Domain Specific Conceptual Model Engineering

© Heinrich C. Mayr
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Alpen-Adria-Universität Klagenfurt, Austria
Joint EMMSAD-BPMDS Keynote at CAISE 2017, Essen
June 12, 2017

Content

- Modeling
- Modeling Method Engineering
- Example: HCM-L and HBMS
- Commercial

Modeling ?!

Fundamental work and readings

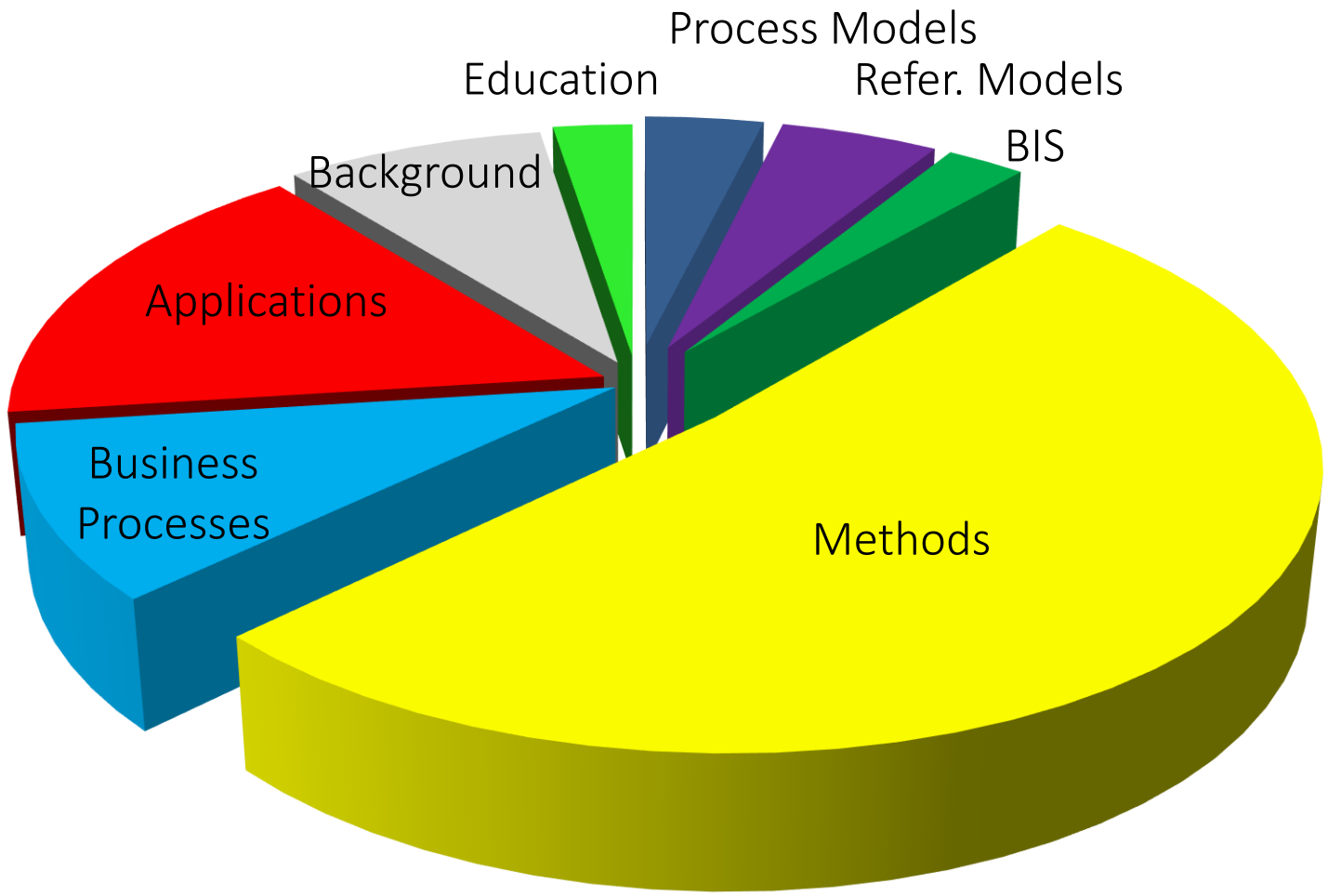
Batini
Becker
Booch
Chen
De Antonellis
Embley
Frank
Guarino
Guizzardi
Hesse
Henderson-Sellers
Jacobsen
Kaschek
Lenzerini
Ling
Ludewig
Mayr
Moody
Mylopoulos
Nijssen
Olivé
Opdahl
Parnas
Pastor
Rolland
Rumbaugh
Smith&Smith
Stachowiak
Thalheim
Verrijn-Stuart
Wand
+++++

D-A-CH Modeling Community

Biennial Conference since 1998: „Modellierung XXXX“

3 days, usually 110-150 participants

D-A-CH Research



International Community

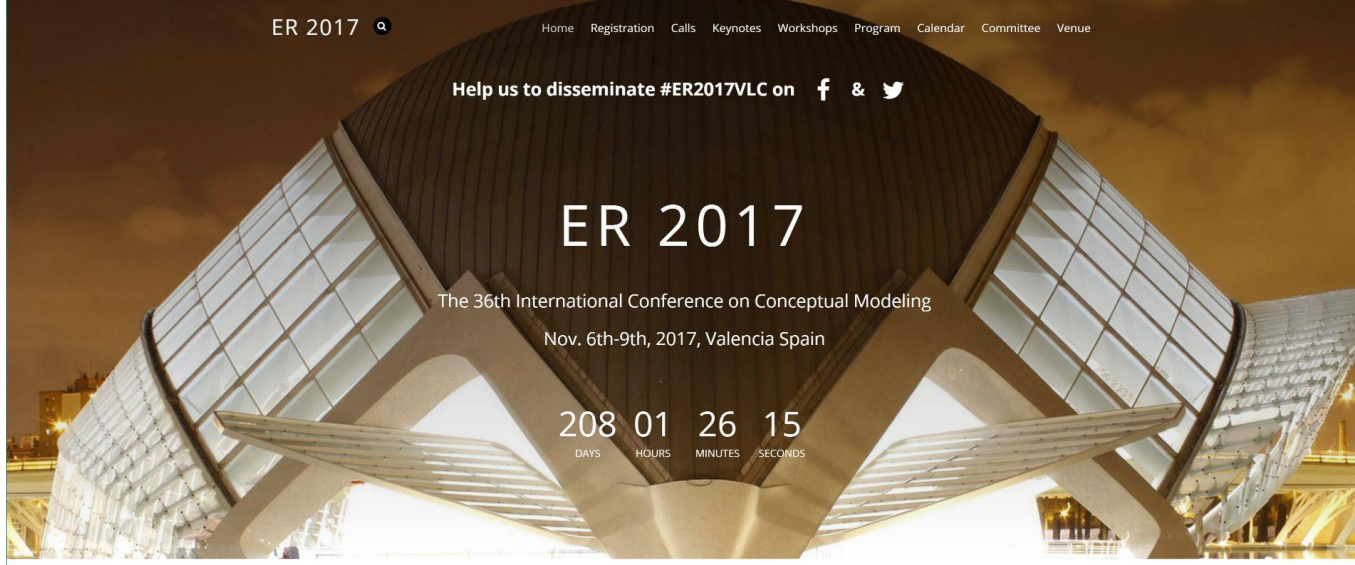
Annual Conference „Conceptual Modeling“ since 1979: **ERxx**

3-4 days, usually 150-200 participants

- http://er2017.pros.webs.upv.es/
- http://conceptualmodeling.org/

Annual Conference on Model Driven Engineering Languages and Systems: **Models xx**

- http://www.cs.utexas.edu/models2017/home



Observation

“Humans have an ambivalent position to modeling”

- they are modeling permanently - but mostly not being aware of it:
  - any kind of thinking, communicating about something implies modeling
  - Writing a novel = Modeling
  - Requirements engineering = Modeling to a large extent
  - Programming = Modeling

Observation

“Humans have an ambivalent position to modeling”

- when modeling consciously, they do it often unwillingly
  - prefer doing to planning; hipp: Agility (“agere”)
  - challenge the benefits of systematic modeling; use cost and time needed as an excuse
- but: in technical and life critical domains, modeling is a must – and done in most disciplines

Observation

“The Law of Logistic Growth* holds for Modeling Languages”

smooth beginning

increasing growth

turning point

decreasing growth

collapse

*Pierre-François Verhulst 1838

PSL/PSA (Teichroew, 1964ff)

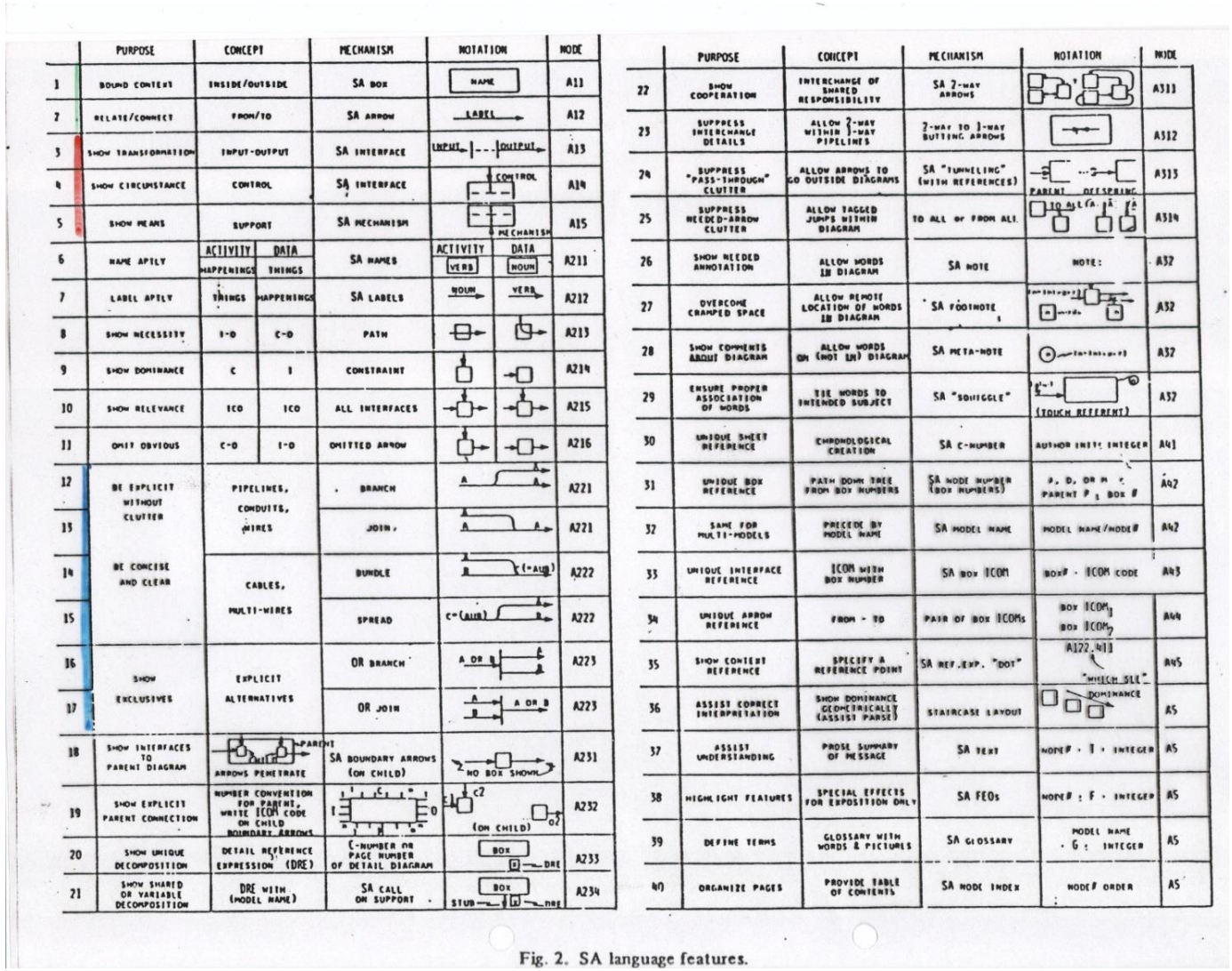
ISDOS: Information System Design and Optimization System

initially lean and clear; at the end:

19 „Objekts“ (ENTITY, ATTRIBUTE, CONDITION, ELEMENT, EVENT, PROCESS, REQUIREMENT etc.)

102 (!) „Relationships“

SA (Tom de Marco, 1978)



	PURPOSE	CONCEPT	MECHANISM	NOTATION	NODE
1	BOUND CONTEXT	INSIDE/OUTSIDE	SA BOX	NAME	A11
2	RELATE/CONNECT	FROM/TO	SA ARROW	LABEL	A12
3	SHOW TRANSFORMATION	INPUT-OUTPUT	SA INTERFACE	INPUT / OUTPUT	A13
4	SHOW CIRCUMSTANCE	CONTROL	SA INTERFACE	CONTROL	A14
5	SHOW MEANS	SUPPORT	SA MECHANISM	MECHANISM	A15
6	NAME APTLY	ACTIVITY: HAPPENINGS / DATA: THINGS	SA NAMES	ACTIVITY: VERB / DATA: NOUN	A211
7	LABEL APTLY	THINGS / HAPPENINGS	SA LABELS	NOUN / VERB	A212
8	SHOW NECESSITY	1-0	C-0	PATH	A213
9	SHOW DOMINANCE	C	I	CONSTRAINT	A214
10	SHOW RELEVANCE	ICO	ICO	ALL INTERFACES	A215
11	OMIT OBVIOUS	C-0	I-0	OMITTED ARROW	A216
12	BE EXPLICIT WITHOUT CLUTTER	PIPELINES, CONDUITS, WIRES	BRANCH	A / A	A221
13			JOIN	A / A	A221
14	BE CONCISE AND CLEAR	CABLES, MULTI-WIRES	BUNDLE	B (=A,C)	A222
15			SPREAD	C=(A,B) / A / B	A222
16	SHOW EXCLUSIVES	EXPLICIT ALTERNATIVES	OR BRANCH	A OR B / A	A223
17			OR JOIN	A / B / A OR B	A223
18	SHOW INTERFACES TO PARENT DIAGRAM	PARENT / CHILD / ARROWS PENETRATE	SA BOUNDARY ARROWS (ON CHILD)	NO BOX SHOWN	A231
19	SHOW EXPLICIT PARENT CONNECTION	NUMBER CONVENTION FOR PARENT, WRITE ICOM CODE ON CHILD BOUNDARY ARROWS	C1 C2 O	C2 (ON CHILD) O2	A232
20	SHOW UNIQUE DECOMPOSITION	DETAIL REFERENCE EXPRESSION (DRE)	C-NUMBER OR PAGE NUMBER OF DETAIL DIAGRAM	BOX D DRE	A233
21	SHOW SHARED OR VARIABLE DECOMPOSITION	DRE WITH (MODEL NAME)	SA CALL ON SUPPORT	BOX STUB D DRE	A234

	PURPOSE	CONCEPT	MECHANISM	NOTATION	NODE
22	SHOW COOPERATION	INTERCHANGE OF SHARED RESPONSIBILITY	SA 2-WAY ARROWS		A311
23	SUPPRESS INTERCHANGE DETAILS	ALLOW 2-WAY WITHIN 1-WAY PIPELINES	2-WAY TO 1-WAY BUTTING ARROWS		A312
24	SUPPRESS "PASS-THROUGH" CLUTTER	ALLOW ARROWS TO GO OUTSIDE DIAGRAMS	SA "TUNNELING" (WITH REFERENCES)	PARENT OFFSPRING	A313
25	SUPPRESS NEEDED-ARROW CLUTTER	ALLOW TAGGED JUMPS WITHIN DIAGRAM	TO ALL OF FROM ALL	TO ALL (A, B, C)	A314
26	SHOW NEEDED ANNOTATION	ALLOW WORDS IN DIAGRAM	SA NOTE	NOTE:	A32
27	OVERCOME CRAMPED SPACE	ALLOW REMOTE LOCATION OF WORDS IN DIAGRAM	SA FOOTNOTE		A32
28	SHOW COMMENTS ABOUT DIAGRAM	ALLOW WORDS ON (NOT IN) DIAGRAM	SA META-NOTE		A32
29	ENSURE PROPER ASSOCIATION OF WORDS	TIE WORDS TO INTENDED SUBJECT	SA "SQUIGGLE"	(TOUCH REFERENT)	A32
30	UNIQUE SHEET REFERENCE	CHRONOLOGICAL CREATION	SA C-NUMBER	AUTHOR INITS INTEGER	A41
31	UNIQUE BOX REFERENCE	PATH DOWN TREE FROM BOX NUMBERS	SA NODE NUMBER (BOX NUMBERS)	P, D, OR M + PARENT P1 BOX #	A42
32	SAME FOR MULTI-MODELS	PRECEDE BY MODEL NAME	SA MODEL NAME	MODEL NAME/NODE#	A42
33	UNIQUE INTERFACE REFERENCE	ICOM WITH BOX NUMBER	SA BOX ICOM	BOX# - ICOM CODE	A43
34	UNIQUE ARROW REFERENCE	FROM - TO	PAIR OF BOX ICOMs	BOX ICOM1 / BOX ICOM2	A44
35	SHOW CONTEXT REFERENCE	SPECIFY A REFERENCE POINT	SA REF.EXP. "DOT"	A122.411 "WHICH SLL"	A45
36	ASSIST CORRECT INTERPRETATION	SHOW DOMINANCE GEOMETRICALLY (ASSIST PARSE)	STAIRCASE LAYOUT	DOMINANCE	A5
37	ASSIST UNDERSTANDING	PROSE SUMMARY OF MESSAGE	SA TEXT	NODE# - T - INTEGER	A5
38	HIGHLIGHT FEATURES	SPECIAL EFFECTS FOR EXPOSITION ONLY	SA FEOs	NODE# : F - INTEGER	A5
39	DEFINE TERMS	GLOSSARY WITH WORDS & PICTURES	SA GLOSSARY	MODEL NAME - G : INTEGER	A5
40	ORGANIZE PAGES	PROVIDE TABLE OF CONTENTS	SA NODE INDEX	NODE# ORDER	A5

Fig. 2. SA language features.

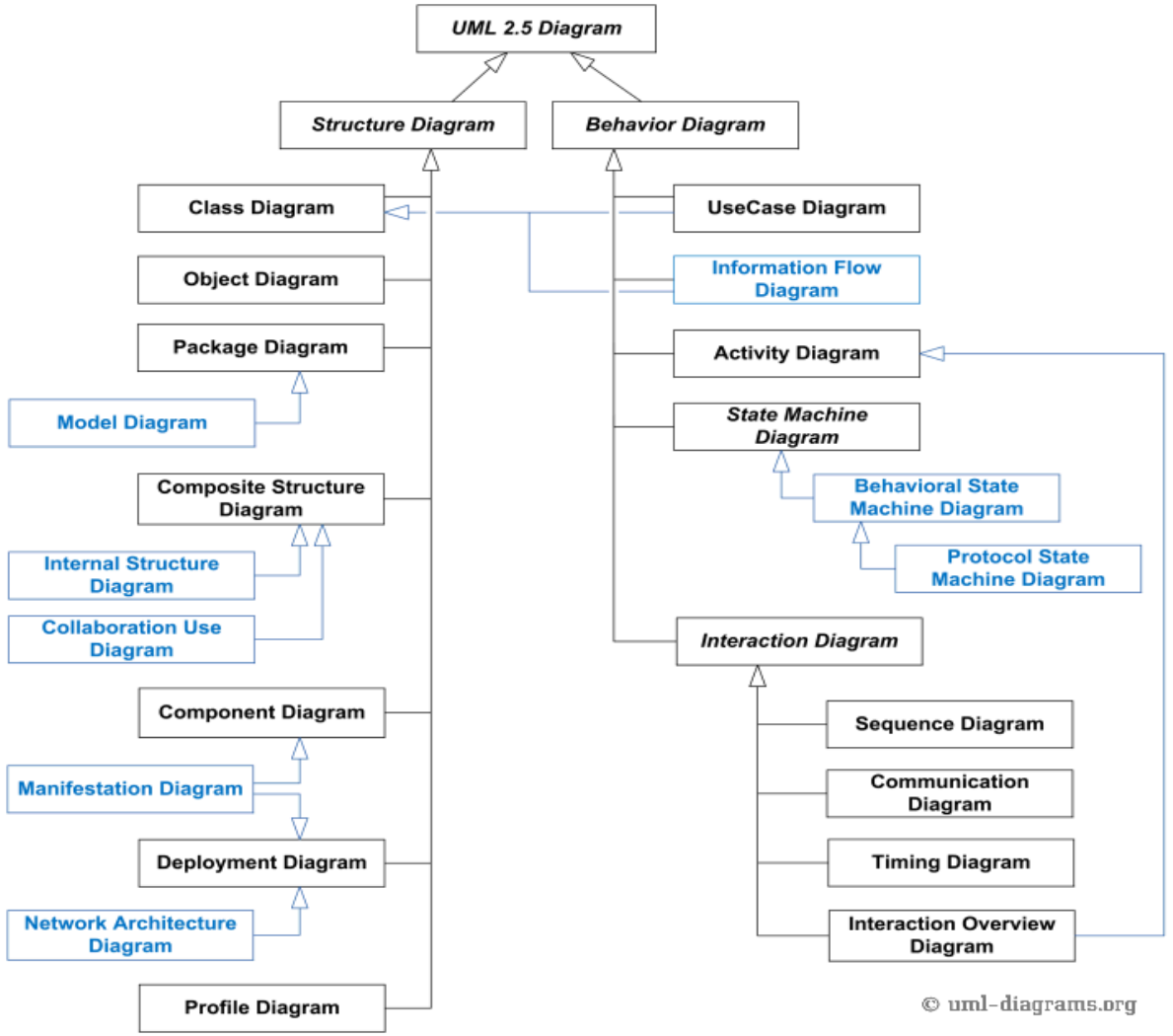
Tool: IDEFx still used? nostalgy?

UML 0.9 (1996)

- Use Case Diagram
- Class Diagram
- Sequence Diagram
- Collaboration Diagram
- State Diagram

UML 2.5 (today)

Note, items in blue are not part of official taxonomy of UML 2.5 diagrams



http://www.uml-diagrams.org/uml-25-diagrams.html

Observation

“The Law of Entropy is valid for Modeling”

Without the input of external energy (e.g., the users’),

the community does not achieve

to put some order

into the world of modeling

ad Entropy:

hugh variety of uncoordinated approaches

terminology

reinventions

method growth

zoo of tools

Terminology

conceptual | conceptional

synonyma | homonyma

parallelism | concurrency

ontology | meta model | conceptual model | schema

Imprecise Terms

semiformal, semistructured, …

mapping | transformation

the attribute concept

the role concept

Reinventions

object orientation + message concept
(Christen Nygaard 1966, B. Langeförs 1973)

diagram types

intension/extensions hierarchy

Reinventions

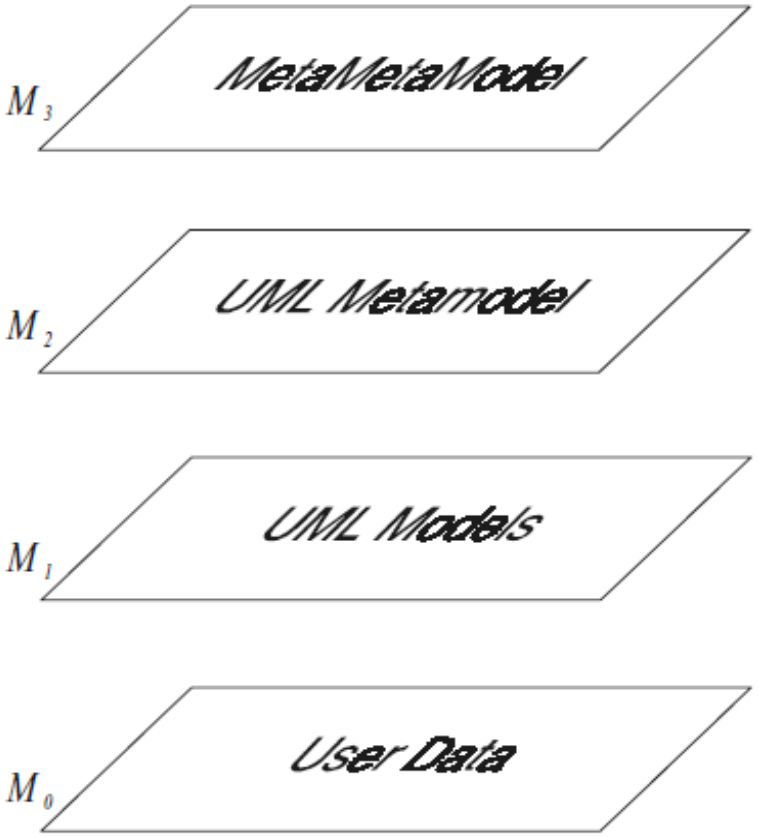


Fig. 1. The four-level metamodeling architecture.

OMG Meta Object Facility (MOF)

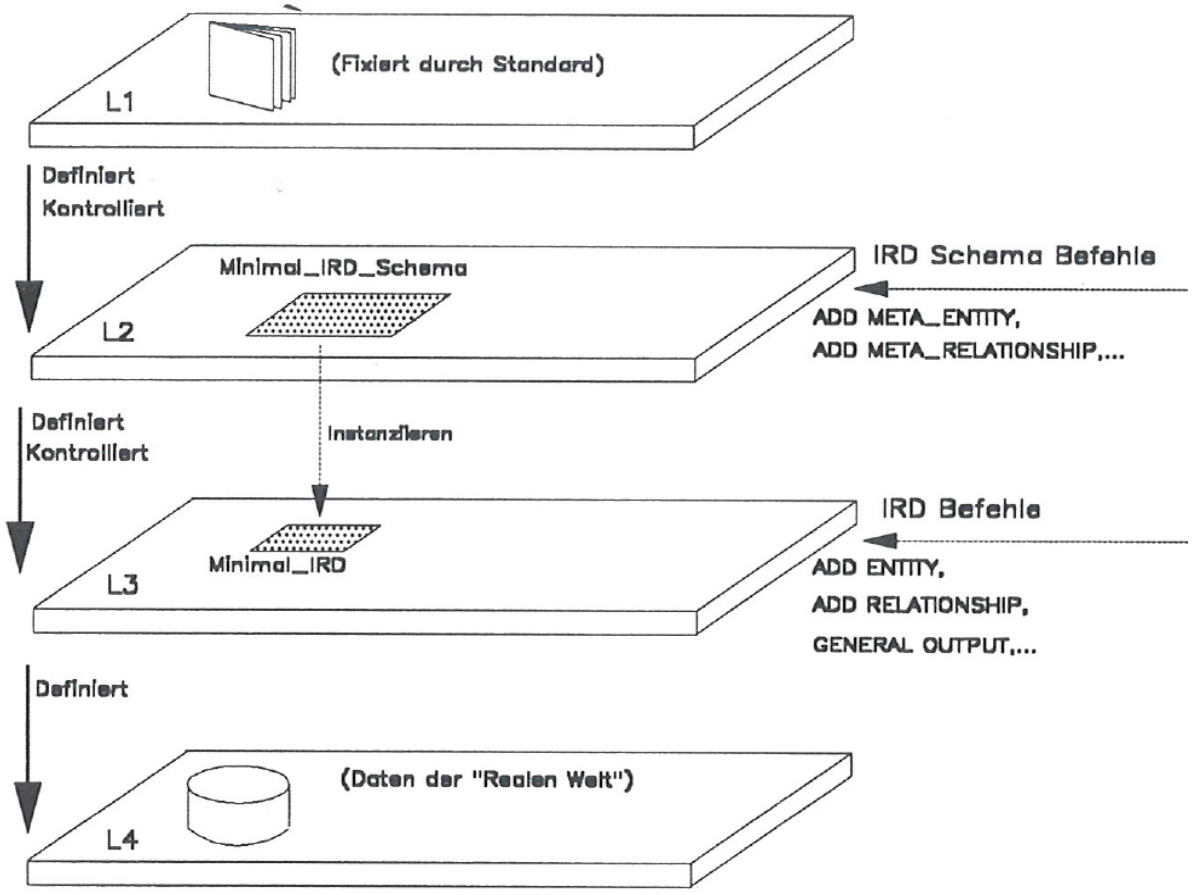


Abb. 5-9: Das ANSI Kern-Modul

IRDS: Information Resource Dictionary System

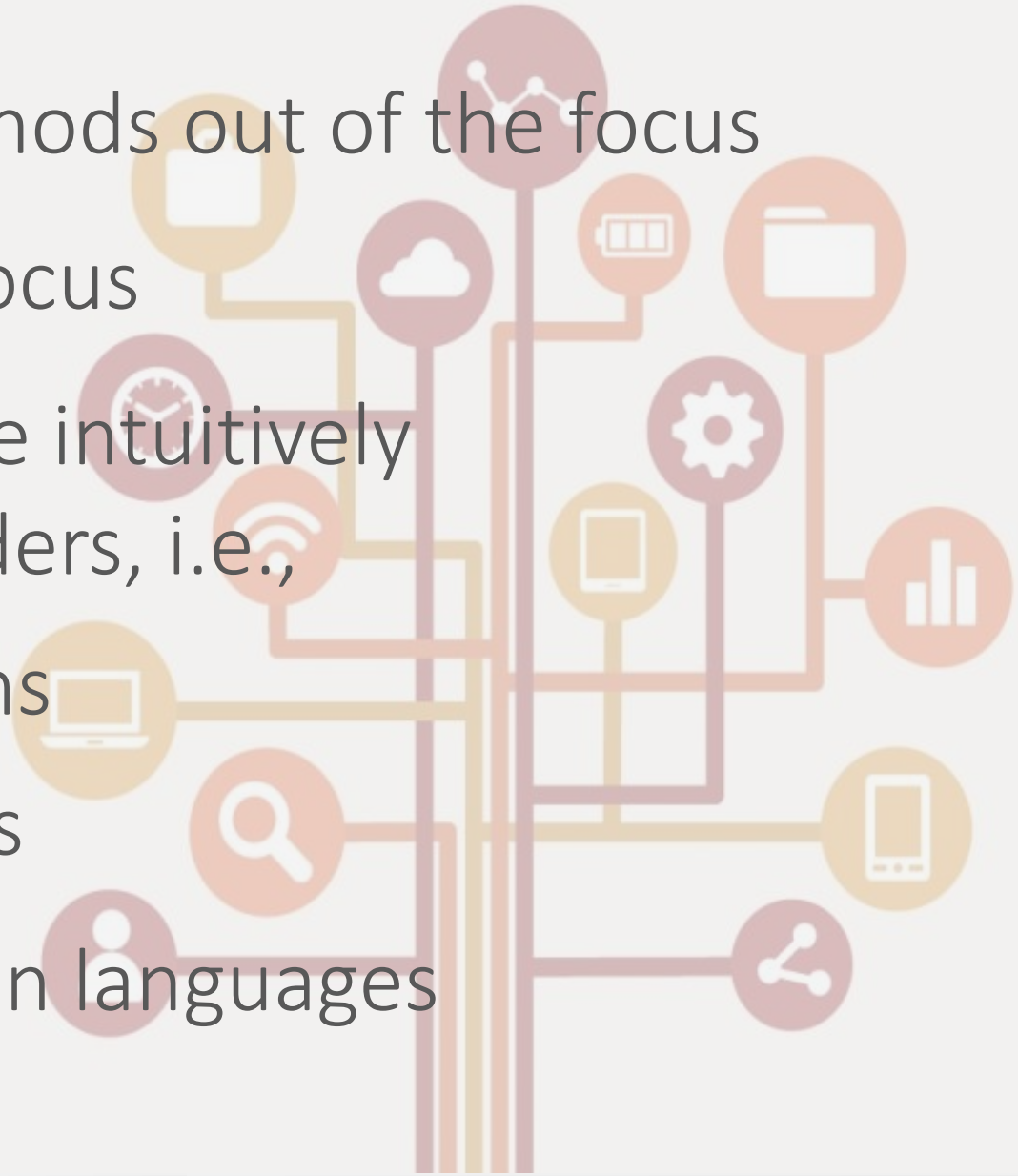
Atkinson, C.; Kühne, Th.: Rearchitecting the UML Infrastructure. ACM Transactions on Modeling and Computer Simulation, Vol. 12, No. 4, 2002.

H. Thoma, EMISA-Forum 1/88

„free methods from
Baroque opulence,
find a compromise between
correctness, completeness and understandability
to have them
profitably used in practise“

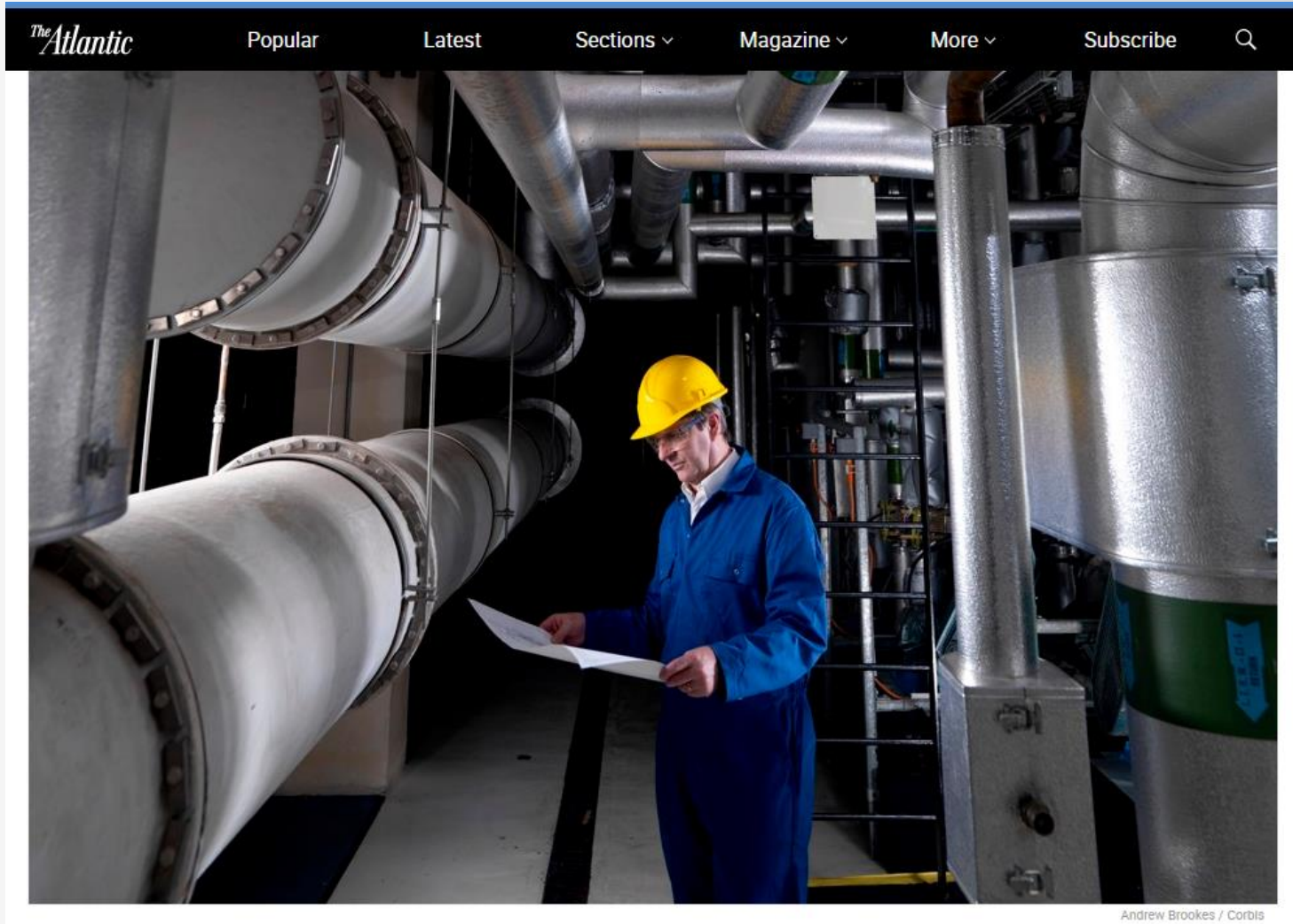
Conclusion

- put „overloaded“, „unified“ methods out of the focus
- put the use of models into the focus
- provide modeling means that are intuitively understandable by the stakeholders, i.e.,
  - lean and focused set of notions
  - use „efficient“ visual notations
- support transformations between languages



Conclusion

- A challenge for Software Development
- Modeling as engineering technique
- initially adopted by database engineers
- Models as kernels of each development
- Mappers and Transformators

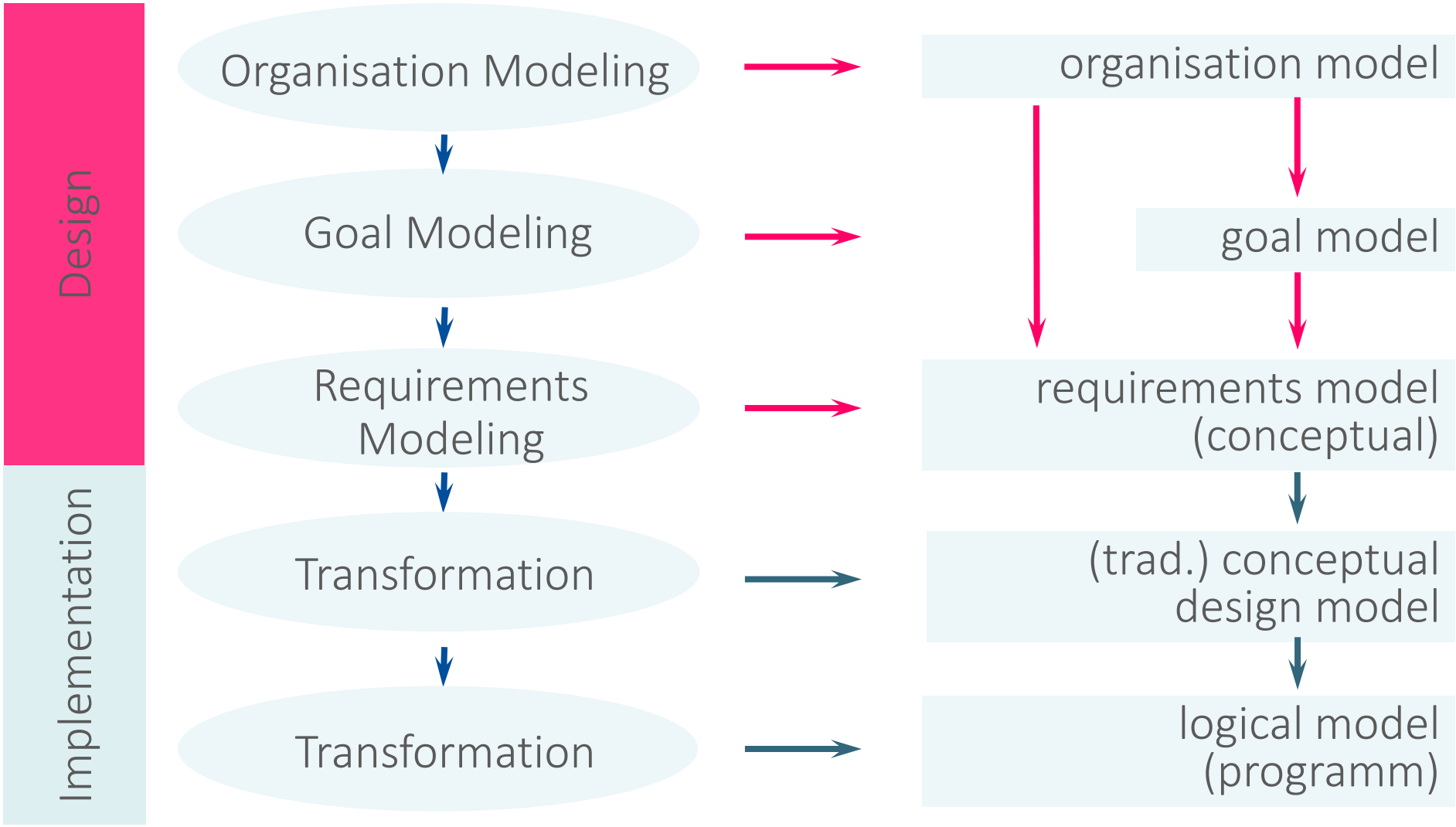


Andrew Brookes / Corbis

Programmers: Stop Calling Yourselves Engineers

It undermines a long tradition of designing and building infrastructure in the public interest.

MDSD: by transformations

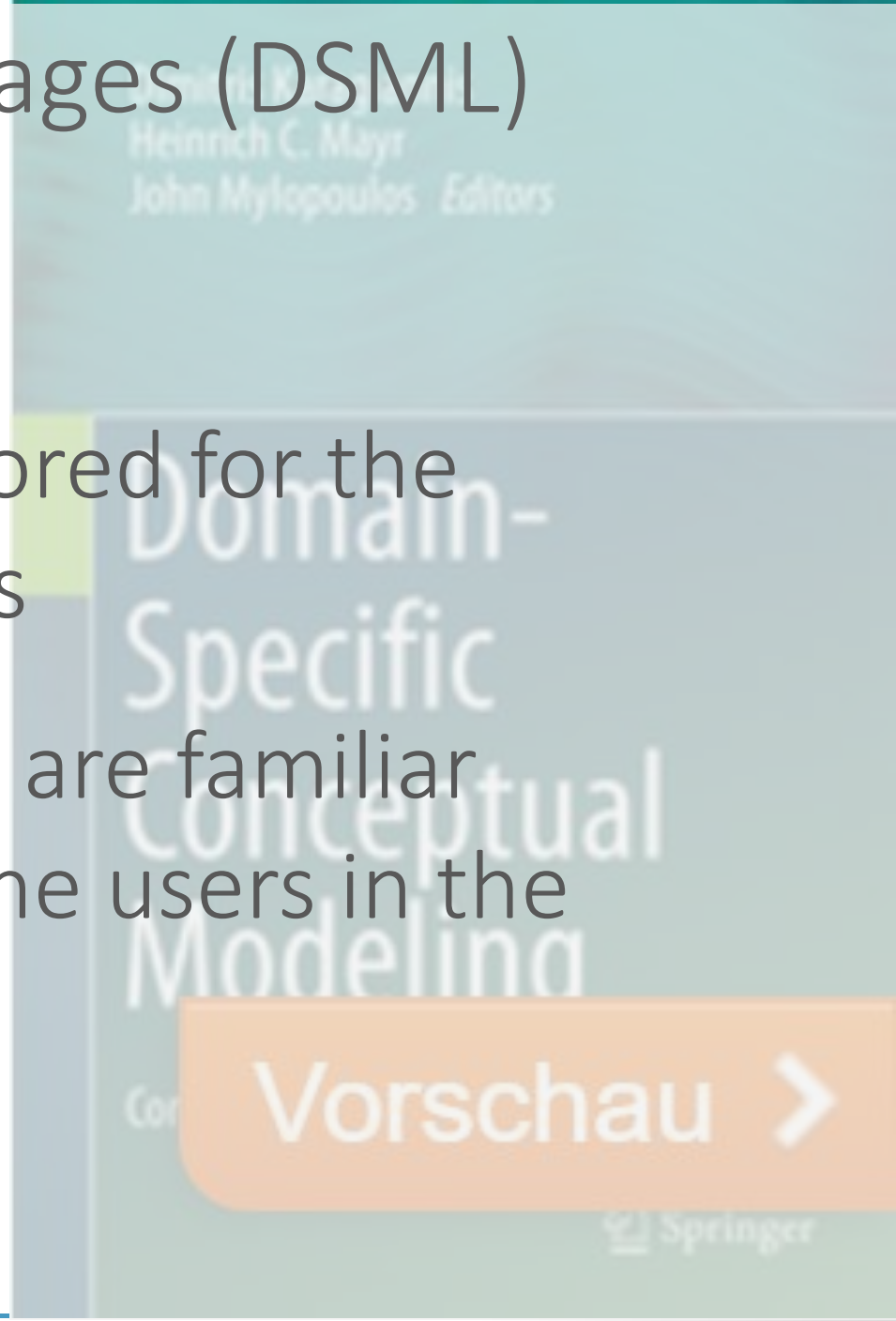


Example: ONME

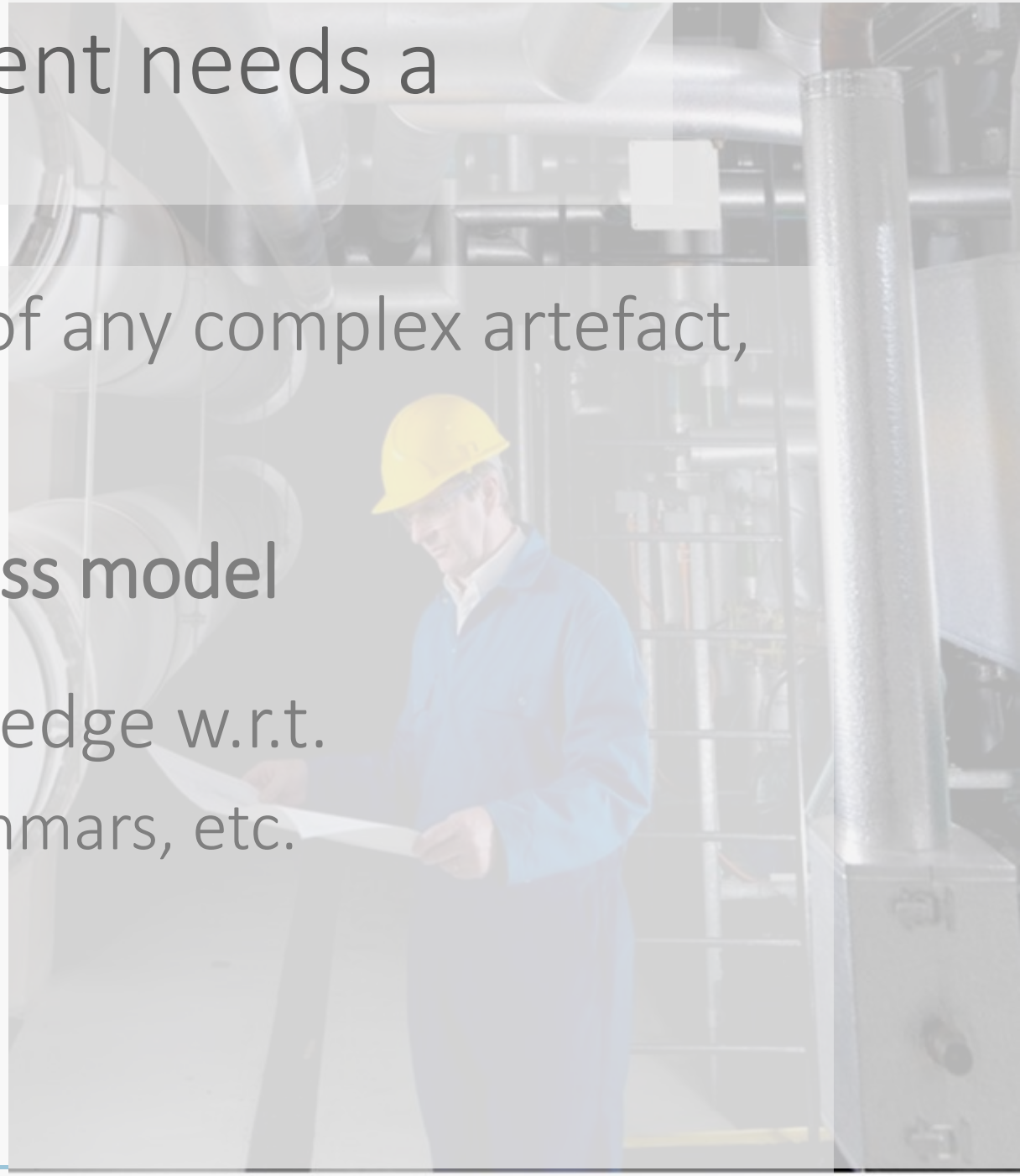
Modeling Method Engineering

Domain Specific Modeling Languages (DSML)

+ Lean set of modeling concepts
+ Explicit constraints that are tailored for the particular domain and purposes
+ Lexical/graphical notations that are familiar and/or easy to understand by the users in the given domain



Successful DSML development needs a systematic procedure



comparable to the development of any complex artefact, i.e. should

be grounded on a validated **process model**

exploit the existing body of knowledge w.r.t.

- formal languages, conceptual grammars, etc.
- semantic interpretation
- effective visual notations

DSMM: Domain Specific Modeling Method

should

provide guidelines, patterns, style guides etc. for its application

be supported by

- a modeling tool, as well as by
- means for model management

Together, these components form a DSMM

Modeling Method Characteristics

Conception

Modeling Language (notions and representations)

Methodology

Documentation

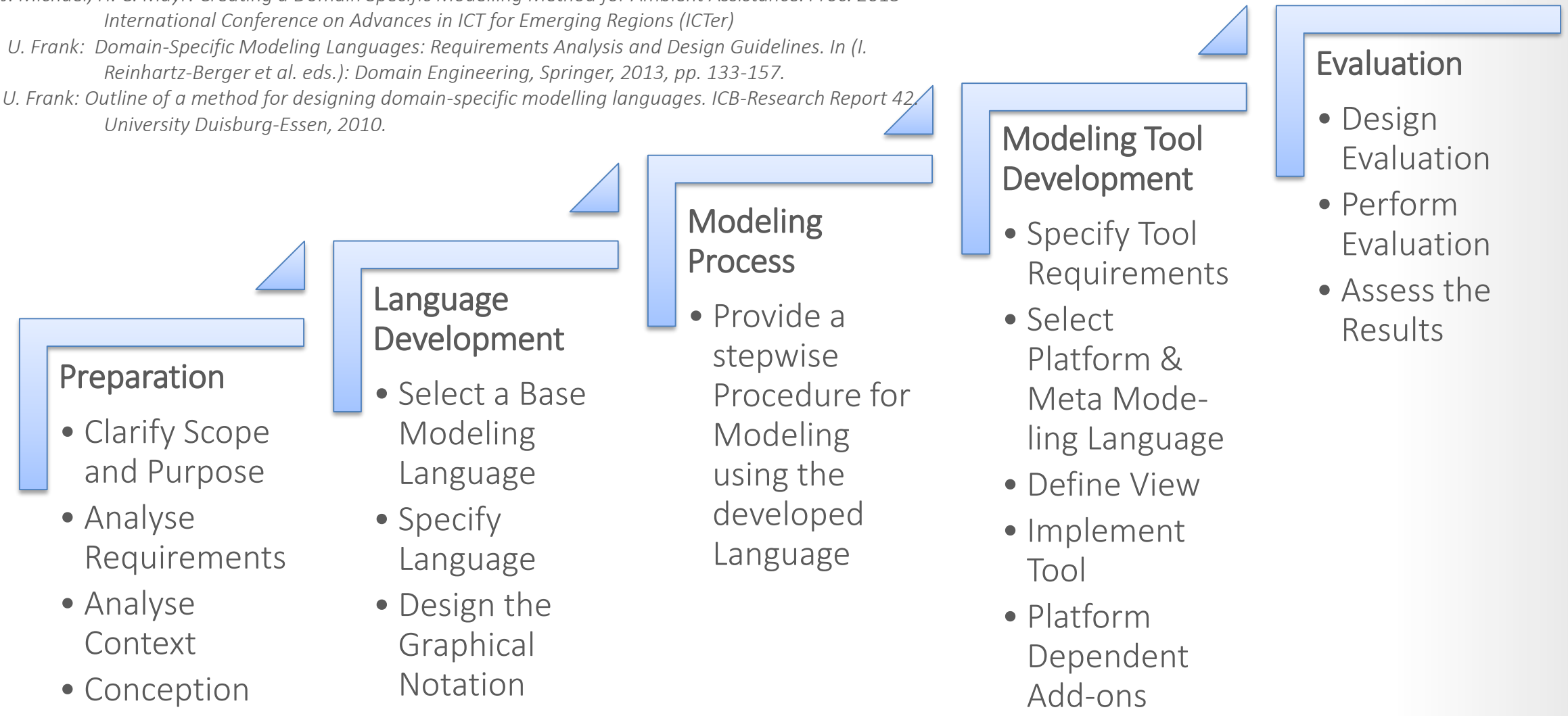
"Historic" references:

*Kaschek, R.; Mayr, H.C.: **A Characterization of OOA-Tools**. Proc. 4th Int. Symposium on Assessment of Software Tools. IEEE Computer Society Press. 1996.*

*Kaschek, R.; Mayr, H.C.: **Characteristics of Object Oriented Modeling Methods**. EMISA Forum 2/1998*

Process of DSMM development

J. Michael, H. C. Mayr: Creating a Domain Specific Modelling Method for Ambient Assistance. Proc. 2015 International Conference on Advances in ICT for Emerging Regions (ICTer)
U. Frank: Domain-Specific Modeling Languages: Requirements Analysis and Design Guidelines. In (I. Reinhartz-Berger et al. eds.): Domain Engineering, Springer, 2013, pp. 133-157.
U. Frank: Outline of a method for designing domain-specific modelling languages. ICB-Research Report 42. University Duisburg-Essen, 2010.



Preparation: Scope, Context, Conception

intended domain, e.g.,

- real time, planning, CAD, embedded systems, enterprise modeling, BPM etc.
- underlying software life cycle (SLC) model and SLC-phases to be instantiated

involved persons (their roles, qualification profiles and responsibilities)

intended design products (documents)

usage operations / use cases

basic philosophy (ontological, epistemological, other)

starting point (e.g. pre design)

Modeling Language, Notions

set of notions: meta model

sets of representation concepts: language

defined submodels (coherence)

quality criteria

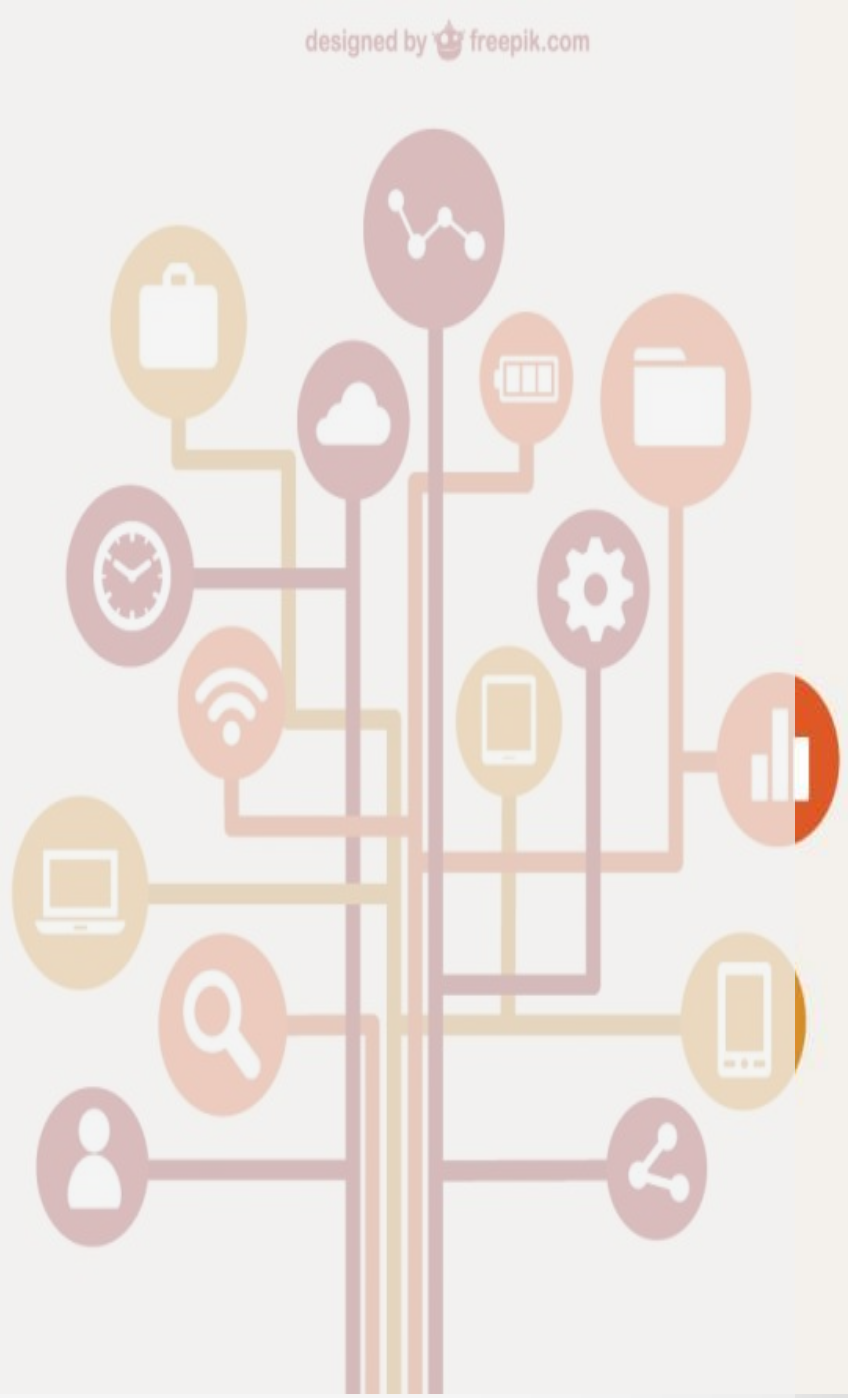
intuitive understandability

orthogonality of modeling notions

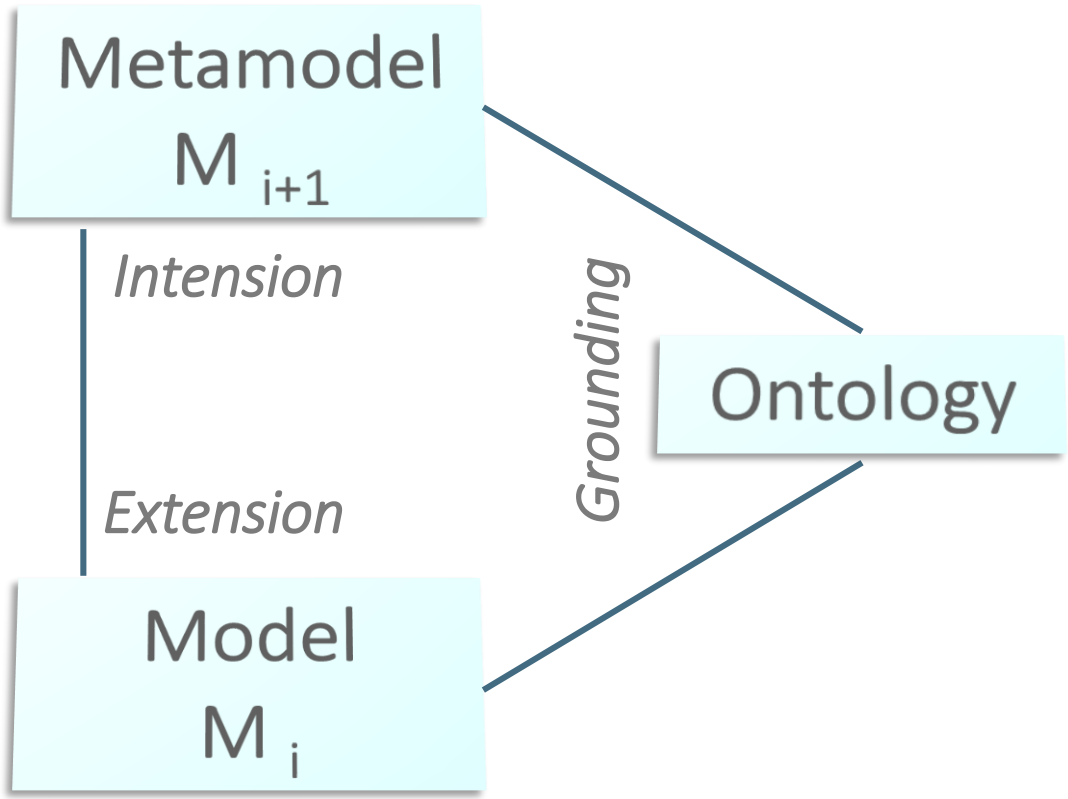
adequacy with respect to the conception

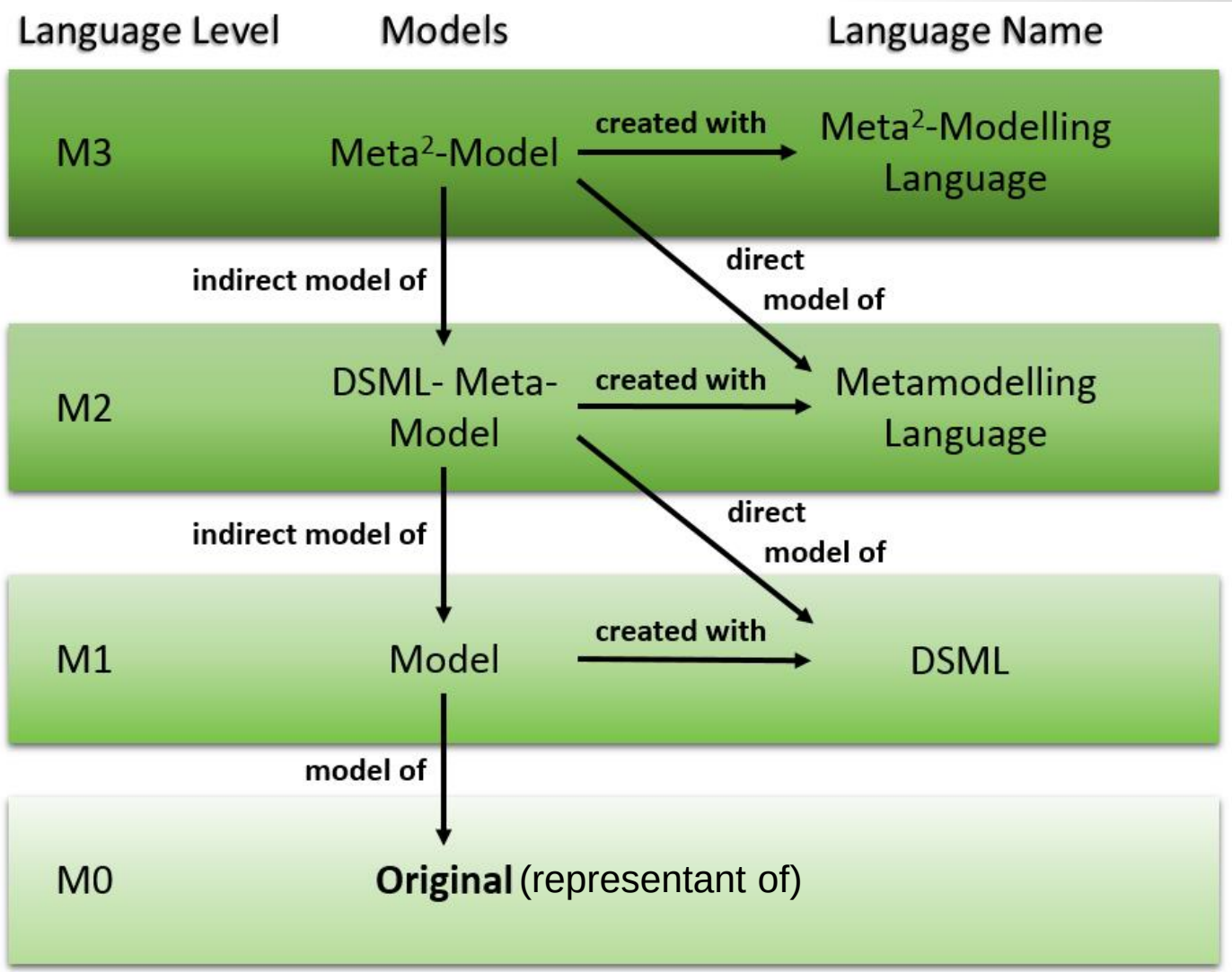
practicability

quantitative aspects



Modeling Concepts: MOF Alignment





Representation Concepts

per set (several are possible):

- correspondence between representation concepts and modeling notions

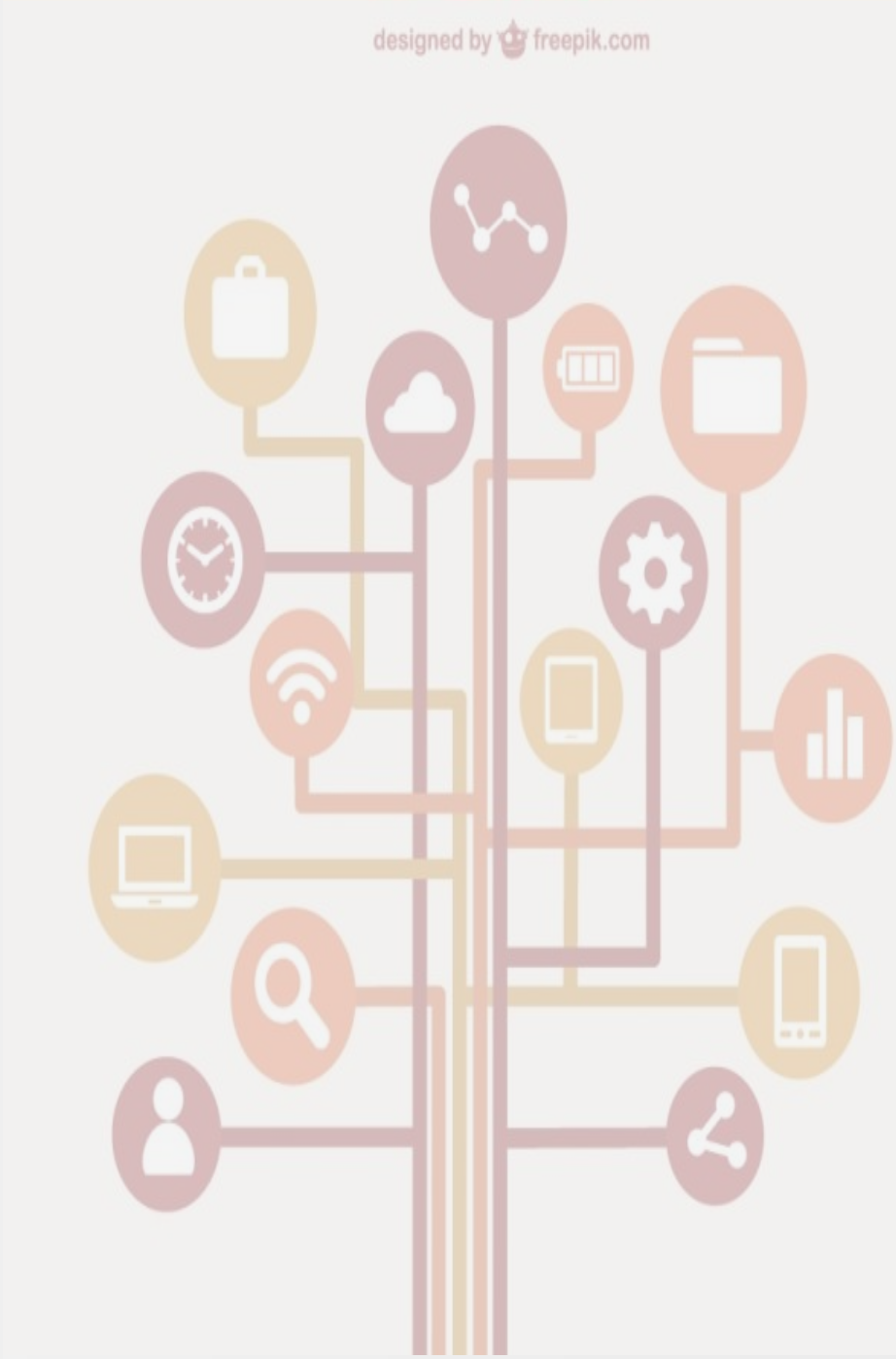
extendibility

practicability

novelty

quality criteria

intuitive understandability



Methodology

process model

goals

- e.g. to reach security, safety, ergonomics, quality levels

design primitives

- schema or design process 'molecules'

means for design product analysis

- e.g., reachability

Process Model Aspects

selection & instantiation of goal templates

complexity treatment

reuse of former design/development results

ensuring performance requirements, security

ensuring quality standards

controlled design document evolution, validation and verification

prototyping

Methodology

method style support

applicability

conclusiveness of process model steps
(intuitive, reasonable, convincing)

learnability of the process model

model management support: tool

Documentation

references

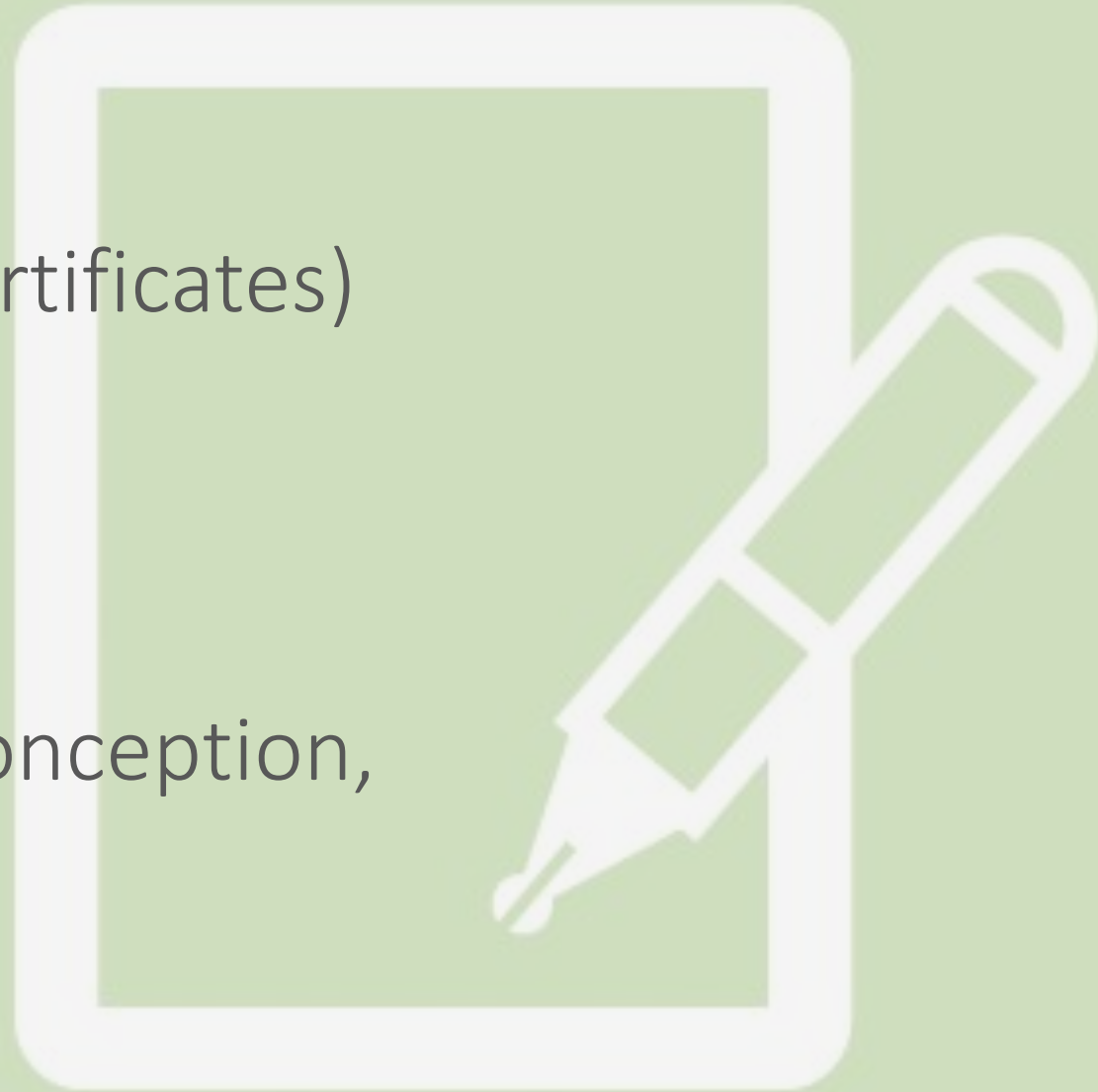
education (textbook, courses, certificates)

clearness

distinction from other DSMMs

tolerance against variations of conception, methodology, process model

description of the DSMM scope



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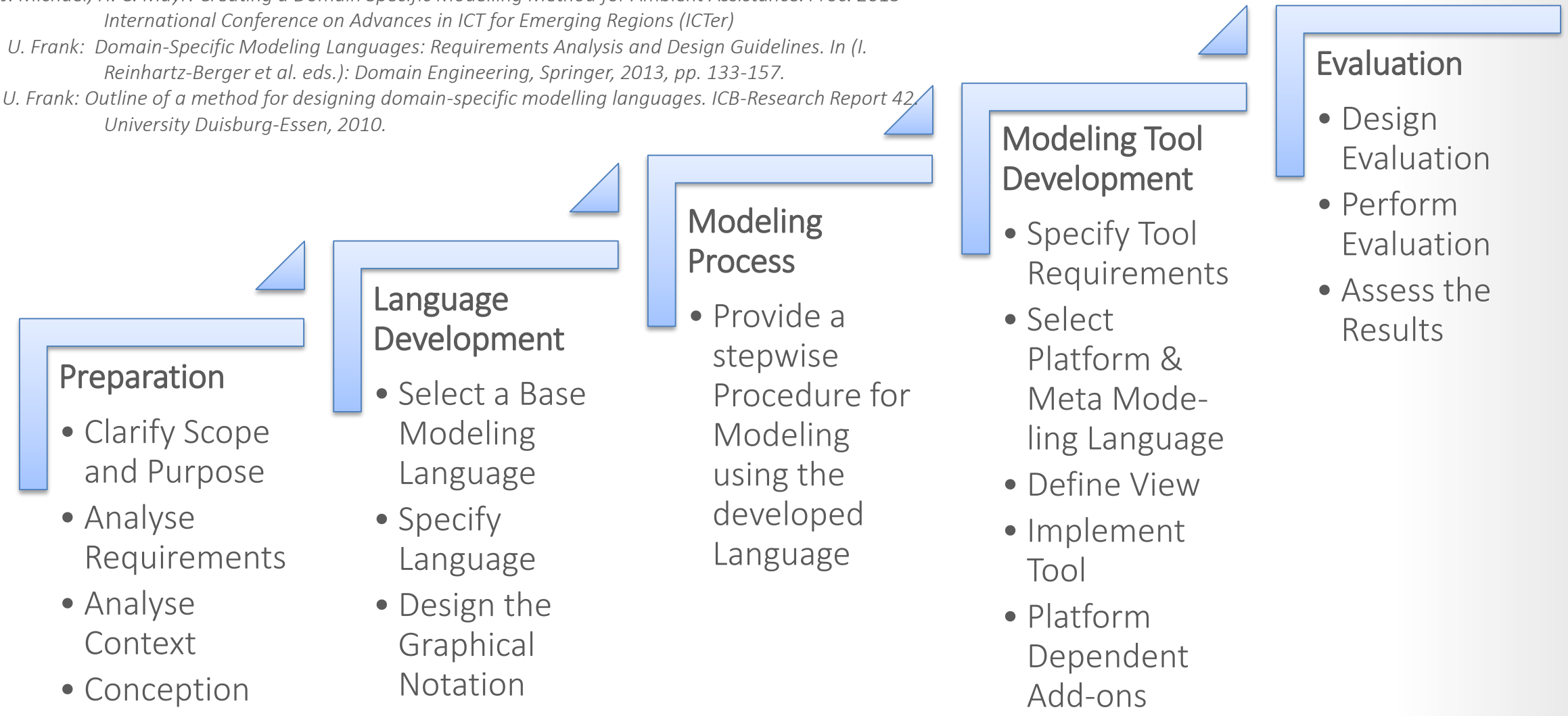


Example HCM-L: A Domain Specific Modeling Language for Ambient Assistance

HCM-L: Human Cognitive Modeling Language

Human Behavior Centered DSML

Reduced complexity: Small set of modeling notions

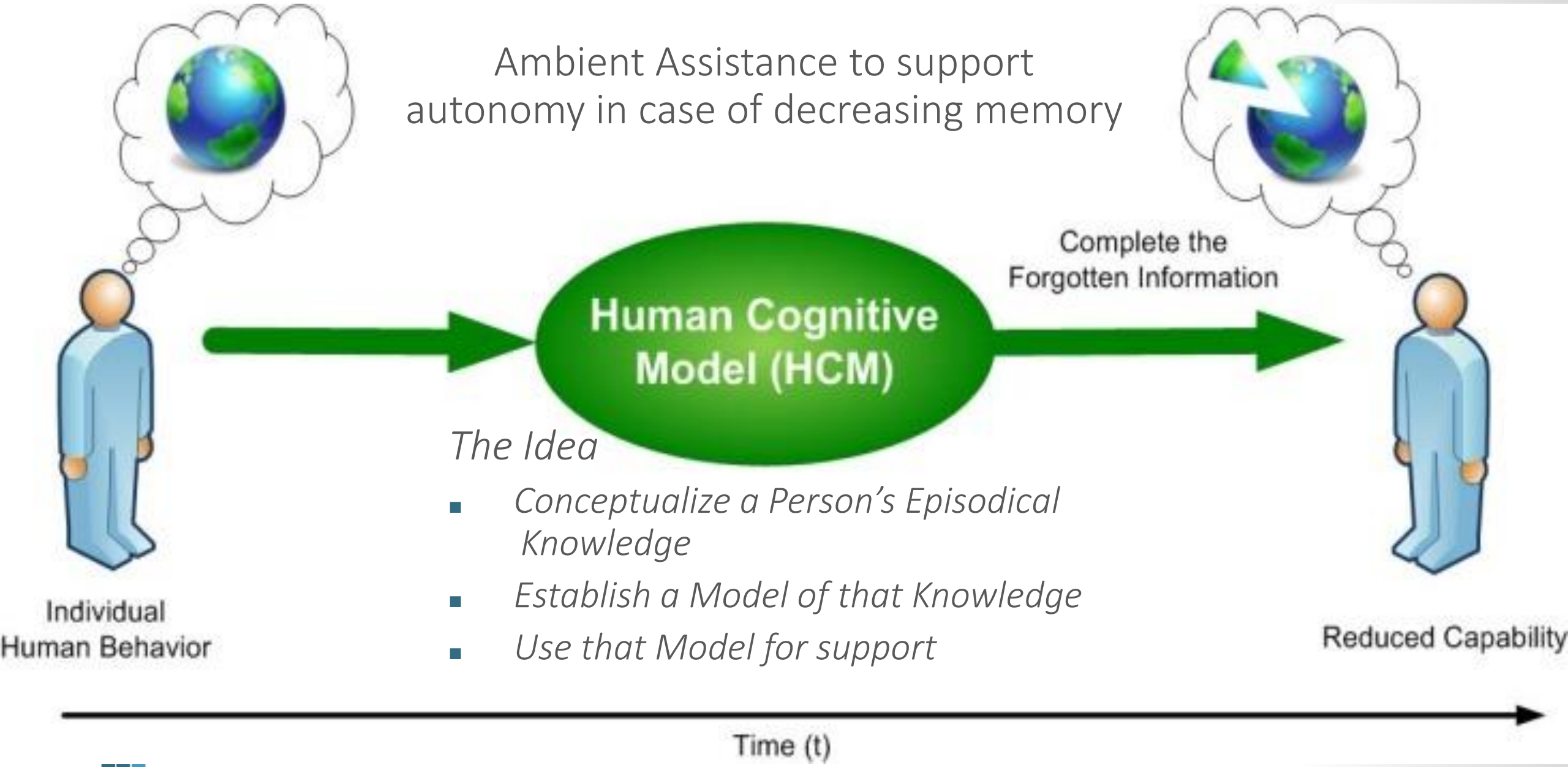
Representations aligned with Moody’s principles

Goal: Intuitive understandability for domain experts (caregivers, doctors)

Developed in the context of the HBMS project

HBMS: Human Behavior Monitoring and Support

Ambient Assistance to support autonomy in case of decreasing memory



The Idea

- *Conceptualize a Person's Episodical Knowledge*
- *Establish a Model of that Knowledge*
- *Use that Model for support*

Motivation

5 “Grand Challenges” of the European Union

Máire Geoghegan-Quinn, EU Commissioner for Research, Innovation and Science; http://www.research-europe.com/index.php/2011/08/595

- climate change, energy, food security, **health**

- ageing population

Population 60+	Europe	Austria	Carinthia
2050	ca. 30%	34,5%	38,8%

[Ref.: Statistik Austria]

→ increasing share of older persons

→ decreasing number of working people

→ increasing lack of care givers

→ **need of assistive systems**

Basic Domains for Assistive Systems

Basic Activities of Daily Living (ADL) [Katz]

- Bathing
- Dressing
- Toileting
- Transferring
- Continence
- Feeding

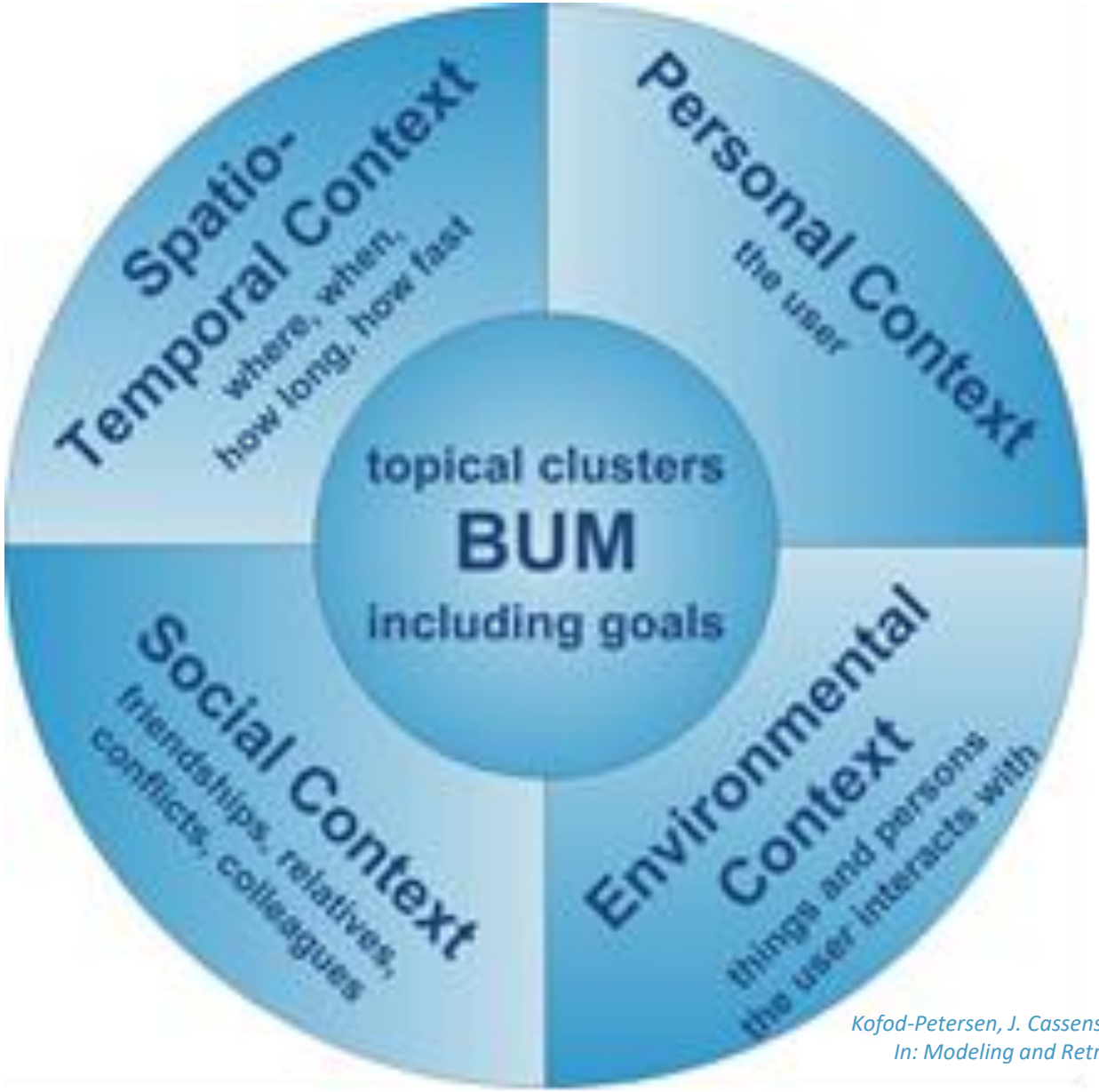
I

Instrumental Activities of Daily Living (IADL)

- Ability to use the phone
- Shopping
- Meal Preparation
- Homework
- Loundry
- Mobility
- Responsibility for taking medications
- Ability to manage finances

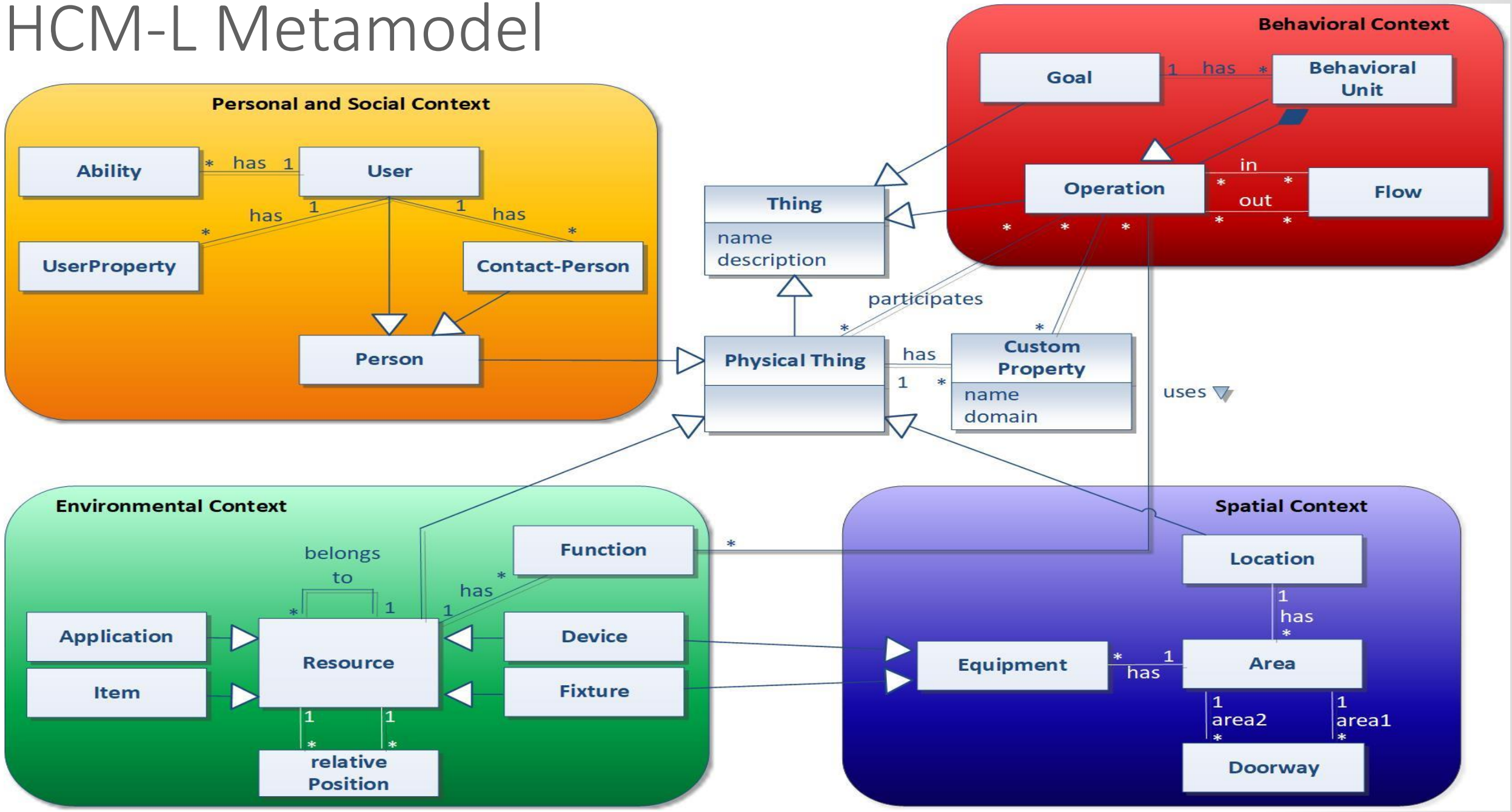
Lawton, M.P., and Brody, E.M. "Assessment of older people: Self-maintaining and instrumental activities of daily living." Gerontologist 9:179-186, 1969. http://son.uth.tmc.edu/coa/FDGN_1/RESOURCES/ADLandIADL.pdf]

Contexts to be considered

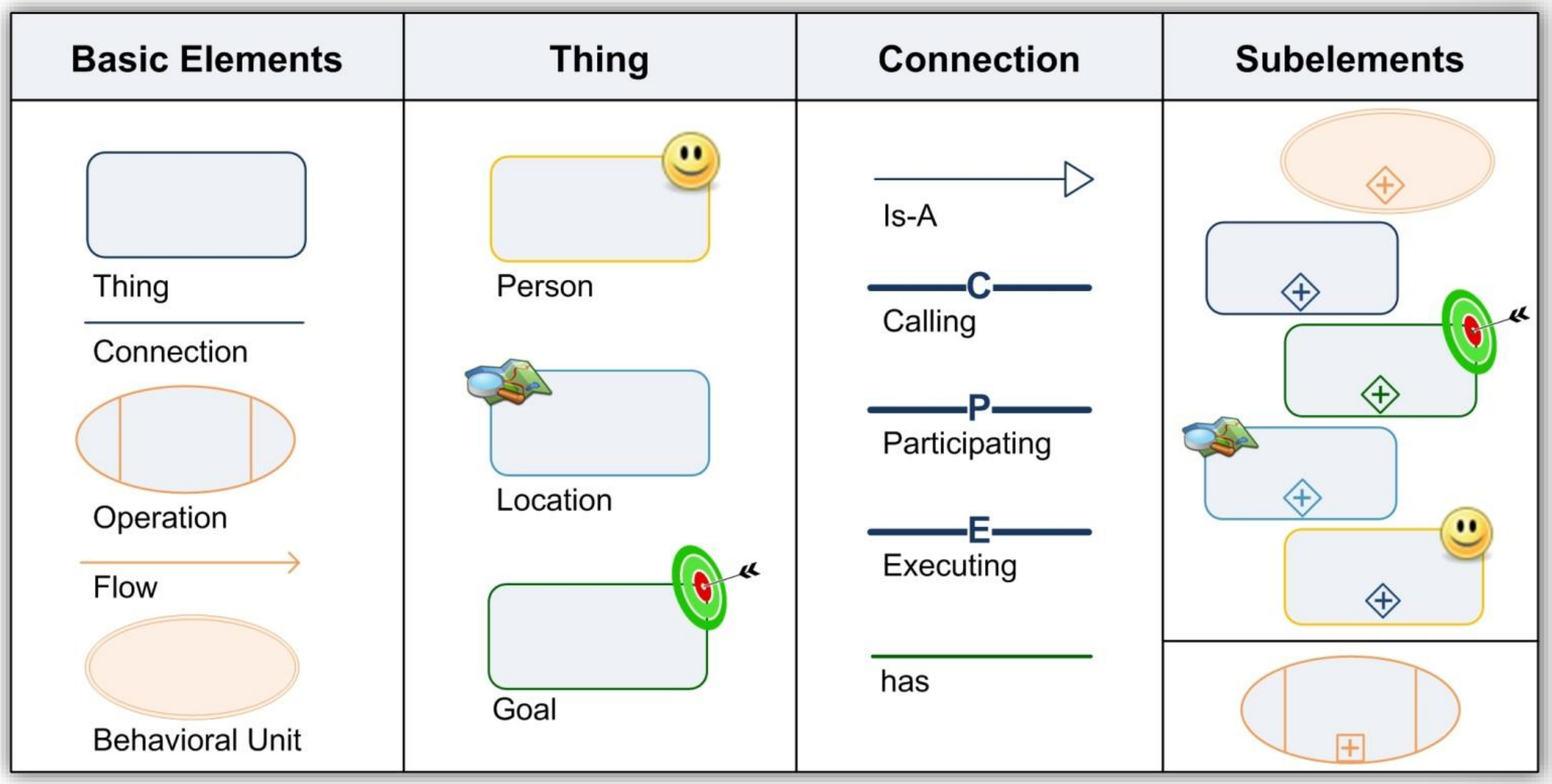


Kofod-Petersen, J. Cassens: Using Activity Theory to Model Context Awareness. In: Modeling and Retrieval of Context, Springer LNCS 3946, 2006, pp 1–17.

HCM-L Metamodel

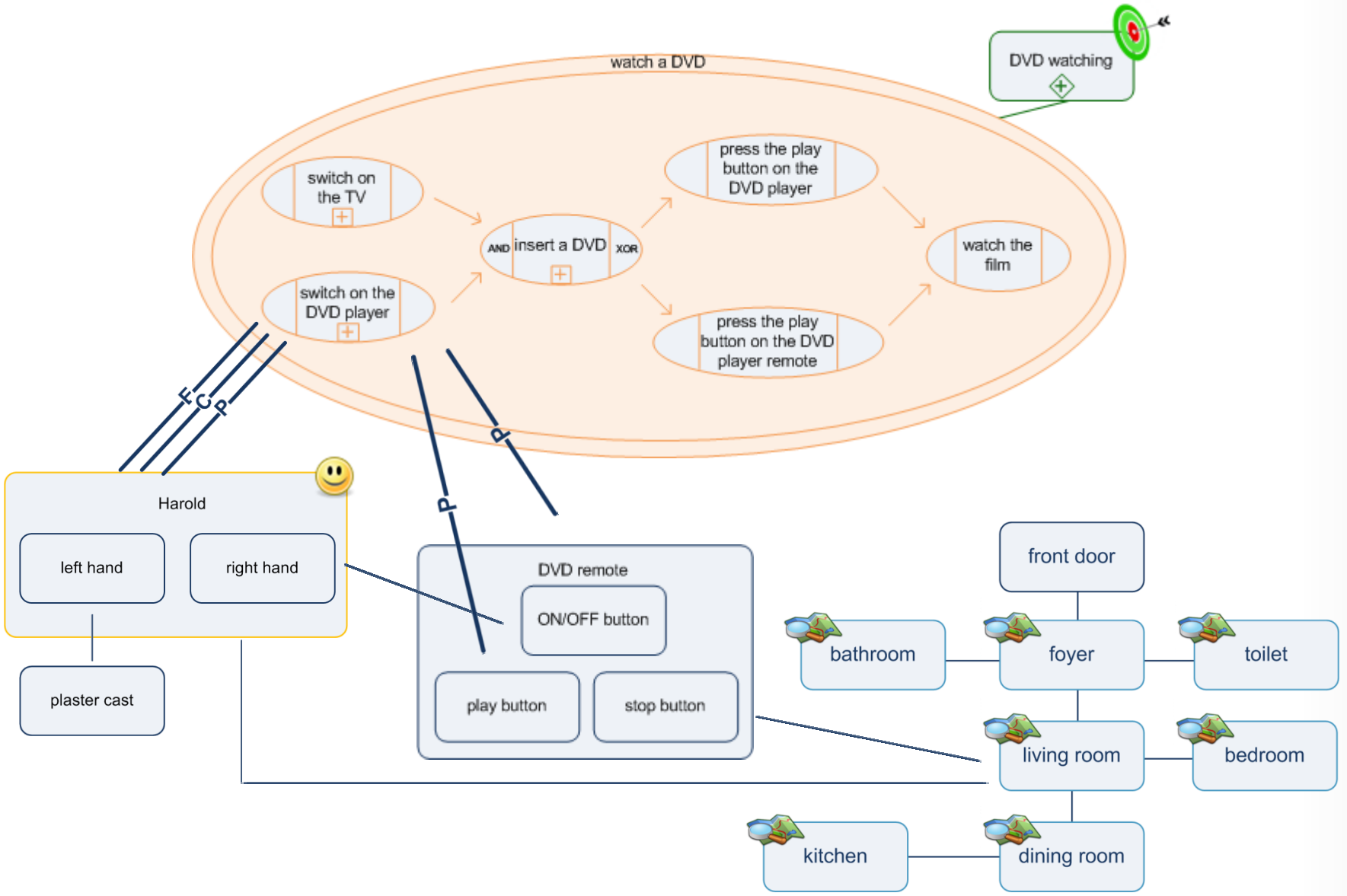


HCM-L Elements

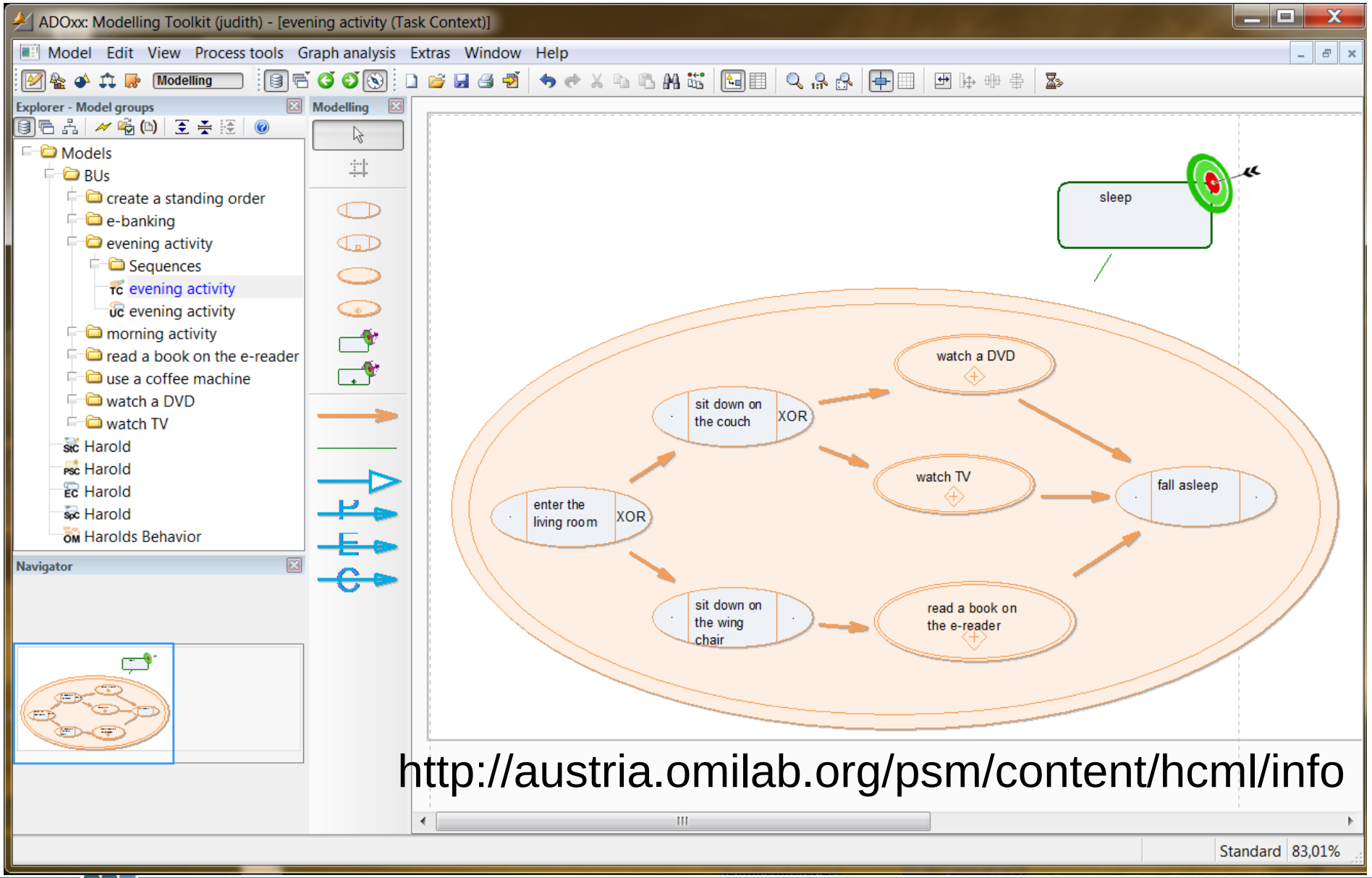


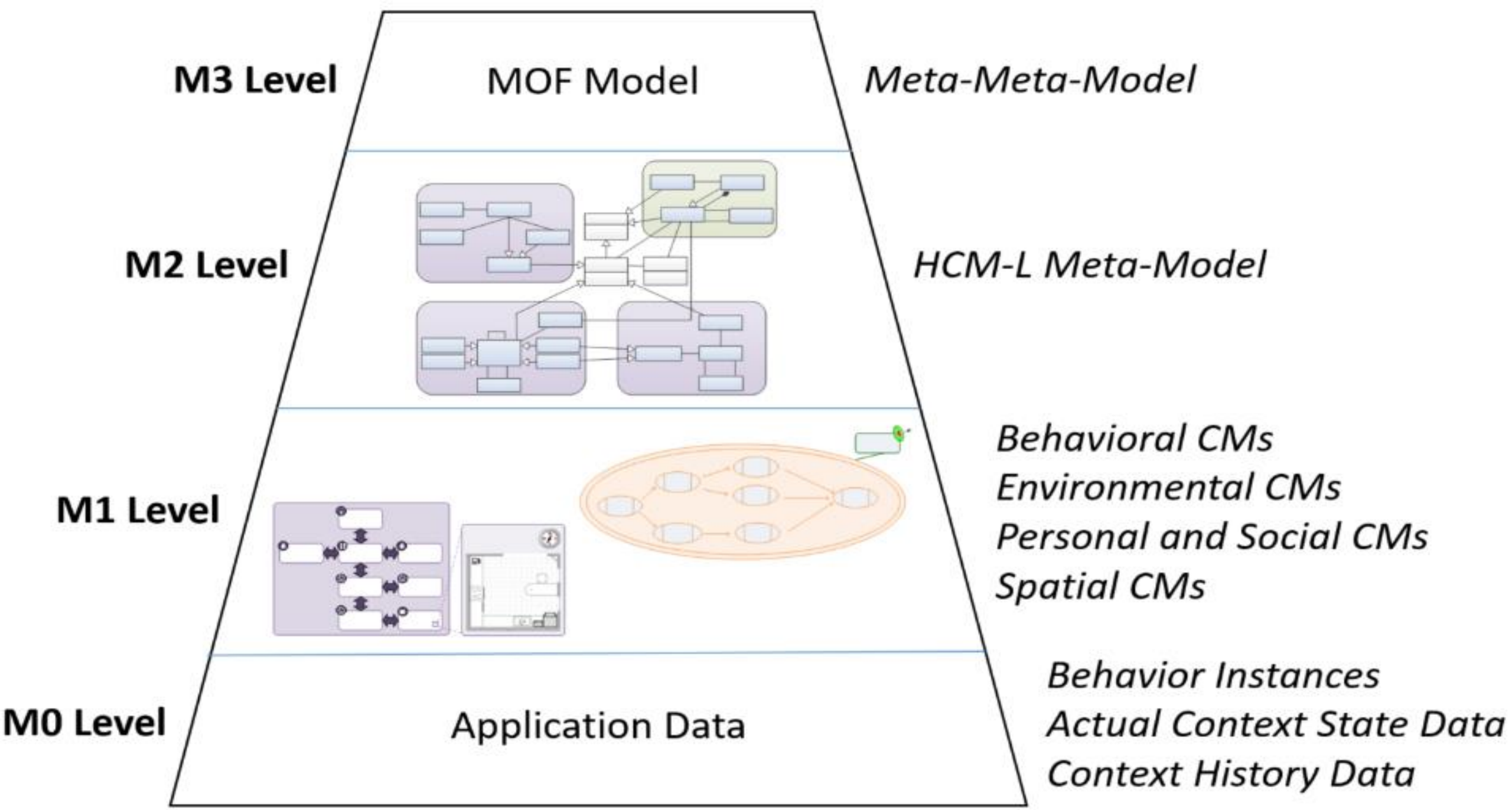
Moody, D.: The "Physics" of Notations: Toward a Scientific Basis for Constructing Visual Notations in Software Engineering. IEEE Trans. Software Eng. 35, 756-779 (2009)

Model Example

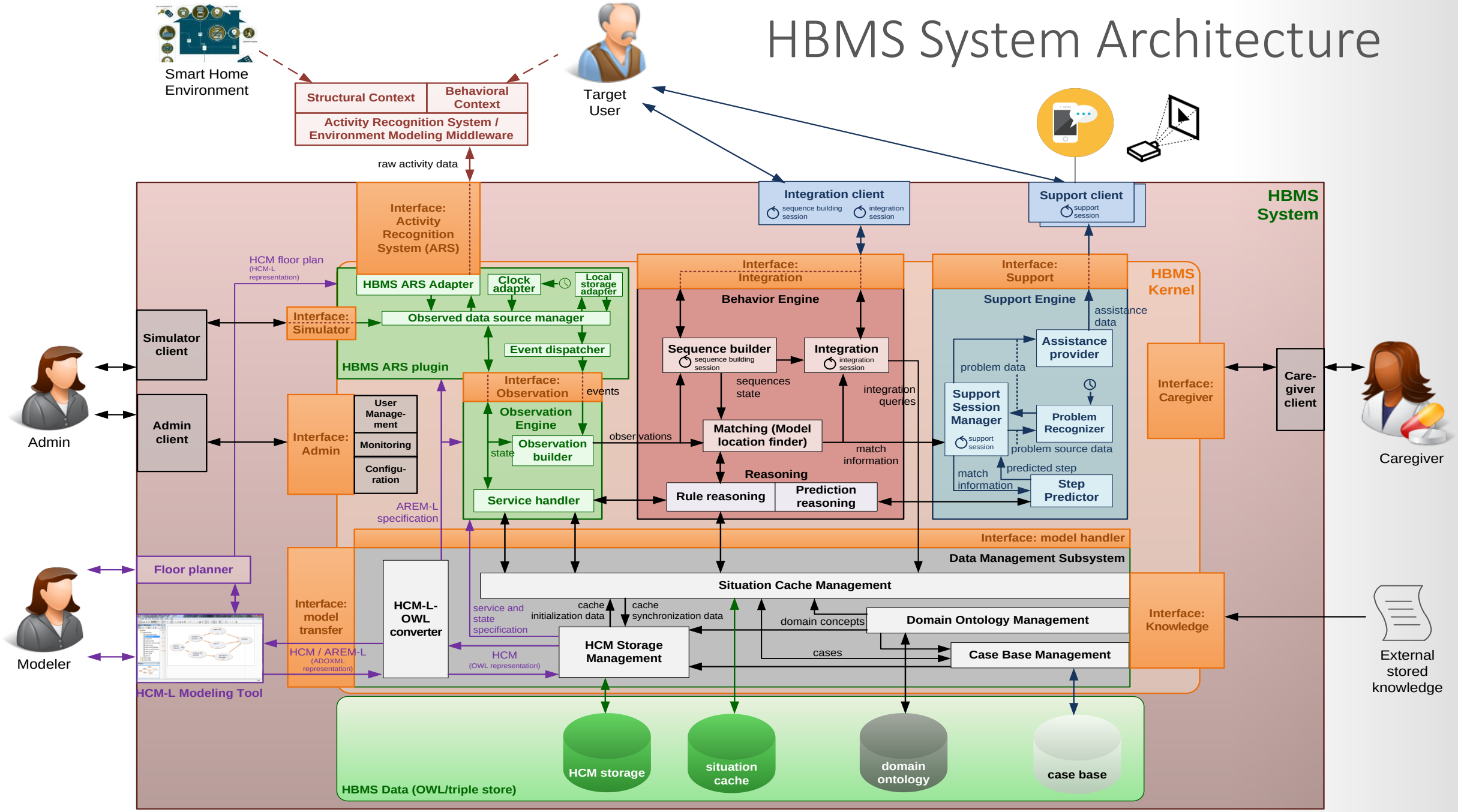


HCM-L Modeler

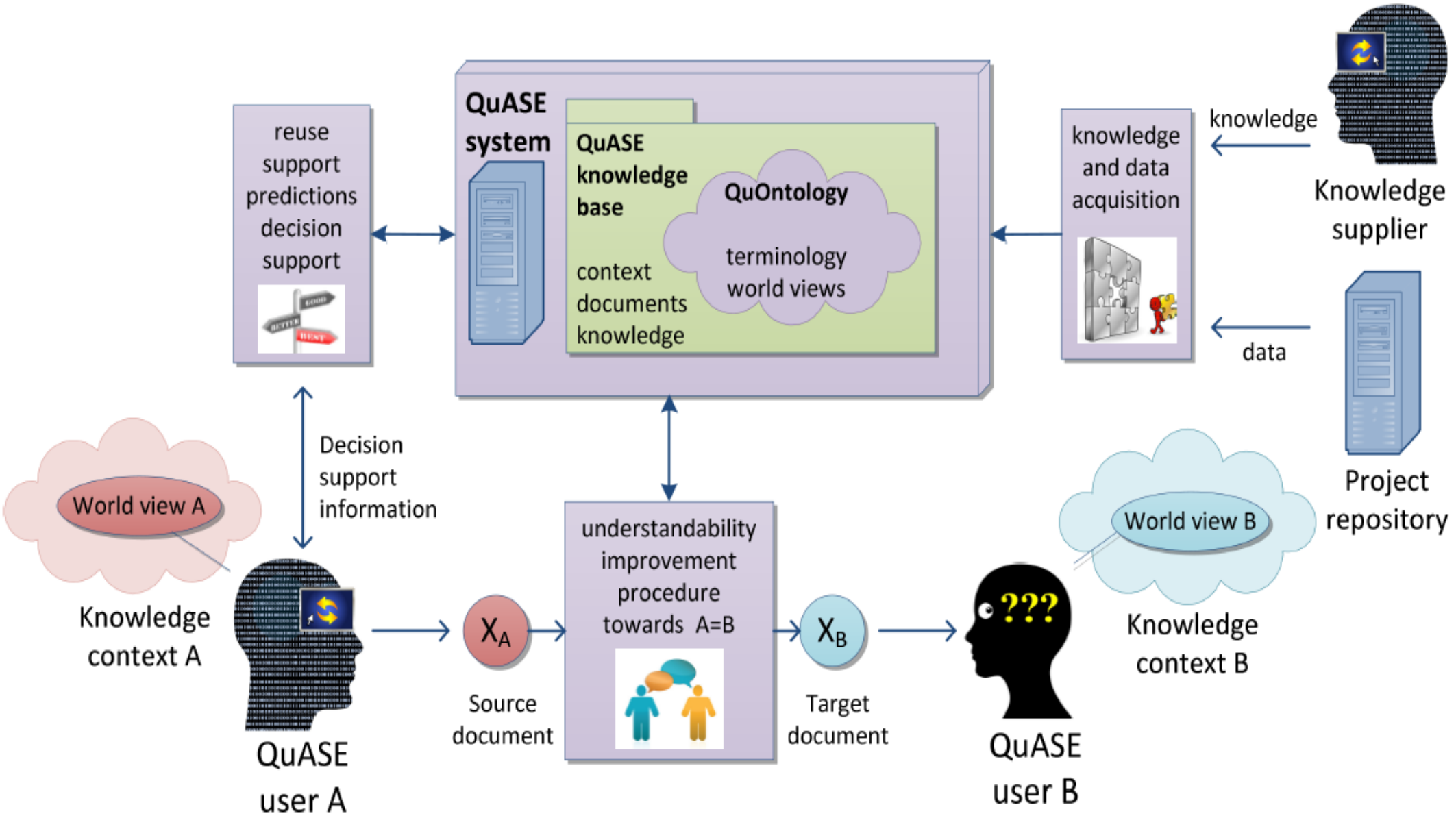



M3 Level
MOF Model
Meta-Meta-Model
M2 Level
HCM-L Meta-Model
M1 Level
Behavioral CMs
Environmental CMs
Personal and Social CMs
Spatial CMs
M0 Level
Application Data
Behavior Instances
Actual Context State Data
Context History Data

HBMS System Architecture



Current Research: Quality Aware Software Engineering



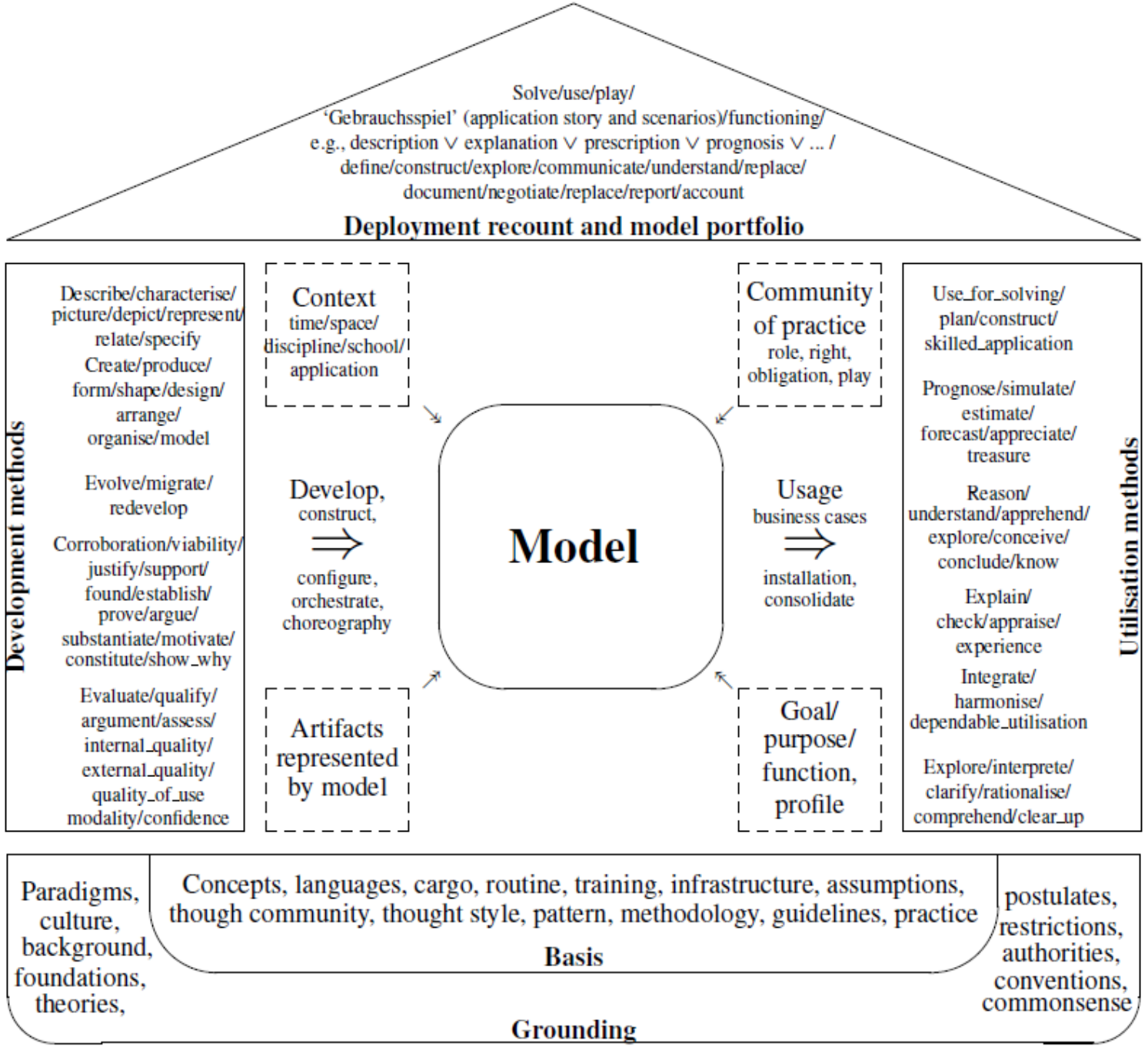


Figure 5: Facets of the model with grounding and basis as the fundament,withfour governing directives,with technical and technological pillars for development and utilisation, and with the application roof

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HBMS papers

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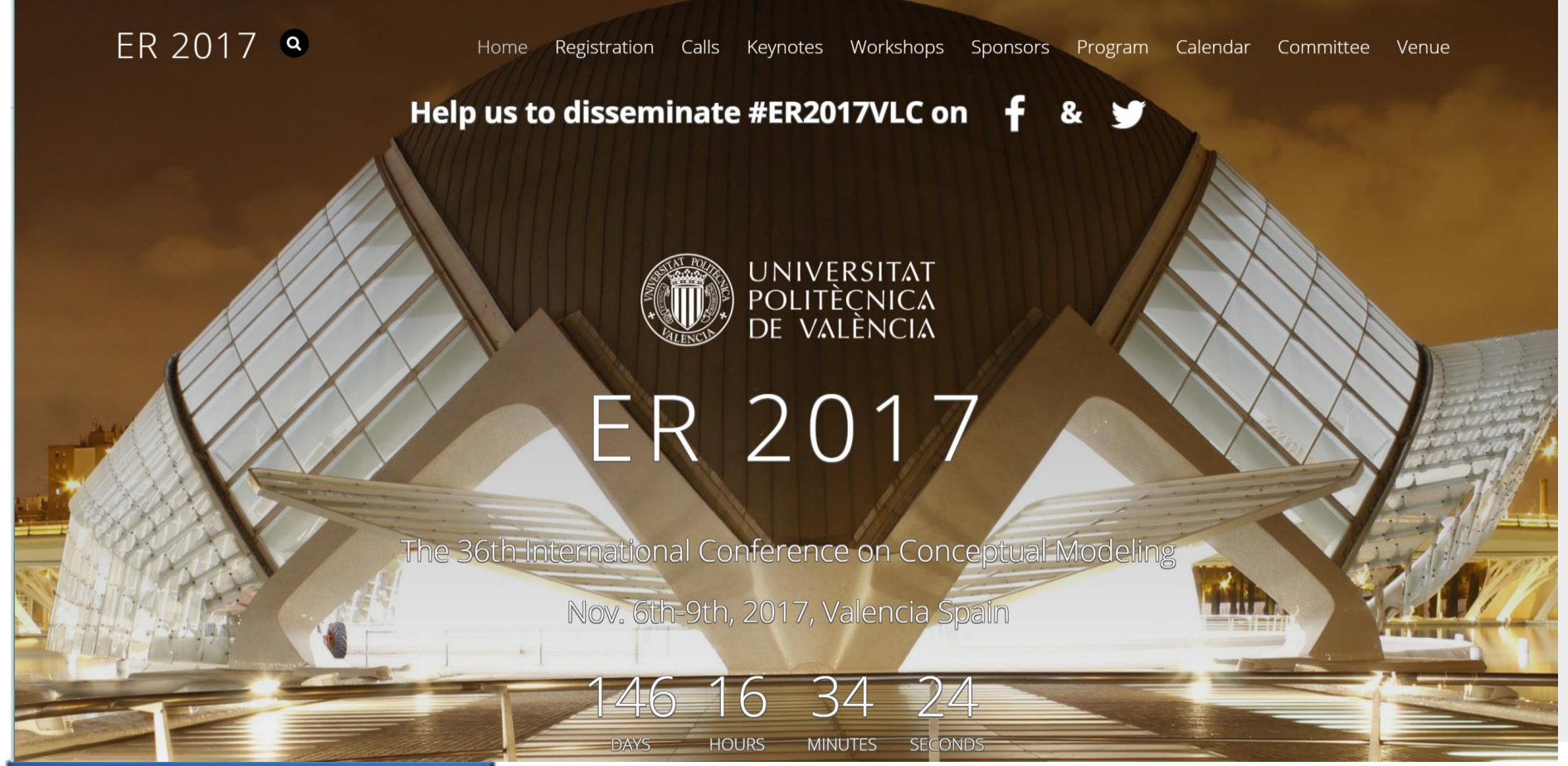
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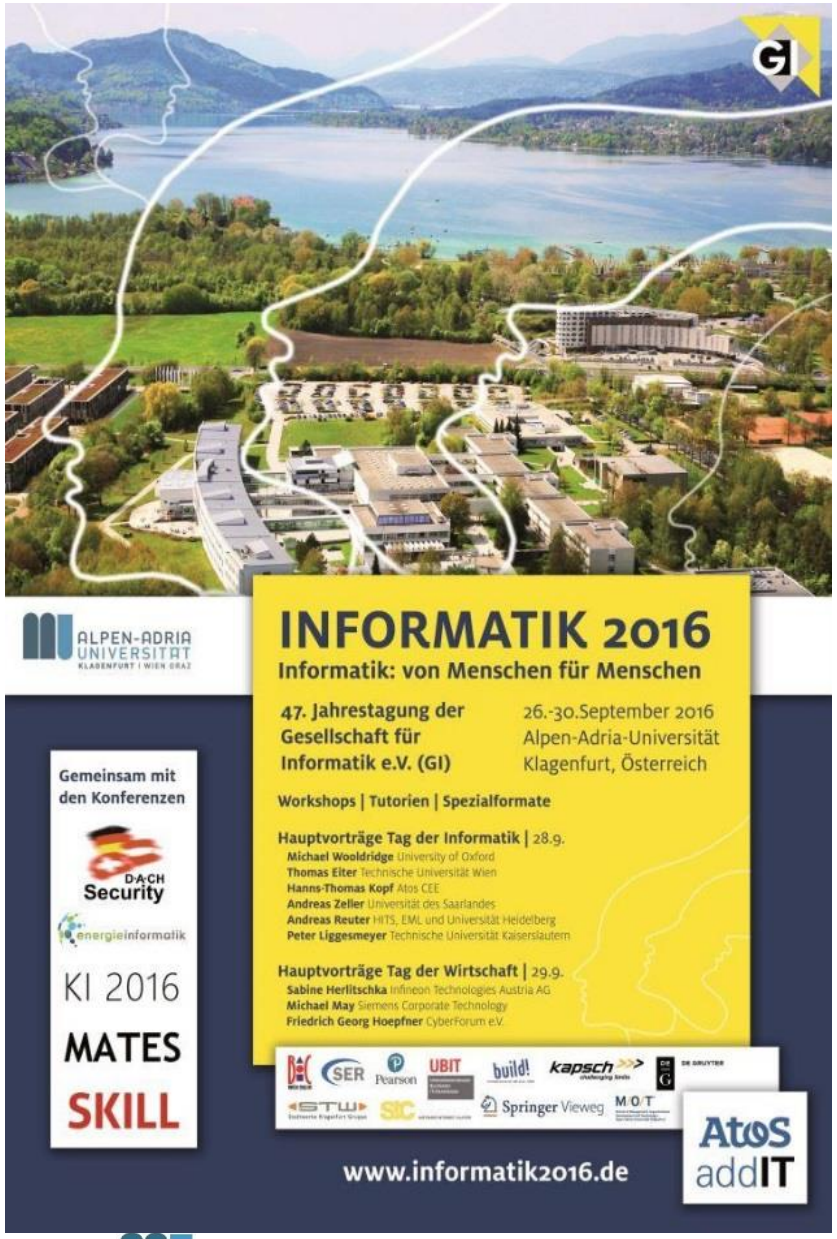
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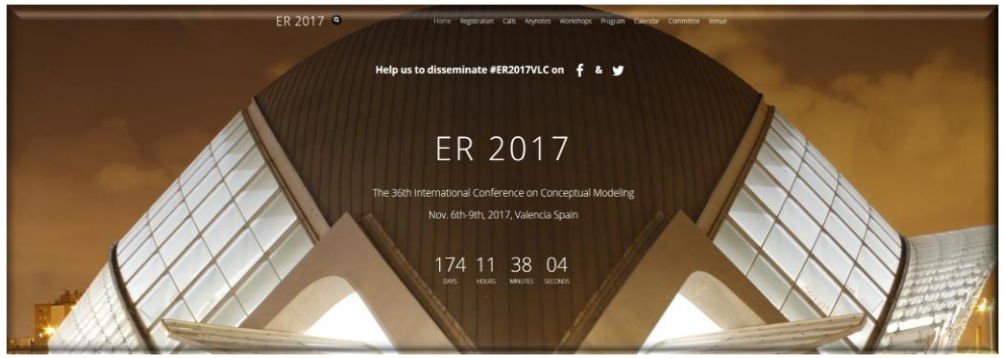
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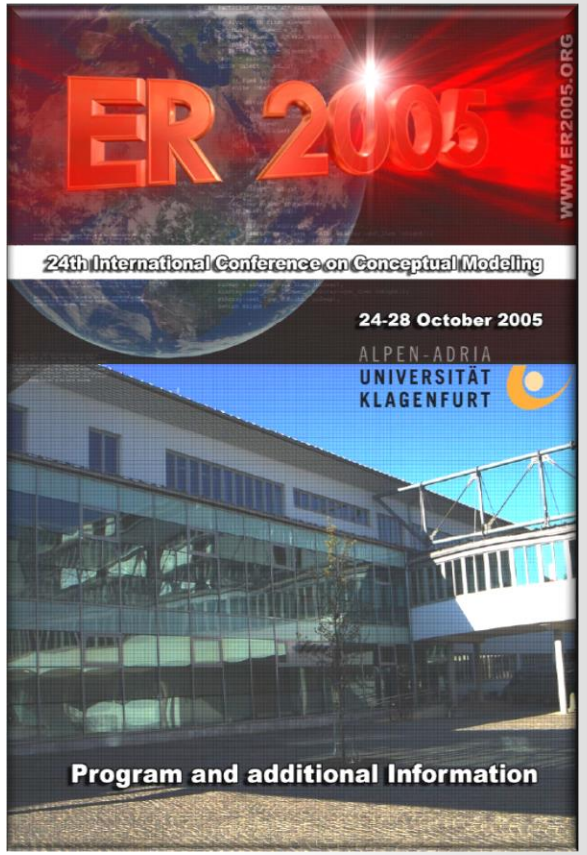
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32 Einheiten — Introduction, Fundamentals
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- Scientific Writing

80 Einheiten — Strategic Management
- Introduction to Strategic Management
- Business Models, Service Level Agreements, Delivery Concepts and IT-Strategy Alignment
- Internal and External Strategic Analysis (SWOT)
- IT Governance and Certificates

88 Einheiten — Operational IT Management
- IT Controlling and IT Benchmarking
- Operational Management 1: IT Cost Accounting
- Operational Management 2: Managing Cost and Success
- Strategic IT-Management

96 Einheiten — Software and Data Management
- IT in Business Processes
- Enterprise Architecture Management and Virtualization
- IT Security and Security Policies, Cryptology and Authentication
- Software Development Processes

112 Einheiten — Technology
- Data Management
- IT Networks and Network Technologies
- Web- and Web-2.0-Technologies
- Workplace Technologies
- Tools and Automation

48 Einheiten — IT Law
- IT Law Overview, Standards, Certificates and Related Areas
- IT Contract Law, Copyright Law, Privacy
- Procurement Law and Tendering

48 Einheiten — IT Business Consulting
- Introduction into Consultative Selling
- Sales and Bid Processes

96 Einheiten — Project, Change and Personal Management
- Project Management According to PMA/IPMA
- Change Management in the context of IT-Systems Implementation
- Competence Development and Time Management
- Team Development

Abschluss — Master Thesis

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- *oder per Email:* heinrich.mayr@aau.at

Danach laden wir Sie zu einem persönlichen Gespräch ein und klären die Details.
Wir freuen uns auf Sie!

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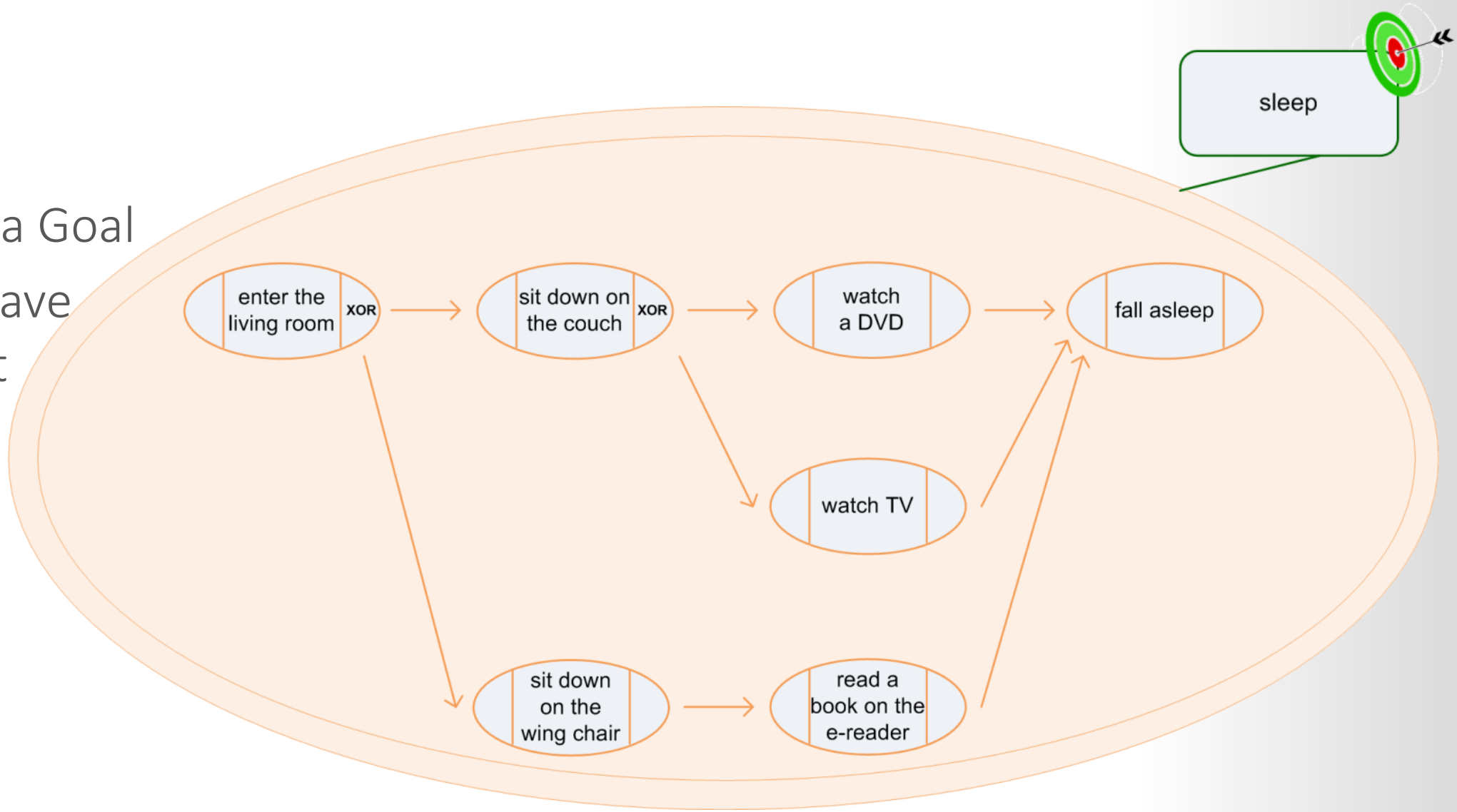
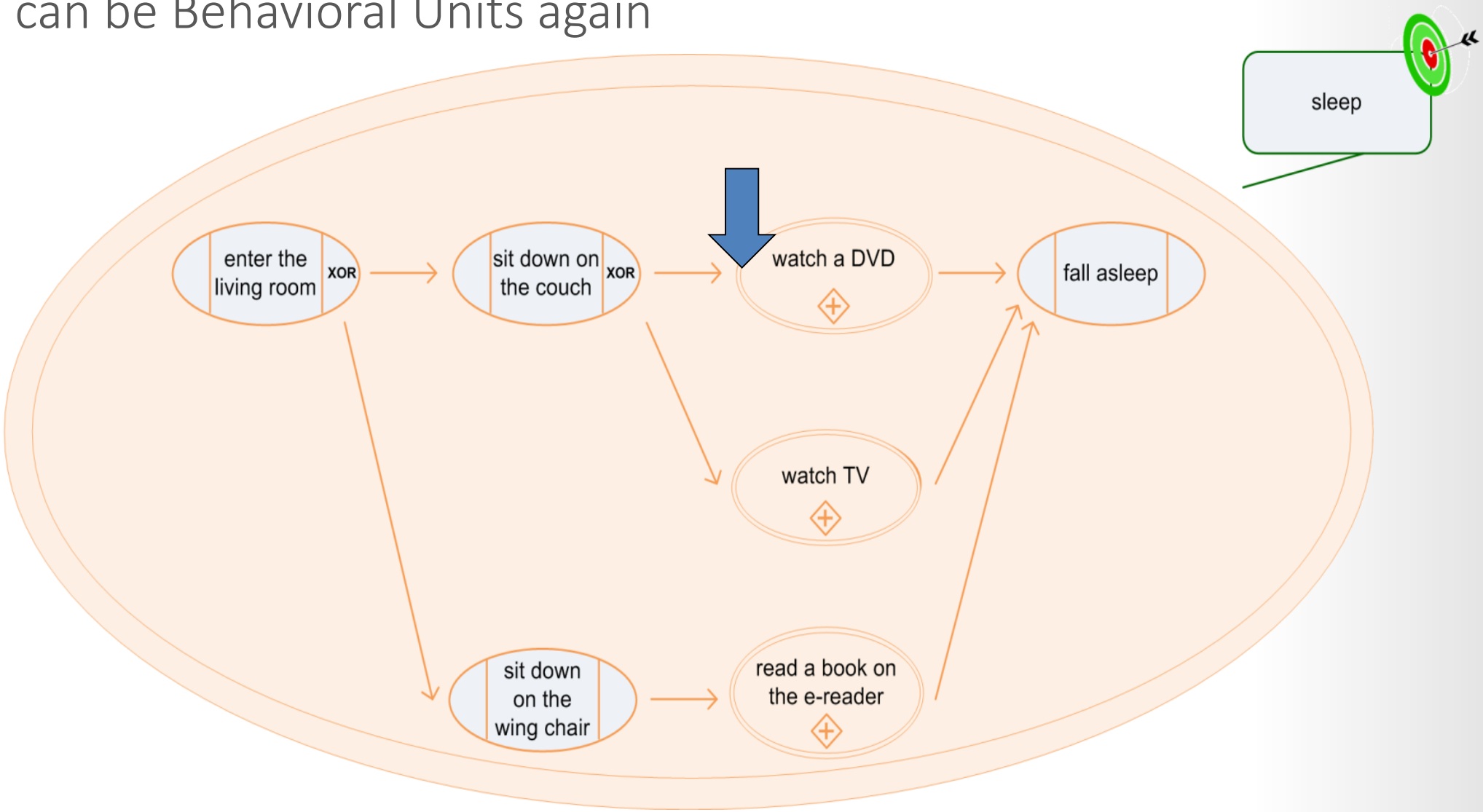
Behavioral Unit

- Aggregate of connected Operations
- Is to achieve a Goal
- Operations have pre- and post conditions

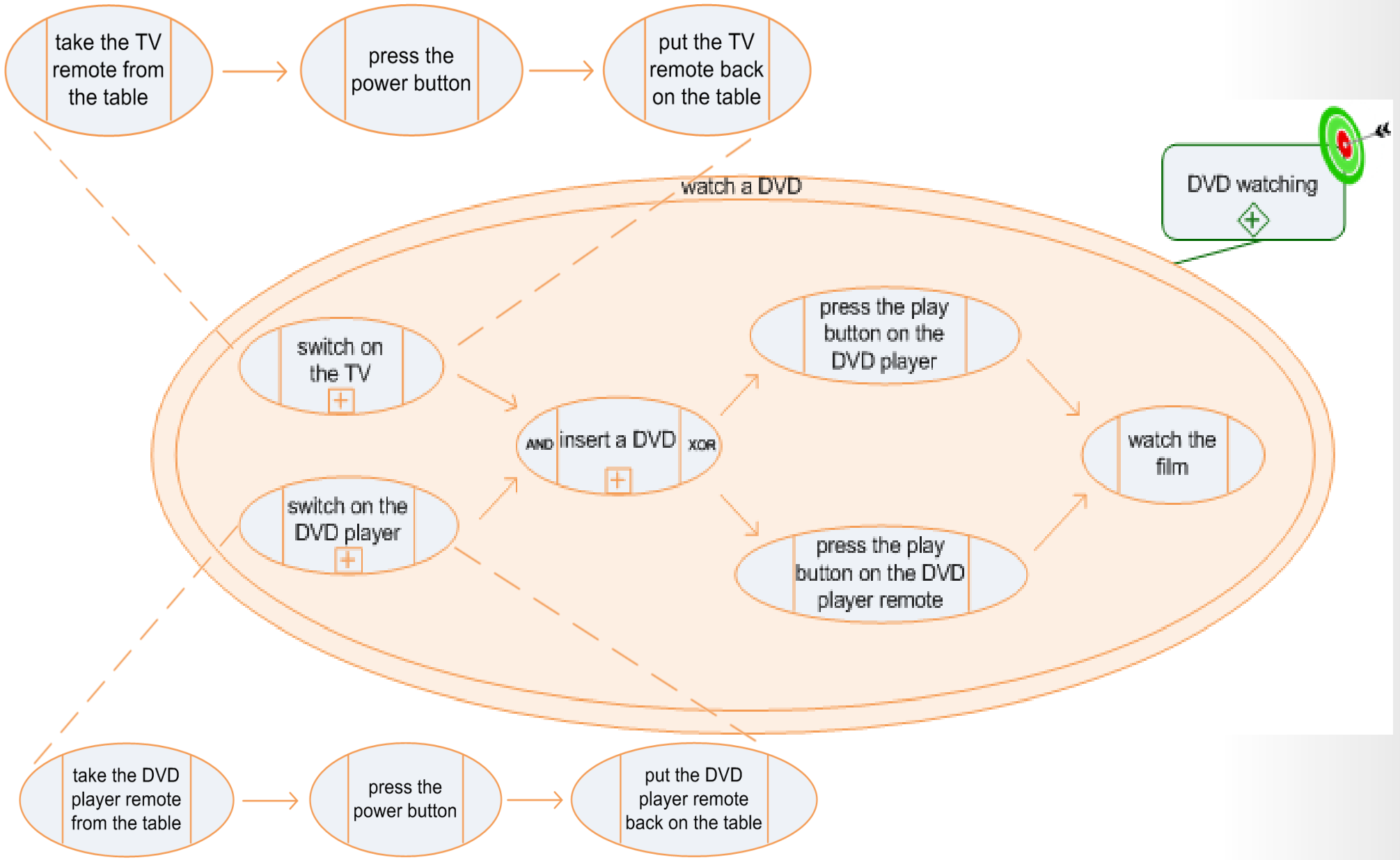


BU Refinement

Operations can be Behavioral Units again



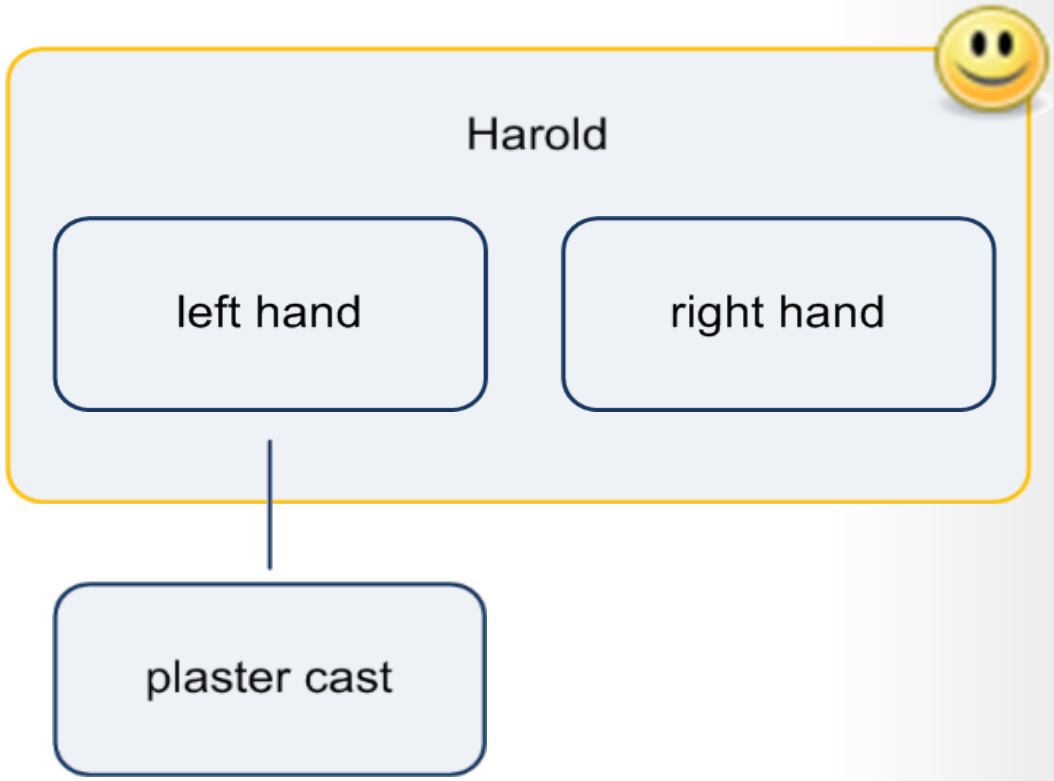
Operation Macros

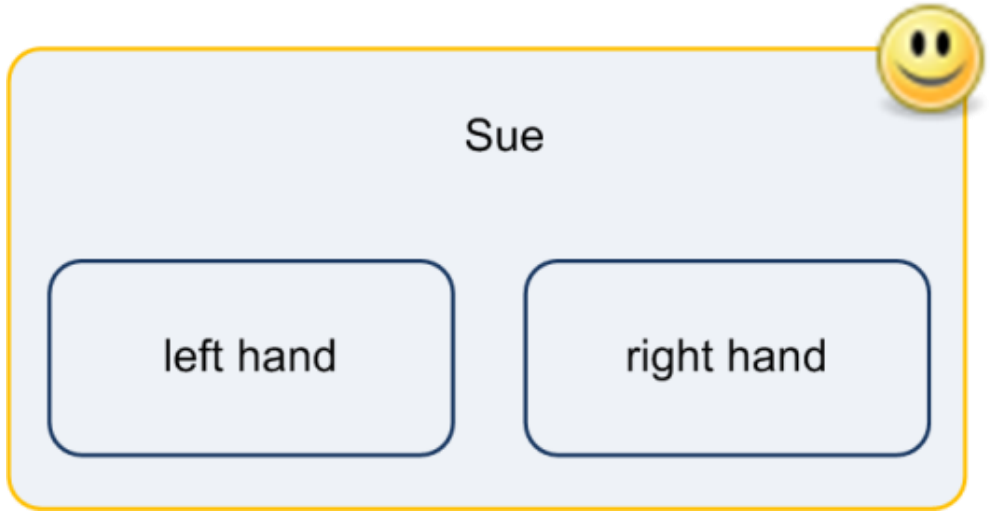


Personal & Social Context

- Person & Things

  Things can be part-of a person
- Connections between Things
- Social environment





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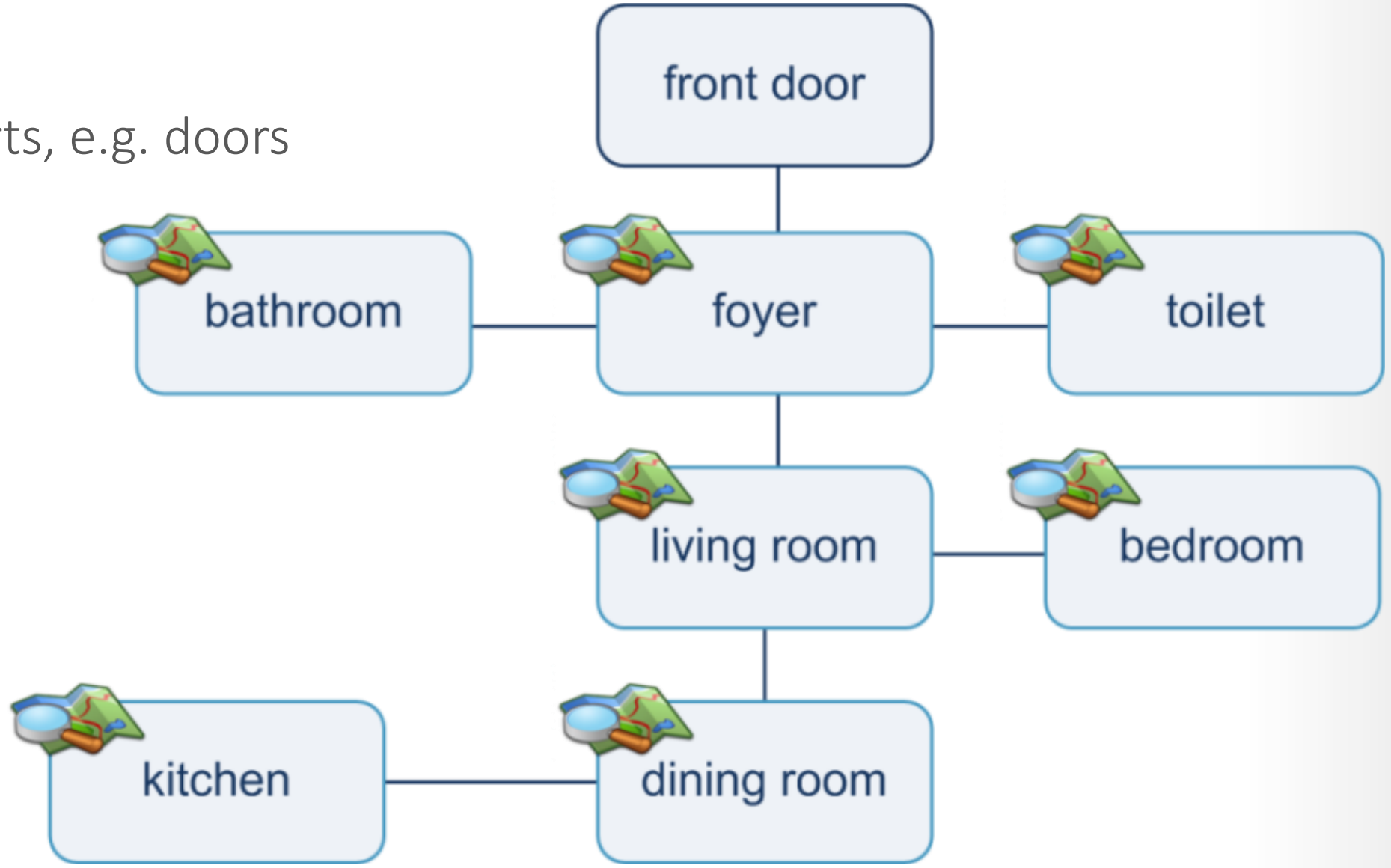
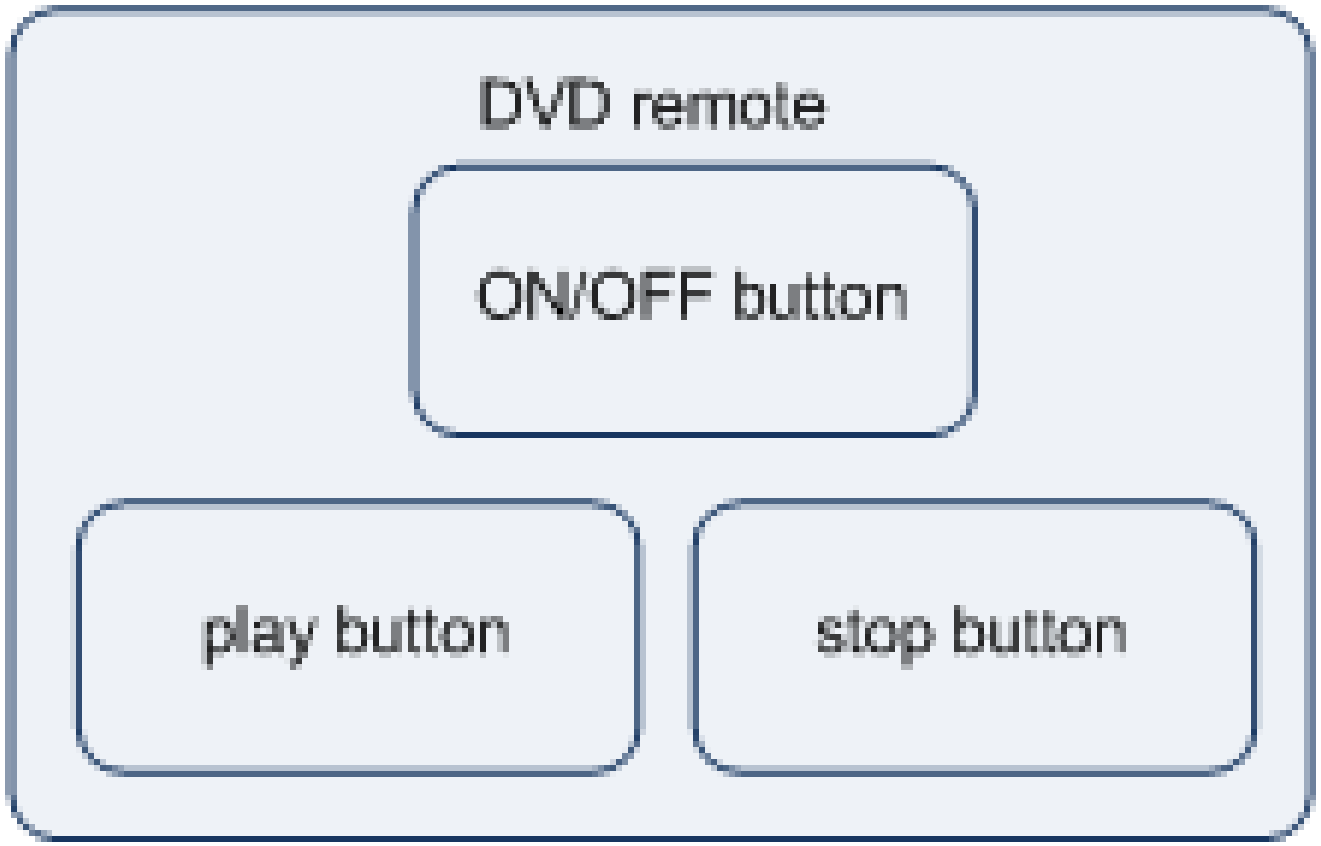
Spatial Context

- Locations
- Stable parts, e.g. doors

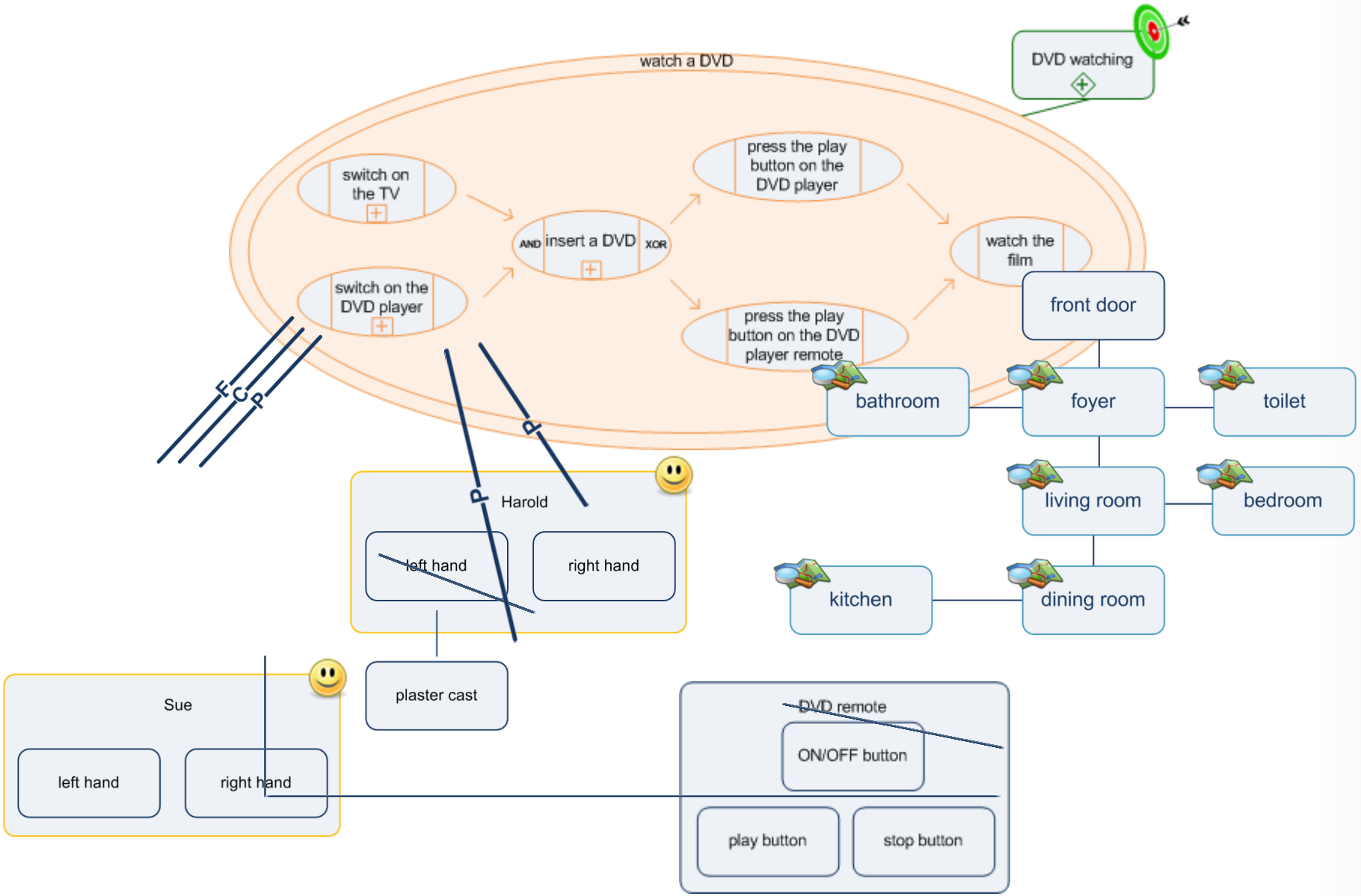


Environmental Context

- All Relevant Things
  - Take Part in Operations
  - Resources
- Connections
- Properties

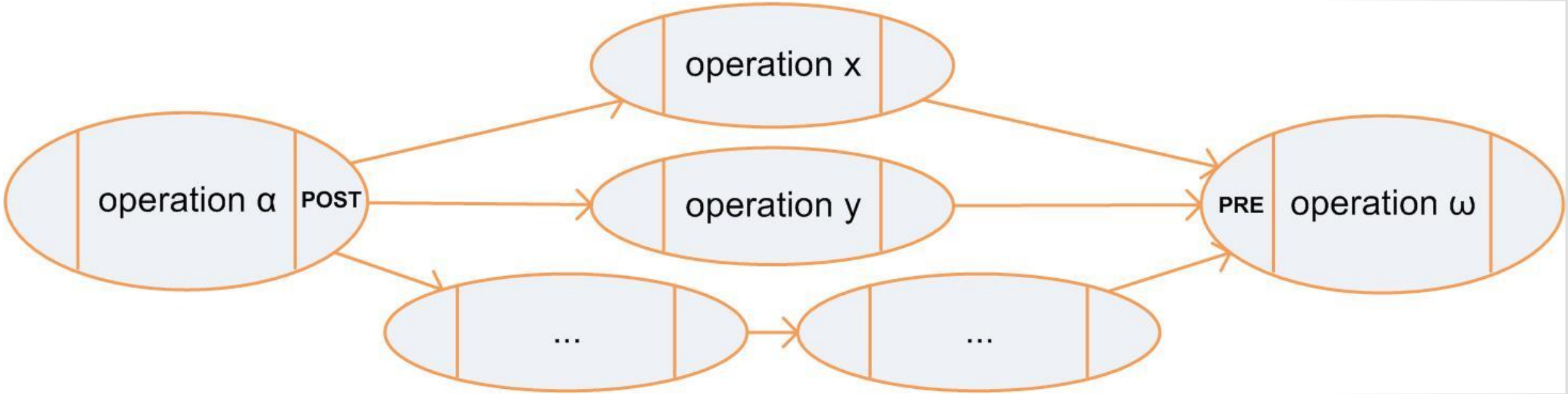


User Context



Textual Notations

- Conditions
- Pre-Condition
- Post-Condition
- Instructions of Operations



Conditions

Logical expressions that refer to (combinations of)

- (values of) properties of things and connections
- time points, time intervals
- operations

Simplified grammar:

<condition> ::= <reference.value> <relop> <value> |
<element> <elop> <element> | <element> <elop> <value>
<condition> {AND,OR, XOR} <condition> |
NOT <condition>

<reference.value> ::= <element.property> | <timefunc>

<relop> ::= <, <=, =, <>, >=, >

<elop> ::= is-in, is-at, is-on, is-under, …

<timefunc> ::= getTIME, getDAY, getMONTH, getYEAR …

Examples

Harold.status <> ‚sleep‘

kitchen.temp >= 20 AND window.state= ‚closed‘
AND getTIME <= 14.00.00

Harold is-in ‚kitchen‘ OR Harold is-at (40.75,73.97,12.00)

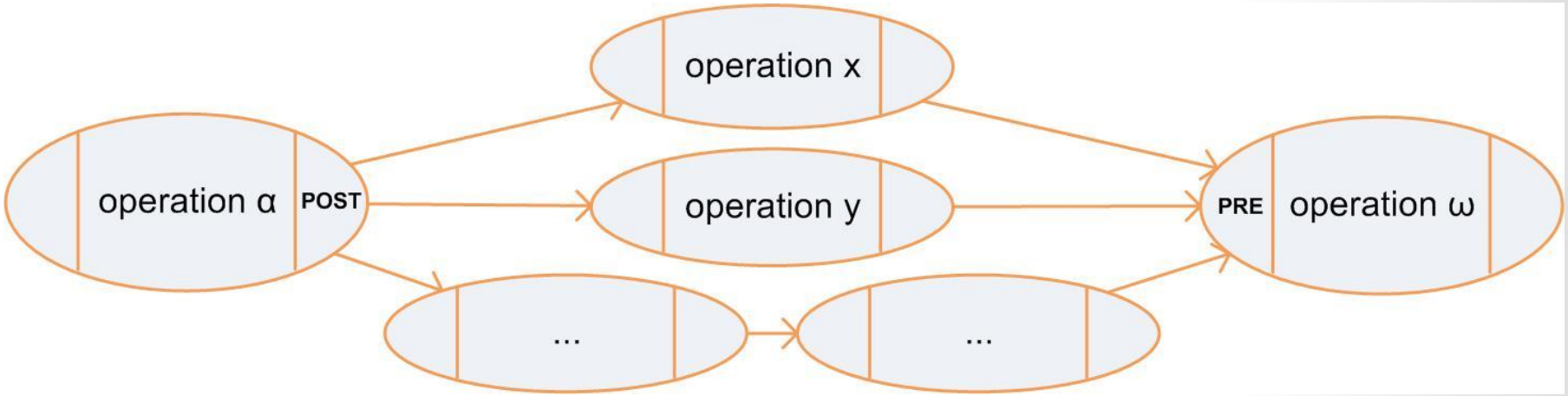
Pre-Condition

<pre-condition> ::= <condition> | <preexp> |

<preexpr> {AND | OR | XOR} condition | NULL

<preexp> :: predecessor {=|<>} <operation> |

{AND | XOR | SOR} (<preexp>, <preexp>)



Examples

predecessor =‘watch a DVD’

AND (predecessor = ‚switch on the TV‘, predecessor = ‚switch on the DVDplayer‘) AND Harold is-in ‚dining-room‘

SOR

Special operator SOR („sychronized OR“)

Execute the operation if

waitfor { n | ALL | list_of <operation>} preceeding operations are finished

Example:

SOR „write mail“ waitfor 1

Post-Conditions

reference to subsequent operations

define, which successor operation(s) is/are executed next based on conditions related to the execution of the given operation

Instructions

Procedure to be executed

Statements

Add (Thing x, Connectionname, Thing y)

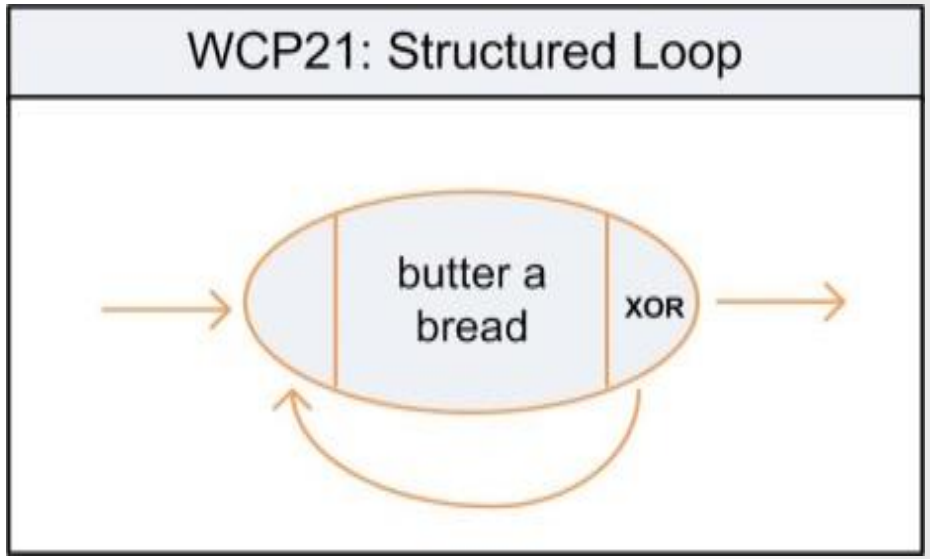
Remove (Thing x, Connectionname, Thing y)

Thing Name.Property Name = new Value

If (condition) then [] else [];

Loops

Graphical language level



Reasoning for Support

based on Answer Set Programming (ASP)

- stable model (answer set) semantics of logic programming
- oriented towards (primarily NP-hard) search problems
- time: extensional predicate with a finite domain
- optimization: via minimization and maximization
- adding a constraint A to a logic program P: eliminates the models that violate A from the set of models of P

Obtained Results

- Clingo Solver
- pITX-SP 1.6 plus board (1.6 GHz Atom Z530 and 2GB RAM)
- Number of facts: 10, 30 and 40 facts (max 8 possible choices)
- Execution time in average: 0.4-0.6 Seconds

$\Rightarrow$ **fits for ambient assistance purposes**

Current Project Activities

- Connection to Activity Recognition Systems
  - Transformation of ARS Output into HBMA Input
  - Evaluation of bidirectional benefits
- Integration of ARS ourput into the HCM
- HCM-L: Specification of the textual language parts
- Model visualization
- Multimodal support

Todo‘s

Reasoning for identifying and comparing goals Semantic Analysis:

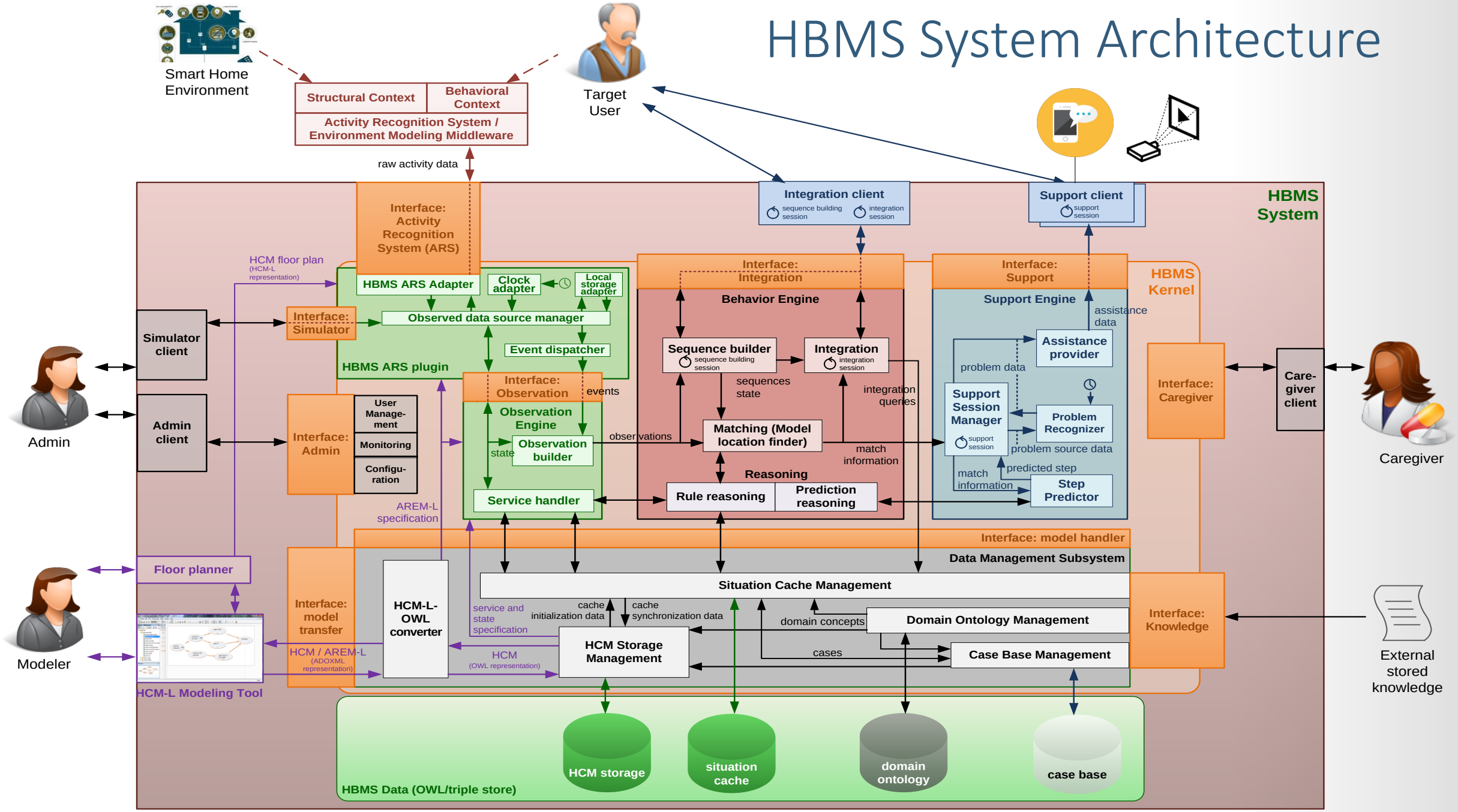
- Uniqueness
- Completeness: A model should describe all intended aspects of ist scope and nothing else

⇒ Semantic Model Checking

⇒ HCM cross checking (all behavioral units)

⇒ „Inconsistency“??

HBMS System Architecture



Traditional Generic Modeling Languages

+ versatility in arbitrary domains
+ broad body of experience and knowledge from intensive use and research
- “law of logistic growth”
- complexity and lack of concept orthogonality corrupts transparency
- hardly manageable for practical use
- misunderstandings and user demotivation