

# ADVANCED TOOLS API - RELEASE 2

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## DELIVERABLE

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# D4.3.2 ADVANCED TOOLS API - RELEASE 2

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02	28/03/2016	S.R. Bergheim Eirik Csak Knutsen Tor Gunnar Øverli	AVINET	Draft for internal review
03	30/03/2017	S.R. Bergheim	AVINET	Final Version

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## Acronyms

Table 1: Table of acronyms used in document

Acronym	Explanation
AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
CORS	Cross-origin resource sharing
DoW	SDI4Apps Description of Work, Annex I to the Grant Agreement
HTTP	Hypertext Transfer Protocol
Http GET	Request supported by the HTTP protocol
Http POST	Request supported by the HTTP protocol
JS	JavaScript
JSON	JavaScript Object Notation
NPM	Node Package Manager
OGC	Open Geospatial Consortium
OSM	OpenStreetMap
SDI	Spatial Data Infrastructure
SFS	Simple Features Specification
SME	Small and medium-sized enterprises
SQL	Structured Query Language
WKT	Well-Known Text

# EXECUTIVE SUMMARY

This document describes the second and final release of the s4a.js client-side JavaScript library. It is based on D4.2 - the high-level API design document, D3.3.1 - “Open API Design & First Release”, D4.3.1 - the first former version of this document – and indirectly on the results of D3.1 “Architecture Concept” and D3.2.1 “Enablers Deployment - First Release”.

As defined in the design specification, the library has formally been given the name “s4a.js”. This is an extension library that sits on top of well-known and widely used libraries including jQuery (for cross-browser JavaScript compatibility and utility methods), D3.js (for data visualization), Crossfilter and DC charts (for dynamic charting), OpenLayers (for map framework) and Cordova (for cross-device compatibility in mobile applications).

This API supplies generically useful functionality that facilitate rapid spatial enabled application development. Application specific functionality has been exempted from the library and is implemented on a pilot-to-pilot basis.

The library includes three types of client functionality:

1. stand-alone functionality that can be used independently;
2. functionality that depend on a running instance of the SDI4Apps OpenAPI platform
3. functionality that depend on the Cordova APIs and only can be run on smart devices

JavaScript libraries must be small and non-intrusive. Thus, applications may not wish to include the overhead of functionality that is not explicitly used in the code. To facilitate this, the library is built in a modular fashion. This architecture also enables the library to be broken up and contributed into stable branches of the source repositories of the underlying components. This is a useful fall-back strategy for long term sustainability if parts of the library should be deprecated,

The five modules of the advanced tools API are:

1. A map module provides methods and widgets to add interactive maps, map tools and data registered with an OpenAPI instance to HTML5 applications.
2. An information retrieval module provides methods and widgets to implements keyword, free-text, spatial and faceted search to HTML5 applications.
3. An advanced visualization module provides methods and widgets to implement a variety of chart and map types - as well as coordinated views composed of charts and maps to HTML5 applications.
4. A mobile module that offers offline editing and map browsing capabilities to mixed connectivity mobile applications. The mobile module offers a solution to this via the introduction of cached offline base maps and feature editing layers to HTML5 applications.
5. The final module of the advanced tools API is the analytics and modelling module that permits end-users invoking complex multi-variable analysis processes on the server side from within HTML5 applications.

Following release 1.0 (D4.2.1deliverable), the s4a.js library has been validated through end-user applications in the SDI4Apps pilots. A number of refinements and performance improvements have been made during the testing period and outstanding components planned for the last year of the project have been implemented.

# 1 PREFACE

This deliverable forms part of the software deliverables of the SDI4Apps project and must be seen in context of the other parallel/connected tasks in work package 3 and 4 respectively.

Particularly, the advanced tools API is dependent on modules and web services exposed by the server-side OpenAPI. To illustrate this dependency, the Information Retrieval module relies on communicating with web services in order to return meaningful results on the client.

The software deliverables, i.e. D4.3.1 and D4.3.2 ((the software release described in this deliverable)) feed into the technical test reports D4.5.1 (submitted at the same time as this deliverable) and D4.5.2 at the end of the project. The results from the testing and evaluation activities, in turn feeds back into the improvement cycle of the software development life cycle. The findings of the testing and evaluation activities have been decisive factors for the work on s4a.js in the final year of the project.

In the interim between version 1.0 (month 24) and 2.0 (month 36) the library has been maintained on GitHub. No intermediate numbered releases have been made but a development branch has been current with the latest enhancements throughout the year.

While release 2.0 constitute the final release within the project execution period, partners' exploitation strategies secures the continued maintenance and development of the library for the near future.

Similarly, while evolving the code of the advanced tools API, it may be necessary to make amendments or enhancements to the Open API services in order to achieve the desired target benefits.

This is the first milestone release of the advanced tools API and the work is now entering into a phase where the emphasis will be on implementing functionality exposed by the API in SDI4Apps pilot applications.

Furthermore, the emphasis will from now on also be shifted from pure software development towards identifying sustainability strategies for the resulting software products and 'packaging' the software in a manner suitable for post-project exploitation.

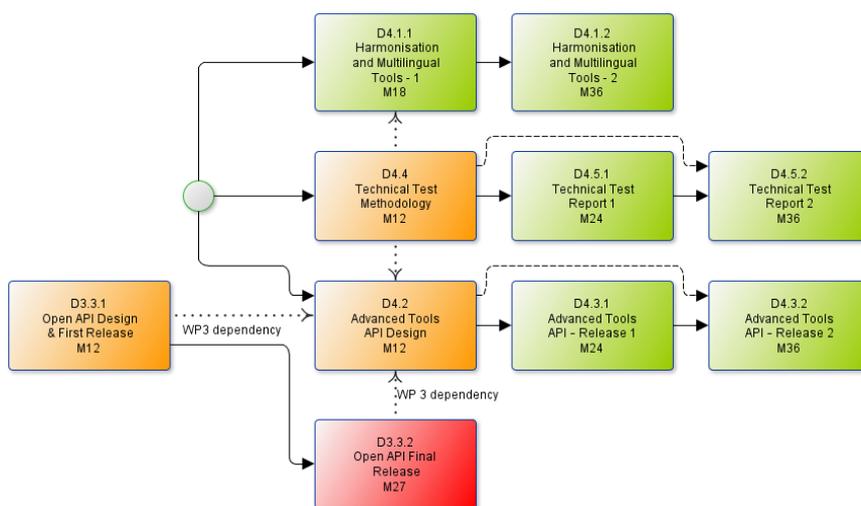


Figure 1: The relationship between D4.3.2 and other SDI4Apps deliverables

## 2 METHODOLOGY

This chapter describes the methodology that has been followed in translating the user requirements and system requirements specifications into a complete software product.

### 2.1 Specification

The first release of the client-side JavaScript library 's4a.js' is based on the system requirements specification in deliverable D4.2 Advanced Tools API Design (Bergheim, et al., 2014). Furthermore, the implementation of the API has drawn on the works 'JavaScript Design Patterns' (Osmani, 2015) and the JavaScript code documentation framework 'JSDoc 3.0' (JSDoc 3 contributors, 2016)

### 2.2 Development

The development of the JavaScript library has adopted good practice from contemporary mainstream JavaScript API library. Since s4a.js is dependent on OpenLayers 3 and jQuery, it has been natural to take the practices adopted by these widely used Open Source frameworks as a starting point for the development.

#### 2.2.1 GitHub

The development has taken place on the 'social' coding platform GitHub, one of the most widely used source control and development management systems on the Internet. The URL of the public repository is <https://github.com/SDI4Apps/s4a.js>.

GitHub provides a technical framework - but does not dictate the development process itself; therefore, the following workflow process has been established to secure optimal benefits from the use of GitHub.

Two main branches have been created:

- Master - It is not permitted to commit code directly to Master
- Develop - Although permitted, no commits shall normally be made directly to Develop

To contribute code to s4a.js the following steps should be made:

- All work shall be carried out on short-lived feature branches, i.e. the implementation of the map module took place on a branch called feature/map-helper
- Once the work was completed, a pull request was created to merge the branch feature/map-helper into develop.
- Prior to merging pull requests created by a single author, the committed code in the pull request should be reviewed by one peer.
- Upon receiving 'all clear' from the peer reviewer, the code is merged into the 'develop branch' where the most recent version of the complete API sits at all times.
- Prior to merging, all conflicts should be resolved offline by the author by rebasing his or her feature branch towards the most recent version of the develop branch.
- Once a feature branch has been merged, it can and should be deleted

Code is always deployed from the master branch

- The develop branch is used to test the integration of all code committed to the repository

- Many developers work simultaneously and it is necessary to verify that the pieces of the puzzle fits together before the API library is deployed
- Once integration tests have passed, the develop branch can be merged into the master branch and the API may be deployed to a content delivery network - or anywhere of the user's choosing

Code has partly been developed in distributed working repositories and contributions have been added to the master repository near the releases.

## 2.2.2 Development methodology

GitHub as a development framework is particularly well suited for use in agile development techniques such as Scrum (Schwaber, 2004).

The implementation of s4a.js has followed the Scrum methodology with minor adaptations to allow for the fact that development teams are decentralized and not located in the same physical space.

All system requirements have been broken down into manageable component tasks and added to a backlog. Tasks have been distributed into sprints - but instead of having 'one sprint' for all developers, each development team (each partner) has been at liberty to define his/her own sprints to comply with the working mode of the individual teams.

Likewise, the daily Scrum has not been applied across the partnership but individual to each team. Overall coordination has been secured through touch points at project events and through periodic online conferences where the progress of the individual tasks have been verified.

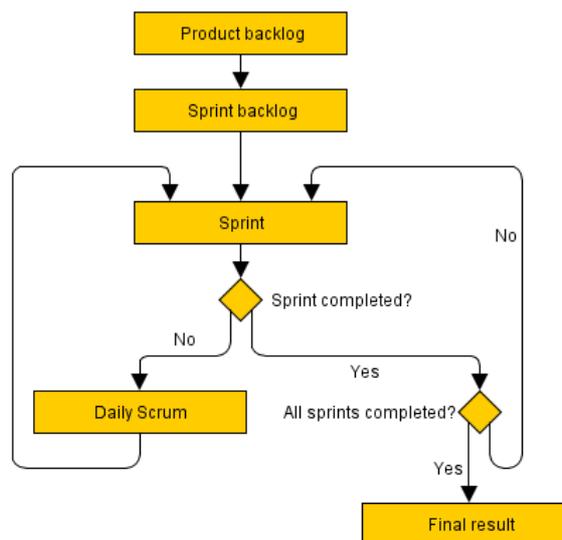


Figure 2: Scrum workflow as it has been applied in the development of s4a.js

## 2.2.3 Use of open standards

The use of open standards is paramount to the implementation of s4a.js. Providing interfaces to known data sources and structures is an absolute requirement when introducing a new utility library into a field that is flooded by half-baked solutions. The work includes the use of many open standards, but it is necessary to highlight the most important ones:

- GeoJSON (Butler, et al., 2008) - a format that enables the encoding of points, lines and polygons along with their attributes as simple JavaScript Object Notation structures.

- TMS (Maso, Pomakis, & Nuria, 2010) - a scheme for identifying map tiles based on location
- MBTiles (MacWright, White, Kaefer, & Miller, 2013) - an SQLite based data format for bundling offline map tiles into a single file for ease of distribution and management
- SFS-WKT (Open G. I. S. Consortium, 1999) - a notation for describing simple features in well-known-text
- jQuery ( The jQuery Foundation, 2016) - a cross-browser infrastructure library that constitute a de-facto standard extension to JavaScript

## 2.2.4 Common repository layout

The following repository layout has been agreed and used throughout the development of the API library

- css - for any Cascading Style Sheet source files
- src - for any JavaScript source files
  - sub-folder per namespace
- test - for any JavaScript source test files
  - sub-folder per namespace
- (dist) - auto-generated upon build (grunt)
- (doc) - auto-generated upon build (grunt)
- (node\_modules) - auto generated and populated by build system (npm)

## 2.2.5 Common coding style

JavaScript is not a strongly typed language - and its semantics permits users to write a piece of code that does 'the same thing' in a multitude of different ways.

One of the objectives of the library is to make it easily extendible and to encourage the formation of a critical mass of interested parties, i.e. developers, who would like to adopt the system.

For this reason, the s4a.js development has agreed on a number of stylistic conventions that have been followed by all developers.

- Namespaces and nesting
  - Design patterns - simulated Object Orientation using design patterns
  - Modules
  - Classes
  - Singletons
  - Factories
  - MixIns
  - Pub Sub
- Code element naming conventions
  - Camel case for functions, methods
  - All upper case for constants
  - Proper case for classes
  - All lower case for namespaces
- Inline code comments
  - Following the JSDoc 3 standard, see sub chapter 2.2.7 below.

## 2.2.6 Build system

Development has taken place in a large number of smaller files that are stored in a hierarchical file structure as described above. For deployment purposes, it is however highly impractical to include

hundreds of individual JavaScript files in the ‘head section’ of the HTML mark-up.

Thus, it has been necessary to choose a build system that performs a number of tasks in the development workflow:

- Test code in each of the source files for syntax or style errors
- Concatenate individual files into a single file for distribution
- Generate API reference documentation by extracting in-line code comments
- ‘Minify’ the single file by auto-refactoring private function and method names
- Run unit tests to verify code

While there are contenders like Gulp or Ant in the market, SDI4Apps has chosen to work with the node.js based Grunt task runner (GRUNT development team, 2016) as a build system.

Dependent packages, i.e. libraries that s4a.js depends on for its operation are managed using the Node Package Manager (npm, Inc., 2016)

## 2.2.7 Documentation

In order for third parties - or for that matter second parties within the project consortium - to use s4a.js it is necessary to provide documentation.

Most JavaScript developers are familiar with API reference documentation that separates between namespaces, modules and classes - and that documents the internal members of each of the aforementioned concepts as either properties or methods.

By following the simple code commenting conventions of JSDoc 3 it is possible to achieve two objectives:

- Make code human-readable for developers who would like to contribute to or branch off from the s4a.js code
- Enable the auto-generation of API reference documentation by means of a documentation generator that parses comments from source code files and compiles them into HTML.

Table 2: Example of JSDoc comment identifying a namespace

```
/**
 * This is a description of the namespace s4a.map
 *
 * @namespace s4a.map
 */
```

Table 3: Example of JSDoc comment identifying a JavaScript 'class'

```
/**
 * A helper class to quickly add maps to your HTML5 applications
 *
 * @class
 */
s4a.map.MapHelper = function(nodeSelector) {
  ...
}
```

Table 4: Example of JSDoc comment identifying a 'class method' or function

```
/**
 * Calculate the shortest path between two network nodes on a topological network
 *
 * @param {Number} from The ID of the from node
 * @param {Number} to The ID of the to node
 * @return {Promise} description
 * @public
 */
module.getRoute = function(from, to) {
  ...
}
```

## 2.3 Testing

The code framework is tested using the Jasmine (Pivotal Labs, 2016) testing framework for unit tests as well as through a set of HTML pages that demonstrate the features of each module.

Table 5: Example of unit test from s4a.js API library

```
describe('Feature synchronization service', function() {
  it('Test 1 km2', function(a) {
    var s = new gh.stats('Test 1 km2');
    for (var i = 0; i < 100; i++) {
      jQuery.post(featureSyncUrl, {
        action: 'CheckOut',
        longitude: 10,
        latitude: 59,
        buffer: 500
      }, function(res) {
        s.log();
      }, 'json').fail(function(res) {
        s.log();
      });
    }
    s.print();
    expect(s.avg).toBeLessThan(1000);
  });
});
```

## 2.4 Deployment

S4a.js is deployed both as part of each SDI4Apps platform instance as well as a stand-alone JavaScript API library that partly may be used independently of the platform.

During the development phase, the software is deployed to the main platform instance at <http://platform.sdi4apps.eu> as well as to AVINET's development servers at <http://s4a.avinet.no>. The latest version may always be found on GitHub.

The library is distributed under the Apache-2-0 Open Source license. The creators are at liberty to issue the library under an alternative license at any later stage.

## 2.5 Post deployment improvement cycle

Since s4a.js 1.0 was deployed, it has been made part of many of the applications in the SDI4apps platform. Consequently, methods have been tested extensively by consortium developers. Feedback from this testing has been logged continuously.

Each issue has been elaborated so that it is fully understood, categorized and assigned a priority.

Categories are:

- Bugs
- Changed functionality
- New functionality

Priorities are:

- Critical
- High
- Medium
- Low

Issues are either rejected or accepted. If accepted they are scheduled for release 2.0 or put on a backlog for future releases.

Releases are:

- 2.0
- 2.1
- Future releases (place holder for minor and major releases >= 2.1)

## 3 WALKTHROUGH OF RELEASE 2.0

This chapter provides a walk-through of the modules that have been completed in the second (and final within the project life cycle) release and describes each module as well as shows code examples on how to invoke the code and the expected output. As the majority of the functionality was established at the time of release 1.0, thus the majority of this section is common with D4.3.1.

### 3.1 Map module

The map module is a simple helper module that implements productivity methods that makes it very easy to add a map component with your own custom background and thematic data to an existing HTML5 application.

The map module also implements functions that make it easy to create new tools and controls and add these to the map interface.

#### 3.1.1 Usage example

*Table 6: Example of instantiating the s4a.js MapHelper class to add a map*

```
var myMap = new s4a.map.MapHelper('#map');  
  
myMap  
  .addData('test.geojson')  
  .addTool([  
    s4a.map.tools.ZoomIn,  
    s4a.map.tools.ZoomOut,  
    s4a.map.tools.Pan)  
  .draw();
```

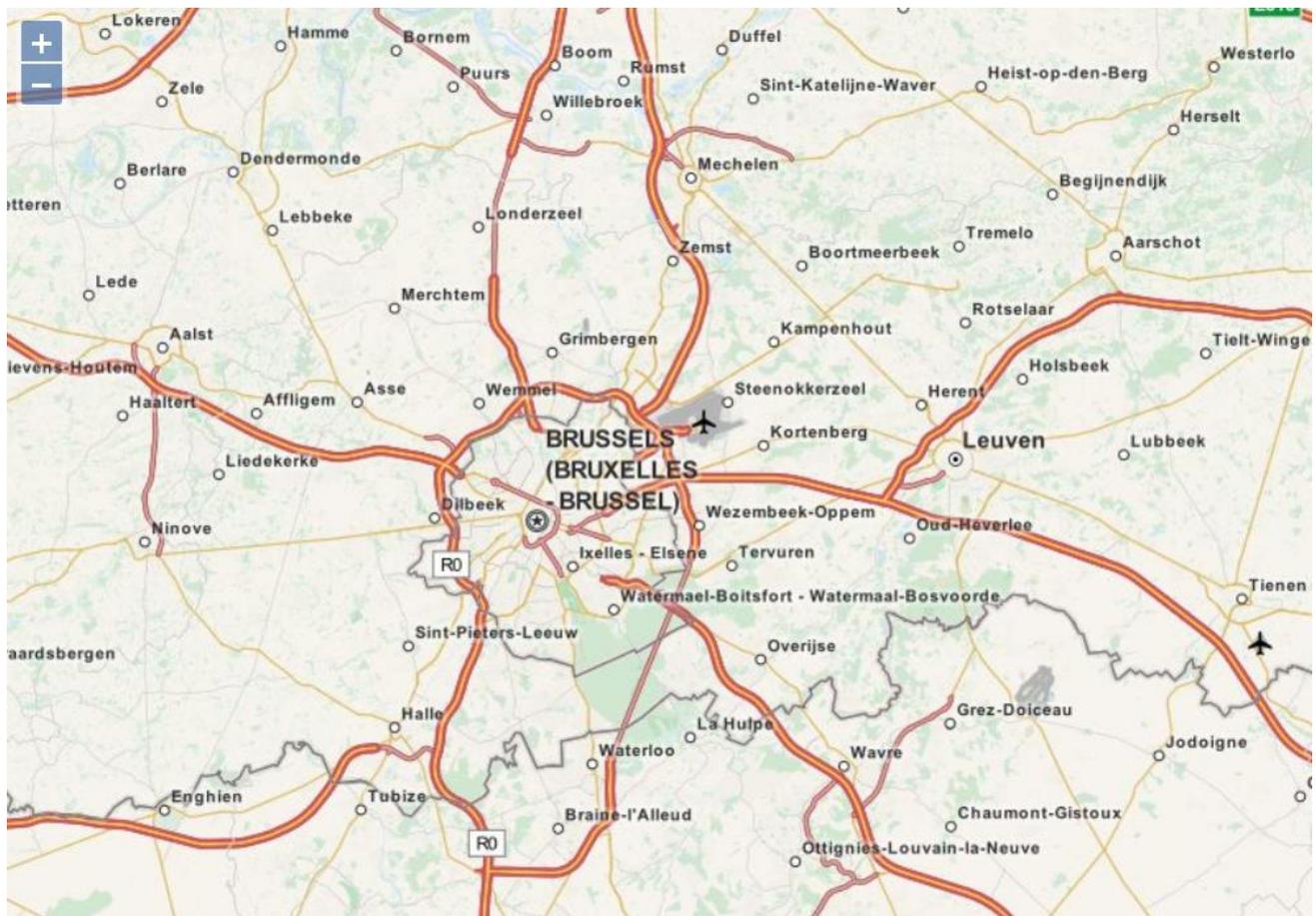


Figure 3: Map created by `s4a.map.MapHelper`

Table 7: Example of creating a new custom tool

```
var myMap = ...

var myTool = new s4a.map.Tool(s4a.map.ToolType.TOOL);
    .setIcon('img/icon.png')
    .setLabel('Click me')
    .setGeomType(s4a.map.GeoType.POINT)
    .onClick(function(clickEvent) {
        alert(clickEvent.lonlat);
    });

myMap.addTool(myTool);
```

## 3.2 Information retrieval module

The information retrieval module enables querying of data from a high performance search API based on a Lucene index managed in the SDI4Apps platform, accessible through the Open API.

Data may also be added to the index from ESRI Shapefiles or PostgreSQL/PostGIS databases. These methods must be invoked on the server as exposing them as public methods would lead to liability risks with regards to content quality, licensing - and nature.

### 3.2.1 Usage example

Table 8: Example of instantiating *s4a.js* QueryHelper to issue a query

```
var myQuery = new s4a.ir.QueryHelper();

var myQueryResults = myQuery
  .setQuery('Brussels')
  .setDistance('POINT(4.3517 50.8503)', 10000)
  .query() // Function returns a jQuery 'promise'

myQueryResults.then(function(response) {
  console.log(response.data); // Output the query results
});
```

Table 9: Example output from QueryHelper

```
{
  "status": "ok",
  "response": {
    "resultList": [
      {
        "address": null,
        "state": "ACTIVE",
        "sourceType": "florence_heritage",
        "path": false,
        "sourceId": "aebAnnunziata_48_1",
        "ente": "null",
        "geometryLine": null,
        "geometryPoint": "MULTIPOINT (11.25755 43.773849)",
        "geometryPolygon": null,
        "geometryType": "POINT",
        "daysBefore": 0,
        "daysAfter": 0,
        "geometry": "MULTIPOINT (11.25755 43.773849)",
        "centroid": "POINT (11.25755 43.773849)",
        "mainImageThumbnailUrl": null,
        "mainImageUrl": null,
        "hash": "ZPI01Q8fCMM97SKCglKkfTFhdHRFWpMuVQckjRFVITc=",
        "facebookId": null,
        "twitterHashtag": null,
        "userGenerated": false,
        "rating": null,
        "recurrency": "",
        "name": [
          {
            "locale": "it",
            "text": "Via dei Servi"
          },
          {
            "locale": "en",
            "text": "Via dei Servi"
          }
        ],
        "description": [
          {
            "locale": "it",
            "text": "Via di collegamento tra piazza del Duomo e piazza SS. Annunziata,
deve il suo nome all'Ordine dei Serviti o Servi di Maria, fondato nel XIII secolo da sette
nobili fiorentini che edificarono la Chiesa della SS. Annunziata. La via, punteggiata di
eleganti palazzi cinquecenteschi, offre da entrambi i lati una suggestiva veduta prospettica"
```

```

    },
    {
      "locale": "en",
      "text": "This street joins piazza del Duomo and piazza SS. Annunziata and
takes its name from the Order of the Serviti or Servants of Mary, founded in the 13th century by
seven Florentine noblemen who built the Church of SS. Annunziata. The street is dotted with some
elegant sixteenth century palaces and gives a very suggestive perspective view from both sides"
    }
  ],
  "uri": "http://purl.org/sics/digitallocation/113b5b2c71fa4d2b9a25ac8358359a5a",
  "categories": [
    {
      "pkCategory": 134,
      "details": [
        {
          "name": "Stazioni di percorsi tematici",
          "description": null,
          "locale": "it"
        }
      ]
    }
  ],
  "profile": 0,
  "scopes": [],
  "validForDL": true,
  "validForDR": true
}],
"pkDigitalEntity": 10046,
"deType": "DL",
"lastUpdateUser": {
  "email": null,
  "ente": null,
  "pkUser": 10612,
  "cognome": "ETL",
  "nome": "ETL"
},
"creationDate": "2013-10-31",
"lastUpdateDate": "2013-10-31",
"creationUser": {
  "email": null,
  "ente": null,
  "pkUser": 10612,
  "cognome": "ETL",
  "nome": "ETL"
}
},
{...}

```

## 3.3 Advanced visualization module

The advanced visualization module builds on three existing components: Crossfilter (for performing map reduce operations on JSON data), D3.js for creating data visualizations in SVG and dc.js (for performing dynamic visualization and filtering of data).

The module extends dc.js with several new chart types.

### 3.3.1 Chart types

The second release of the advanced tools API includes the following chart types:

- Pie chart
- Bar chart
- Grouped bar chart

- Row chart (horizontal bar chart)
- Stacked row chart
- Scatter chart
- Bubble chart
- Line chart
- Stacked line chart

Each chart type object implements a shared interface 'IVizObj' that enables any chart object to be added to a view coordinator that can update it whenever the underlying data that it displays are updated, filtered or otherwise manipulated.

## Usage example

Table 10: Pie chart, bar chart example

```
var data0 = [
  {country: 'NO', measurement: 10},
  {country: 'CZ', measurement: 12},
  {country: 'DK', measurement: 4},
  {country: 'AT', measurement: 5}
];

var vc = new s4a.viz.ViewCoordinator(data);

var chart1 = new s4a.viz.chart.Pie('#chart1', vc, 'measurement');
var chart2 = new s4a.viz.chart.Bar('#chart2', vc, 'measurement');

vc.draw();
```

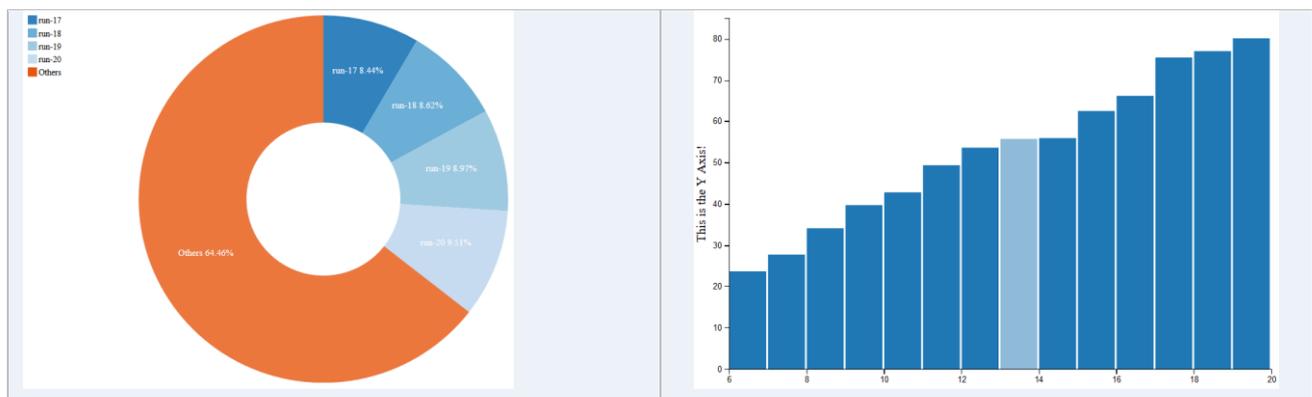


Figure 4: Example visualization objects (generated via s4a.js using dc.js methods)

## 3.3.2 Map types

The first release of the advanced tools API includes the following map types:

- Choropleth map
- Symbol map
- Heat map
- Live data map
- Bubble pie map

- Prism map (via three.js)

Each map type object implements a shared interface 'IVizObj' that enables any of the map objects to be added to a view coordinator that can update it whenever the underlying data that it displays are updated, filtered or otherwise manipulated.

NB! For the benefit of reviewers, it is worth noting that the Prism map object type has not yet been implemented. This is planned for the second release and has been pending the choice of a suitable 3d library that does not add too much overhead to the overall s4a.js distribution comparing to the rather limited purpose it serves in the infrastructure. Candidate technologies that currently are being assessed include Cesium and Three.js. The decision has been delayed while looking for a solution with a smaller memory and CPU 'foot print'.

## Usage example

Table 11: Choropleth map example

```
var data = [
  {country: 'NO', measurement: 10},
  {country: 'CZ', measurement: 12},
  {country: 'DK', measurement: 4},
  {country: 'AT', measurement: 5}
];

var vc = new s4a.viz.ViewCoordinator(data);

var map1 = new s4a.viz.chart.Pie('#map1', vc, 'measurement', 'country', 'countries.json');

vc.draw();
```

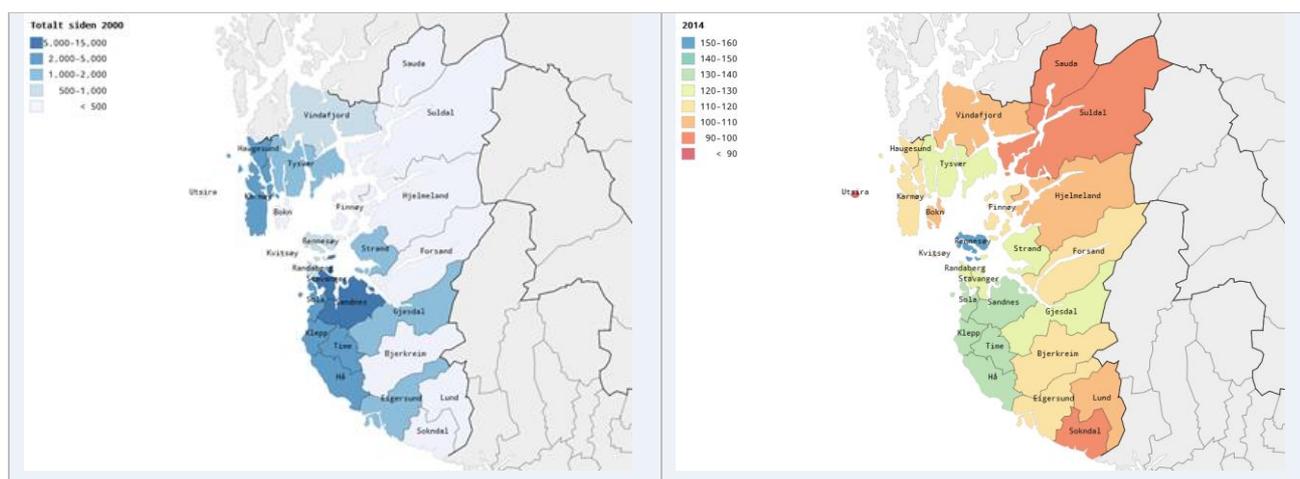


Figure 5: Example of choropleth map (generated via s4a.js using D3.js methods)

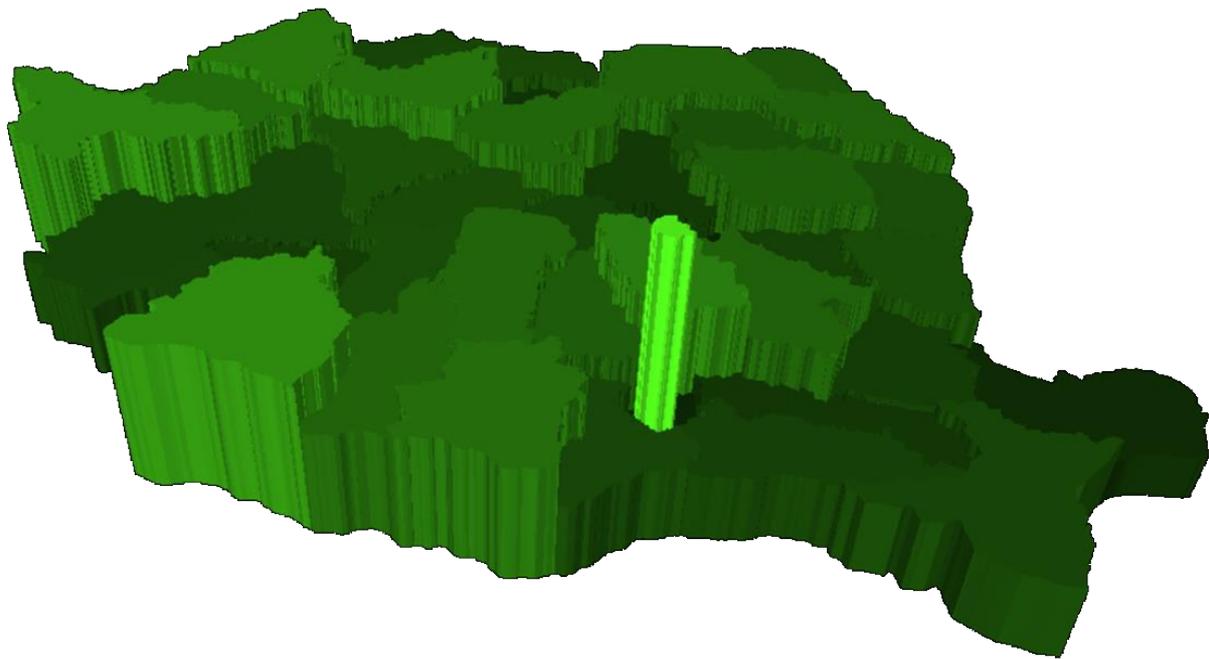


Table 12: Example of extruded polygons used to generate Prism map

### 3.3.3 Coordinated view

The coordinated view is what puts ‘advanced’ into the advanced tools API. This is a data object that visualization objects can subscribe to and that will update each subscribed object whenever the underlying data are altered.

The inspiration for this module is the Crossfilter object as it is used in dc.js - but we have extended the object in order to allow a broader range of visualizations compared to the narrow, albeit high-performance, scope addressed by dc.js.

## Usage example

Table 13: Coordinated view example

```

var data = [
  {country: 'NO', measurement: 10},
  {country: 'CZ', measurement: 12},
  {country: 'DK', measurement: 4},
  {country: 'AT', measurement: 5}
];

var options = {
  geocol = 'country',
  geotype = s4a.viz.GeoType.COUNTRY
};

// Create a view coordinator
var vc = new s4a.viz.ViewCoordinator(data, options);

// Create a choropleth map and add it to the view coordinator
// passing the vc object automatically takes care of this.
var map1 = new s4a.viz.map.Choropleth('#map1', vc, 'measurement', 'country', 'countries.json');

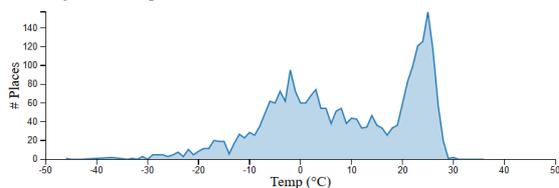
// Add a pie chart too
var chart1 = new s4a.viz.chart.Pie('#chart1', vc, 'measurement');

// Draw map1 and chart1
vc.draw();

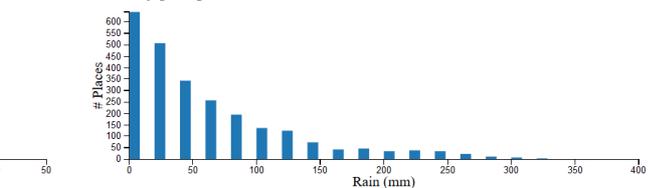
// Display only records where the measurement value is 12 and
// redraw all visualisation objects that are connected to the view coordinator
// internally loops through all objects added to the view coordinator and calls their
// .update() method.
vc.filterExact('12');

```

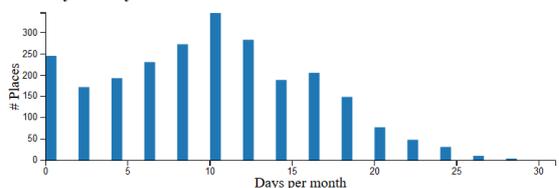
Filter by mean temperature



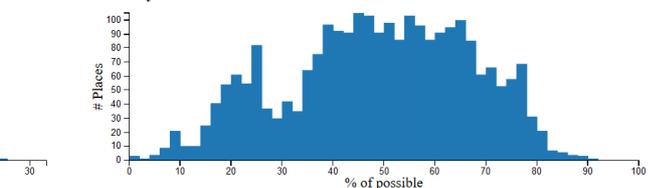
Filter by precipitation



Filter by wet days



Filter by amount of sunshine



Top #50 map



Figure 6: Illustration showing interlinked charts that are mutually linked and 'filterable'

## 3.4 Mobile module

The mobile module implements functions that makes it possible to browse background maps on mobile devices while in offline mode. Furthermore, the module enables checking out a portion of a feature layer as a GeoJSON file, editing it locally (i.e. while offline) and checking it back into the server, resolving any conflicts that may have arisen as a consequence of concurrent editing etc.

### 3.4.1 Offline feature layer

The first function of the mobile module is the capacity to check out a feature layer. The prerequisite for this function is that the feature layer exists as a PostgreSQL database table on the SDI4Apps platform instance server. Furthermore, the layer must be registered in a metadata table that lists layers that should be made available for offline use.

If these two conditions are met, it is possible to check out a portion of the map by supplying the layer identifier and an extent.

The methods to create the layer communicates with an Open API server instance via AJAX Http POST requests and requires CORS to be implemented on the server side.

### Usage example

Table 14: Example of checking out, editing and checking in offline feature layer

```
var myCheckOut = s4a.mobile.featureSync.CheckOut('layer-001',
  {
    minX: -180,
    minY: -90,
    maxX: 180,
    maxY: 90});

myCheckOut.then(function(response) {
  // GeoJSON object
  var myGeoJson = response.data;

  // modify GeoJSON

  // Check in the modified data
  var myCheckIn = s4a.mobile.featureSync.CheckIn('layer-001', myGeoJson)
    .then(function(response) {

      // If no conflicts, myConflicts should return an empty array
      var myConflicts = response.data;

    })
})
```

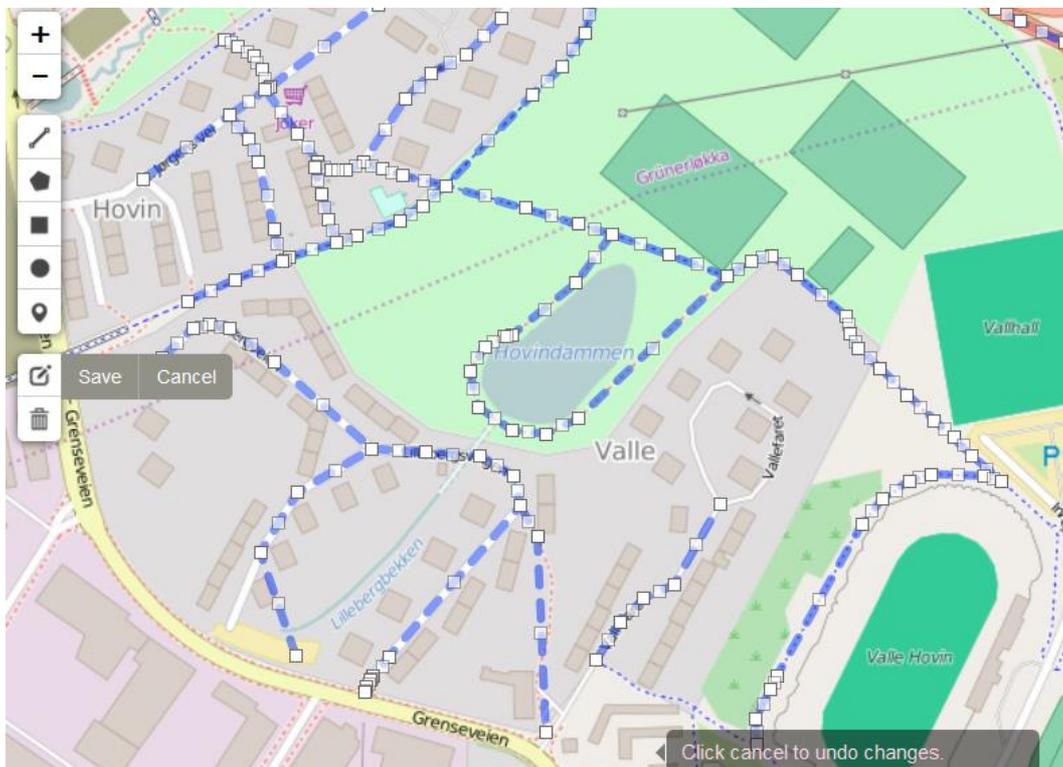


Figure 7: Example showing OfflineFeatureLayer being edited

### 3.4.2 Offline tile layer

The offline tile layer serves the simple purpose of providing background map tiles while in offline mode. It works by downloading a pre-populated SQLite database onto the device and creating a new OpenLayers layer type.

This layer is **ONLY** possible to use in mobile applications developed using Cordova and with the SQLite plugin 'cordova-sqlite-ext' installed. It is not possible to use it on desktop computers, as there is no facility to read/write persistent SQLite databases on the client side.

#### Usage example

Table 15: Example of creating offline tile layer and adding it to a map

```
var myMap = new s4a.map.MapHelper();
var myOfflineTileLayer = new s4a.mobile.OfflineTileLayer('osm.mbtiles');
myMap.setBasemap(myOfflineTileLayer);
```

### 3.4.3 SensLog API

Using s4a.js it is easy to develop Javascript applications that make the client device emulate a mobile or distributed sensor, reporting observations and measurements back into a running SensLog instance in the SDI4Apps OpenAPI platform.

Table 16: Example of logging into SensLog instance and inserting observation

```
s4a.data.SensLog.login('username', 'password')
```

```

.then(function(data) {
  S4a.data.SensLog.insertObservation(1.0, 2345, 123, '20.03.2017 11:54:12')
    .then(function(data) {
      alert(data);
    }, function(error) {
      // error handling not implemented
    });
}, function(error) {
  // error handling not implemented
});

```

## 3.5 Analytics and modelling module

The analytics and modelling module is an emphasis for the second release and at present only one service exists within the module, namely the routing service that corresponds to the routing service exposed by the Open API in an SDI4Apps platform instance.

### 3.5.1 Routing

The routing component is a wrapper on top of PostgreSQL, PostGIS and pgRouting that enables users to execute three common routing scenarios from JavaScript without having to have access to their own server infrastructure or data.

It communicates with the server via AJAX Http POST requests and requires CORS to be implemented on the server side.

- GetNearestNode - routing operations go between nodes in the topological network - function returns the node id closest to a lon/lat location
- GetShortestPath - given the id of a start and an end node, calculates the shortest path between the two
- GetReachableArea - given the id of a start node id and a distance, calculates the reachable area (along the road network)
- GetOptimalRoute - given a set of node ids, calculates the optimal route to visit them all

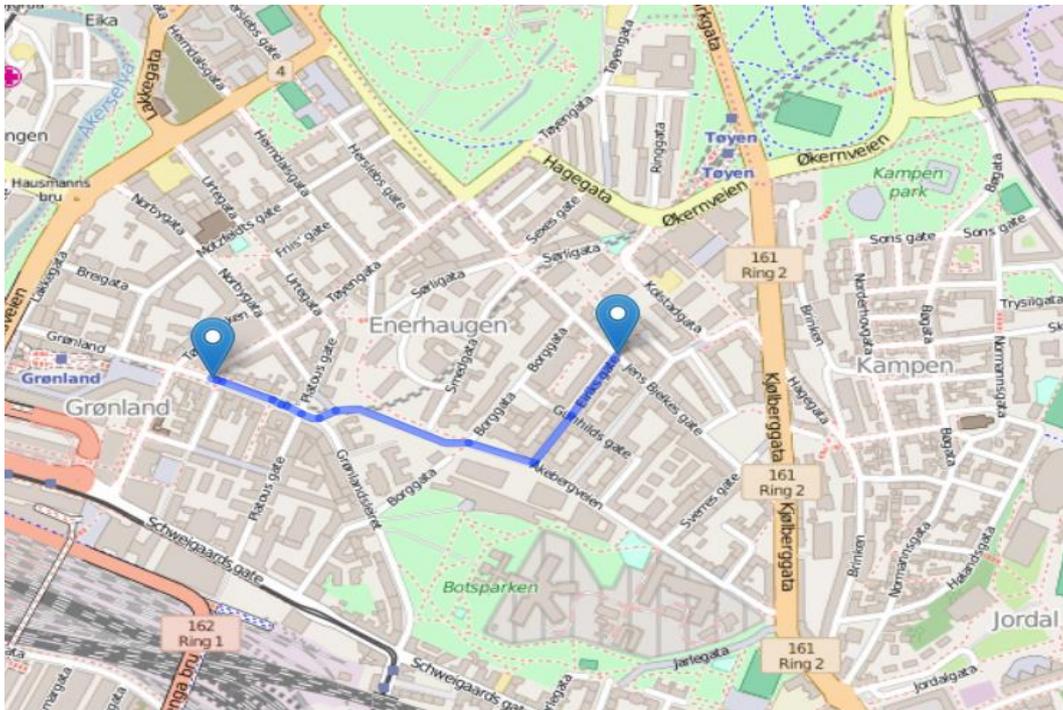
### Usage example

Table 17: Example of routing request on dynamic road network stored in PostGIS

```

s4a.analytics.routing.GetRoute(1, 2)
  .then(function(response) {
    // Route response object, including representation of
    // route as GeoJSON
    var myRoute = response.data;
  });

```



Example of result from invoking routing

### 3.5.2 Area Suitability Analytics

As a front-end to the OpenAPI analytics and modelling service, a client module in the s4a.js library has been implemented. This module makes it possible to execute combined analysis operations between the Open Land Use map and Smart Points of Interest map.

- Extract all OLU areas of a specific type
- Extract all relevant points of interest
- Count the number of points of interest that falls inside or within a specific buffer distance from the perimeter of each area.
  - ✓ Cache the findings for better performance
  - ✓ For the purpose of the prototype, the distance was set to 5 km.
  - ✓ Selected points of interest included tourism services such as restaurants, hotels, cafes, bars etc.
- Based on these factors, it calculate a score that indicates the relative suitability of an area compared to other areas.
  - ✓ It is at difficult to identify candidates that definitively are suitable
  - ✓ Easier to identify the order of suitability.

For the prototype, a naive relevance algorithm has been employed:

- A point that falls inside an area has a relevance of 1
- A point that is 5 000 meters away from the area has a relevance of zero.

- A point that is equal to or closer than 4 999 meters away from the area has a relevance of  $([\text{buffer distance}] - [\text{distance}]) / [\text{buffer distance}]$ 
  - ✓ if 10 meters away  $(5000 - 10) / 5000 = 0.998$
  - ✓ if 4900 meters away, a relevance of  $(5000 - 4900) / 5000 = 0.02$ .

Summarizing the scores will indicate the relevance of the area in a given context, i.e. the relative density of relevant SPOIs for tourism for a specific brown field area.

This calculation is simple but potentially powerful when applied to a large number of areas.

The interesting aspect lies in the geographical coverage of the base data SPOI and OLU -- since these have cover all of Europe, the potential to establish a re-usable algorithm that can be applied to business cases across a very large market exists.

The algorithm accepts as input a selection of areas as well as a selection of point of interest categories. The output is a GeoJSON polygon dataset with a score attribute calculated as described above.

## 4 NEW IN RELEASE 2.0

This section provides an overview of the new developments and enhancements that are available in the 2.0 release of s4a.js.

### 4.1 Analytics and modelling module

In addition to network analytics (route calculations), as implemented in version 1.0, this release includes front-end tools to invoke the analytics and modelling tools from the final release of the SDI4Apps OpenAPI. It is now possible to generate real-time GeoJSON.

This is described in detail in section 3.5.2 above

### 4.2 Additional visualizations, 3D, prism map

Using a combination of Three.js (additional dependant library) and D3.js (already in infrastructure), the capability to draw prism maps was implemented. Since Three.js uses WebGL specific functionality, this diagram type is marked as experimental in the library since not all browsers yet support WebGL operations.

Also, a few other diagram types have been implemented since the previous release. These are predominantly variations over regular diagram types and little space has been devoted to discuss these here.

The new chart and map types are described in detail in section 3.3.1 above.

### 4.3 Robustness, scalability, cloud optimization

A wide range of code updates and bug fixes have been implemented, of which the following are central:

- Upgrading of code to fit with upgrades in underlying libraries to remove deprecated method calls.
- Fixing of memory leaks from poorly handled garbage collection in some methods, notably non-recycling of memory allocated to large numbers of dc.js diagrams used in the same application page.
- Minimizing polling requests between client and server, whereby reducing the performance degrade due to network latency and waiting for the completion of asynchronous operations. This also reduces load on the server-side. This is important to increase the capacity of the server-side back-end to handle a large number of concurrent requests.

The methodology employed to improve the library since version 1.0 is described in section 2.5 above.

### 4.4 Product packaging in context of exploitation

In the final year of the project, efforts have been made to plan for the sustainability of the project results, including this software deliverable.

The pure ‘business aspects’ of sustaining and potentially monetizing the products resulting from the project has taken place in its own work package. However, technical measures in support of ensuring ‘exploitable’ products have been made in each technical work package, as evident in this deliverable.

Two major hurdles have been cleared:

- The IPR is clarified both in terms of external licensing and internal ownership
- The software architecture is modular, as noted in chapter 6 below

At the time of release 1.0, it was identified that the generic nature of the library at the same time was both a strength and a liability. It can do something for anyone - but 'anyone' is a difficult market group to reach by means of traditional marketing techniques within the geo-informatics sector. It was therefore determined necessary to augment the library to meet the business requirements of a specific market niche.

In the last year of the project, the library modules have been targeted towards four sectors:

1. Transparent integration of geo-enabled white-box search and indexing into existing applications
2. Visualization of geospatial statistics
3. Map support for hybrid apps on mobile devices

This indicates that the most promising sustainability strategies at the time of release 2.0 are:

- Use as a support library for delivering application and development and customization services based on the SDI4Apps OpenAPI platform by consortium partners
- Re-used as individual modules, integrated into existing software packages.

As is evident from the business plan of partners, both these forward paths will be pursued.

A second measure that has been made in support of easing deployment and re-use of s4a.js is making the library available through commonly used package manager repositories, namely Bower.

Assuming a user has node.js and the node package manager installed – something which more or less is the norm for most concurrent HTML5 development environments – the process of deploying s4a.js for a project is as simple as running the following command line statements:

*Table 18: Adding s4a.js to existing project using Bower and npm*

```
npm install -g bower // install bower globally, if not already installed
cd ... // to project directory
bower init // create bower.json file for project
bower install s4a-js // install JavaScript library
```

New versions have been deployed on both [GitHub](#) and [Bower](#) at on the 20<sup>th</sup> of March 2017.

## 5 FUTURE IMPROVEMENTS

The Open Source nature of s4a.js means that the final release within the project lifetime is merely a 'way point' for the library. Already at this stage, there are planned improvements, scheduled for release 2.1 in June 2017.

The immediate scheduled improvements are:

- Replace jQuery with a compatible but more lightweight alternative – Zepto.js. jQuery is a de-facto standard for utility methods, as such it is essential to support it, however in order to avoid the large file-size, a smaller sub-set written with low memory footprint in mind, will substitute nicely for most purposes.
- Integrate the Babel compiler in the s4a.js development project to gradually enable the codebase to be translated into ECMAScript 6 (ES6/ECMAScript 2015/ES2015)
- Enhanced relevance calculations for the area suitability analytics module
- Differentiated distances by type of SPOI, a flat distance of 5 km to determine which POIs are relevant is obviously wrong.
- in many cases the distance when travelling along a road network would be more interesting than Euclidean straight line
- Here could be an extension point towards the OTN dataset.
- *Normalization of scores by area size:*
  - A very large area will usually have a very large score and the relative comparison of the score to a small area may and will in most cases give the wrong impression.
- Varying quality of SPOIs
  - Luxembourg, very rich in SPOIs but all park trees and garbage bins exist as points of interest there
- Completeness/accuracy of OLU polygons
  - Size and degree of detail in areas vary greatly

However, the model will improve as the algorithm repeatedly is applied to quality increments in the underlying data

## 6 SUSTAINABILITY PRINCIPLES

This chapter re-iterates important sustainability principles that were defined in the specification document and that have been retained and rigorously observed in the implementation of s4a.js

The functionality of the library has been implemented in a modular fashion in order to secure that the components easily may be split into different libraries and exploited independently of each other.

The prime objective of the JavaScript library is to be an interface to advanced server-side functionality exposed by the SD4Apps platform; the modular design does however allow a wider range of sustainability options to ensure that SDI4Apps results will be used after the project ends.

These measures have not imposed limitations on functionality in the library - nor have they added to the complexity of the implementation task. They just serve to demonstrate that following well-proven design principles when writing code is beneficial on many levels.

Modules that do not rely on the SDI4apps platform but merely implements client-side visualization functions may have an after-life both as part of s4a.js and as contributed modules in existing Open Source libraries that already have a critical mass of users. This is a two-tier exploitation strategy.

## 7 WORKS CITED

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# 8 APPENDICES

## Appendix A: Updated s4a.js API reference

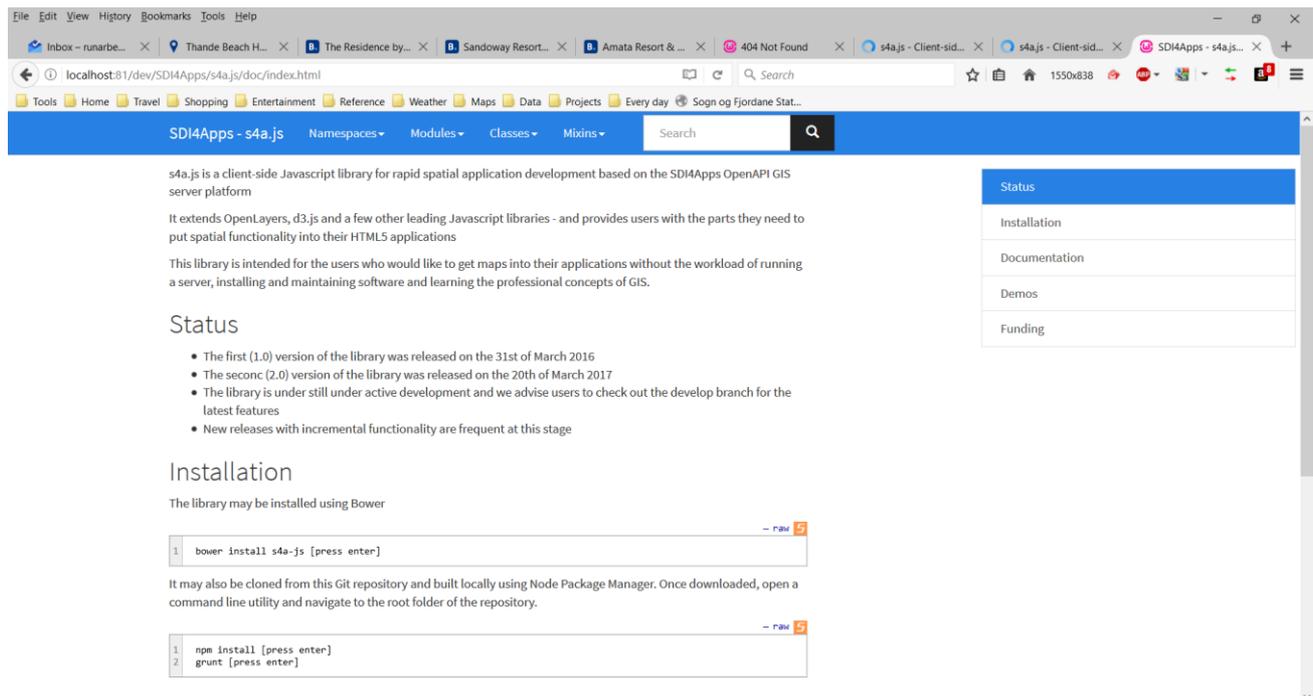


Figure 8: Screenshot from the online s4a.js API reference documentation

The reference documentation may be found at <http://s4a.avinet.no/apidocs> or may be built by cloning the GitHub repository and running the build commands npm/grunt.