



MODELING UNCERTAINTY IN COMPLEX SOFTWARE SYSTEMS TO SUPPORT TESTING (U-TEST PROJECT)

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www.u-test.eu



OVERALL CONSORTIUM

Research Partners

[**simula** . research laboratory]
- by thinking constantly about it



Test Bed Provider



Case Study Providers



Exploitation



Tool Vendors



Dissemination/ Administration/ Financial



U-TEST

- **Objective:** Improve the dependability by Cost-Effective Uncertainty testing
- **Means:** Model-based and Search-based Testing
- **Objective will be achieved by:**
 - Uncertainty Taxonomy
 - Holistic Modeling and Testing Frameworks
 - Standards

TESTING CPS UNDER UNCERTAINTY

- Motivation

- ✓ Uncertainty is inherent in CPSs
- ✓ Handling uncertainty in a graceful manner during the real operation of CPS is critical.

- Definition

- ✓ The lack of certainty (i.e., knowledge) about the timing and nature of inputs, the state of a system, a future outcome, etc.

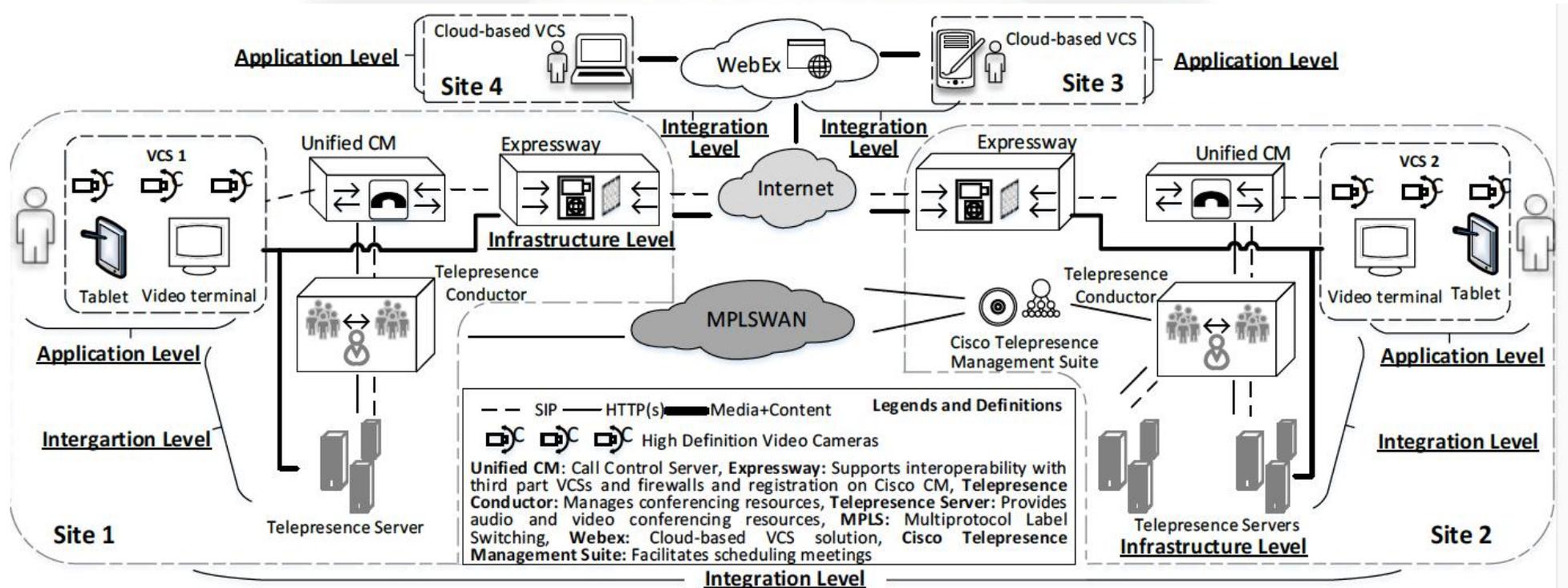
- Steps

- ✓ Understanding Uncertainty
- ✓ Modeling Uncertainty
- ✓ Testing Uncertainty

TESTING LEVELS FOR CPS (1/2)

- **Application** Level : Events and data coming from the user space, e.g., from applications and human
- **Infrastructure** Level : Events and data coming from, e.g., physical units, network equipment, and cloud infrastructure
- **Integration** Level : Interactions between the above two levels

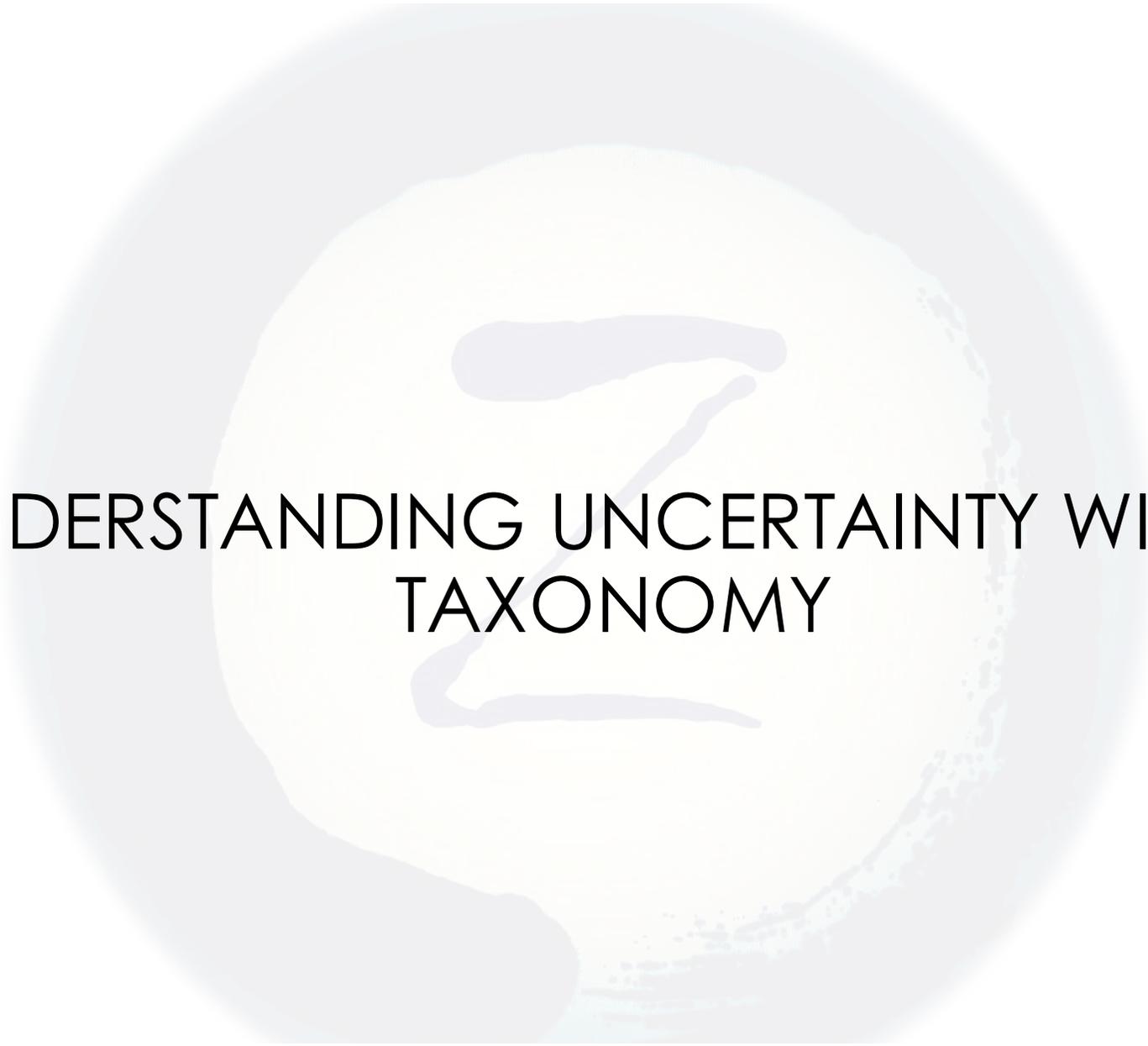
TESTING LEVELS FOR CPS (2/2)



M. ZHANG, B. SELIC, S. ALI, T. YUE, O. OKARIZ AND R. NORGRN, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model In European Conference on Modelling Foundations and Applications (ECMFA)., 2016.

M. Zhang, B. Selic, S. Ali, T. Yue, O. Okariz and R. Norgren, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model,

<https://www.simula.no/file/u-modeltrfinalpdf/download>

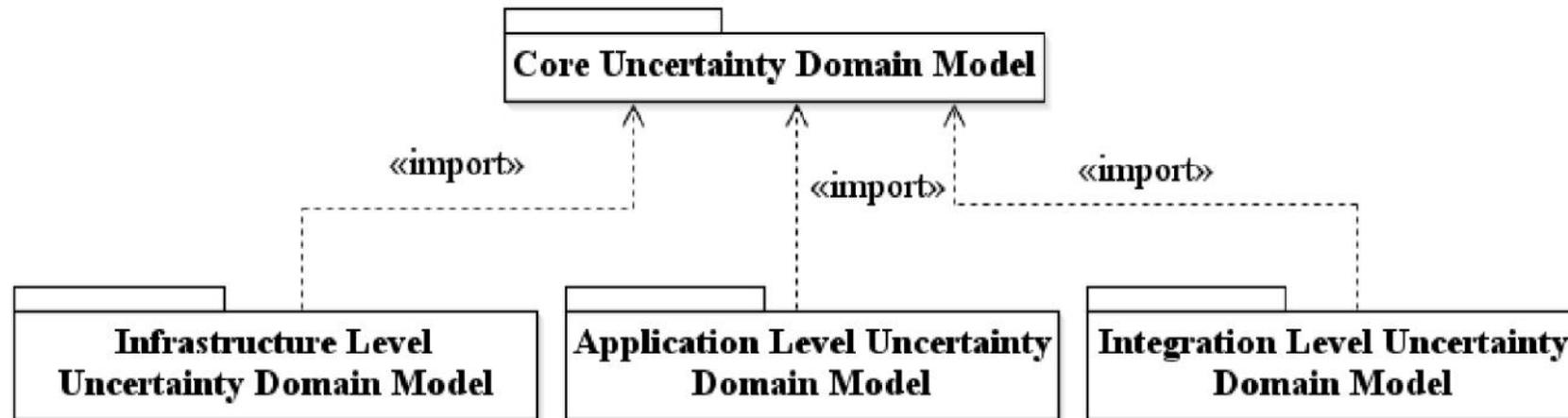


UNDERSTANDING UNCERTAINTY WITH U-
TAXONOMY

U-TAXONOMY

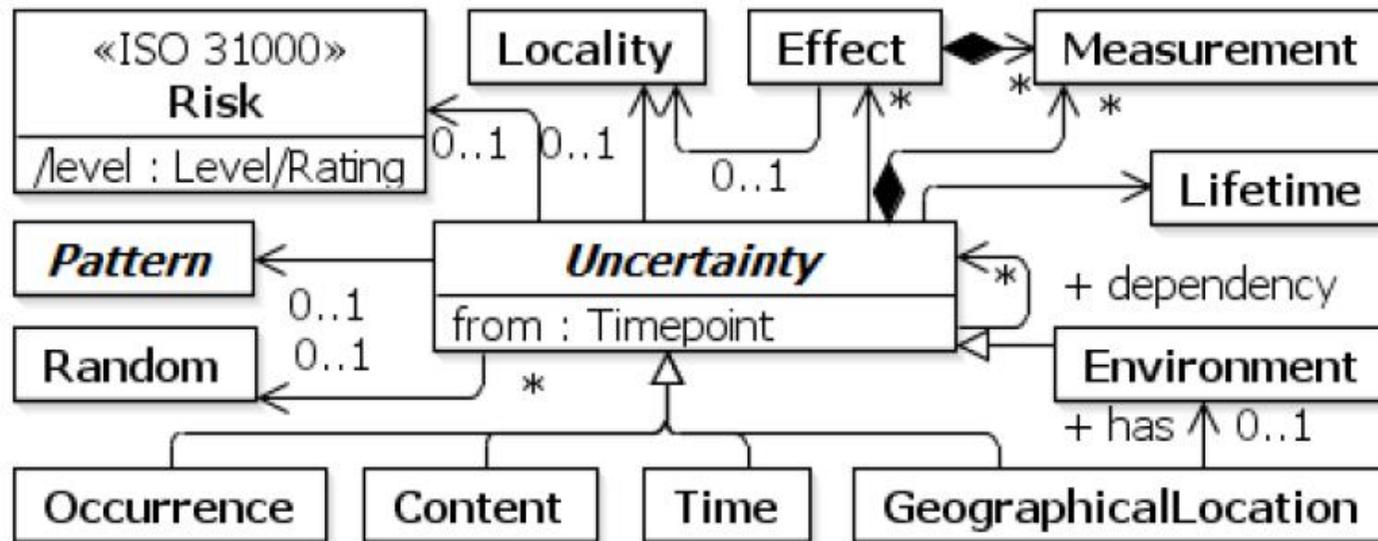
- The ***U-Taxonomy*** takes a subjective approach to represent uncertainty.
- Provide a unified and comprehensive description of uncertainties.
- Classify uncertainties with the aim of identifying common representational patterns.
- Serve as a methodological baseline for modeling uncertain behaviors in CPS.

STRUCTURE OF U-TAXONOMY



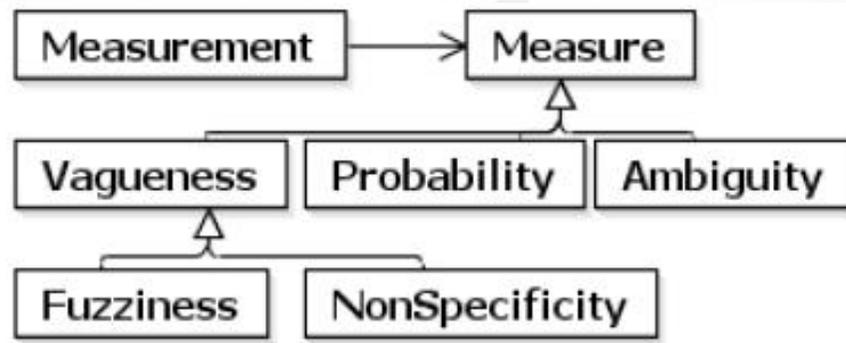
M. ZHANG, B. SELIC, S. ALI, T. YUE, O. OKARIZ AND R. NORGRÉN, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model In European Conference on Modelling Foundations and Applications (ECMFA)., 2016.
M. Zhang, B. Selic, S. Ali, T. Yue, O. Okariz and R. Norgren, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model, <https://www.simula.no/file/u-modeltrfinalpdf/download>

CORE MODEL: UNCERTAINTY MODEL



M. ZHANG, B. SELIC, S. ALI, T. YUE, O. OKARIZ AND R. NORGRÉN, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model In European Conference on Modelling Foundations and Applications (ECMFA)., 2016.
 M. Zhang, B. Selic, S. Ali, T. Yue, O. Okariz and R. Norgren, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model, <https://www.simula.no/file/u-modeltrfinalpdf/download>

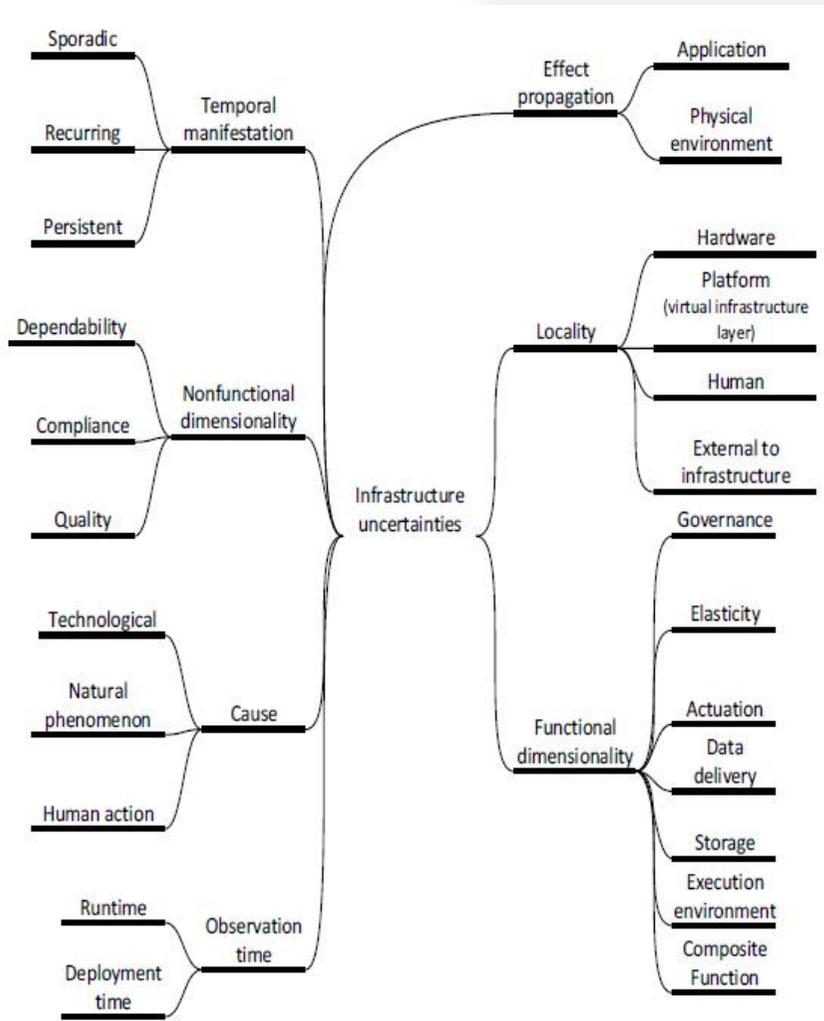
CORE MODEL: MEASURE MODEL



M. ZHANG, B. SELIC, S. ALI, T. YUE, O. OKARIZ AND R. NORGRÉN, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model In European Conference on Modelling Foundations and Applications (ECMFA)., 2016.

M. Zhang, B. Selic, S. Ali, T. Yue, O. Okariz and R. Norgren, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model, <https://www.simula.no/file/u-modeltrfinalpdf/download>

INFRASTRUCTURE LEVEL TAXONOMY: SAMPLE

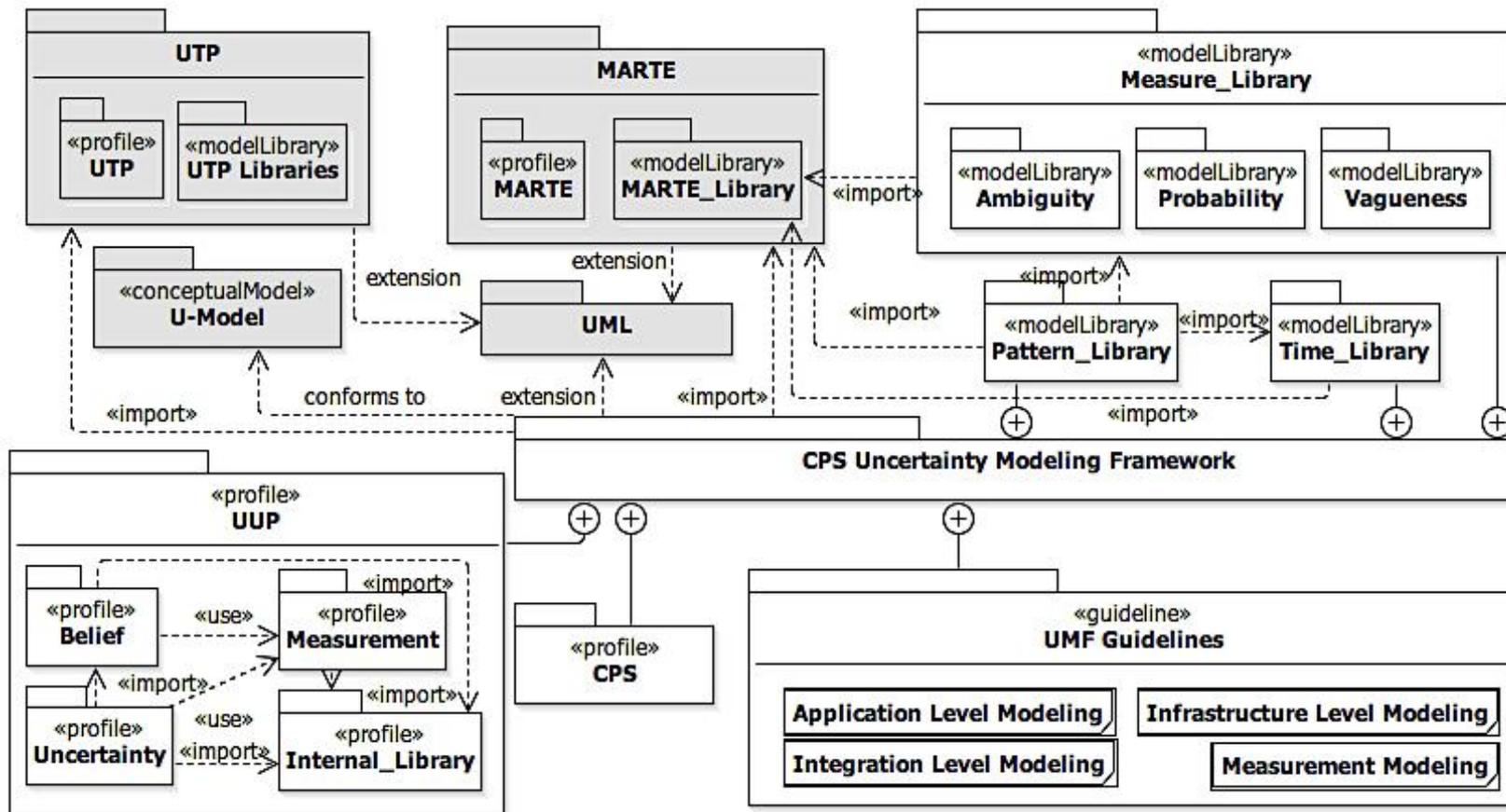


Stefan Nastic and Hong-Linh Truong, Infrastructure-Level Uncertainties V2.0,
<http://dsg.tuwien.ac.at/staff/snastic/public/u-taxonomy.pdf>

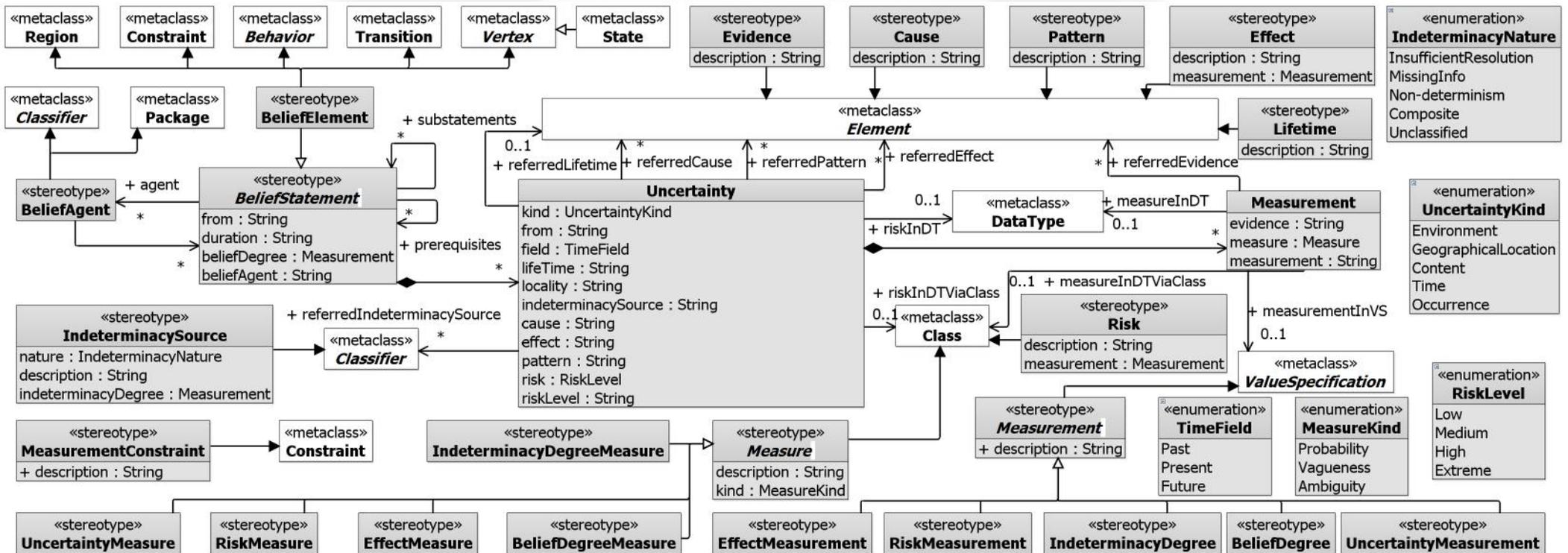


MODELING TEST READY MODELS WITH
UNCERTAINTY

UNCERTAINTY MODELING FRAMEWORK (UMF)

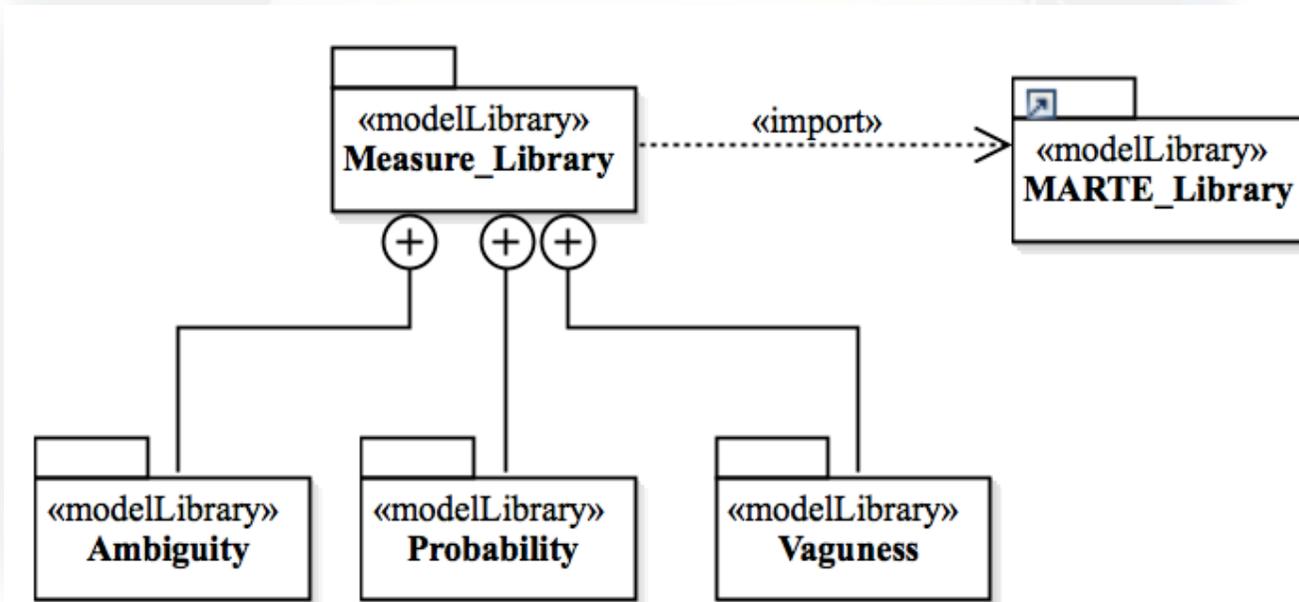


UML UNCERTAINTY PROFILE (UUP): IMPLEMENTATION OF U-TAXONOMY

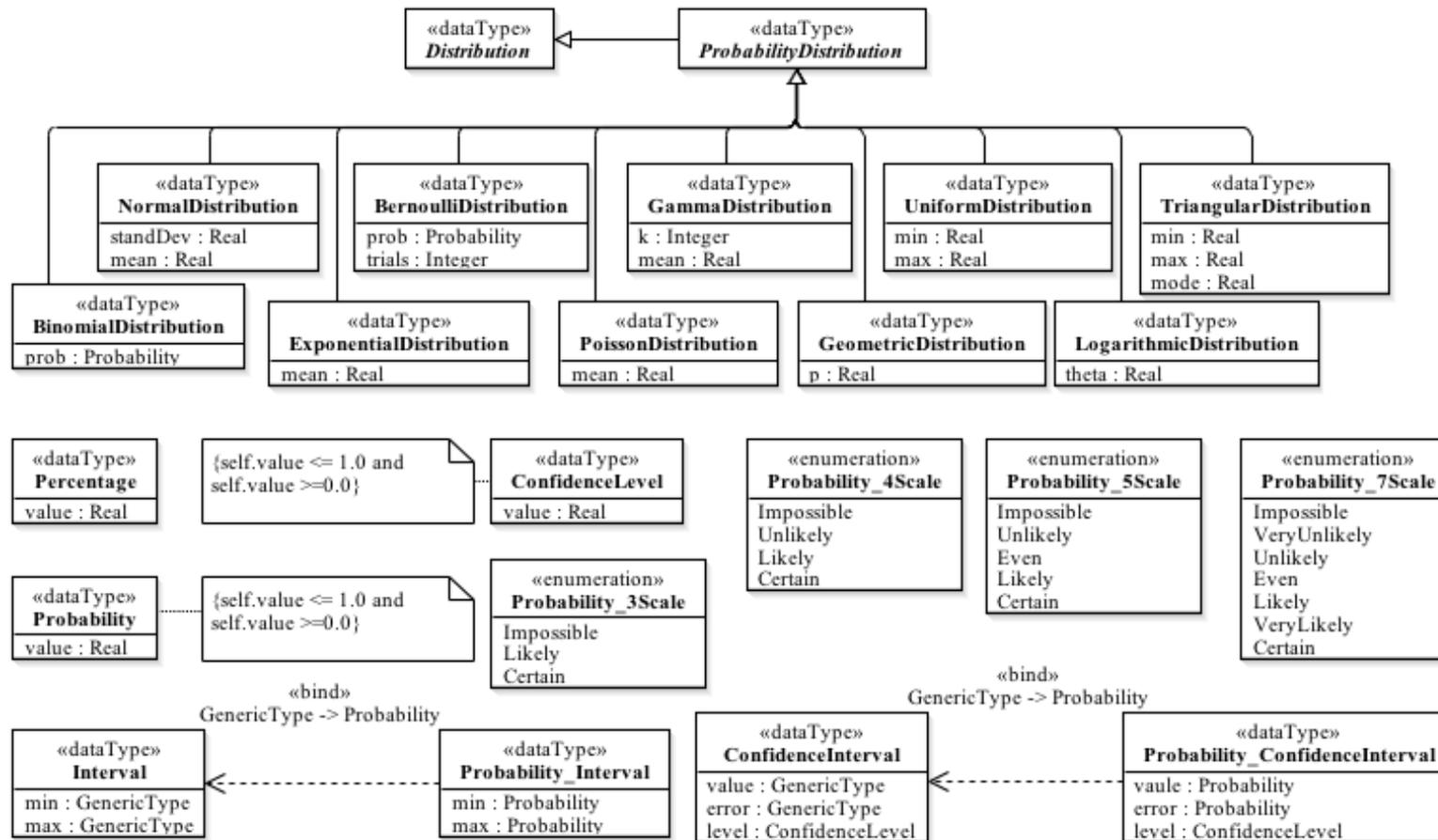


M. Zhang, S. Ali, T. Yue and P. H. Nguyen, Uncertainty Modeling Framework for the Integration Level V.1, <https://www.simula.no/file/uupv1pdf-1/download>

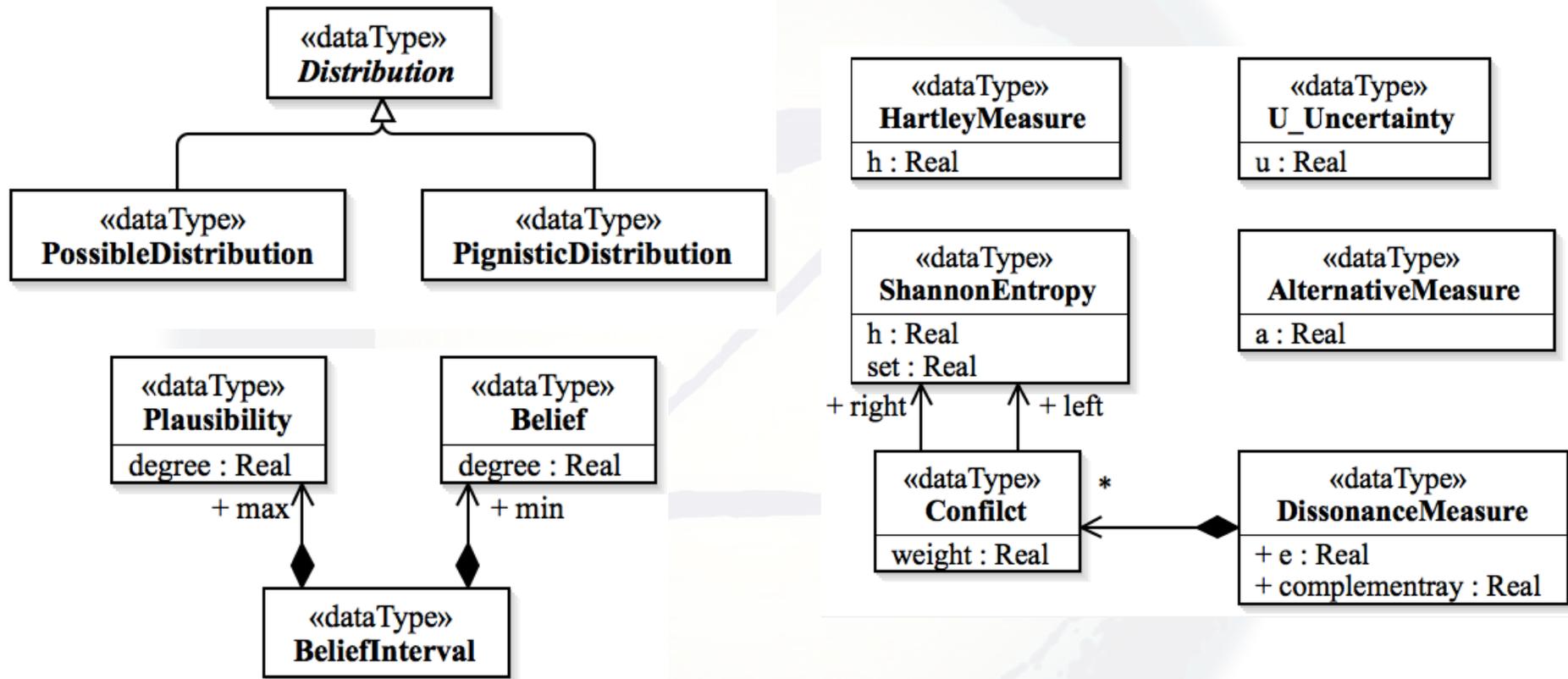
OVERALL MODEL LIBRARY ARCHITECTURE



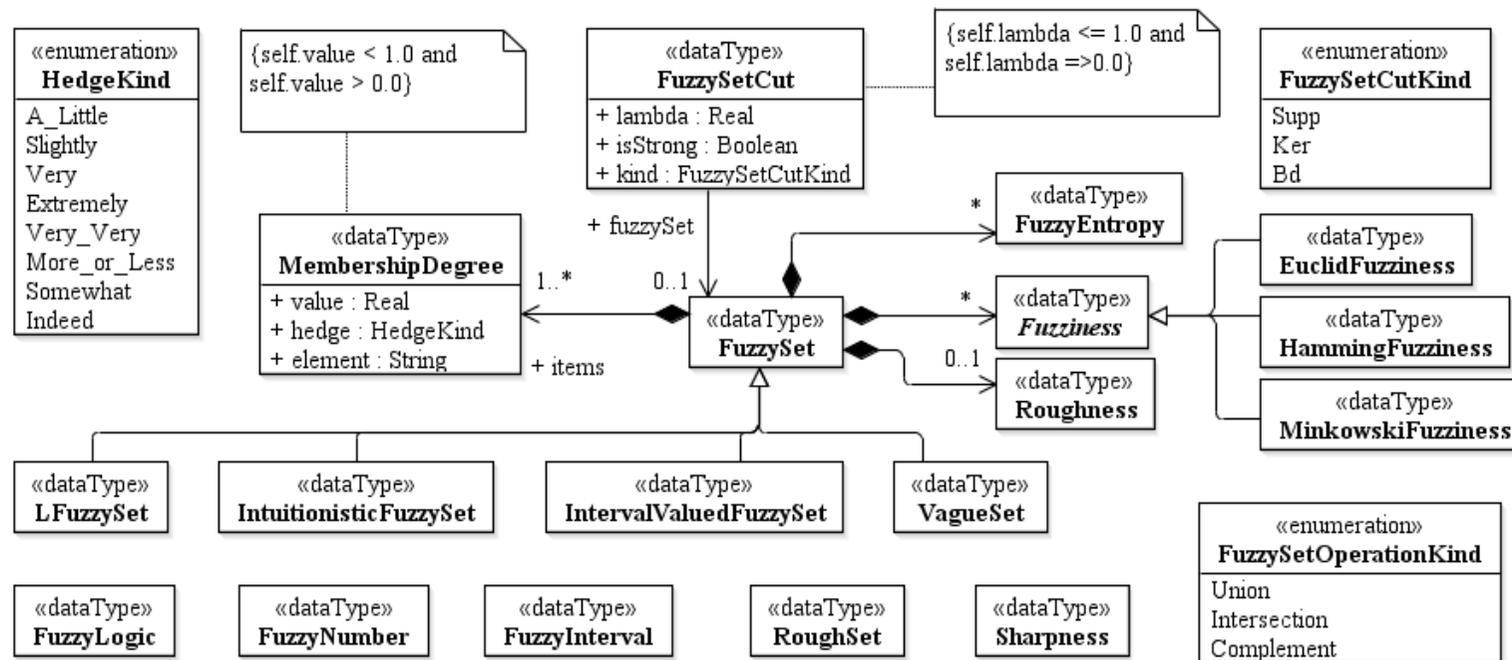
PROBABILITY MODEL LIBRARY



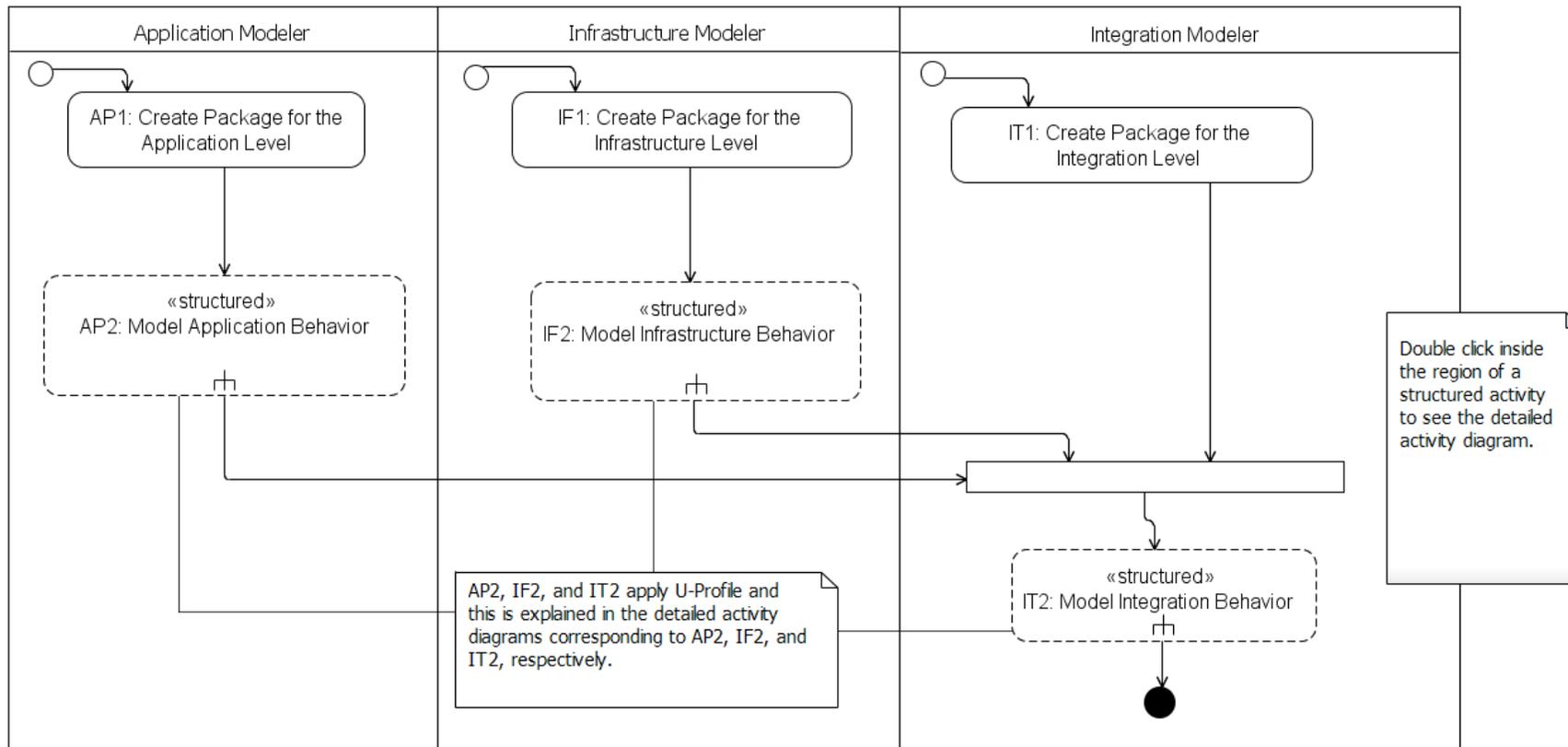
AMBIGUITY MODEL LIBRARY



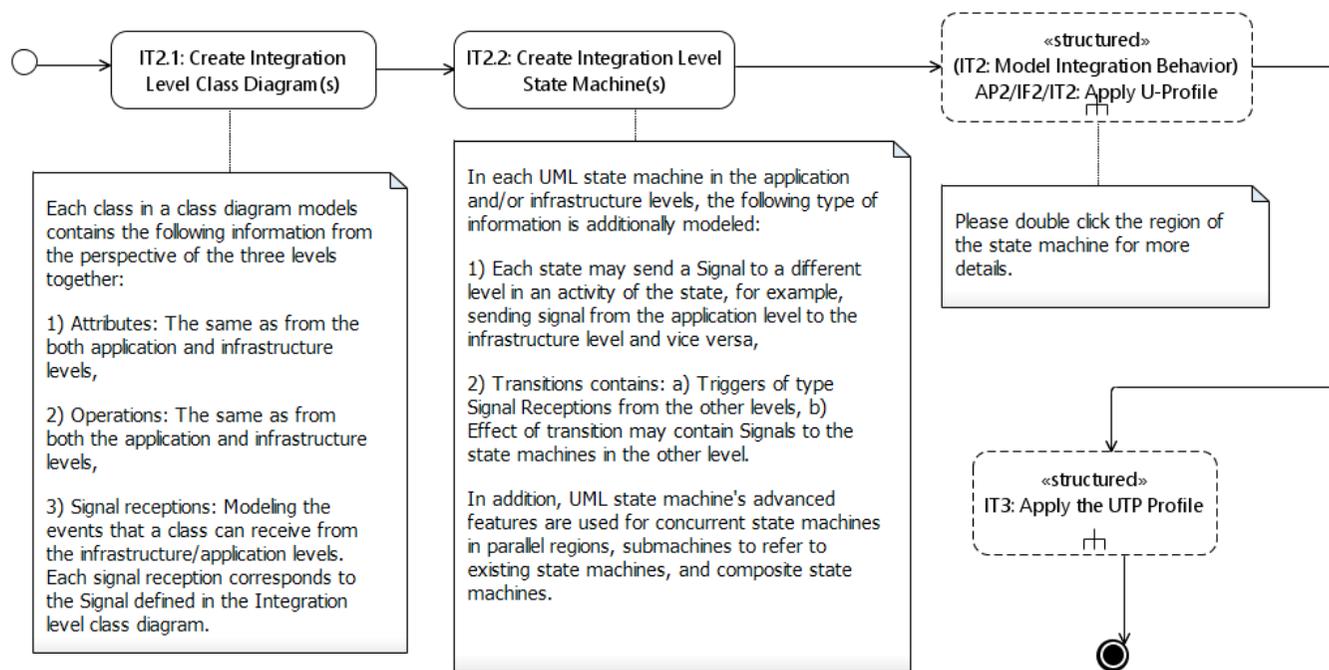
VAGUENESS LIBRARY



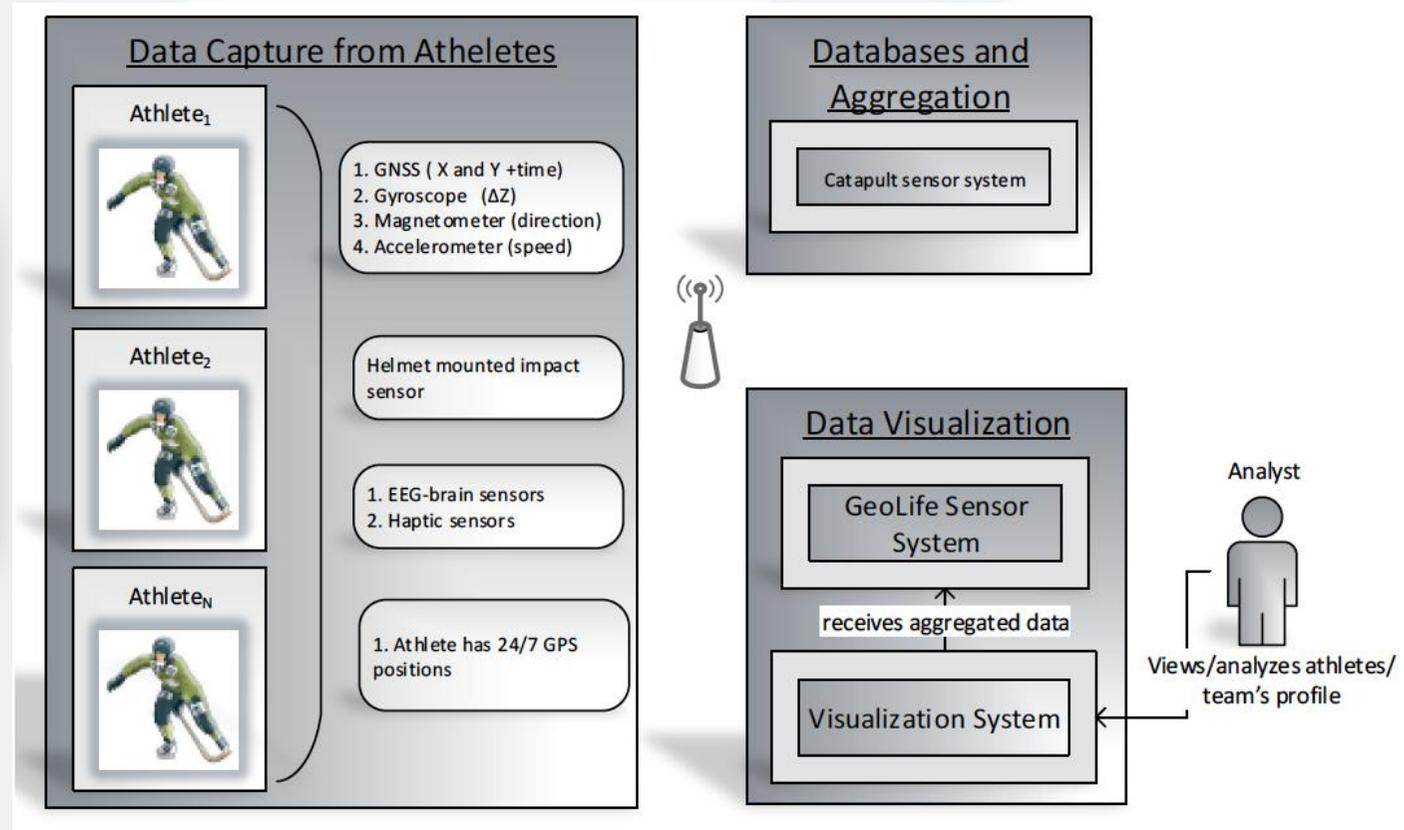
METHODOLOGY EXAMPLE (1/2)



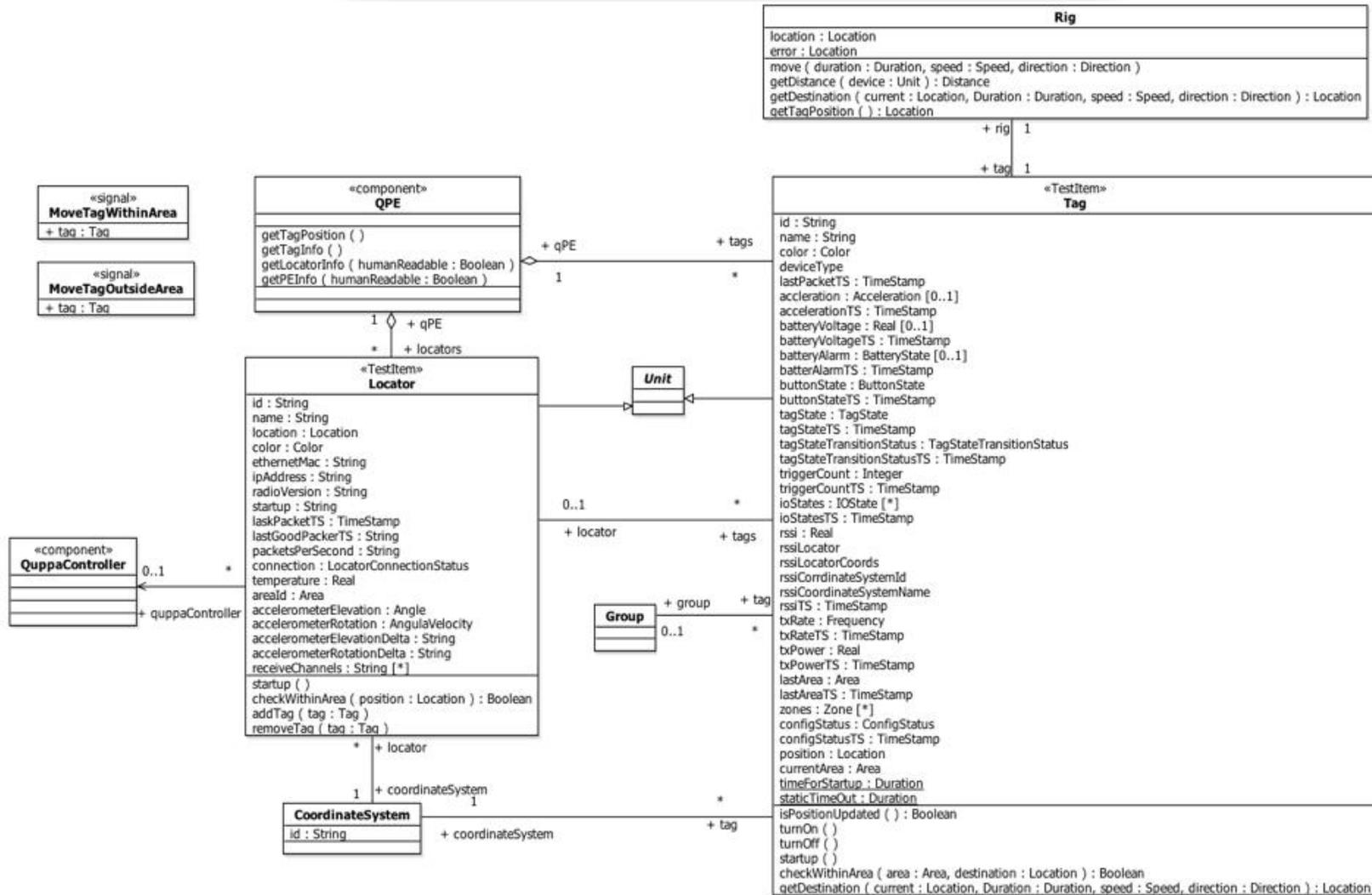
METHODOLOGY EXAMPLE (2/2)



CASE STUDY PROVIDERS: GEO SPORTS



EXAMPLE MODELS: GEOSPORTS CASE STUDY



Locator: Connect with Tags

Idle State Invariant
 «CheckPropertyAction»
 {self.tags->size() = 0 and Tag.allInstances()
 > select(self.checkWithinArea(position))-
 > size()=0}

Effect
 {self.tags->size() =self.tags@pre->
 size() +1}

Connected With Tags State Invariant
 «CheckPropertyAction»
 {self.tags->size() > 0 and self.tags-> includesAll(Tag.allInstances(
 > select(self.checkWithinArea(position))) and Tag.allInstances()-
 > select(self.checkWithinArea(position))-> size() = self.tags-> size()

Effect
 {self.tags-> size() = self.tags@pre-> size()

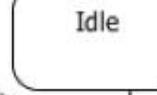
«BeliefElement»
 [checkWithinArea(tag.position)]
 MoveTagWithinArea(tag : Tag)
 addTag

Incomplete Connected With Tags
 {(not self.tags-> includesAll(Tag.allInstances()-
 > select(self.checkWithinArea(position)))) and
 Tag.allInstances()-
 > select(self.checkWithinArea(position))-> size() >
 self.tags-> size() }

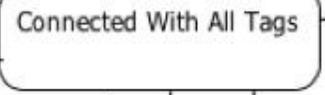
«BeliefElement»
 [checkWithinArea(tag.position)]
 MoveTagWithinArea(tag : Tag)
 addTag

[not checkWithinArea(tag.position)]
 MoveTagOutsideArea(tag : Tag)
 removeTag

[checkWithinArea(tag.position)]
 MoveTagWithinArea(tag : ...)
 addTag



[not checkWithinArea(tag.position)]
 MoveTagOutsideArea(tag : Tag)
 removeTag



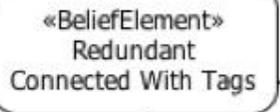
Effect
 {self.tags-> size()
 =self.tags@pre-> size()-1}

«BeliefElement»
 [not checkWithinArea(tag.position)]
 MoveTagOutsideArea(tag : Tag)
 removeTag

Effect
 {self.tags-> size()
 =self.tags@pre-> size() }



[checkWithinArea(tag.position)]
 MoveTagWithinArea(tag : Tag)
 addTag



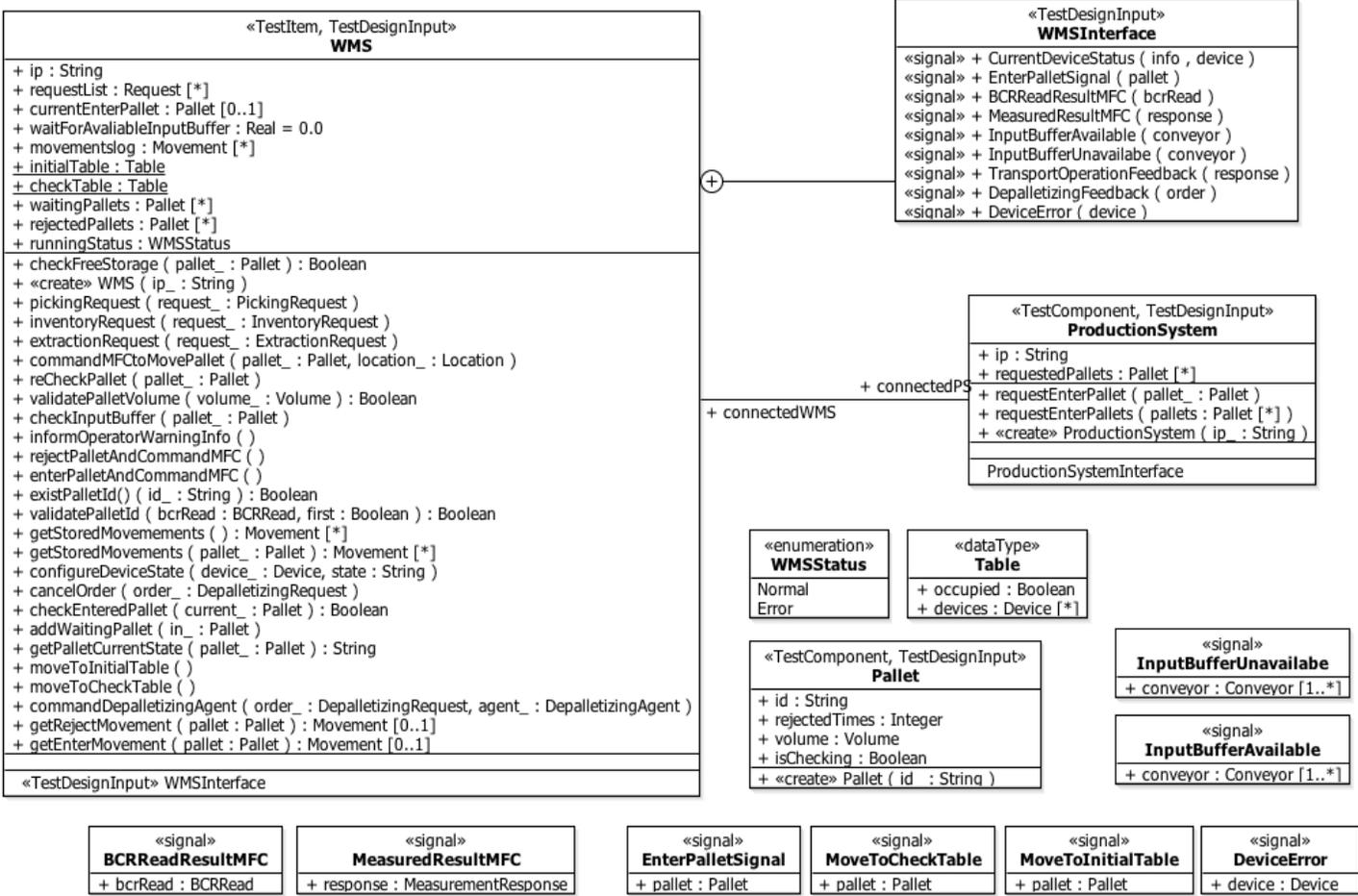
Effect
 {self.tags-> size()
 =self.tags@pre-> size() }

Redundant Connected With Tags
 {(self.tags-> includesAll(Tag.allInstances()-
 > select(self.checkWithinArea(position)))) and Tag.allInstances()-
 > select(self.checkWithinArea(position))-> size() < self.tags-> size()

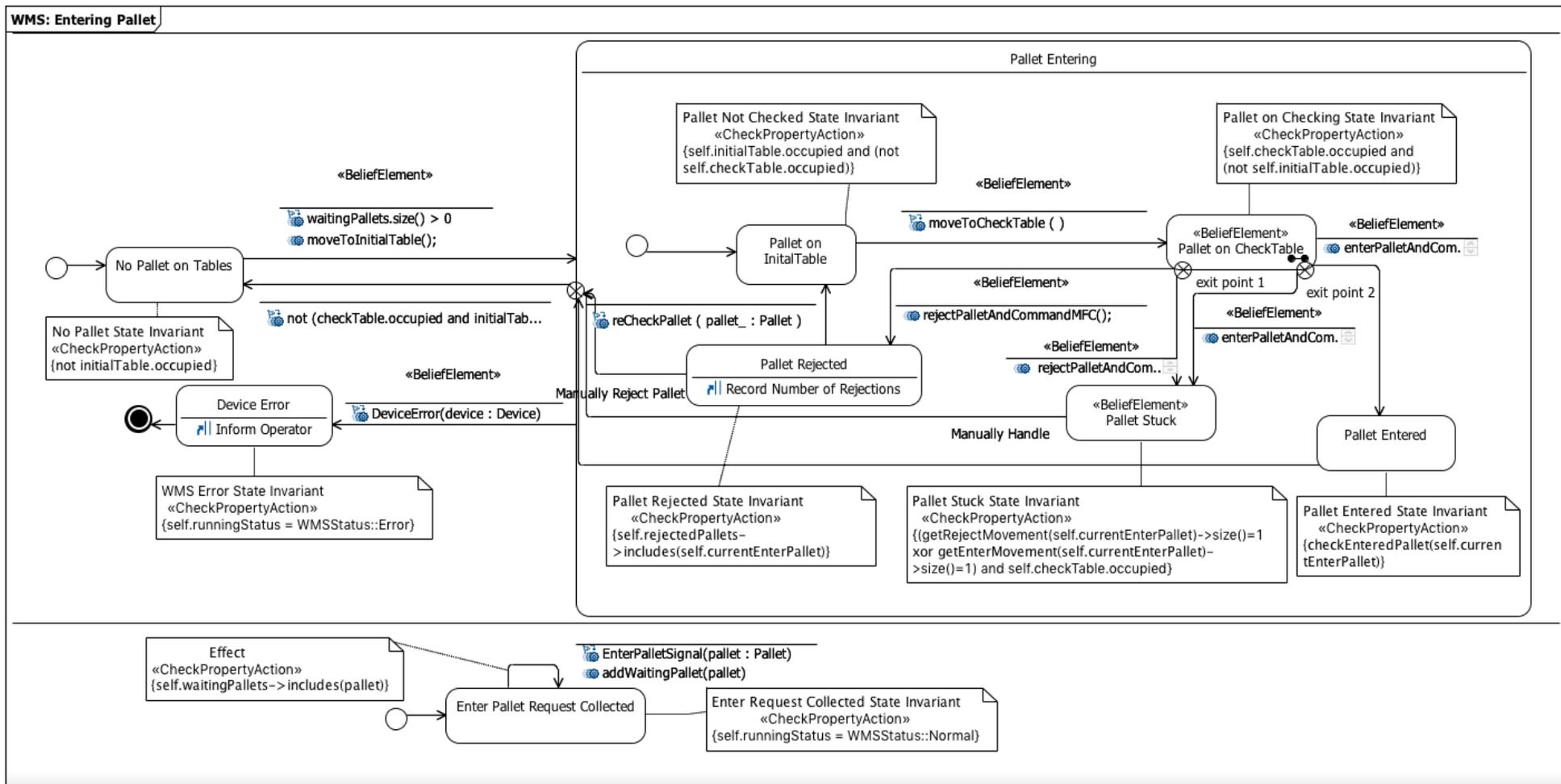
CASE STUDY PROVIDERS: HANDLING SYSTEMS



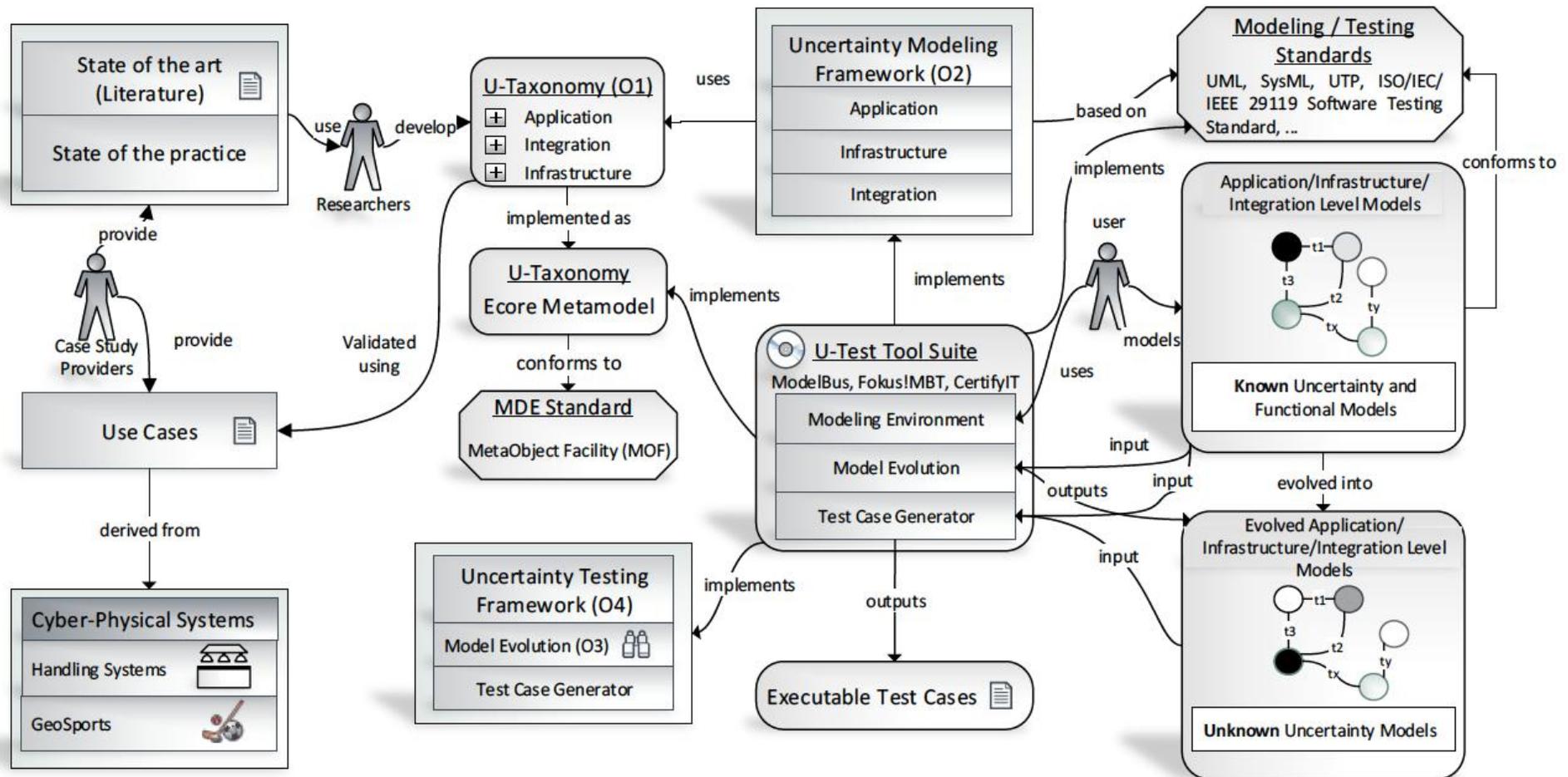
EXAMPLE MODELS: ULMA HANDLING SYSTEMS CASE STUDY



EXAMPLE MODELS: ULMA HANDLING CASE STUDY



OVERALL APPROACH



Ali, Shaukat, and Tao Yue. U-Test: Evolving, Modelling and Testing Realistic Uncertain Behaviours of Cyber-Physical Systems In The Testing in Practice track of International Conference on Software Testing (ICST). IEEE, 2015, <https://www.simula.no/file/preprintpdf/download?token=i3p2Axiq>