ExArch: Enabling Architecture Traceability by LLM-based Architecture Component Name Extraction

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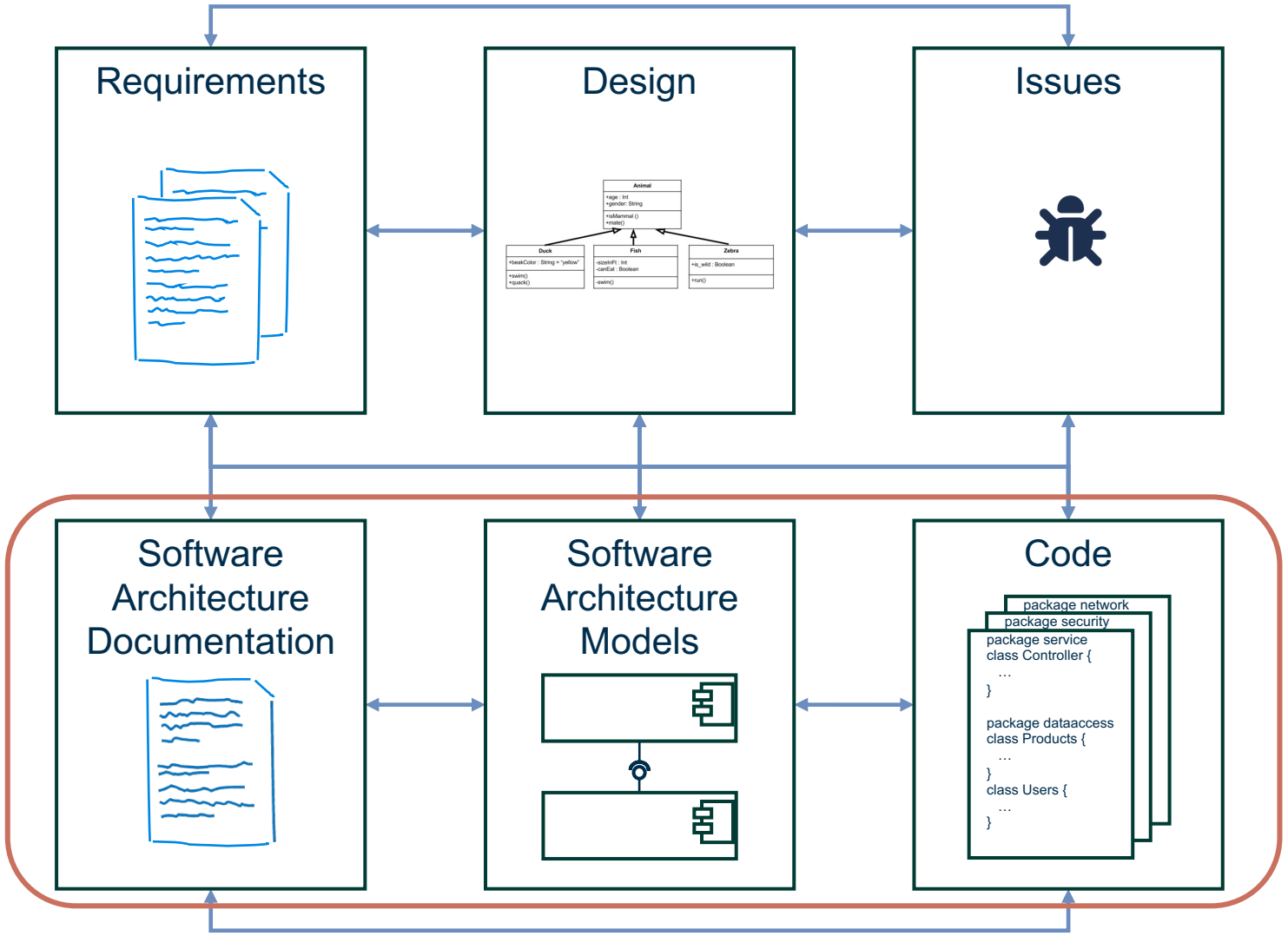
What makes Trace Links important?

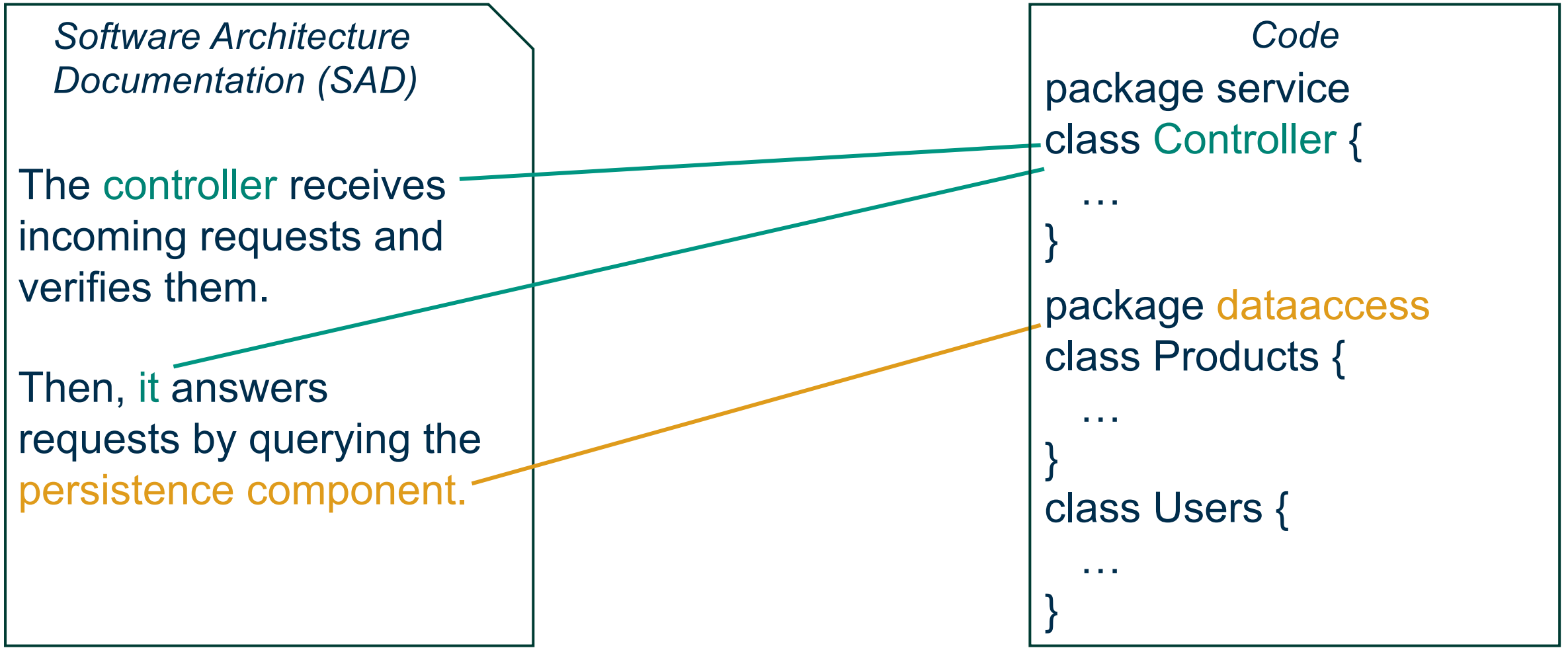


Trace links are evidently useful for

- Software Maintenance
- Bug Localization
- Change Impact An.
- System Security
- …

Artifact
Relation

Traceability Link Recovery between Documentation & Code

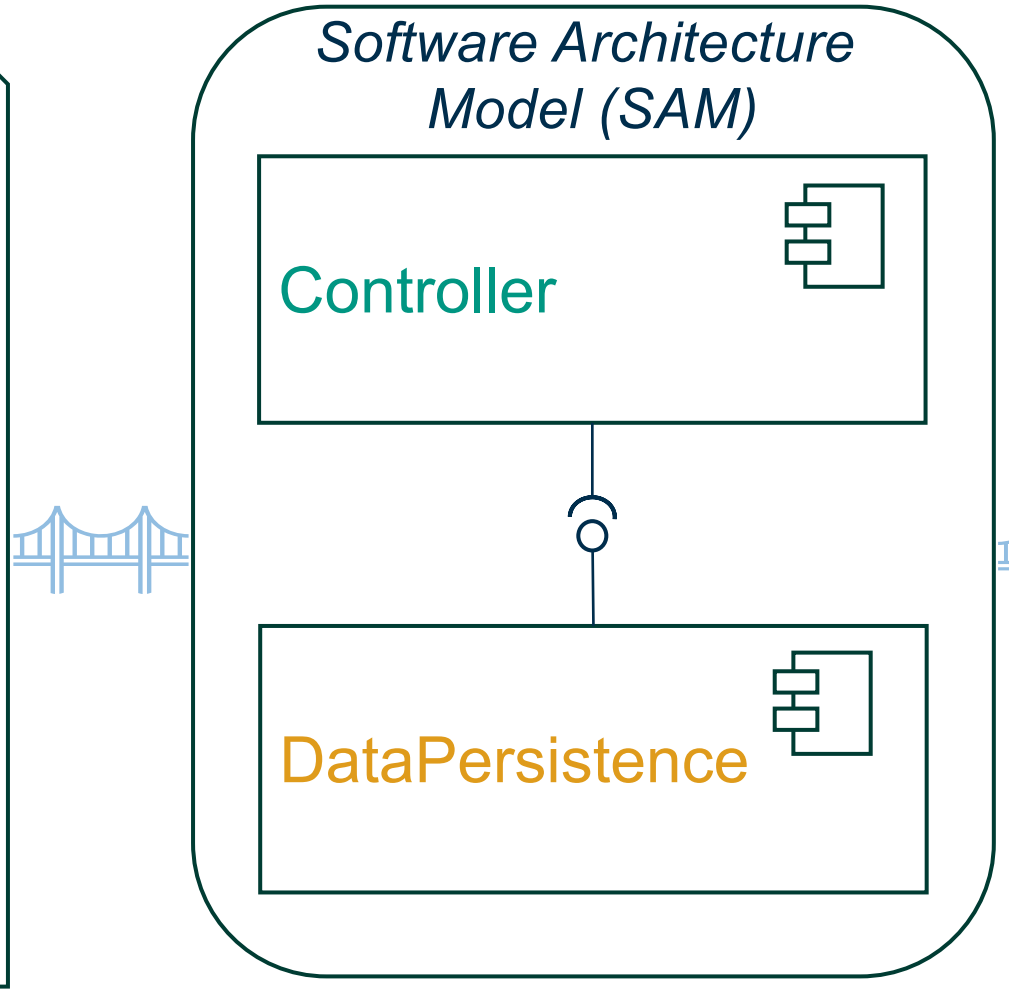


Traceability Link Recovery between Documentation & Code

Software Architecture Documentation (SAD)

The controller receives incoming requests and verifies them.

Then, it answers requests by querying the persistence component.



Code

```
package service
class Controller {
    …
}
package dataaccess
class Products {
    …
}
class Users {
    …
}
```

Traceability Link Recovery between Documentation & Code

Software Architecture Documentation (SAD)

The controller re
incoming reque
verifies them.

Then, it answers requests by querying the persistence component.

Software Architecture Model (SAM)

Code

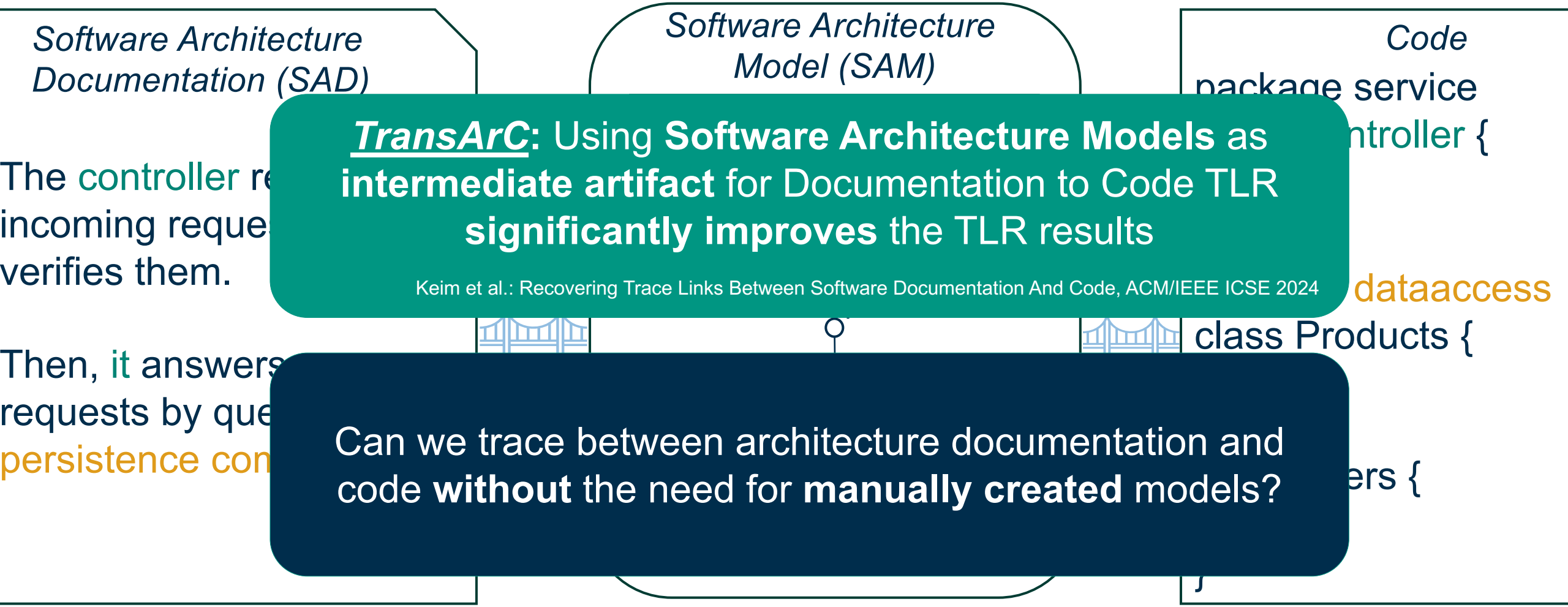
package service
ntroller {

dataaccess
class Products {
…
}
class Users {
…
}

***TransArC*: Using **Software Architecture Models** as **intermediate artifact** for Documentation to Code TLR **significantly improves** the TLR results**

Keim et al.: Recovering Trace Links Between Software Documentation And Code, ACM/IEEE ICSE 2024

Traceability Link Recovery between Documentation & Code



***TransArC*: Using **Software Architecture Models** as **intermediate artifact** for Documentation to Code TLR **significantly improves** the TLR results**

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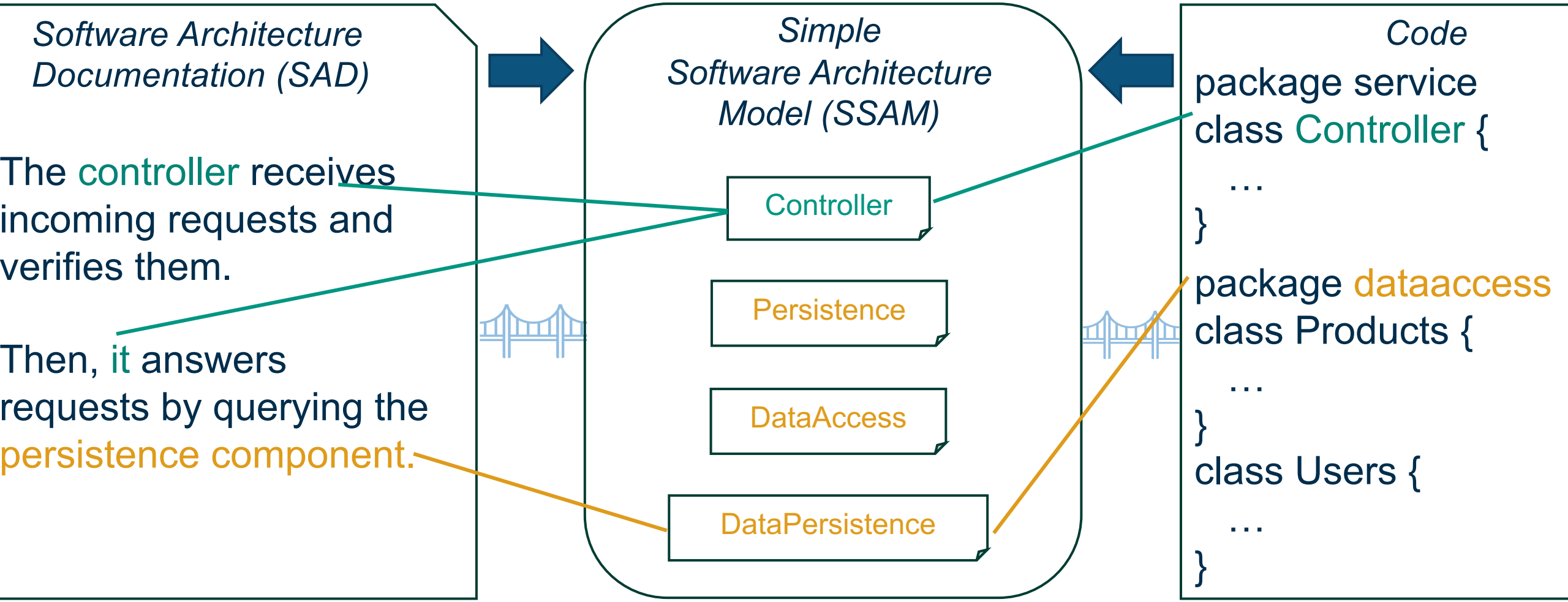
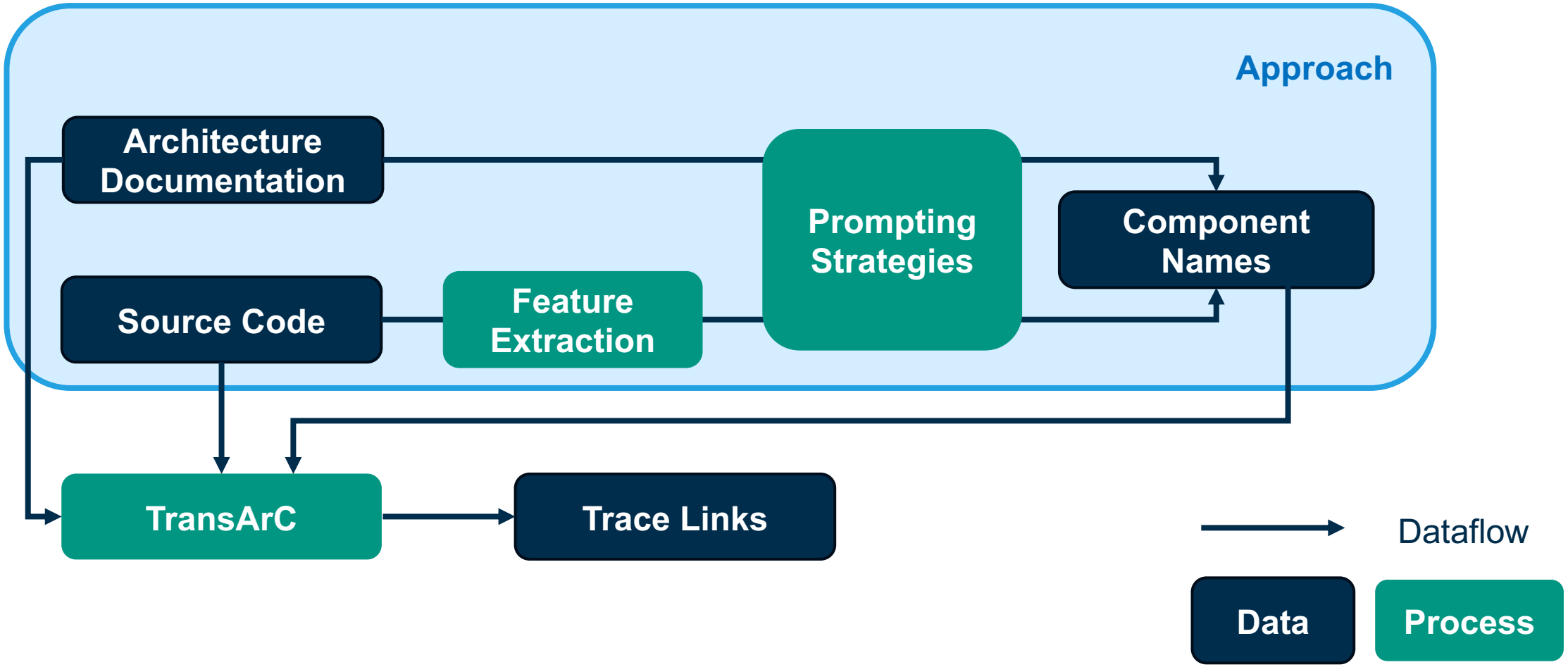
Can we trace between architecture documentation and code **without** the need for **manually created** models?

Traceability Link Recovery between Documentation & Code



Approach to get a Simple Software Architecture Model



Approach to get a Simple Software Architecture Model

Idea of Prompt: Documentation to Architecture

Your task is to identify the **high-level components** based on the software architecture documentation.

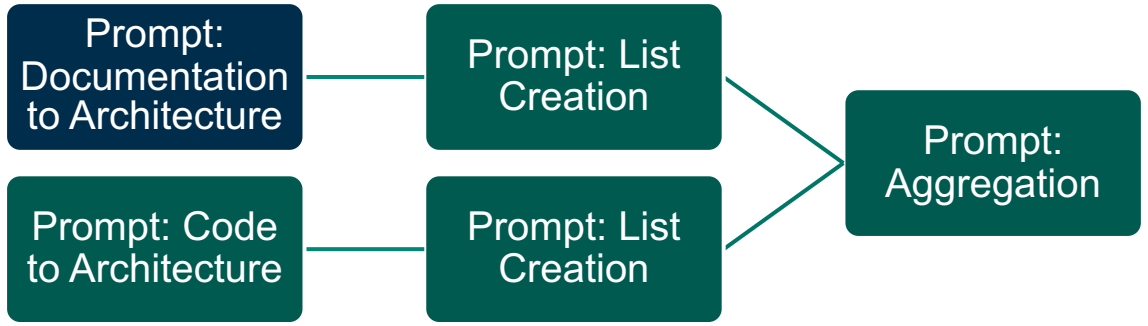
In a first step, you shall elaborate on the following documentation:
{Software Architecture Documentation}

Idea of Prompt: Code to Architecture

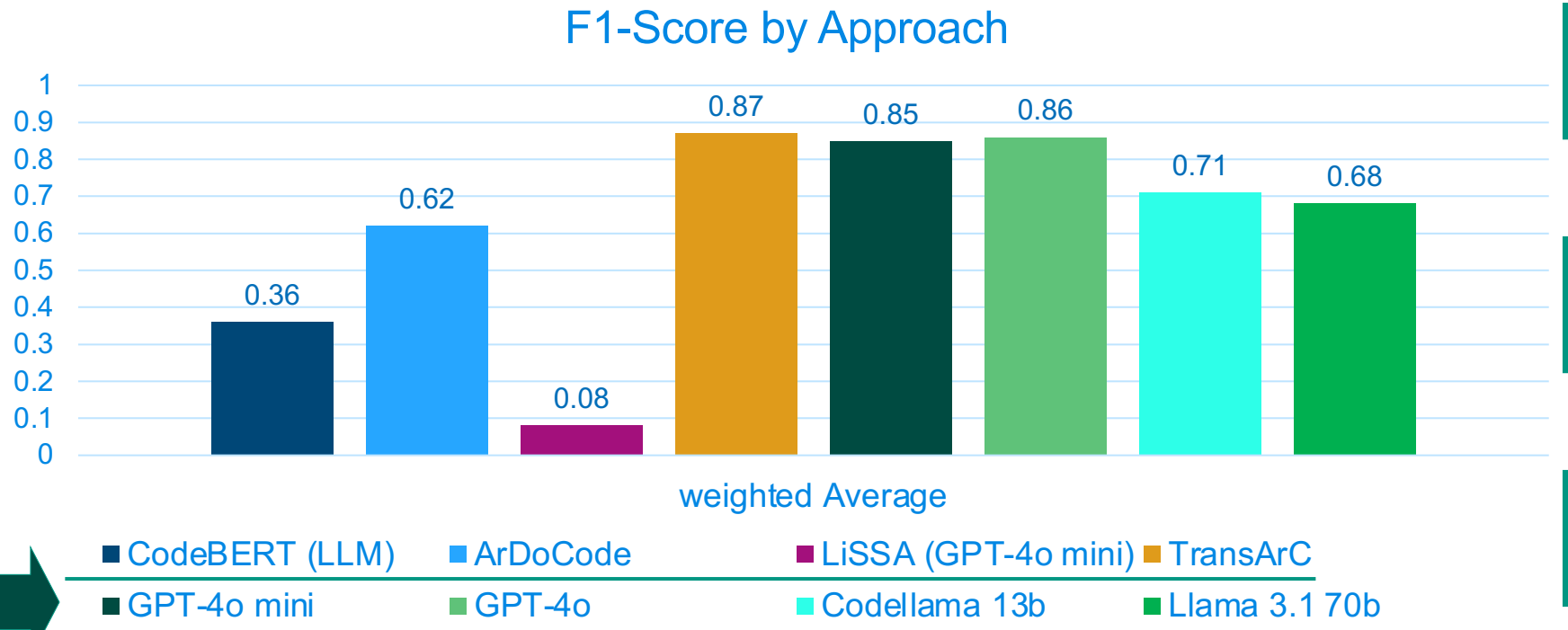
You get the **{Features}** of a software project.

Your task is to summarize the {Features} w.r.t. the **high-level architecture** of the system.

Try to identify **possible components.** {Features}: {Content}



Eval: Component Names derived from Documentation



ExArch

RQ 1: Comparable to TransArC ?

RQ 2: Better than SotA w/o SAMs?

RQ 3: Open-Source vs. Closed-Source LLMs?

F1-Score: Harmonic Mean of Precision and Recall

Eval: Component Names derived from ...

SSAM derived from …	Average F1	Weighted Average F1
Documentation	**0.76**	**0.86**
Code	0.58	0.81
Both (Similarity Aggregation)	0.73	0.86
Both (Prompt Aggregation)	0.72	0.85

RQ 1: Comparable to TransArC ?

RQ 2: Better than SotA w/o SAMs?

RQ 3: Open-Source vs. Closed-Source LLMs?

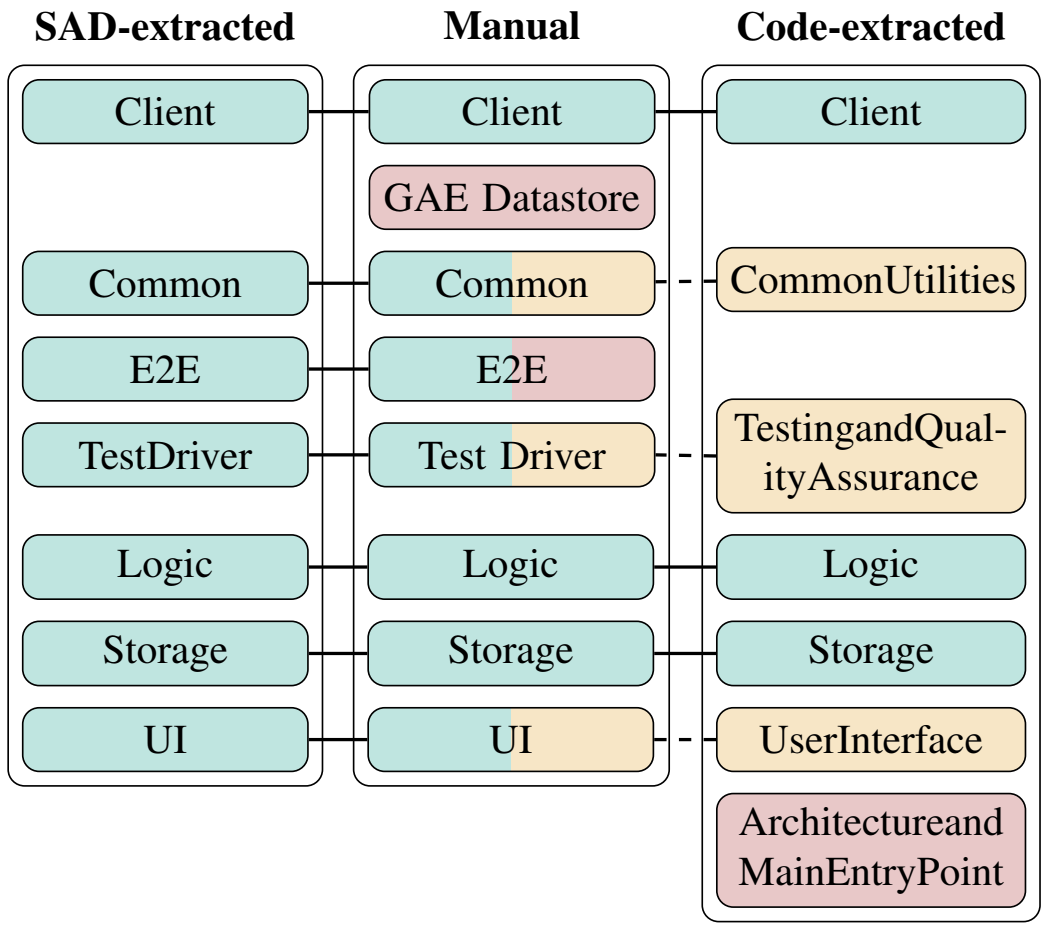
RQ 4: Influence of different artifacts (i.e., Code/SAD)

Eval: Problems with LLM-extracted Simple Models

Example:

- GPT-4 Turbo
- TEAMMATES

- F1-Score
  - Documentation: 0.80
  - Code: 0.34



RQ 1: Comparable to TransArC ?

RQ 2: Better than SotA w/o SAMs?

RQ 3: Open-Source vs. Closed-Source LLMs?

RQ 4: Influence of different artifacts (i.e., Code/SAD)

Conclusion

- We use LLMs to derive Simple Software Architecture Models (Component Names) to support the TLR between Architecture Documentation and Code

- In the evaluation,
  - Our approach performs comparable to TransArC (best avg. F1: 0.76)
  - Extraction based on documentation often performs better than only code (best avg. F1: 0.76 vs. 0.58)
  - Fusion (Doc + Code) can reach similar, but still less good results

- Outlook:
  - Prompt Optimization might be needed (e.g., dealing with “sub-components” in the results)
  - Analysis of the different meanings of “Trace Link”

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