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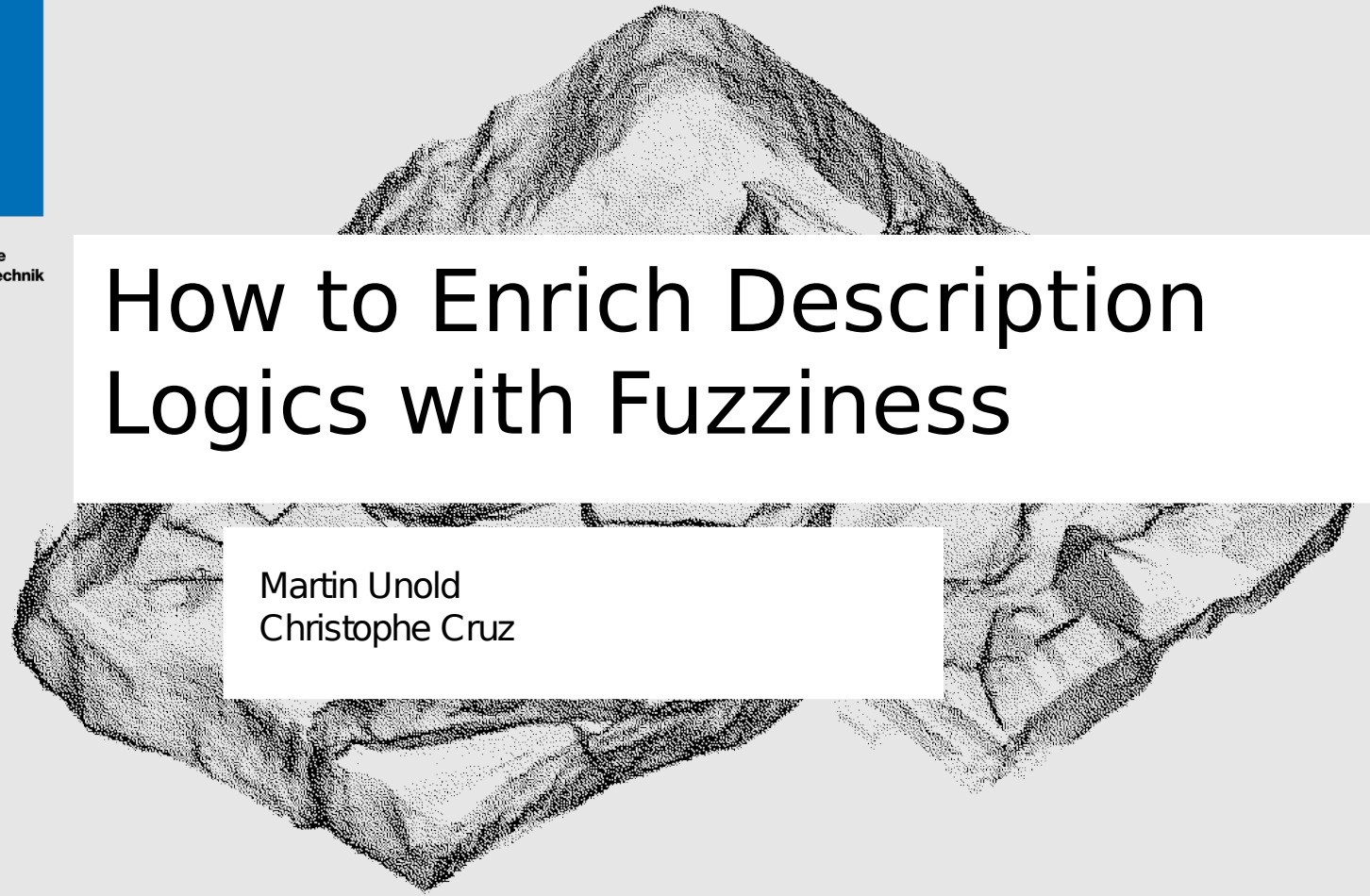
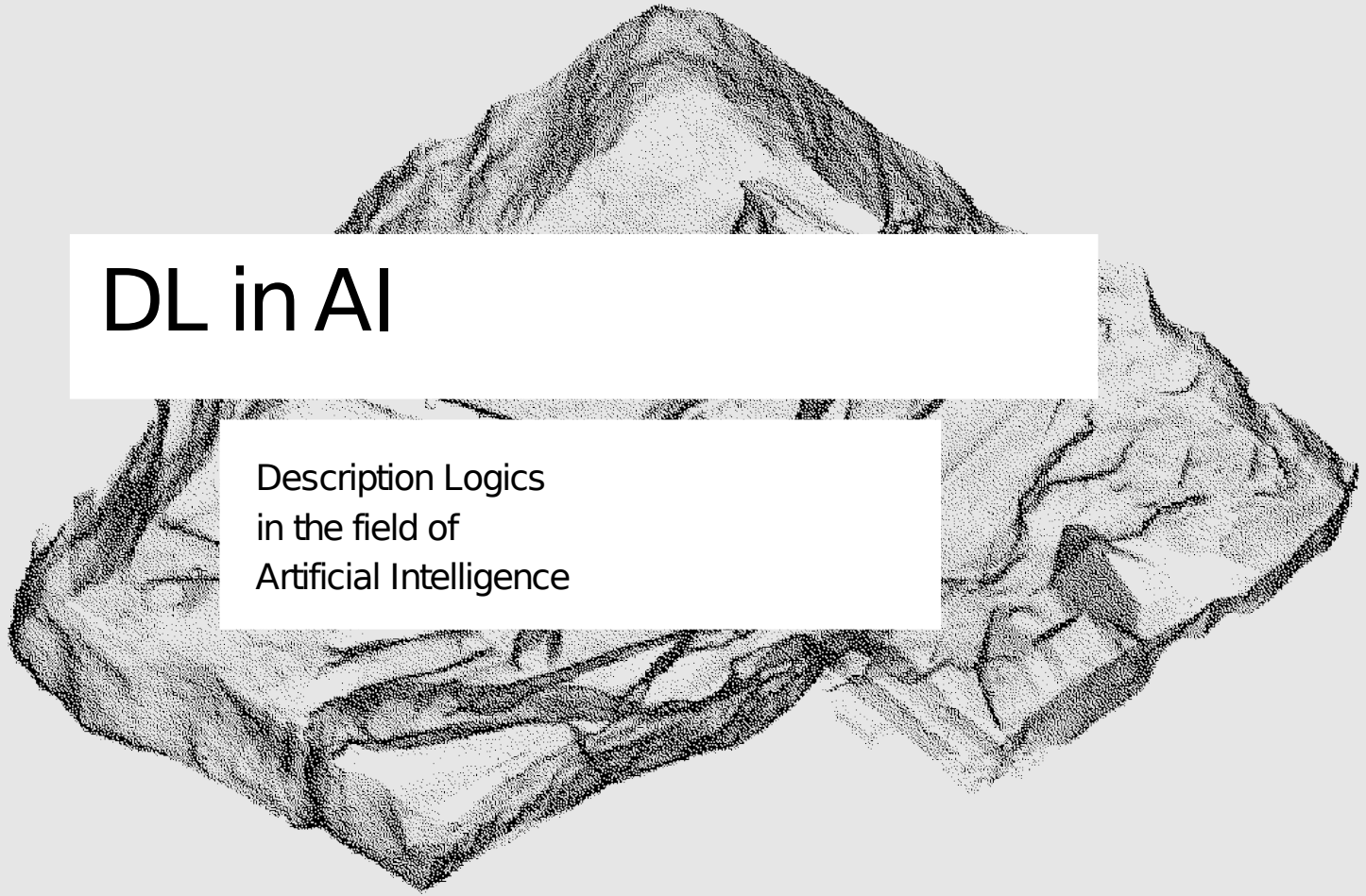


How to Enrich Description Logics with Fuzziness

Martin Unold
Christophe Cruz

Outline

- Description Logics (DL)
  in Artificial Intelligence (AI)
- Description Logics + Fuzziness
- Some Applications



DL in AI

Description Logics
in the field of
Artificial Intelligence

Approaches in Artificial Intelligence

Symbolic	Numeric
Complexity	Noise
Structure	Probabilities
Logic	Values
Abstraction	Graphical
Resolution	Expectation
Generalization	Optimization
Modules	Regularization

http://journal.frontiersin.org/researchtopic/5640/statistical-relational-artificial-intelligence

(Crisp) Description Logic (DL)

- Logical formalisms to store and manage knowledge
- DL consists of
  - Individuals
  - Concepts
  - Roles

Example DL with cities

- Individuals
  - London, Paris, Berlin
- Concepts
  - Town, City, Capital
- Roles
  - NorthOf, NearBy, BiggerThan

Knowledge Base (KB)

- KB consists of Axioms
  - Assertional Axioms
    - An individual belongs to a certain concept
    - Two individuals are connected by a role
  - Terminological Axioms
    - General Relation between Concepts and Roles

Example: Assertional Axioms

- London a Capital
- London northOf Paris

Example: Terminological Axiom

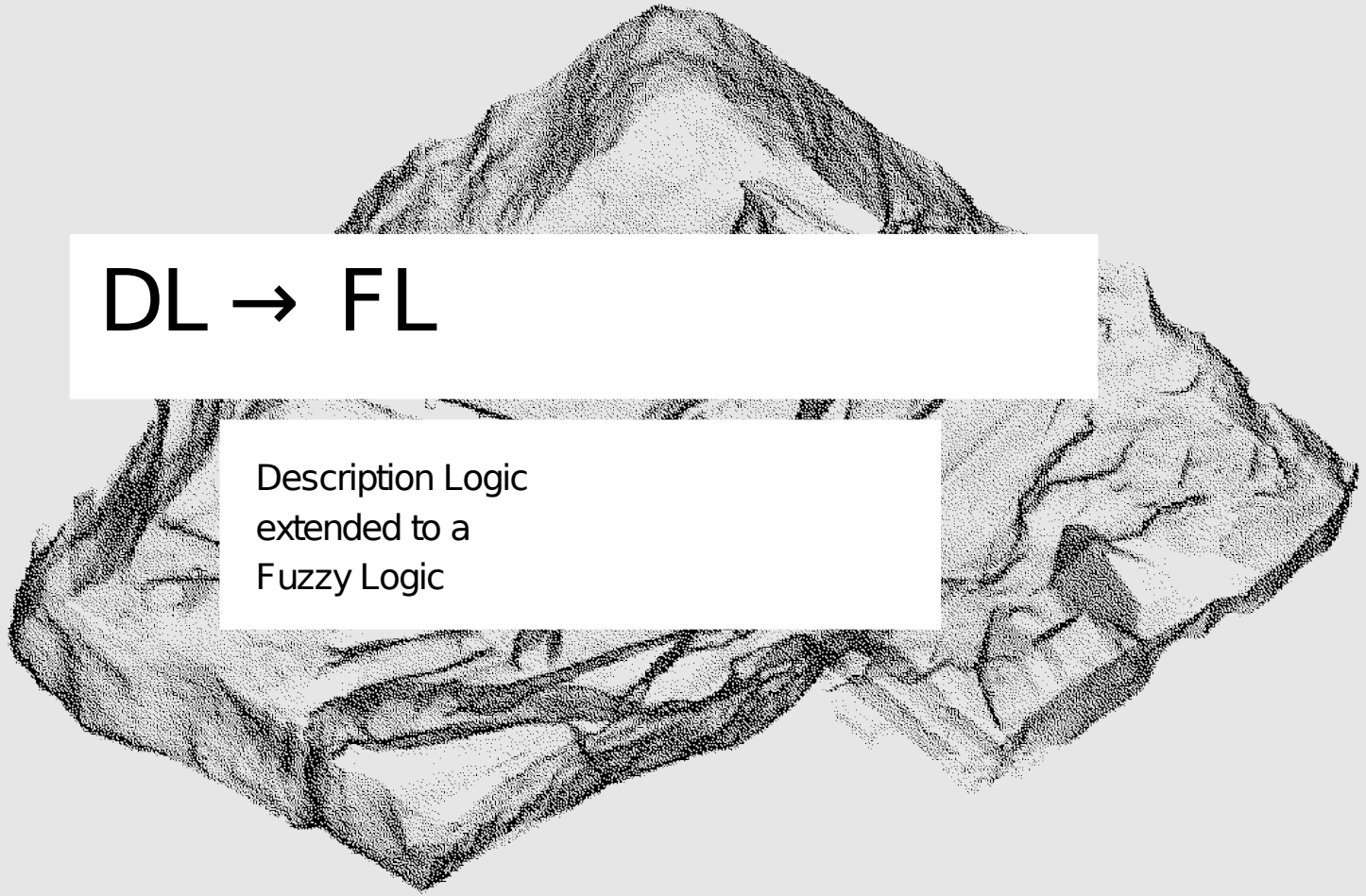
- NorthOf is a Transitive Property

Example: Terminological Axiom

- NorthOf is a Transitive Property

```
A northOf B .
B northOf C .

→ A northOf C .
```



DL → FL

Description Logic
extended to a
Fuzzy Logic

Vagueness vs Uncertainty

Vagueness

Information is formulated in an inexact way.

There is space for interpretation.

Uncertainty

It is unknown, if an information is correct.

The information is either true or false.

Typical Axioms

Vagueness

Peter is tall.

The tomato is ripe.

Uncertainty

P = NP.

Tomorrow is doomsday.

Wheather forecast: 20% Rain tomorrow

Vagueness

Tomorrow it will rain rather light
(with 20% intensity)

Unsicherheit

In 1 of 5 cases, it will rain tomorrow.

In 4 of 5 cases, it will not rain tomorrow.

Wheather forecast: 90% Rain tomorrow

Vagueness

Tomorrow will rise a heavy thunderstorm.

(with 90% intensity)

Unsicherheit

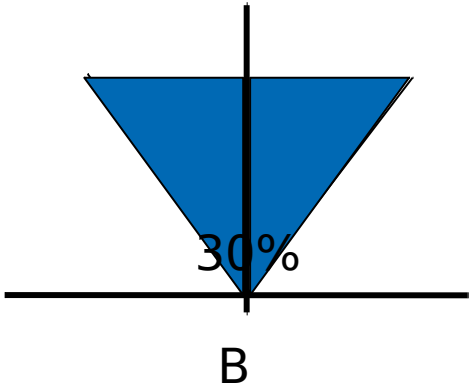
In 1 of 10 cases, it will not rain tomorrow.

In 9 of 10 cases, it will rain tomorrow.

A is north of B (70%)

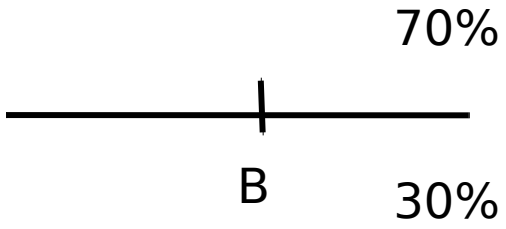
Vagueness

Where is A ?



Uncertainty

Where is A ?



Implications for inference

- Transitive Property

```
A northOf B p .
B northOf C q .

→ A northOf C ? .
```

Uncertainty

```
(1) A northOf B p .
(2) B northOf C q .
(3) A northOf C ? .
```

- (1) and (2) true → (3) true (probability: `p*q`)
- (1) and (2) false → (3) false (probability: `(1-p)*(1-q)`)

- Unknown in the other cases

Uncertainty

```
(1) A northOf B p .
(2) B northOf C q .

(3) A northOf C
    [p*q,1-(1-p)*(1-q)] .
```

Vagueness

```
(1) A northOf B p .
(2) B northOf C q .
(3) A northOf C ? .
```

- There is no „correct“ way to calculate the value for (3)
- Only heuristic approaches

Vagueness

- Examples

  Product-Logic

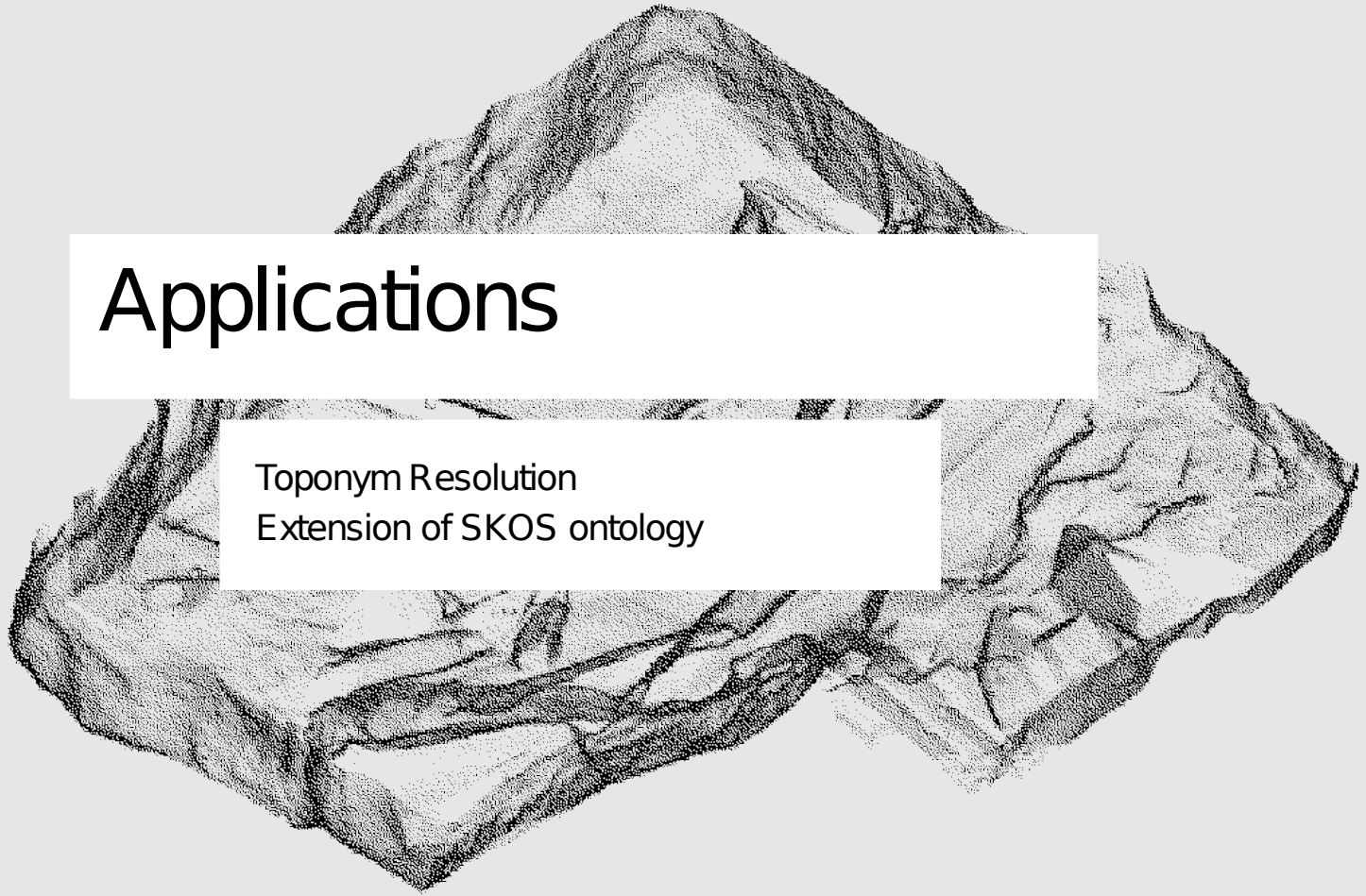
  `p*q`

  Goedel-Logic

  `min(p,q)`

  Lukasiewicz-Logic

  `max(p+q-1,0)`



Applications

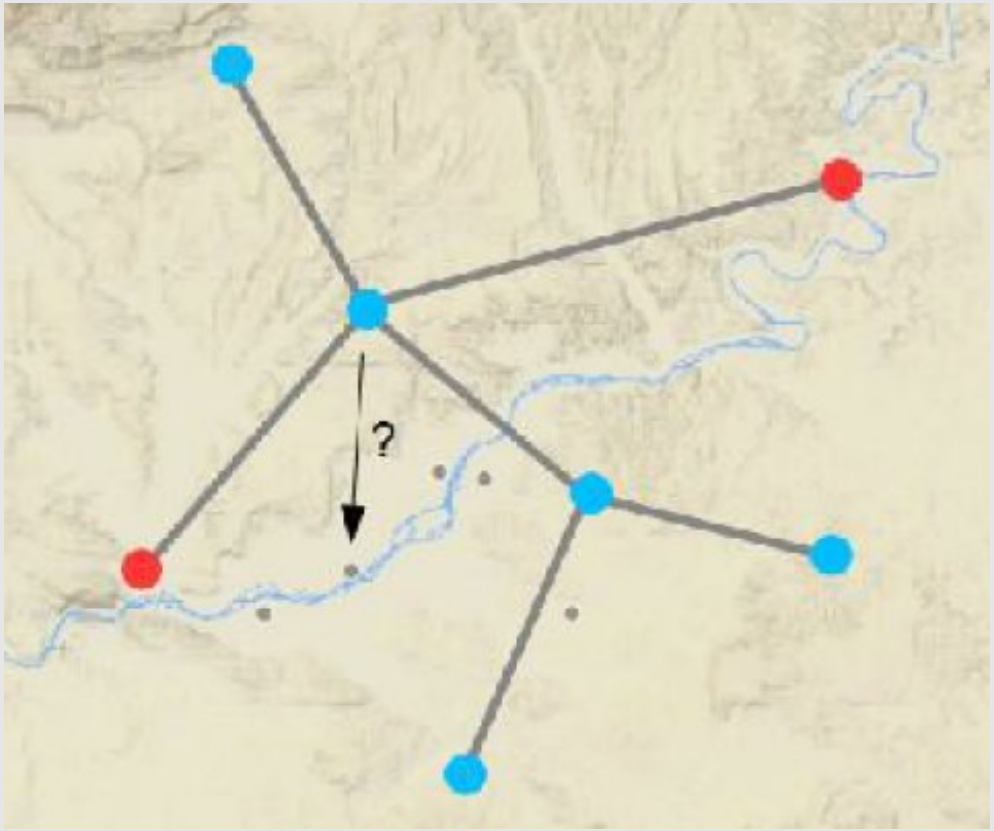
Toponym Resolution
Extension of SKOS ontology

Toponym Resolution

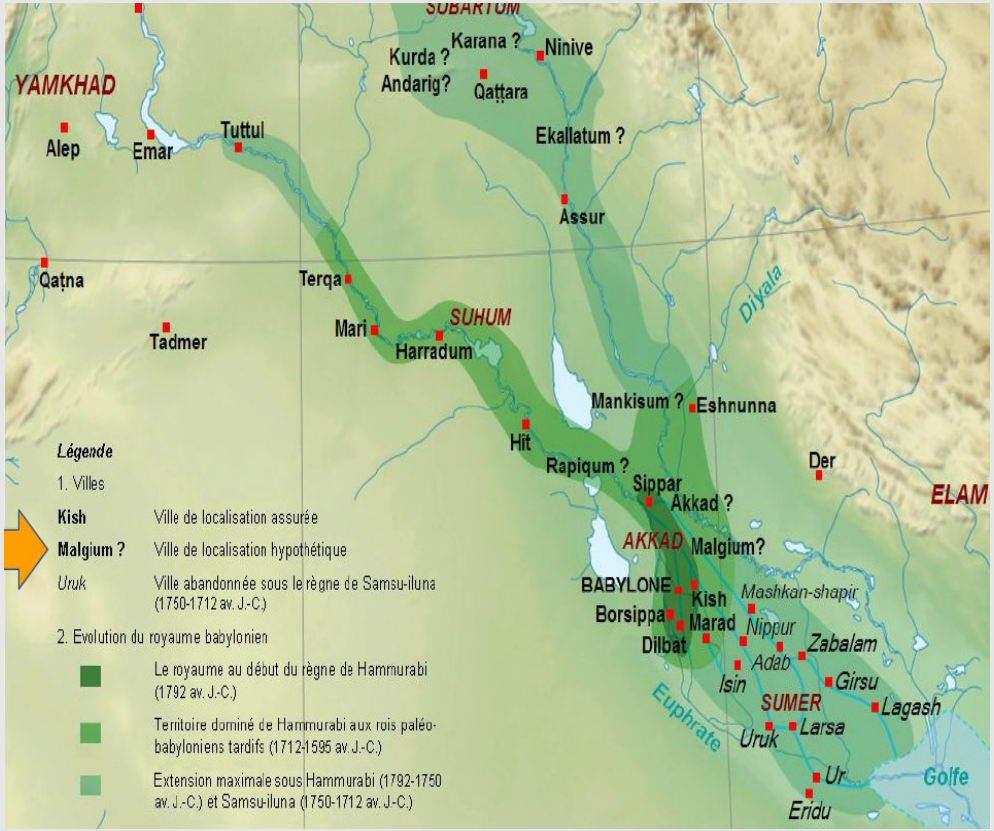
```
X northOf Paris 70% .
London closeTo X 90% .
X a Town 80% .
```

- Goal: Where is X ?

Toponym Resolution



higeomes.org



SKOS

- Roles
  - Broader
  - Narrower
  - Match

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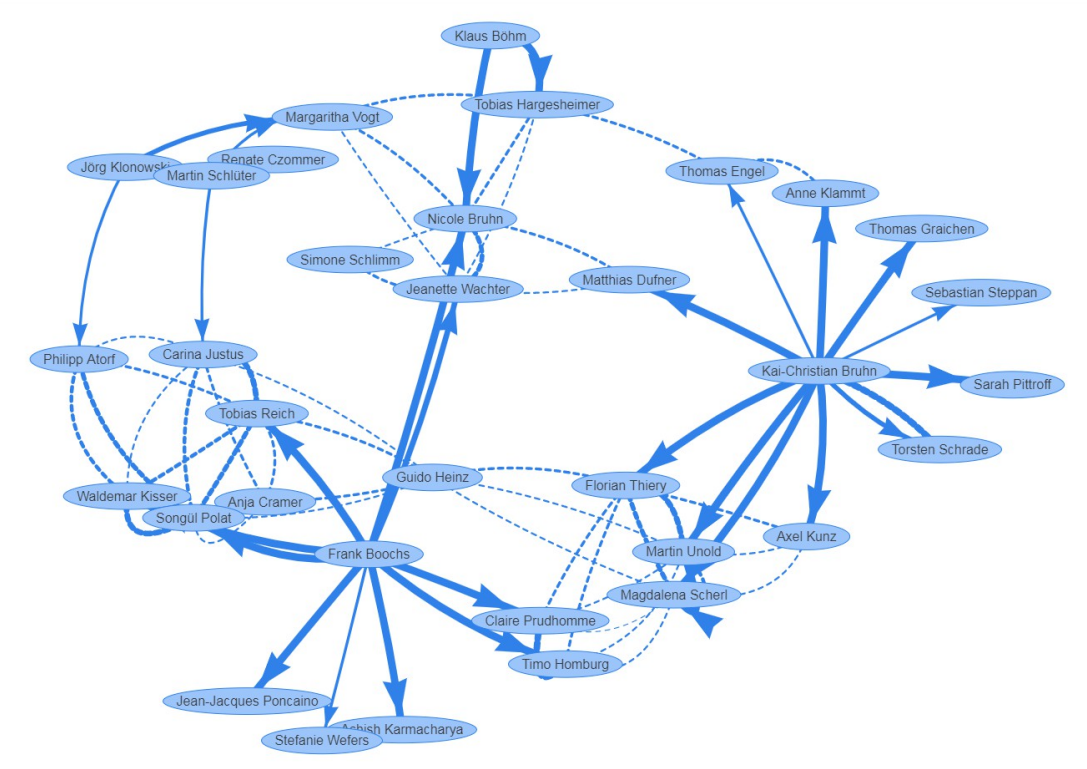
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Thank You

For Your Attention