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A Low-Code Approach for Creating Dynamic Map-Based Web Applications Using W3C Web Components

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Outline

- Introduction
  - Leaflet Library
  - W3C Web-Components
- Our Concept
  - Architecture
  - Implemented Components
  - Examples
- Summary & Outlook

Introduction - Leaflet library

- Javascript library to build web-mapping applications
- Open Source
- Features
  - Allows to display tiled web maps and overlays (WMTS)
  - Supports Markers, Polylines, Polygons, Circles, Rectangles, Popups
  - Supports GeoJSON format
  - Allows various interactions with maps
  - lightweight (< 50KB)
  - huge community (many extensions)
  - very good documentation
  - supports many desktop/mobile browsers
- Widespread usage (i.e. Flickr, pinterest, github, FourSquare)

Introduction - Web-Components

- Composite W3C standard
- Create your own HTML-Elements with arbitrary semantics
- Run in the browser
- Implementation in ES2015 Javascript class (inherit from HTMLElement)
  - Implementation of callback methods
- Parameter can be passed in native way as attributes
- Attribute values are monitored for changes
- Shadow DOM to encapsulate Web-Component
- Templates (inactive HTML fragments that can be repeatedly used within a component)
- Slots (placeholder)

Introduction - Web-Components

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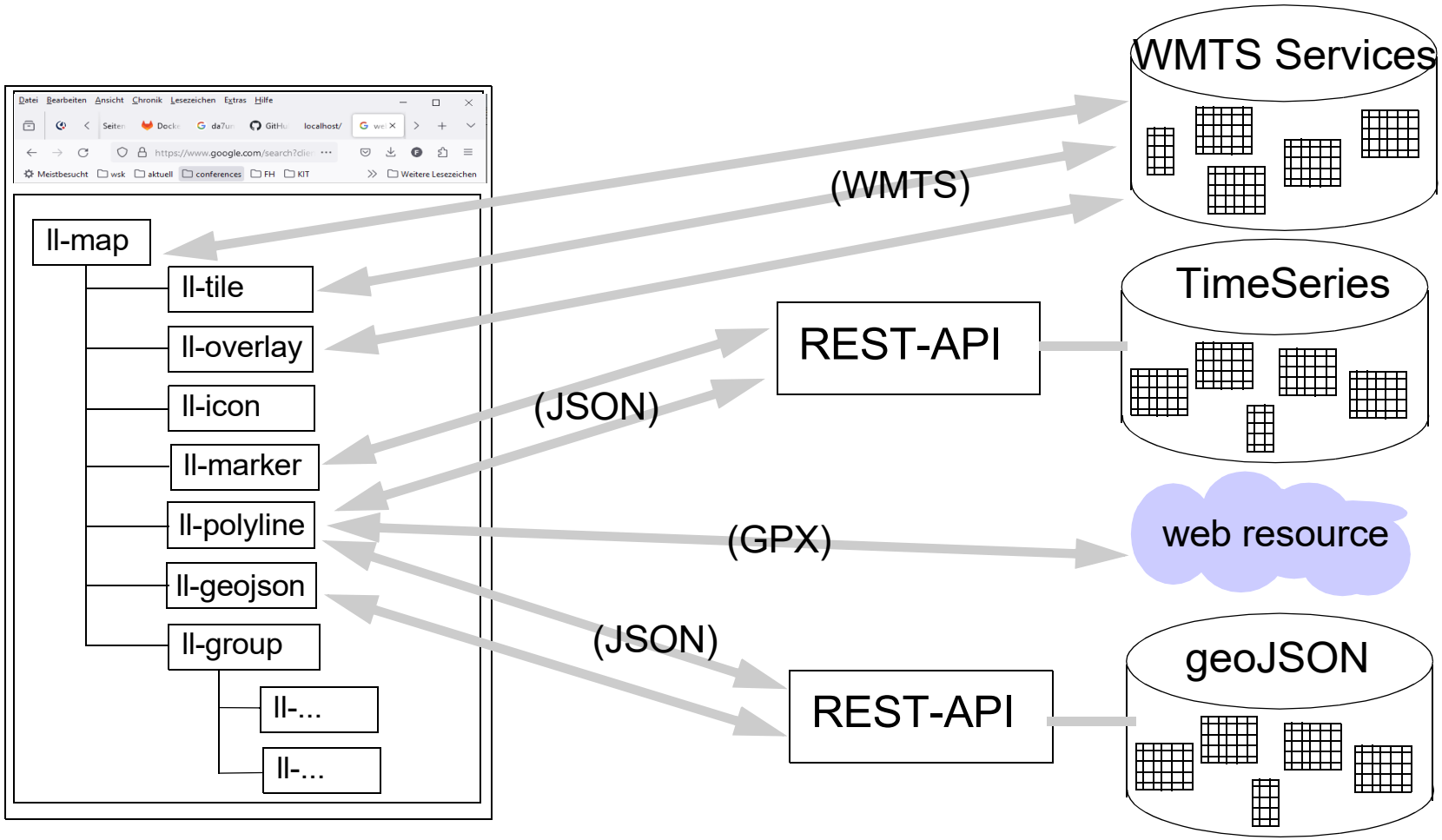
support declarative web-mapping development

Our Concept

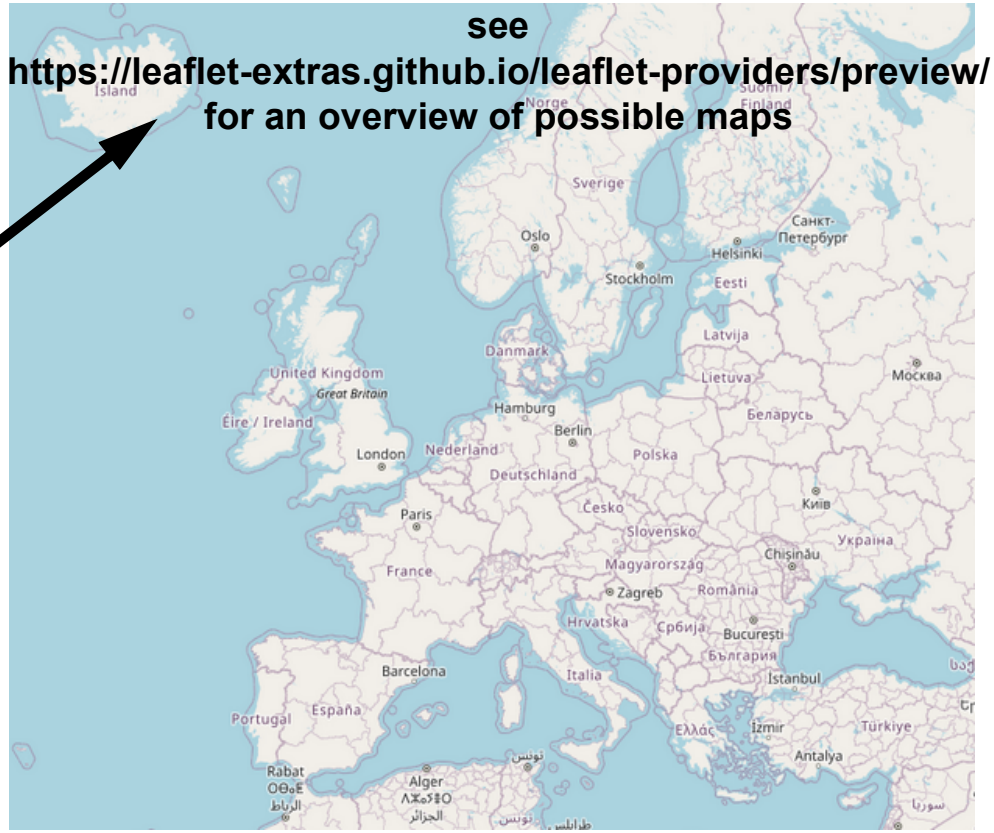
- The general idea is to enable the visualization of maps together with user-specific content in a HTML page.
- Build a web-component for each of leaflets key concepts
  - maps, tiles
  - overlays
  - markers (point)
  - Polyline
  - icons
  - geojson objects
  - groups
- Interaction of maps, tiles, overlays, groups, and geojson objects with leaflets *layer control* (switch on/off a group of artefacts)
- Support of time series databases, GPX and GeoJSON datasources
- Easy connection of leaflet web-compoment attributes with other elements in the page (i.e. select-box, input-box, ...)

Architecture



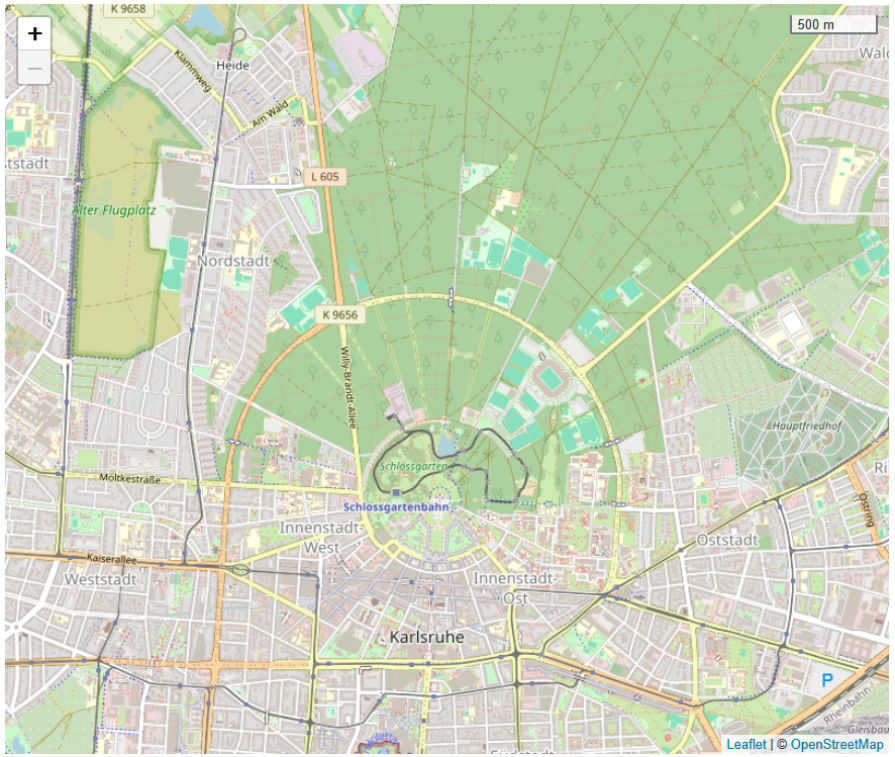
<ll-map>

- Central web-component, responsible for displaying a map in the browser.
- All other elements are subelements of ll-map.
- Specification of general features like ...
  - tile-server (look and feel of base-map)
  - central coordinate and zoom level
    or
  - fixed bounding box
  - Dynamic bounding box (based on subelements)
  - further options



<ll-map> - Example

```
<!DOCTYPE html>
<html>
   <head>
     <script type="module" src="llwc2.js"></script>
   </head>
   <body>
     <div id="map"></div>
     <ll-map
         ref="map"
         height="300px"
         width="100vw"
         lat="49.02"
         lng="8.405"
         zoom="14"
         options='{
                 "min-zoom":14,
                 "max-zoom":16,
                 "scale-position": "topright"
                 }'>
     </ll-map>
   </body>
</html>
```



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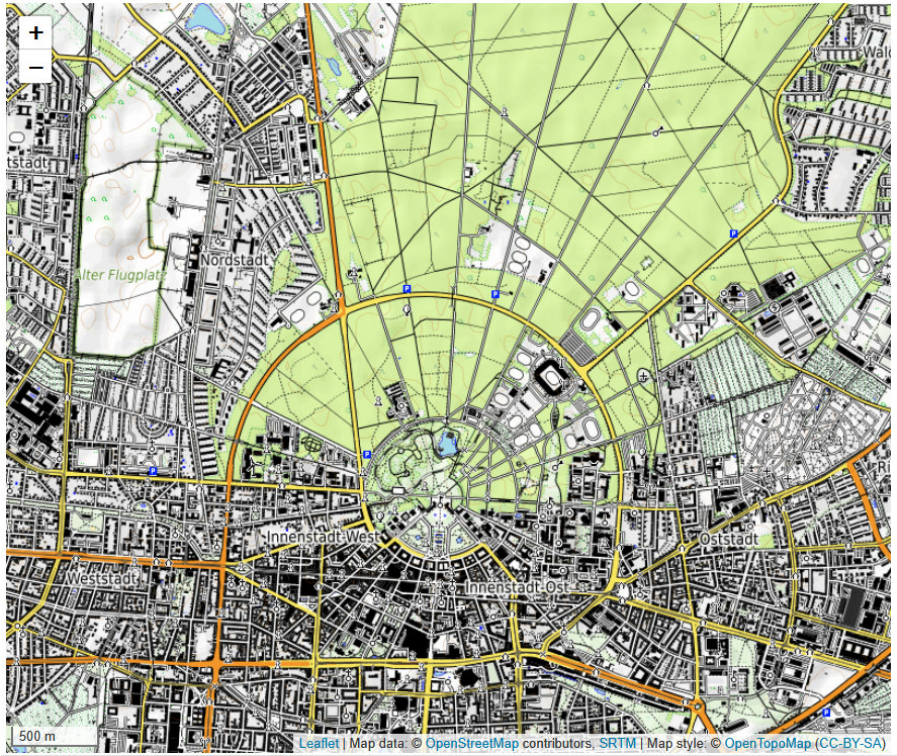
         width="100vw"
         lat="49.02"
         lng="8.405"
         zoom="14"
         options='{
                 "min-zoom":14,
                 "max-zoom":16
                 }'>
         base-url="https://{s}.tile.opentopomap.org/{z}/
{x}/{y}.png"
         attribution='Map data: &copy; ...'
     </ll-map>
   </body>
</html>
```



<ll-marker>

- Represents a point on a map
- Can be customized with an icon and size
- coordinates are specified
  - hardcoded
  - obtained from other elements at runtime
  - read from a time series database (json-format) or geoJSON resource

```
<ll-marker id="m1"
      lat="48.875215"
      lng="8.1356334"
      icon-size="20"
      icon="../icons/kanu.png"
      tooltip="Smiff">
</ll-marker>

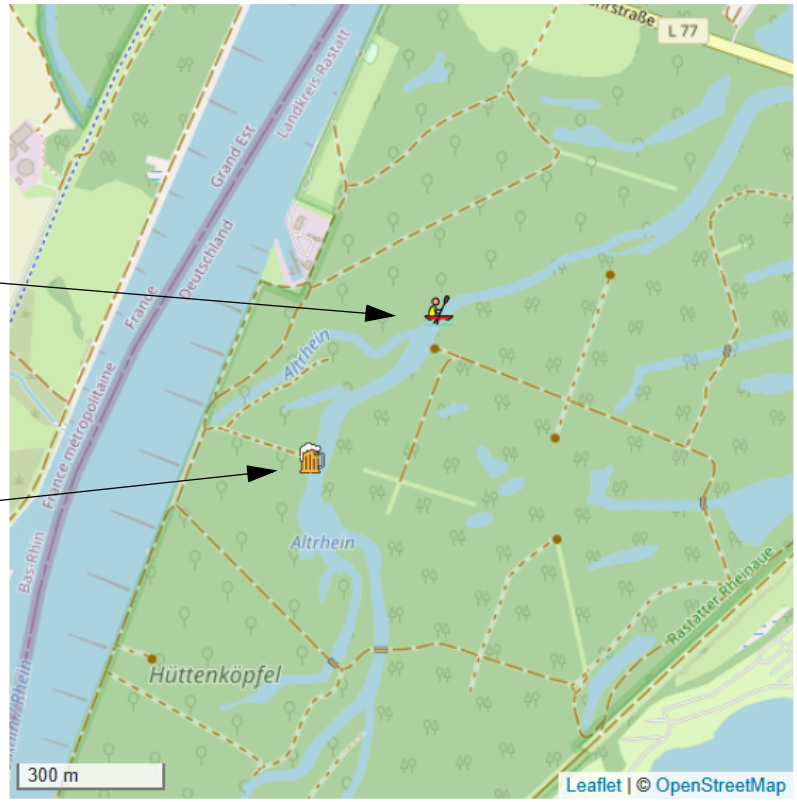
   <ll-marker id="m2"
         lat="{{latitude.value}}"
         lng="{{longitude.value}}"
         icon-size="20"
         icon="../icons/sailing-boat.png"
         tooltip="Thomas">
   </ll-marker>

<ll-marker id="m3"
      url="./REST/getActualPosition.php?id=m3"
      lat-path="result.lat"
      lng-path="result.long"
      icon-size="20"
      icon="../icons/canoe.png"
      tooltip="Ingo"
      path-color="blue">
</ll-marker>
```

<ll-marker> Example

```
<ll-map
     ref="map2"
     zoom="15">
     <ll-marker
          lat="48.880352"
          lng="8.1374788"
          icon="../icons/canoe.png"
          icon-size="20"/>

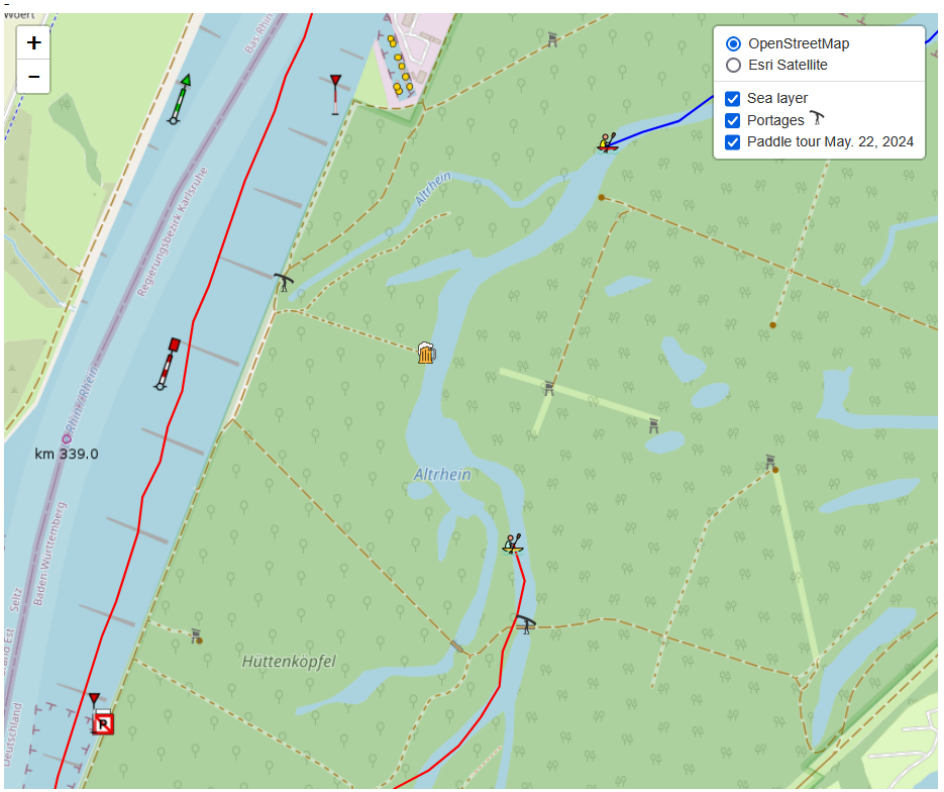
     <ll-markerlat="48.87767129477924"
          lng="8.133959770202638"
          icon-size="20"
          icon="../icons/beer.png"/>
</ll-map>
```



dynamic determination of center of the map and zoom level, based on subelements

<ll-tile> & <ll-overlay>

- Add further maps
  - alternate base-maps
  - overlay maps (on top of base-map)
- If more than one basemap (via <ll-tile>) is specified, you can choose one from the upper part of the layer-control
- zero or more overlays can be selected from the lower part of the layer control



<ll-tile> & <ll-overlay>

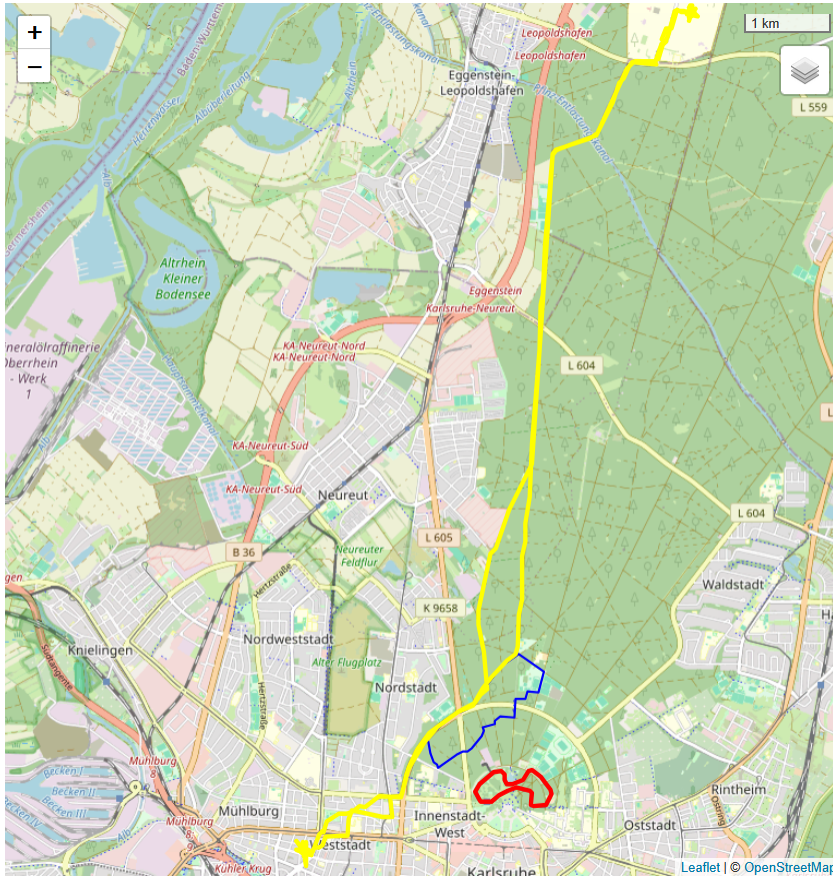
```
<ll-map ref="map2"
        lat="48.880352"
        lng="8.1374788"
        zoom="16">
    <ll-tile url='http://.../World_Imagery/MapServer/tile/{z}/{y}/{x}'>
        &copy; <a href="http://www.esri.com/">Esri Satellite</a>
    </ll-tile>

    <ll-overlay url="http://t1.openseamap.org/seamark/{z}/{x}/{y}.png"
                label="Sea Layer">
        &copy; <a href="http://t1.openseamap.org/copyright">OpenSeaMap</a>
    </ll-overlay>

    ...
</ll-map>
```

<ll-polyline>

- Draws a multiline
- Sources:
  - json- array holding lat, lng pairs
  - gpx-file (one trk)
  - Time series database (json format)
  - geoJSON resource



<ll-polyline> Examples

```
<ll-polyline color="red" weight="2"
             points="[
                      [48.890512743964791, 8.148843431845307],
                      [48.890063557773829, 8.148915097117424],
                      [48.889614371582866, 8.148628436028957]
                      ...
                     ]">
</ll-polyline>

<ll-polyline color="blue" weight="2"
             gpx="../data/Schlossgartenpfad.gpx">
</ll-polyline>

<ll-polyline color="yellow" weight="4"
             url="http://localhost/gps-location/readFromInflux.php/smiff?from=2025-01-
20T6:00:00.000Z&to=2025-01-20T23:00:00.000Z&mmnt=dbkda-demo"
             lat-path="result.lat"
             lng-path="result.lon">
</ll-polyline>
```

<ll-geojson>

- Support of import from GeoJSON objects
- Single object or **multiple** objects import possible
- <ll-geojson> element can also act as group (if attribute „label“ is set) and its members can activated/deactivated via layer control.
- Example:

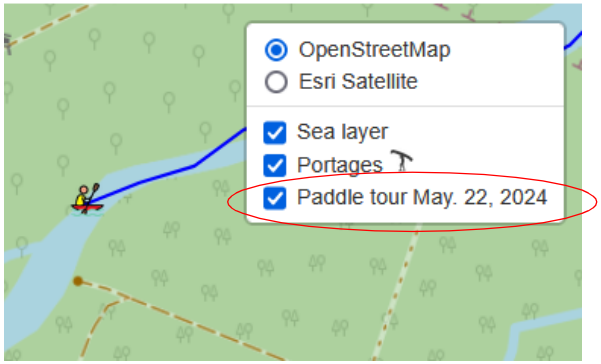
```
<ll-geojson
    label="Portages &lt;img src=&apos;icons/portage.png&apos; width=&apos;15&apos;&gt;"
    icon-url="./icons/portage.png"
    url="http://localhost/llwc/readGeoJSON.php?file=data/portages.json">
    path="result">
</ll-geojson>
```

see portages on Slide 13

<ll-group>

- Group multiple elements (i.e. markers, polylines, circles, ...) together, so that they can be shown/hidden together

- groups appears in the lower part of the layer-control (see attribute „label“) and so the elements in this group can be activated/ deactivated together




```
<ll-group label="Paddle tour May 22, 2024">
    <ll-marker
       icon="icons/kanu2.png" icon-size="20"
       url="./REST/getActualPosition.php?id=m3"
       lat_path="result[0].lat"
       lng_path="result[0].lon"
       path-color="blue">
    </ll-marker>

    <ll-marker icon="icons/kanu.png" icon-size="20"
       tooltip="Andreas"
       url="./REST/getActualPosition.php?id=m7"
       lat_path="result[0].lat"
       lng_path="result[0].lon"
       path-color="red">
    </ll-marker>
    ...
</ll-group>
```

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Summary

- Library of web-components to build web-mapping applications
- Encapsulation of Javascript code behind intuitive markup interface
- Low-code environment that allows the creation of interactive map-applications without coding (markup only)
- Automatic coupling of components
- connection of the components to external databases, like GeoJSON sources and time series databases
- Can easily be extended with supplemental javascript code to build application specific bahaviour (access to the leaflet instances of map, markers, groups, geoJSON objects, ...)

Outlook

- Evaluate the usefulness of our components
  - Test our components in real-world scenarios (at IAI)
  - Build online game, based on our components (course at University of Applied Sciences)
- Extend functionality
  - move, drag & drop of markers, geoJSON objects
  - integrate leaflet draw functionality
- Filter functionality, based on properties of imported GeoJSON objects
- Wizard to build markup code
- Reimplementation using Lit-library [3]
- Declarative interface to the leaflet event system.

Resources

[1] Volodymyr Agafonkin, leaflet-library: https://github.com/Leaflet/Leaflet

[2] Michael Dorman, Introduction to Web Mapping, CRC Press, 2020

[3] Lit library. https://lit.dev/

[4] Gary Sherman, Leaflet Cookbook: Recipes for Creating Dynamic Web Maps, Locate Press, 2019