Towards a Semantic Message-driven Microservice Platform for Geospatial and Sensor Data

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Overview

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Motivation
Why Geiser?

- Flexible integration of live data
  - Sensor data
  - Social media feeds

- Inherently related to geospatial data
  - Location of sensor measurements
  - Places mentioned in tweets

- Potential applications:
  - Routing
  - Geomarketing
  - Analytics (e.g., business intelligence, predictive maintenance)

- Issues:
  - Small but frequent service requests
  - Flexible and reliable communication
  - Scalability
Use Cases

Use Case 1: Data-driven Geomarketing

- Current situation for local businesses:
  - Geomarketing based on static data
  - No fine-grained dynamic adaptations

- Goals:
  - Enable companies to adapt products, services, offers etc. to their audience
  - Integrate and interpret live data

- Relevant data:
  - Events from social media / news
  - Mobility and cellular network data
  - Weather warnings and forecasts
  - Own customer data
Use Cases

Use Case 1: Data-driven Geomarketing
Use Cases

Use Case 2: Intelligent parking

- **Current situation:**
  - Finding road-side parking in cities is difficult
  - Little support from satnavs

- **Goals:**
  - Compute parking probabilities
  - Provide approximate routing service on satnav device

- **Relevant data:**
  - Sensor data (floating car data)
  - Mobility / cellular network data
  - Traffic events
  - Events (e.g., football matches)
Use Case 3: Predictive maintenance and industrial service

Device sensors

Weather

Traffic

- Current situation:
  - Sensor networks in industrial appliances not connected to service technician scheduling
  - High cost of halted manufacturing processes

- Goals:
  - Link predictive maintenance with service deployment planning and spare part logistics

- Relevant data:
  - Predictive maintenance data
  - Weather forecasts and warnings
  - Traffic information
Approach
**Geiser Architecture**

**GEISER Platform**
- Generic Services, e.g. LIMES, DEER, FOX, AGDISTIS
- Application Services (only samples included, use case specific)
- Data Services (querying, manipulation, geospatial, etc.)

**Unified GEISER REST API**

**Compatible Tooling** (loosely coupled)
- Features: visualization, exploration, dashboarding, data analytics, semantic search, etc.
- Examples: metaphactory, Facete, mappify, etc.

**Private or public cloud** (Semantic Databases, SPARK ecosystem, SANSA ...)

**Compute Infrastructure**

**Use Cases & Applications**
Geiser architecture

- **Message bus**
  - RabbitMQ based (flexible exchange patterns, reliable asynchronous messaging, simple consumer implementation, MQTT support)
  - Usually AMQP topic exchanges (most flexible)

- **Service layers**
  - Data services (for accessing, querying and manipulating RDF data)
  - Generic services (e.g., LIMES for interlinking, DEER for data fusion, FOX and AGDISTIS for extracting unstructured data)
  - Application services (e.g., probabilistic routing or weather forecast parsing)

- **Usage**
  - REST API for external requests (application-specific)
  - External tools like metaphactory
Invocation of services: Geomarketing use case

Example: Extracting and processing tweets for event information

- Twitter Feed pushes new tweets to message bus, e.g.:
  "ESWC started in Heraklion"
- NER annotates identified Named Entities
- Fusion applies an enrichment pipeline, e.g., adding geocoordinates and geometries from related resources (via owl:sameAs)
- Distance computes geospatial distance to region of interest, e.g.,
  \( \text{st_distance(entity.geom, Greece.geom)} \)
- Classifier filters messages, e.g., by distance, discards irrelevant tweets
- Storage adds annotated tweet to RDF store
Message passing

- Message passing (instead of RPC between a controller and services):
  - Messages flow through list of services (see example)
  - Invocations specified in AMQP routing key, e.g., for messages from Twitter: `ner-v1.fusion-v1.distance-v1.classifier-v1.storage-v1`
  - Workflow can be modified at runtime

```
// routing key: fusion-v1.distance-v1.classifier-v1.storage-v1
// ... other header fields ...
{
  "@context": "http://example.org/context/fox.jsonld",
  "text": "ESWC started in Heraklion",
  "fox": [{
    "uri": "http://dbpedia.org/resource/Heraklion",
    "name": "Heraklion"
  }]
}
```

Example message from NER service in JSON-LD format
Implementation
Implementation

- Implementing services
  - Wrapper for services already exposing a REST API\(^1\)
  - Support library for developing an AMQP interface, based on Spring AMQP:

```java
@Component
public class MyService {
    public static final String ROUTING_KEY = "myservice-v1.#";
    public static final String QUEUE_NAME = "myservice-v1";

    @RabbitListener(bindings = @QueueBinding(key = ROUTING_KEY, exchange = @Exchange(type = ExchangeTypes.TOPIC, value = ServiceUtils.EXCHANGE, durable = "true", autoDelete = "true"), value = @Queue(autoDelete = "true", value = QUEUE_NAME)))
    public void handleMsg(@Payload Message message) throws IOException {
        /* handle request */
        rabbitTemplate.send(ServiceUtils.EXCHANGE, ServiceUtils.nextRoutingKey(message), MessageBuilder...build());
    }
}

\(^1\)https://github.com/AKSW/micropipe-proxy
```

Wauer & Ngonga Ngomo (DICE)
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Deployment

- Services are dockerized and configurable, e.g., regarding inputs
- Set of services required for a use case specified in Docker Compose, e.g.:

```yaml
services:

geiser-twitter-feed:
  image: mwauer/geiser-twitter-feed
  environment:
    - locations=-122.75,36.8,-121.75,37.8,-74,40,-73,41
    - routing=ner-v1.fusion-v1.distance-v1.classifier-v1.storage-v1

storage:
  image: mwauer/geiser-rdf-writer-service

rabbit:
  image: rabbitmq:management
  ports:
    - 5672:5672
```
Available services

- **Generic services**
  - NER and Relation Extraction (FOX/AGDISTIS)
  - Translation (APIs like Yandex or DeepL)
  - Interlinking (LIMES with RADON)
  - Fusion (DEER)
  - Transformation (Sparqlify)

- **Data services**
  - Basic RDF reading and writing services
  - RDF graph store, repository, SPARQL (in work)
  - Twitter feed (in work)

- **Application services (internal)**
  - Weather (openweathermap.org, DWD)
  - Pollen warning (DWD)
  - Routing (TomTom)
  - Traffic (TomTom)
  - Reachable areas (TomTom)
Evaluation
Validation

- Functional validation
  - Running service composition similar to data-driven geomarketing scenario
- Component evaluation:
  - NER: FOX at OKE 2017 challenge
  - Semi-automatic extraction of RDF from tables: TAIPAN
  - Interlinking: RADON (rapid discovery of topological relations)
Related Work
Related Work

- Semantic Service Infrastructures
  - METEOR-S
  - SADI (Semantic Automated Discovery and Integration)
  - SSWAP (Simple Semantic Web Architecture and Protocol)
  - MicroWSMO / hRESTS

- Semantic Data Processing
  - LinkedPipes ETL / UnifiedViews
  - GeoKnow
  - EW-Shopp
Conclusions and Future Work
Conclusions and Future Work

- **Geiser**, a platform for
  - Flexible processing of geospatial and sensor data
  - Using semantic technologies
  - Message-passing approach

**Future Work:**
- Implementation of the use cases
- Scalability of the platform
- Support in components (e.g., interlinking on data streams)

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