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PyRDV: a Python-based solution to the requirements traceability problem

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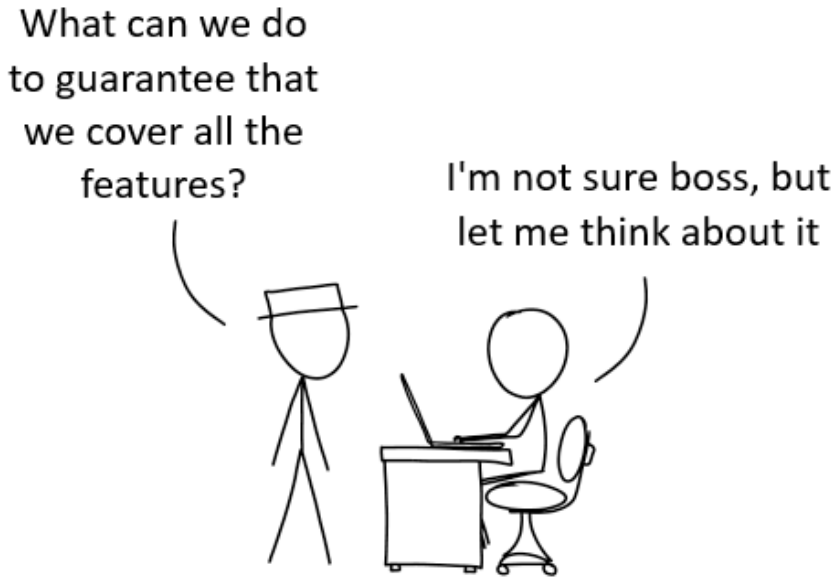
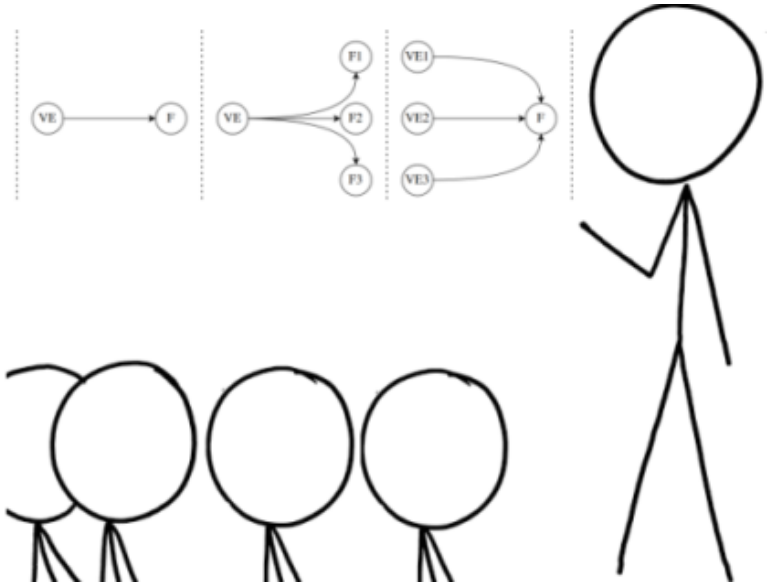
Agenda

- Motivation
- What's PyRDV?
- Sample Case
- Conclusions

Motivation


Hi boss, I'm going to do a master!
Let me know when you've learned something new...


What can we do to guarantee that we cover all the features?
I'm not sure boss, but let me think about it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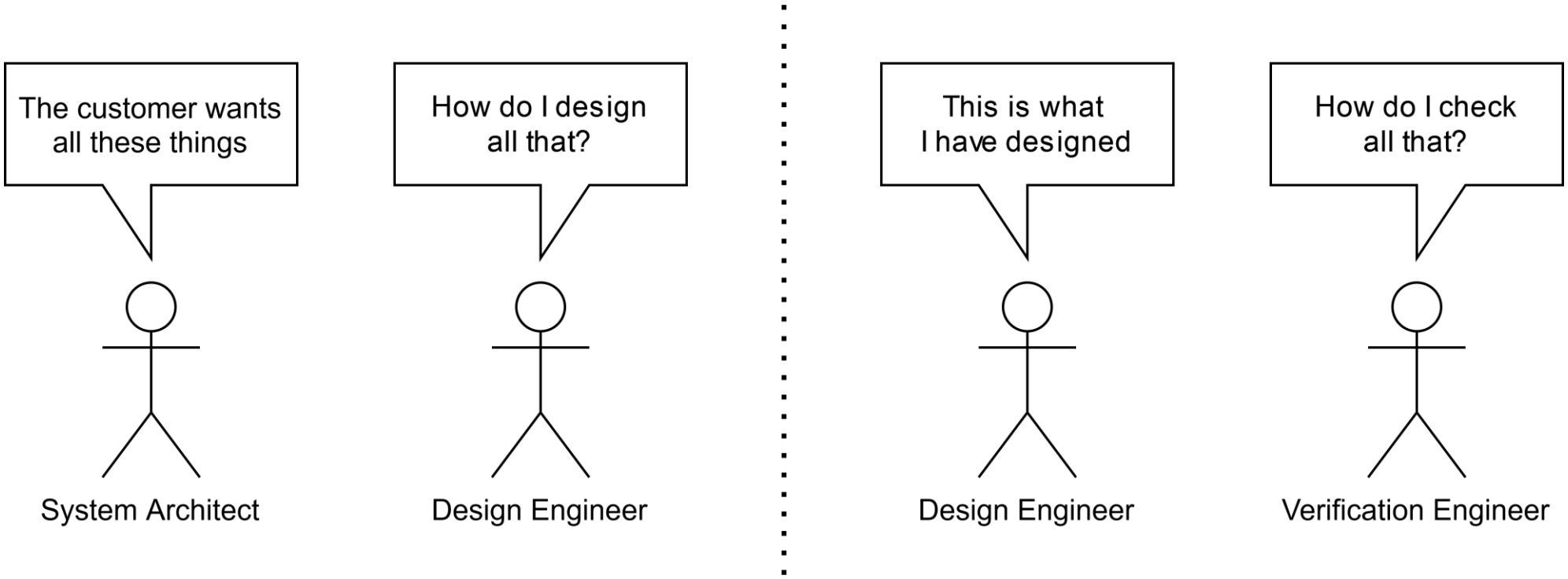
Motivation



Two consumer-producer problems

Motivation

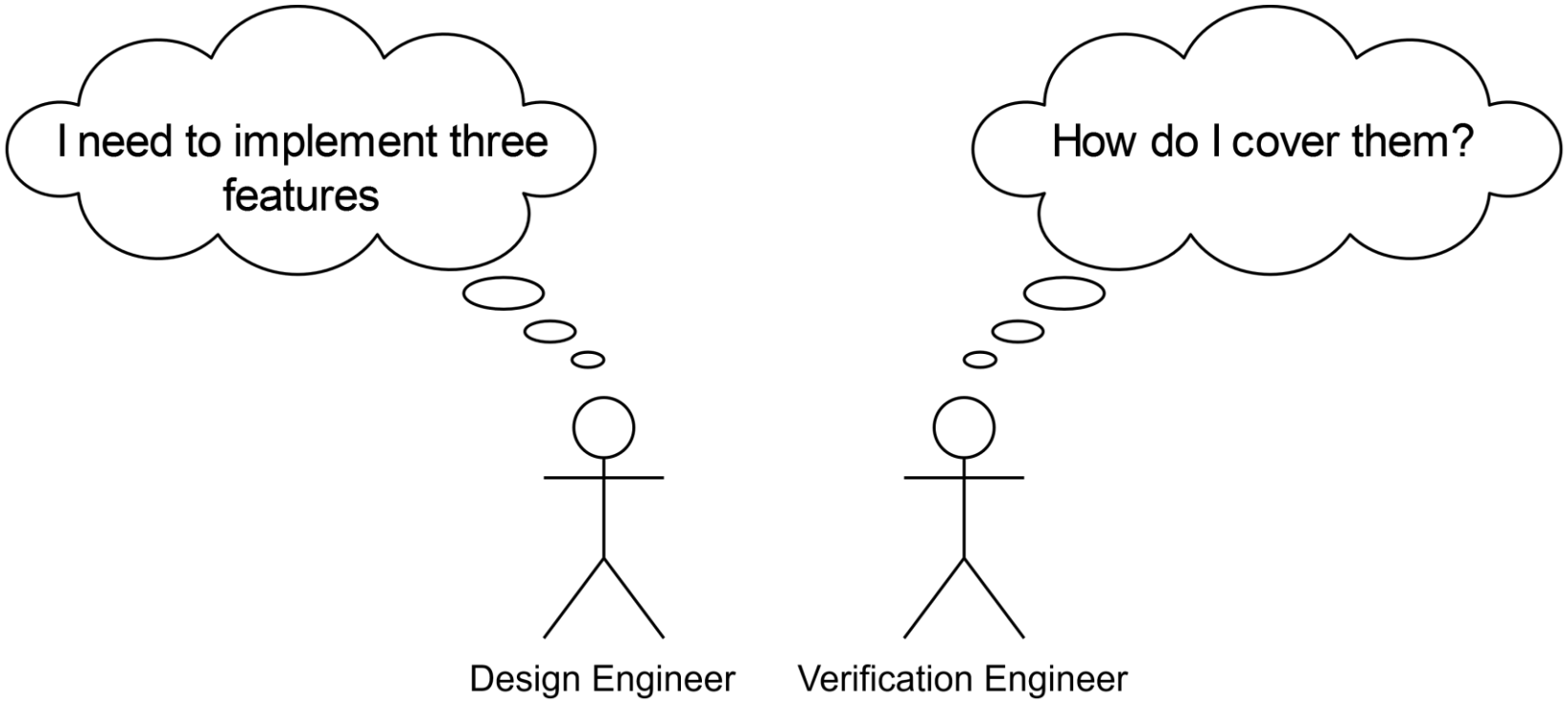
- A successful design will meet the following conditions:
  - Designers must implement all the requirements
  - Verification engineers must verify all design specifications

- We need to solve
  - Requirements To Features Mapping Problem
  - Features To Verification Elements Mapping Problem

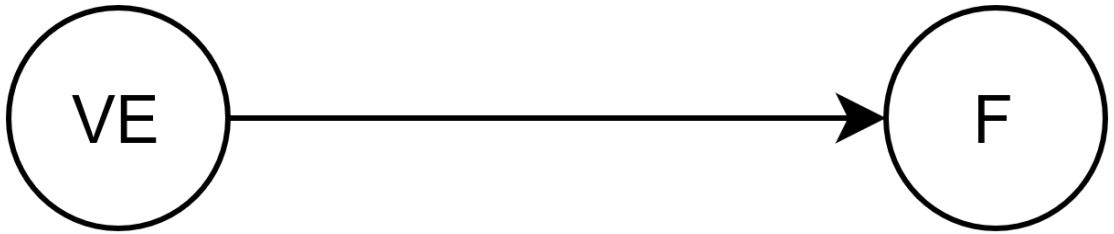
What's PyRDV?

- A theoretical framework to prove the solution to the problem
- A detailed workflow for IC Developers
- A CI / CD service to periodically check for sign-off metrics
- A Python-based software solution

Theoretical Framework

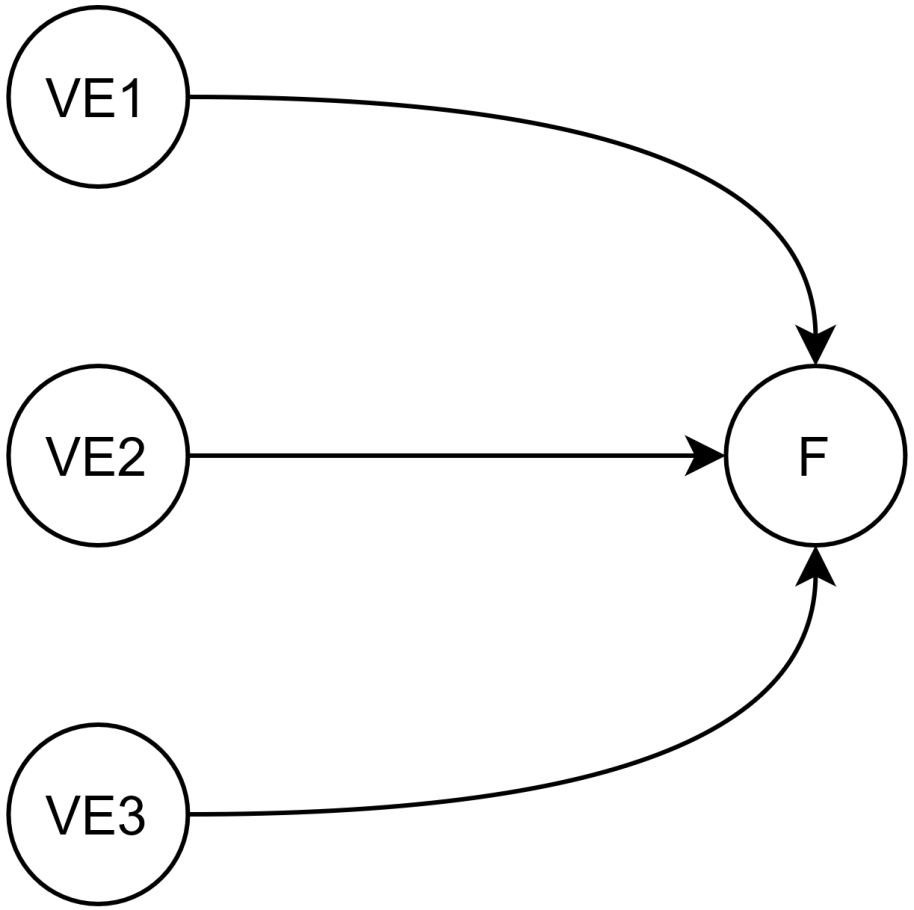


Theoretical Framework



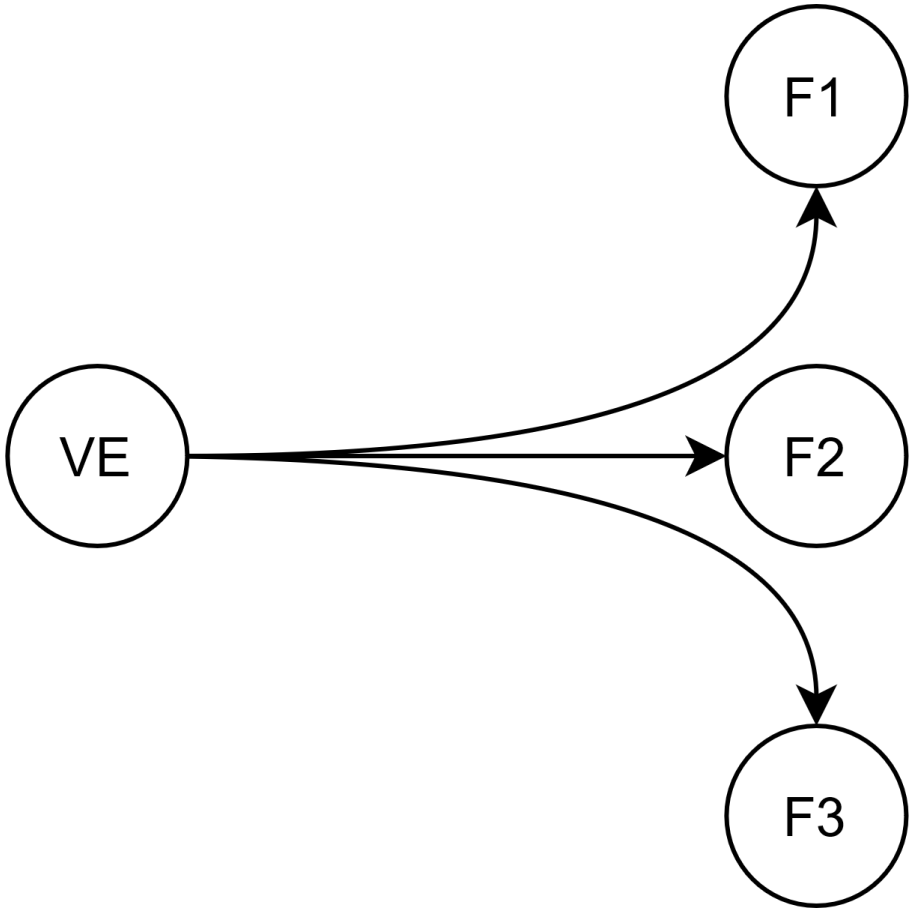
- One-To-One Relation
- Preferred case
- **Strongly covered** feature
- **Strongly linked** verification element

Theoretical Framework



- Many-To-One Relation
- **Weakly covered** feature
- Not atomic feature
- Might require feature slicing

Theoretical Framework



- One-To-Many Relation
- **Strongly covered** features
- Integration/top-level test
- Simple features

Theoretical Framework

- Unrelated elements
- **Uncovered** feature
  - Coverage hole
- **Useless** verification element
  - Over-engineering

Theoretical Framework

$$g : F \times V \rightarrow \{0,1\} \; such \; that \; g(i,j) = \begin{cases} 1 & if \; feature_i \; is \; verified \; by \; verification \; element_j \\ 0 & if \; not \end{cases}$$

$$\begin{pmatrix} g(1,1) & g(1,2) & ... & g(1,N) \\ g(2,1) & g(2,2) & ... & g(2,N) \\ ... & ... & ... & ... \\ g(M,1) & g(M,2) & ... & g(M,N) \end{pmatrix} = \begin{pmatrix} 0 & 1 & ... & 0 \\ 1 & 0 & ... & 0 \\ ... & ... & ... & ... \\ 0 & 0 & ... & 1 \end{pmatrix}$$

Theoretical Framework

$$\begin{pmatrix} g(1,1) & g(1,2) & \dots & g(1,N) \\ g(2,1) & g(2,2) & \dots & g(2,N) \\ \dots & \dots & \dots & \dots \\ g(M,1) & g(M,2) & \dots & g(M,N) \end{pmatrix} = \begin{pmatrix} 0 & 1 & \dots & 0 \\ 1 & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & 1 \end{pmatrix}$$

Theoretical Framework

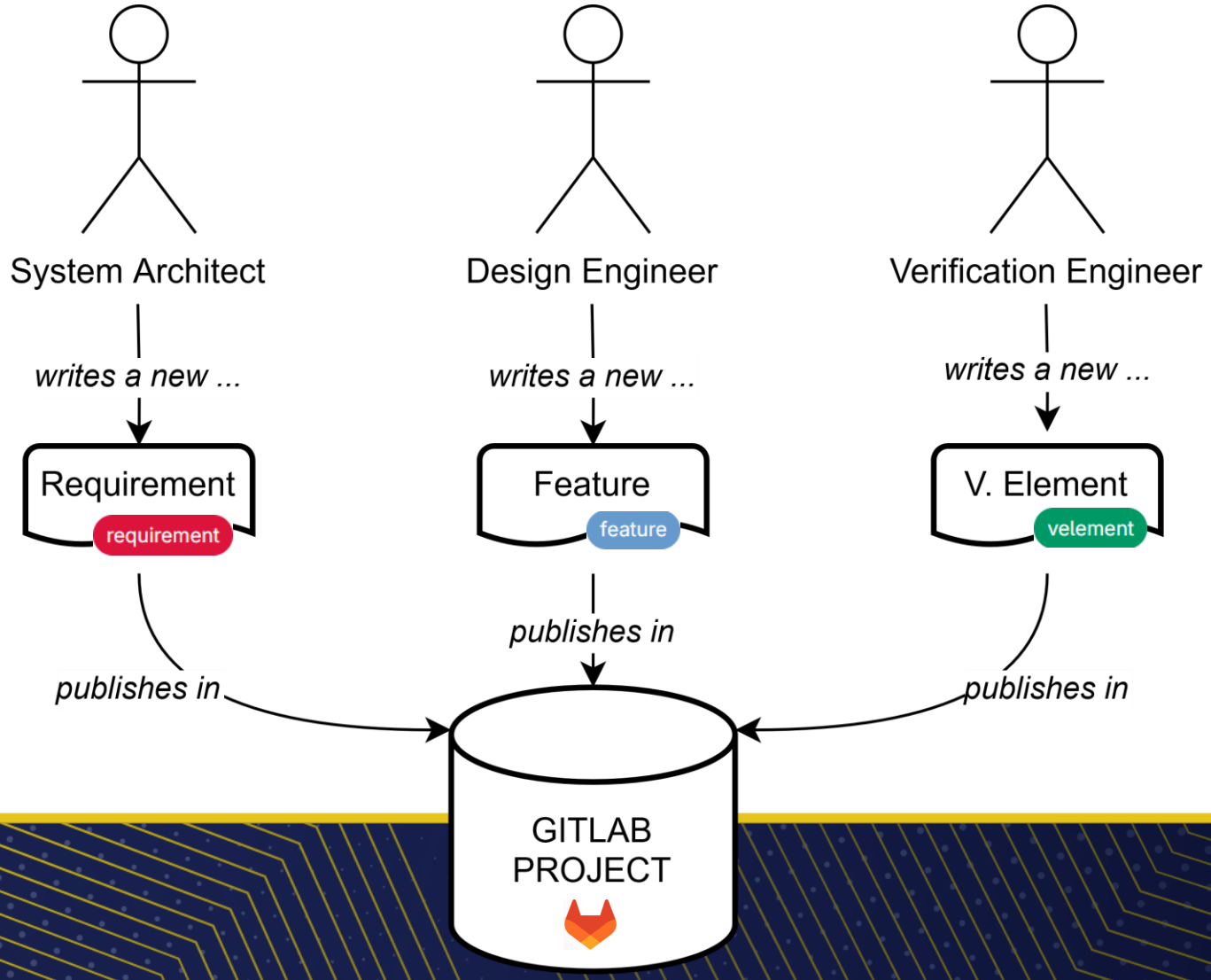
$$\begin{pmatrix} g(1,1) & g(1,2) & \dots & g(1,N) \\ g(2,1) & g(2,2) & \dots & g(2,N) \\ \dots & \dots & \dots & \dots \\ g(M,1) & g(M,2) & \dots & g(M,N) \end{pmatrix} = \begin{pmatrix} 0 & 1 & \dots & 0 \\ 1 & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & 1 \end{pmatrix}$$

Theoretical Framework: Job is done when…

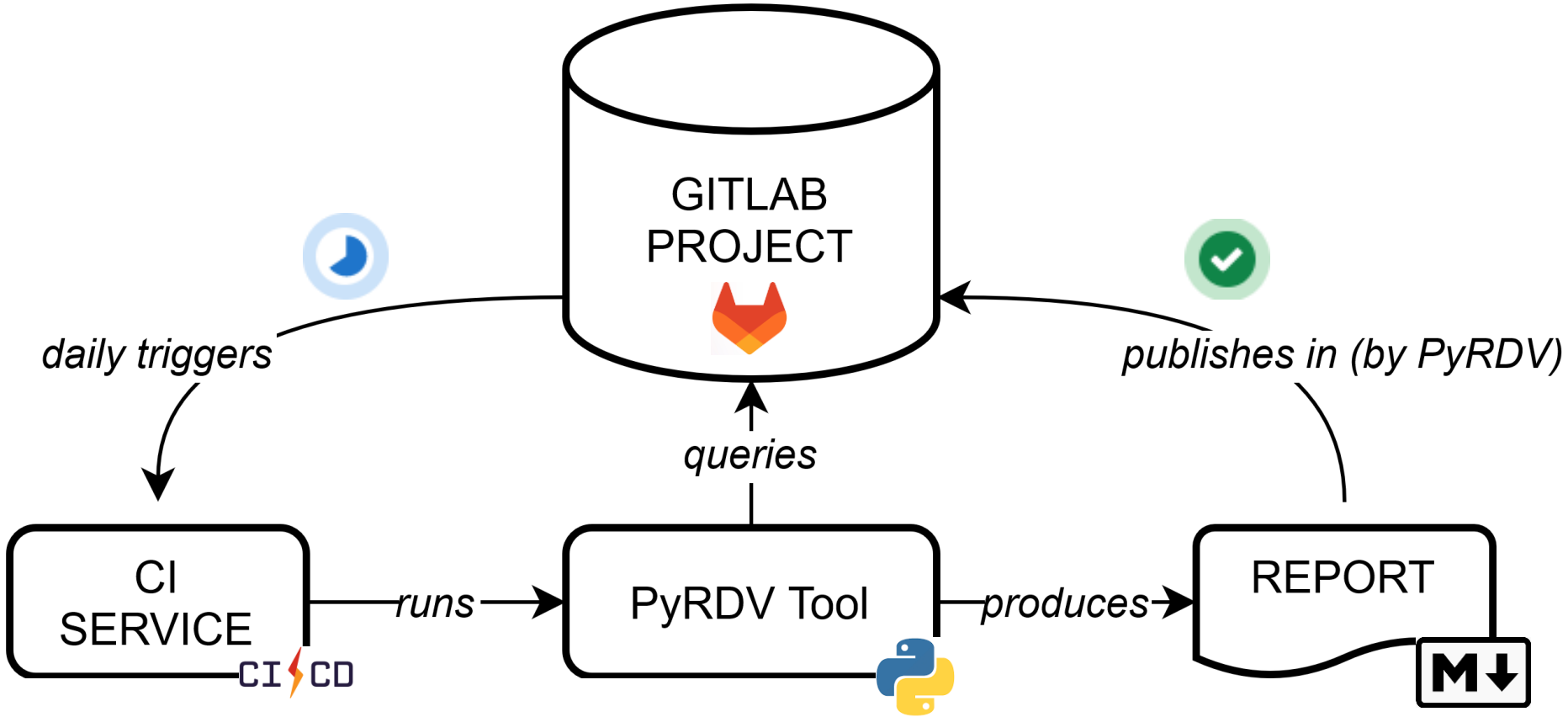
$$\sum_{j \in V} g(i,j) \geq 1, \ \forall i \in F \quad and \quad \sum_{i \in F} g(i,j) \geq 1, \ \forall j \in V$$

- All features are **strongly** or **weakly covered**
- All verification elements are **linked**
- This is the **completeness condition**
- Can be extrapolated to also solve
  - Requirements To Features Mapping Problem
  - Requirements To Verification Elements Mapping Problem

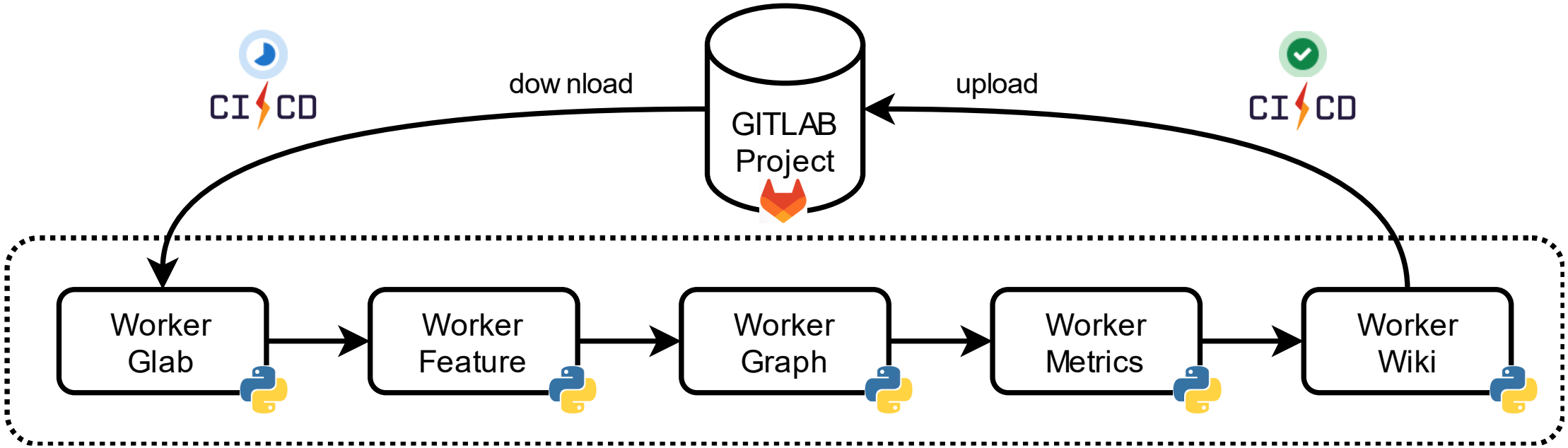
Workflow of IC Developers



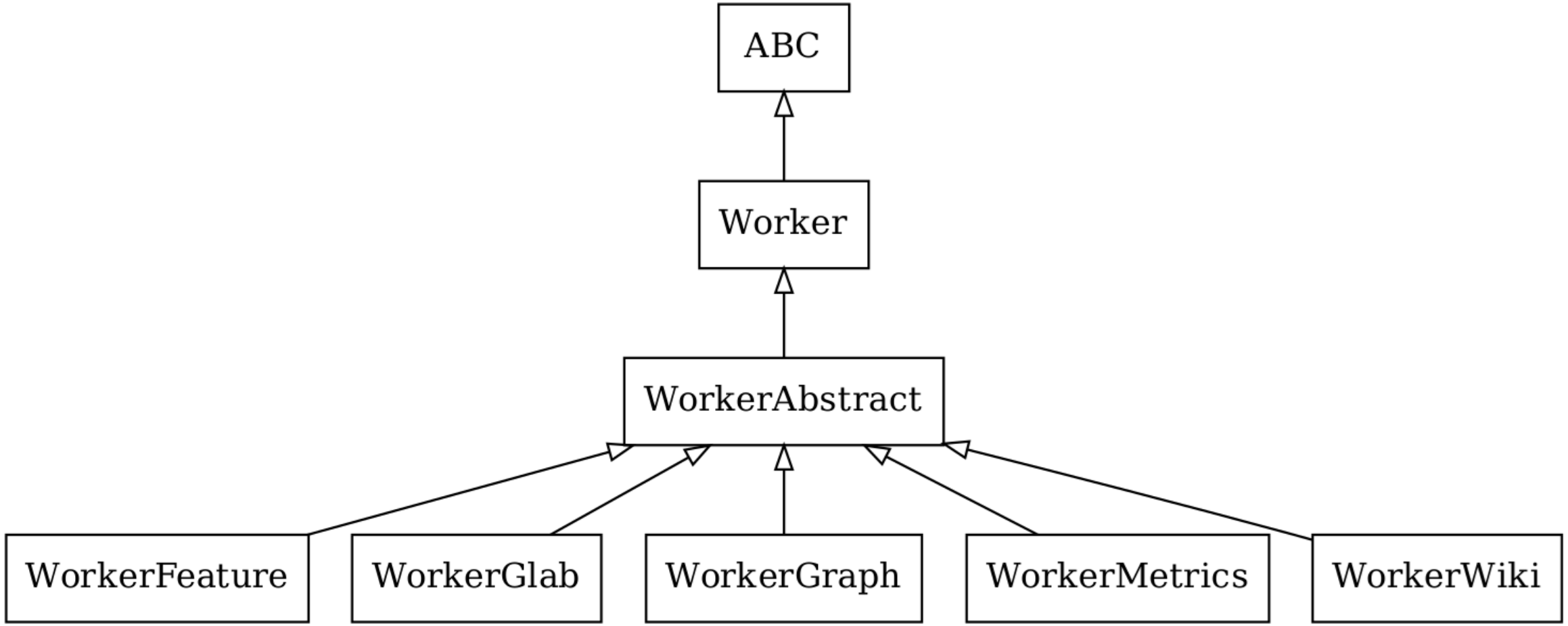
CI/CD Service



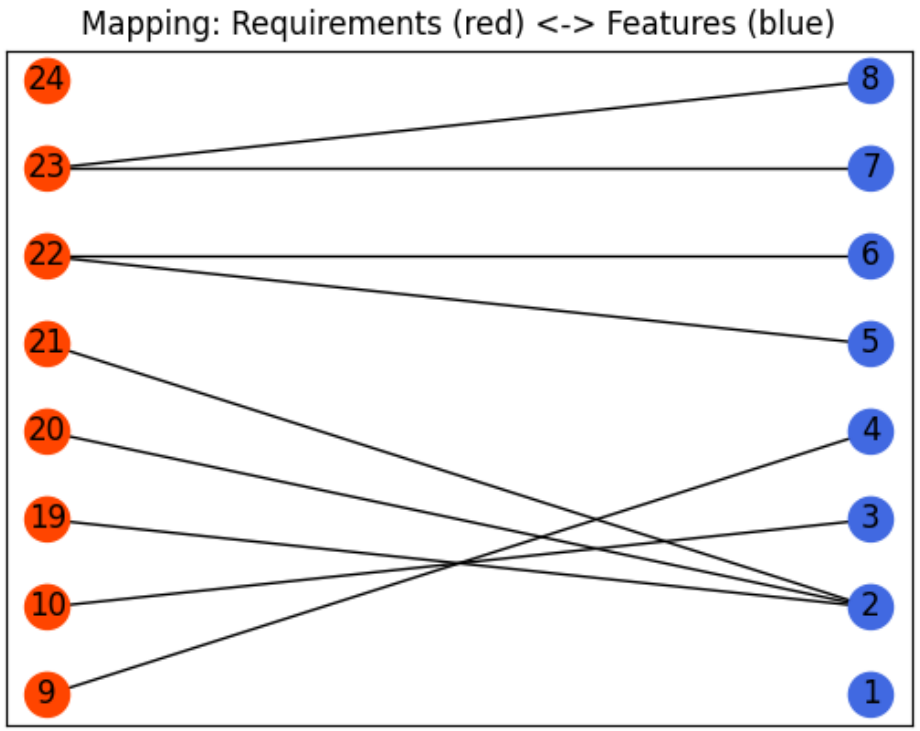
Python-based software solution



Python-based software solution



Sample Case


Mapping: Requirements (red) <-> Features (blue)
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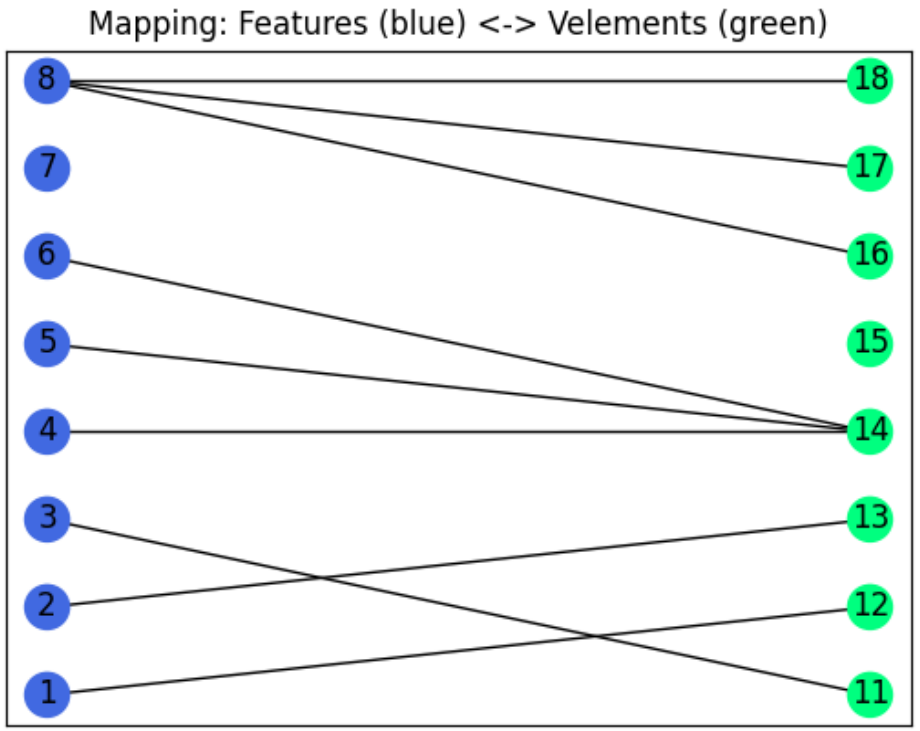
Mapping: Features (blue) <-> Velements (green)
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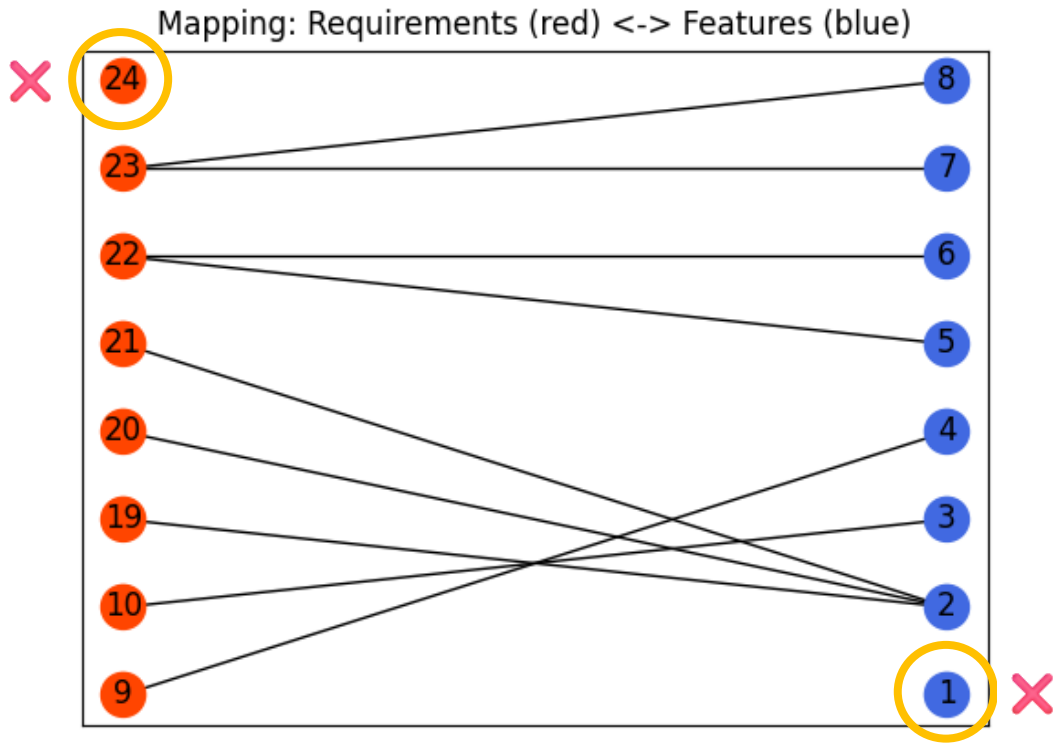
Sample Case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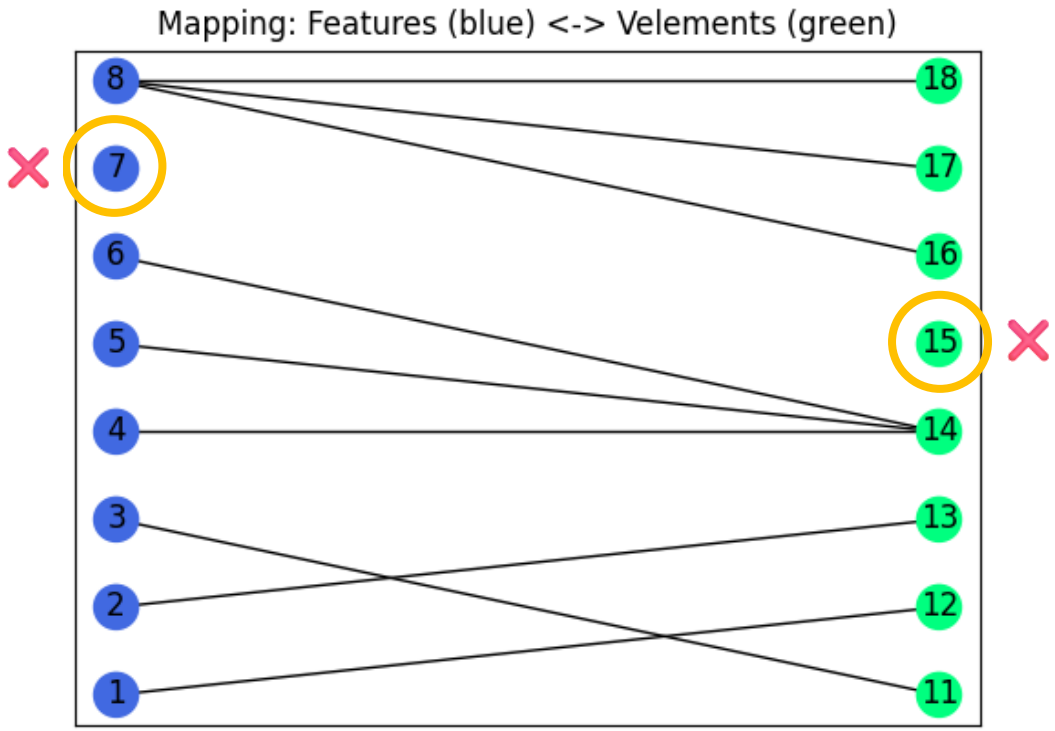
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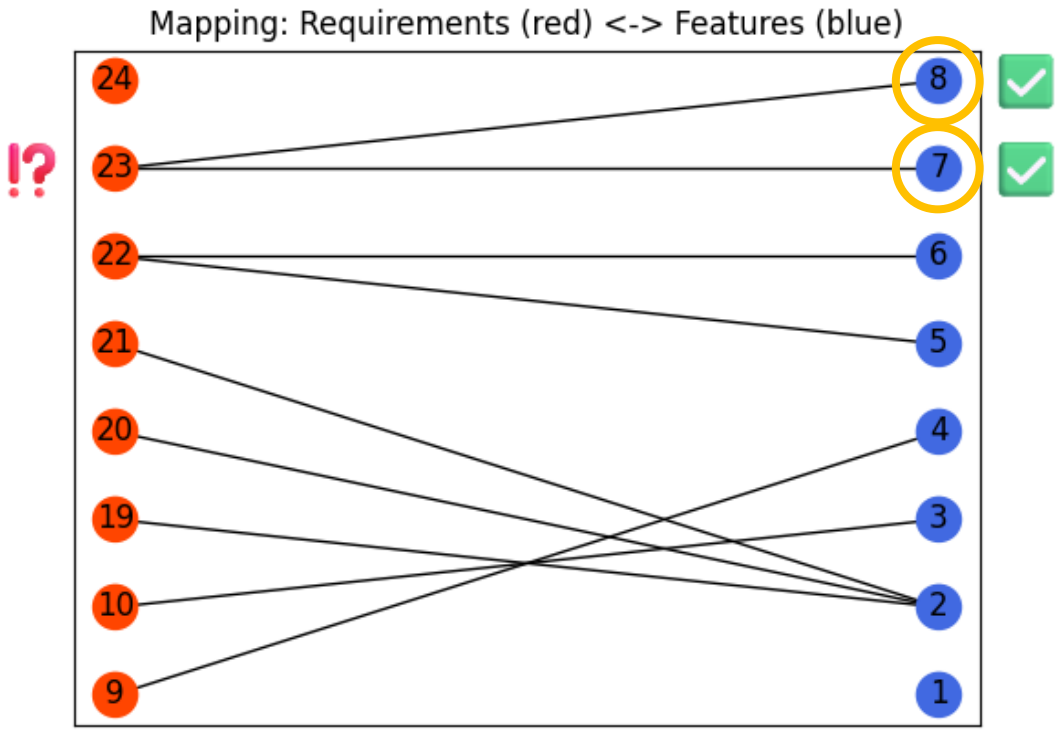
Sample Case


Mapping: Requirements (red) <-> Features (blue)
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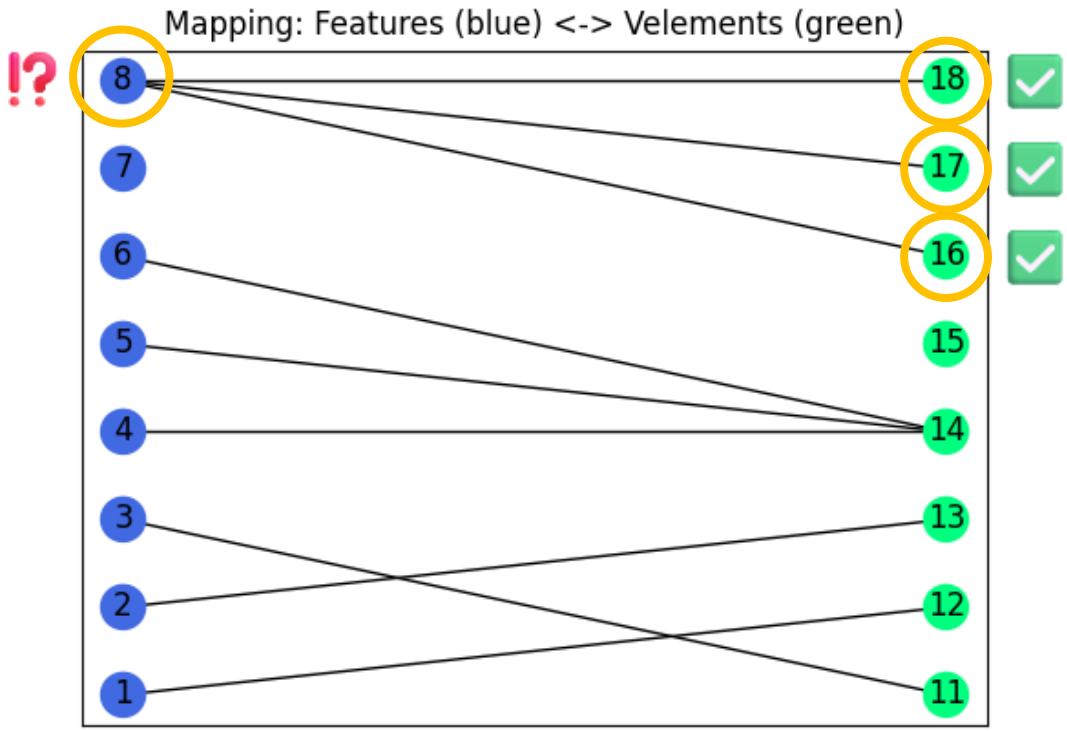
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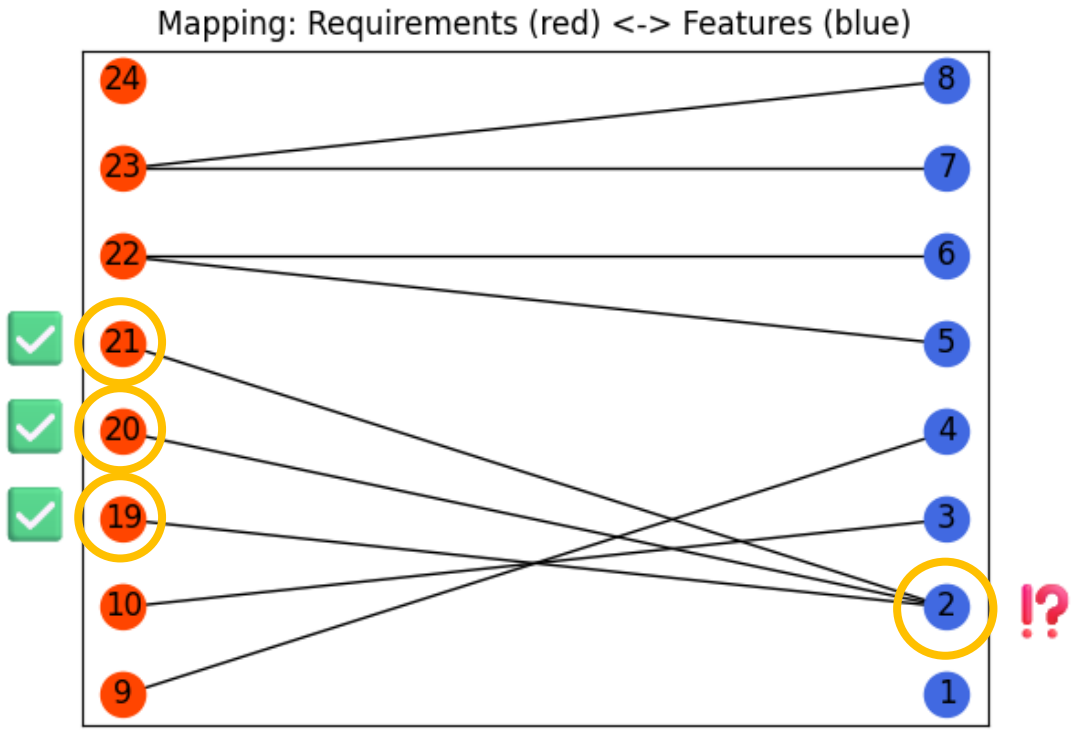
Sample Case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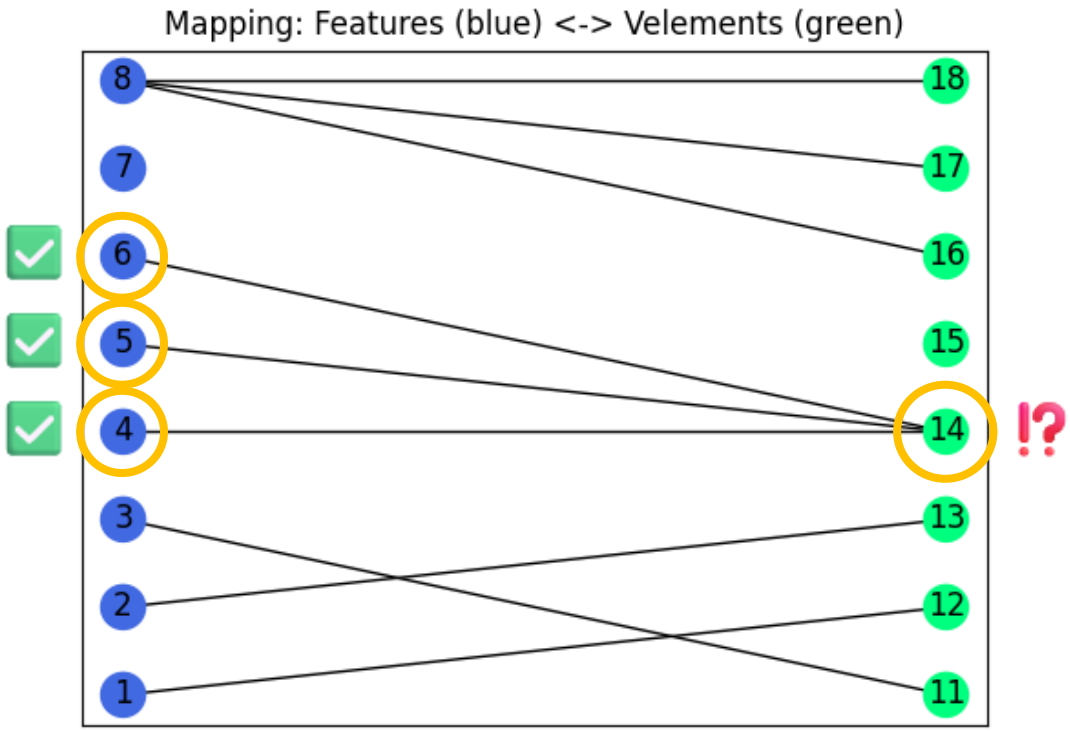
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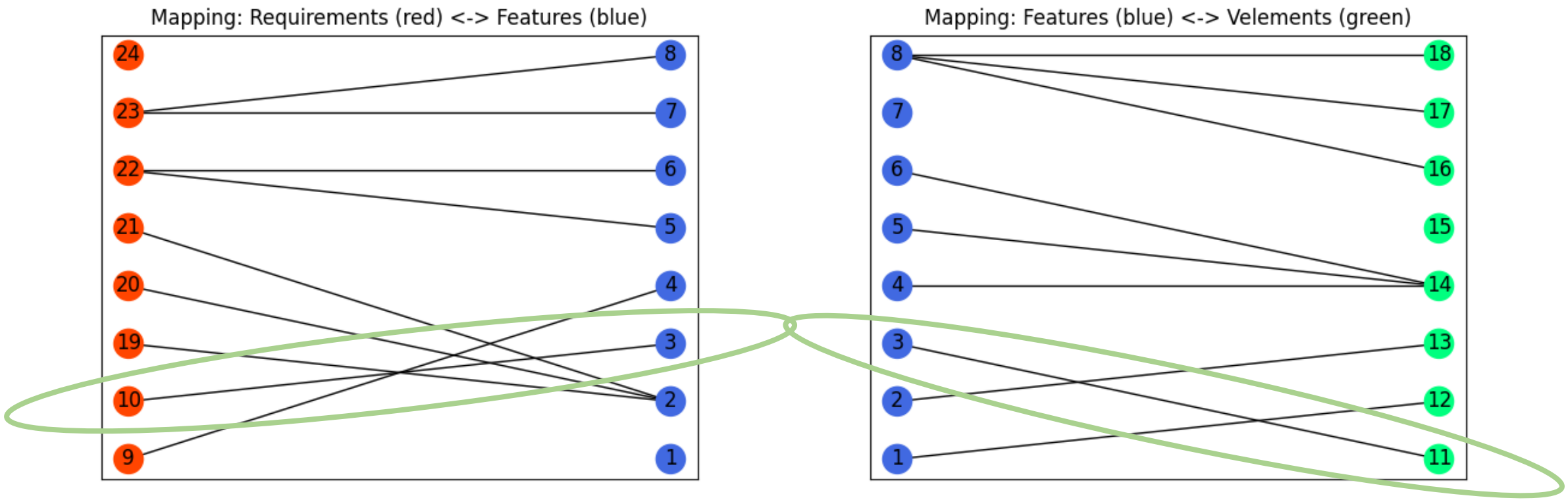
Sample Case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Mapping: Features (blue) <-> Velements (green)
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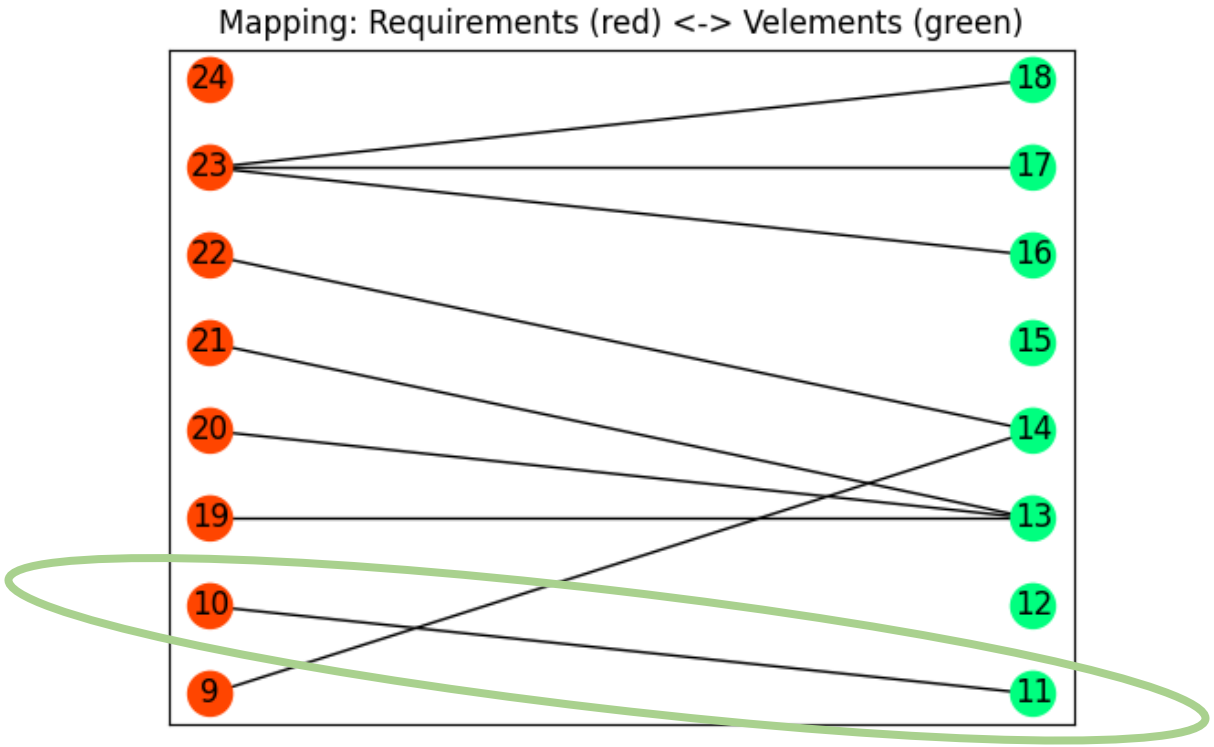
Sample Case


Mapping: Requirements (red) <-> Velements (green)
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Reports

Requirements

Requirement	Related Features	GRADE	STATUS
#9	#4	STRONGLY COVERED	✅
#10	#3	STRONGLY COVERED	✅
#19	#2	STRONGLY COVERED	✅
#20	#2	STRONGLY COVERED	✅
#21	#2	STRONGLY COVERED	✅
#22	#5 #6	WEAKLY COVERED	⁉
#23	#7 #8	WEAKLY COVERED	⁉
#24		NOT COVERED	❌

Features

Feature	Related Vplan Elements	GRADE	STATUS
#1	#12	STRONGLY COVERED	✅
#2	#13	STRONGLY COVERED	✅
#3	#11	STRONGLY COVERED	✅
#4	#14	STRONGLY COVERED	✅
#5	#14	STRONGLY COVERED	✅
#6	#14	STRONGLY COVERED	✅
#7		NOT COVERED	❌
#8	#16 #17 #18	WEAKLY COVERED	⁉

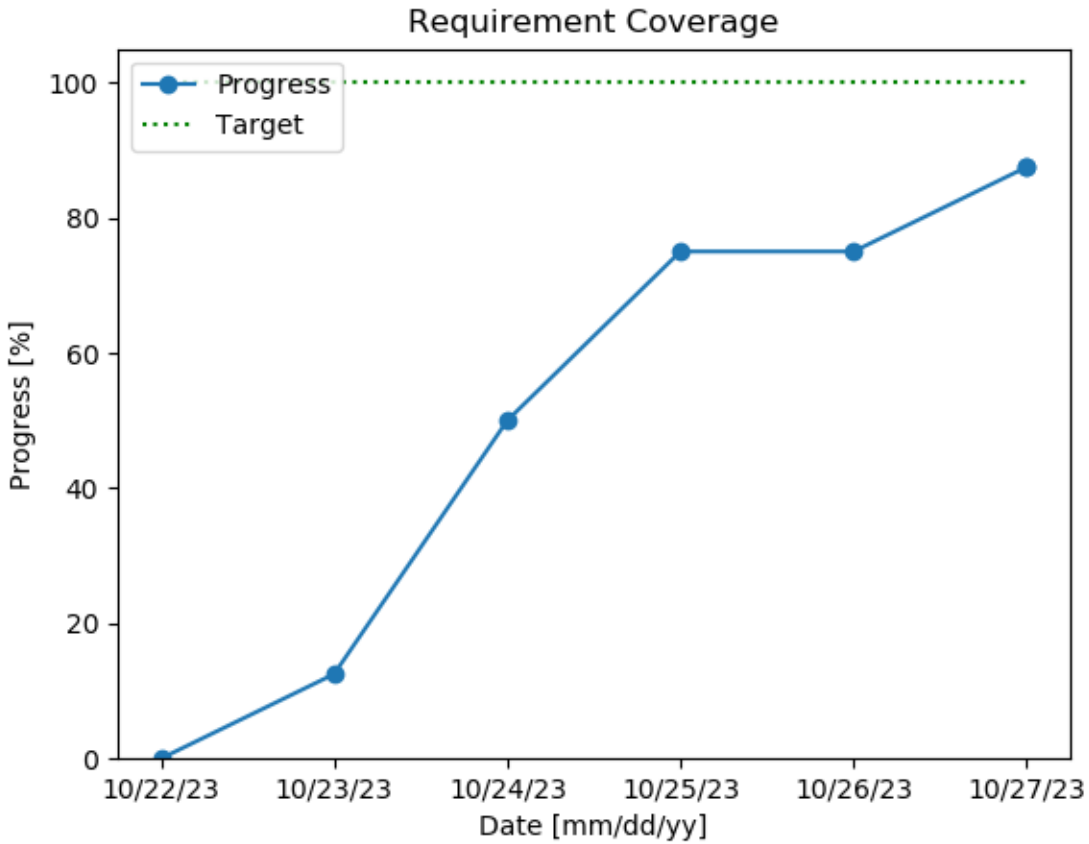
Features

Feature	Related Requirements	GRADE	STATUS
#1		NOT LINKED	❌
#2	#21 #20 #19	WEAKLY LINKED	⁉
#3	#10	STRONGLY LINKED	✅
#4	#9	STRONGLY LINKED	✅
#5	#22	STRONGLY LINKED	✅
#6	#22	STRONGLY LINKED	✅
#7	#23	STRONGLY LINKED	✅
#8	#23	STRONGLY LINKED	✅

Vplan Elements

Vplan Element	Related Features	GRADE	STATUS
#11	#3	STRONGLY LINKED	✅
#12	#1	STRONGLY LINKED	✅
#13	#2	STRONGLY LINKED	✅
#14	#4 #5 #6	WEAKLY LINKED	⁉
#15		NOT LINKED	❌
#16	#8	STRONGLY LINKED	✅
#17	#8	STRONGLY LINKED	✅
#18	#8	STRONGLY LINKED	✅

Reports


Requirement Coverage
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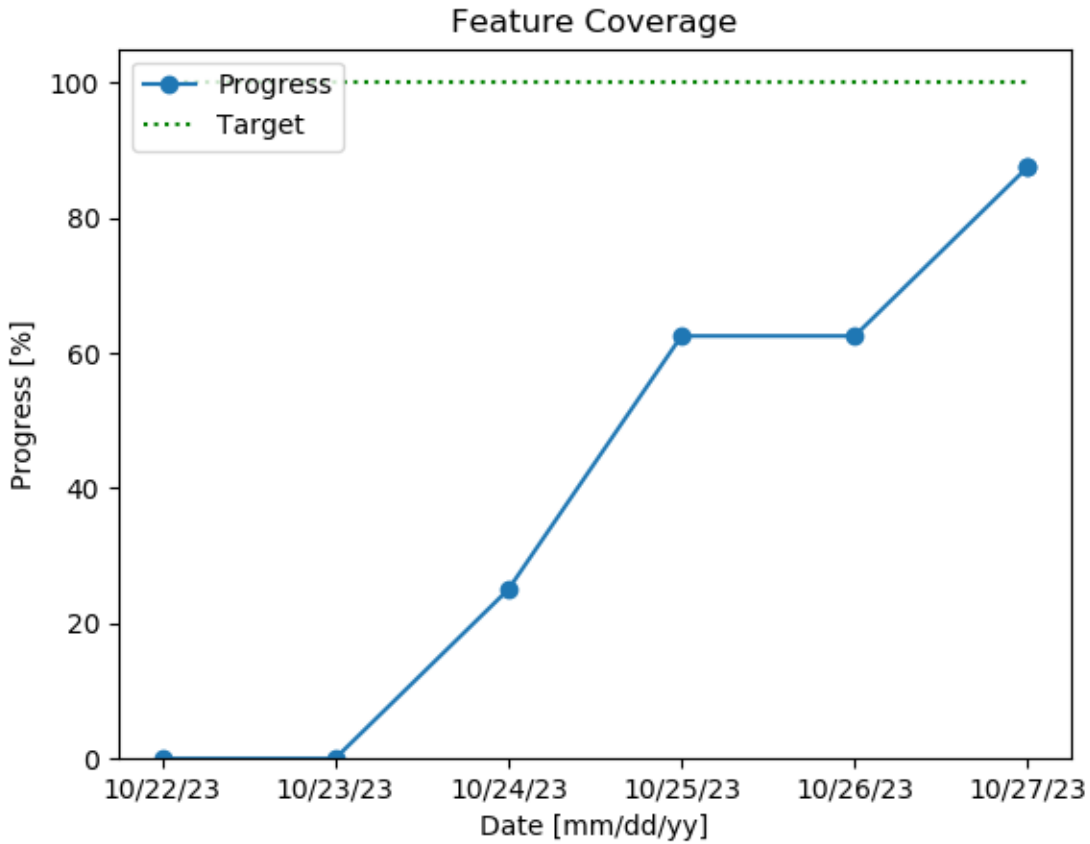
Feature Coverage
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Conclusions

- We used GitLab to centralize and manage all the information.
  - Including requirements, features or design specification and verification plan.
- We eliminated the need for developers to adapt to a new tool.
  - GitLab was already a tool in use by the company.
- We used CI/CD services to improve design and verification workflow.
  - It allows us to find potential coverage holes faster.
- The framework is not limited to GitLab.
  - Can be applied to any platform that offers an issue-tracking capability.

Conclusions

- We developed a Python-base solution.
  - The algorithms and the design pattern can be applied to any other language.
- We can improve the effectiveness and efficiency of the design process.
  - We can always check that all requirements are implemented.
  - We can always check that all specifications are verified.
- We are planning to use AI techniques to predict the execution time of future projects based on the information collected by the PyRDV tool.

Thanks for attending
Questions?