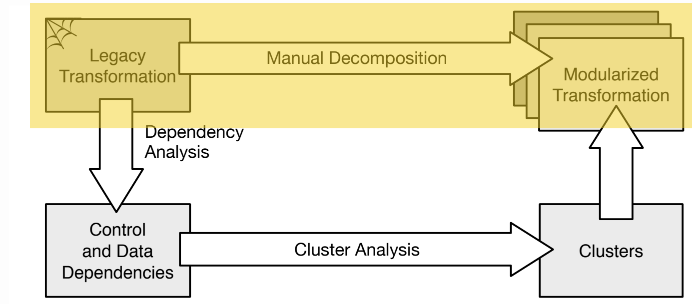
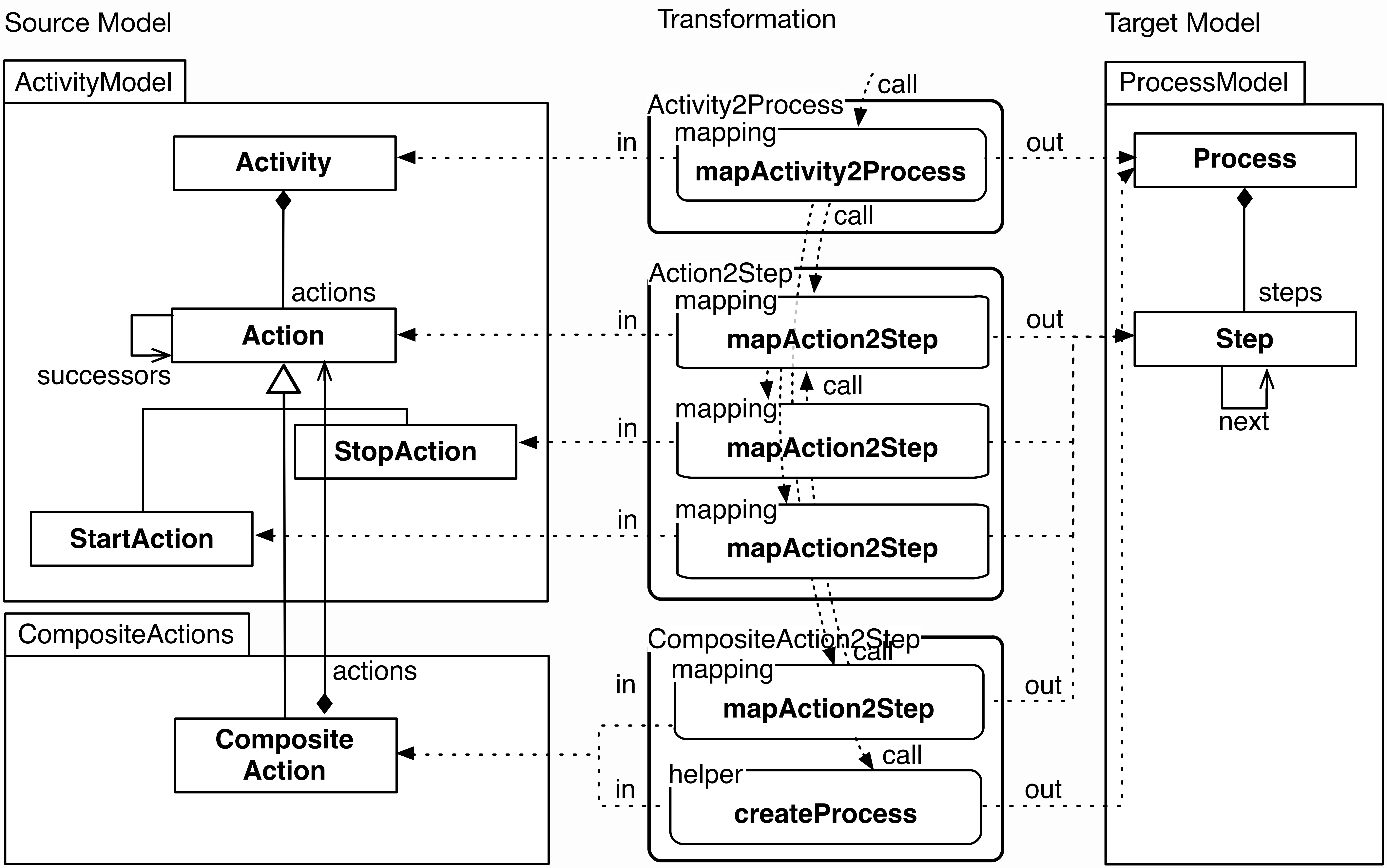
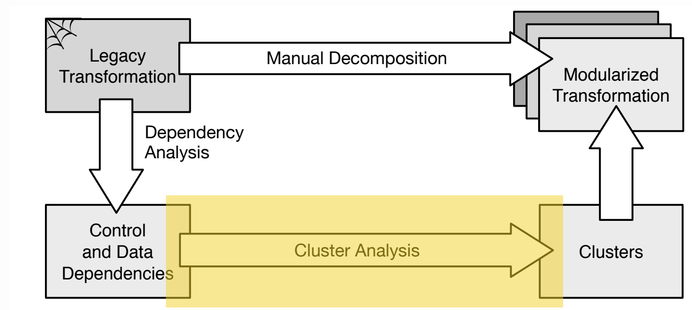
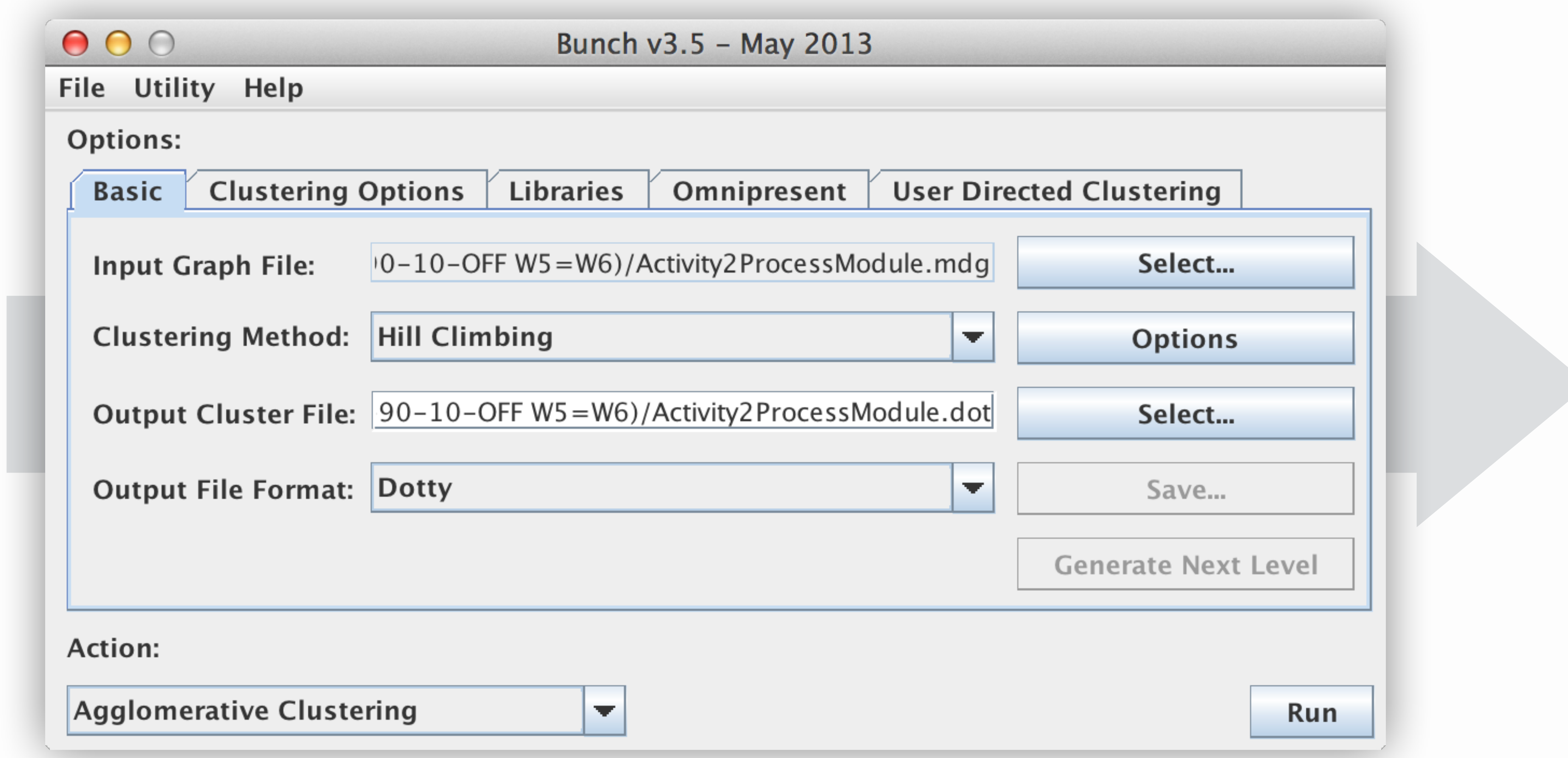


# The *Bunch* Clustering Approach*




* by [Mitchell06]; alternative approaches are ARCH, ACDC, LIMBO, … [Shtern12]

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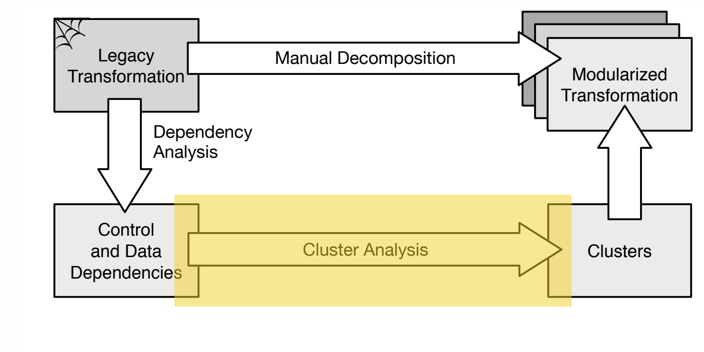


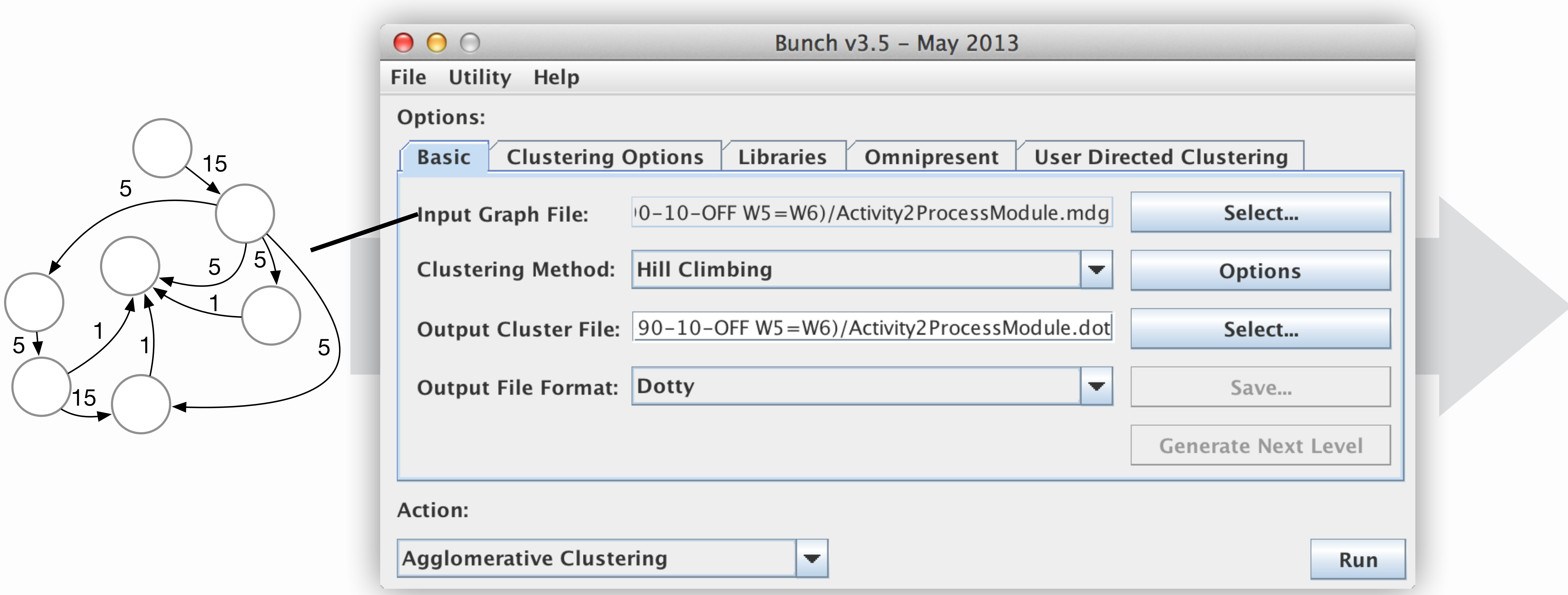


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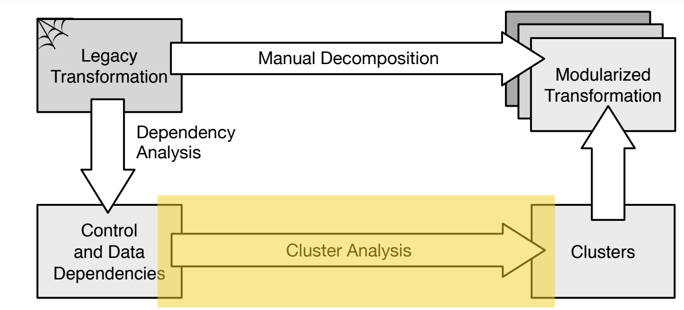


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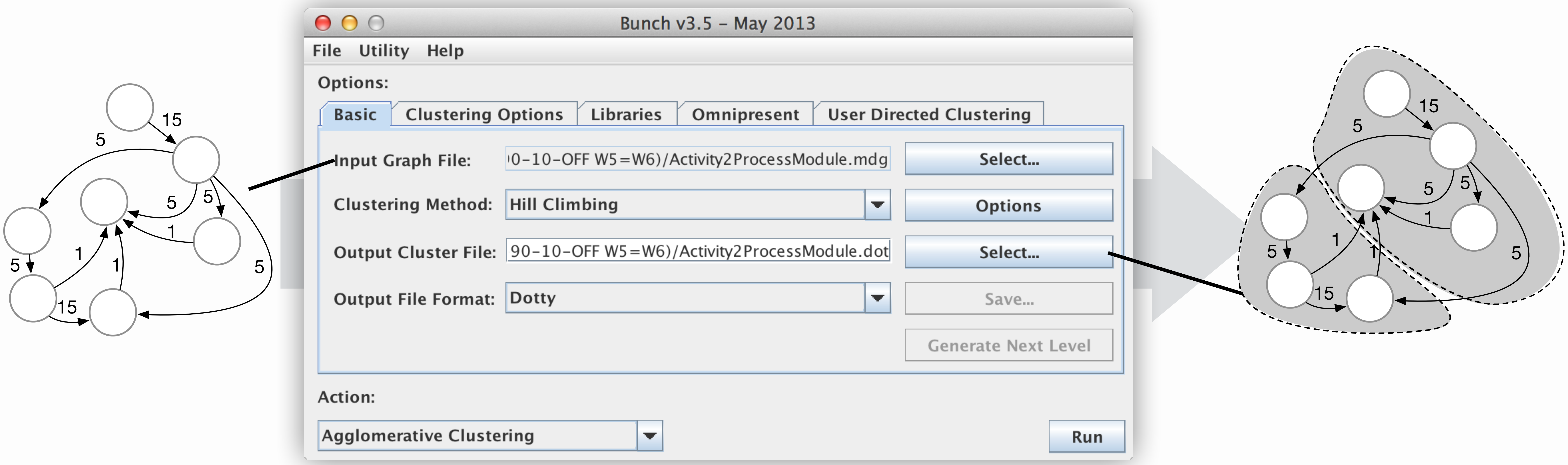


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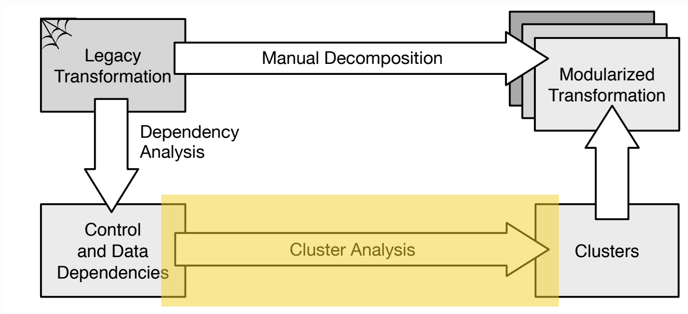
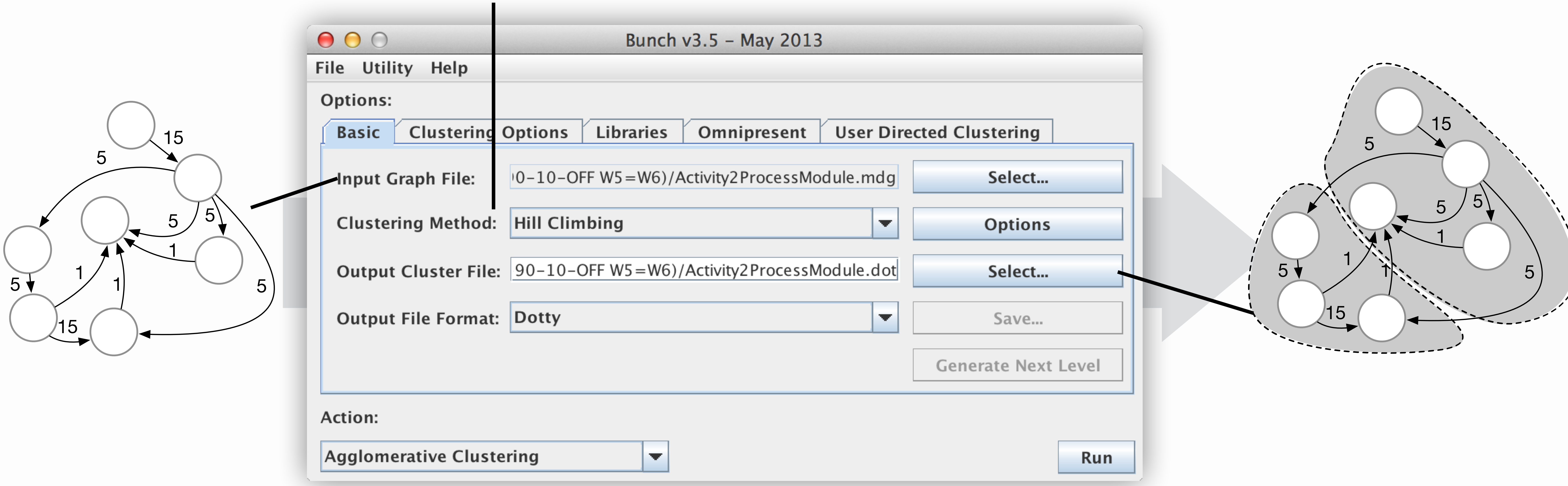



Clustering methods: hill climbing, genetic, exhaustive

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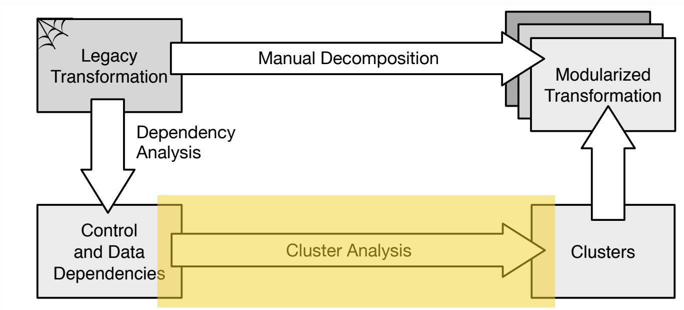


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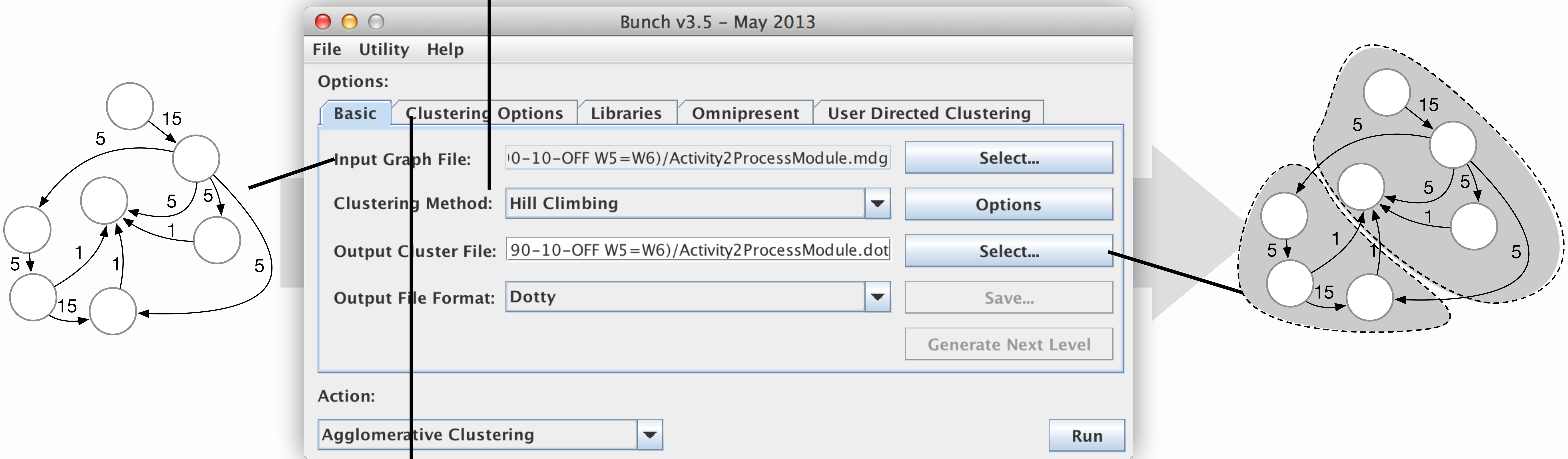


Modularity quality index: favor low coupling & high cohesion

$$MQ = \sum_{i=1}^{k} CF_i, \quad CF_i = \begin{cases} 0, & \mu_i = 0 \\ \frac{\mu_i}{\mu_i + \frac{1}{2}\sum_{\substack{j=1 \\ j \neq i}}^{k} (\epsilon_{i,j} + \epsilon_{j,i})}, & \text{otherwise} \end{cases}$$

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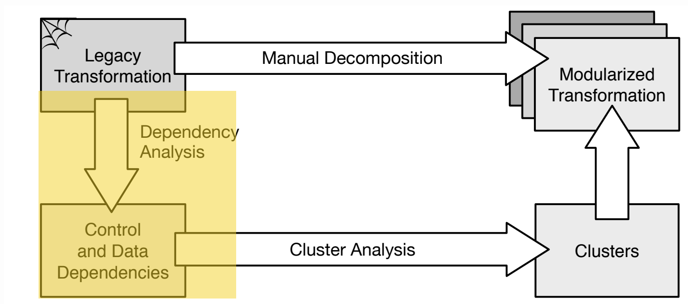
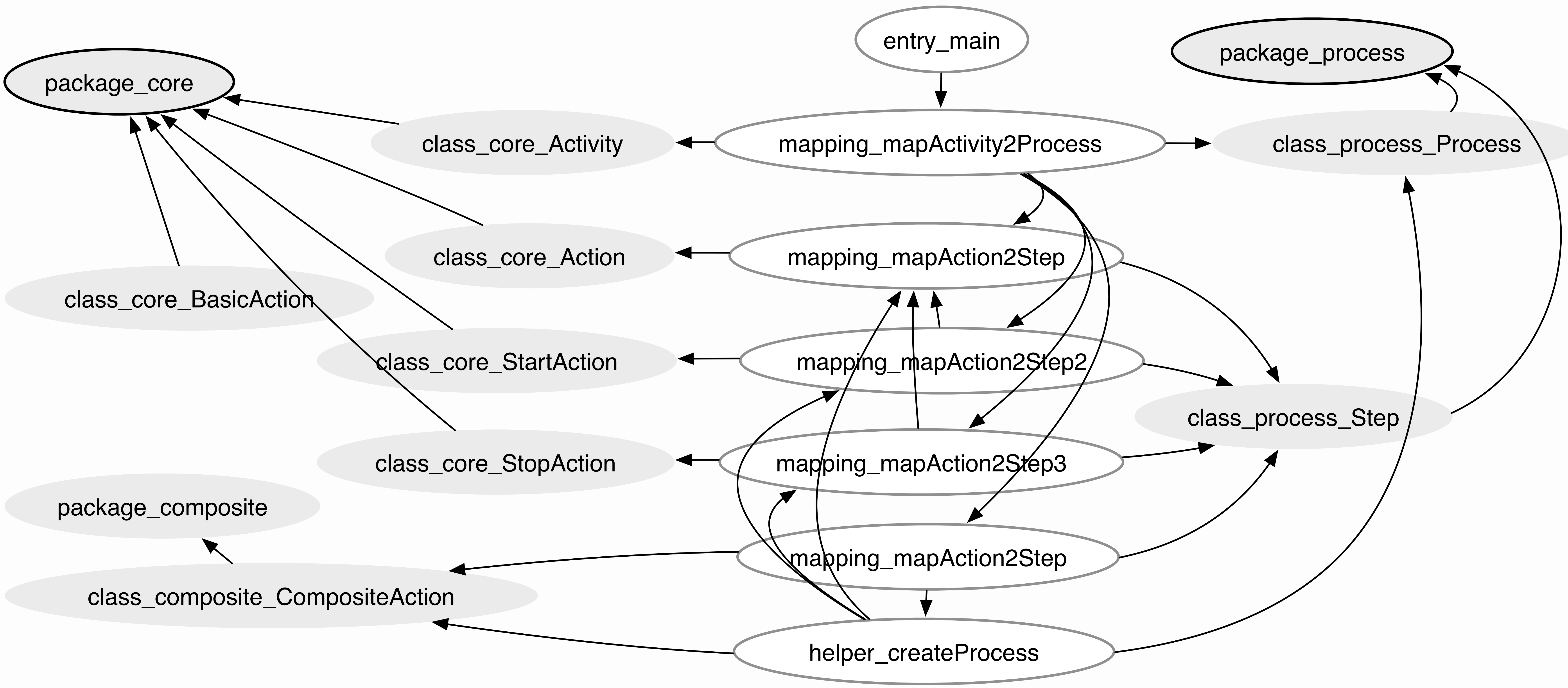
# Dependence Analysis



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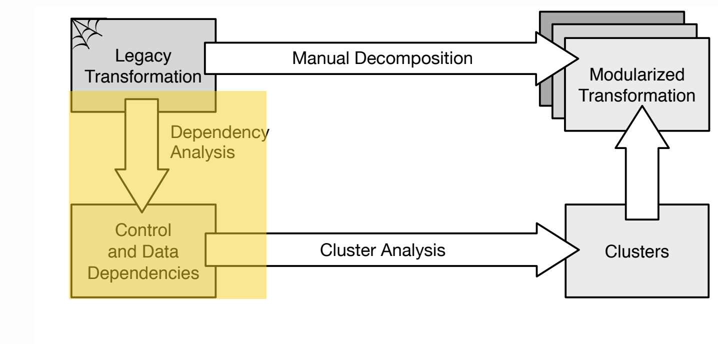
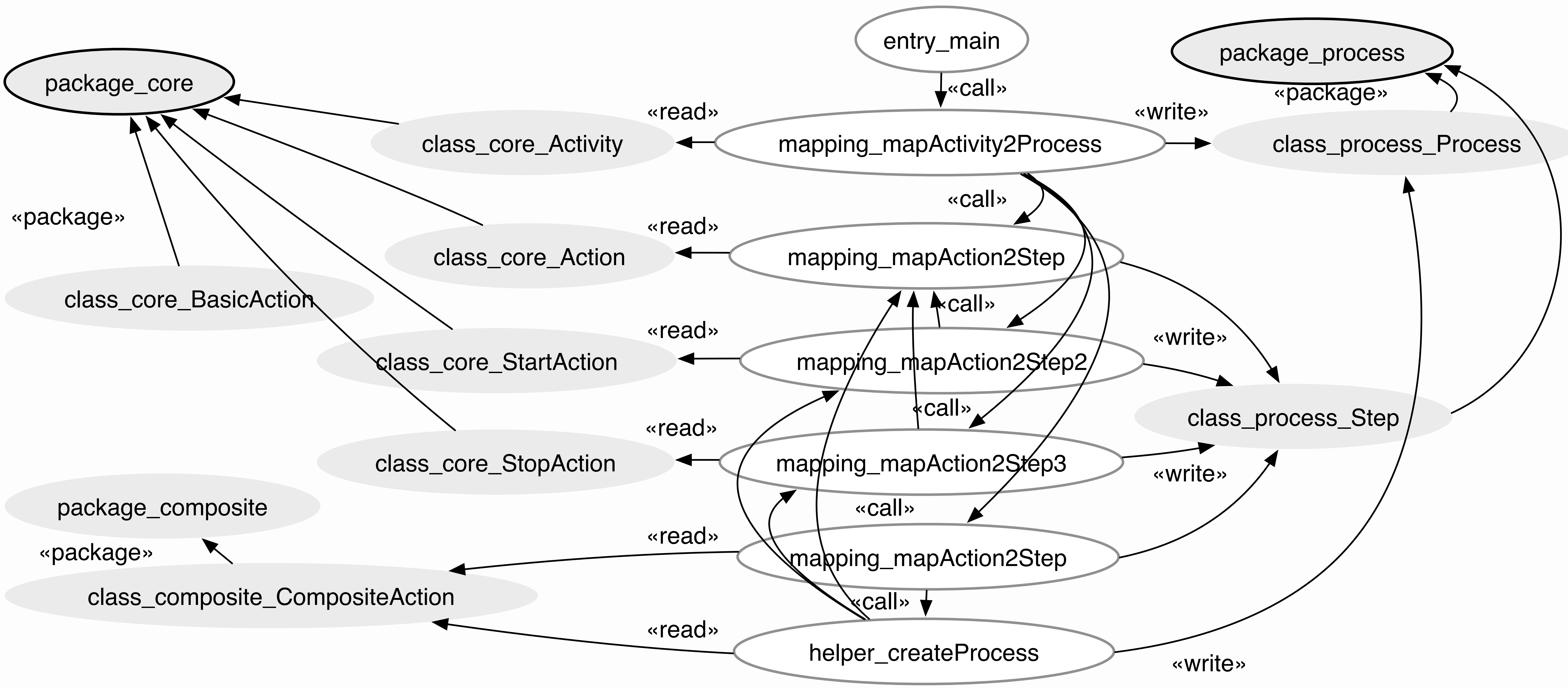
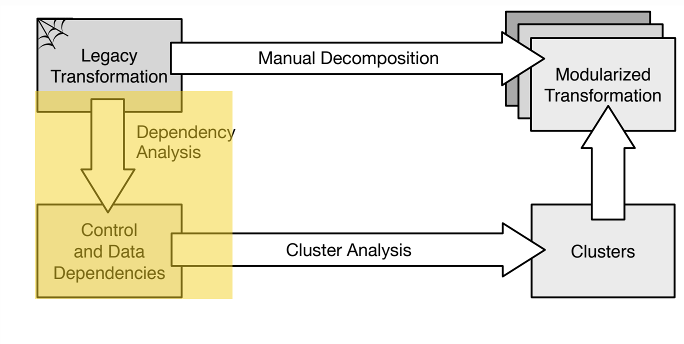


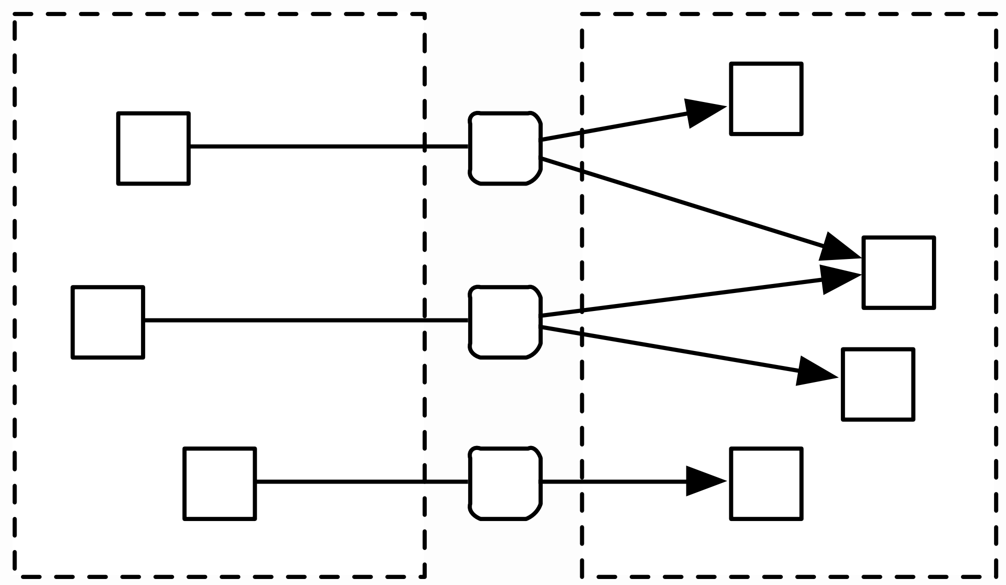





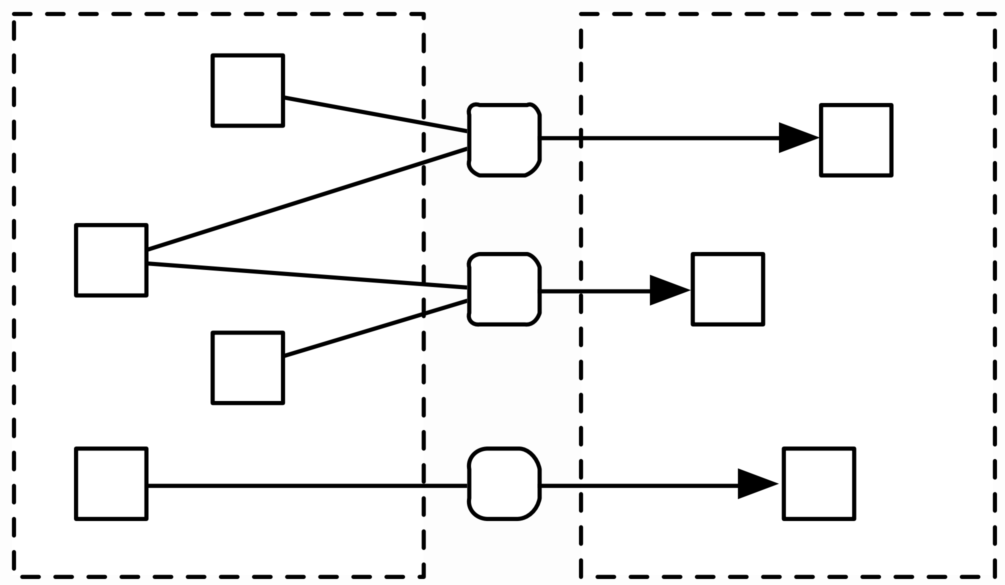

# Weight Configuration

Depending on the style…

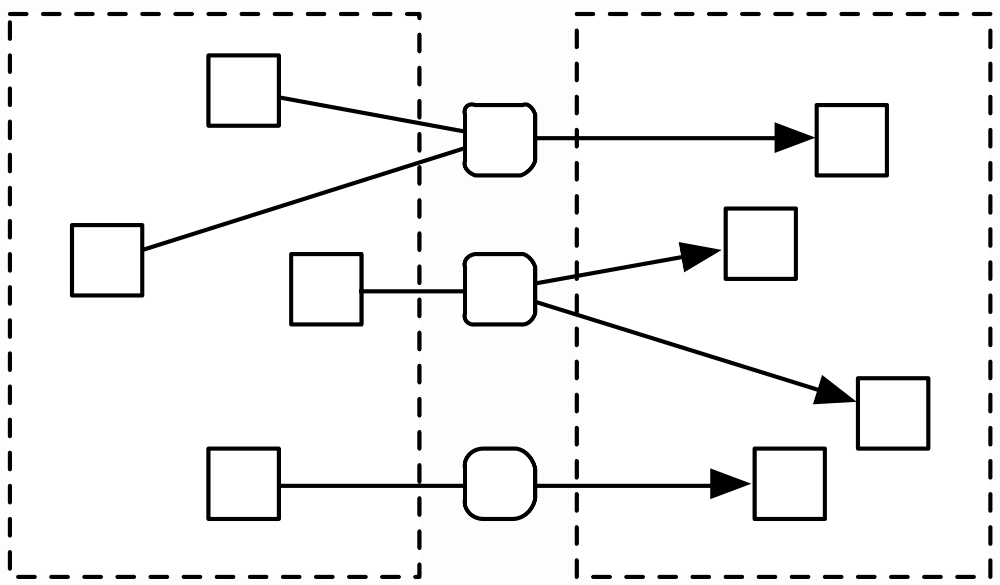
Source-driven



Target-driven



Aspect-driven



…initialize a configuration vector for weighting the various types of edges:

$$WC := \langle W_{write}, W_{read}, W_{call}, W_{package} \rangle \in \mathbb{N}_0^4$$

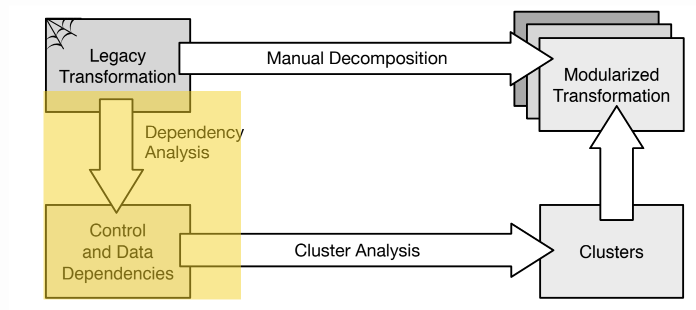
Model element is contained in package

Method invokes another method

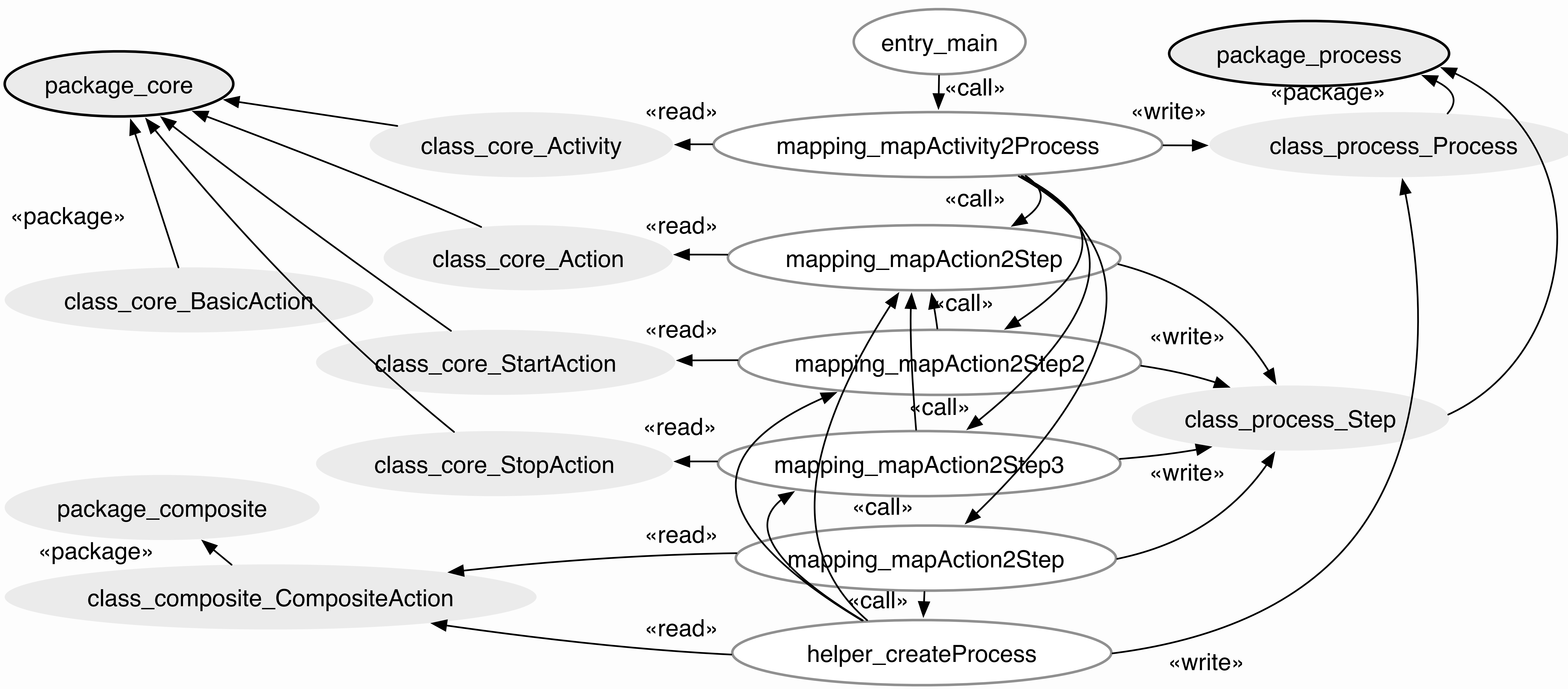
Method reads model element

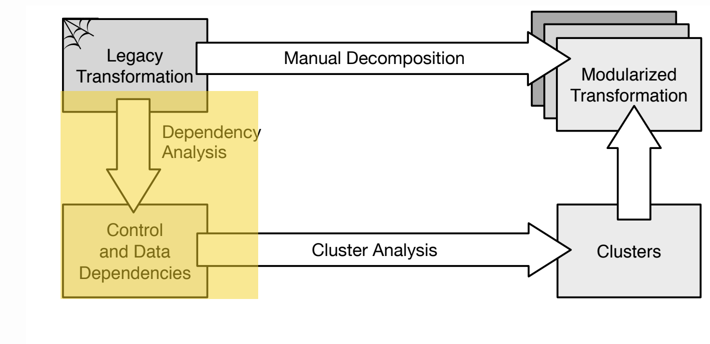
Method creates/updates model element

# Assigning Weights




$$
\begin{aligned}
WC &:= \langle W_{write}, W_{read}, W_{call}, W_{package} \rangle \\
&= \langle 1, 15, 5, 15 \rangle
\end{aligned}
$$



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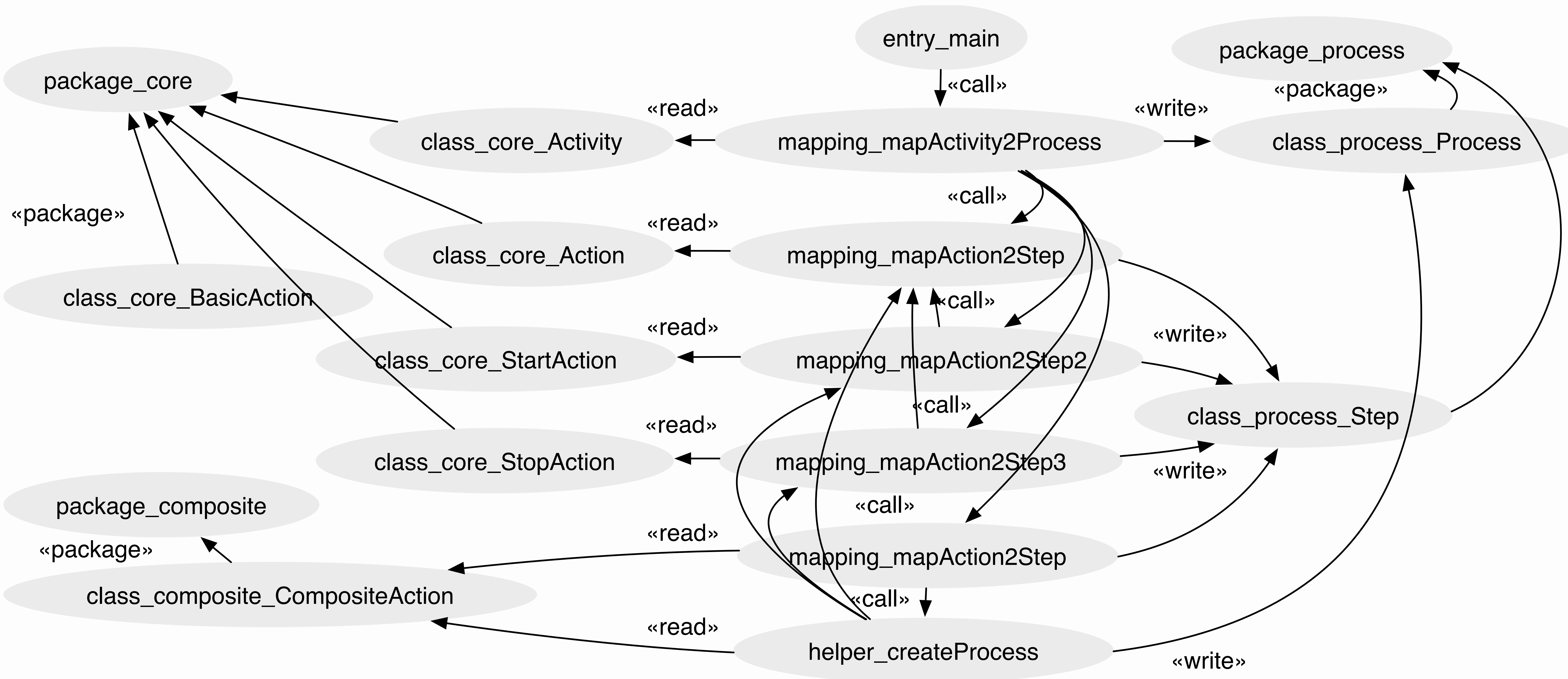

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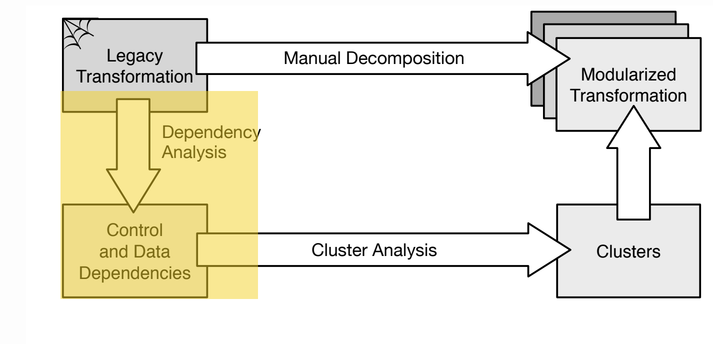


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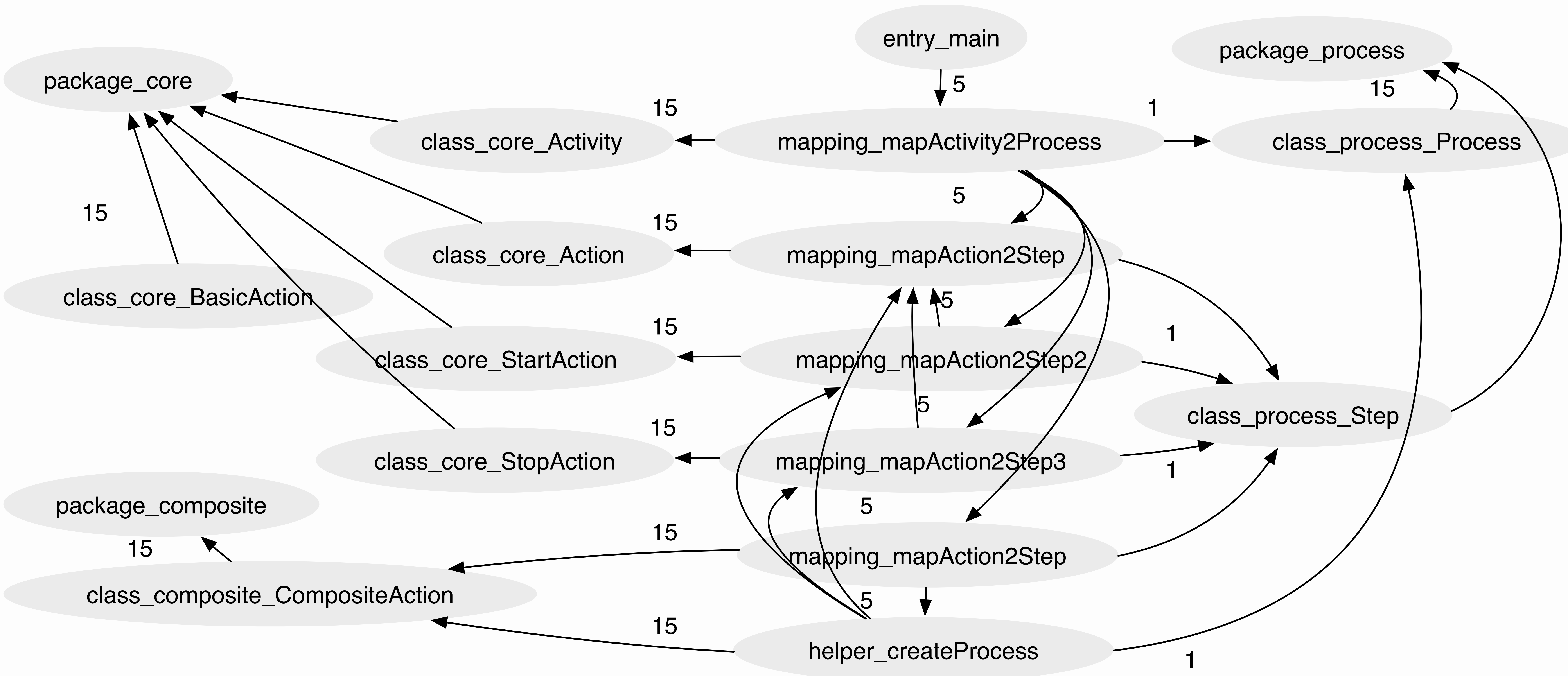
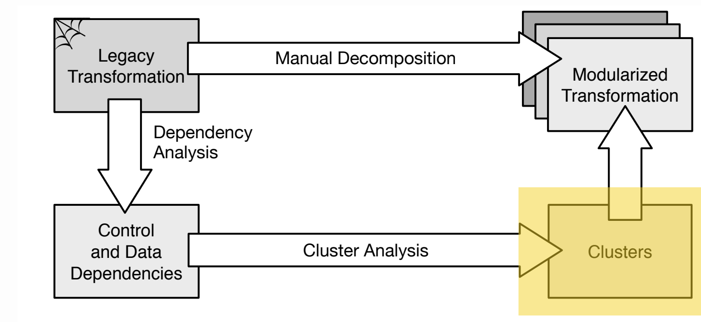
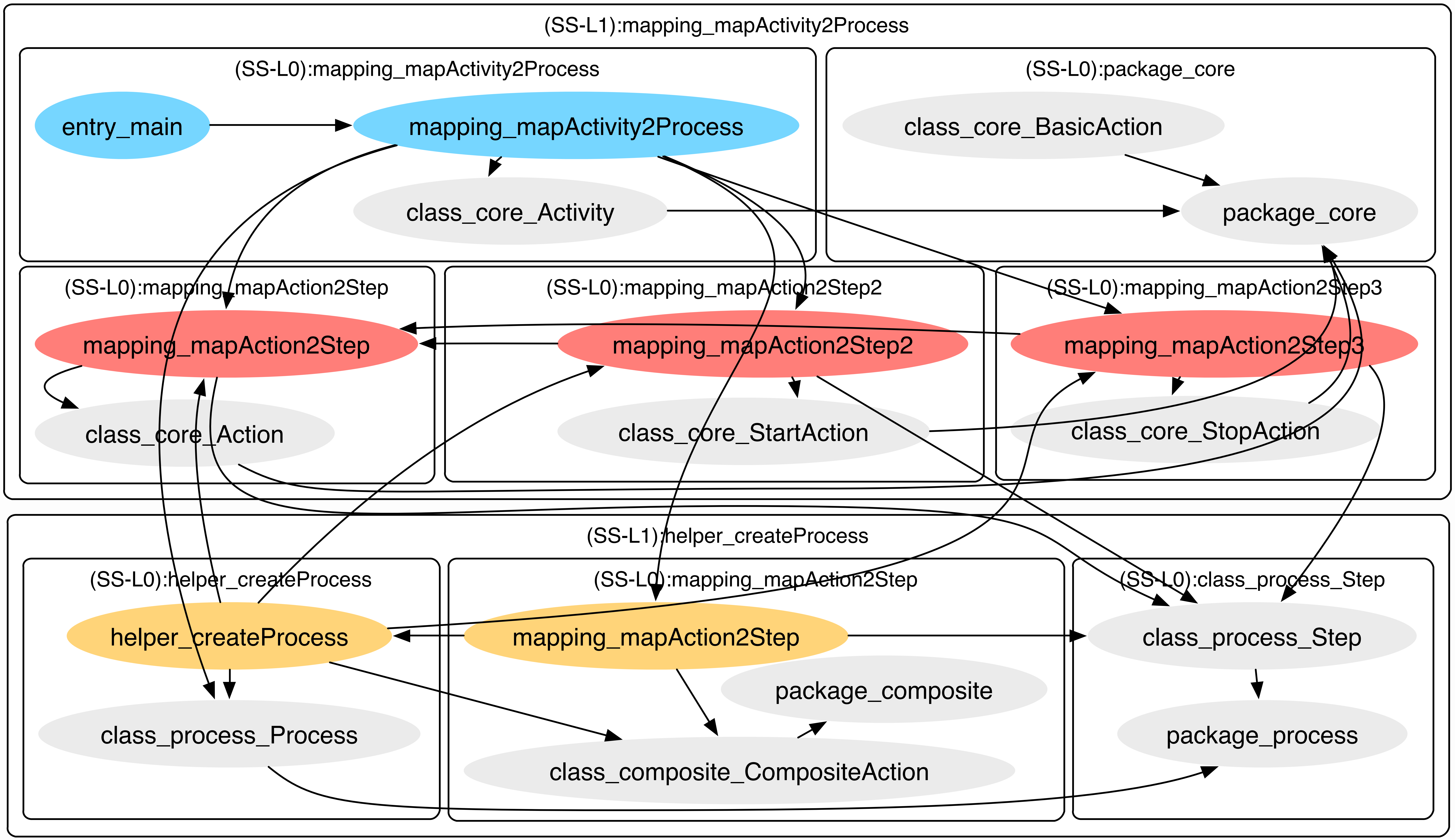
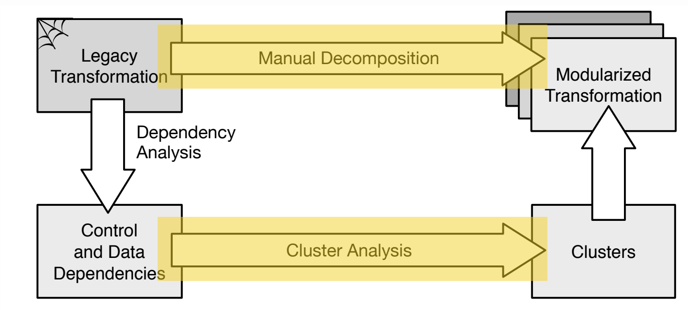


# Example Clustering



# Assessing Results




- Compare derived clustering with a manual expert clustering
- Using three similarity/distance metrics

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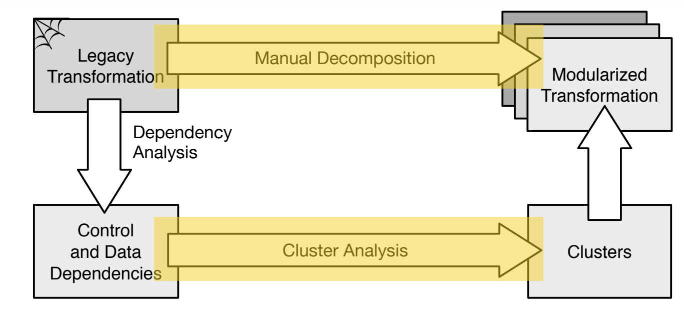


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| Configuration | Statistics | | Similarity to expert clustering | | | |
|---|---|---|---|---|---|---|
| | # Clusters | MQ index | Precision | Recall | EdgeSim | MeCl |
| **Expert clustering**<br>Derived manually | 3 | 1.067 | 100% | 100% | 100 | 100% |

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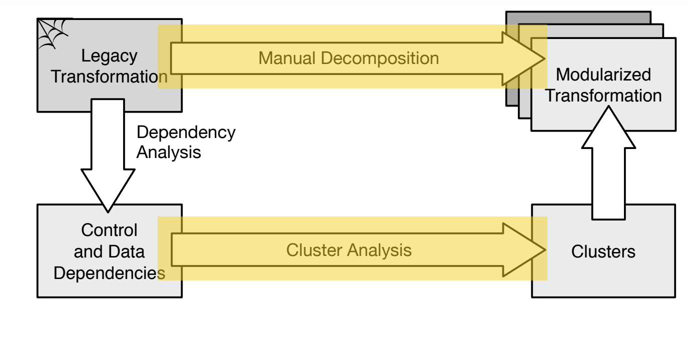


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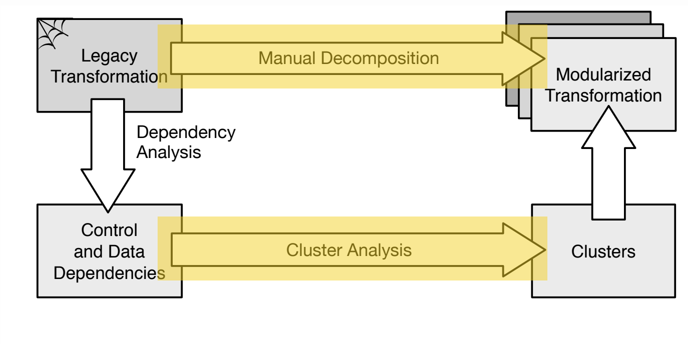


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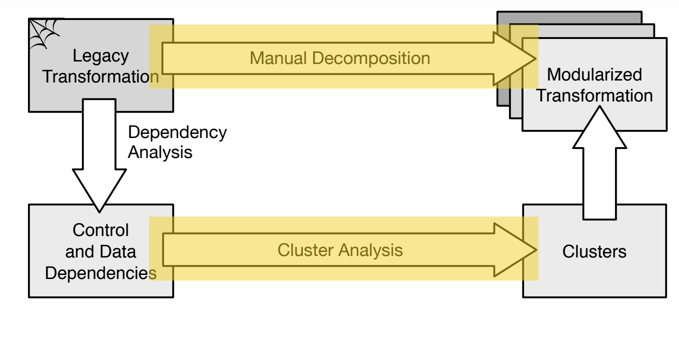


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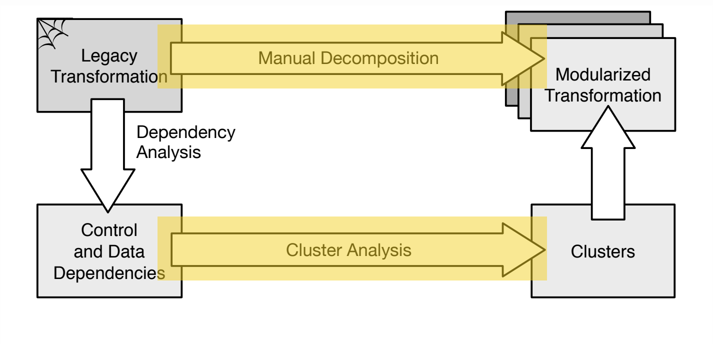


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➡ Significantly better results with model elements considered

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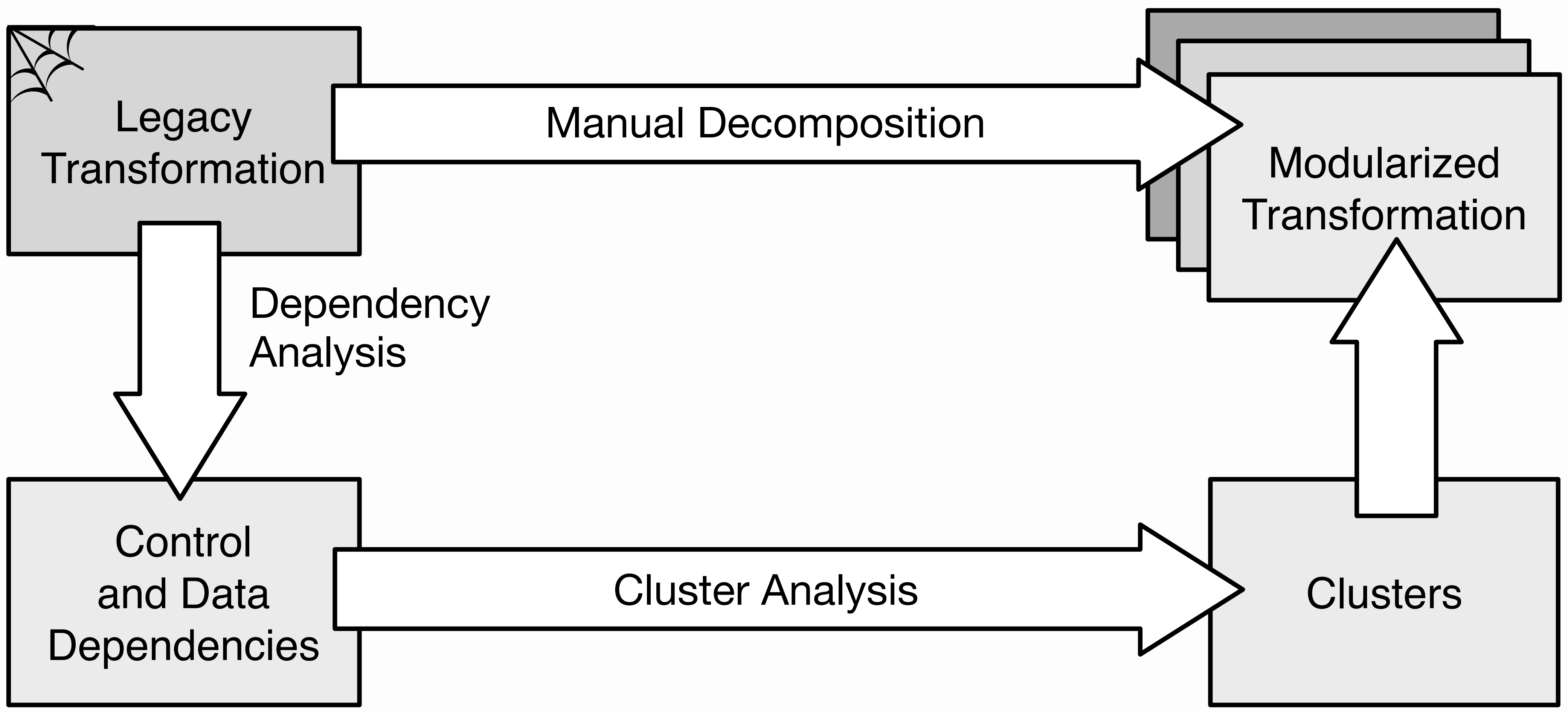

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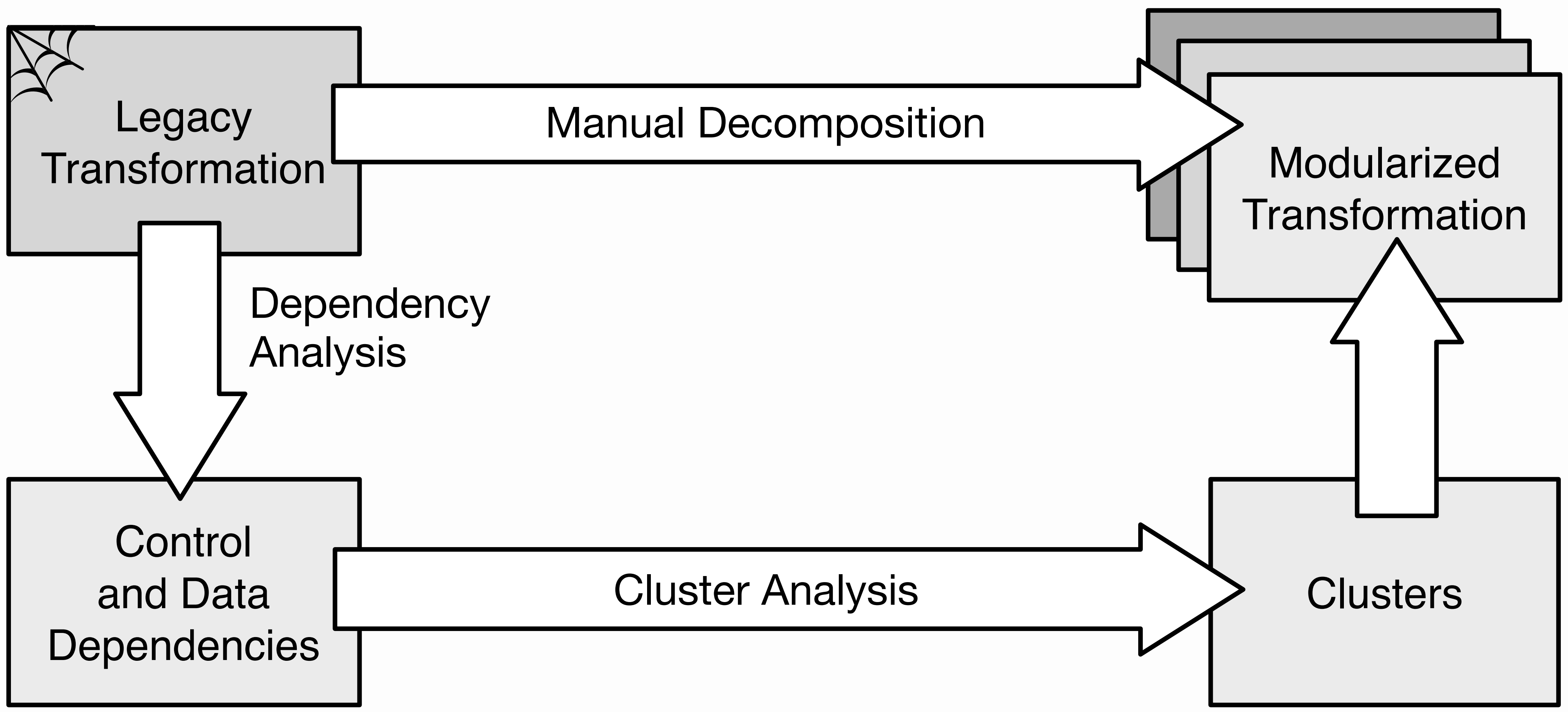


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- By including the model structure, we can derive clusterings that follow source and target-driven decompositional styles.
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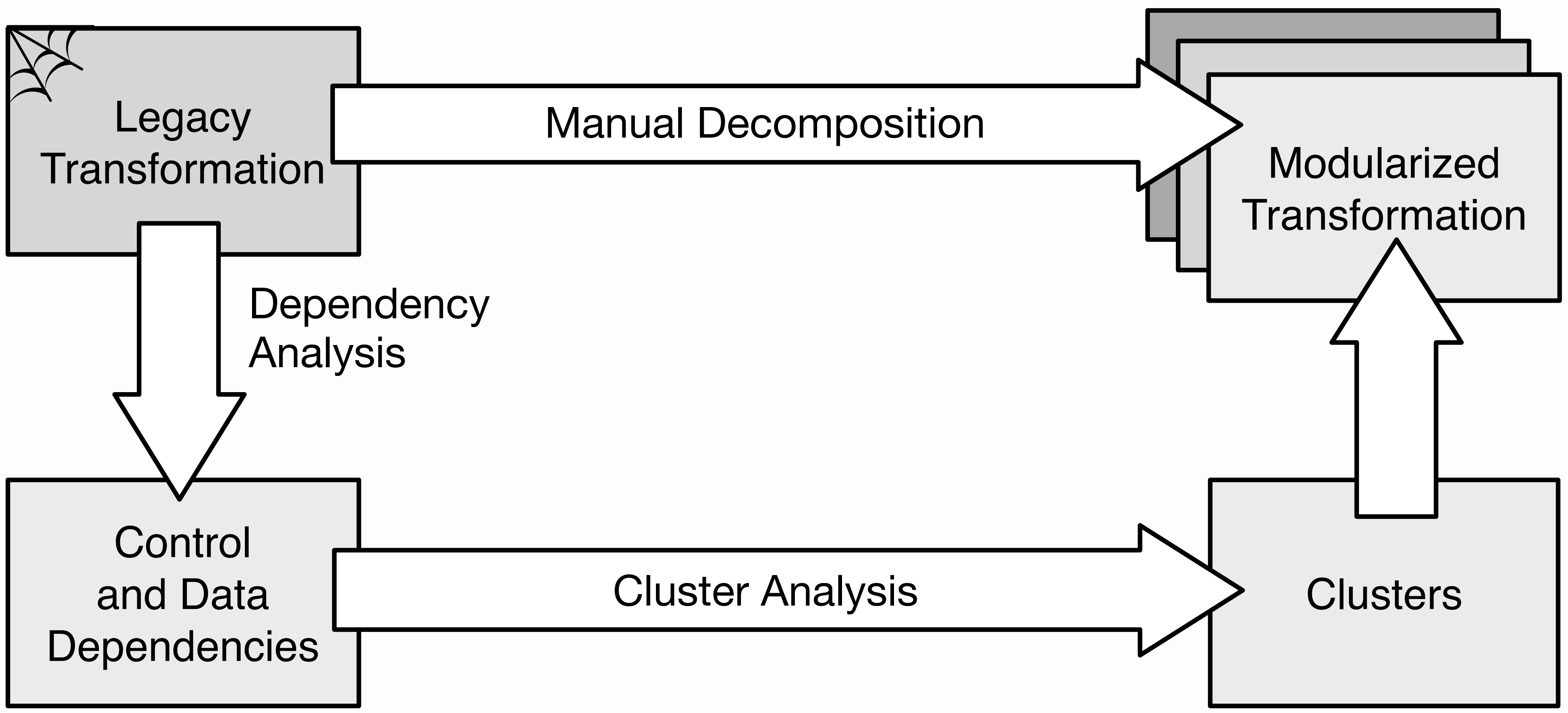


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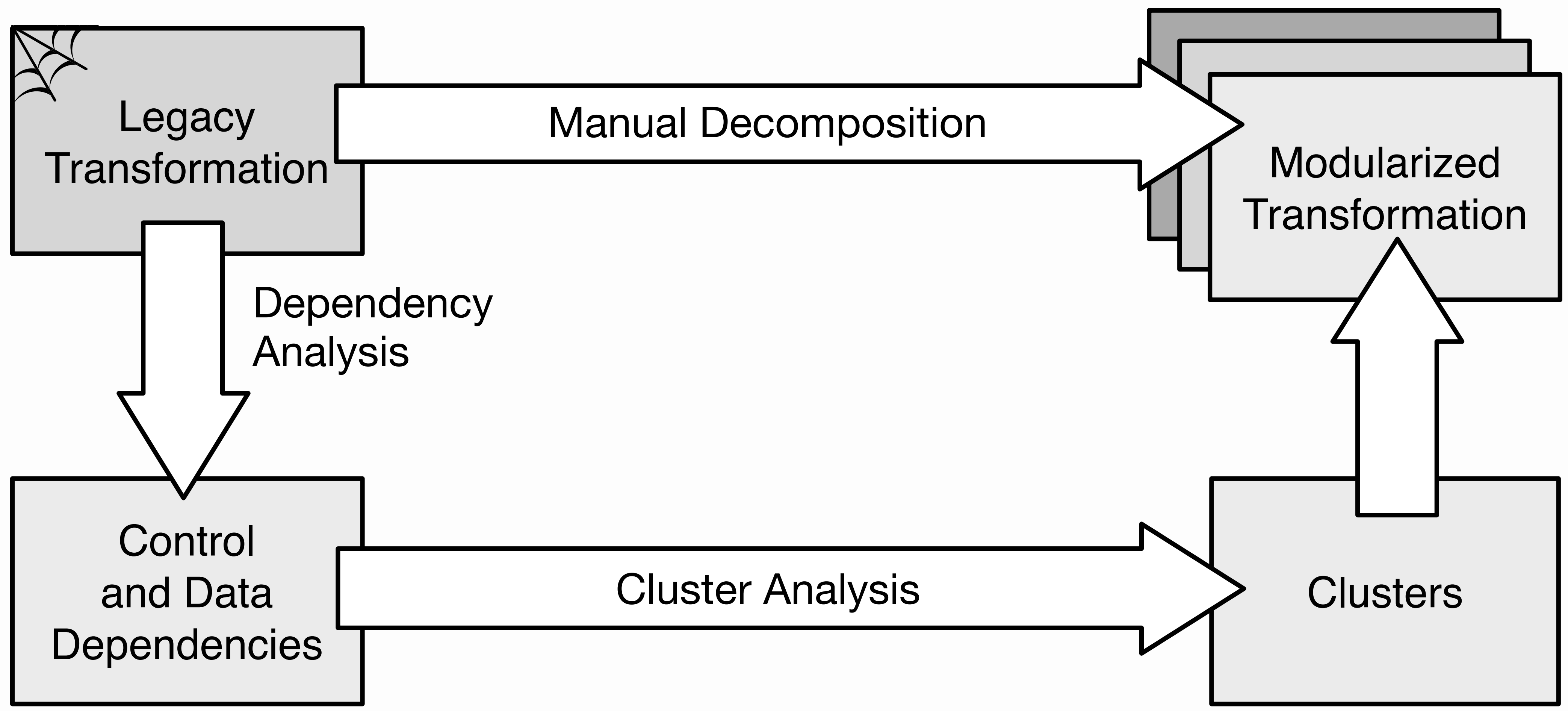


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Thanks!