Towards Multi-level Modeling of Just-in-Time Adaptive Intervention (JITAIs) in Mobile Health

– Position Paper –

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Background

Just-in-Time Adaptive Intervention (JITAI)

- Intervention design to support health behavior changes [1]
  - e.g., to increase physical activity [2]

At 2021-07-15 12:10, Jane is available for intervention. She has been sedentary for the last 30 minutes and the weather is fine. The system suggests to take a walk to the lakeside restaurant. Jane follows the suggestion and makes 3.000 steps in the next hour.

- Provide interventions [3]
  - Just-in-time: „*when needed or appropriate*“
  - Adaptive: „*tailored to the individual‘s needs and context*“

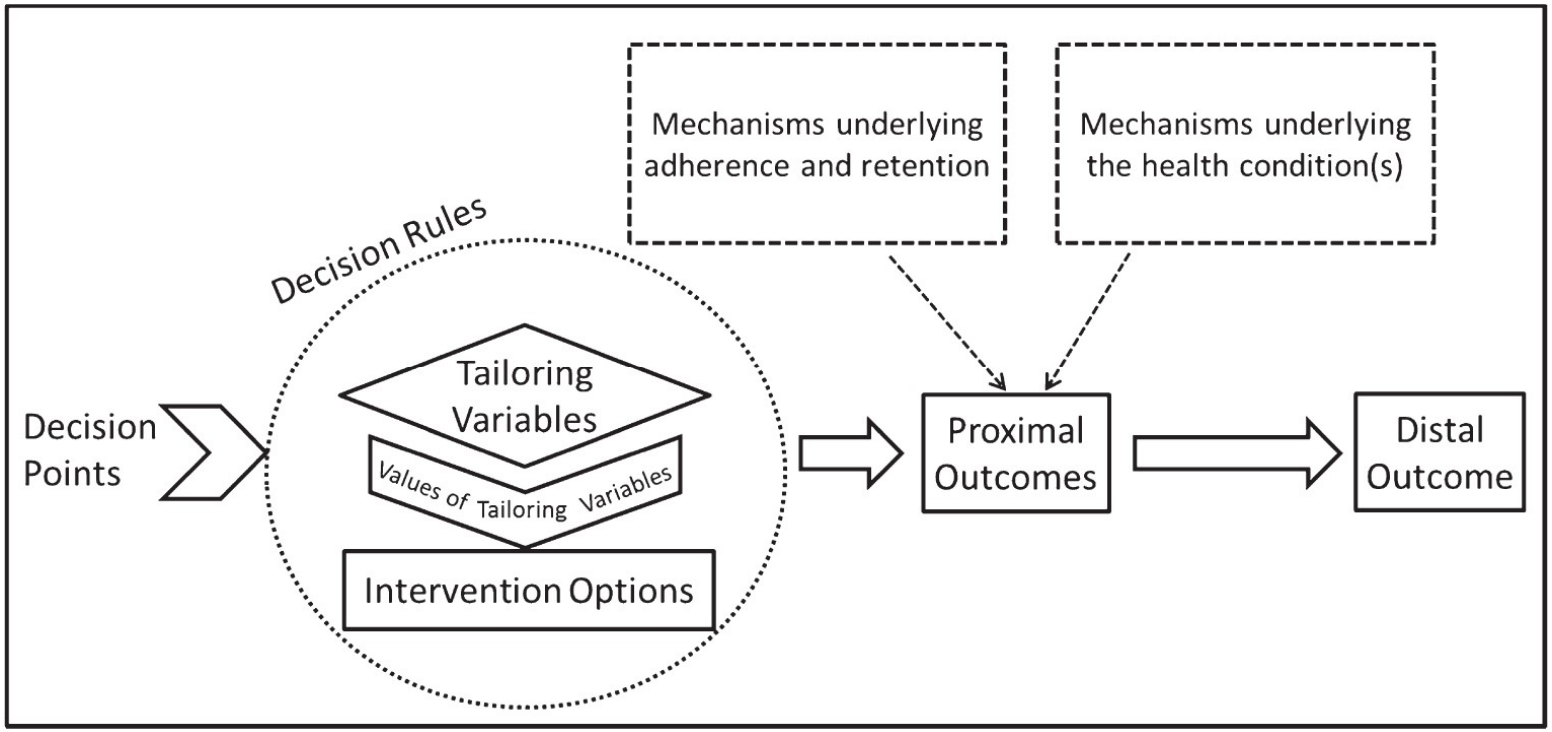
- The development, improvement and evaluation of JITAIs requires different study designs [4, 5]

[1] Nahum-Shani et al.: **Just-in-time adaptive interventions (JITAIs) in mobile health: key components and design principles for ongoing health behavior support.** Annals of Behavioral Medicine 52(6): 446-462 (2018)
[2] Hardeman et al.: **A systematic review of just-in-time adaptive interventions (JITAIs) to promote physical activity.** International Journal of Behavioral Nutrition and Physical Activity 16(1): 1-21 (2019)
[3] Spruijt-Metz, Nilsen: **Dynamic models of behavior for just-in-time adaptive interventions.** IEEE Pervasive Computing 13(3): 13-17 (2014)
[4] Almirall et al.: **Introduction to SMART designs for the development of adaptive interventions: with application to weight loss research.** Translational behavioral medicine 4(3): 260-274 (2014)
[5] Golbus et al.: **Microrandomized Trial Design for Evaluating Just-in-Time Adaptive Interventions Through Mobile Health Technologies for Cardiovascular Disease.** Circulation: Cardiovascular Quality and Outcomes 14(2): e006760 (2021)

Background

Conceptual Model of JITAI Components

by Nahum-Shani et al. (2018)



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Motivation

Why do we need multi-level modeling for JITAIs?

- Goal: **integration-preserving adaptability**
  - Facilitate adaptability (heterogeneity)
    - e.g., configuration for JITAI studies, personalization for participants
  - Preserve data integration (homogeneity) for data analytics
    - e.g., machine learning over JITAI outcomes of different participants
    - e.g., data aggregation over JITAI outcomes in different JITAI studies
- Solution Idea: a kind of **multi-level object-oriented modeling**
  - Use specialization (subclasses) for configuration and personalization
  - Use metaclasses to control the specialization
  - Derive hierarchies of subclasses and metaclasses from a two level model

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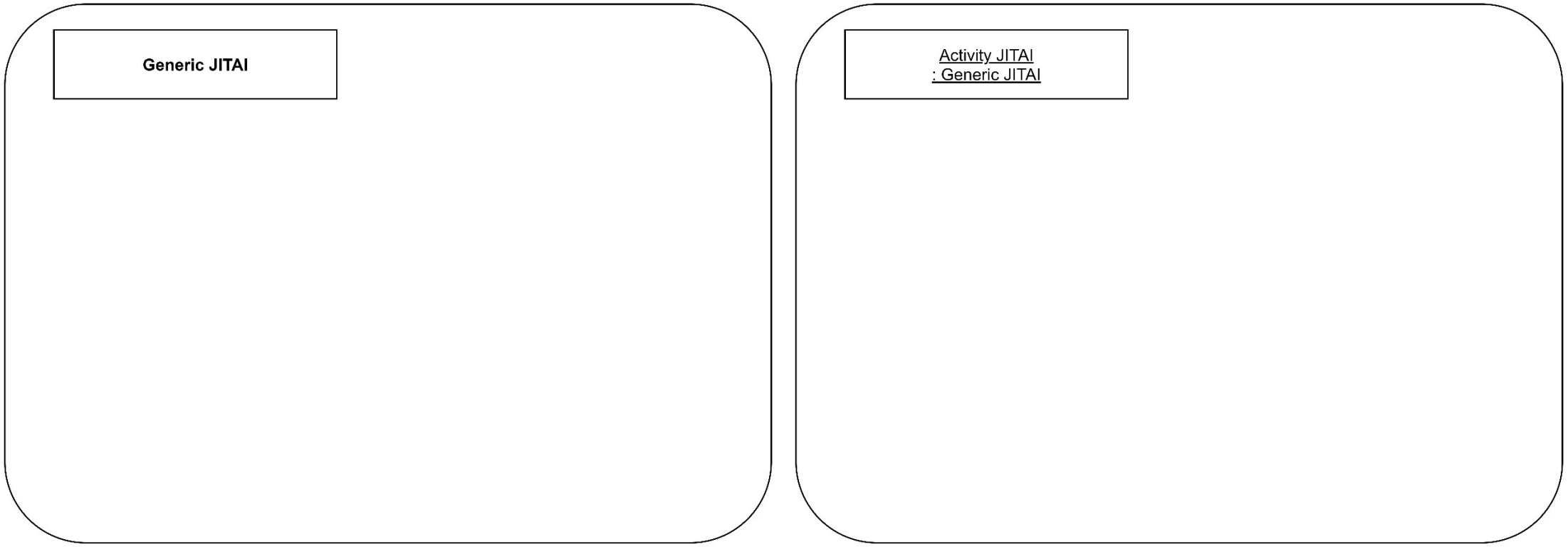
main focus of this paper

In the paper we introduce a

Structure of Multi-level JITAI Models

represented in UML using Composition and Association Classes



with examples from the HEART Study [1]

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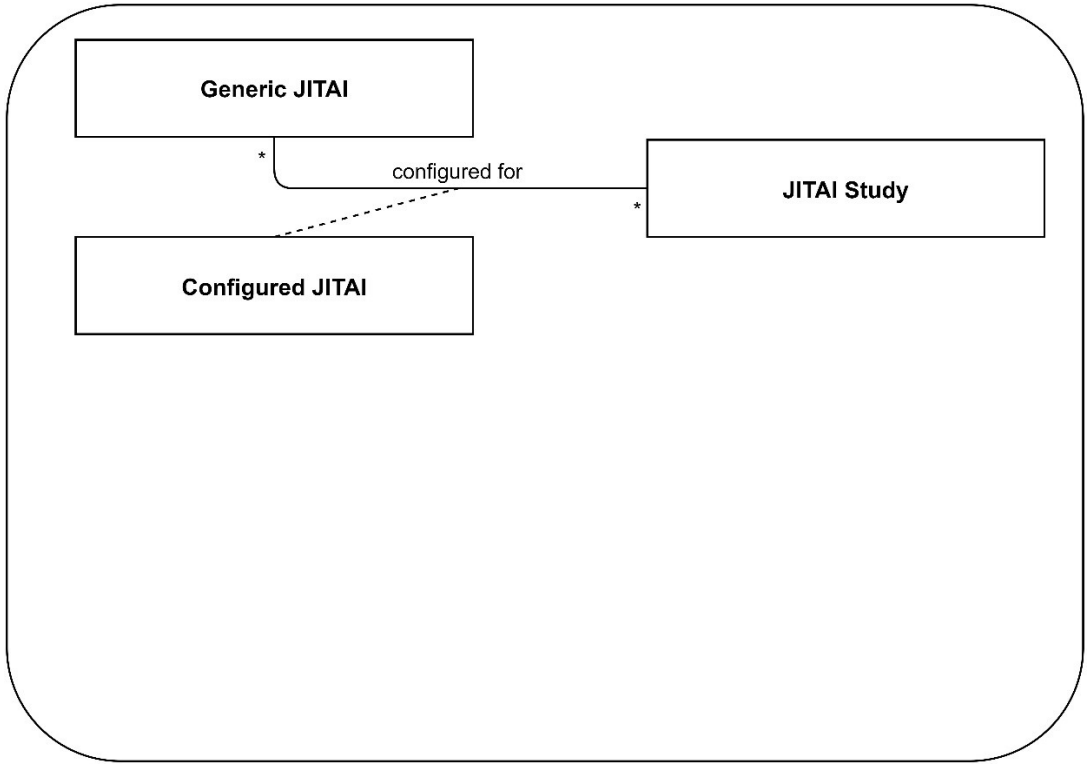

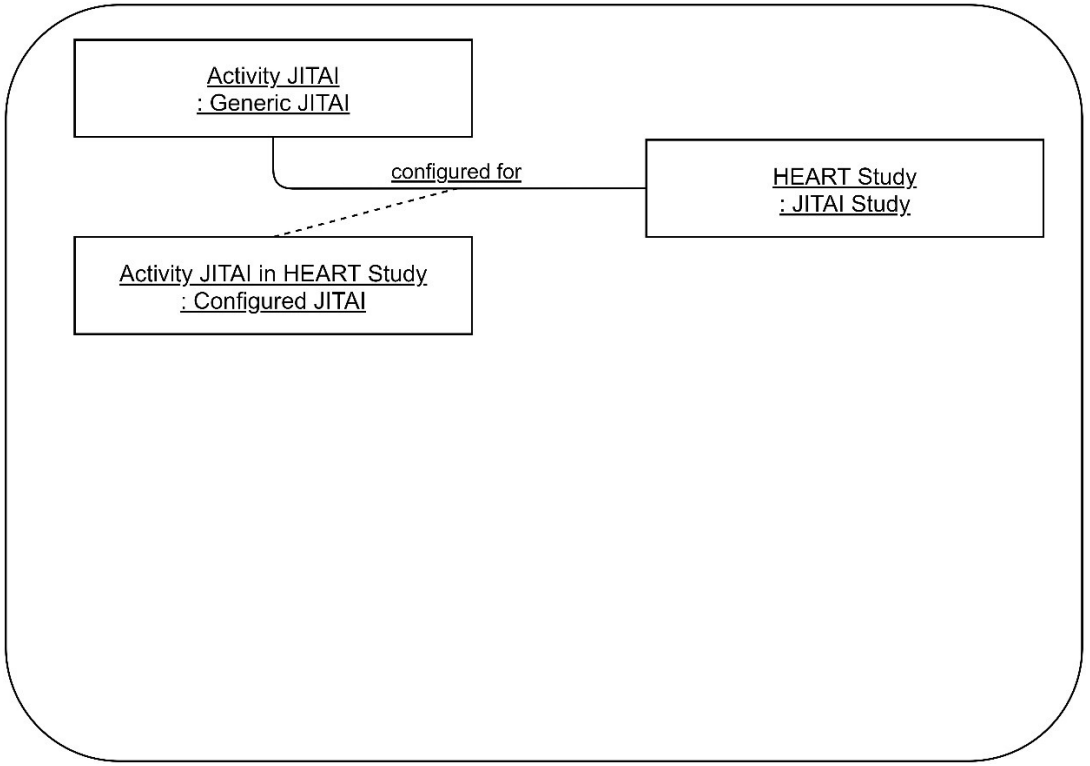

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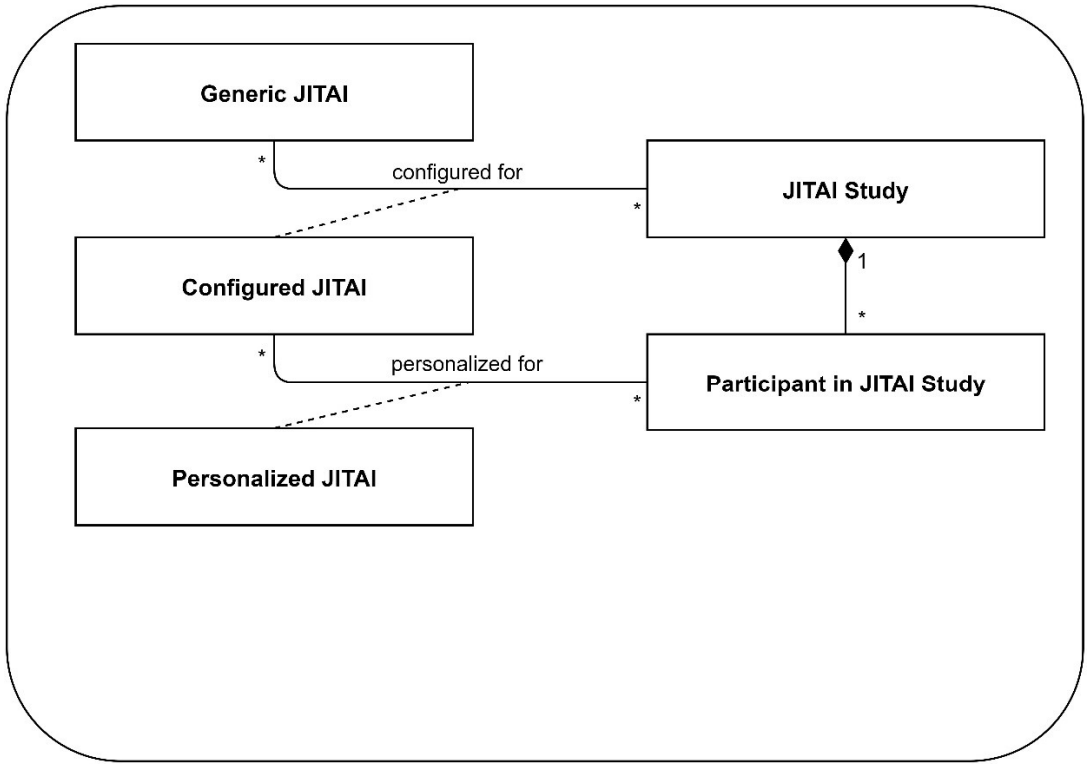

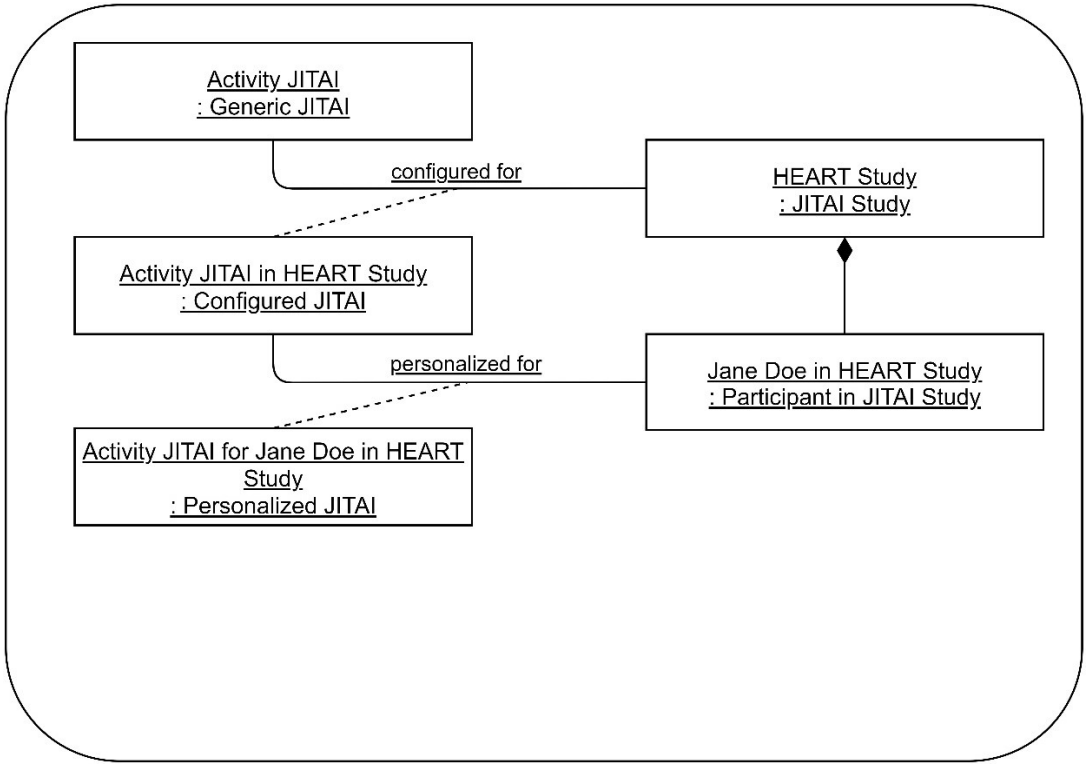

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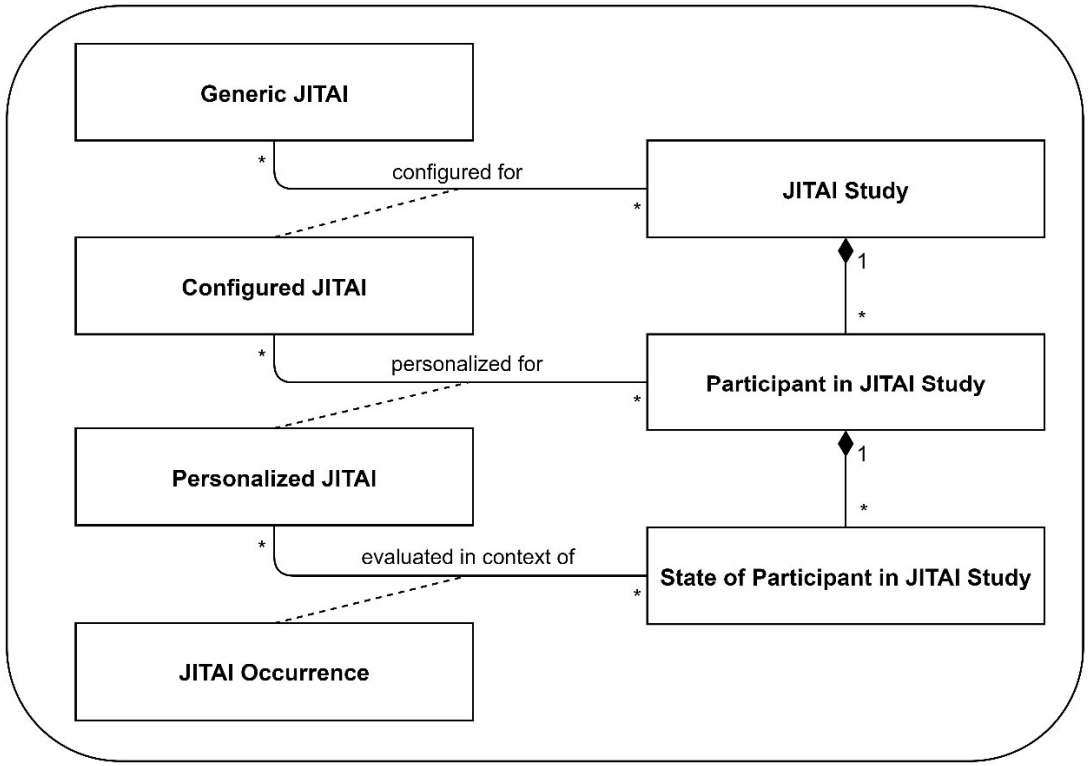

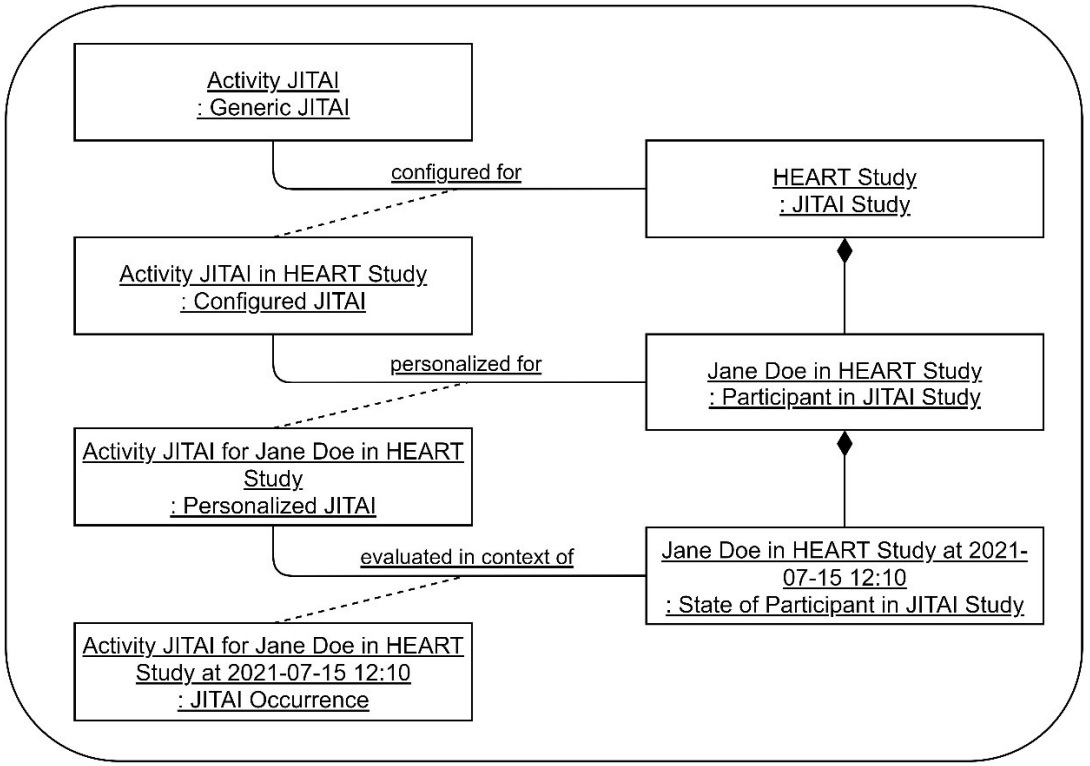

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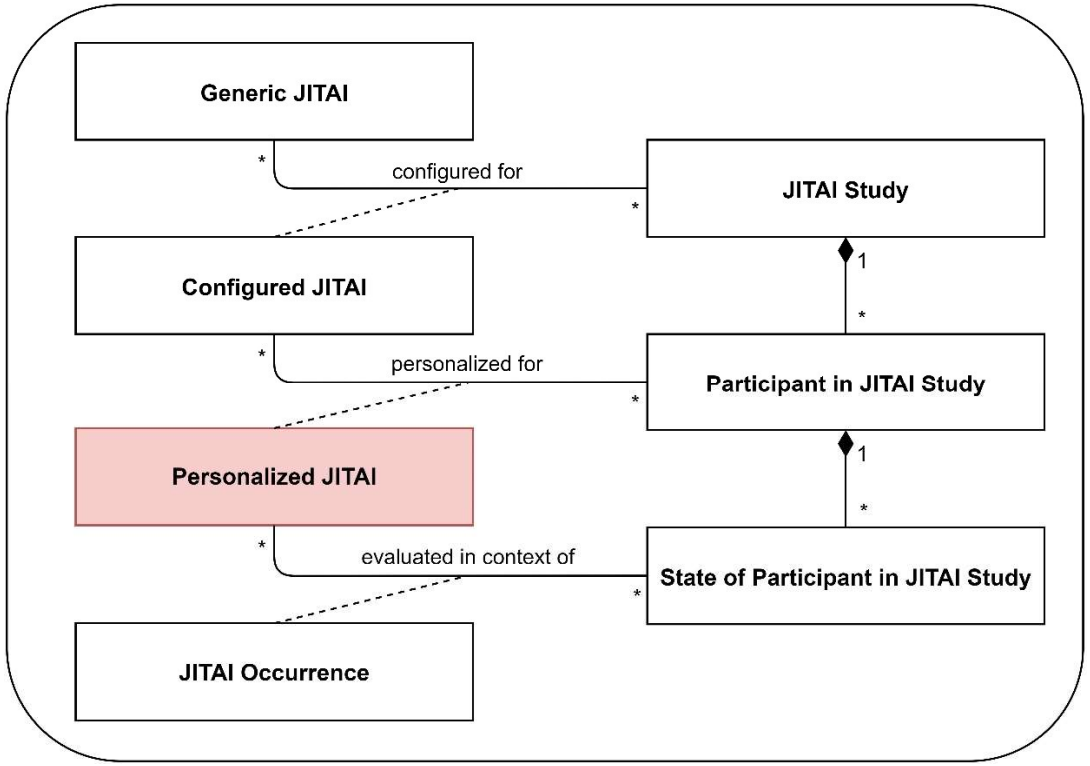
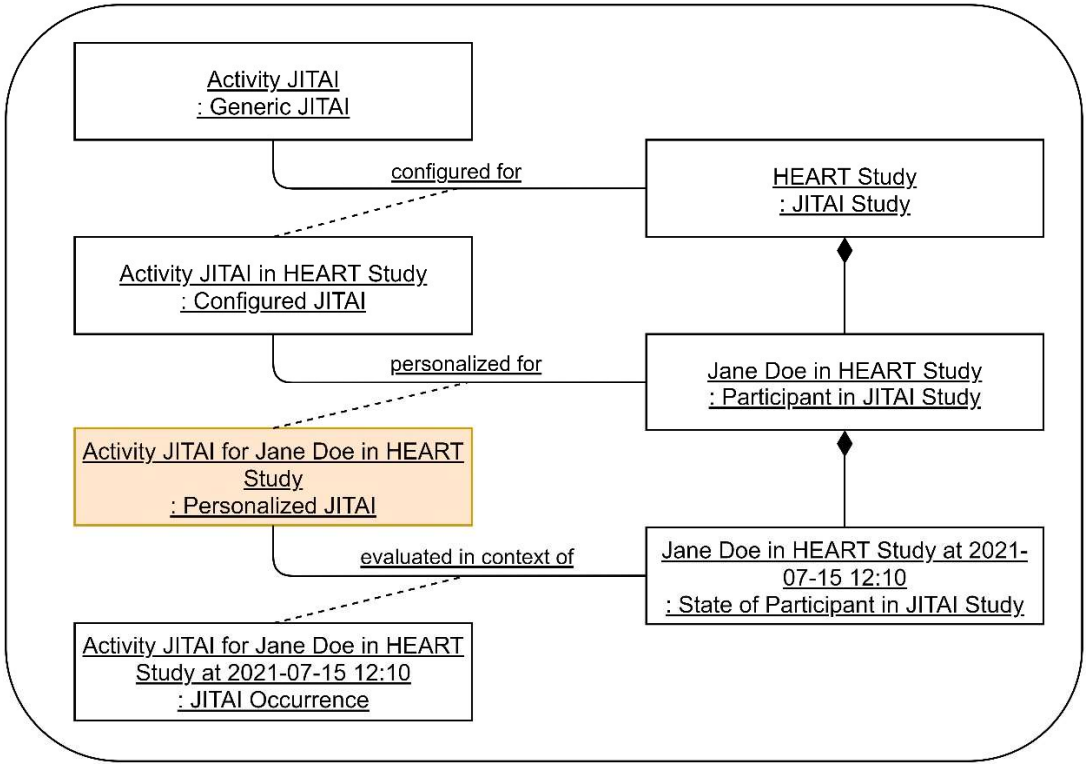
... and derive (exemplified for class *Personalized JITAI* and object *Activity JITAI for Jane Doe in HEART Study*)





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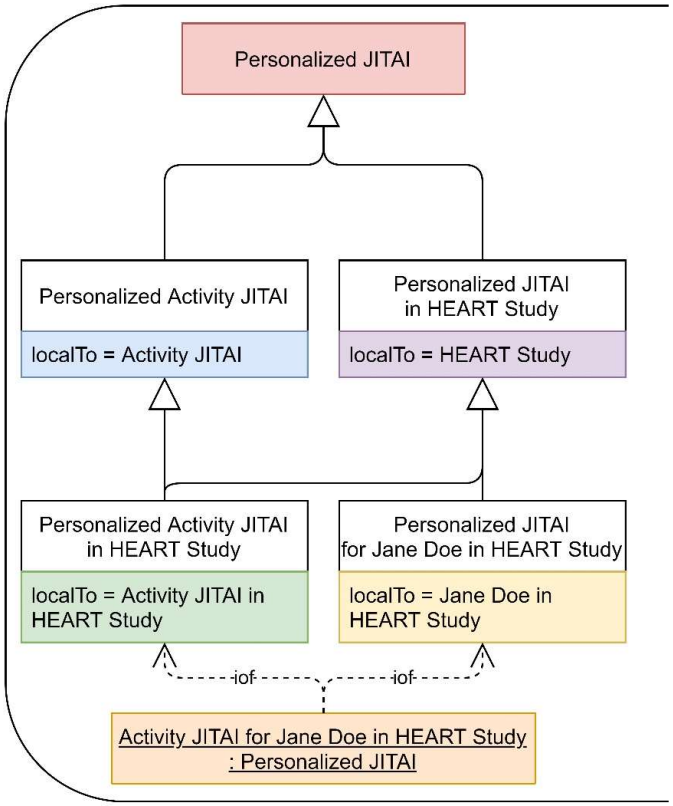
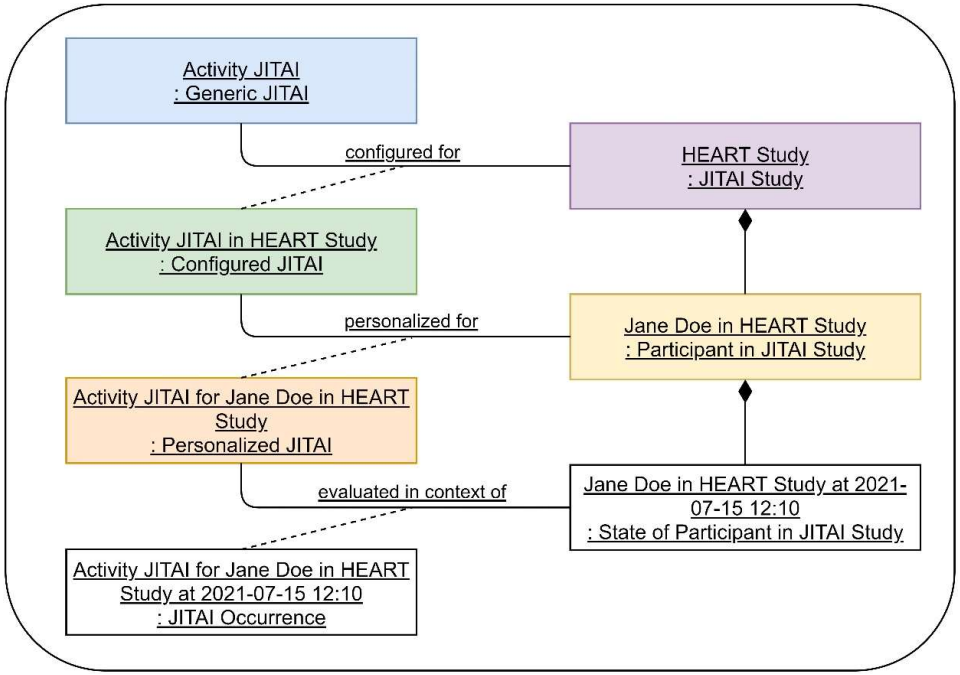
... and derive (exemplified for class *Personalized JITAI* ...)

Induced Subclasses

with dependency *localTo* (inspired by [1])



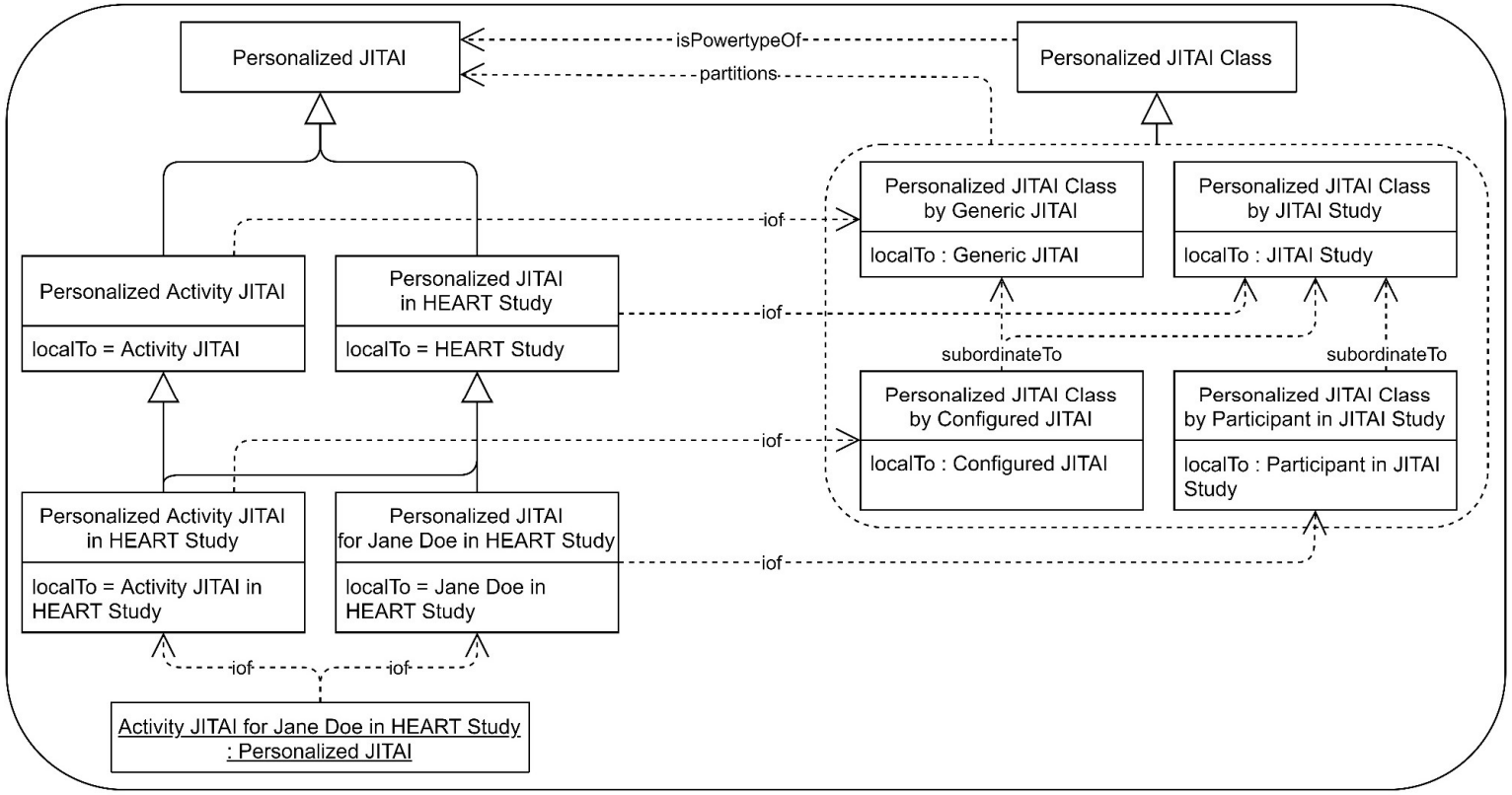


[1] Kappel, Schrefl: **Local referential integrity.** ER 1992: 41-61

... and derive (exemplified for class *Personalized JITAI* ...)

Induced Subclasses and Metaclasses

with dependency *localTo* (inspired by [1]) aligned with the MLT [2]

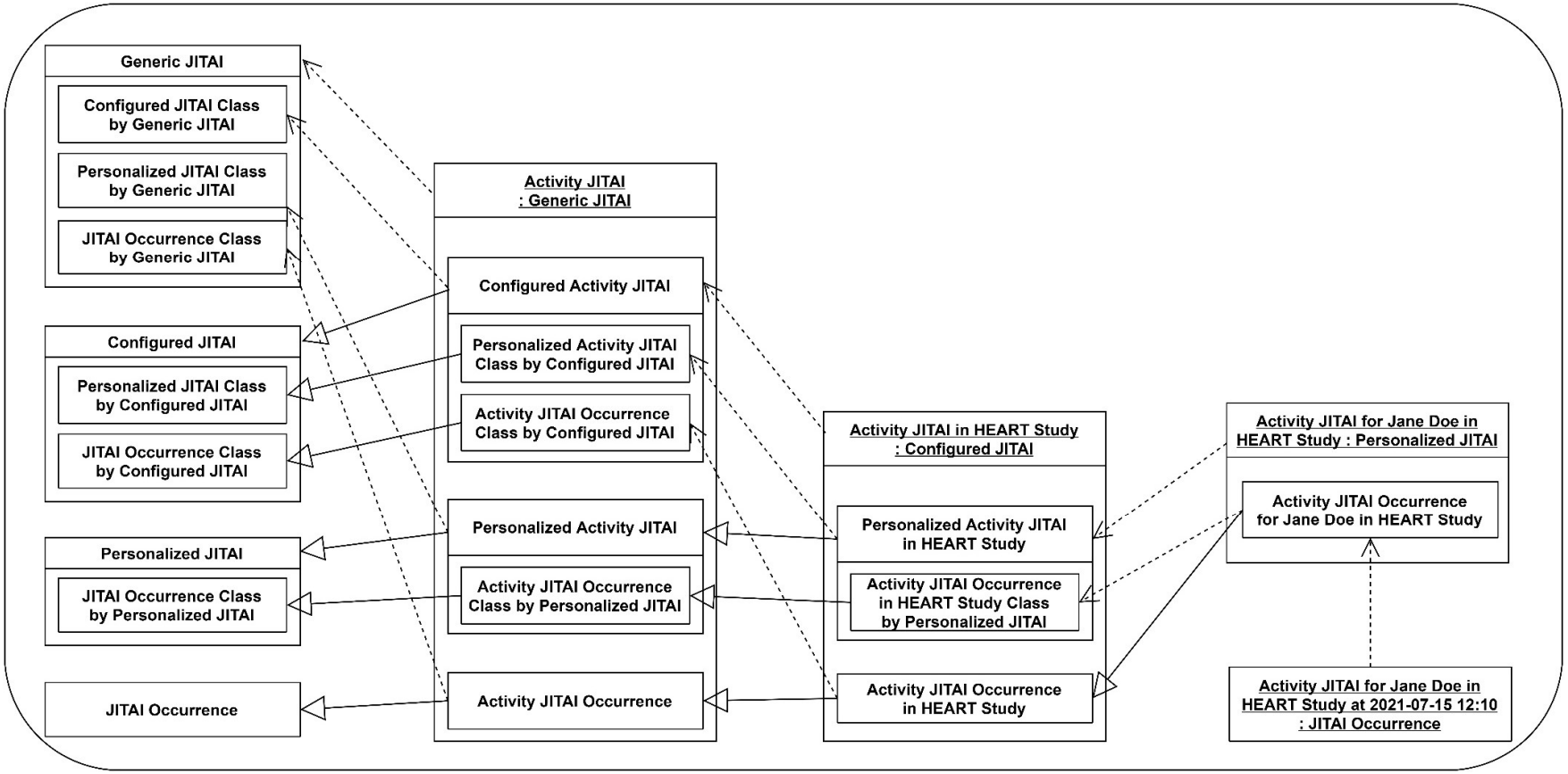


[1] Kappel, Schrefl: **Local referential integrity.** ER 1992: 41-61

[2] Carvalho, Almeida: **Toward a well-founded theory for multi-level conceptual modeling.** *Softw. Syst. Model. 17*(1): 205-231 (2018)

... and introduce, based on the localTo dependency, a

Nested representation of classes / metaclasses



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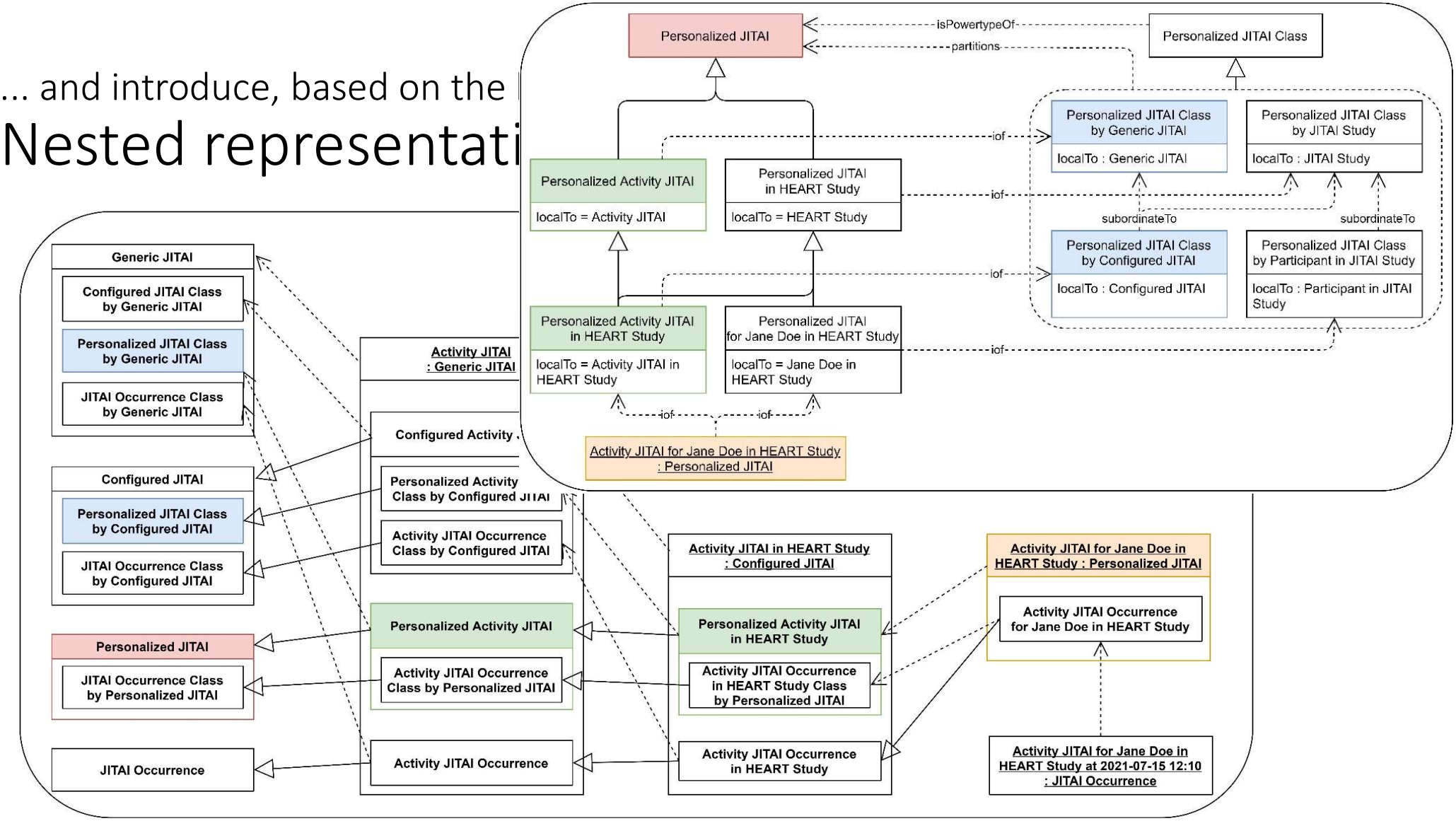
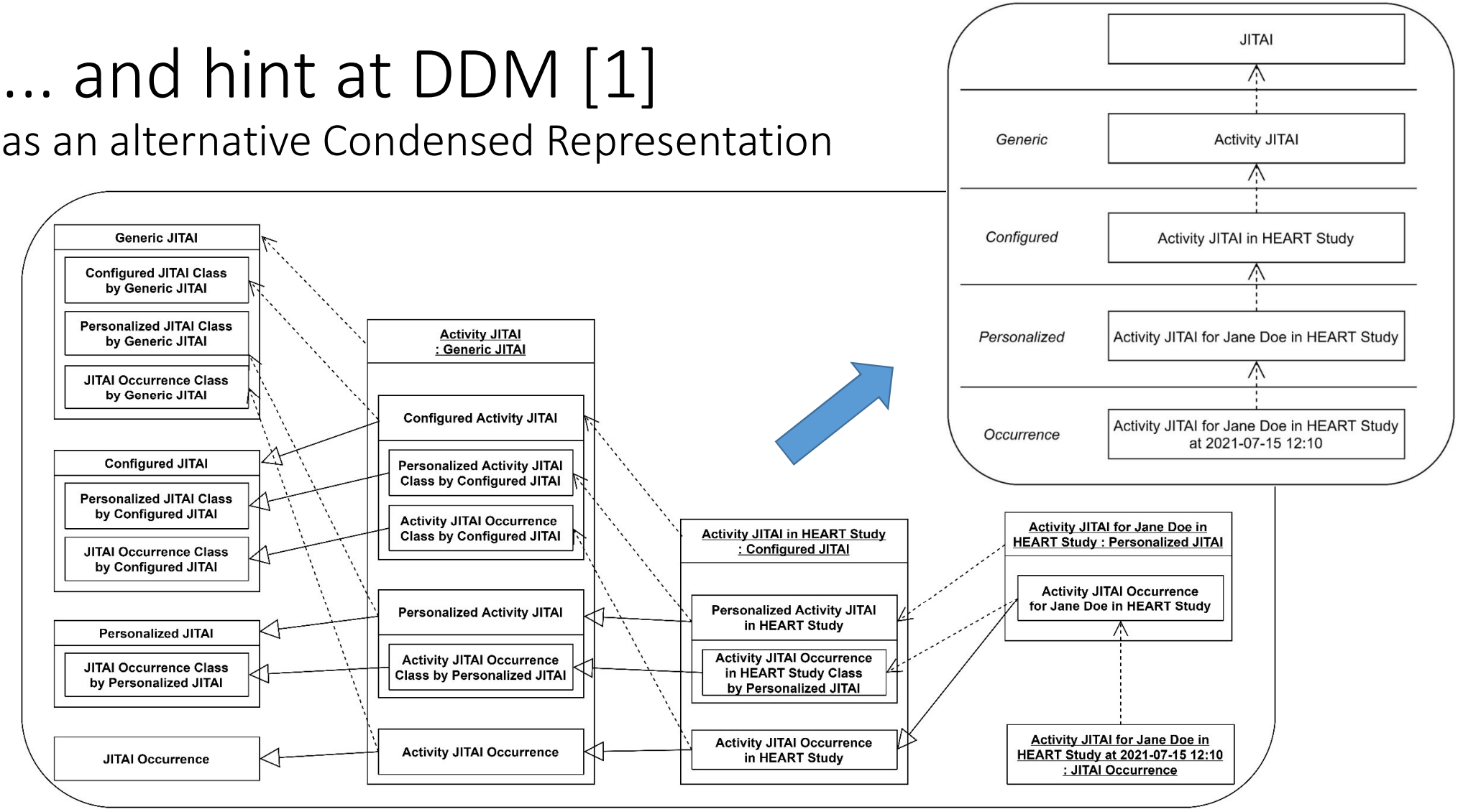


… and hint at DDM [1]

as an alternative Condensed Representation



Conclusion

- Summary
  - MLM of JITAIs for „integration-preserving adaptability“
  - Multi-level JITAI structure using composition and association classes
  - Models are aligned with MLT [1] and extended with dependency localTo [2]

- Current/Future Work
  - Exploration of several options for detailed MLM of JITAIs
  - Knowledge-Graph-based JITAI system

[1] Carvalho, Almeida: **Toward a well-founded theory for multi-level conceptual modeling.** *Softw. Syst. Model. 17*(1): 205-231 (2018)
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Thank you for your attention!

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