

# A UML Profile for Goal-Oriented Modeling

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# Why Goal-oriented Modeling (GoM)?

- Goals are important drivers for requirements elaboration
  - Stakeholders goals are complex and often conflict
- GoM is meant to express and clarify tentative, ill-defined and ambiguous requirements (especially non-functional ones)
- GoM supports argumentation, negotiation, and conflict detection & resolution
- GoM captures decision rationale and criteria (documentation!)
- GoM provides traceability from strategic objectives to technical requirements, enabling consistency and completeness analysis
- GoM provides a basis for validation, performance management and adaptation
- ***Nothing like this in UML...***

# Problem

- UML (Unified Modeling Language) does not address explicitly the modeling of goals.
- Can UML be profiled to support goal-oriented modeling with a semantics rooted in a standard metamodel such as that of URN's Goal-oriented Requirement Language (**GRL**)?
- Can such a profile be supported by a commercial UML tool?

# Contributions

- The creation of a UML profile for GRL (URN standard), where UML metaclasses are stereotyped and mapped in detail to GRL's metaclasses. Standard guidelines (ITU-T Z.119) have been followed while defining this profile.
- A proof of concept implementation, which demonstrates the feasibility of supporting such profile in Telelogic Tau G2 4.x
- Illustration of typical usage of this profile with examples where GRL is used standalone in a model, and then where GRL diagrams are combined with selected UML diagrams in a model.

# Rest of the Presentation...

- Requirements and background work
- GRL and current tool support (jUCMNav)
- UML profiles
- GRL profile in Tau: Stereotype Mechanism
- GRL profile in Tau: Metamodel Extension Mechanism
- Example
- Evaluation and Conclusions

# Requirements

- Some work in the area of UML profiles for goal modeling exist, but the solutions proposed suffer from many shortcomings, including non-compliance to minimal requirements such as:
  - **R1**: Integration with UML
  - **R2**: Diagram pollution avoidance
  - **R3**: Metamodel stability
  - **R4**: Implementability of the profiling mechanism

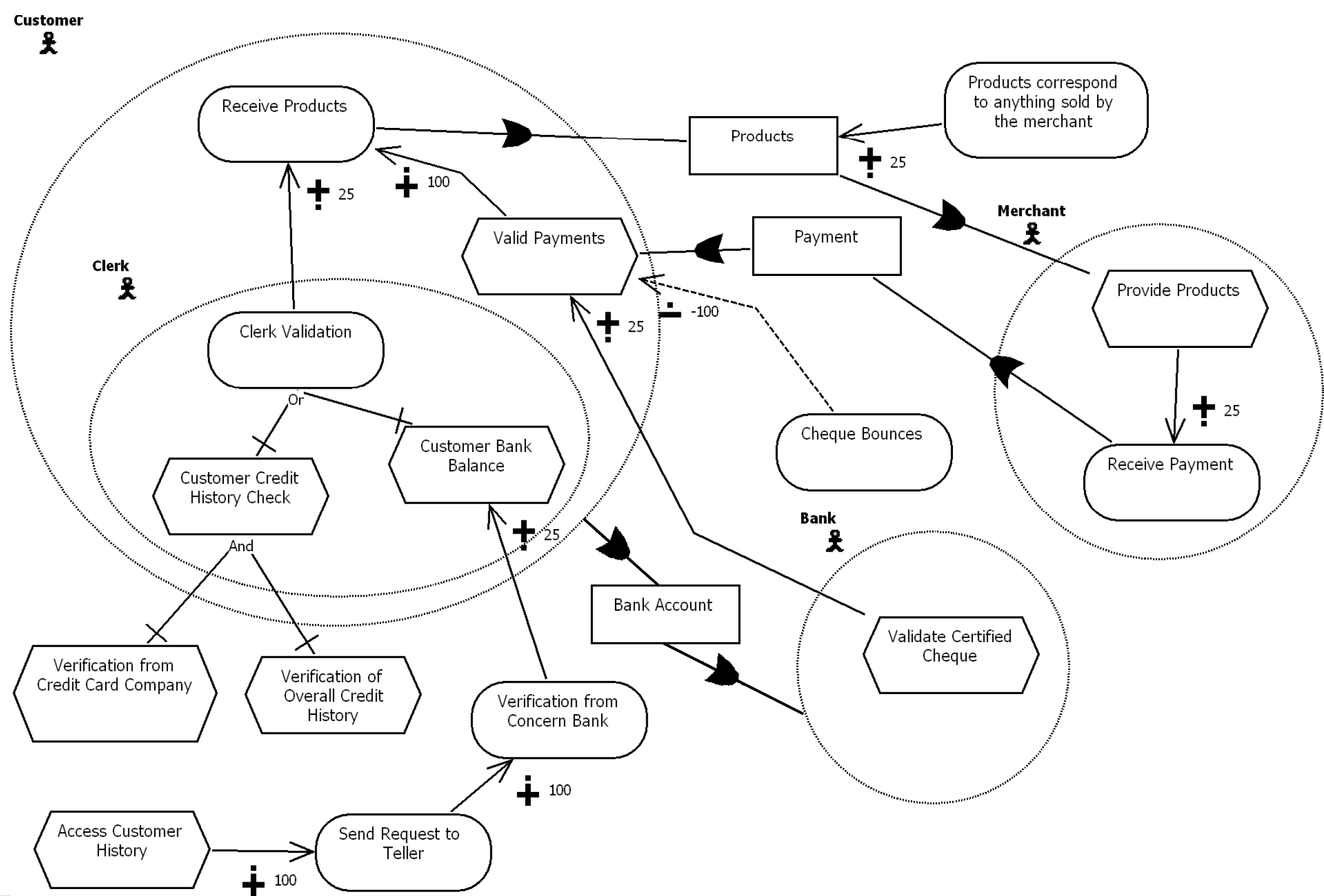
# Sample Related Work

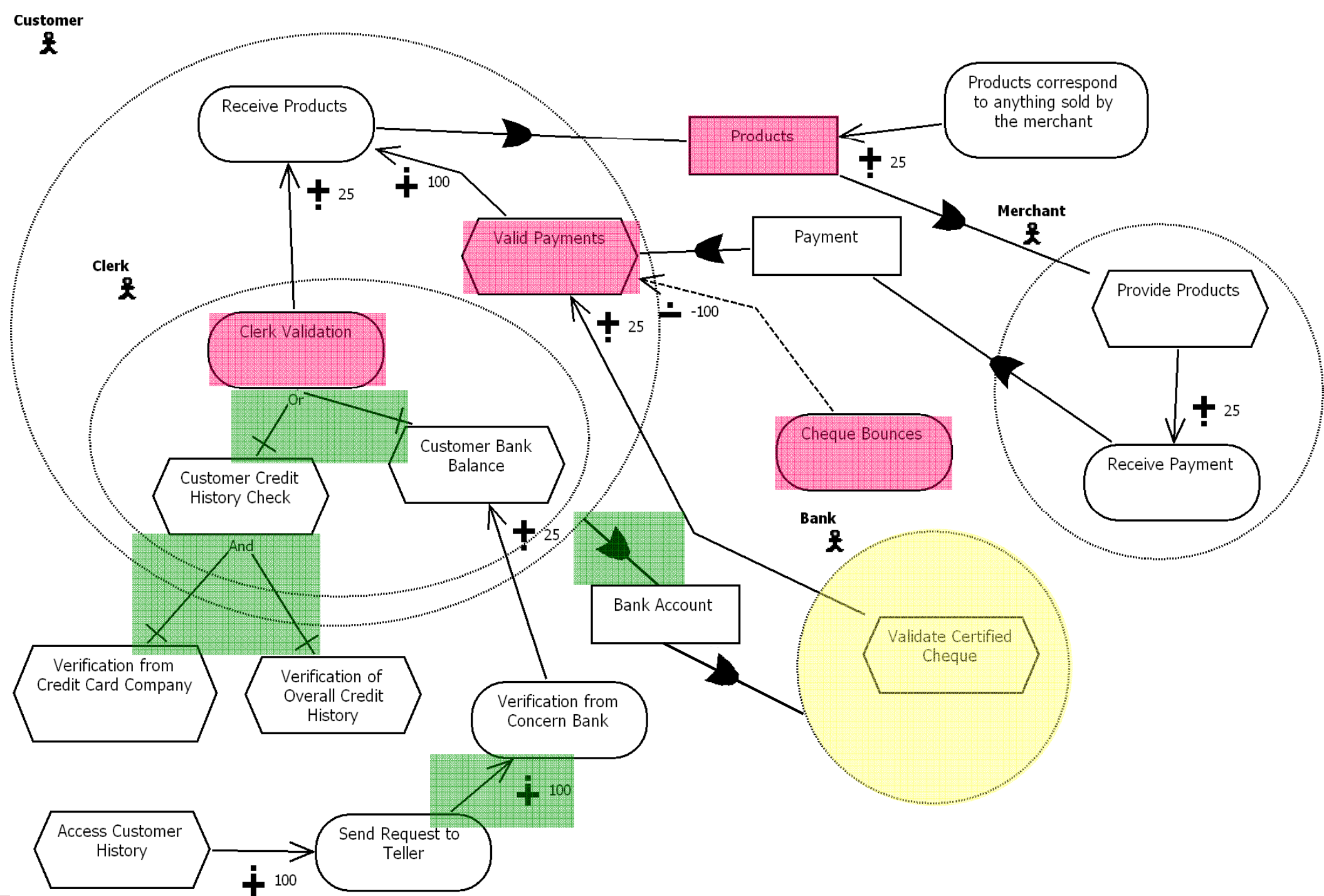
- *Cysneiros et al. (2001): Using UML to Reflect Non-Functional Requirements*
  - Does not satisfies R1 and the remaining requirements are not applicable
- *Supakkul and Chung (2006): UML Profile for Softgoal by Use Case Driven Approach*
  - Satisfies R2, partially satisfies R3, and R4 is not applicable
- *Grangel et al. (2008): UML Profile for Enterprise Goal Modeling*
  - Satisfies R1 and partially satisfies R4
- *Van Lamsweerde (2009): Requirements engineering: From System Goals to UML Models to Software Specifications*
  - Partially satisfies R1 and R3, and R4 is not applicable.

# Goal-oriented Requirement Language

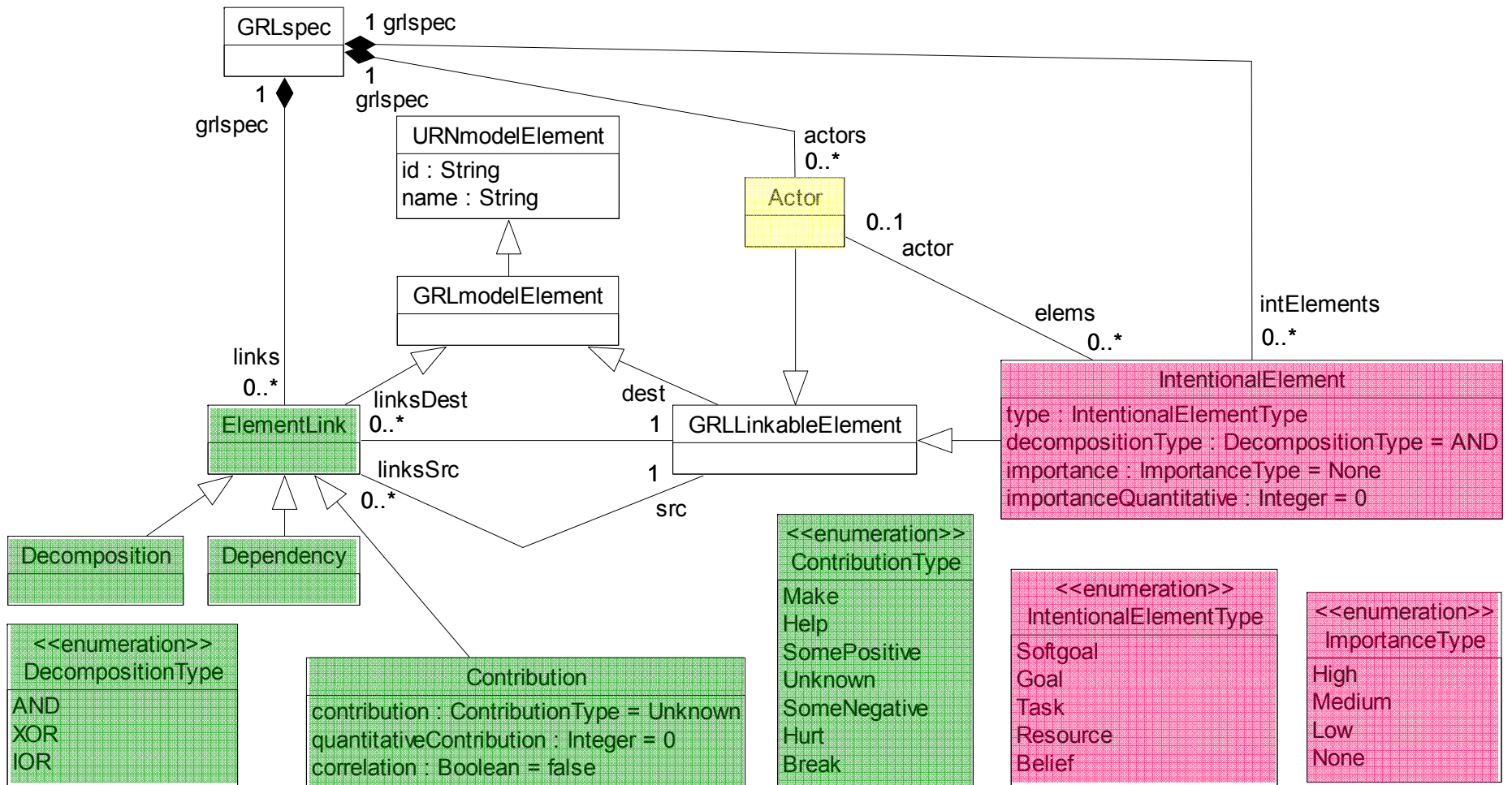
- Part of ITU-T's User Requirements Notation (**URN** - Z.151)
- Three main categories of concepts:
  - Actors
  - Intentional elements
  - Links







# GRL's Metamodel (Extract)



# Current GRL tool: jUCMNav

- An Eclipse-based GRL editor:
  - Supports the User Requirements Notation (GRL + UCM)
  - Allows users to create and maintain GRL models
  - Supports the analysis of GRL models
  - Supports the creation of links and annotations
  - Supports OCL-based constraints and metrics
  - Exports to various formats
  - Open source (EPL)
- Version 4.0 to become available soon.
  - <http://jucmnav.softwareengineering.ca/jucmnav/>

View all elements

jUCMNav Debug

Navigator

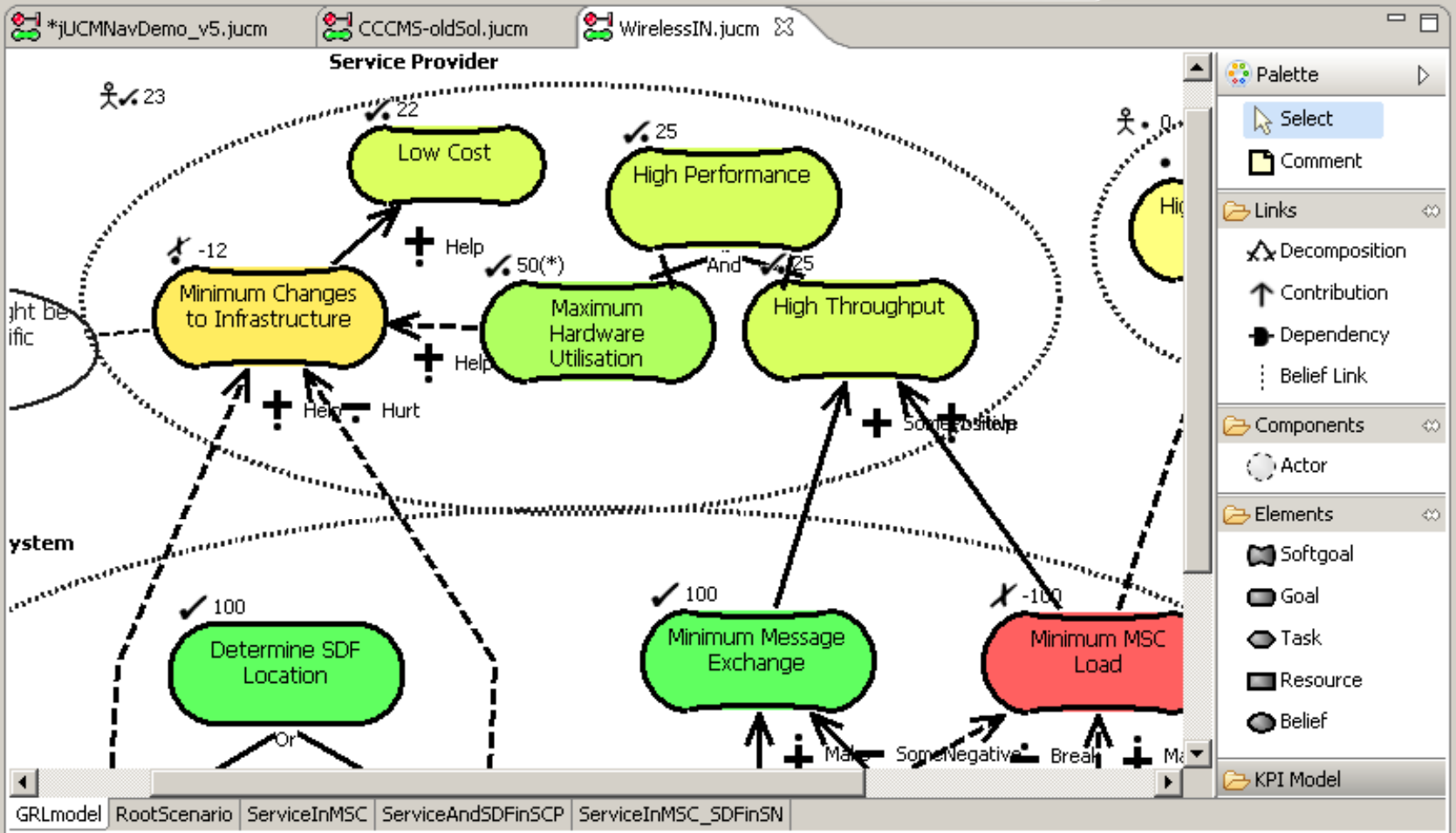
- MCEtech09.jucm
- radio 4-gM.jucm
- WirelessIN-inMSC.jucm
- WirelessIN-inSCP.jucm

Outline

- GRLmodel
  - Vendor
  - Service Provider
  - User
  - System
  - Belief76
  - Low Cost
  - High Performance
  - High Evolveability
  - Minimum Changes to

Elements

- Low Cost
- High Performance
- High Evolveability
- Minimum Changes to Infra
- Maximum Hardware Utilis
- High Throughput



Scenarios and List of Key Pe

- GRL Evaluation Strategies
  - ArchAlternatives
    - GRL ServiceAndSDFinSCP
    - GRL ServiceInMSC
    - GRL ServiceInMSC\_SDFinSN
  - Enumerations
  - Variables

Standard Name: ServiceInMSC\_SDFinSN

Metadata

Advanced Description:

## A UML Profile Can...

- Enable the tailoring of UML to a particular domain.
- Specify new “standard elements”.
  - Addition of new stereotypes and attributes
- Specify “well-formedness rules”.
  - Addition of new constraints without violating existing/inherited constraints
- Specify semantics
  - Decisions on semantics variation points.

# Profiling Mechanisms

Profiles can usually be created in one of two ways:

- 1) Stereotype Mechanism (**SM**)
- 2) Metamodel Extension Mechanism (**MEM**)

# Stereotype Mechanism

- Very straightforward way of customizing UML.
- Extension of basic UML elements.
- Allows simple customizations (names, attributes, appearance).
  - For instance, GRL's *task* intentional element can be represented as a stereotype of UML's *class*.
- Limitations
  - GRL elements that are just stereotypes of existing UML elements can only be used in regular UML diagrams.
  - Non-GRL elements can be included in GRL diagrams.
  - Pollution! Tend to violate R2 and leads to unfriendly editors and confusing models.



# Metamodel Extension Mechanism

- More robust extension mechanism.
- Includes all functionalities of stereotype mechanism.
- Also allows to customize non-basic UML elements such as *diagrams*.
  - E.g., a GRL diagram can be represented as a metaclass extension of UML's class diagram and then restrictions on the GRL diagram can be added to allow only GRL elements.
- More flexible but more complex way of profiling.

# UML Profile for GRL: Highlights

<b>Stereotype</b>	<b>Stereotyped metaclass (UML)</b>
GRLspec	Model
GRLmodelElement	NamedElement
GRLLinkableElement	Class
Actor	Class
IntentionalElement	Class
IntentionalElementType	Enumeration
ImportanceType	Enumeration
ElementLink	Relationship
Contribution	Association
ContributionType	Enumeration
Dependency	Association
Decomposition	Association
DecompositionType	Enumeration

# Tool Support: Telelogic/Rational Tau G2 4.0

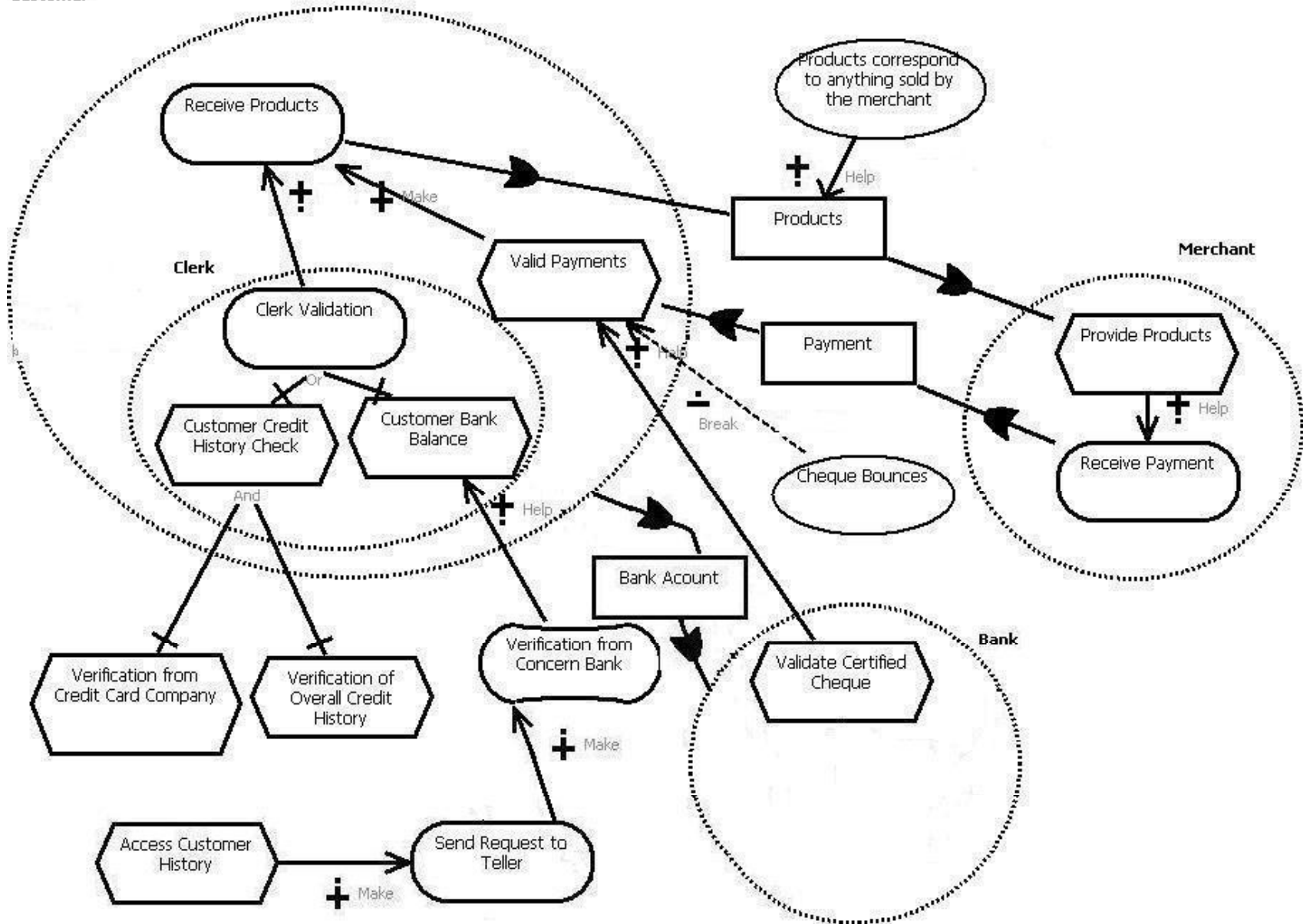
- Supports Model Driven Development (MDD) in a UML-based environment
- Supports both Stereotype Mechanism and Metamodel Extension Mechanism for UML profile creation
  - Both approaches were tested for the GRL profile
- Allows the tailoring of the editor

# Example of Profile Usage

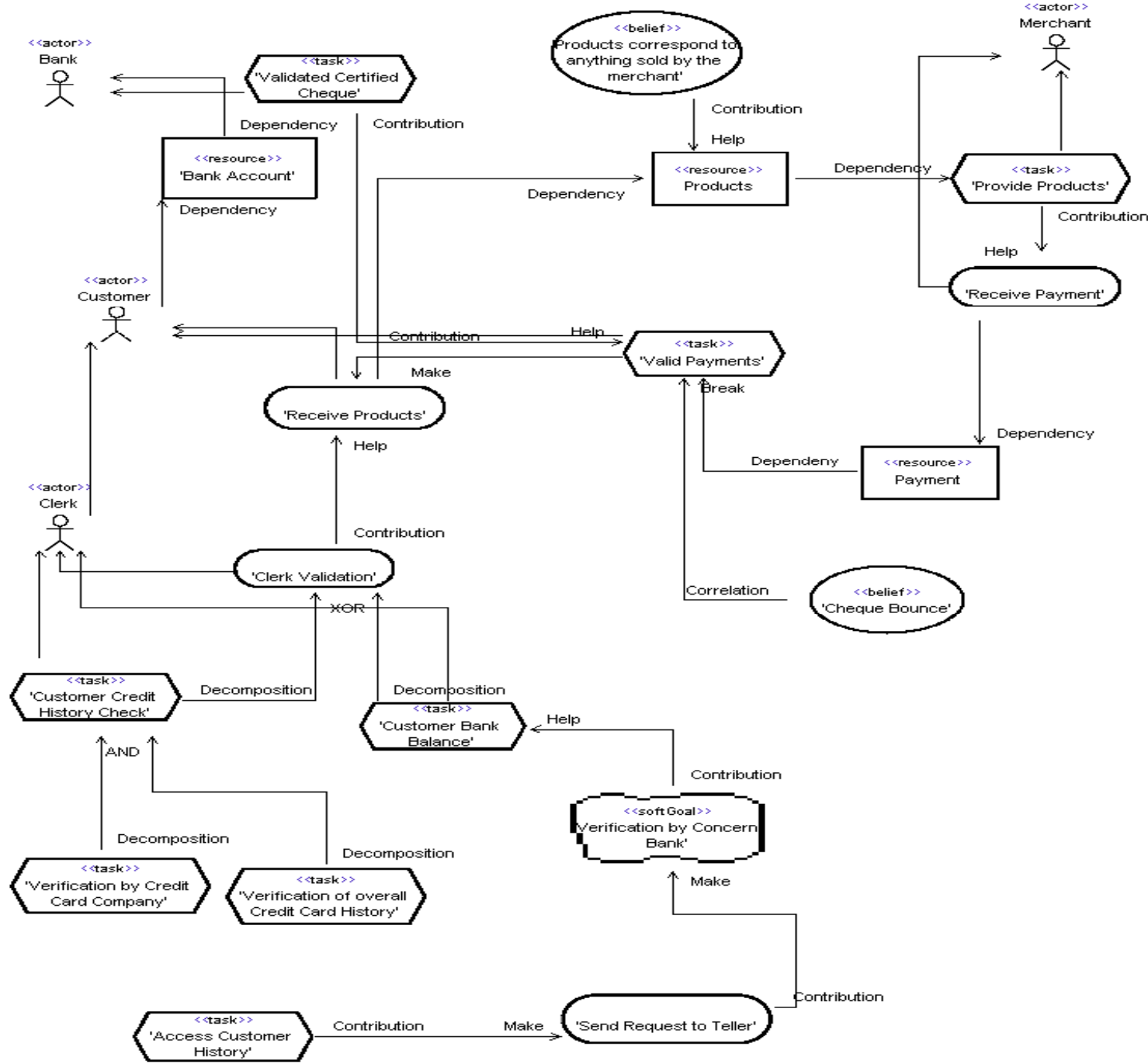
- Merchant and Customer Dependencies
  - Covers almost all the possible usage scenarios of GRL constructs
  - Includes GRL goal, softgoal, task, belief, resource, dependency, contribution, correlation, decomposition and actor
  - Includes four actors: Customer, Clerk, Bank and Merchant

# Example in jUCMNav

Customer



# Example in Tau G2 – GRL Profile



# Tau Support for GRL Profiling

- Provides predefined stereotypes to obtain advanced profile functionalities.
- Many options are in property view
  - makes the environment easier to use.
- Supports the association of customized icon with Enumeration literals which enable us to assign customized icons.
- Allows to create a specific GRL editor with a customized tool palette.
- Provides start link and end link features that allows to navigate from one diagram construct to the other.
- Provides the re-usability of the constructs. A UML diagram can re-use a reference to a GRL construct from another diagram.

## Tools Limitations (1/2)

- Tau does not support all of the UML metamodel classes, e.g. Enumeration metaclass and the NamedElement metaclass.
- No construct or mechanism by which an Actor boundary can be created.
- Tau lacks support for the association of customized multiple icons with Enumeration literals.
- The stereotypes that are associated with metaclasses other than the Class metaclass are neither applied nor selected automatically by the tool at runtime.

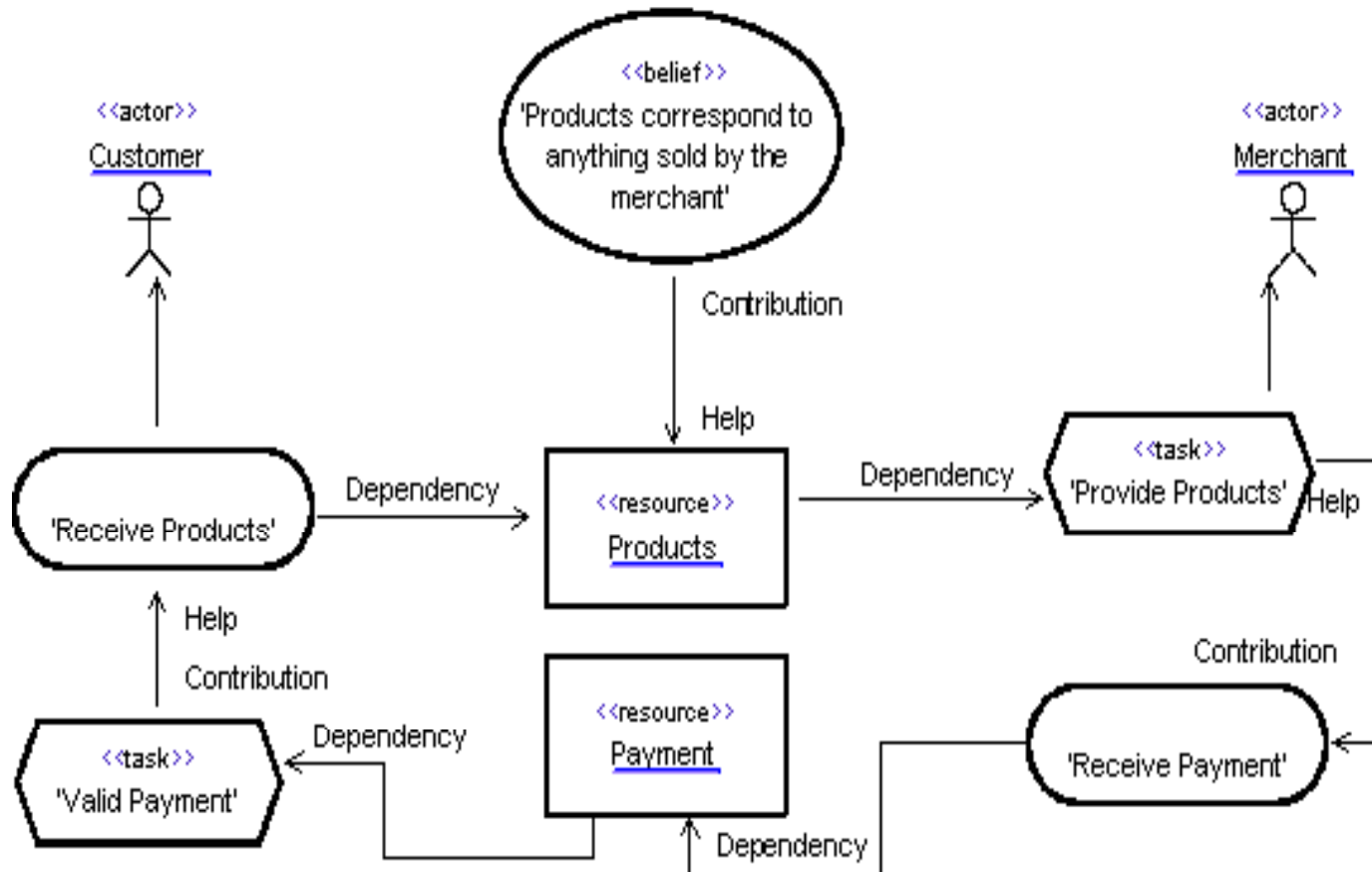


## Tools Limitations (2/2)

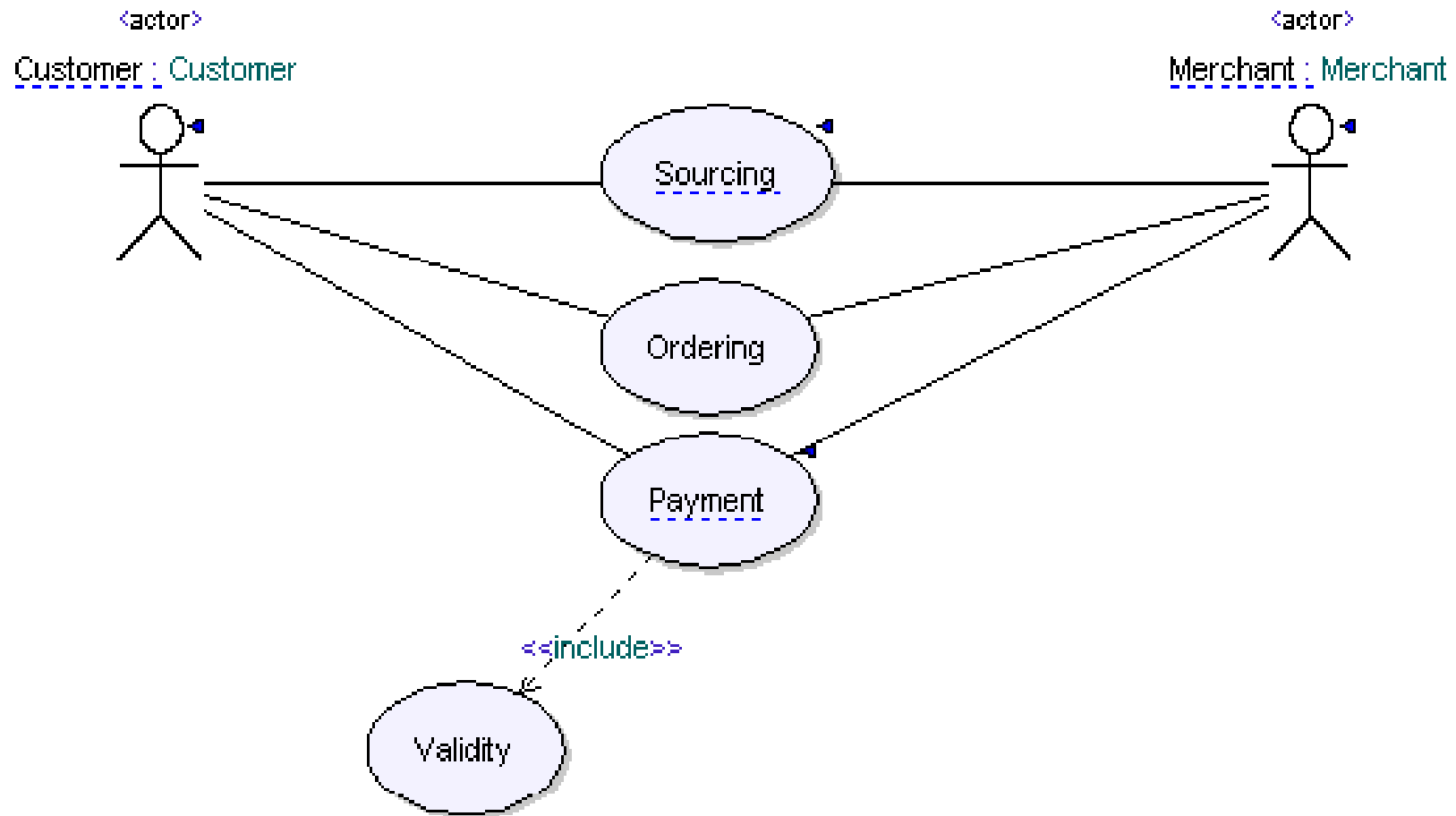
- Some limitations handling the “GRL view”
- Decompositions differ visually in the jUCMNav example from the Tau GRL profile. This is because there is no customized appearance for links in our Tau GRL profile.
- Tau does not support OCL validation for profiling. There is a notion of informal constraints in Tau that are limited to text.

# Profile Analysis (1/4)

- Integration with UML *Satisfied*
  - UML diagram and GRL Diagram connected with each other
  - Reusability of constructs

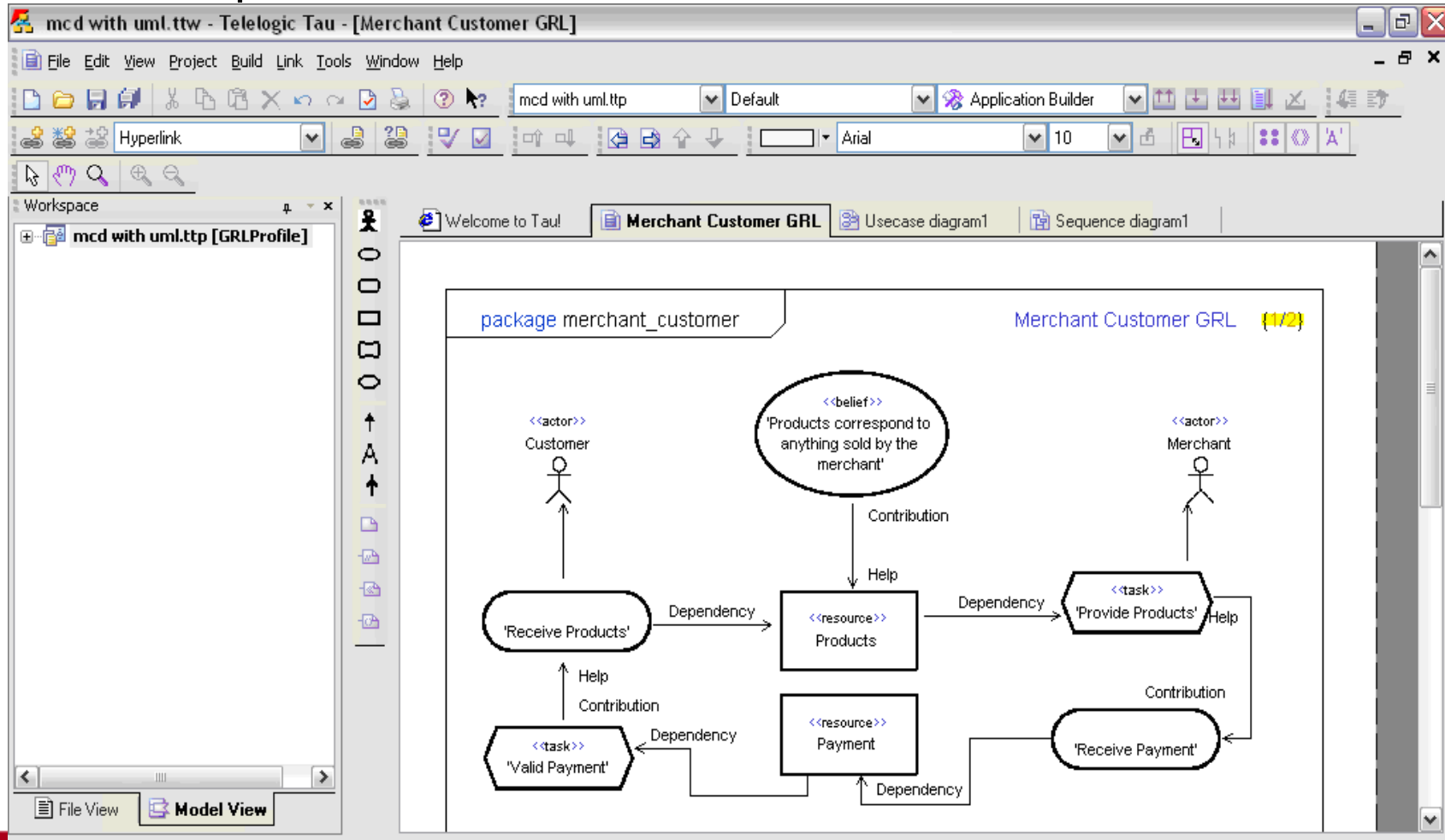


# Profile Analysis (2/4)



# Profile Analysis (3/4)

- Diagram Pollution Avoidance *Satisfied*
  - Separate GRL editor
  - Separate customized tool bar



# Profile Analysis (4/4)

- Metamodel Stability *Satisfied*
  - Considered metamodel is standard (ITU-T Z.151)
- Implementability of the Profiling Mechanism *Satisfied*
  - Implementation in both Stereotype Mechanism and Metamodel Extension Mechanism

# Conclusions

- Tool-supported, UML Profile for Goal-oriented modeling will make GRL more accessible to UML users.
  - Satisfies the 4 requirements identified
  - Current editor has some visualization/usability limitations
- Thesis contains more examples and analysis results, as well as step-by-step instructions on profile creation
- Z.119 (02/07): *Guidelines for UML profile design*
  - Useful for the profile structure and documentation
  - Does not provide guidance on selecting appropriate UML metaclasses...

# Future Work

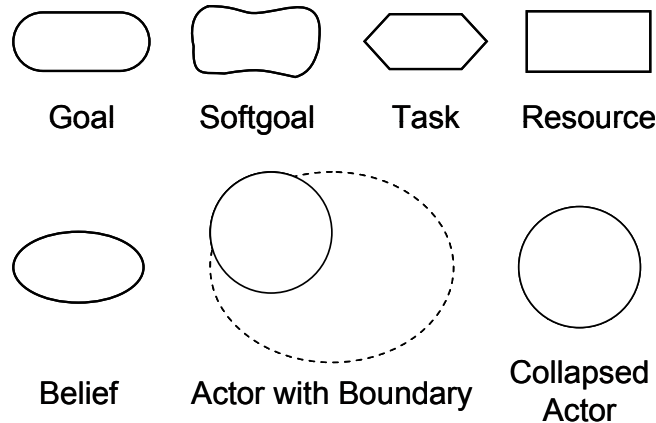
- Support of GRL strategies (for analysis) in the profile.
- Usability / practice study.
- Support of UCM for complete URN profile?
  - Looking for volunteers 😊
  - Towards ITU-T Z.159 standard on URN *or* GRL profile

# Thank you!

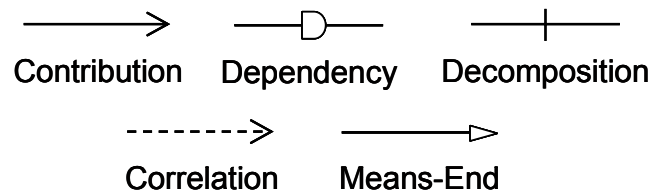
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  - University of Ottawa
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  - Master of Computer Science thesis available online
    - <http://www.UseCaseMaps.org/pub>
- jUCMNav Tool
  - <http://jucmnav.softwareengineering.ca/jucmnav/>



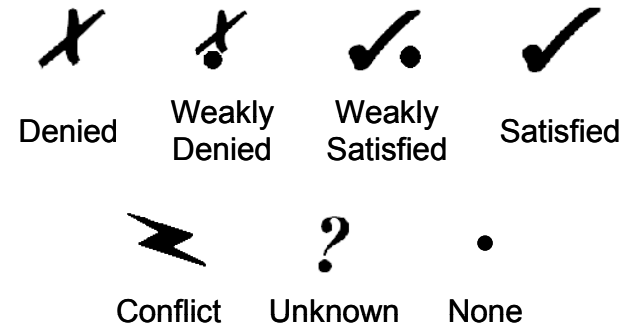
# GRL Notation Elements



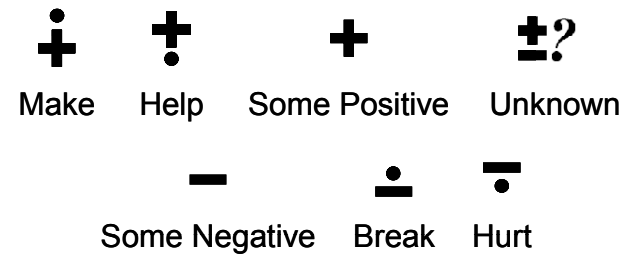
(a) GRL Elements



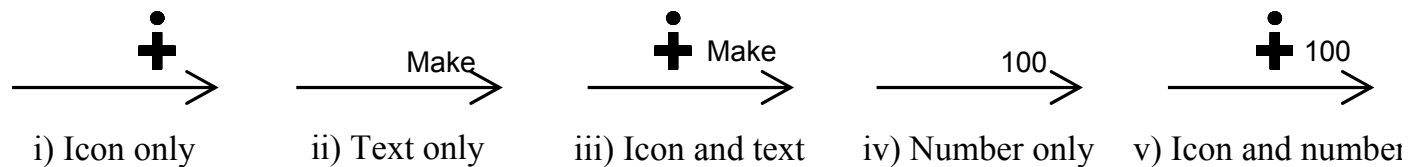
(b) GRL Links



(c) GRL Satisfaction Levels



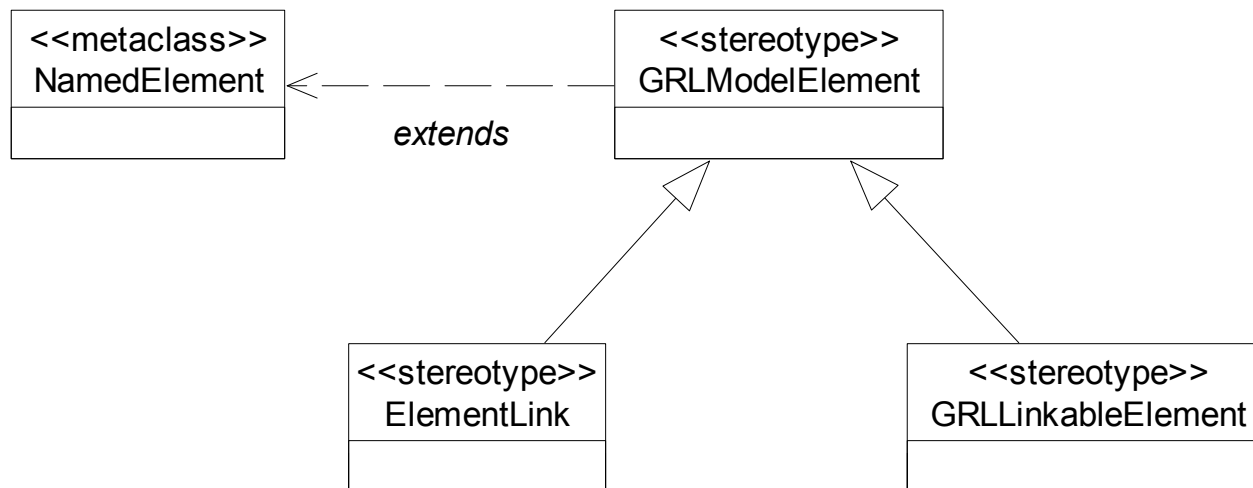
(d) GRL Contributions Types



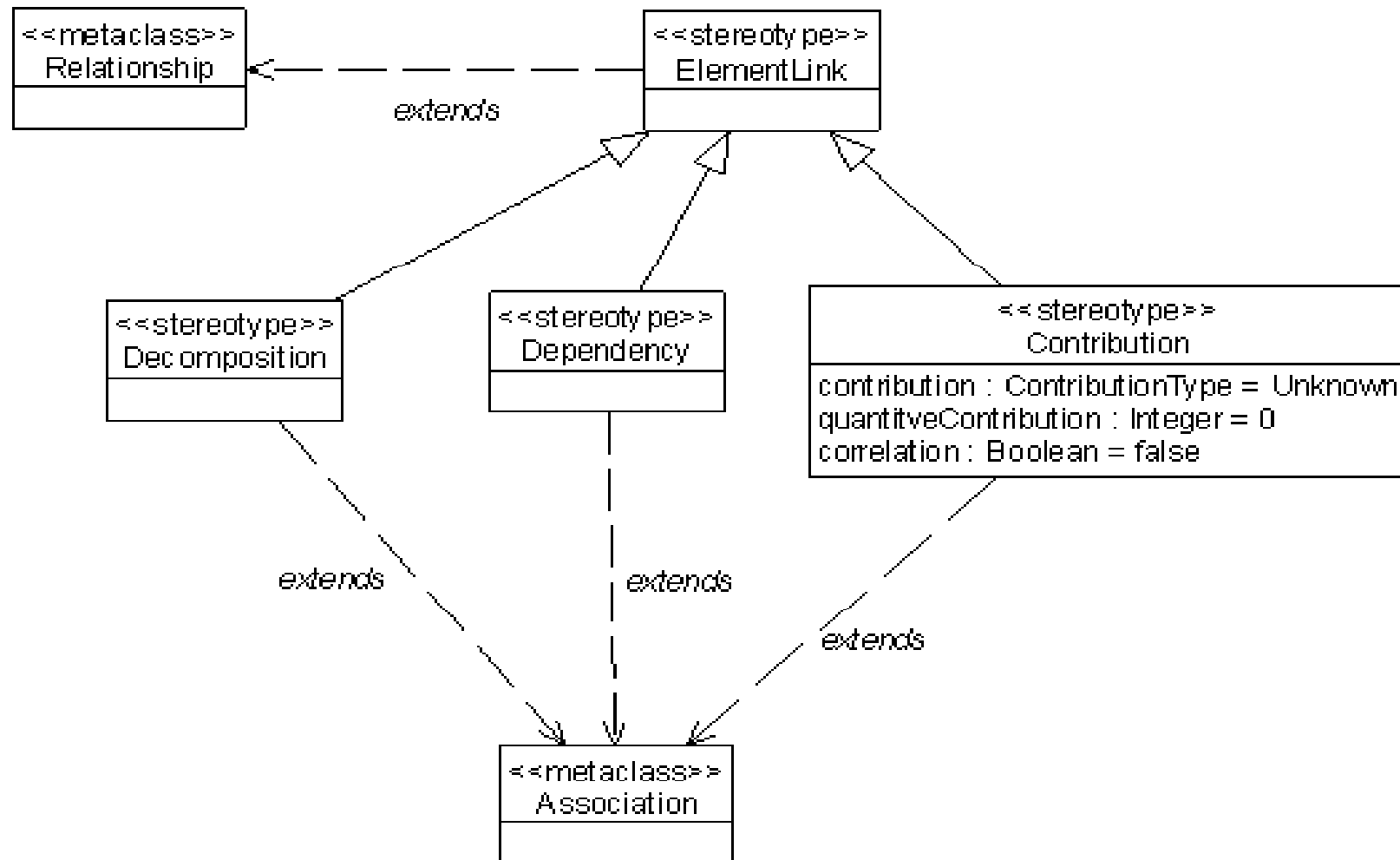
(e) Representations of Qualitative and Quantitative Contributions

# Overview of Profile

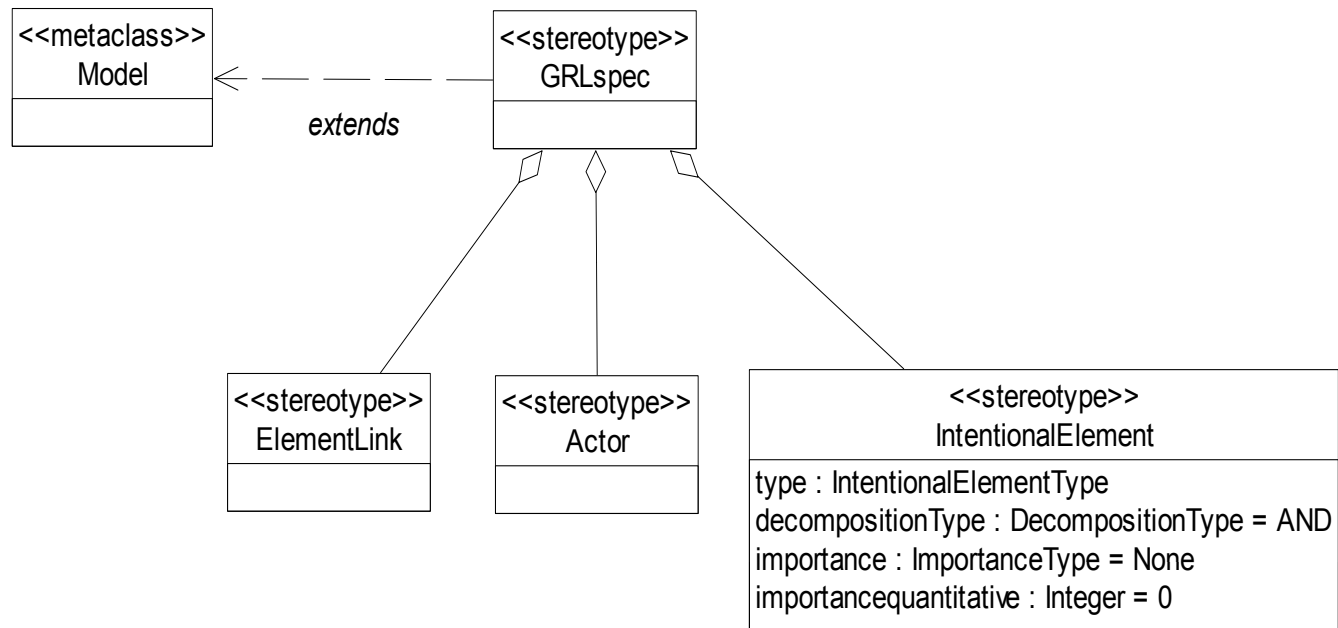
## GRL Model Element



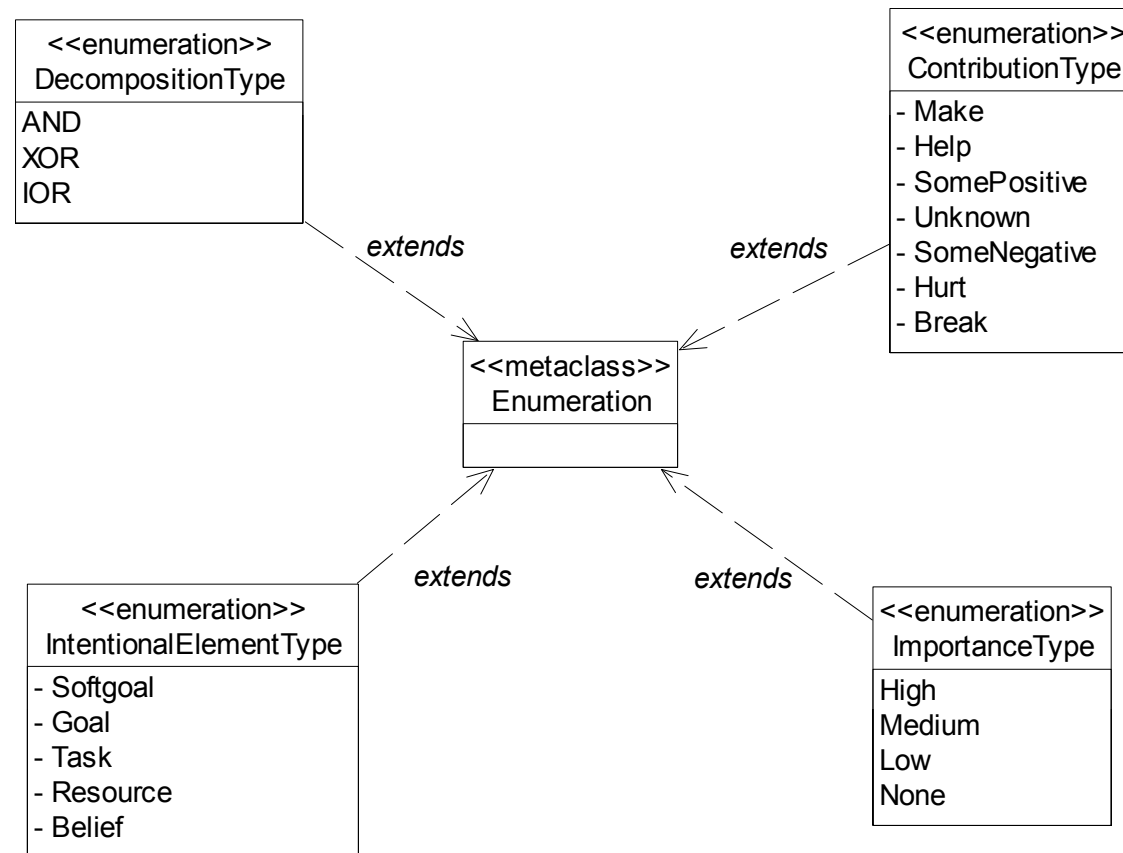
# Element Link



# GRL Spec

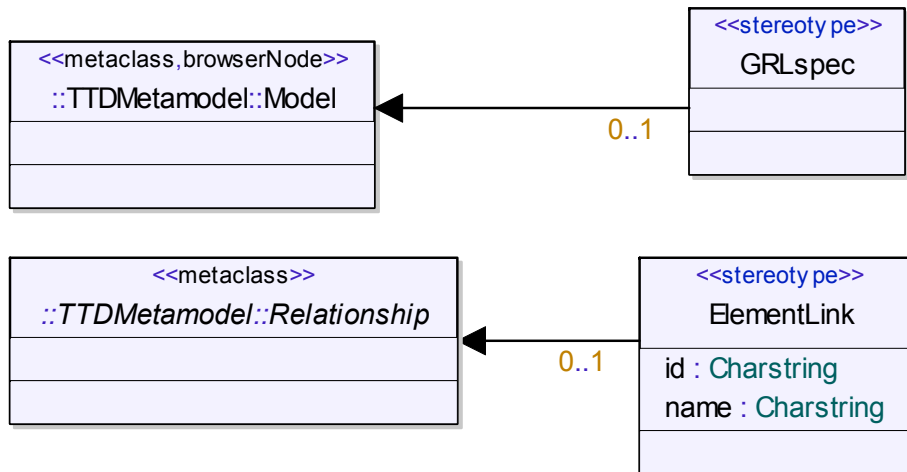
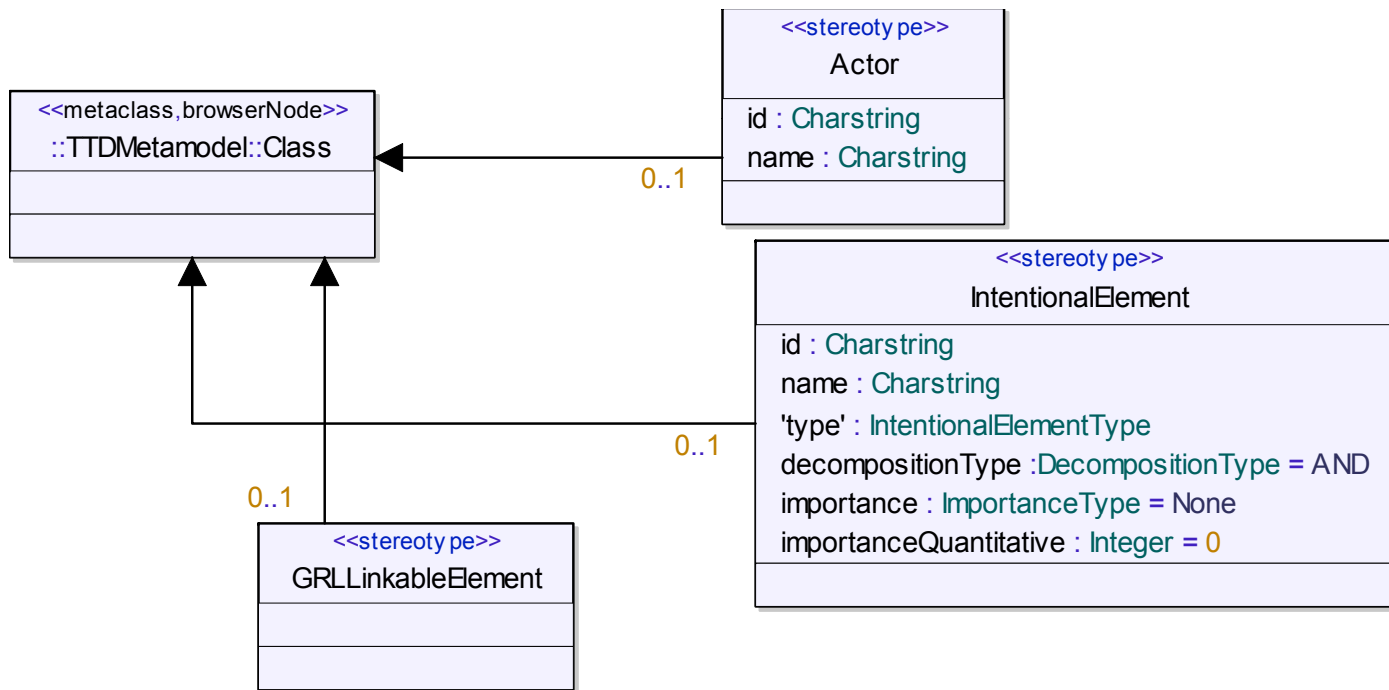


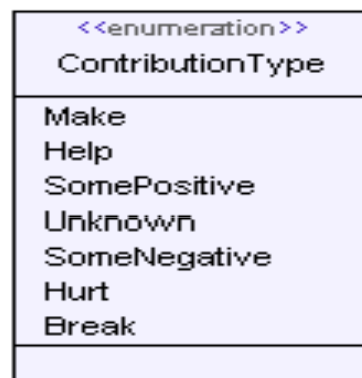
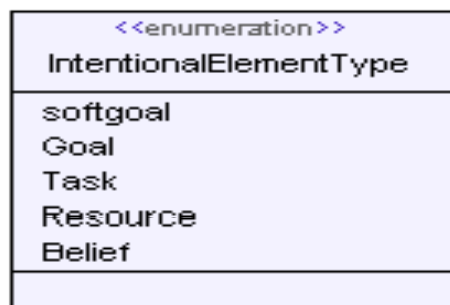
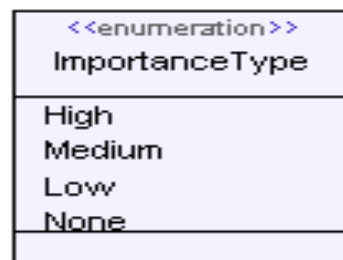
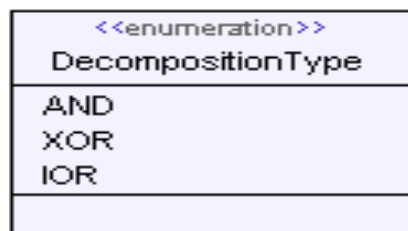
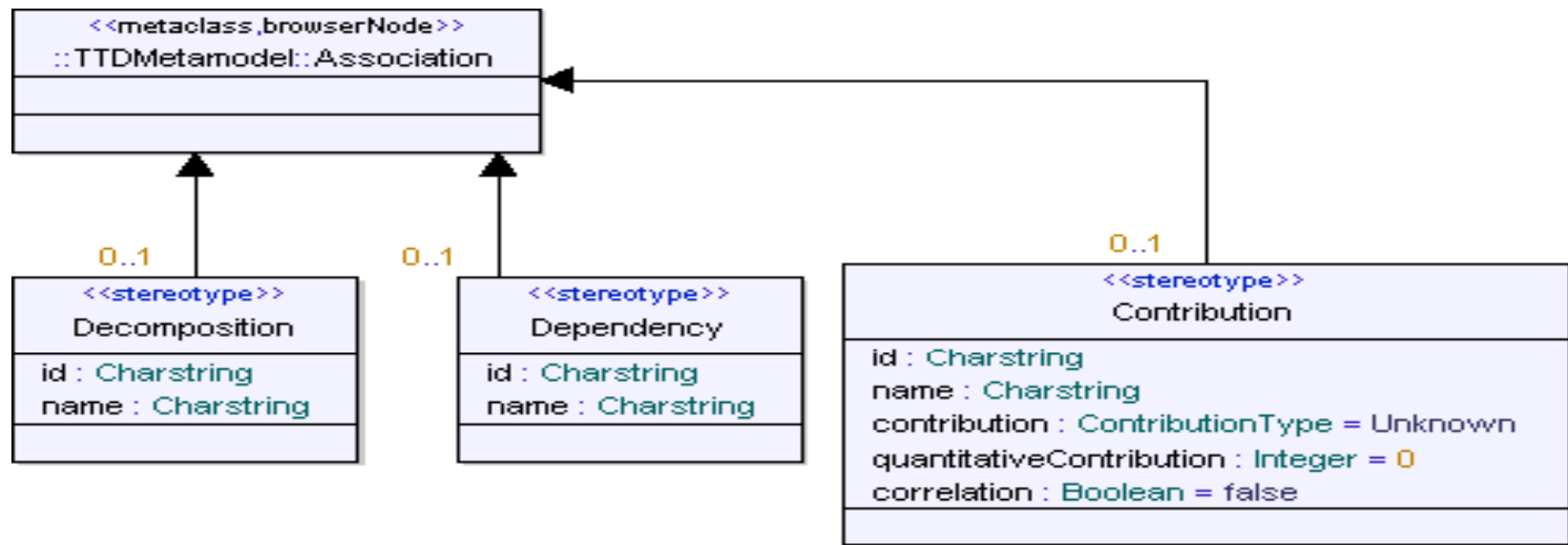
# Enumerations



# **GRL Profile in TAU**

## **Stereotype Mechanism**







# **GRL Profile in TAU**

## **Metamodel Extension Mechanism**

# Four Sub-Packages

- **GRL Model**
  - Contains all metaclasses used for GRL model creation.
- **GRL Editor**
  - Contains all of the information necessary to create a GRL editor, to specify which information can be kept by the editor, as well as to whom this information can be passed to.
- **GRL Concrete Elements**
  - Shows the metaclasses created for GRL elements. These metaclasses describe the actual GRL constructs.
- **GRL Abstract Elements**
  - Contains all of the stereotypes that represent the GRL profile elements.

