Comparison of Web Applications Geolocation Services

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***Abstract*—This article deals with WiFi based geolocation in web applications. This is the only one possible method of location in mobile devices (notebook, tablet or smartphone) which are not equiped with a navigation system such as GPS - other known methods such as IP or cellular network location are not commonly used in applications due to their high inaccuracy. The location accuracy has a key role for usability of applications offering location based services (LBS) because a lot of them, widely used by public, are dependent on a very accurate location. Therefore the main goal of this article is an analysis of accuracy of WiFi geolocation services used by web applications in current web browsers. Measurement of accuracy of WiFi geolocation services and comparison between them is the result of this article.**

I. INTRODUCTION

Importance of applications offering local information has been strongly growing in last years - 74% of mobile device (smartphone) owners say they use applications to get directions or other information based on their current location (2013, [9]). Every application in any mobile device (notebook, tablet, smartphone) providing information based on current location has to use some method of geolocation of mobile device. This submission is focused on implementations of WiFi based geolocation in web applications. This is the only one possible method of location in mobile devices which are not equiped with a navigation system (such as GPS or GLONASS which can be used only outdoor) [12] - other known methods such as IP or cellular network location are not commonly used in applications due to their high inaccuracy (even hundreds of meters and more) [14]. The location accuracy has a key role for usability of applications offering location based services (LBS) because a lot of them, widely used by public, are dependent on a very accurate location. The typical LBS application is very famous Google Maps. Therefore the main goal of this article is an analysis of accuracy of WiFi geolocation services (from providers Google, Microsoft, Apple and Mozilla) used by web applications in current web browsers. Measurement of accuracy of WiFi geolocation services and comparison between them is the result of this paper.

II. POSSIBILITITES OF WIFI GEOLOCATION

Geolocation is available for web applications through geolocation API (Application Programmable Interface) standardized by W3C (World Wide Web Consorcium) [6]. Within the API, there are functions of ECMA scripts for obtaining location coordinates. The key fact is that these functions result coordinates of mobile device, but they do not specify the method of geolocation. It means that the browser itself decides if these coordinates are obtained by GPS, WiFi or cell network geolocation in order to get the best results. This article is focused only on the WiFi geolocation because it provides the best results in case the navigation system such as GPS is not available.

The Wifi geolocation works in a way that the browser scan the nearby WiFi signals (their Mac address of WiFi network, SSID, strength – for example, Windows command "netsh wlan show networks mode=bssid") and a list of them sends in JSON (JavaScript Object Notation) format record to server with a location service (see Table I). The location service has a huge database of the existing WiFi networks with the assigned coordinates and thanks to this list, through the triangulation, tries to calculate approximate coordinates of mobile device from which it receives this list. In fact, there are world wide available WiFi location services from providers Google, Microsoft, Apple and from Mozilla, but this last one is still in development and currently, it is building its own database of the WiFi networks. Every web browser at the same time uses only one location services – a list of the existing location services and their assignment to web browser is shown bellow (see Table II).

TABLE I.
EXAMPLE OF JSON DATA RECORD. SOURCE: [8].

```
{
"version":"1.1.0",
"access_token":"2:TxOUf1FvIIchp7rY:V46pKmYW2fVPkhLb",
"wifi_towers":[
  {
    "mac_address":"00-1d-0f-e4-4b-12",
    "ssid":"nygrynovo",
    "signal_strength":-67
},
  {
    "mac_address":"00-19-cb-58-1f-0f",
    "ssid":"Homeless",
    "signal_strength":-50
  },
  {
    "mac_address":"e8-39-df-9a-ae-2a",
    "ssid":"nas net",
    "signal_strength":-90
  }
  ]
}
```

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TABLE II.
ASSIGNMENT OF LOCATION SERVICES TO WEB BROWSERS. SOURCE: AUTHOR, APPLICATION WIFI ANALYZER 3.6.6.

Location service	Web browser
Microsoft Location Service	Internet Explorer (IE)
Google Location Service	Chrome
Optional Google Location Service or Mozilla Location Service	Firefox
Google Location Service	Opera
Apple Location Service	Safari

III. ANALYSIS OF WIFI GEOLOCATION SERVICES

The measurement of accuracy was carried out on Atheros AR9485WB-EG WiFi adapter inside the ultrabook and confirmed on Broadcom 802.11bgn Wireless SDIO Adapter inside the tablet, both of them are the most common mafucturers of WiFi adapters. The reason of confirmation is a difference in sensitivity of WiFi chipsets in adapters. That consequently can cause differences in receiving information about strength of the WiFi network signals and in the result of small differences in the geolocation based on these Wifi network signals. Between mobile devices with Atheros and Broadcom Wifi adapter there was in the end a difference about 5 meters, measured at the same moment thanks to synchronisation barrier in JavaScript. Another problem is the WiFi signal strength fluctuation (see Figure 1) in time caused by interferences around the WiFi adapters. Both of these factors make diffferences in accuracy across the time within couple of meters.

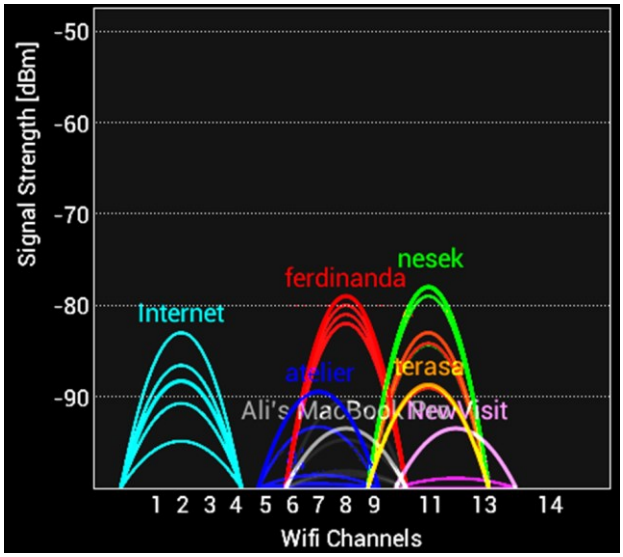

Figure 1. WiFi signal strength fluctuation (within one minute).

For the best results the measurement in JavaScript was carried out with option high accuracy (attribute "highaccuracy" set to value "true") of geolocation and with option high freshness (attribute "maximumAge" set to value "0") of coordinates. The attribute "position.timestamp" guarantees the refreshed coordinates shown in the test results. The test consisted in every place of 3 individual measuring, synchronized on both mobile devices at the same time thanks to a barrier in code of JavaScript. The results of all measurements and calculated differencies was saved into CVS (Comma-separated values) file format by PHP script (see Table 3). After that, an average filter was applied on all measurements. Of course, the JavaScript assumes synchronized time on both mobile devices intended for these measurements. The source code (key parts of the code) in JavaScript and HTML v5 using geolocation API, is placed in Table III.

TABLE III.
SOURCE CODE OF MEASUREMENT APPLICATION. SOURCE: AUTHOR, FUNCTION DISTANCE FROM [11].

Measurement.html

```
…
function getPosition(position){
lat1.value=position.coords.latitude;
lon1.value=position.coords.longitude;
accuracy.value=position.coords.accuracy;
timestamp.value=new Date(position.timestamp);
}

function getLocation(){
if(navigator.geolocation)
  navigator.geolocation.getCurrentPosition(getPosition,getError,
                {maximumAge:0, enableHighAccuracy:true});
else res.innerHTML="Geolocation not supported by this browser.";  }
…
while(new Date().getSeconds()>0) { } // synchronization barrier
getLocation();
…
```

Measurement.php

```
…
// Function distance by GeoDataSource.com, edited by author
function distance($lat1, $lon1, $lat2, $lon2) {
  $theta = $lon1 - $lon2;
  $dist = sin(deg2rad($lat1)) * sin(deg2rad($lat2))
          + cos(deg2rad($lat1)) * cos(deg2rad($lat2)) *
cos(deg2rad($theta));
  $dist = acos($dist);
  $dist = rad2deg($dist);
  $miles = $dist * 60 * 1.1515;
  return ($miles * 1609.344);
}
…
```

This comparison analysis of the location services includes results (shown in Figure 4) of two parameters which are as follows:

- Parameter "coords.accuracy" – the first one parameter indicates the approximate accuracy of geolocation, roughly estimated by API.
- Real accuracy – difference between measured coordinates (in API attributes "position.coords.longitude" and "position.coords.latitude") and real location of mobile device during the measurement. This difference (in

meters) was obtained by JavaScript and PHP script (see Table III) and verified by Distance Calculator tool [1], working with coordinates in WGS84 (World Geodetic System 1984) geodata format.

The comparison of the individual geolocation services from Google, Microsoft, Apple and Mozilla proved that there were differences between them and they are more or less sensitive to WiFi signal stability (see Figure 1) – focused areas included the center and outside of the center locations of cities and towns:

- Hradec Kralové (about 93 thousands inhabitants) – center at cooordinates N 50.209434, E 15.833652, outside of the center at coordinates N 50.204486, E 15.829105.
- Pardubice (about 90 thousands inhabitants) – center at cooordinates N 50.038904, E 15.779486, outside of the center at coordinates N 50.033502, E 15.754561.
- Jičín (about 16 thousands inhabitants) – center at cooordinates N 50.436917, E 15.351121, outside of the center at coordinates N 50.434505, E 15.355094.
- Ústí nad Orlicí (about 14 thousands inhabitants) – center at cooordinates N 49.973587, E 16.394184, outside of the center at coordinates N 49.968353, E 16.39578.

The comparison analysis results (obtained on Atheros WiFi adapter) proved that an average real accuracy was around 29 meters regardless of indoor (in ordinary buildings with WiFi transparent walls) or outdoor use, which is on average only a little bit worse accuracy than usual public GPS navigation system [10], but of course, this method is much more dependent on a lot of factors such as density of the nearby WiFi networks and WiFi networks have to be collected in the location service database (example of the city coverage, see Wigle WiFi map in Figure 2 and 3). Therefore the verdict is that the WiFi geolocation is the recommended method of location areas covered by the WiFi signals (mostly urban areas) in LBS applications, and for most of current applications provides an acceptable value as compared with the cellular network geolocations which have a minimal accuracy of 250 meters [10].

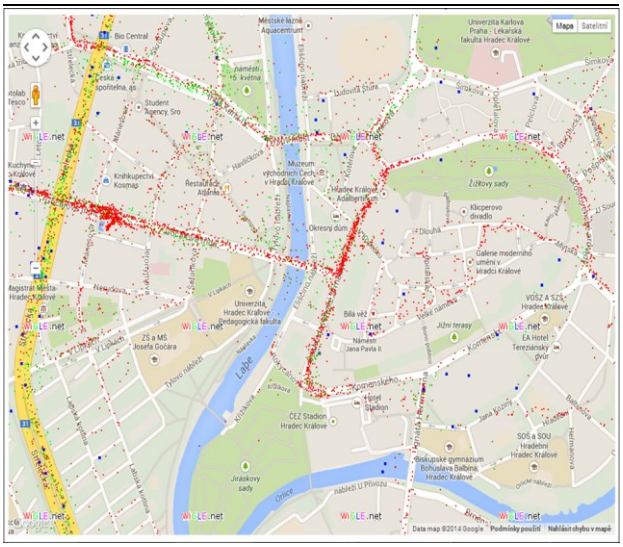

Figure 2. City coverage by WiFi networks (- green and red points, below detailed with Mac address). Source: [7].

Figure 3. Detailed City coverage by WiFi networks (- green and red points, below detailed with Mac address). Source: [7].

Web browser	Place	Pardubice – center [meters]	Pardubice – outside center [meters]	Hradec Králové – center [meters]	Hradec Králové – outside center [meters]	Average [meters]
IE v11 coords.accuracy		57.3	68.3	57.5	107	72.5
IE v11 real accuracy		29.8	18.3	24.4	10.5	20.8
Opera v20 coords.accuracy		30	29	97	30	46.5
Opera v20 real accuracy		15.1	18.1	37.5	30.7	25.3
Chrome v33 coords.accuracy		30	29	97	30	46.5
Chrome v33 real accuracy		15.1	18.1	37.5	30.7	25.3
Firefox v28 coords.accuracy		*Geolocation out of WiFi range (40000).*	500	*Geolocation out of WiFi range (40000).*	30	*265 (Only selected measure ments.)*
Firefox v28 real accuracy		*Geolocation out of WiFi range (37850.4).*	24.7	*Geolocation out of WiFi range (56380.2).*	37.6	31.2 *(Only selected measure ments.)*
Safari v5.1.7 coords.accuracy		80	500	80	*Geolocation service could not determine the position.*	220
Safari v5.1.7 real accuracy		31.3	29.9	9.6	*Geolocation service could not determine the position.*	23.6

Figure 4a. Comparison of location services accuracy in cities by web browsers. Source: author.

Web browser / Place	Jičín – center [meters]	Jičín – outside center [meters]	Usti nad Orlici – center [meters]	Usti nad Orlici – outside center [meters]	Average [meters]
IE v11 coords.accuracy	63.7	104.7	58	101.3	81.9
IE v11 real accuracy	8.1	31	23.9	79.2	35.5
Opera v20 coords.accuracy	44.7	69.7	51.3	72.3	59.5
Opera v20 real accuracy	28.4	17.6	19.5	94.2	40
Chrome v33 coords.accuracy	44.7	69.7	51.3	72.3	59.5
Chrome v33 real accuracy	28.4	17.6	19.5	94.2	40
Firefox v28 coords.accuracy	*Geolocation out of WiFi range (40000).*	*Geolocation out of WiFi range (40000).*	*Geolocation out of WiFi range (40000).*	*Geolocation out of WiFi range (40000).*	*Lack of input data.*
Firefox v28 real accuracy	*Geolocation out of WiFi range (77112.7).*	*Geolocation out of WiFi range (218014.4).*	*Geolocation out of WiFi range (68744.1).*	*Geolocation out of WiFi range (68646.5).*	*Lack of input data.*
Safari v5.1.7 coords.accuracy	500	500	80	500	395
Safari v5.1.7 real accuracy	*Geolocation out of WiFi range (3862429.4).*	*Geolocation out of WiFi range (1931192.8).*	30.2	*Geolocation out of WiFi range (1924382.6).*	30.2 *(Only selected measurement.)*

Figure 4b. Comparison of location services accuracy in towns by web browsers. Source: author.

Web browser / Place	Average of cities [meters]	Average of towns [meters]	General average [meters]
IE v11 coords.accuracy	72.5	81.9	77.2
IE v11 real accuracy	20.8	35.5	28.2
Opera v20 coords.accuracy	46.5	59.5	53
Opera v20 real accuracy	25.3	40	32.7
Chrome v33 coords.accuracy	46.5	59.5	53
Chrome v33 real accuracy	25.3	40	32.7
Firefox v28 coords.accuracy	*Geolocation out of WiFi range (20132.5).*	*Geolocation out of WiFi range (40000).*	*Lack of input data.*
Firefox v28 real accuracy	*31.2 (Only selected measurements.)*	*Geolocation out of WiFi range.*	*Lack of input data.*
Safari v5.1.7 coords.accuracy	220	395	307.5
Safari v5.1.7 real accuracy	23.6	30.2 *(Only selected measurement.)*	26.9

Figure 4c. General comparison of location services accuracy by web browsers. Source: author.

From the measurements described above, the following statistics were obtained: Microsoft had the most accurate location service with average accuracy of 28 meters, Google had still very good location service with average accuracy of 33 meters, Apple location service with accuracy of 27 meters is more accurate than the previous services but has a lot of not covered places. Last competitor from Mozilla is still in development [3] [4] and due to this reason it provides the worst and not acceptable values.

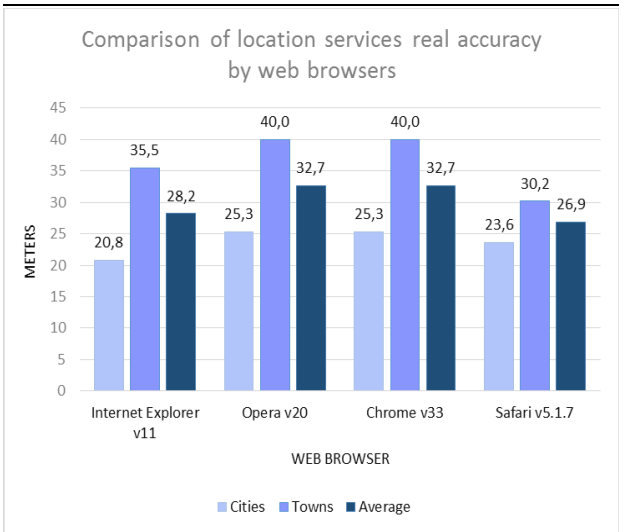

Figure 5. General comparison of location services real accuracy by web browsers. Source: author.

IV. CONCLUSION

Every LBS application requires to use some method of geolocation. Therefore, the accurate location has the key role for providing the right information to user. Actually there do not exist too much reliable methods of geolocation for applications – in case of the missing navigation system (GPS, GLONASS) in mobile device or use it indoor, there is possible to use only the WiFi geolocation method. Due to this reason, this article tried to analyse the accuracy of WiFi geolocation services (from providers Google, Microsoft, Apple and Mozilla) used by web applications in current web browsers.

The measurement of accuracy (on Atheros AR9485WB-EG WiFi adapter inside the ultrabook and Broadcom 802.11bgn Wireless SDIO Adapter inside the tablet) of the WiFi geolocation services and comparison between them was the result of this article. These results proved that an average accuracy is around 29 meters regardless of indoor or outdoor use, which is on average only a little bit worse accuracy than usual public GPS navigation system, but of course, this method is much more dependent on a lot of factors such as density of the nearby WiFi networks and WiFi networks have to be collected in location service database. Therefore the verdict is that the WiFi geolocation is the recommended method of location areas covered by the WiFi signals (mostly urban areas) in LBS applications, and for most of current applications provides an acceptable value as

compared with the cellular network geolocations which have a minimal accuracy of 250 meters. The comparison of individual geolocation services from Google, Microsoft, Apple and Mozilla proved that there were differences between them – Microsoft had the most accurate location service with average accuracy of 28 meters, Google had still very good location service with average accuracy of 33 meters, Apple location service with accuracy of 27 meters is more accurate than the previous services but has a lot of not covered places. Last competitor from Mozilla is still in development and due to this reason it provides the worst and not acceptable values.

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