



## Human Factors in Modeling HuFaMo – MODELS'2017

# VISUAL VARIABLES IN UML: A FIRST EMPIRICAL ASSESSMENT

**Authors:** Yosser El Ahmar<sup>1,2</sup>, Xavier Le Pallec<sup>1</sup>, Sébastien Gérard<sup>2</sup>, Truong Ho Quang<sup>3</sup>

<sup>1</sup> University of Lille, CRISTAL Lab UMR 9189  
59650 Villeneuve d'Ascq,  
France

[xavier.le-pallec@univ-lille1.fr](mailto:xavier.le-pallec@univ-lille1.fr), [yosser.elahmar@etudiant.univ-lille1.fr](mailto:yosser.elahmar@etudiant.univ-lille1.fr)

<sup>2</sup> CEA, LIST, Laboratory of Model Driven Engineering for  
Embedded Systems. PC. 174, Gif-sur-Yvette,  
91191, France

{yosser.ELAHMAR, Sebastien.GERARD}@cea.fr

<sup>3</sup> Chalmers - Goteborg Univ, Sweden  
[truongh@chalmers.se](mailto:truongh@chalmers.se)





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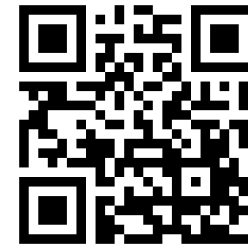
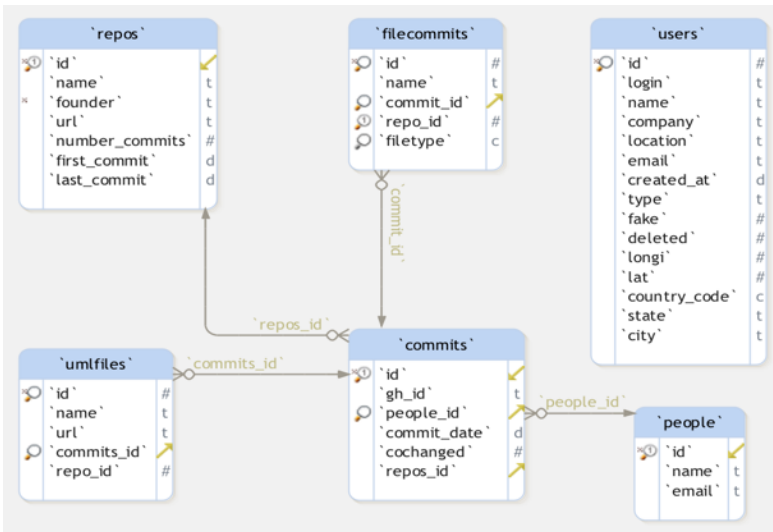
discussions



UML  
diagrams

# Lindholmen dataset

Understandings



<http://oss.models-db.com/>  
**93 648 UML models**  
**24 797 projects**

Motivations

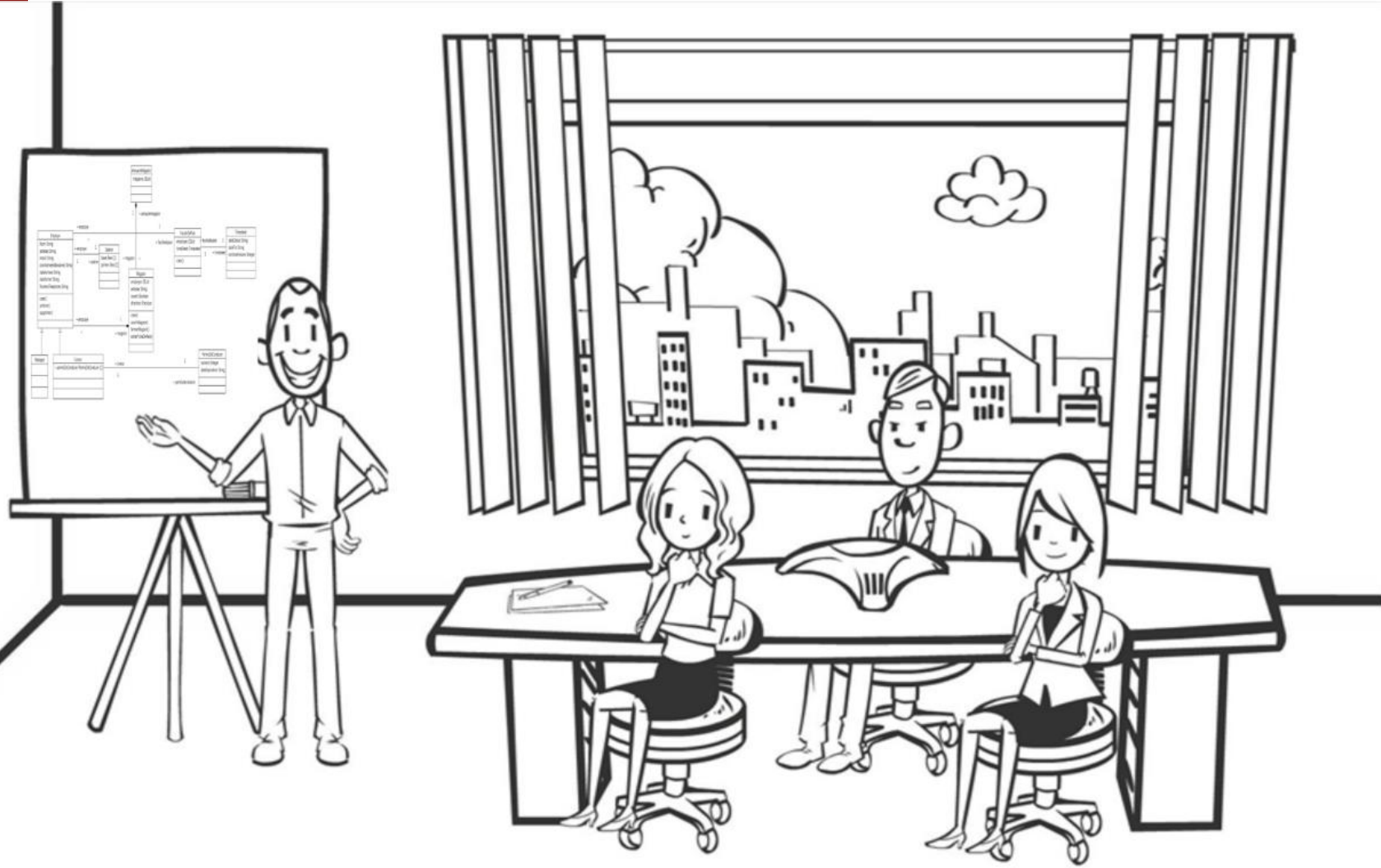
State of the art: The visual variables and UML

Design methodology: qualitative and quantitative methods

Obtained results: some statistics!

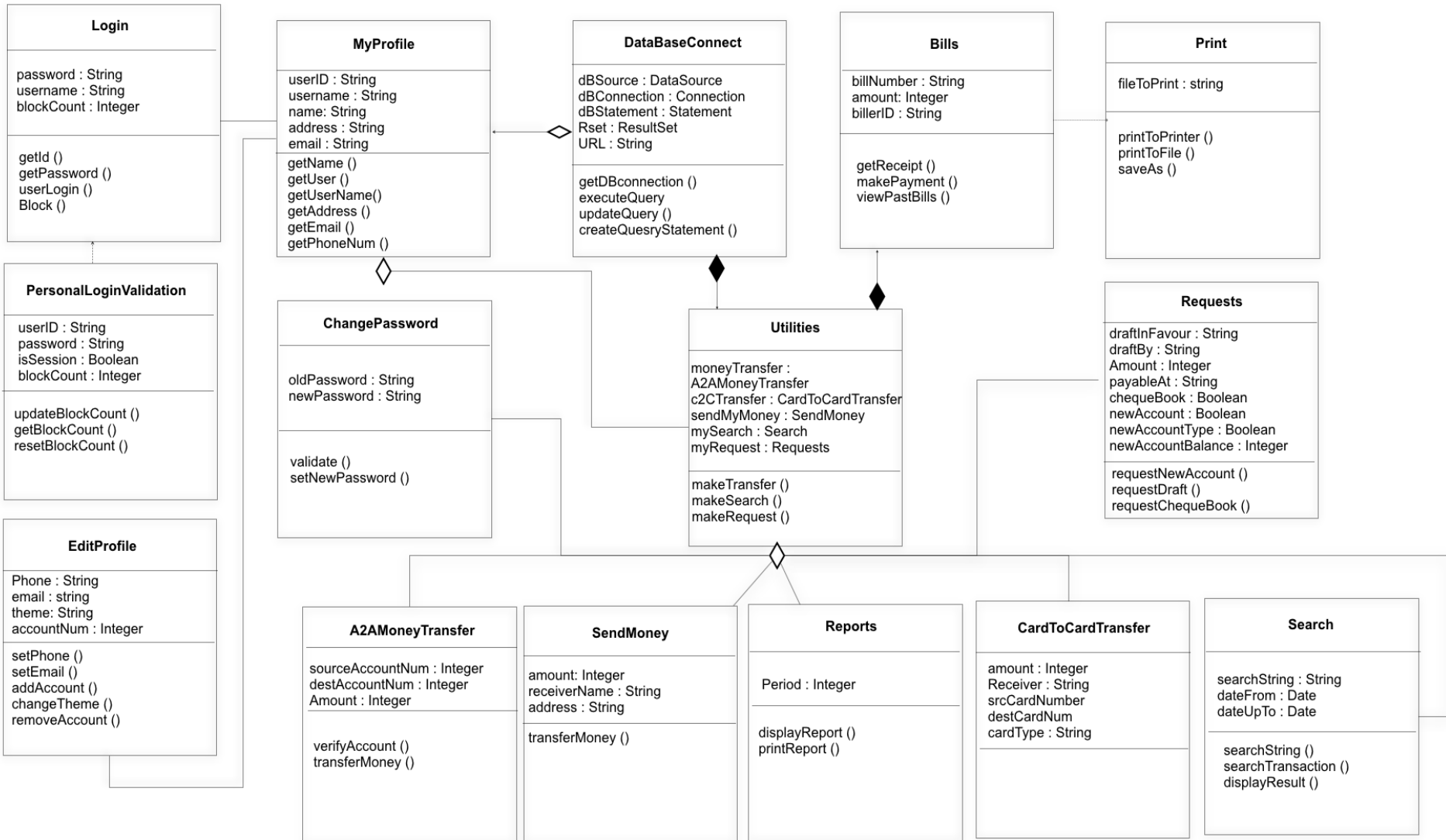
Discussion & conclusion

# COMMUNICATION WITH UML

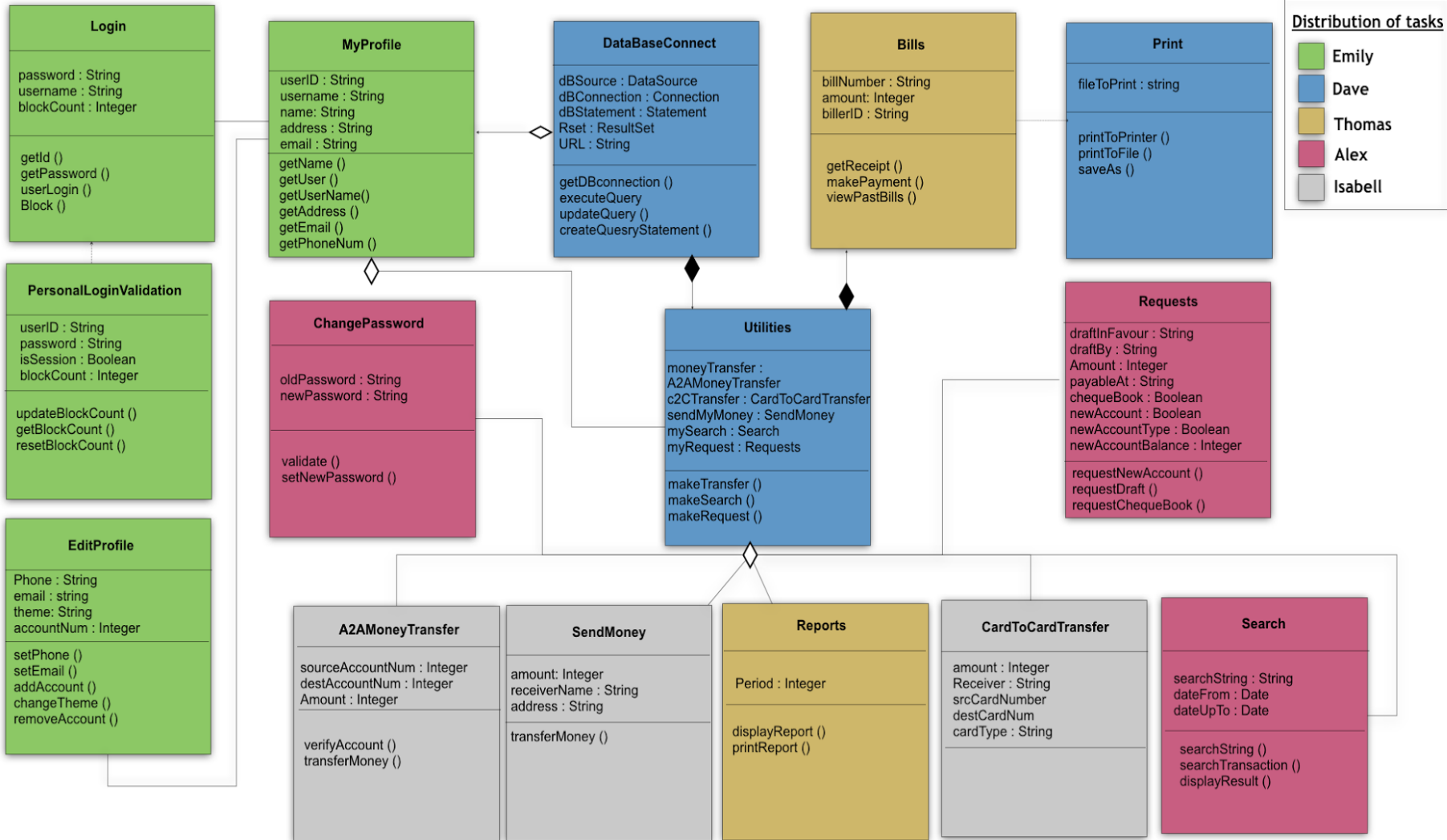




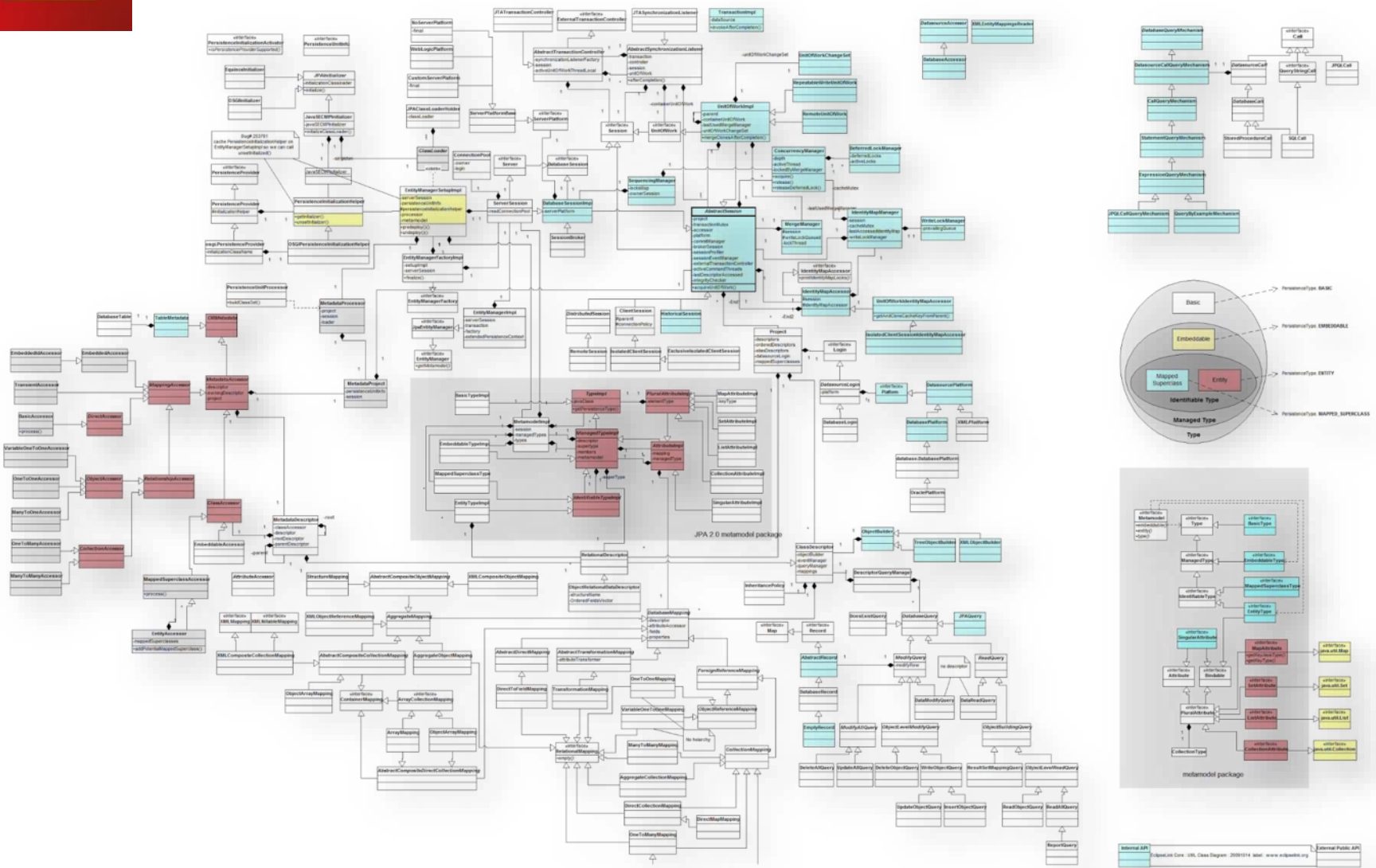
# EXAMPLE: A “SIMPLE” CLASS DIAGRAM



# BETTER COMMUNICATION WITH COLORS?



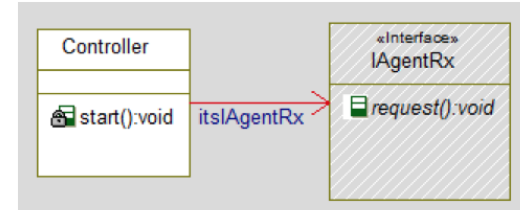
# A UML DIAGRAM IN REAL OSS PROJECT



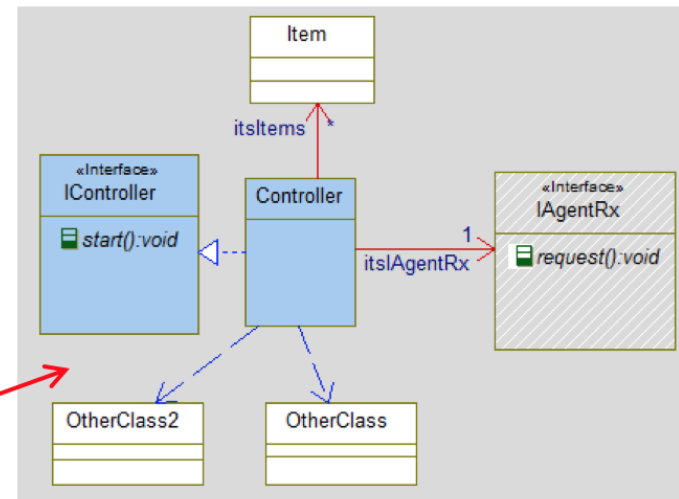
<https://github.com/ideaCompany/ideaCompany.github.io/blob/master/imgs/bigDiagram.png> - fullpage js

# UML DIAGRAM IN A REAL INDUSTRIAL PROJECT \*

- › Classes from referenced packages should be marked with (Format->Fill->Pattern: *Downward Diagonal*)
- › Classes that are the main focus of a diagram should be highlighted with blue (Format->Fill->Fill Color: *Blue*)
  - This typically includes any interfaces the class supplies as well
  - In unit tests the class under test is usually the main focus



Agent is referenced from another package



Controller (and its interface) is the focus of this diagram

\* Names of classes are changed



- **Cartography:**

[4] Bertin, J. Semiology of graphics: diagrams, networks, maps.

**Semiology of graphics:** A set of 7 visual variables + objective rules to control their effective use.

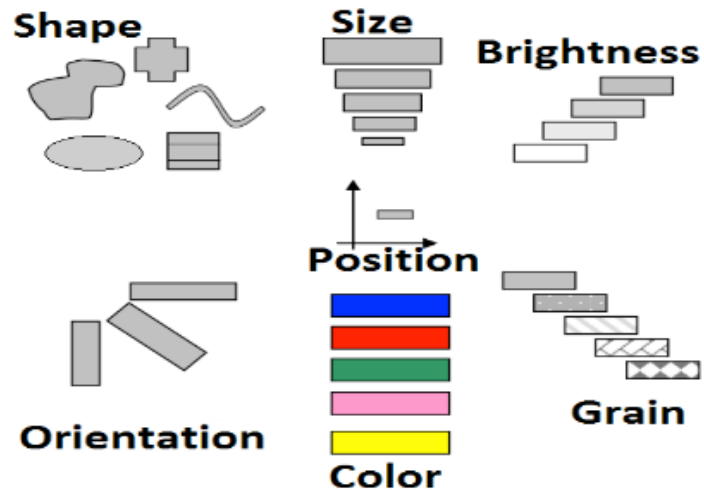


Fig1: Visual variables: Planar dimensions + retinal variables

# INSUFFICIENT EMPIRICAL RESEARCH ABOUT VISUAL VARIABLES IN UML

- **Empirical studies focus only on layouts and colors. The other visual means are not yet evaluated.**

[1] Yusuf, S., Kagdi, H., and Maletic, J. I. Assessing the comprehension of UML class diagrams via eye tracking. In 15th IEEE International Conference on Program Comprehension (ICPC'07) (2007), IEEE, pp. 113{122.

[2] K. Wong and D. Sun, "On evaluating the layout of UML diagrams for program comprehension," Software Quality Journal, vol. 14, no. 3, pp.233–259, 2006.

[3] B. Sharif and J. I. Maletic, "An empirical study on the comprehension of stereotyped UML class diagram layouts," in Program Comprehension, 2009. ICPC'09. IEEE 17th International Conference on. IEEE, 2009, pp. 268–272.

[4] H. C. Purchase, L. Colpoys, D. Carrington, and M. McGill, "UML class diagrams: an empirical study of comprehension," in Software Visualization. Springer, 2003, pp. 149–178.

- **Several existing empirical studies about UML use in practice**

[5] A. Forward, T. C. Lethbridge, and O. Badreddin, "Perceptions of Software Modeling: A Survey of Software Practitioners," University of Ottawa, Tech. Rep., 2010.

[6] B. Dobing and J. Parsons, "How uml is used," Commun. ACM, vol. 49, no. 5, pp. 109–113, May 2006. [Online]. Available: <http://doi.acm.org/10.1145/1125944.1125949>

[7] M. R. V. Chaudron, W. Heijstek, and A. Nugroho, "How effective is uml modeling?" Software & Systems Modeling, vol. 11, no. 4, pp. 571–580, 2012.

- **Research questions**

- (1) What are the contexts of the use of UML models in the software practitioner's real situations?
- (2) What is the state of use of the visual variables in UML?

- **Theoretical perspective**

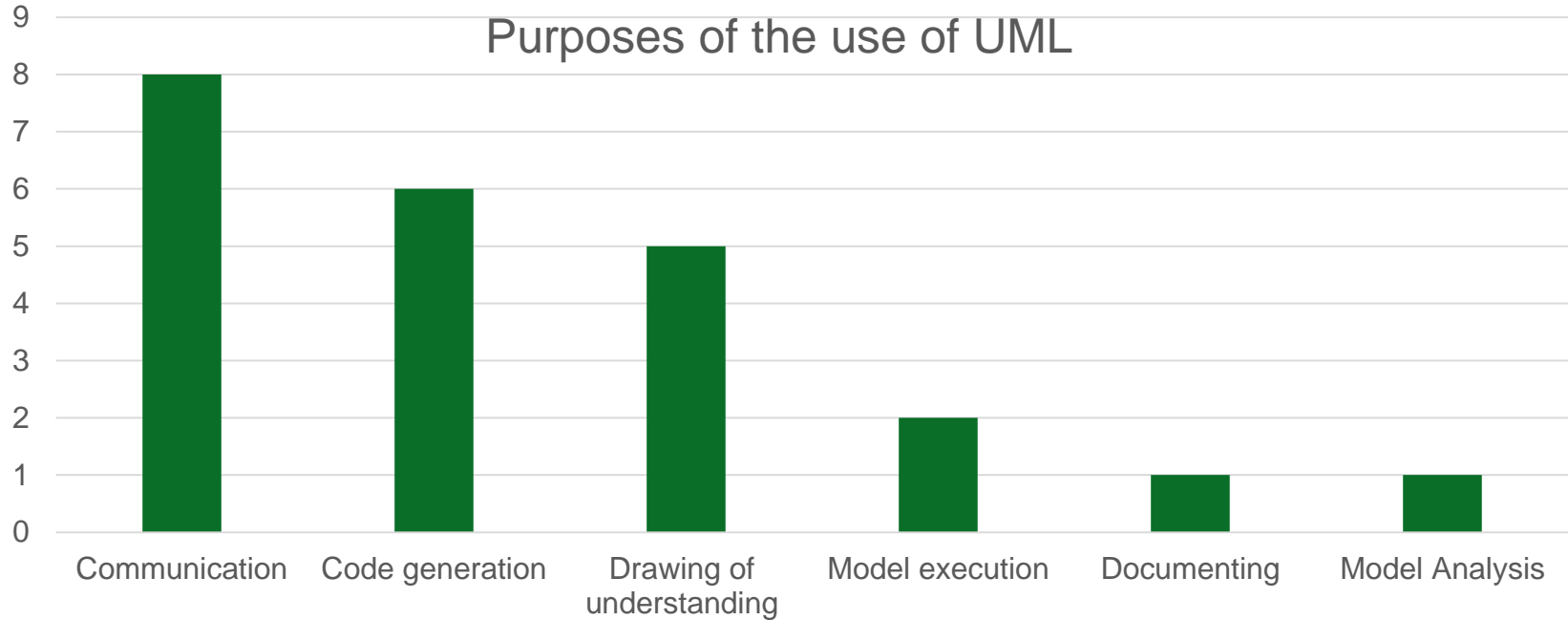
- Studying the benefits of the visual variables in UML.
- Providing scientific frameworks and effective tools.

- **Qualitative method:**
  - **Data collection procedure:** Interviews
  - **Focus:** Papyrus tool developers and users community + MDE community
  - **Actors:** 8 experts & practitioners of UML
  - **Roles of the actors:** requirement manager, software architect, software designer, software engineers
  - **Domains:** transportation, aerospace engineering and defense, avionics, telecommunication, E-commerce, insurance, banking.
- **Quantitative method: Analysis of +3500 UML diagrams**
  - 3328 class diagrams, 392 sequence diagrams
  - Manual classification
  - Diagrams from open source projects in GitHub (<http://oss.models-db.com/>)

R. Hebig, T. Ho-Quang, G. Robles, M. Fernandez, and M. R. V. Chaudron, "The quest for open source projects that use uml: mining github," in Proceedings of the ACM/IEEE 19th International Conference on Model Driven Engineering Languages and Systems. ACM, 2016, pp. 173–183.

# Qualitative study: Interviews

# COMMUNICATION IS THE FIRST PURPOSE OF USING UML



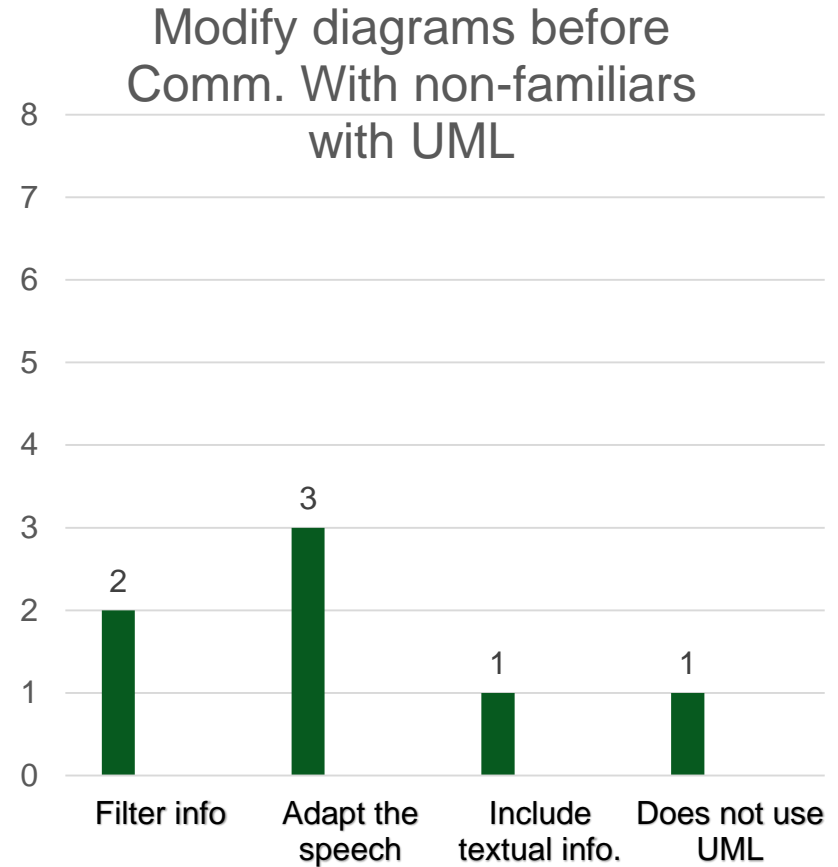
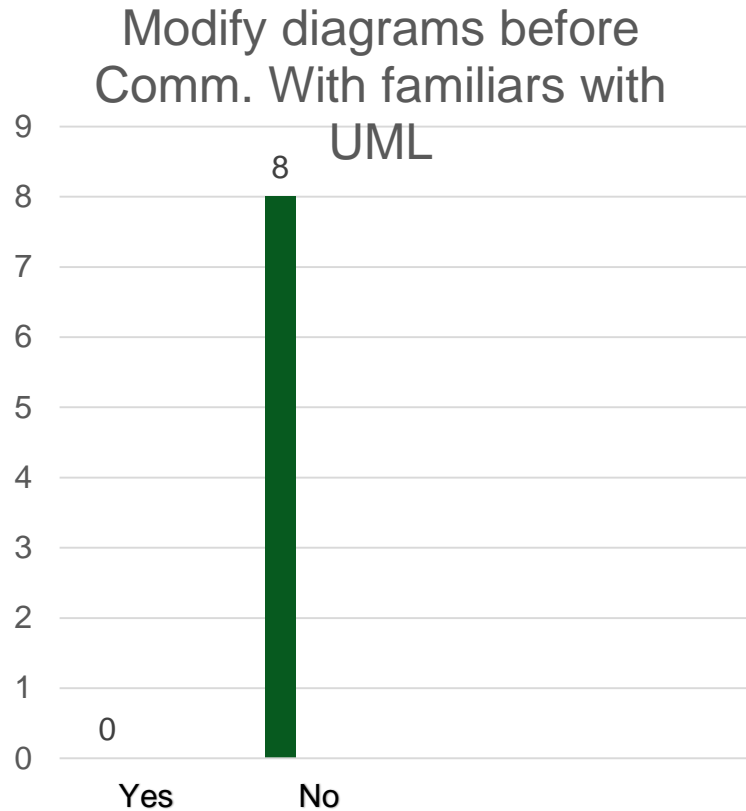
- Coherence with existing empirical researches

[8] Ho-Quang, Truong, et al. "Practices and perceptions of UML use in open source projects." Proceedings of the 39th International Conference on Software Engineering: Software Engineering in Practice Track. IEEE Press, 2017.

[8] W. J. Dzidek, E. Arisholm, and L. C. Briand, "A realistic empirical evaluation of the costs and benefits of UML in software maintenance," Software Engineering, IEEE Transactions on, vol. 34, no. 3, pp. 407–432, 2008.

[9] B. Dobing and J. Parsons, "How uml is used," Commun. ACM, vol. 49, no. 5, pp. 109–113, May 2006. [Online]. Available: <http://doi.acm.org/10.1145/1125944.1125949>

# CONTEXTUALIZE DIAGRAMS ONLY WITH NON-FAMILIARS WITH UML



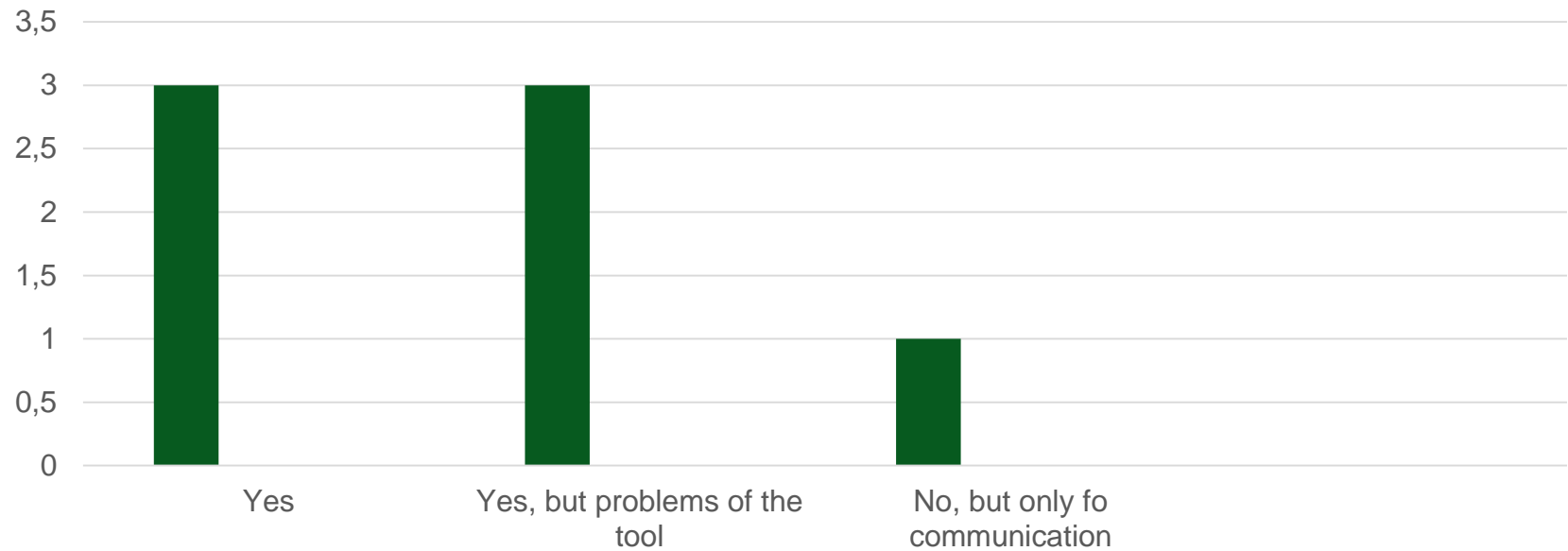
# PRACTITIONERS NEED TO VISUALIZE INFORMATION IN THEIR DIAGRAMS

- **Semantic information** (Search for what is modeled)
  - Input and outputs statements for the requirements
  - The communication in a sequence diagram to understand the logic
  - Functionalities of the system
  - Across functions
  - Interactions of a system
  - Reference for specific signals or events in the model
- **Extra-semantic information** (Something that cannot be described by UML)
  - What has been implemented
  - Bugs in the model



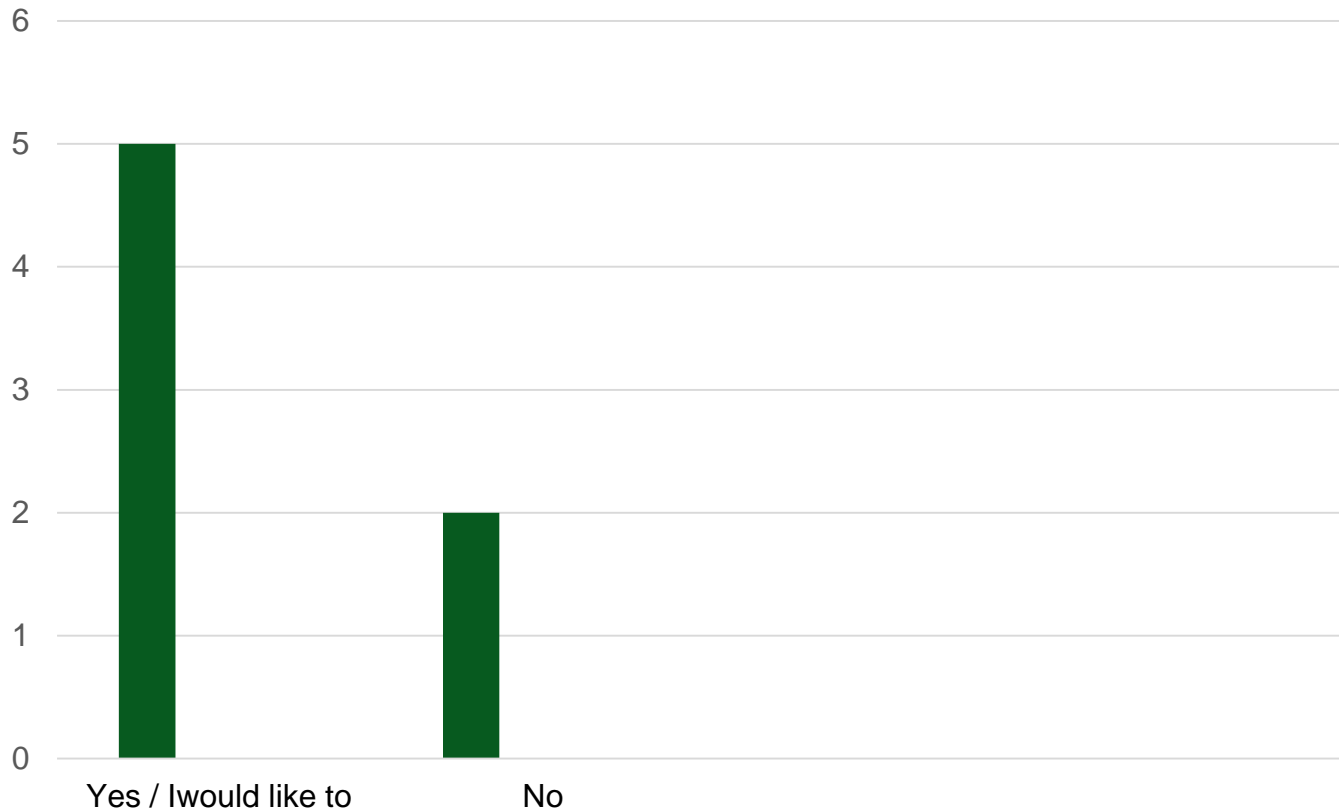
- **Semantic information**
  - Important features like inheritance, interface
  - Elements that have the same semantic
  
- **Extra-semantic information**
  - Specific layers: entities, dataAccessObjects, services.
  - Critical functions : the order
  - Progress of the development
  - Model, View and Controller elements MVC
  - Levels of security
  - Comments: color the text inside
  - My subsystem in the whole system

Were colors helpful?



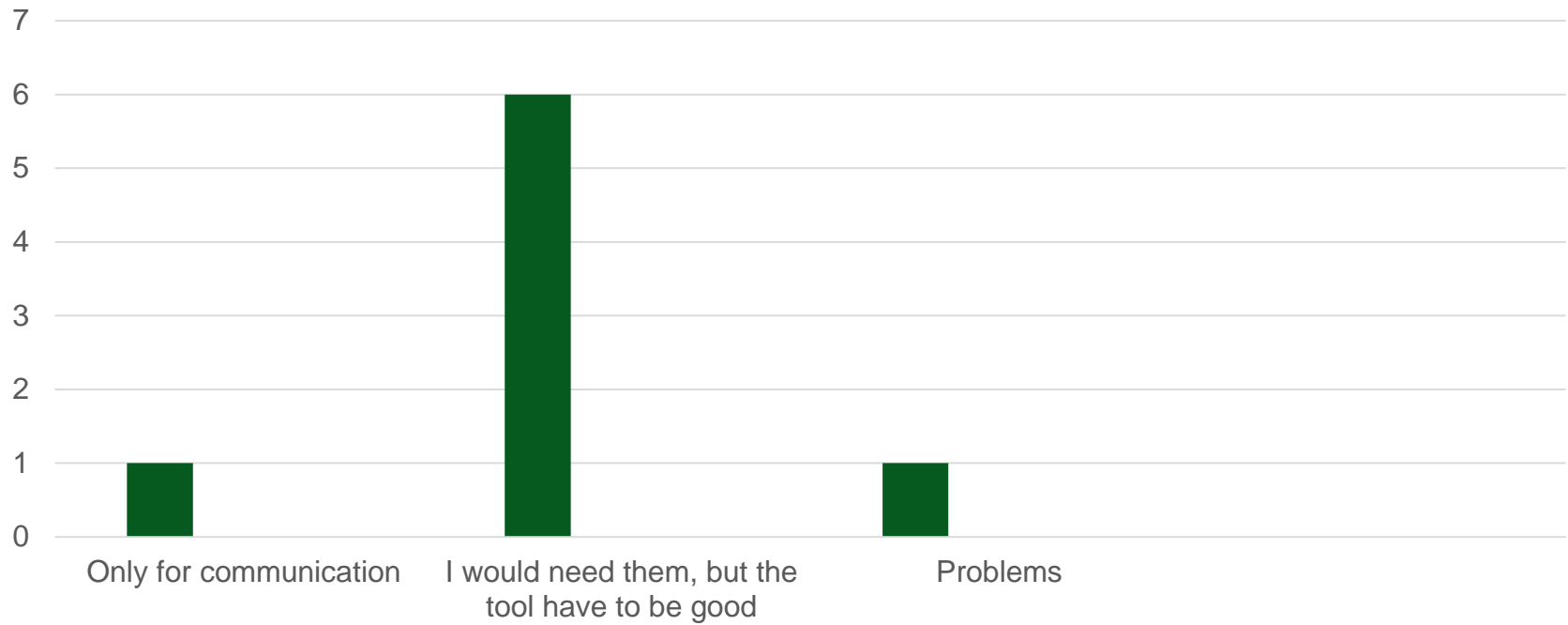
## KEYS ARE NEEDED

Need for keys when you use colors?



# THE VISUAL VARIABLES MIGHT BE HELPFUL

Do you think that the visual variable are helpful?



# Quantitative analysis of UML models

3328 class diagrams, 392 sequence diagrams

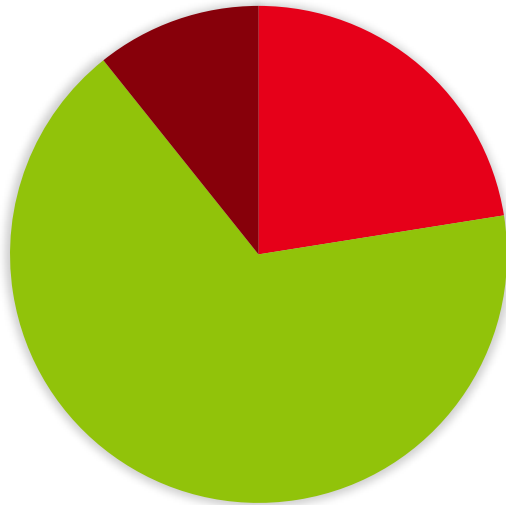
Manual classification

Diagrams from open source projects in GitHub (<http://oss.models-db.com/>)

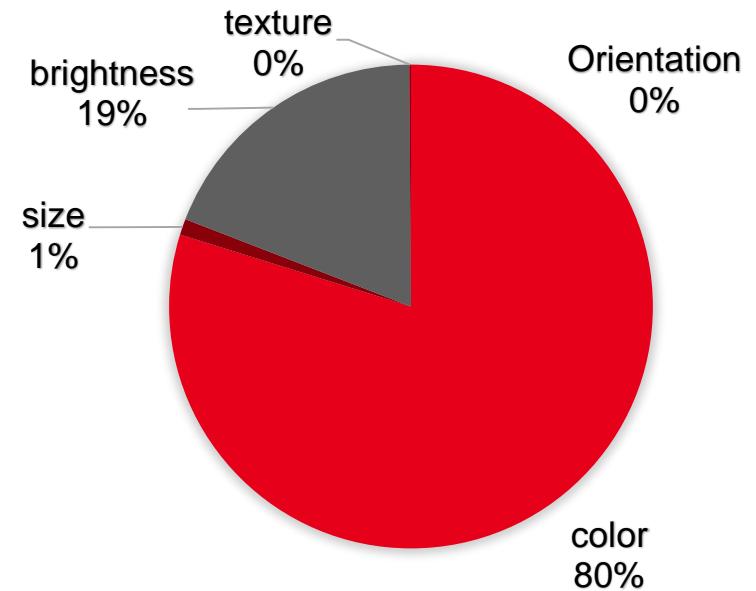
# COLOR IS THE MOST USED VISUAL VARIABLE

## 6.1: VISUAL VARIATIONS

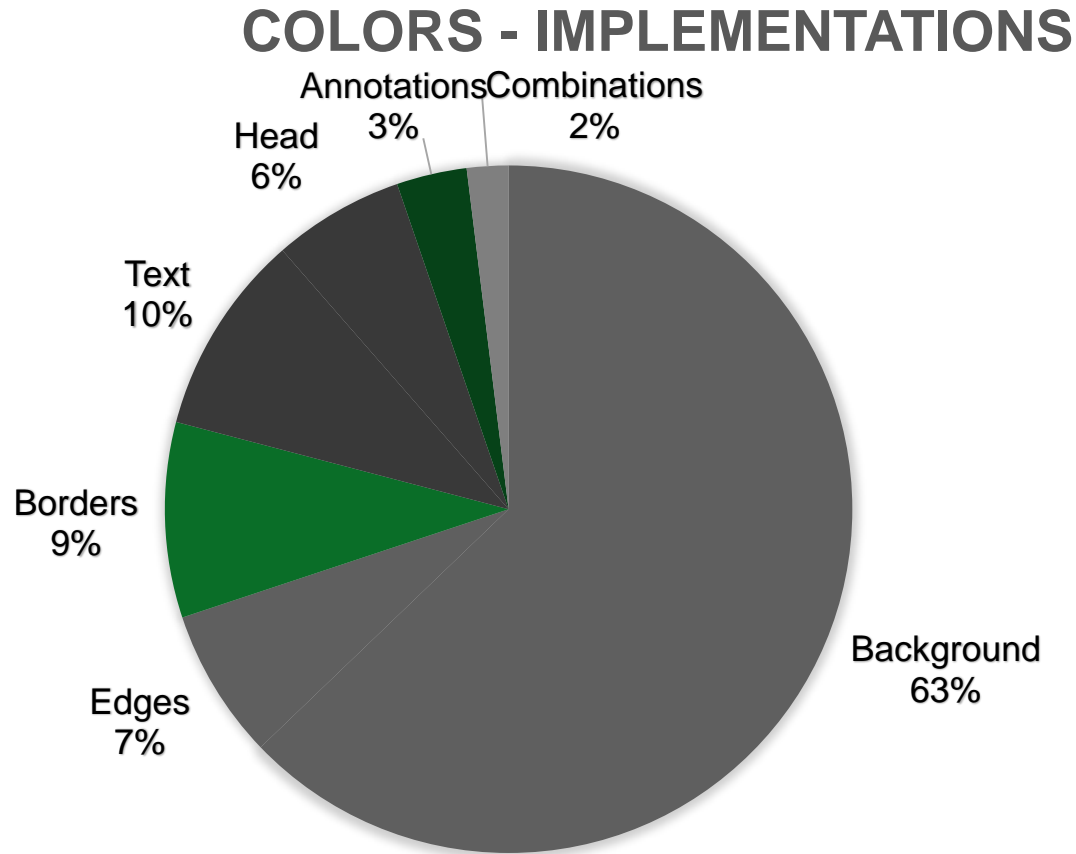
No visual  
variations  
11%



## 6.2: SIGNIFICANT VARIATIONS: VISUAL VARIABLES

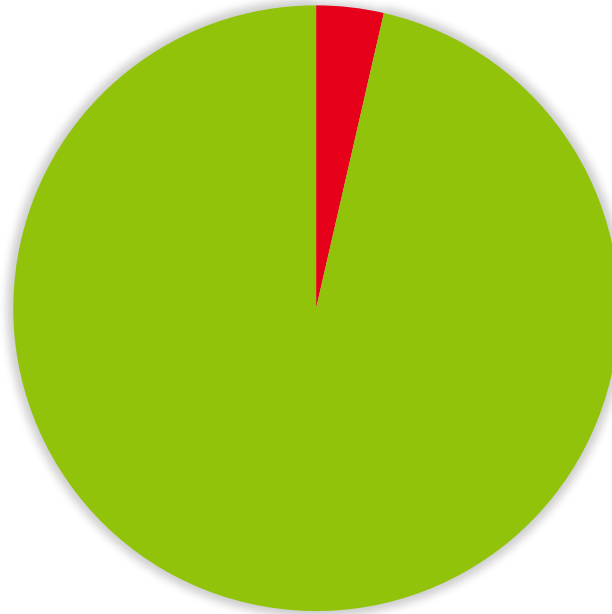


# DIFFERENT IMPLEMENTATIONS OF THE COLORS



**NO KEYS !**

## PRESENCE OF KEYS WITH SIGNIFICANT VISUAL VARIATIONS





- Different usages of UML in different situations
- Need to visualize semantic and extra-semantic information
- Highlighted information using colors are mostly selective

- Color is the most used visual variable
- A recurrent non effective use of colors: No keys
- The other visual variables might be helpful in practice \*

- **Possible improvement to modeling tools**
  - Automatic
  - Allows adding keys: interactive keys
  - Definition of rules of mappings between the visual variables and the information to highlight
  - Subtlety of the visual variations
  - Considering large organizations and collaboration
  - Different usages of colors in UML elements: background, borders, text, etc: What are the most effective ones?

Thank you for your attention

Questions?

yosser.ELAHMAR@cea.fr

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