Trace Link Recovery for Software Architecture Documentation

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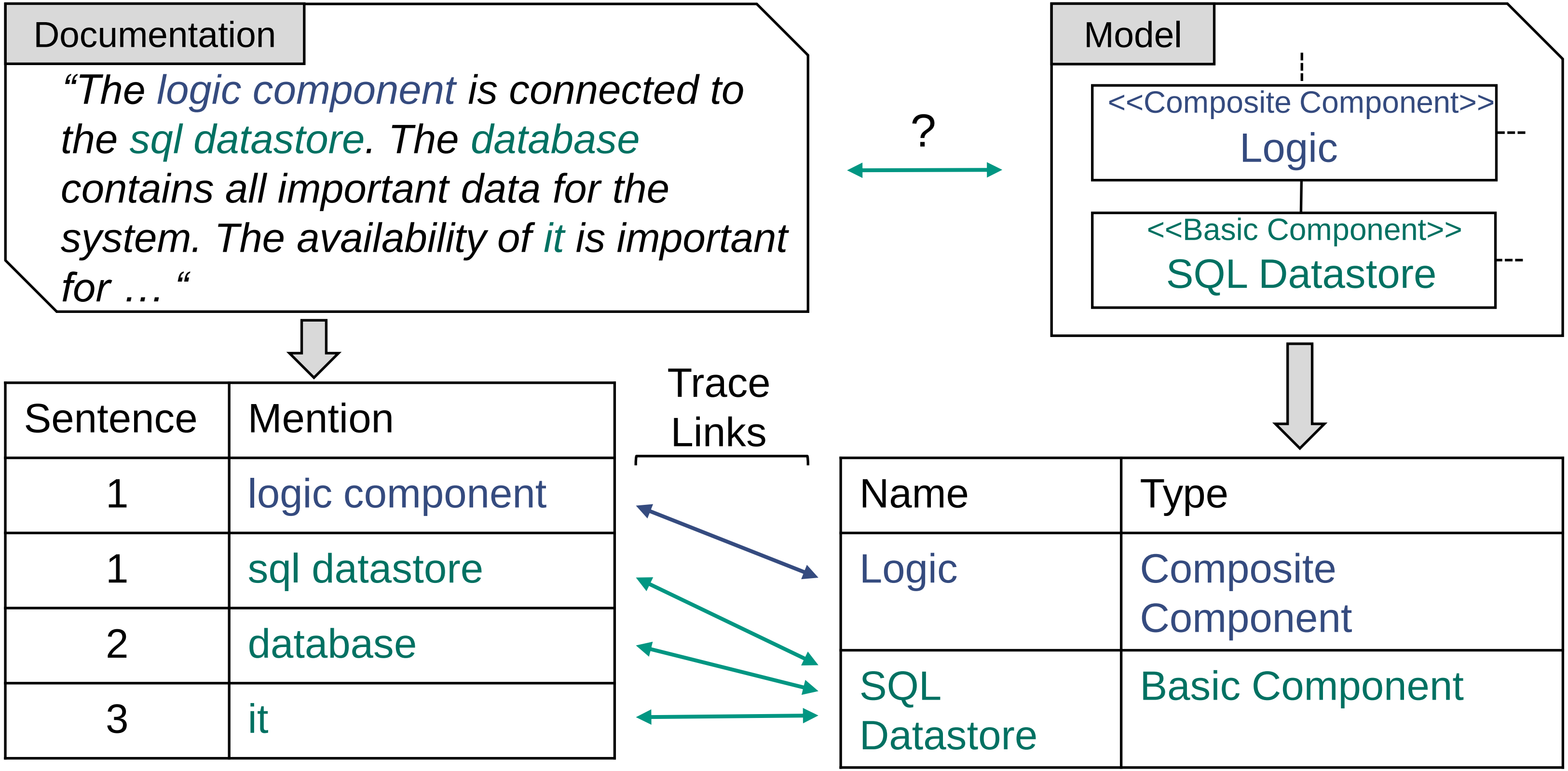


Documentation

“The logic component is connected to the sql datastore. The database contains all important data for the system. The availability of it is important for … “

?

Model

<<Composite Component>>
Logic

<<Basic Component>>
SQL Datastore

Trace Links

Sentence	Mention
1	logic component
1	sql datastore
2	database
3	it

Name	Type
Logic	Composite Component
SQL Datastore	Basic Component

Existing approaches

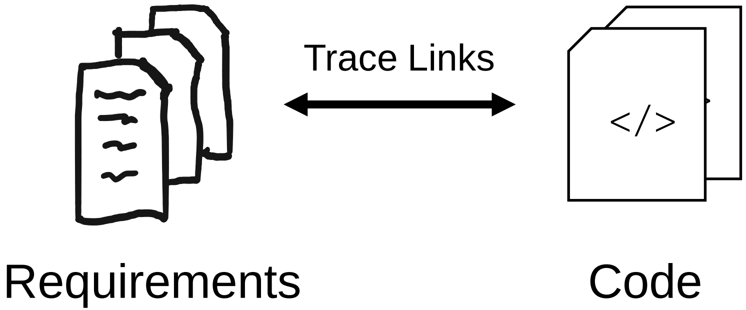
IR-based

[Rodriguez20]

NLP-based

[Zhang16]

[Guo17] [Moran20]



Trace Links

Requirements

Code

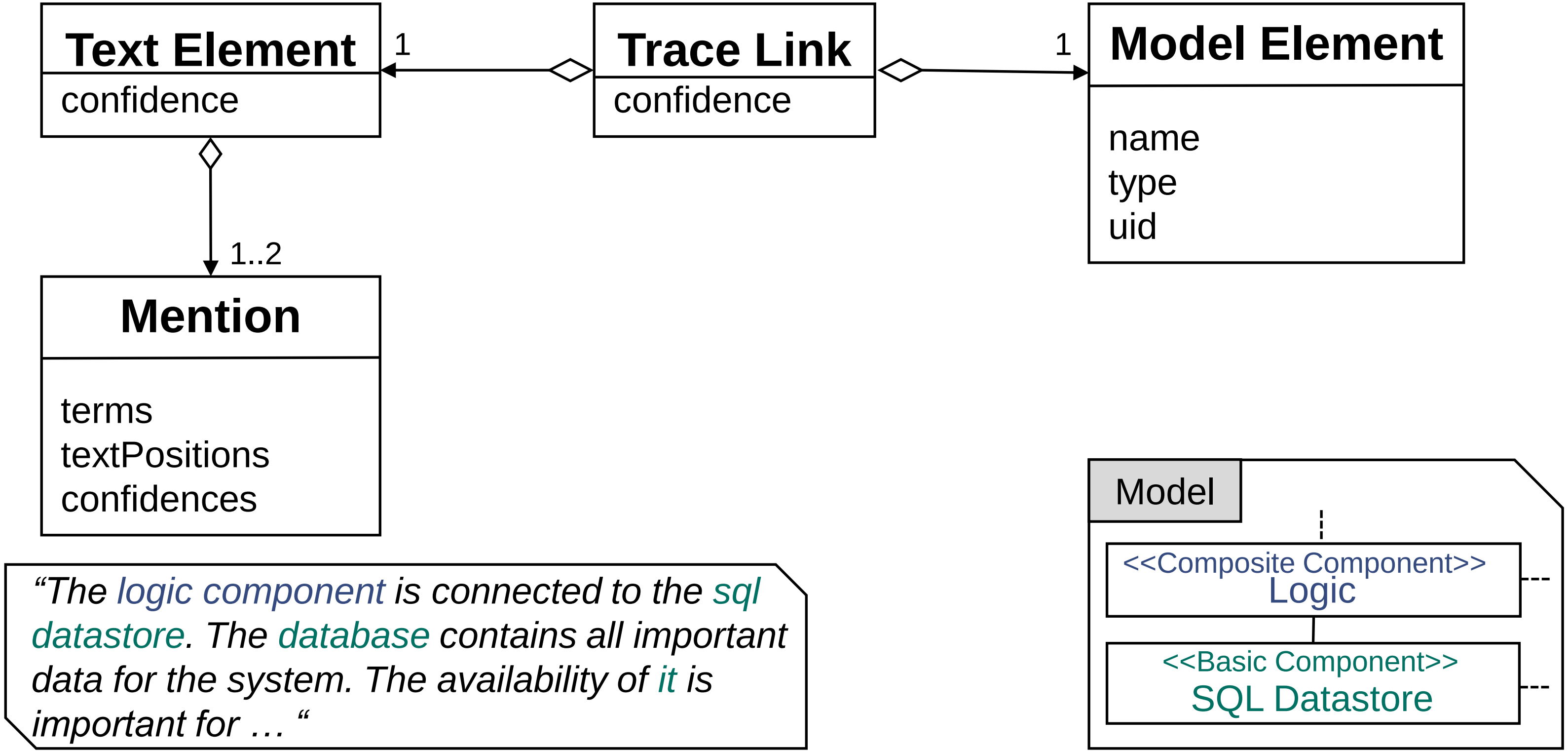
Research Question and Contributions

- How accurately can we identify trace links between textual informal SAD and formal models with our approach?

- Contributions
  - Extendable framework SWATTR (SoftWare Architecture Text Trace link Recovery) for creating such trace links
  - Data sets for evaluation
  - (Re-) Implementations of baseline approaches for comparison
  - Code, evaluation results, and reproduction packages online

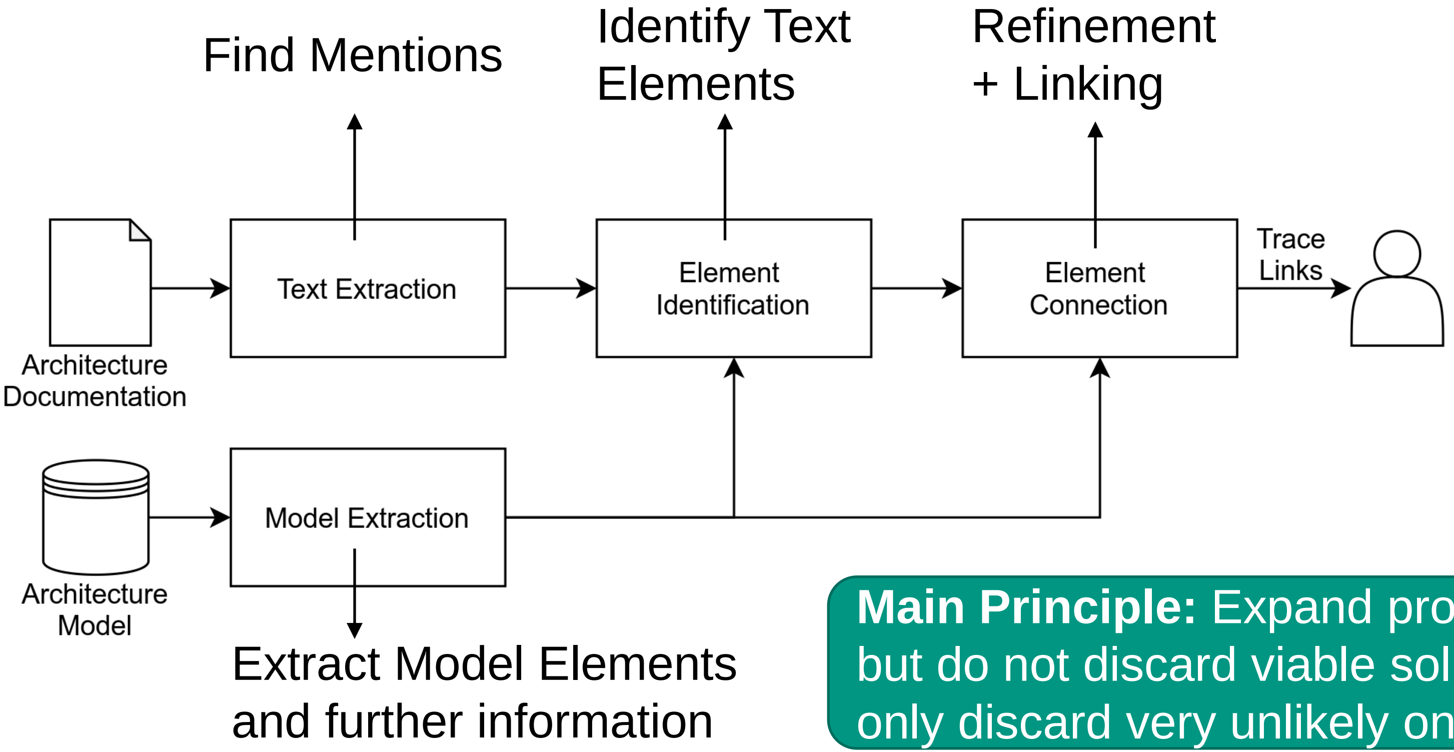
Artifacts at https://zenodo.org/record/4767470

Our Trace Link Model



“The logic component is connected to the sql datastore. The database contains all important data for the system. The availability of it is important for … “

SWATTR Overview



Find Mentions

Identify Text Elements

Refinement + Linking

Architecture Documentation

Text Extraction

Element Identification

Element Connection

Trace Links

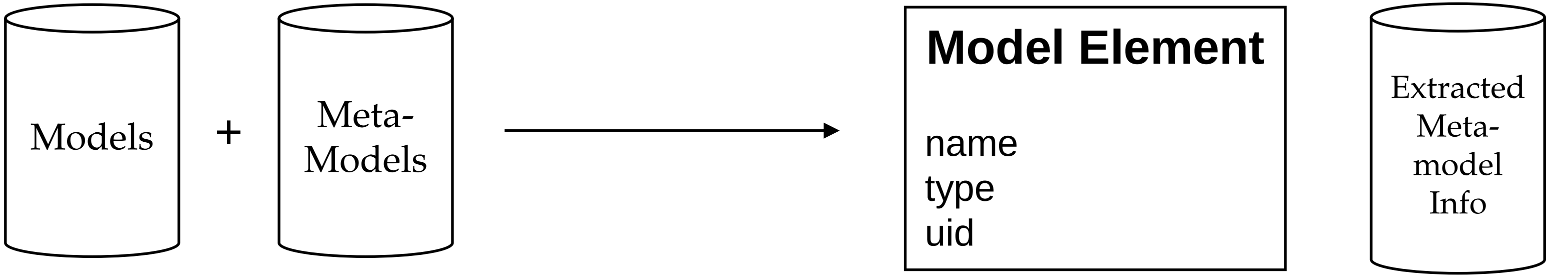
Architecture Model

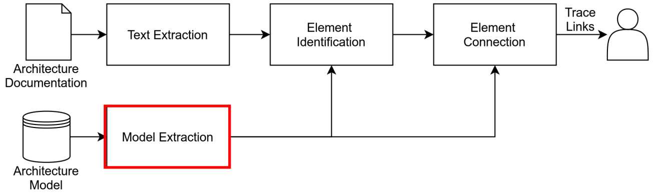
Model Extraction

Extract Model Elements and further information

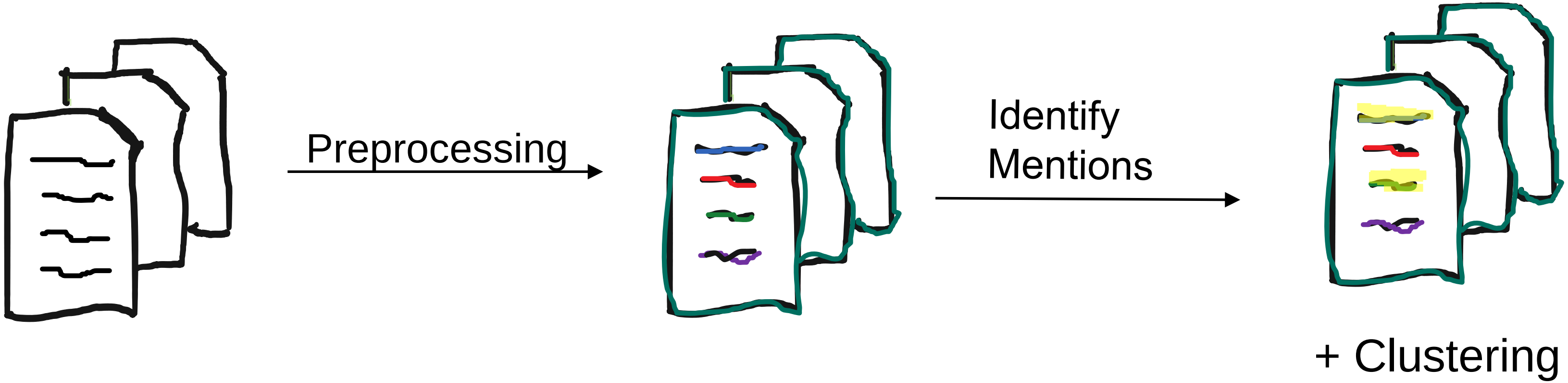
Main Principle: Expand promising results, but do not discard viable solutions too early; only discard very unlikely ones

Extracting Model Information



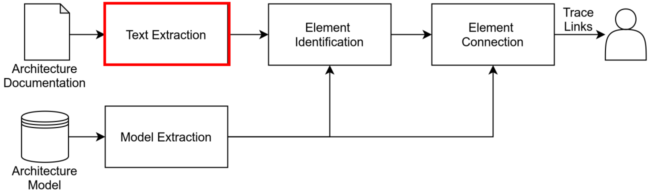


Extracting Text Information

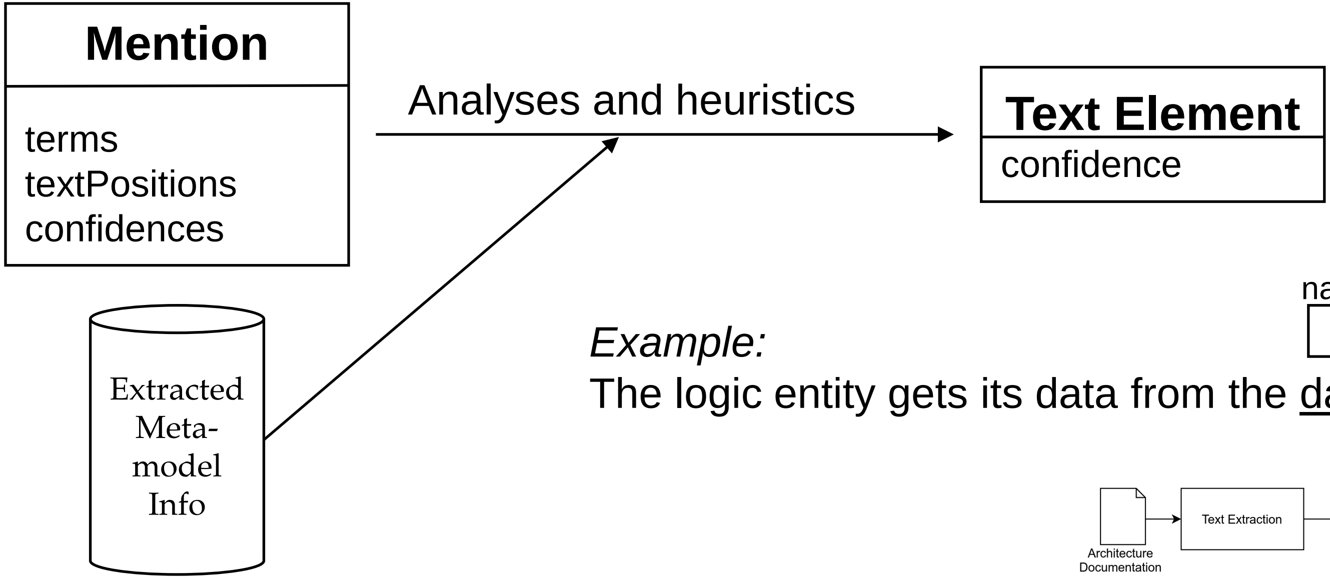


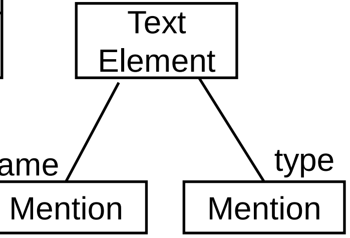
Analyses and Heuristics that contribute:

- Nouns and Plural Nouns
- Incoming/Outgoing Dependencies
- Pattern search
- Separators and Compound Terms

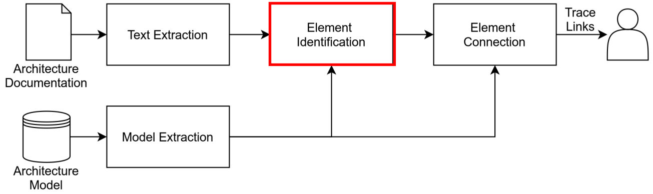


Identifying (Text) Elements

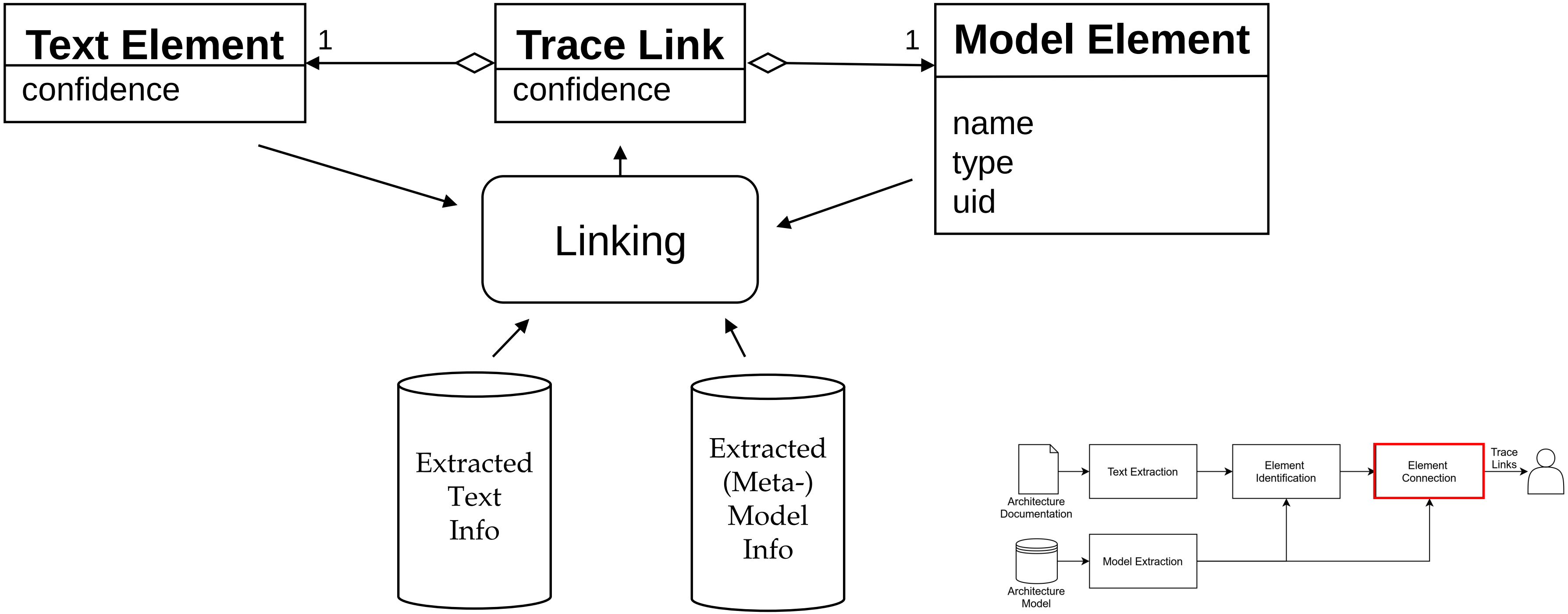




Example:
The logic entity gets its data from the <u>database</u> <u>component</u>



Connect Elements & Create Trace Links



Evaluation Setup

- Metrics: Precision, Recall, F1-Score
- Recall is more important than precision
- Comparison with two approaches

Measure	Acceptable	Good	Excellent
Recall	.60 - .69	.70 - .79	.80 - 1.0
Precision	.20 - .29	.30 - .49	.50 - 1.0

[Hayes06]

	Mediastore	TeaStore	Teammates
No. Sentences	37	43	198
No. Trace Links	25	25	80
No. Model Elements	14	13	8
Max TL per Sentence	2	2	7
Sentences Without TL	13 (35%)	22 (51%)	131 (66%)

Evaluation Results

	Mediastore			TeaStore			Teammates			Average			Weighted Avg.		
	P	R	F1	P	R	F1	P	R	F1	P	R	F1	P	R	F1
SWATTR	.47	**.60**	.53	**.63**	**.88**	**.73**	**.69**	**.89**	**.78**	**.60**	**.79**	**.68**	**.64**	**.83**	**.72**
Rodr.&C.	.07	.32	.12	.10	.20	.13	.10	.15	.12	.09	.22	.13	.10	.19	.13
Zhang et al	**.76**	.52	**.62**	.35	.28	.31	.49	.30	.37	.53	.37	.44	.52	.34	.41

Identified Weaknesses

- Wrongly identified terms when terms have close naming to model elements
  - E.g. *image* and *image components*
- Model elements have similar naming
  - E.g. *MediaManagement* and *UserManagement*
- Short terms and abbreviations cause problems
  - E.g. *GAE* instead of *Google App Engine (GAE) Database*

→ Dependent on configurations, needs configuration per project based on identified properties

Discussion, Conclusion & Future Work

- Results are good to excellent and outperform baseline approaches

- Limitation: linking is reliant on word similarity
  - Assumption that naming should be consistent

- Future Improvements and other work
  - Improve linking, less reliance on word similarity
  - Take relations into account
  - Combine results of different approaches to improve results
  - Find inconsistencies

Artifacts at
https://zenodo.org/record/4767470

References

- **[Hayes06]** Hayes, J.H., Dekhtyar, A., Sundaram, S.K.: Advancing candidate link generation for requirements tracing: The study of methods. IEEE Transactions on Software Engineering 32(1), 4 (2006)
- **[Rodriguez20]** Rodriguez, D.V., Carver, D.L.: Multi-objective information retrieval-based NSGA-II optimization for requirements traceability recovery. In: 2020 IEEE EIT. pp.271-280. https://doi.org/10.1109/EIT48999.2020.9208233, ISSN: 2154-0373
- **[Zhang16]** Zhang, Y., Wan, C., Jin, B.: An empirical study on recovering requirement-to-code links. In: 17th IEEE/ACIS SNPD. pp. 121-126 (2016)
- **[Guo17]** Guo, J., Cheng, J., Cleland-Huang, J.: Semantically enhanced software traceability using deep learning techniques. In: 2017 IEEE/ACM 39th ICSE. pp. 3-14 (2017)
- **[Moran20]** Molenaar, S., Spijkman, T., Dalpiaz, F., Brinkkemper, S.: Explicit alignment of requirements and architecture in agile development. In: REFSQ 2020. pp. 169-185. Lecture Notes in Computer Science, Springer International Publishing (2020)