# Indoor Navigation

by

**Lennart (XXXXXXX)**
**Jan (XXXXXX)**
**Eridy (XXXXXXX)**
**Andreas (XXXXXXX)**

A project documentation submitted to

Technische Universität Berlin
School IV - Electrical Engineering and Computer Science
Department of Telecommunication Systems
Service-centric Networking

Project Documentation

February 11, 2016

Supervised by:
Sebastian Zickau and Mathias Slawik

# Abstract

Short summary of project outcome.

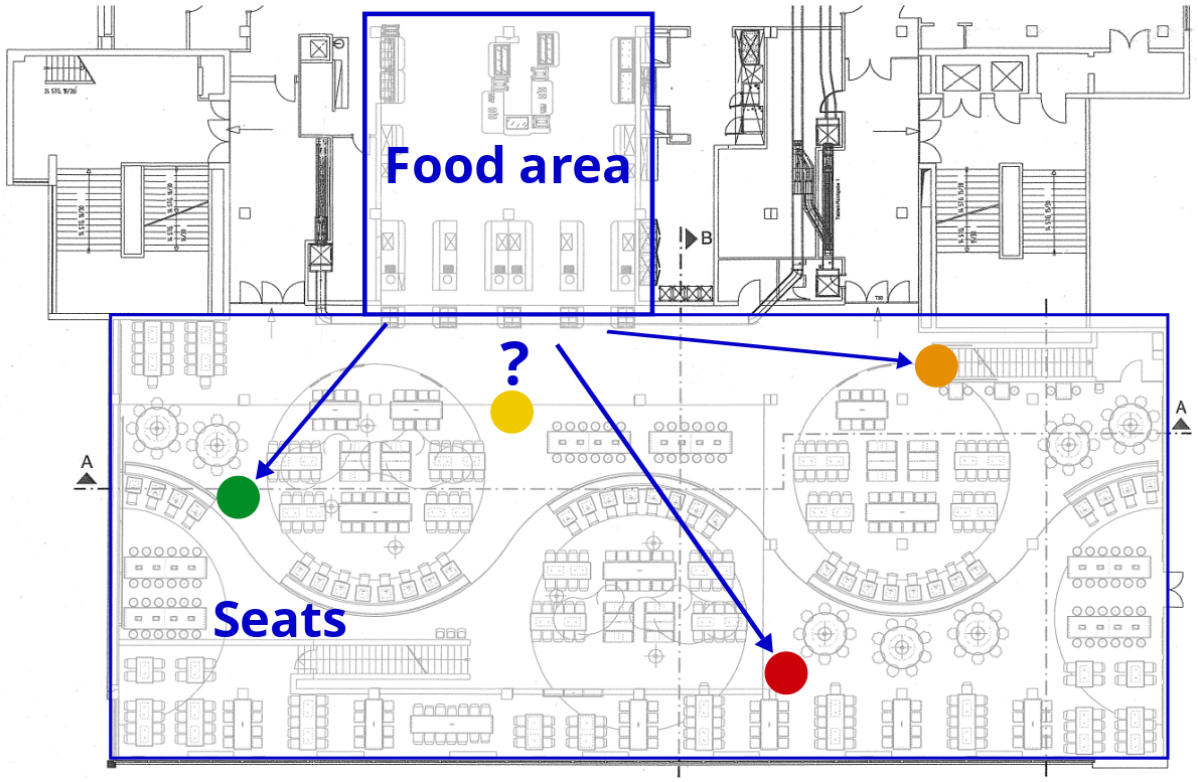
# Contents

# 1 Introduction

Motivation:

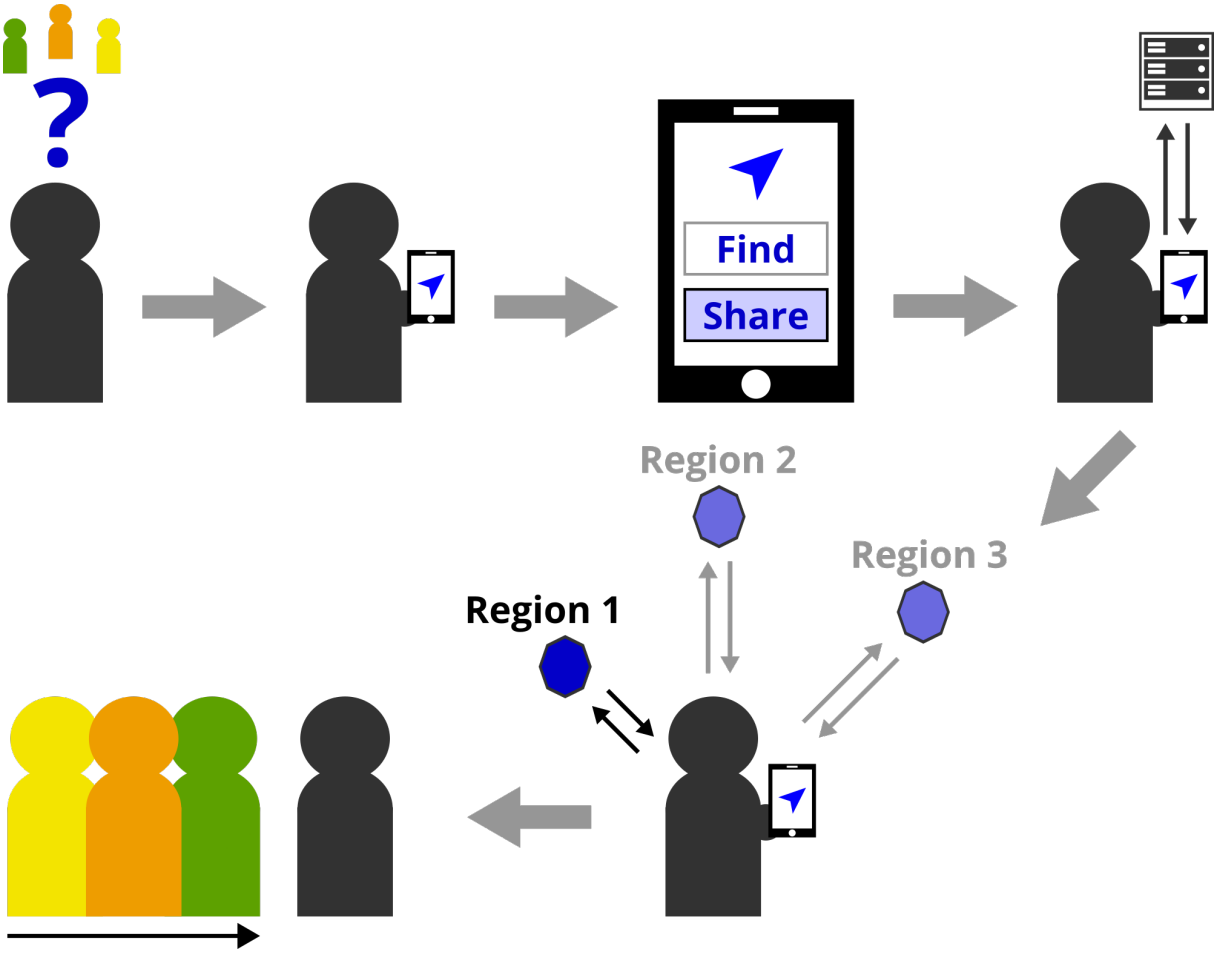
- Write down what the idea behind our project was
- Include the use case images and explain them
- State constraints and requirements

The mensa in Hardenbergstraße at TU Berlin.




Yellow person looking for her/his friends in crowded mensa.

Imagined use of our app on mensa tray.




Steps on user's way to her/his friends.

# 2 Related Work

The state of the art goes here. This includes:

- an overview over available technology
- a dicussion which technology is best to use
- CISCO MSE API wrapper test results

We are now going to take a look into what technology is available to accomplish our project goals defined in the previous chapter. First, we are starting with an overview of localization technologies that are in the reach of our project. After that we evaluate which ones are suitable for the circumstances our project is positioned in. And at the end one specific available solution will be examined more deeply in order to determine its possible value for our implementation.

## 2.1 Projects With Same Idea

## 2.2 Localization Technologies

## 2.3 Evaluation of Available Technologies

## 2.4 CISCO MSE API Wrapper Tests

In order to determine whether the CISCO MSE API wrapper provided by tubIT would be sufficient for the project's requirements we were asked to perform tests on it. Especially it was asked for details on how the API worked where, so what values could be retrieved via the API wrapper in which locations on campus and how precise the values would turn out to be.

Concerning use cases our project was focused on the mensa and the library, therefore we initially planned to be conducting tests in only these two locations. As the provided wrapper around the CISCO MSE API we had access to delivered back one short, simple XML line we decided to invest some time into developing a small tool which routinely queried the API for it's current status and saved the result into an easily readable JSON file for later investigation. The source code of the developed tool you can find in appendix 1.

```
<Info changedOn="2015-10-30T15:32:27.185+0100"
confidenceFactor="40.0" building="MAR" floor="Erdgeschoss"
WLAN-Status="EDUROAM" username="[redacted]"
lon="13.323857725896488" lat="52.516801767504241"/>
```

What the CISCO MSE API wrapper response looks like.

It was planned to be conducting the tests on one day in the mensa and on another day in the library. On the first day we started around noon and ran the test tool on one of our notebooks connected to university WiFi, "eduroam". We started in the south-western corner near the windows, walked towards the south-eastern corner, went to the stairs in the northern part and upstairs and again at the window front to the south-western corner on the first floor. As it turned out, the results we got back were definitely not what we had hoped for, most importantly because longitude and latitude of the requesting user were missing completely. The following listing shows the first ten results logged in two second periods from the API wrapper:

```
{
    "signal": [
        {"timestamp": 1445344391, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344393, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344395, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344397, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344399, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344401, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344404, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344406, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344408, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        {"timestamp": 1445344410, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "Mensa", "floor": "
           Mensa 1. OG"},
        ...
```

```
    ]
}
```

Clearly it can be observed that the longitude and latitude values are unusable. Another take away was that the floor change during our test did not reflect into our captured results. Therefore we decided to directly test the library for comparable results. Inside the library, we started on ground floor and went upstairs in "circles" through the different levels. From the fourth floor we went back down straight forward. During that second test ten of the first fifteen responses from the API looked like:

```
{
    "signal": [
        {"timestamp": 1445345843, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445345845, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445345848, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445345850, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445345852, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445345854, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "
           Erdgeschoss"},
        ...
        {"timestamp": 1445345870, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "1.
            Obergeschoss"},
        {"timestamp": 1445345872, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "1.
            Obergeschoss"},
        {"timestamp": 1445345874, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "1.
            Obergeschoss"},
        {"timestamp": 1445345876, "latitude": "0.000000000000000", "
           longitude": "0.000000000000000", "building": "BIB", "floor": "1.
            Obergeschoss"},
        ...
    ]
}
```

First, longitude and latitude were again unusable. This time though the floor information worked quite reliably and indicated very fast on which floor we currently measured. After that we were wondering whether eventually we would get back longitude and latitude values anywhere on campus and decided to give it one last try by taking one more measurement in the MAR building (Marchstraße).

One more measurement turned into three as during the first two attempts we got sudden disconnects and therefore unusable results. We walked the whole foyer from north to south side and somewhere near the entrance we suspect the wireless signal got bad and our notebook conducting the tests disconnected. In the third try though we finally were able to get back usable results, in which chosen ten results logged looked like this:


```
{
    "signal": [
        {"timestamp": 1445350550, "latitude": "52.516903688639005", "
           longitude": "13.323958376544699", "building": "MAR", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445350552, "latitude": "52.516903688639005", "
           longitude": "13.323958376544699", "building": "MAR", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445350554, "latitude": "52.516903688639005", "
           longitude": "13.323958376544699", "building": "MAR", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445350557, "latitude": "52.516903688639005", "
           longitude": "13.323958376544699", "building": "MAR", "floor": "
           Erdgeschoss"},
        ...
        {"timestamp": 1445350686, "latitude": "52.516864921942748", "
           longitude": "13.323953890659670", "building": "MAR", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445350688, "latitude": "52.516864921942748", "
           longitude": "13.323953890659670", "building": "MAR", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445350690, "latitude": "52.516864921942748", "
           longitude": "13.323953890659670", "building": "MAR", "floor": "
           Erdgeschoss"},
        ...
        {"timestamp": 1445350845, "latitude": "52.516402095317481", "
           longitude": "13.323531401046099", "building": "MAR", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445350847, "latitude": "52.516402095317481", "
           longitude": "13.323531401046099", "building": "MAR", "floor": "
           Erdgeschoss"},
        {"timestamp": 1445350849, "latitude": "52.516402095317481", "
           longitude": "13.323531401046099", "building": "MAR", "floor": "
           Erdgeschoss"},
        ...
    ]
}
```


Finally we received some longitude and latitude values. Unfortunately the three different pairs of longitude and latitude above were the only ones we could observe during the whole walk from north end to south end of the foyer, thus still rather unusable values.

In the end, our conclusion at that point in the project progress was to use the CISCO MSE API wrapper provided by the tubIT in order to retrieve the rough position of a user. This means the building and floor the request originated from. We recommended back to our supervisors not to use this API for receiving longitude and latitude as these values were either quite imprecise

or not available at all. The full result files of all our three measurements can be found at [2].

# 3 Concept and Design

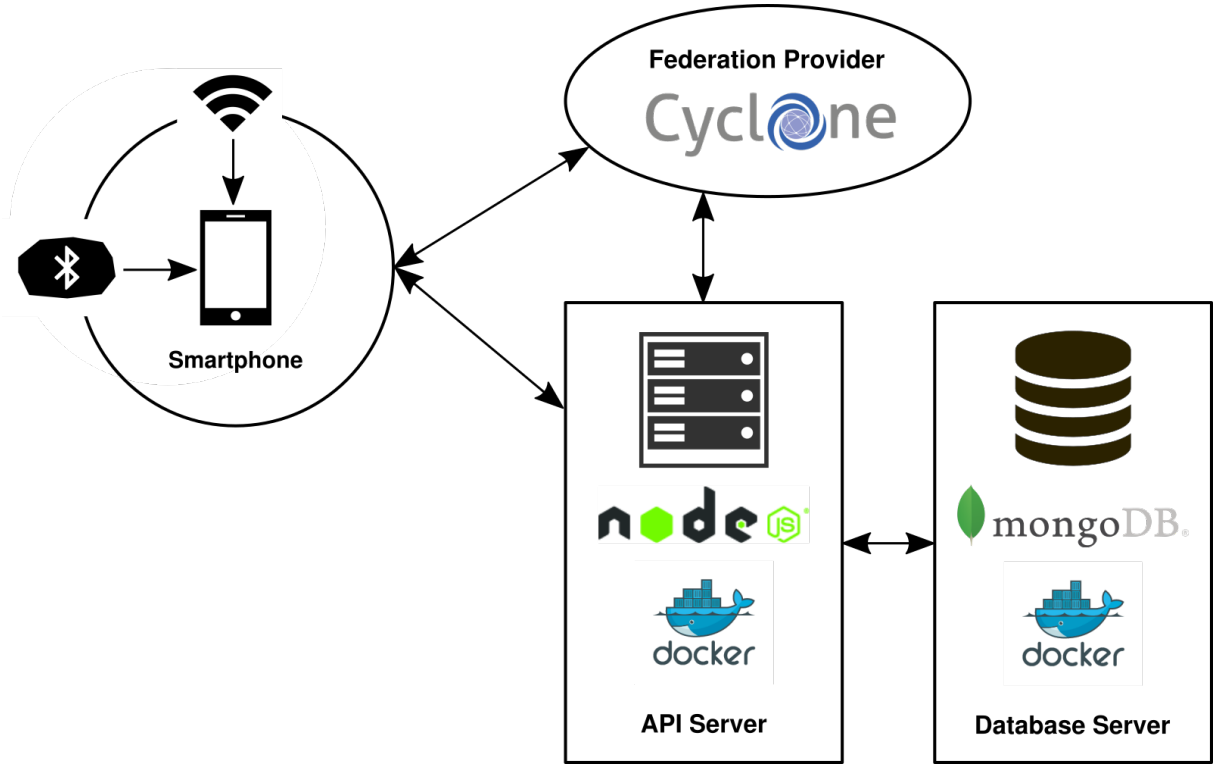
Explain what defines our concept (setup):

- Big picture setup explanation
- API format (RESTful JSON API)
- Client side vs. server side
- Authentication idea
- Database design
- etc...

## 3.1 Big Picture

As already mentioned our system will consist of two parts, the mobile clients side and the backend side which interconnectedly exchange data. The backend part itself is split up again in three parts of which one is an "external" (means: SNET) resource, the CYCLONE Federation Provider. This entity provides us with user management and session handling functionalities so that we are able to out source these tedious and error-prone tasks to them. On the other side CYCLONE profits from our experiences with its rather young service. Concerning our part of the backend side, the task was to serve two machines independently, the API server and the database server. This was expected to be achieved with Docker.

To gain an understanding of what system we were trying to build, the following image should be at help:




All components of our envisioned system working together.

To sum it up, the idea is to gather position information aligned to the user's preferences locally on the smartphone, preform some processing steps on it, contact our backend for which authentication via the CYCLONE Federation Provider is needed and after that create, read, update or delete information (CRUD principle) in the backend and therefore in the database.

## 3.2 API Considerations

We had to decide on which paradigm our API should be based on. The client-server and stateless nature in combination with the just mentioned approach of relying on HTTP verbs such as POST, GET, PUT and DELETE for the CRUD operations, the decision to go for a RESTful API was quite clear (see chapter five [1]).

## 3.3 Workload Split Between Clients and Server

## 3.4 Authentication and Session Management

## 3.5 Database Design

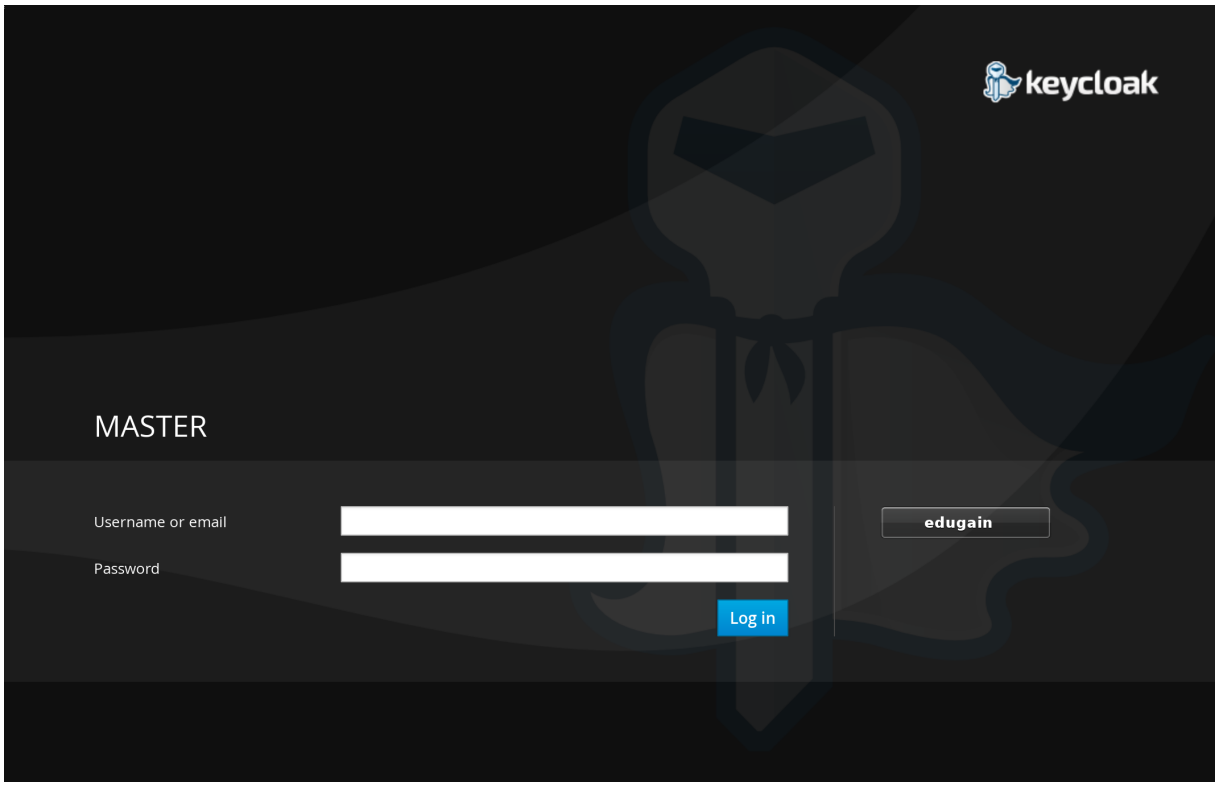
# 4 Implementation

Implementation:

- Backend architecture
- Android
- iOS

## 4.1 Backend

### 4.1.1 CYCLONE Federation Provider




Login screen to CYCLONE Federation Provider.

## 4.2 Android

## 4.3 iOS

# 5 Evaluation

Evaluate:

- What does work so far? What does not?
- What were the observed issues (see final presentation)?
- $\rightarrow$ MSE API, beacons, interplay server with clients, Node.JS, Mongoose (MongoDB), etc.

# 6 Conclusion

Conclusion:

- What did we do, how did it work out?
- Mention “team work issues”?
- Future work

## 6.1 Future Work

# List of Tables

# List of Figures

# Bibliography

[1] Roy Thomas Fielding. "Architectural styles and the design of network-based software architectures". PhD thesis. University of California, Irvine, 2000. URL: http://jpkc.fudan.edu.cn/picture/article/216/35/4b/22598d594e3d93239700ce79bce1/7ed3ec2a-03c2-49cb-8bf8-5a90ea42f523.pdf.

[2] IoSL-INav team. *Project repository of IoSL-INav*. Feb. 2016. URL: https://github.com/IoSL-INav/project (visited on 02/09/2016).

# Appendices

# 1 Tool for performing tests on the CISCO MSE API wrapper

```
1  package main
2
3  import (
4      "fmt"
5      "log"
6      "os"
7      "syscall"
8      "time"
9
10     "encoding/xml"
11     "io/ioutil"
12     "net/http"
13     "os/signal"
14 )
15
16 type WiFiInfo struct {
17     XMLName           xml.Name `xml:"Info"`
18     ChangedOn         string   `xml:"changedOn,attr"`
19     ConfidenceFactor  float32  `xml:"confidenceFactor,attr"`
20     Building          string   `xml:"building,attr"`
21     Floor             string   `xml:"floor,attr"`
22     Network           string   `xml:"WLAN-Status,attr"`
23     UserName          string   `xml:"username,atrr"`
24     Longitude         float64  `xml:"lon,attr"`
25     Latitude          float64  `xml:"lat,attr"`
26 }
27
28 type LogWiFiStruct struct {
29     Timestamp int     `json:"timestamp"`
30     Latitude  float64 `json:"latitude"`
31     Longitude float64 `json:"longitude"`
32     Building  string  `json:"building"`
33     Floor     string  `json:"floor"`
34 }
35
36 func handleUserExit(signalChannel chan os.Signal) {
37
38     for _ = range signalChannel {
39
40         // Define a useful result file name (format: "wifi-measurement-year-
               month-day-hour-minute-seconds.json")
41         fileName := fmt.Sprintf("wifi-measurement-%s.json", fileNameTime)
42
43         // Open measurement result file
44         fileResult, fileError := os.OpenFile(fileName, os.O_CREATE|os.O_RDWR|os.
               O_APPEND, 0666)
45
46         if fileError != nil {
47             log.Fatal(fileError)
48         }
```

```
49
50          // Close open logging file
51          defer fileResult.Close()
52
53          log.Printf("\nWritten measurement values to file %s. Good bye.\n",
                fileName)
54
55          os.Exit(0)
56      }
57  }
58
59  func main() {
60
61      // Put in here the API endpoint to the wifi location service.
62      const apiURL = "PUT THE API ENDPOINT IN HERE"
63
64      // Get time data
65      startTime := time.Now()
66      fileNameTime := startTime.Format("2006-1-2-3-4-5")
67
68      // Define a clean up channel
69      signalChannel := make(chan os.Signal)
70      signal.Notify(signalChannel, os.Interrupt, syscall.SIGTERM)
71      go handleUserExit(signalChannel)
72
73      log.Printf("Starting to measure WiFi API.\n")
74
75      for {
76
77          // Make a GET call on that URL
78          apiResp, apiError := http.Get(apiURL)
79
80          if apiError != nil {
81              log.Fatal(apiError)
82          }
83
84          // Read in all body content we got and close connection
85          xmlData, ioError := ioutil.ReadAll(apiResp.Body)
86          apiResp.Body.Close()
87
88          if ioError != nil {
89              log.Fatal(ioError)
90          }
91
92          // Our go struct representation of the tubIT XML
93          wInfo := WiFiInfo{}
94
95          // Parse received XML into struct
96          xmlError := xml.Unmarshal([]byte(xmlData), &wInfo)
97
98          if xmlError != nil {
99              log.Fatal("XML parsing error: %v.\n", xmlError)
```

```
100         }
101
102         // Get the current UNIX epoch timestamp for logging
103         timeResult := time.Now().Unix()
104
105         // Build up the log string
106         logResult := fmt.Sprintf("\t\t{\"timestamp\": %d, \"latitude\": \"%.15f
                \", \"longitude\": \"%.15f\", \"building\": \"%s\", \"floor\": \"%s
                \"},\n", timeResult, wInfo.Latitude, wInfo.Longitude, wInfo.Building,
                 wInfo.Floor)
107
108         // Write log string to opened file
109         fileResult.WriteString(logResult)
110
111         log.Printf("Received: \"long\": %v, \"lat\": %v.\n", wInfo.Longitude,
                wInfo.Latitude)
112
113         // Let the execution wait for 2 seconds
114         time.Sleep(2 * time.Second)
115     }
116 }
```