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Models@run.time: A Guided Tour of the State of the Art and Research Challenges*

14th October 2018

13th International Workshop on Models@run.time
at MODELS'18, Copenhagen, Denmark

* Work, which is currently in revision for publication in a journal

Motivation: Problems and Objectives

Research Problems

- A plethora of approaches has been presented since the term „Models@run.time“ was coined in 2006
- Work on Models@run.time is distributed among many venues
- By now, only one overview article from 2013 on the research topic exists

Research Objectives

- Thus, a new overview article is required, which
 - Guides researchers new to the field
 - Helps the researchers to position their work

Contributions of the Study

Based on these objectives, our study offers the following contributions:

1. A novel taxonomy to classify work on models@run.time
2. A quantitative overview of the current state-of-the-art
3. A catalogue of open research challenges based on gaps in the state of the art

Research Method

Research Method

- An adjusted version of Kitchenham's Systematic Literature Review:
 - Venue-based search to get initial literature corpus
 - Initial taxonomy based on experience
 - In-/exclusion criteria-based filtering
 - Evolving the taxonomy while iterating the literature corpus
 - adding classes to dimensions
 - Splitting/merging dimensions
 - Classifying the literature alongside
 - Keyword-based search to include papers from further venues
 - Cross-dimensional gap-analysis

In-/Exclusion Criteria

Inclusion Criteria

- The paper covers research where a model, which reflects the state of a system, should be causally connected with that system.
- The paper addresses runtime models or explicitly uses the term `models@run.time`.
- The paper uses self-representation, reflection or self-modelling.

Exclusion Criteria

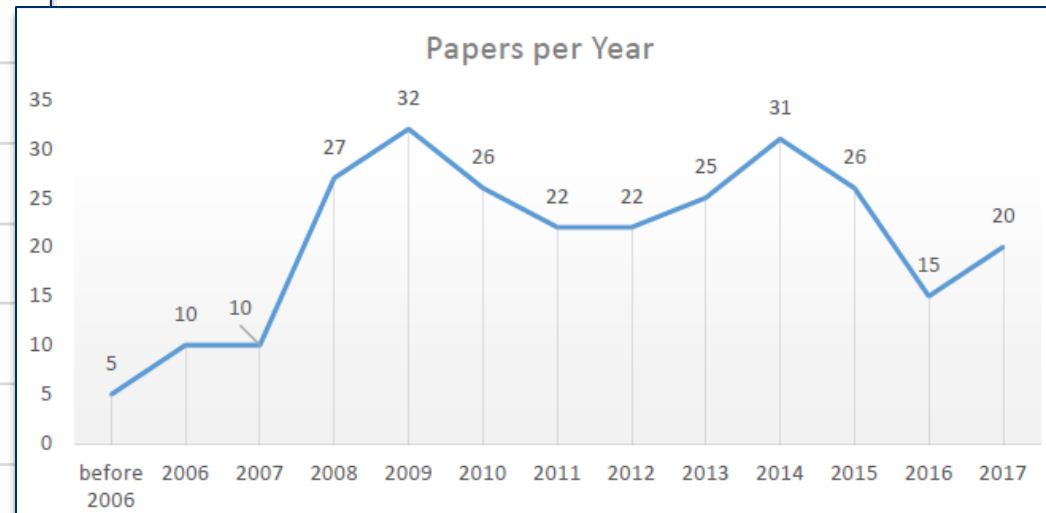
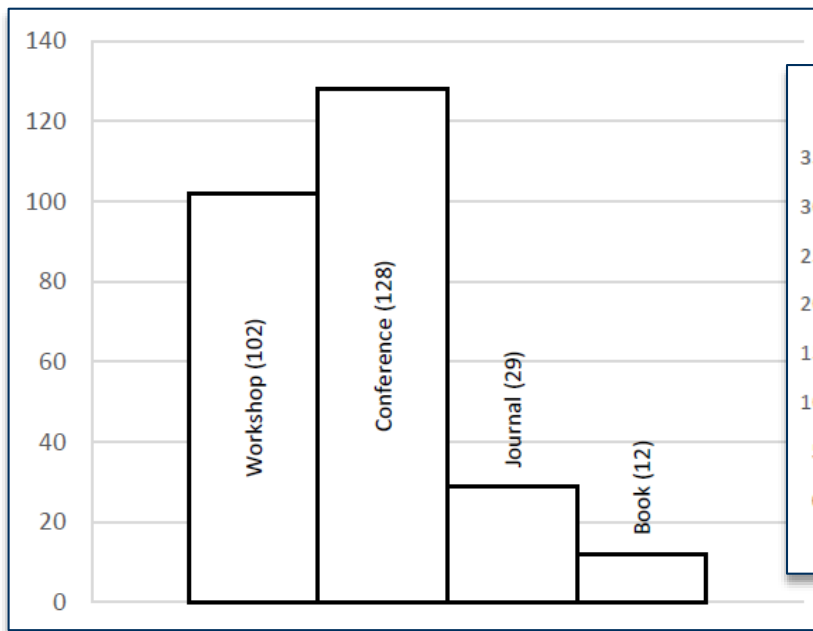
- Approaches on *executable models* are not to be considered `models@run.time` approaches, if they lack the causal connection to the system, but are the actual system.
- The survey includes papers published until December 2017.

Overview of Literature Corpus

Name	Type	#AllPapers	#Included
Models@run.time	Workshop	95	80
Requirements@run.time	Workshop	13	11
RAM-SE	Workshop	61	6
MRT Dagstuhl	Book	11	9
MODELS	Conference	545	23
SEAMS	Conference	182	29
ICAC	Conference	366	31
SASO	Conference	385	11
CompArch	Conference	330	7
ECSA/WICSA	Conference	334	8
RE	Conference	528	6
SPLC	Conference	120	2
ICSE	Conference	640	6
MRT Special Issues	Journal	25	9
SoSyM	Journal	n/a	3
JSS	Journal	n/a	2
TOSEM	Journal	n/a	1
TSE	Journal	n/a	4
TAAS	Journal	n/a	4
GoogleScholar Search	n/a	n/a	20
Total		3635	272

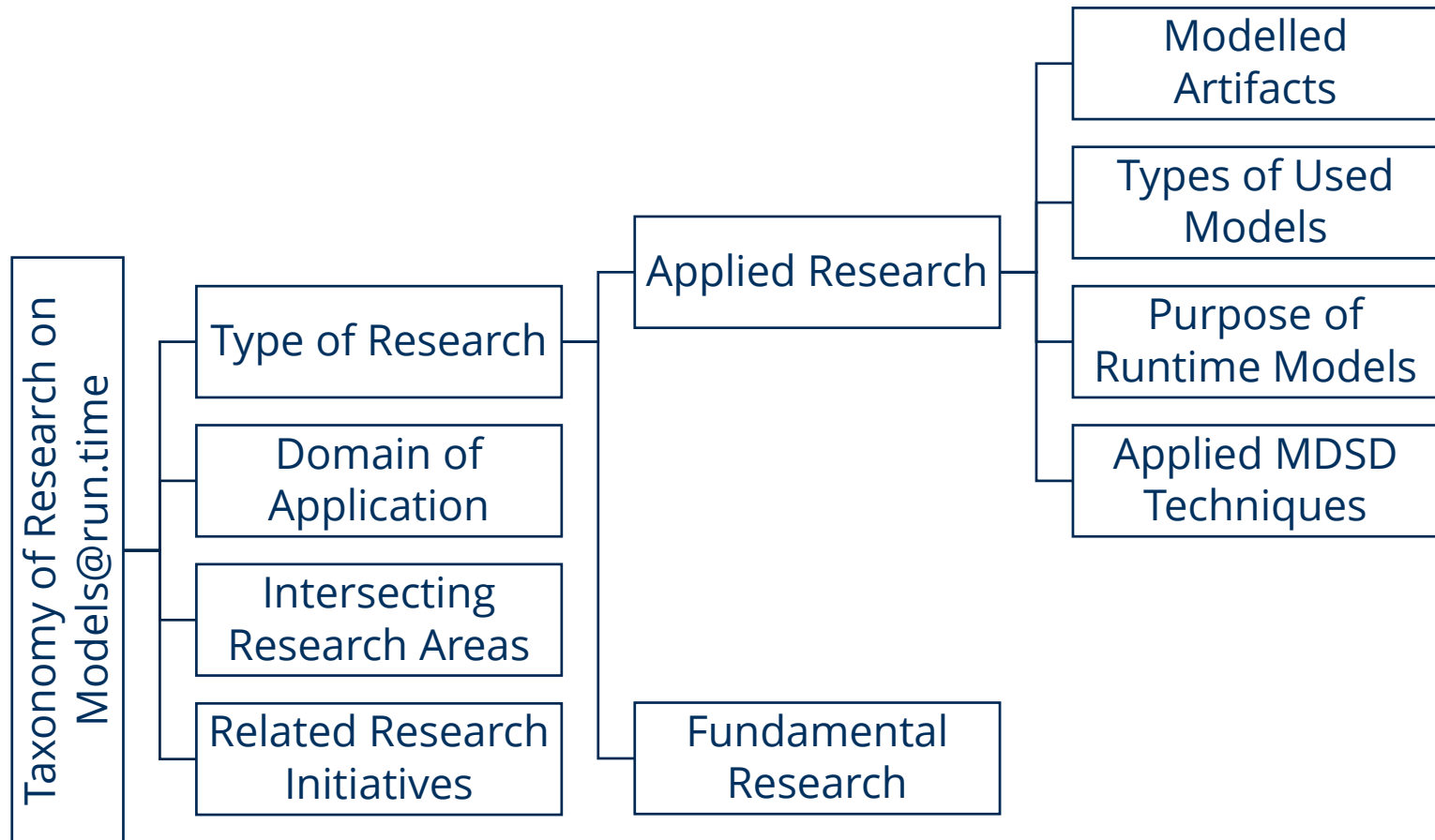
Overview of Included Papers

- Notably, most papers are published at conferences
- Since 2008 until 2017, every year at least 15 papers on models@run.time have been published

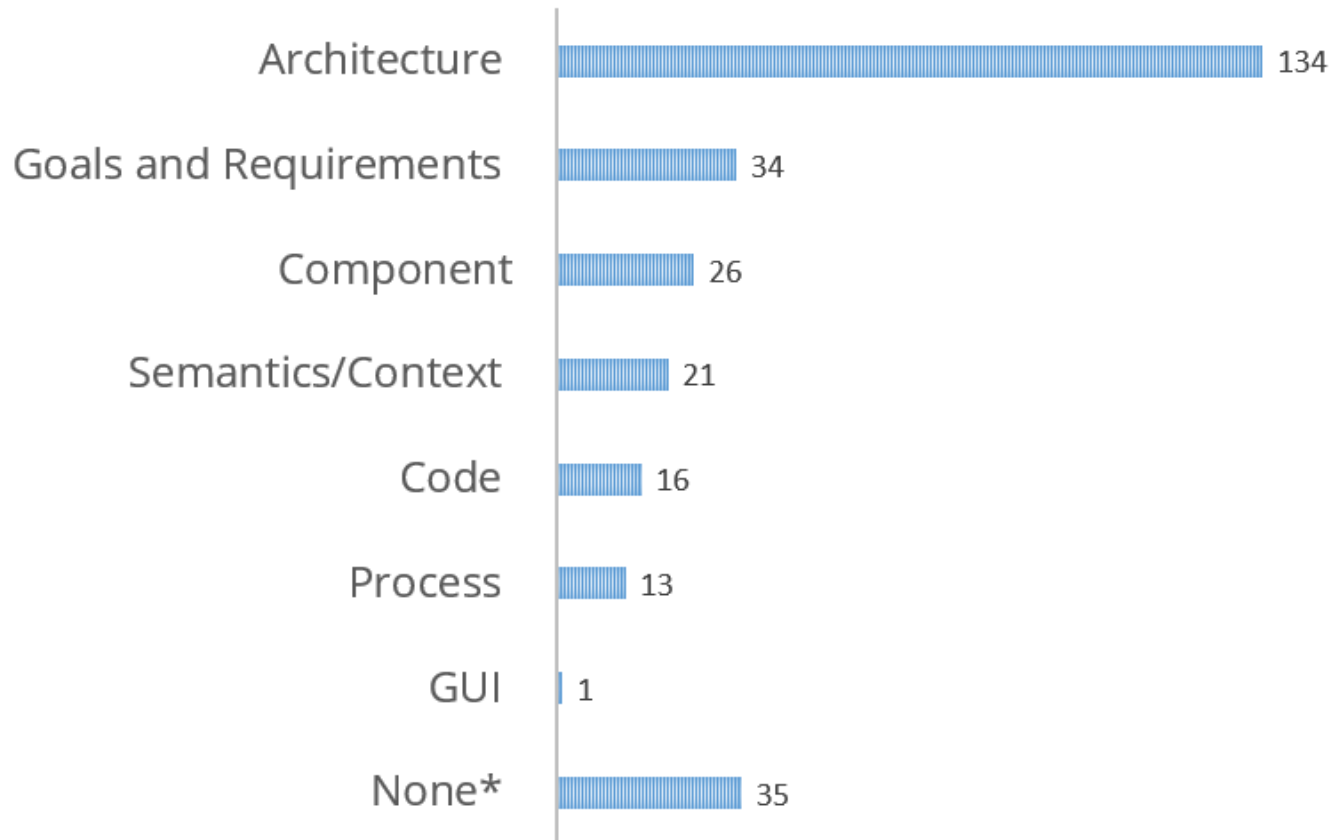


The Taxonomy

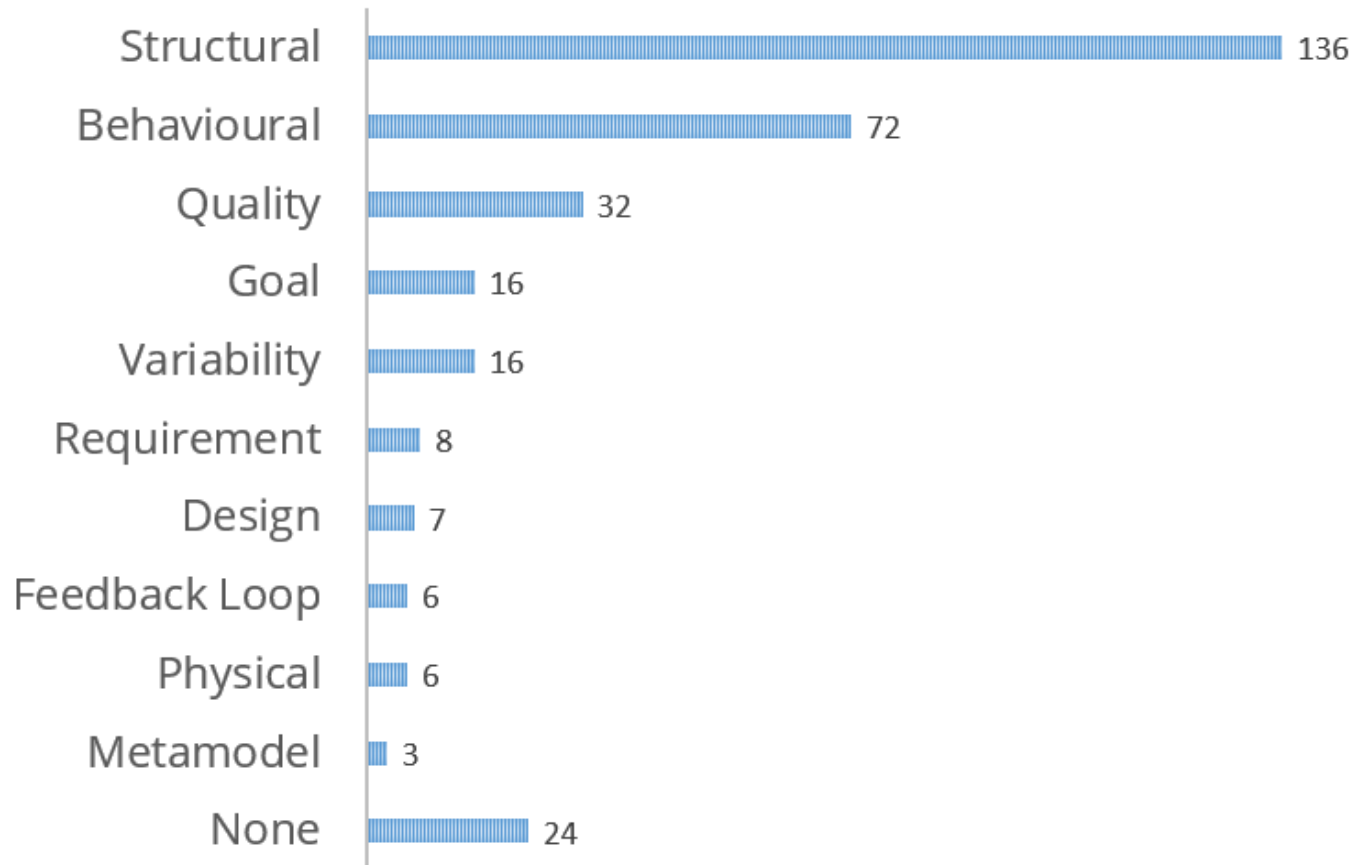
A Novel Taxonomy for Models@run.time



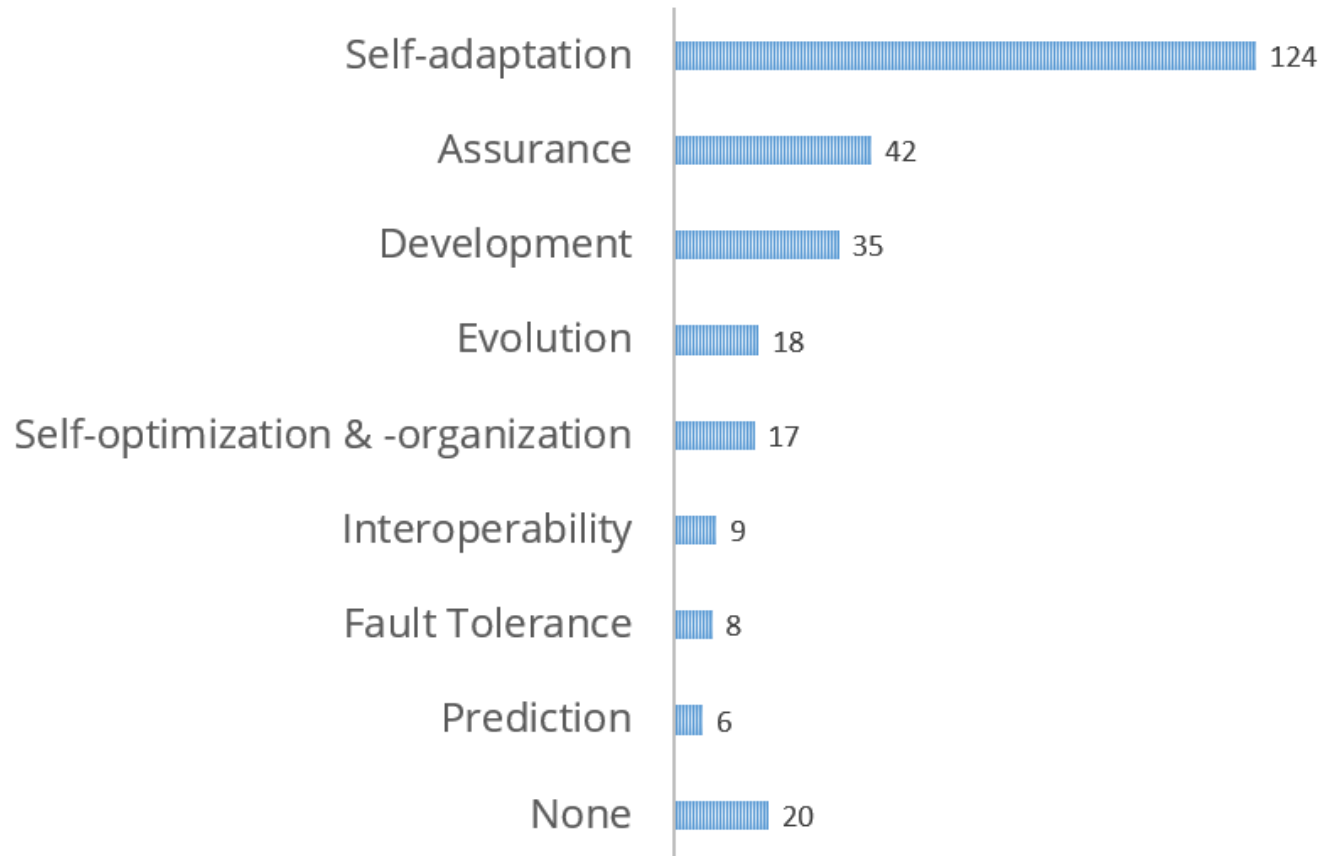
The Taxonomy – Modelled Artifacts



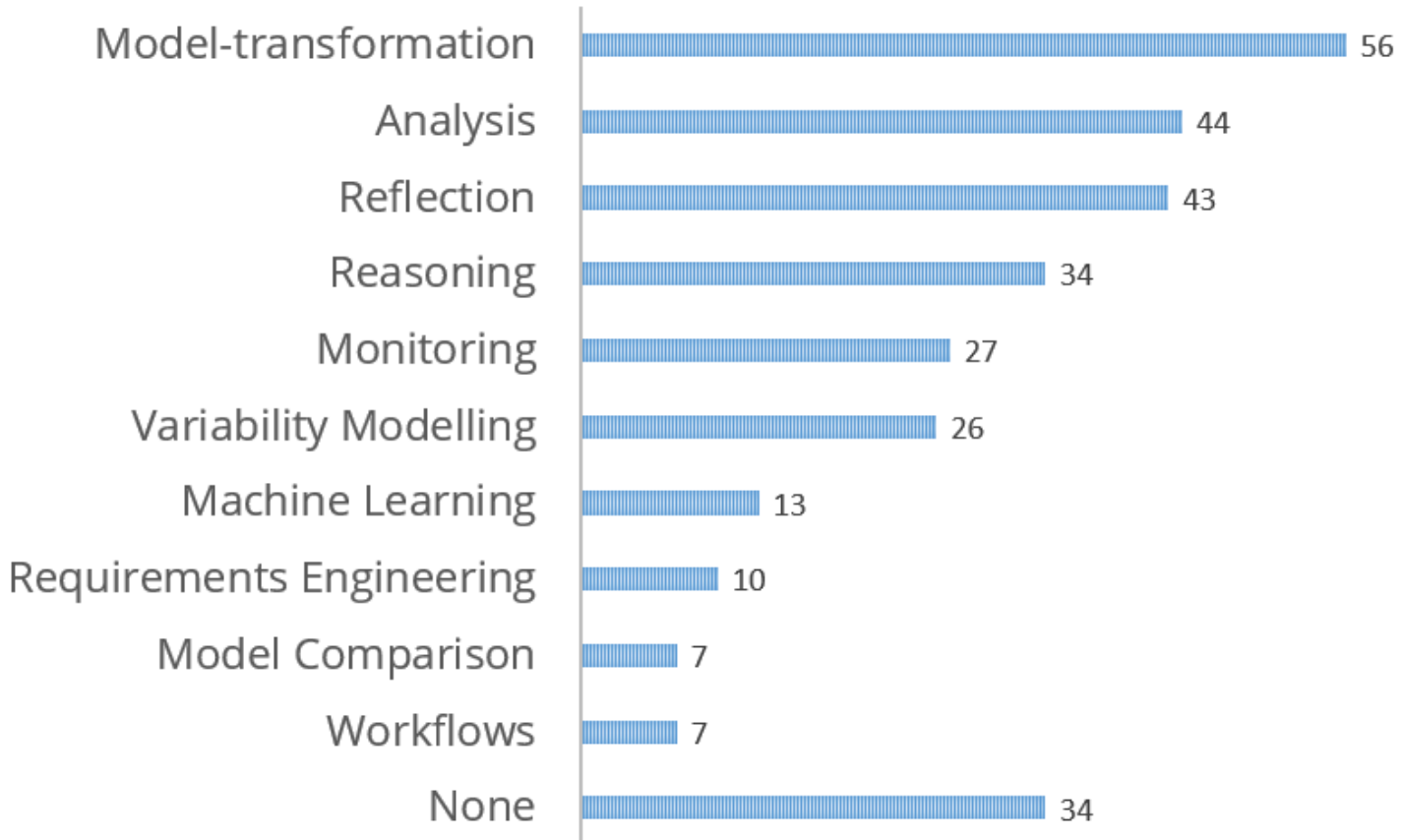
The Taxonomy – Types of Runtime Models



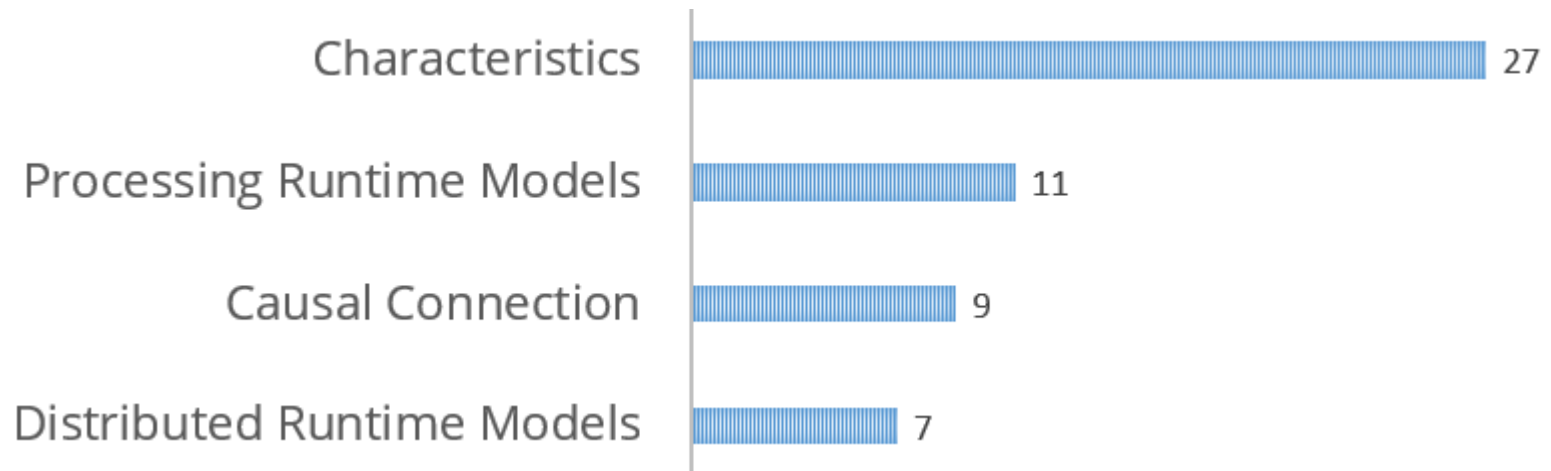
The Taxonomy – Purposes of Using Runtime Models



The Taxonomy – Applied Model-driven Techniques



The Taxonomy – Fundamental Research Topics



The Taxonomy – Application Domains, Research Areas and Initiatives

Application Domains

- Most work (23) has been evaluated in an enterprise software context
- In total we found 25 different application domains used for evaluation

Intersecting Research Areas

- We found 25 intersecting research areas, confirming the hypothesis that models@run.time is highly interdisciplinary
- The most prominent research area is „self-adaptive systems“ (78)

Initiatives

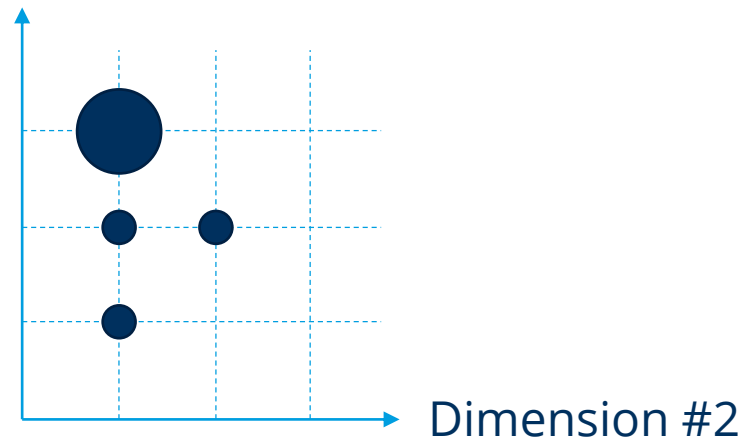
- We found a very large number of research projects (19 EU, 26 regional)
- But, only few projects directly focus on models@run.time

Analysis

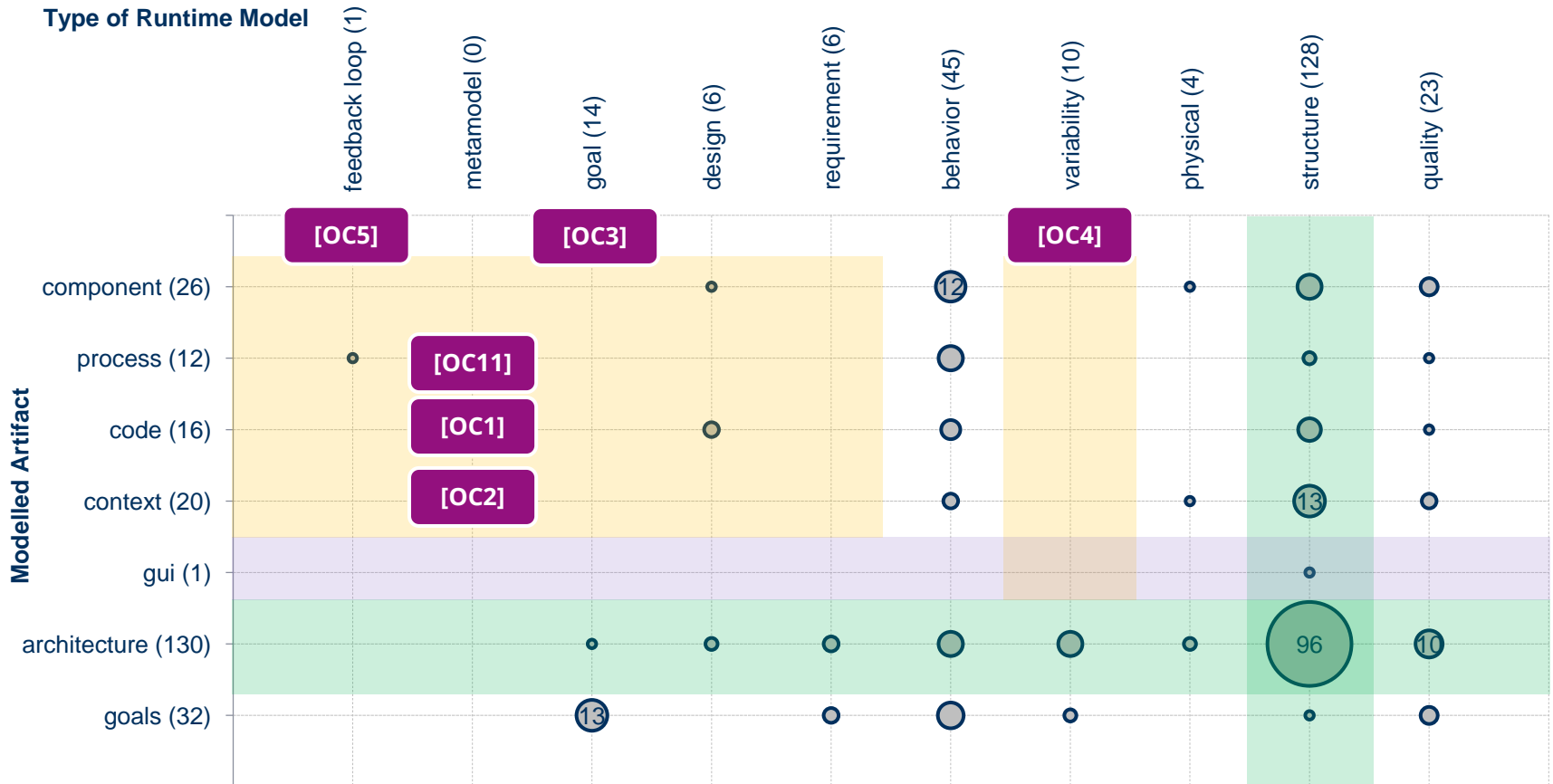
Cross-dimensional Gap-Analysis

- To identify research gaps, we performed a cross-dimensional gap-analysis
- We compared the four dimensions of applied research on models@run.time

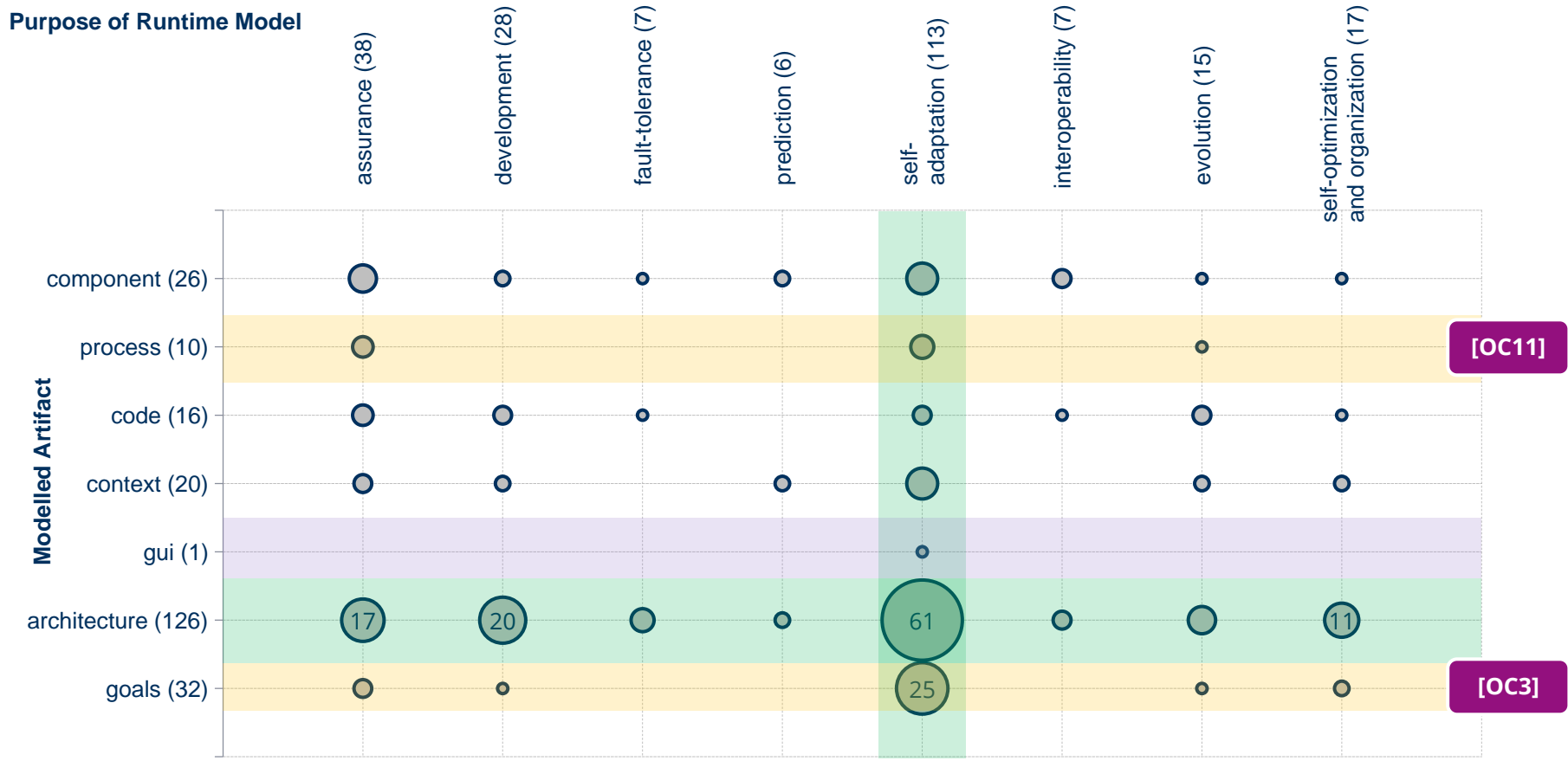
Dimension #1



Analysis – Modelled Artifact vs. Type of Model

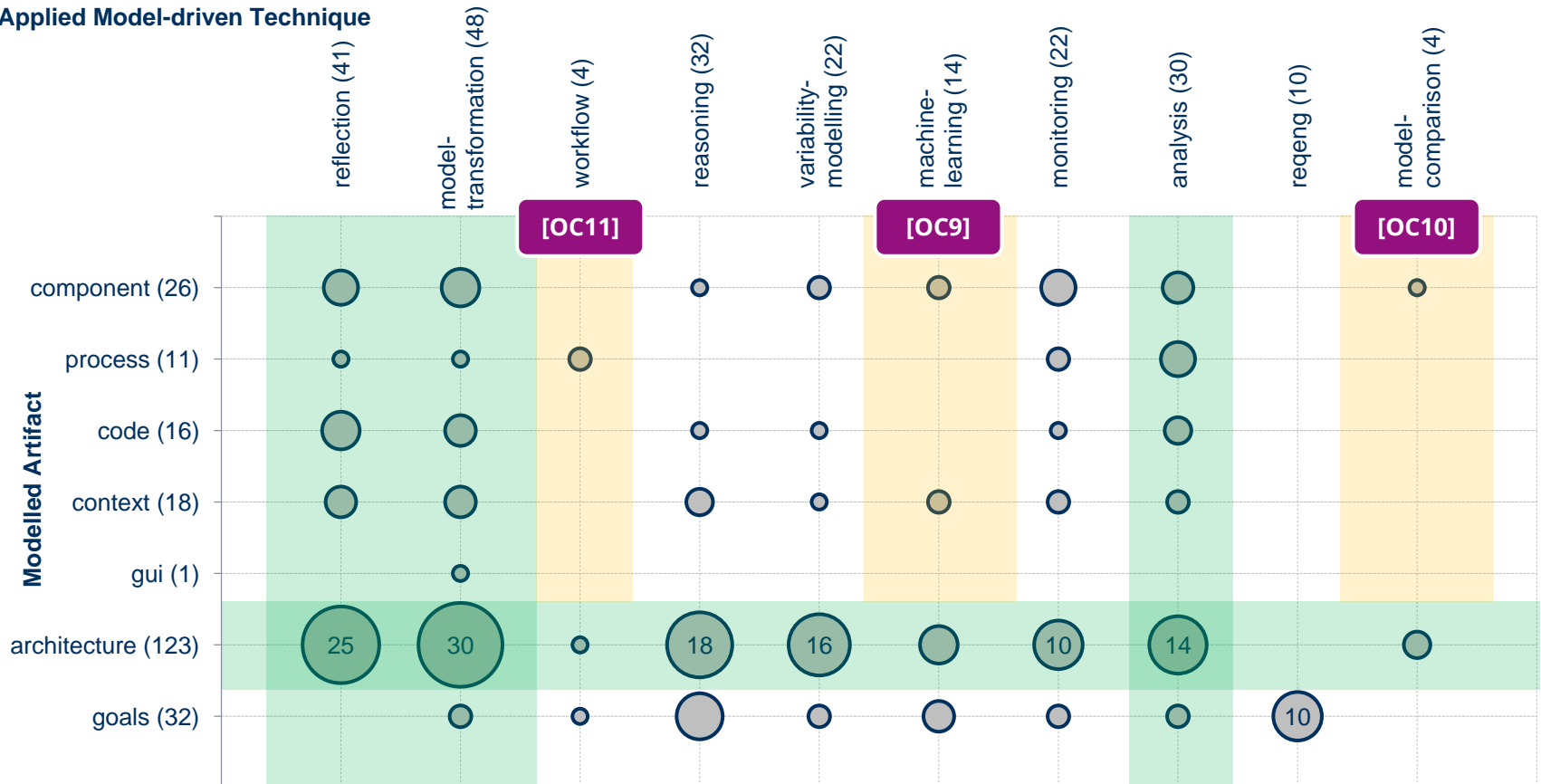


Analysis – Modelled Artifact vs. Purpose of Runtime Model

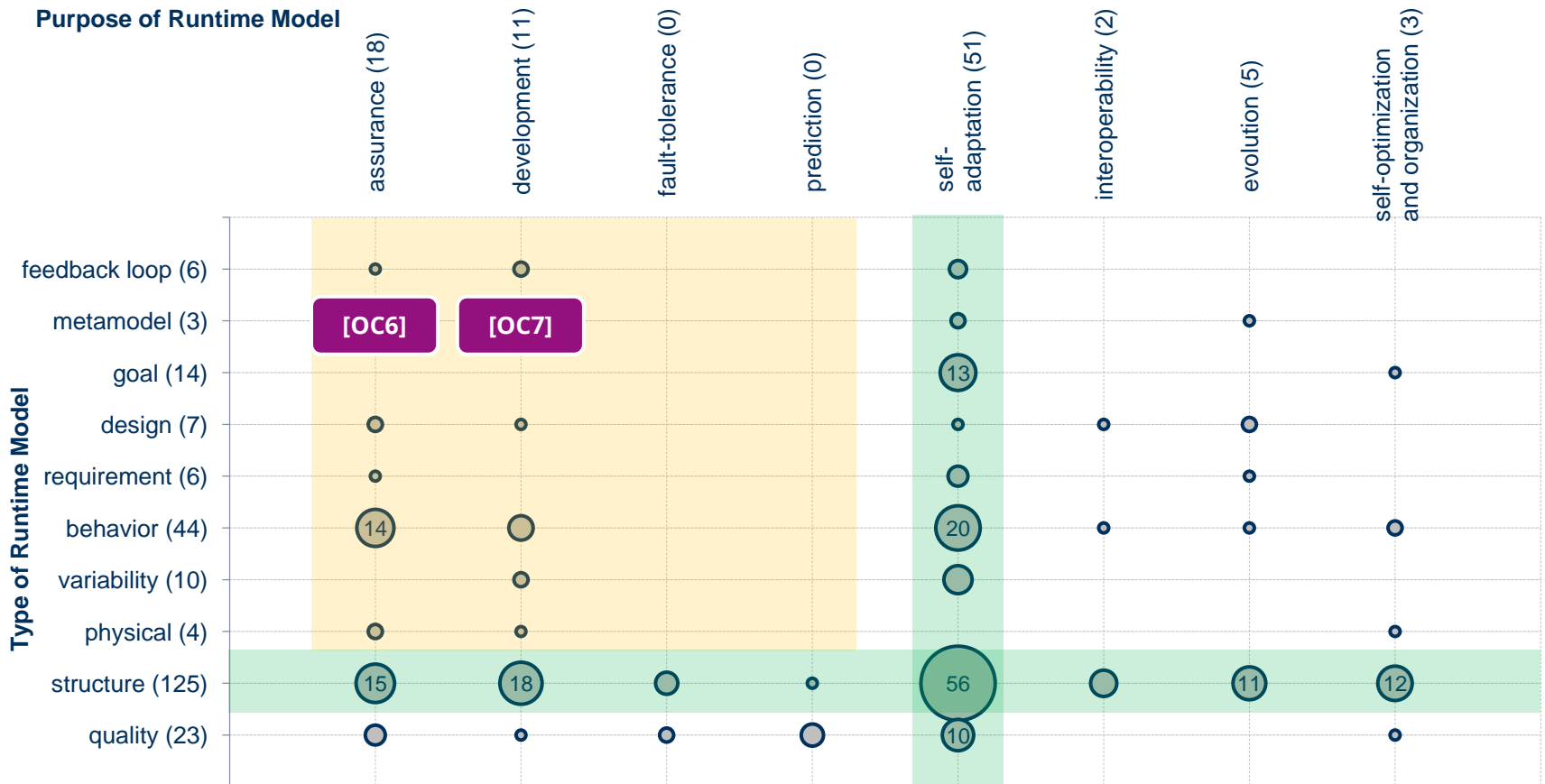


Analysis – Modelled Artifact vs. Applied Model-driven Technique

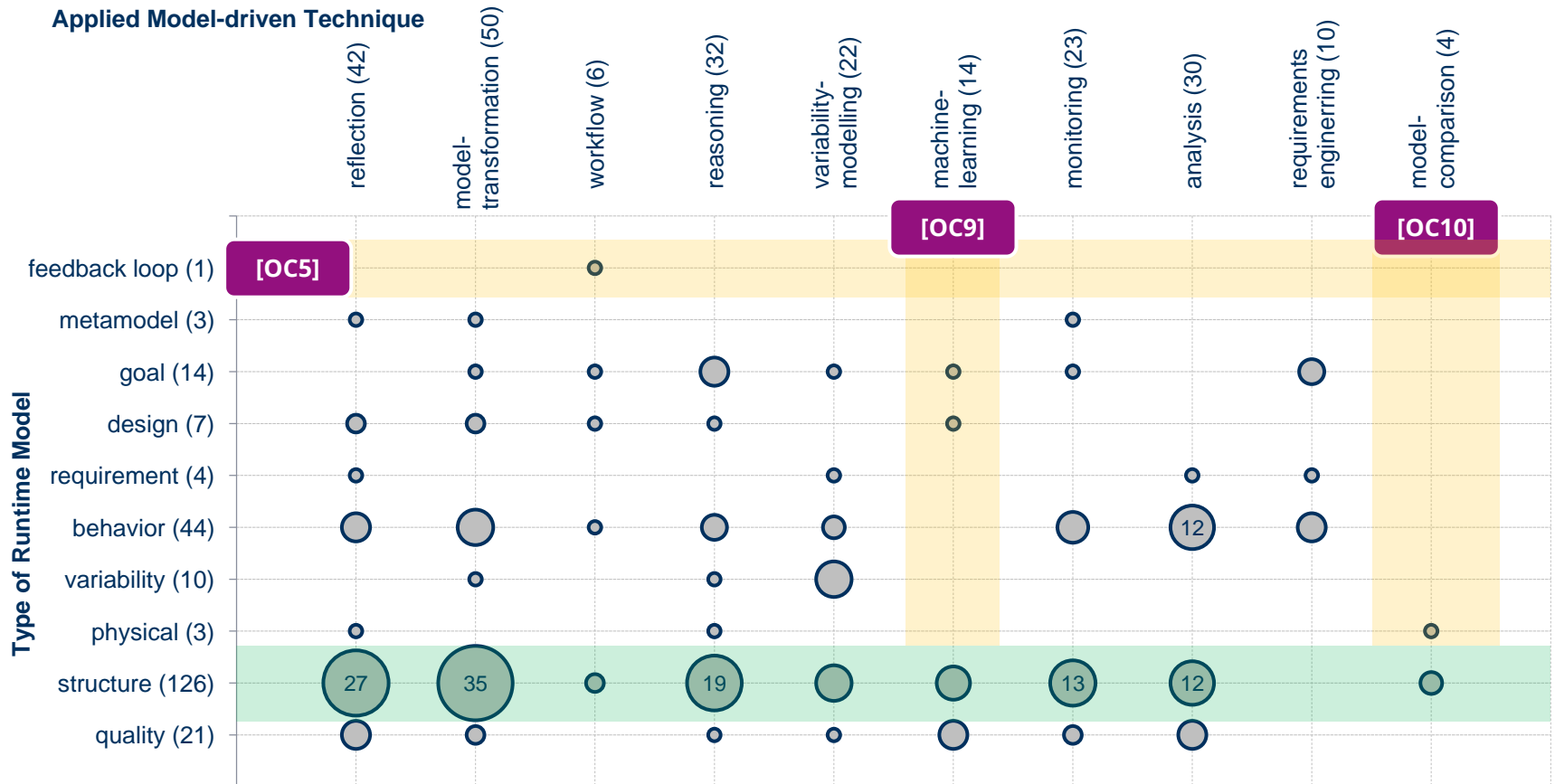
Applied Model-driven Technique



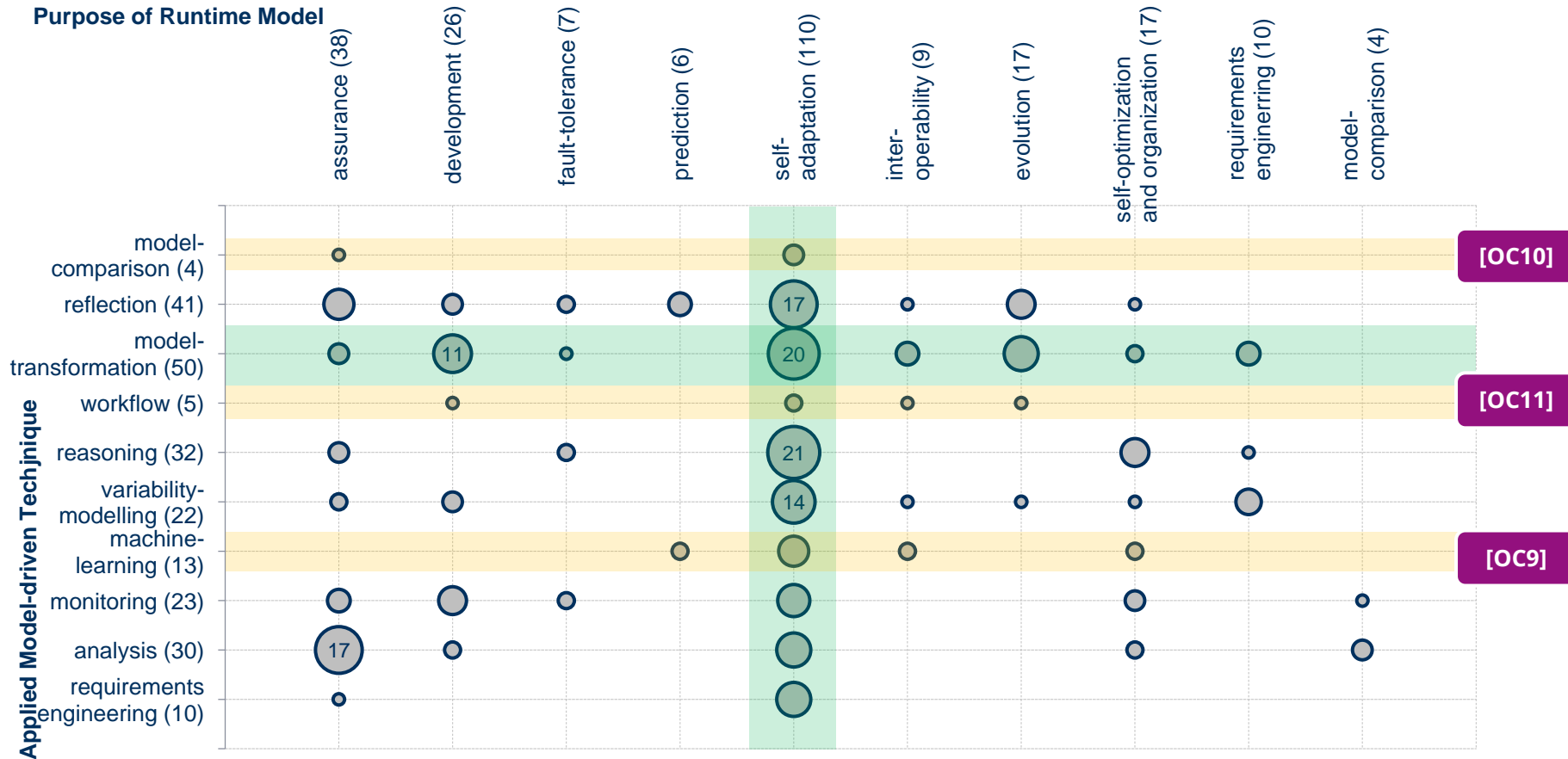
Analysis – Model Type vs. Purpose of Runtime Model



Analysis – Model Type vs. Applied Model-driven Technique



Analysis – Purpose of Runtime Model vs. Applied Model-driven Technique



Research Challenges

Future Research Challenges – Artifact-based

- The need to apply models@run.time **at lower levels** than architecture
 - Especially, on code-level (e.g., working with the AST) [oc1]
- The need to apply models@run.time **at higher levels** than architecture [oc2]
 - Systems-of-systems
 - Collective self-aware systems

Future Research Challenges – Model-Type-based

- **Goal models** at runtime to address uncertainty [oc3]
- **Variability models** at runtime (SPLC and DSPL workshop series) [oc4]
- Runtime **feedback loop** models [oc5]

Future Research Challenges – Based on Purposes

- **Assurance**, especially for safety-critical systems (i.e., certification) [oc6]
- **Development** (seamless integration with development-time models) [oc7]
- **Self-aware** computing systems (especially, collectives thereof) [oc8]

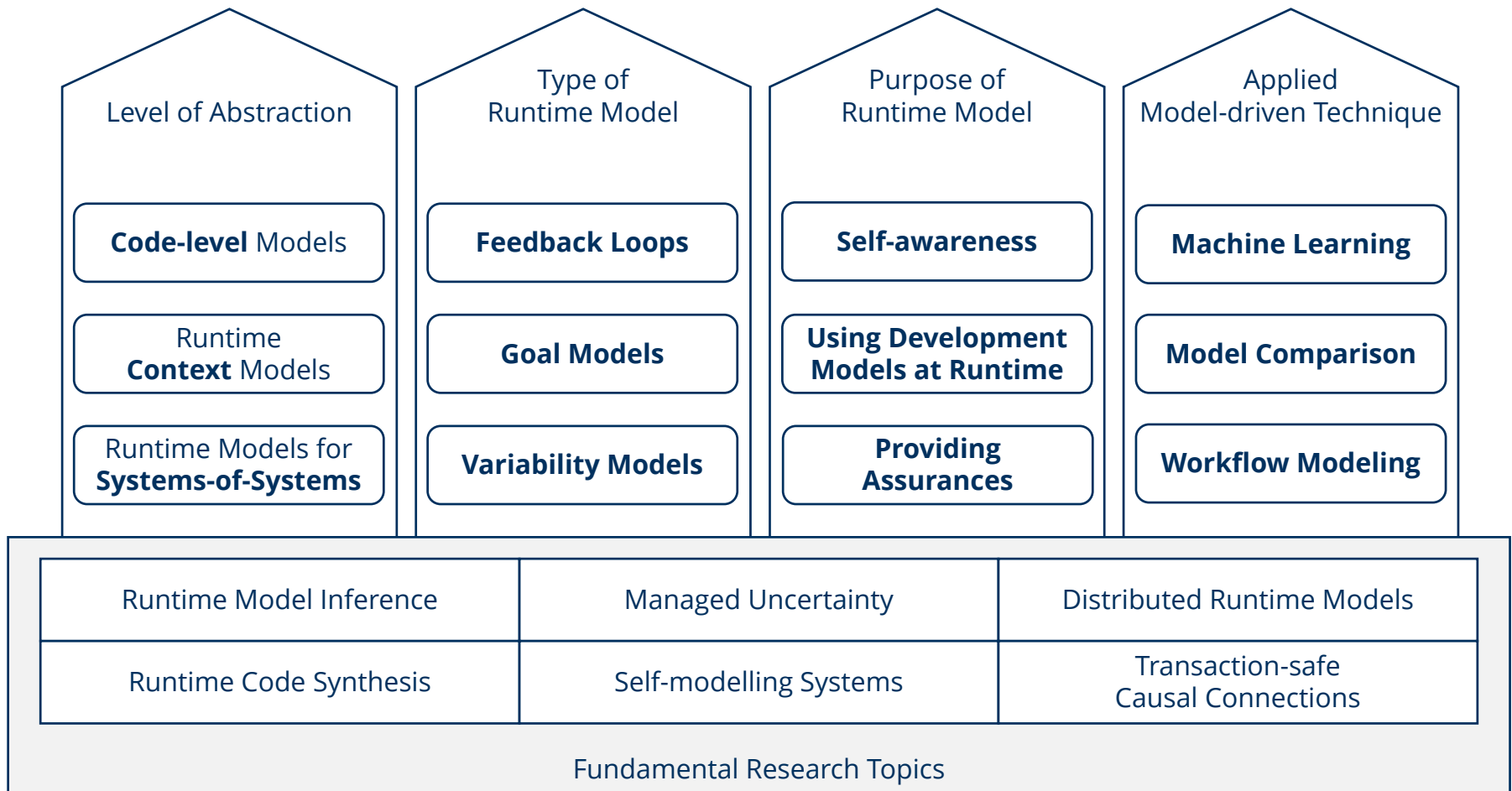
Future Research Challenges – Based on Techniques

- Machine Learning [oc9]
- Systematic Model **Comparison** [oc10]
- Runtime **Workflow** Models (trend stopped 5 years ago) [oc11]

Future Research Challenges – Fundamental Research

- Towards Managed Uncertainty at Runtime
- Runtime Model Inference
 - Inferring the runtime model from the running system
- Runtime Code Synthesis
 - Inferring the running system from the runtime model
- Distributed Models@run.time
- Transaction-safe Causal Connections
- Self-modelling systems

Overview of Future Directions



Tool Support

The Systematic Literature Review Toolkit

- To automate common manual tasks in our study, we developed an Eclipse-based RCP: the SLR Toolkit
- Tool Demo on Friday, 10:00, 2A56 (Aud 3)
- Tool paper in this years MODELS Proceedings

MRT

type filter text

- ◆ Blair2009
- ◆ Bousse2014
- ◆ Buerger2015
- ◆ Bures2014
- ◆ Burger2016
- ◆ Calinescu2007
- ◆ Calinescu2013
- ◆ Camara2013
- ◆ Castaneda2014
- ◆ Cavalcante2015
- ◆ Cavallaro2012
- ◆ Cazzola2004
- ◆ Cazzola2013
- ◆ Cazzola2014
- ◆ Cazzola2014a
- ◆ Cedillo2014
- ◆ Cetina2008
- ◆ Cetina2009

A Model-Driven Approach for Developing Self-Adaptive Pervasive Systems

Scholar

[PDF] A Model-Driven Approach for Developing Self-Adaptive Pervasive Systems [PDF] psu.edu

C Cetina, P Giner, J Fons, V Pelechano - Models@ runtime, 2008 - Citeseer

Adaptive systems are generally difficult to implement, and their quality depends much on the designer experience or creativity. This paper presents a model driven approach to develop adaptive systems by means of run-time models. Our approach applies techniques from the Software Product Lines (SPLs) to address the different requirements of evolution and involution scenarios in Pervasive Systems. Finally, we show how models drive the adaptation in order to dynamically change the system architecture.

☆ 59 Zitiert von: 6 Ähnliche Artikel Alle 8 Versionen

Bestes Ergebnis für diese Suche [Alle Ergebnisse](#)

Abstract Properties Webpage

Taxonomy

- ▼ Type of Research (272)
 - ▼ Applied (272)
 - ▼ Modelled Artifact (272)
 - architecture (130)
 - none (35)
 - component (26)
 - context (20)
 - goals (32)
 - code (16)
 - process (12)
 - gui (1)
 - ▼ Model type (272)
 - structure (130)
 - behavior (45)
 - quality (23)
 - none (24)
 - goal (14)
 - variability (10)
 - design (7)
 - feedback loop (6)
 - requirement (6)
 - physical (4)
 - metamodel (3)
 - > Purpose (272)
 - > Techniques (272)
 - > Fundamental (272)
 - > Application Domains (272)
 - > Research areas (272)
 - > Initiative (272)
 - > Venue (272)
 - > Venue Type (272)

ChartView Bibtex Term Search

Number of Papers per Modelled Artifact

Modelled Artifact	Number of Papers
architecture	130
none	35
goals	32
component	26
context	20
code	16
process	12
gui	1

Progress

No operations to display at this time.

Thank you!

