

# Distributed and Sensor Based Spatial Data Infrastructure for Dike Monitoring



## FIG Working Week 2016

CHRISTCHURCH, NEW ZEALAND 2-6 MAY 2016

Recovery



Dr.-Ing. Ralf Becker, RWTH Aachen University

from disaster

Geodetic Institute - Chair for Computing in Civil Engineering & GIS

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## 1 Introducing the EarlyDike Project

## 2 Sensor and Spatial Data Infrastructure

### 2.1 Proposed Architecture

### 2.2 Sensor Layer – Geo Sensor Network

### 2.2 Integration Layer

### 2.3 Presentation Layer – GeoPortal

## 3 Conclusion and Outlook



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## Recovery

- 12.000 km<sup>2</sup> protected by more than 1,200 km of sea dikes
- 2,400,000 people endangered
- more than 10 Billions of Euro value in the city of Hamburg
- more than 48 Billions of Euro value in Schleswig-Holstein
- Current early warning systems are only based on water level observations and water level predictions
- Current early warning systems **do not** take into account:
  - wind-induced waves
  - currents
  - resistance of coastal dikes





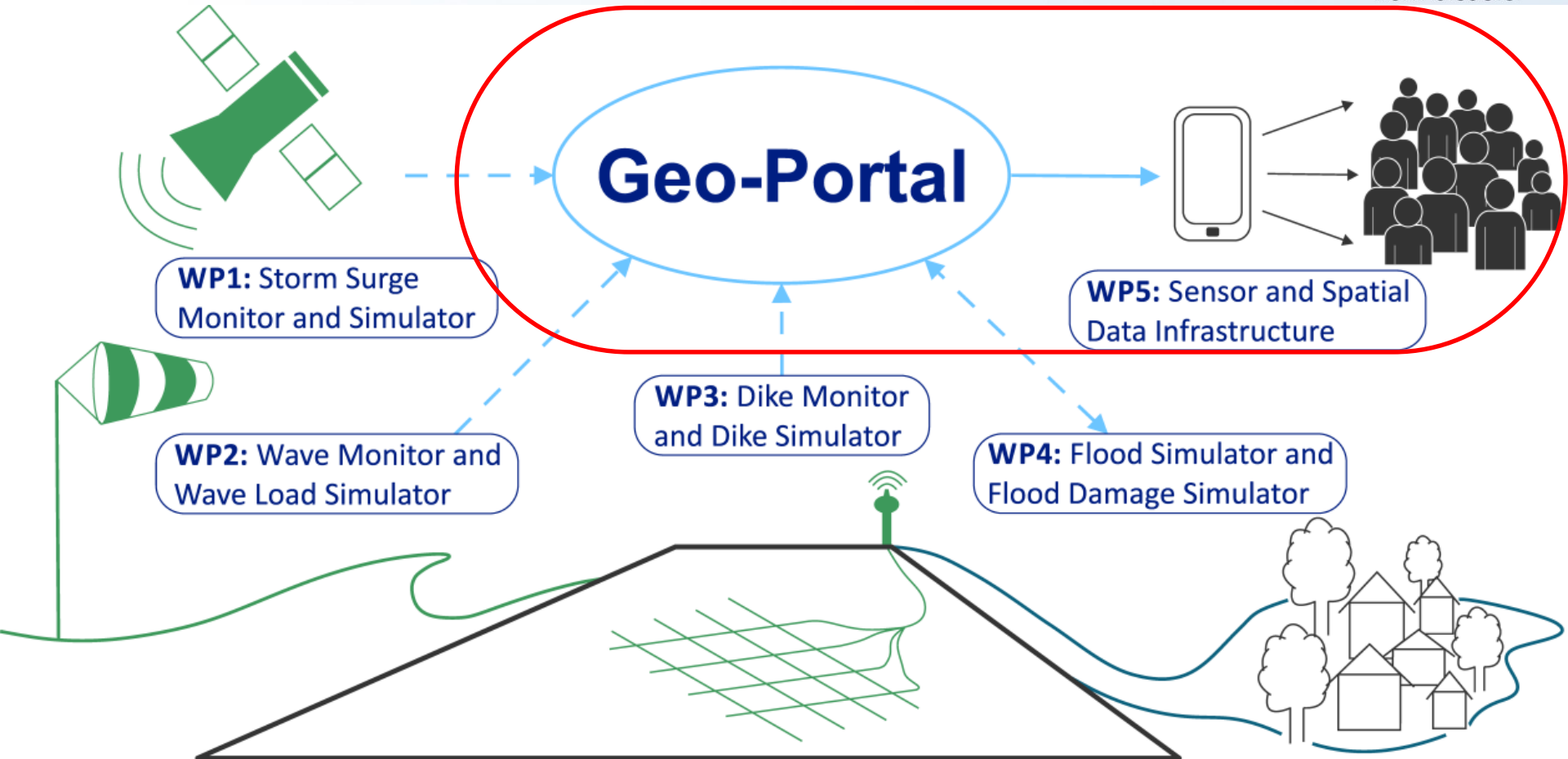


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## Recovery

from disaster

- “...aim is to develop a **Sensor and Spatial Data Infrastructure (SSDI)** for early warning...”
- “In order to ensure interoperability thereby **international standards** from geo information science defined by **INSPIRE of the European Union and the OGC** are adapted.”
- “...interoperable access of sensor data is accomplished by using data types and services of the **SWE initiative**, e.g. **Sensor Observation Service (SOS)**...”



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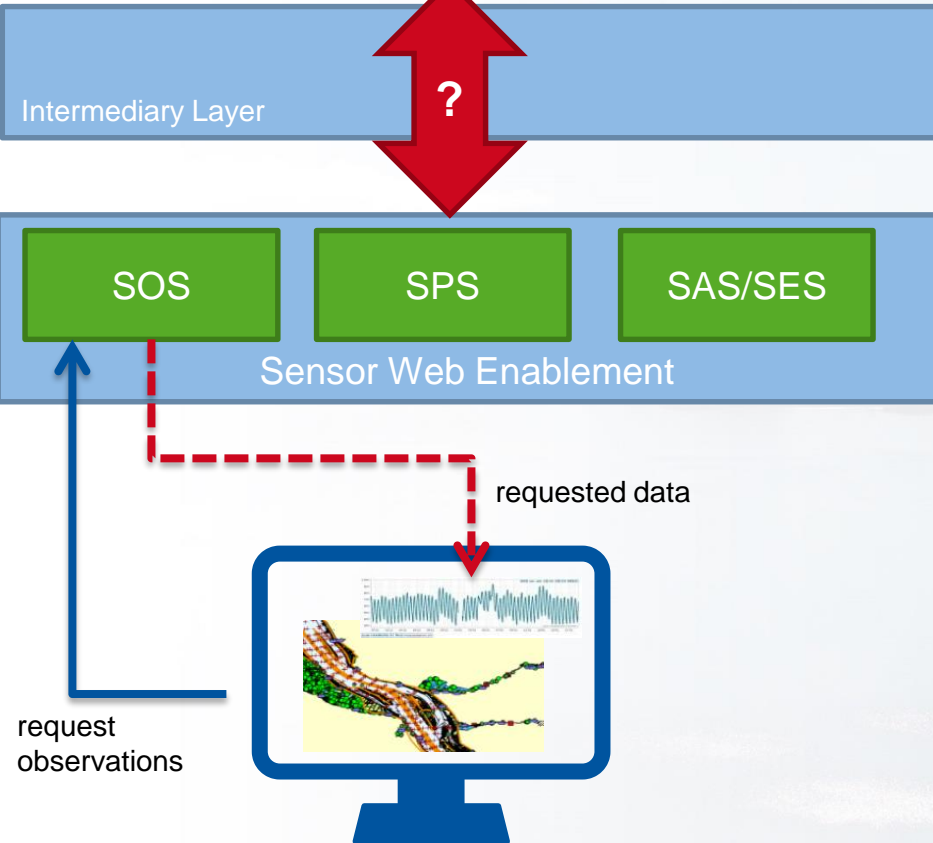


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## Wireless Geo Sensor Networks (WGSN)

- Wasp mote = Arduino clone & gateway
- Low-level protocol:
  - ZigBee (connectionless protocol)
  - Proprietary data format

## OGC Sensor Web Enablement (SWE)

- Different standards for discovering, accessing and using sensors and sensor data repositories via the Web
- High-level protocols:
  - TCP/IP
  - XML documents for transfer

→ Solution: Introducing a **Sensor Bus** (Broering, Foerster & Jirka 2010)

- Push-based technology instead of Pull (or Poll)



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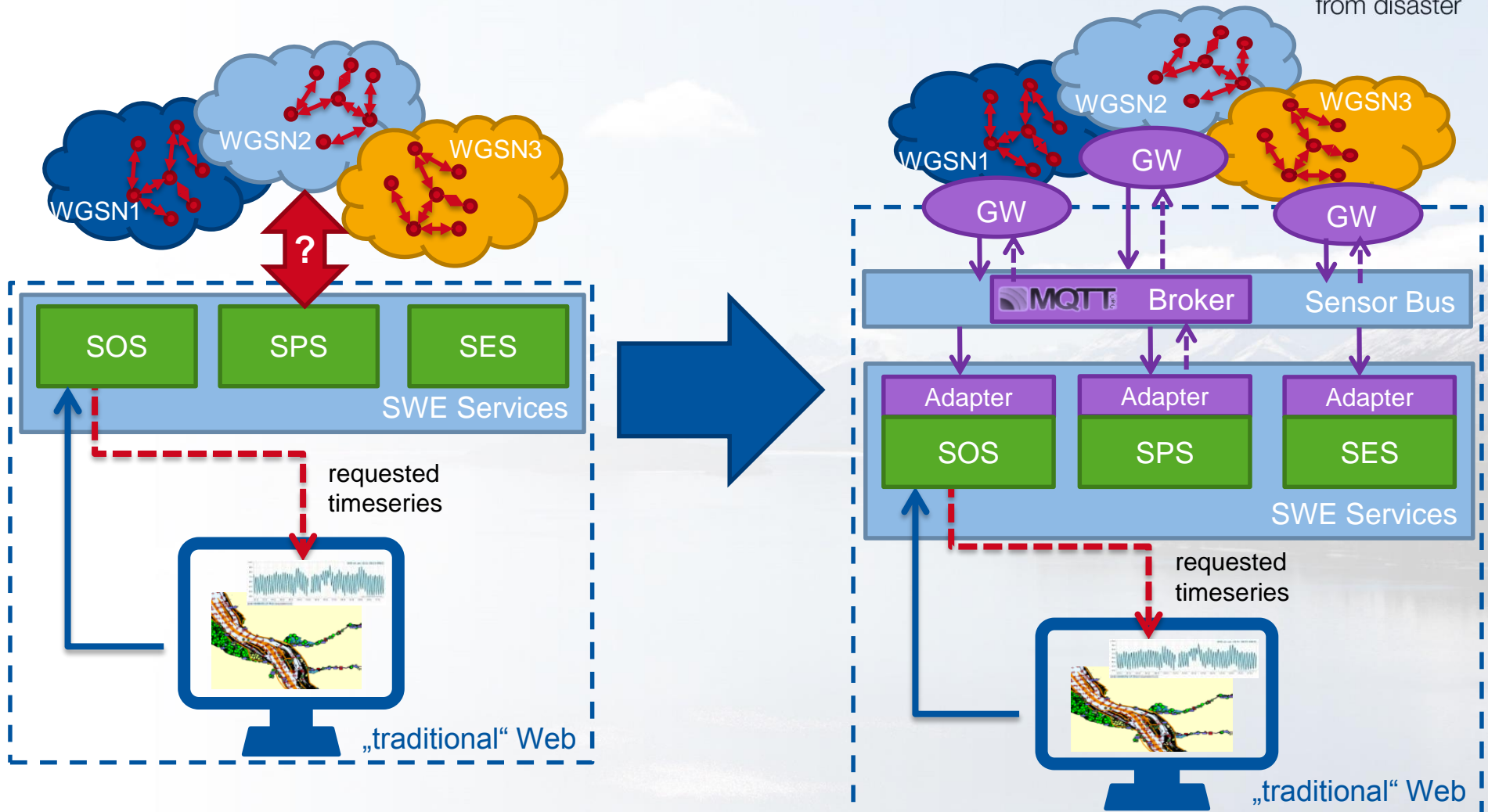


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## Recovery

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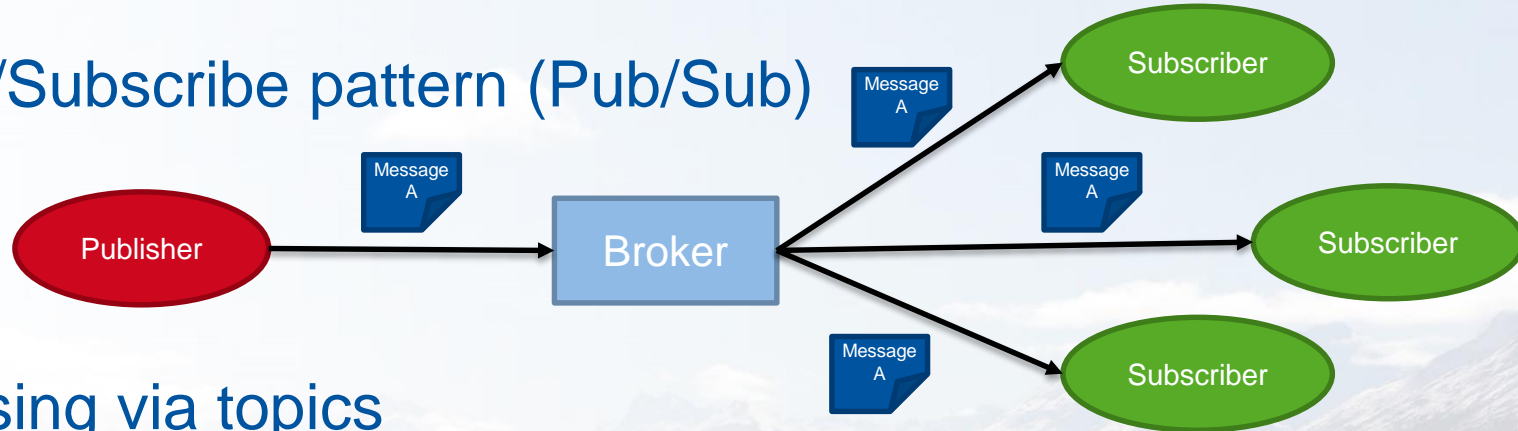
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### ■ Publish/Subscribe pattern (Pub/Sub)



### ■ Addressing via topics

- Subscribe to topics – topic-hierarchy with „/“:

→ `sensor_node/id_2/temperature`

- Wildcards

- „+“: single level wildcard → `sensor_node+/temperature`

- „#“: multi level wildcard → `sensor_node/id_2/#`

### ■ MQTT-SN for connectionless transmission → ZigBee





- Based on MQTT but introduces temporal & spatial filter
- Subscription:

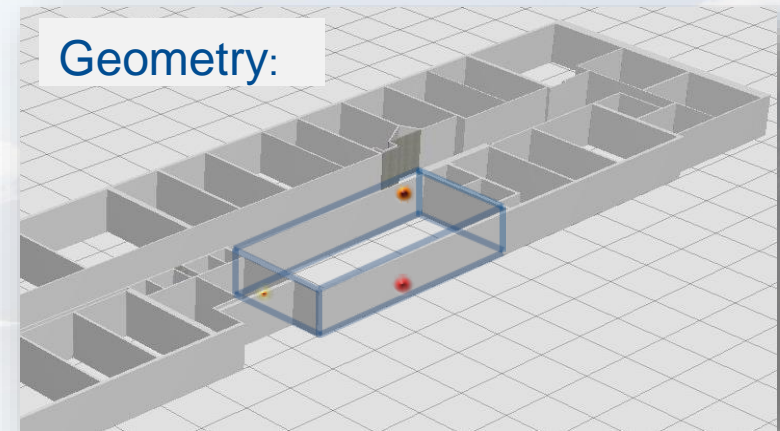
### Topic:

- `node/+/air_temperature`

### Temporal:

- Start: `0 0 8 ? * SAT`
- Intervall: `120 min.`

→ Every Saturday morning from 8-10 AM



- GeoPublish Message:

`(2015-09-22T11:21+00:00; 50.77906 6.06799; node/2/air_temperature; ...)`

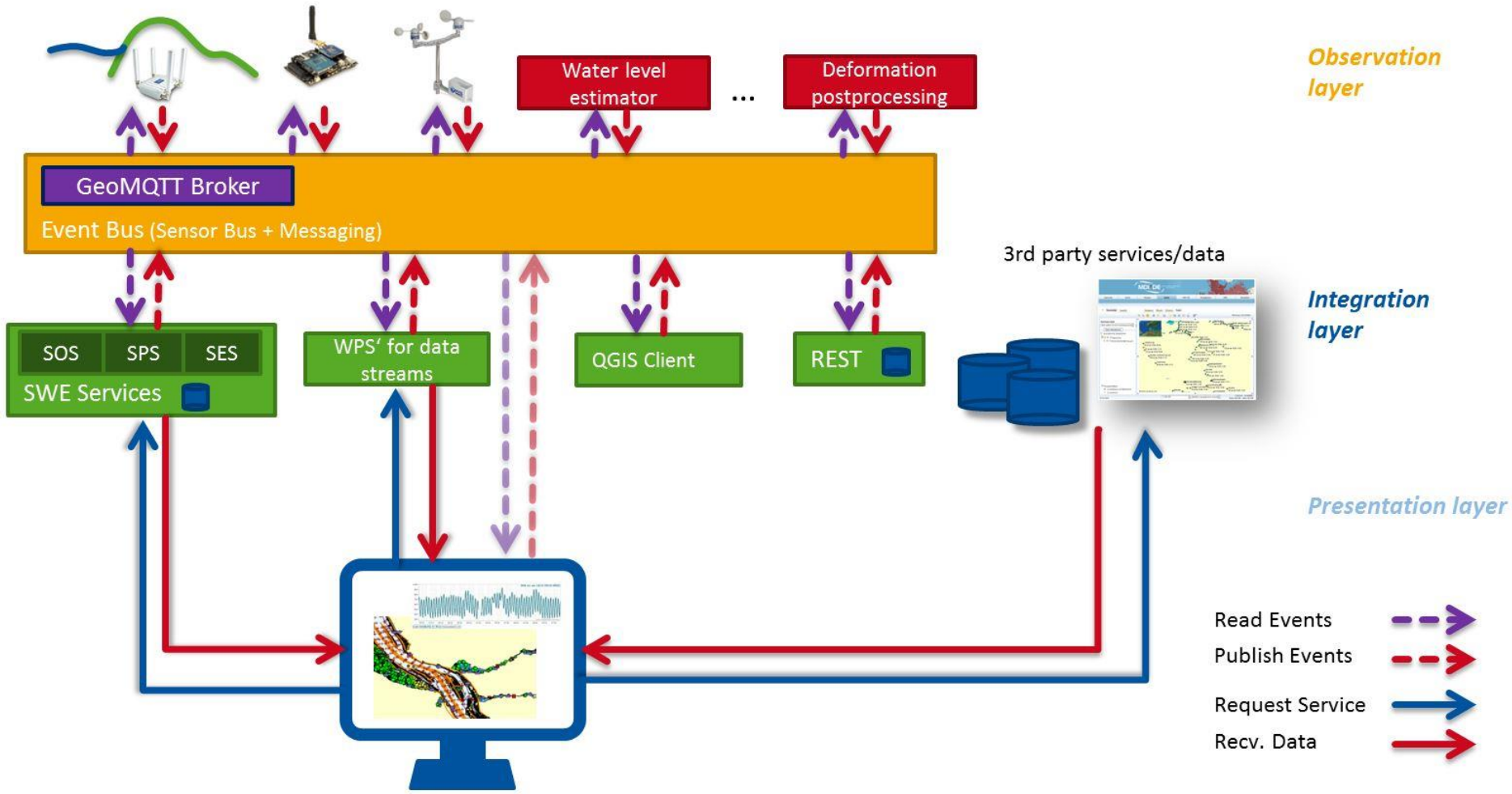


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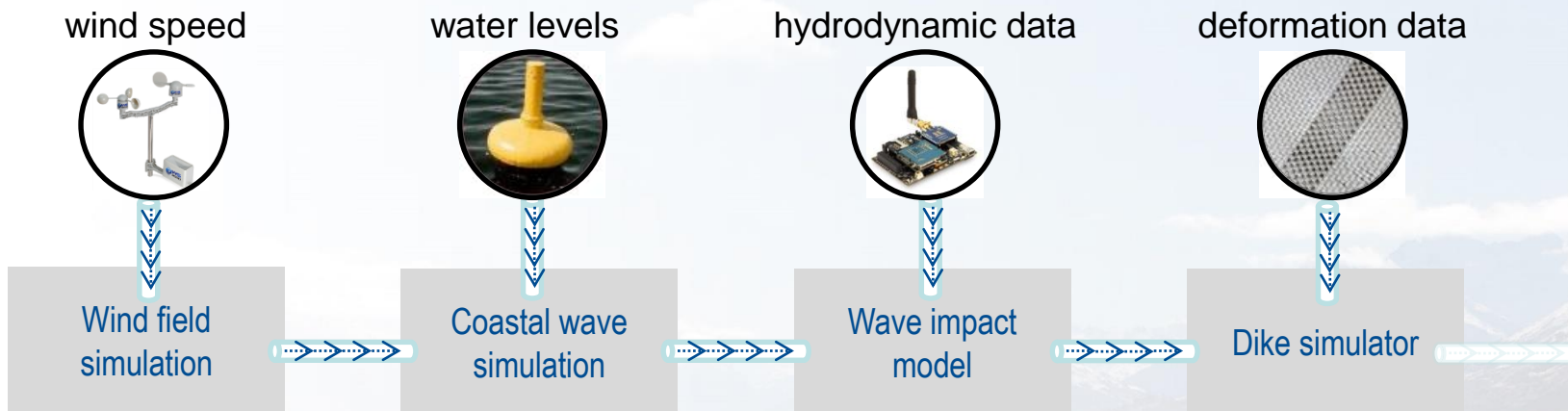


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### ■ Event-driven process chains (e.g. threshold)



### ■ User-driven process chains

→ „Streaming“ Web Processing Service (WPS)





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EarlyDike

**base map:**

layer\_WebAtlasDE

**WMS Layer**

- EarlyDike\_Deichlinie\_lin\_niv\_gesamt\_2011  
 Visibility  
Opacity:
- DGM200: Relief  
 Visibility  
Opacity:
- DWD GeoServer WMS: Fachlayer: Klima: Klimamonitoring: Referenzkarten: Mittlere jährliche Windgeschwindigkeiten in [ 0.1 m/s] von 10 m bis 100 m (in 10 m Stufen) über Grund für 1981-2000. GRID Felder (1 km)  
 Visibility  
Opacity:
- WMS des Landwirtschaft- und Umweltatlas Schleswig-Holstein: pegel  
 Visibility  
Opacity:
- HWRM: Gewidmete Deiche  
 Visibility  
Opacity:

**Map Geografisch (LonLat)**

**gisSOS/featureOfInterest/dike\_1/SN\_fwu\_waterlevel\_0075 giaSOS\_waterlevel**

Source: <http://127.0.0.1:8084/52n-sos-webapp/service>

Highcharts.com

**WFS Layer**

- GeoServer Web Feature Service: Deichlinie LKN-SH 2011  
 Visibility
- German waterways: German Water Levels  
 Visibility
- DWD GeoServer WFS: FLUESSE\_A  
 Visibility
- WFS des Landwirtschaft- und Umweltatlas Schleswig-Holstein: :pegel  
 Visibility

**SOS Layer**

- GIACS giags\_soil\_moisture  
 Visibility
- GIACS giags\_soil\_temperature  
 Visibility
- GIACS giags\_waterlevel  
 Visibility
- GIACS giags\_waterlevel\_fc  
 Visibility

**Monitors and Simulators**

Storm Surge Monitor and Simulator	<input type="button" value="Start"/>
Wave Monitor and Simulator	<input type="button" value="Start"/>
Dike Monitor and Simulator	<input type="button" value="Start"/>
Flood Simulator	<input type="button" value="Start"/>



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- „EarlyDike“ is an innovative real-time early warning system for dike breaches with a sophisticated sensor and spatial data infrastructure (SSDI)
- MQTT is extended to a GeoMQTT
- **Event Bus** and **Process chains** enable complex spatial workflows from data measuring till visualization in real-time
- Dike monitoring and simulating is only one use case. The architecture also allows other scenarios (e.g. energy or traffic management)



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## Thanks for your attention !

Franz Karl Basler-Kopp (1879-1937): Der Schimmelreiter (engl.: The Rider on the White Horse)

**EarlyDike**

base map: layer\_WebAtlasDE

**WMS Layer**

- EarlyDike\_Deichlinie\_lin\_niv\_gesamt\_2011
  - Visibility
  - Opacity:
- DCM200: Relief
  - Visibility
  - Opacity:
- DWD GeoServer WMS: Fachlayer: Klima: Klimamonitoring: Referenzkarten: Mittlere jährliche Windgeschwindigkeiten in [ 0.1 m/s] von 10 m bis 100 m (in 10 m Stufen) über Grund für 1981-2000. GRID Felder (1 km)
  - Visibility
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  - Visibility
  - Opacity:
- HWRM: Gewidmete Deiche
  - Visibility
  - Opacity:

Map Geografisch (LonLat)

Map showing a coastal area with various markers and a legend. A popup window displays details for a specific dike: Name: giaSOS/featureOfInterest/dike\_1/SN\_fwu\_waterlevel\_0075, giags\_waterlevel: 1.7324 cm, Time\_UTC: 2015-02-15T00:00:00.000Z, and coordinates 8.979247408583761, 54.07110870640725.

**WFS Layer**

- GeoServer Web Feature Service: Deichlinie LKN-SH 2011
  - Visibility
- German waterways: German Water Levels
  - Visibility
- DWD GeoServer WFS: FLUESSE\_A
  - Visibility
- WFS des Landschaft- und Umwelatlas Schleswig-Holstein: -pegel
  - Visibility

**SOS Layer**

- GIAGS giags\_soil\_moisture
  - Visibility
- GIAGS giags\_soil\_temperature
  - Visibility
- GIAGS giags\_waterlevel
  - Visibility
- GIAGS giags\_waterlevel\_fc
  - Visibility

**Monitors and Simulators**

Storm Surge Monitor and Simulator	Start
Wave Monitor and Simulator	Start
Dike Monitor and Simulator	Start
Flood Simulator	Start

giags\_waterlevel (cm) vs local time (2015-02-09 to 2015-02-15). Source: http://127.0.0.1:8084/52n-sos-webapp/service. Local Time: 2015-02-13 23:45:00, giags\_waterlevel: 0.2528 cm.



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