Improving Semantic Interoperability of Distributed Geospatial Web Services:

G-MAP SEMANTIC MAPPING SYSTEM

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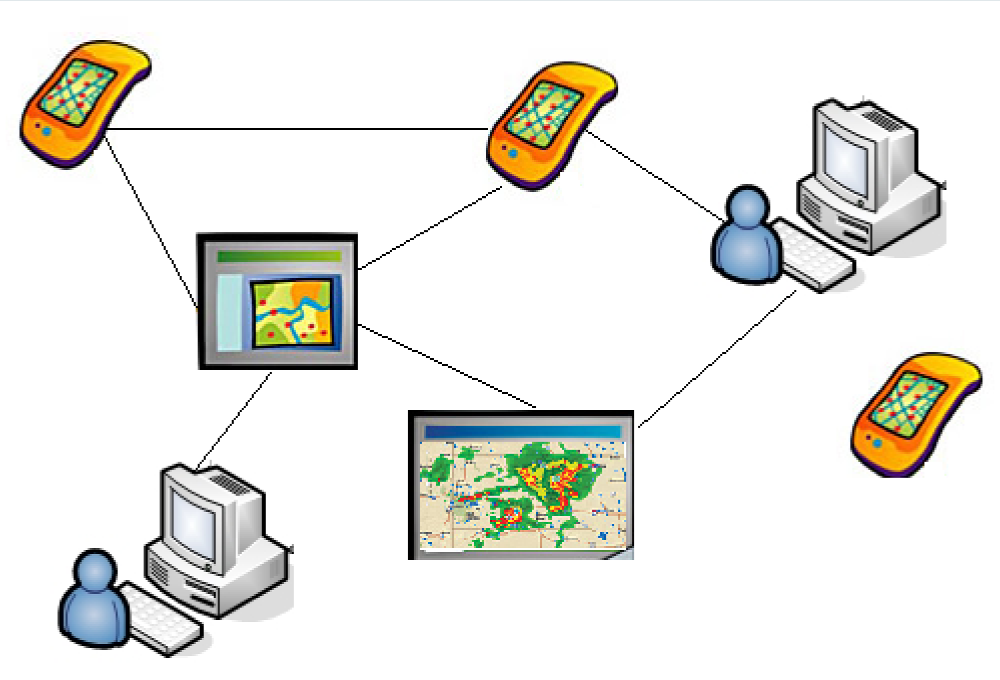
Content

- Context: GWSs interoperability
- Problematic: Semantic mapping
- Objective improve semantic interoperability of GWSs
- Proposed Approach : G-MAP Semantic Mapping System and its components
- Benefits of G-MAP System
- Conclusion and Future Work

Context

Distributed Geospatial Web Services ….



• GWS are modular components of geospatial computing applications
• Previously, geospatial services were available through GIS desktop application
• Nowadays, available on the Web, through distributed applications and networks

Need semantic interoperability to discover and combine relevant GWSs

Problematic

- Standards were created to support interoperability at the syntactic level (e.g., Web Service Modeling Language, WSDL; SOAP to support service binding)
- Those standards cannot help to overcome semantic heterogeneity, i.e. differences in meaning of concepts
- Differences arise because geospatial web services were build for different purposes, by different organizations

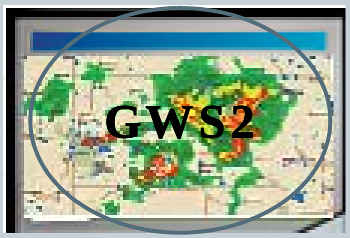
Problematic

Example of semantic heterogeneity of geospatial web services:

The function of this geospatial web service is to ‘’display flooded regions’’ …

Output: flooded regions which are adjacent to watercourse only

The function of this geospatial web service is to ‘’display flooded regions ’’ …



Output: flooded regions which are close to cities only

GWS with similar functionalities have different outputs

Problematic

- Existing solutions:
  - **OGC Catalog of Geospatial Web Services**: tedious task for the user to search within a catalog; catalog needs to be updated any time a new service becomes available
  - **Semantic similarity measure** : indicates the degree of similarity between a query and existing web services descriptions
  - Semantic similarity (quantitative) is not expressive enough to help the user to select the most relevant service (e.g., does not indicate if the service is more specific, less specific than the query, or overlapping the query ...)

Objectives

- Propose a solution for semantic interoperability of geospatial web services which is:
  - Based on a rich service description
  - Produces qualitative relationships between a query and a service description, or between different services descriptions
  - Automatic (to be operational in ad hoc environments)

Proposed Approach

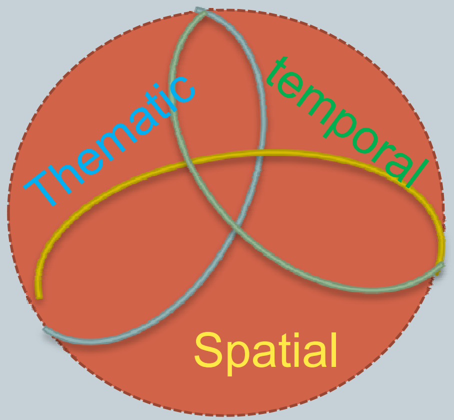
The G-MAP Semantic Mapping System:

- Uses an ontological service description based on our previous research: the Multi-View Augmented Concept (MVAC) Model
- Uses rule-based inference engine principle to automatically infer semantic relations between a query and a service description, or between different services descriptions

MVAC Model for Geospatial Web Services

- The MVAC represents the different **views** that a concept have in different **contexts:**

- **A MVAC concept is composed of :**
  - Name
  - Properties
  - Relations
  - Spatial descriptors
  - Temporal descriptors
  - Views (defined based on Contexts)
  - Dependencies



C_{MVAC} = < n(c), {p(c)}, {r(c)}, {spatial_d(c)}, {temporal_d(c)}, {v(c)}, {dep(c)}>

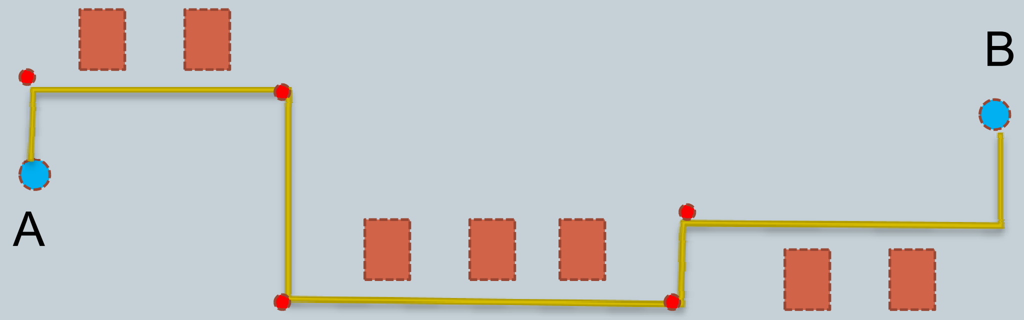
MVAC Model for Geospatial Web Services

- The MVAC :
  - represents the different **views** that a concept have in different **contexts** (examples of contexts are tourism, transportation, etc.)
  - uses “spatiotemporal descriptors” to describe semantics of spatiotemporal features (ex: surface of waterbody corresponds to ‘’maximal waterlogged area’’)
  - augments the concept with **dependencies** between concept’s features (ex: a dependency between ‘’depth’’ and ‘’status’’ is

    depth(floodedLand) = high → status(floodedLand) = navigable)
  - can be expressed with Description Logics (DL) to support reasoning

MVAC Model for Geospatial Web Services

- GWS are described with following parameters: a function, input and output, pre-conditions and post-conditions
- Each GWS parameter is described not only with a word, but with an enriched concept called ‘’Multi-View Augmented Concept’’ (MVAC)



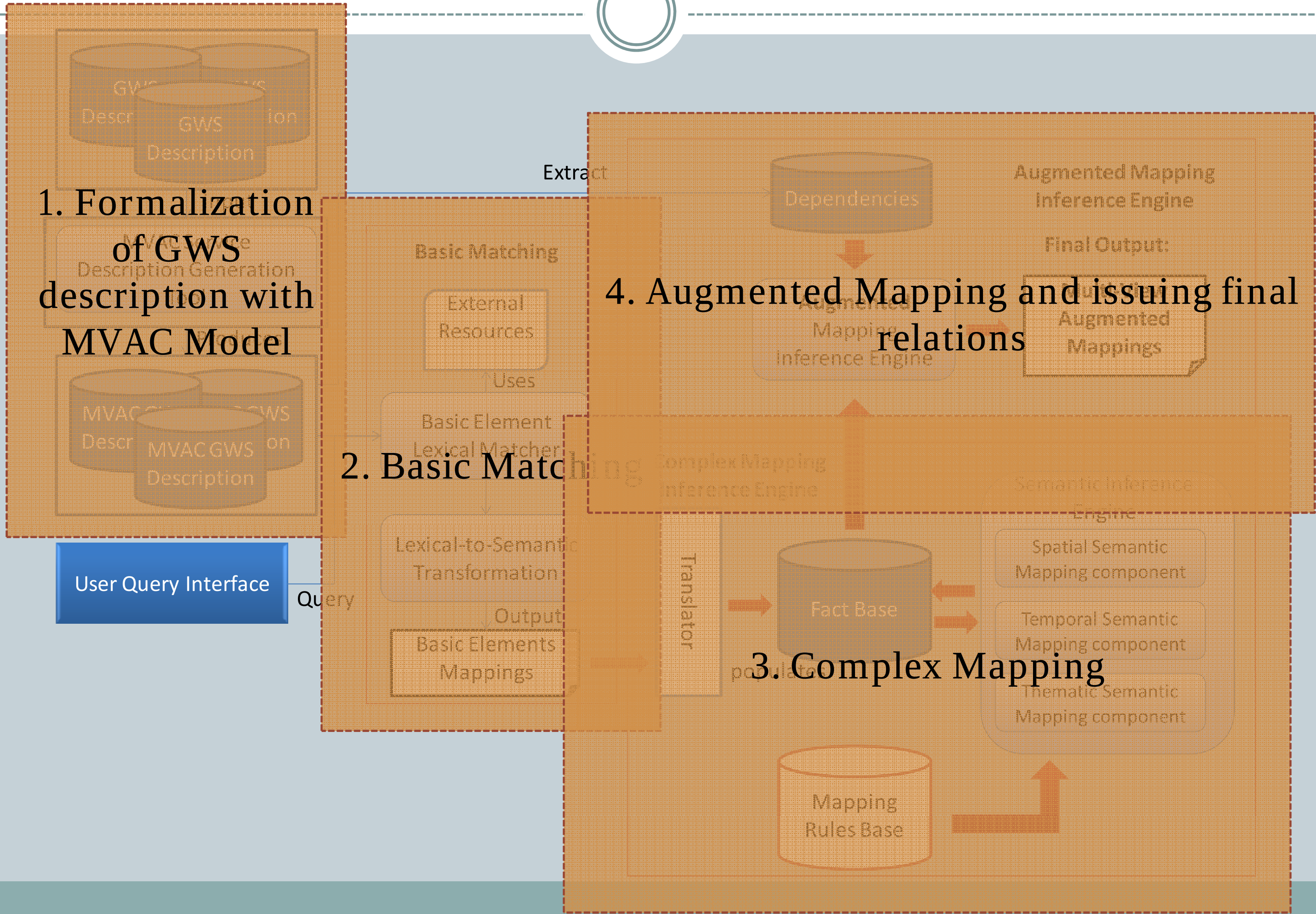
Example of a GWS : Compute distance between two locations

MVAC Model for Geospatial Web Services

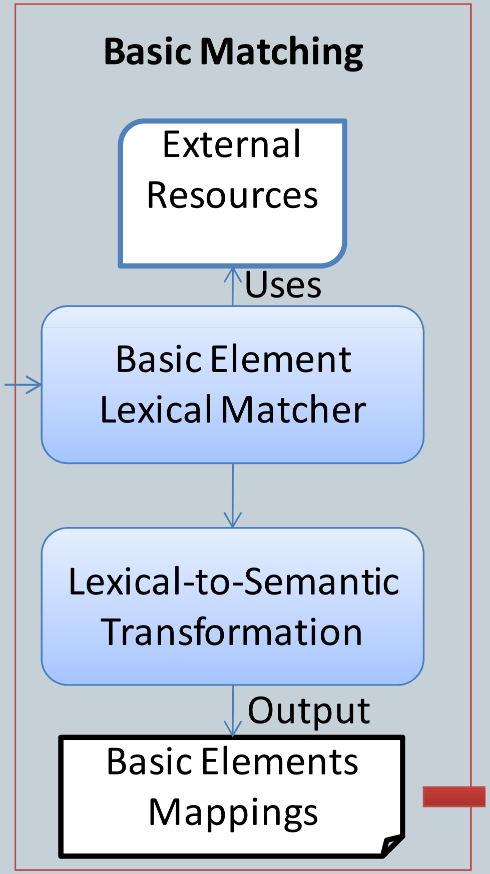
```
Class(input complete restriction(is-A someValuesFrom
(GML: surface)))
Class(pre-condition complete restriction(part-of
someValuesFrom(NorthAmerica)))
Class(function complete restriction(is-A
someValuesFrom(LocalisationOfFloodRiskZone)))
Class(output complete restriction(is-A
someValuesFrom(GML: surface) restriction (hasContext someValues-
From(floodDisasterResponse, floodPrevention)))
Class(output_FloodPrevention_Context complete restriction(is-A some-
ValuesFrom(GML: surface) restriction (CloseTo someValues-
From(waterbody)))
Class(output_ floodDisasterResponse_Context complete restriction(is-A
someValuesFrom(GML: surface) restriction (AdjacentTo someValues-
From(waterbody)))
Class(post-condition complete restriction(hasSpatialAccuracy
(5meters)))
```

```
Class(floodedLand complete restriction(is-A someValuesFrom
(GML: surface) restriction (depth hasSomeValuesFrom(high)) restric-
tion (status hasSomeValuesFrom (navigable)))
```

G-MAP Semantic Mapping System

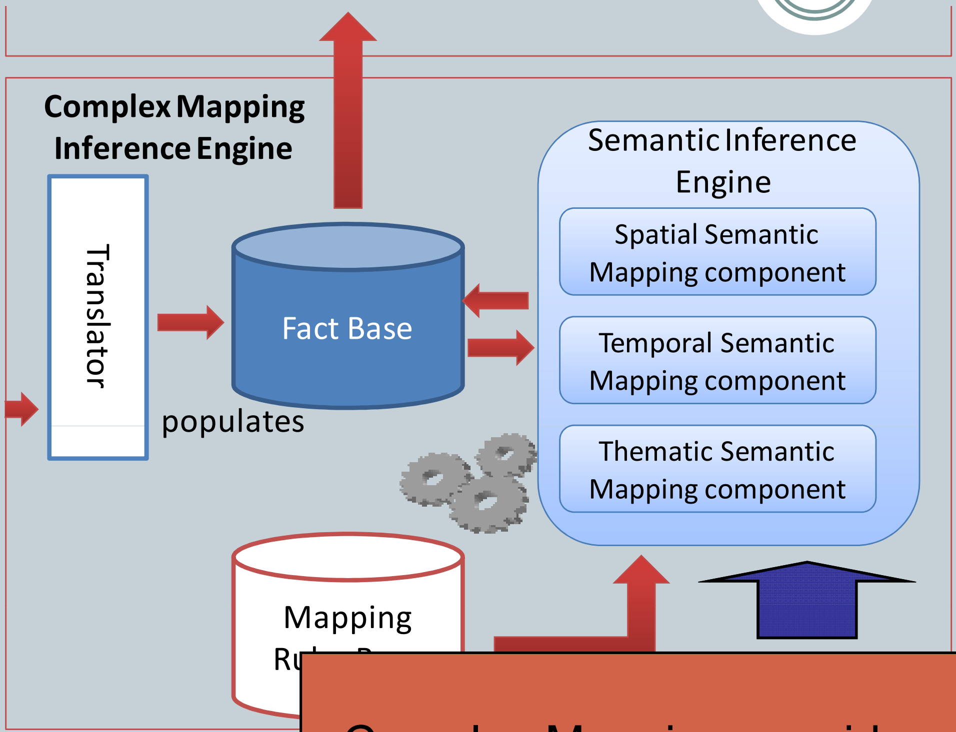


Basic Matching



- computes a lexical relation (synonymy, hyponymy, hypernymy, partonomy)
- uses several appropriate external resources to infer the lexical relation
- lexical relations are transformed into semantic relations

Complex Mapping

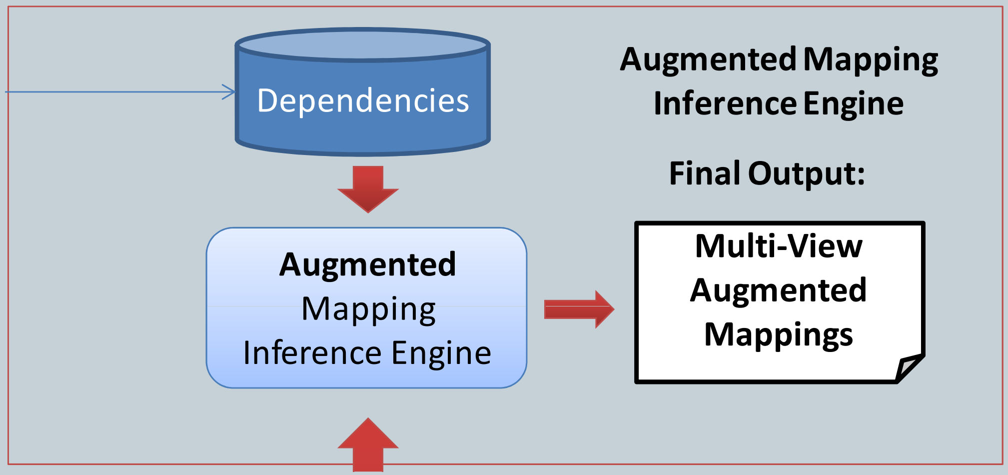


- **inference engine** based on the idea of verifying a set of **logical rules**, which express the condition for a **semantic relation** between two features to be true

Complex Mapping consider spatial, temporal and thematic features separatly with distinctive mapping rules, which allow better understanding of the semantic relation between services descriptions

- **1)** translate rel (facts)
- **2)** Match facts
- **3)** if a rule is ve nd stored

Augmented Mapping Inference Engine



- uses a new structural matching criteria to discover more mappings: the dependencies
- principle: features that participate in structurally similar dependencies can be similar too

Example:

dependency1: depth (floodedLand) = high→ status (floodedLand) = navigable
dependency2: water level (floodplain) = high→ status (floodplain) = navigable

“depth” and “water level” participate in structurally similar dependencies

Implementation example

example of an augmented multi-view mapping result: semantic relation between the requested service description and two views of a given GSW description

	View1 of GWS1	View2 of GWS1	GWS2
Semantic Relations	Query Includes (⊒) View1 of GWS1	Query Overlap (⊓) View2 of GWS1	Query Included In (⊑) GWS2
Context	FloodPrevention_Context	floodDisasterResponse_Context	DisasterMonitoring_Context
Function	LocalisationOfFloodRiskZone With temporal relation: before someValuesFrom(rainstorm)	LocalisationOfFloodRiskZone With temporal relation: after someValuesFrom(rainstorm)	LocalisationOfRiskArea With temporal relation: previous to (disaster)
Input	GML: surface	GML: surface	GML: surface ⊔ GML: point
Output	GML: surface with Spatial Descriptor: GroundLevel someValuesFrom(<=3m)	GML: surface with Spatial Descriptor: AdjacentTo someValuesFrom(FloodedLand)	GML: surface
Preconditions	part-of someValuesFrom(Ontario)	part-of someValuesFrom(Ontario)	part-of someValuesFrom(Canada)
Postconditions	hasSpatialAccuracy (4meters)	hasSpatialAccuracy (4meters)	hasSpatialAccuracy (100meters)
Dependencies	GroundLevel(GML:surface, low) → riskLevel(GML:surface, high)	WaterLevel(GML: surface, >2m) → status(GML: surface, navigable)	DisasterFrequency(riskArea, high) → risk(riskArea, high)

Benefits of G-MAP System

- Identifies several types of relations between GWS descriptions (equivalent, includes, overlap..), with several sub-types:
  - Thematic equivalence/spatially disjoint/temporal equivalence
  - Thematic inclusion/spatial equivalence/temporal inclusion

  Etc.
- Varifyes complex cases to improve the interpretation of relations between GWS but remain intuitive to understand
- Supports multi-context semantic interoperability:
  - Semantic mapping depends on the context

Conclusions

- G-MAP is a semantic mapping system useful to:
  - Discover relevant Geospatial Web Services beyond simple syntax comparison between concepts from GWS
  - infering some implicit information in the description of GWS that helps to their interoperability
- Limitation
  - It is still difficult to have fully automatic semantic interoperability approach and human reasoning intervention is needed for final decision making

Future Work

- G-MAP Semantic Mapping System opens new research opportunities:
  - Investigate how G-MAP can support propagation of user queries to relevant services in an ad hoc network of geospatial web services.
  - Investigate how G-MAP can support dynamic classification of services, to support the user searching for relevant services.

- THANK YOU