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Visualizing Location Based Data on an HTML Platform

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Tekijä Otsikko Sivumäärä Aika	Janne Salminen Sijaintipohjaisen datan visualisointi HTML-alustalla 31 sivua 17.4.2015
Tutkinto	Insinööri (AMK)
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Insinöörityön tarkoitus oli luoda verkon käyttödataa visualisoiva sovellus. Sovellus tuli matkapuhelinverkkoyhtiölle markkinointikäyttöön, tarkoituksena havainnollistaa verkon datamäärien ja käyttäjien määrän räjähtävää kasvua ja sitä myötä uusien verkkoinvestointien tarvetta. Sovelluksen oli tarkoitus toimia automatisoidusti tietokoneen selaimessa.

Kaikenlaisen sijaintipohjaisen datan määrä on kasvussa, ja sen hahmottaminen numeroina on hankalaa. Sijaintipohjaisen datan näyttämiseen ja muokkaamiseen on perinteisesti käytetty paikkatietojärjestelmiä. Nämä järjestelmät ovat kuitenkin lähinnä tieteelliseen käyttöön, joten selkeämpi datan visualisointi on tehokkain tapa havainnollistaa suuria määriä tietoa. Verkossa toimivien karttapalveluiden kehitys on tuonut paikkatiedon lähemmäs kuluttajia ja sitä myötä myös paikkatietodatan visualisointi on mullistunut.

Datan visualisointiin on kehitetty erilaisia työkaluja lähinnä karttapalvelutarjoajien toimesta. Karttapalveluiden ohjelmointirajapinnat ja karttavisualisointiin varta vasten tarkoitetut työkalut yhdistettynä uusiin HTML5-teknologioihin ja kirjastoihin mahdollistavat monipuoliset selaimessa toimivat visualisoinnit. Osassa palveluista on graafinen käyttöliittymä, ne ovat hyvin pelkistettyjä ja sopivatkin tavallisille käyttäjille, koska aloituskynnys on matala. Kokeneemmat käyttäjät voivat yhdistellä ja muokata olemassa olevia teknologioita, jolloin on mahdollista luoda hyvinkin näyttäviä visualisointeja.

Insinöörityössä vertailtiin erilaisia sijaintipohjaisen datan visualisointiin soveltuvia alustoja ja niiden käyttömahdollisuuksia. Tällä hetkellä kaikki alustat kärsivät jonkinlaisista vajavaisuuksista, ja ominaisuuksiltaan ne lähinnä täydentävät toisiaan. Tämän takia oikean alustan valinta riippuu hyvin pitkälti käyttötarkoituksesta, kuten tiedon määrästä ja tyypistä, halutusta ulkoasusta ja interaktiivisuus- tai automaatio-ominaisuuksista. Jotta alustan valinta onnistuisi, tekniset vaatimukset olisi määriteltävä huolellisesti ennen valintaa.

Itse sovellus tehtiin käyttämällä alustaa, joka mahdollistaa kolmiulotteiset visualisoinnit. Valinta oli hyvä, koska dataa näytettiin maailmanlaajuisesti. Työn edetessä vaatimukset kuitenkin muuttuivat, jolloin alustan ominaisuuksissa olevat rajoitteet aiheuttivat paljon haasteita, joiden ratkaisemiseksi jouduttiin käyttämään muita teknologioita. Lopputuloksesta tuli toimiva, joskin esimerkiksi datan päivittäminen on melko hidasta.

Avainsanat	Power Maps, paikkatietojärjestelmä, sijaintipohjainen data, visualisointi, html5

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In this final year project, the target was to create an application for a mobile network company which visualizes network data usage. The purpose of the application is to demonstrate the huge growth in the usage of networks. The application is to run automatically in a computer web browser.

Location based data is a big trend and the amount of it is growing exponentially. Reading the data in a numerical form is difficult, so it is usually viewed and managed using geographical information systems. Data visualization is the most effective way of using it. The development of online mapping services has made location data more available to ordinary people and made location data visualization available for everyone.

For data visualization there are several tools provided mostly by the online mapping service providers. The online mapping service APIs and platforms specifically developed for map visualization, combined to modern HTML technologies and libraries, enable a wide selection of visualization possibilities. For standard users there are simple but limited platforms with graphical user interfaces. More advanced users can combine and modify the technologies available, which makes it possible to create very complex and impressive visualizations.

This thesis compares different location data visualization platforms and their possibilities. Currently every platform has its weaknesses and it is very important to map the requirements to choose the right platform.

The application was implemented using a platform which enables 3D visualizations. The platform is quite limited by its customization features so many difficulties were faced and solved using different technologies. The end result was satisfactory, though updating the data is quite slow.

Keywords	Power Maps, GIS, location data, data visualization, html5

Contents

Abbreviations

KPI	Key performance indicator is a type of performance measurement which evaluates the success of the activity it engages.
API	Application programming interface is a set of routines, protocols and tools for building software applications. In web use it defines the interfaces through which interactions happen between an enterprise and application that use its assets.
HTML	Hypertext markup language is the standard markup language used to create web pages. Its newest version is HTML5.
JS	JavaScript is a programming language used for programming web applications.
CSS	Cascading Style Sheets is a style sheet language used for styling documents written in a markup language.
Big Data	Big data is a broad term for data sets so large or complex that traditional data processing applications are inadequate.
WGS84	WGS84 is a coordinate system founded and maintained by the US military. GPS uses this coordinate system.
GPS	The Global Positioning System is a free satellite navigation system widely used.
Geocoding	Geocoding means translating coordinates into street and place names and backwards.
GIS	A geographic information system is a system built to view and manage location data on map platform.
KML	Keyhole Markup Language is a markup language used for expressing geographic annotation and visualization.

GeoJSON	GeoJSON is an open standard format for encoding collections of simple geographical features using JSON.

1 Introduction

In today's world approximately 2.5 quintillion bytes of data is created daily. The speed is increasing so rapidly that 90% of the world's data was created within the last few years. This data comes from everywhere: sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction records, and cell phone GPS signals to name a few. This data is called big data and it often contains some kind of location information which makes it location data. [1.]

Location data is data containing information of location in space. The data itself can be anything, but it contains information to answer the question where [2]. The precision of the location can be anything from a micrometric location on a circuit board into an entire universe. The most common location data used is geographic data, which can be located on a geographic map. This is usually accurate coordinate data, such as GPS coordinates. It can be collected using GPS satellites, cell towers or IP addresses [3]. The location data contains coordinates and a property parameter, which explains the coordinate system used [4]. This data can be automatically collected through for example a personal device that is connected to a network, or it can be manually inserted. Geographic location data can also be more imprecise data which contains the location only with the accuracy of a zip code or an entire continent. This kind of data could be for example regional statistics. A common usage for all this kind of data is that it can be translated into a suitable form for viewing on a map. Smart map platforms can handle and translate various kinds of location information. Some platforms need the information in a more specific form. There are also various different coordinate systems, but digital mapping is usually based on WGS84.

While the amount of data including location data grows rapidly, it becomes more challenging to view and manage it in a usable form. Location data is most commonly translated into a graphical form to be used on a map. For this purpose, there are several geographic information systems. Presented on a map, the data comes more easily readable and understandable. Also visualizing it in different ways makes it more efficient to outline, because the human brain is much better at understanding visual patterns than rare numbers [5].

As data visualization is so important today, this thesis will cover the development of a location based data visualization application made for Nokia, which is a well-known network company, and some theory and comparison about the technologies. Chapter 2 will cover theory about geographic information systems and chapter 3 about the most common online mapping services. Chapters 4 and 5 will discuss the possibilities of visualizing location data on an HTML platform. Chapter 6 explains specifically the steps of the development process. Conclusions are given in chapter 7.

2 Digital Mapping

2.1 Geographic Information System

GIS is a system which incorporates geographical features with data. It consists of a hardware running the system, the actual software containing the maps, the input to specify the use of the system and the user [6]. The software itself can be very complex. It is used to inventory, analyze and manage many aspects of the world. It turns the numbers and words in a database into a visible form on a map [7]. If location data answers the question where, GIS will help to answer the questions when and why.

The base layer is a coordinate system, which is commonly WGS84. There are several different coordinate systems and many countries have their own coordinate realization. The global system is called ITRS (International Terrestrial Reference System). Because of the movement of the continental shelves, the system has an updated realization called ITRF (International Terrestrial Reference Frame). The latest update is from 2005 which is called ITRF 2005. For example Finland is using EUREF-FIN coordinate system realization which is anchored to the Eurasian continental shelf. This allows the shelf to move without any changes on the coordinate system. [8.]

WGS84 was built by the United States Department of Defense to be an international standard that is suitable also for satellite and space use. It is anchored on the mass center of the earth. The difference between EUREF-FIN and WGS84 is less than a meter, so in most cases the difference is meaningless. [9.]

Above the coordinate system there are different layers to visualize the map. There can be several rasterized aerial images including satellite images.

Vectored data is used to illustrate for example roadmaps.

Additional information can be anything from 3 dimensional topology to temperature maps or bird nests. On a 2 dimensional flat map the basic location types are points (for example addresses or locations), line strings (for example highways or gas lines), polygons (for example countries or provinces) and a multi-part collection of these types. One popular format for this information in web use is GeoJSON, which is an open standard format designed for this purpose [10]. Figure 1 shows how GIS data is compiled.

The GIS has a graphical user interface which allows the user to navigate in the map. This makes it possible to easily change the layers and data illustrated on the map. All of the data cannot be immediately visible because it would not fit on the screen. This is why the data streams in from the database or server when zooming in closer. Every time the map extent changes, the system calculates which data should become visible [5]. The same functionality is applied to online mapping services.

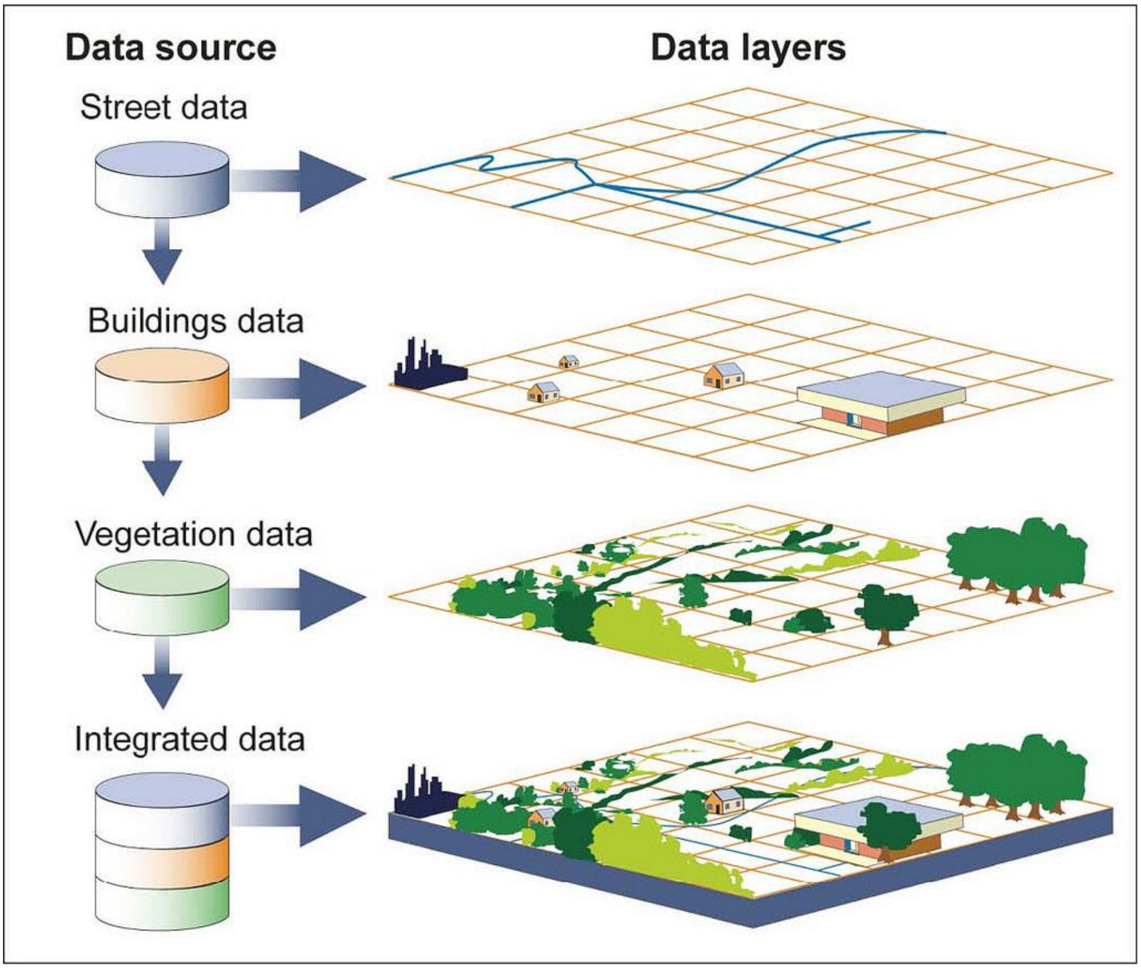

Figure 1. The structure of a GIS. Reprinted from Gao. [11]

This data is often collected from other institutions than the GIS provider, and the more external information it can handle, makes it a better GIS.

Location data in other forms than coordinates can be translate into coordinates using geocoding. A Geocoding service can translate exact points like street addresses into coordinates or bigger areas like cities into areas drawn by coordinates. Geocoding service can be included in the GIS as a part of the GIS platform or as an third party service. There are several geocoding services including the following: Google Maps, HERE, MapQuest, Yahoo and Bing.

Mapping platforms are not only to be used by professionals. They are used more and more widely in online services like apartment locators [12]. GIS can be used for statistical research for a good location. Both GIS and simpler online mapping services can take data input and are connected to several other services to get information from restaurants, traffic data, air pollution or anything that users might find useful.

2.2 Online Mapping Service or GIS

There have been arguments about the definition of a GIS. Is for example Google Maps a GIS? The definition is blurry and there are many uses in web maps, so there is no clear answer. The regular customer friendly user interface of an online mapping service is not a GIS, but the whole platform the service is built on could be considered as a GIS after it contains multiple GIS features such as customized layers, data input and output. The difference between a mapping service and a traditional GIS is becoming all the time narrower while the online maps are becoming richer and containing more and more features [13]. The traditional GIS definition includes four features: data, representation, operations and transformations. The two first ones are commonly used in several online services. The two last ones are possible, but they require some programming skills using the map service API [14]. GIS has these functions natively in a usable form, but in an online mapping service this has to be done manually. However, the traditional GIS services are getting closer to online mapping services after they have been developed to become more user friendly and even run online. Therefore, this report is not going to refer to online mapping services with the name GIS, though it would not be completely false. There are also terms like GIS Lite and WebGIS which could be used in this case.

Which solution should be used then? For pure analytics, measurements and managing GIS is naturally better. GIS usually are for advanced users and quite complex as figure 2 shows, so using a heavy duty tool for simple tasks is usually ineffective. For more simple tasks where usability and the look is more important, online mapping service is good as long as it can be implemented with a reasonable contribution. Like Trevor Robar from the largest GIS provider Esri said: “Want to show the world your favorite fishing locations? –Google can help with that. Want to show property boundaries, wastewater infrastructure, building footprints, contours, etc,? –Esri can help with that.” [15] In summary, GIS is for working and an online map is for showing.

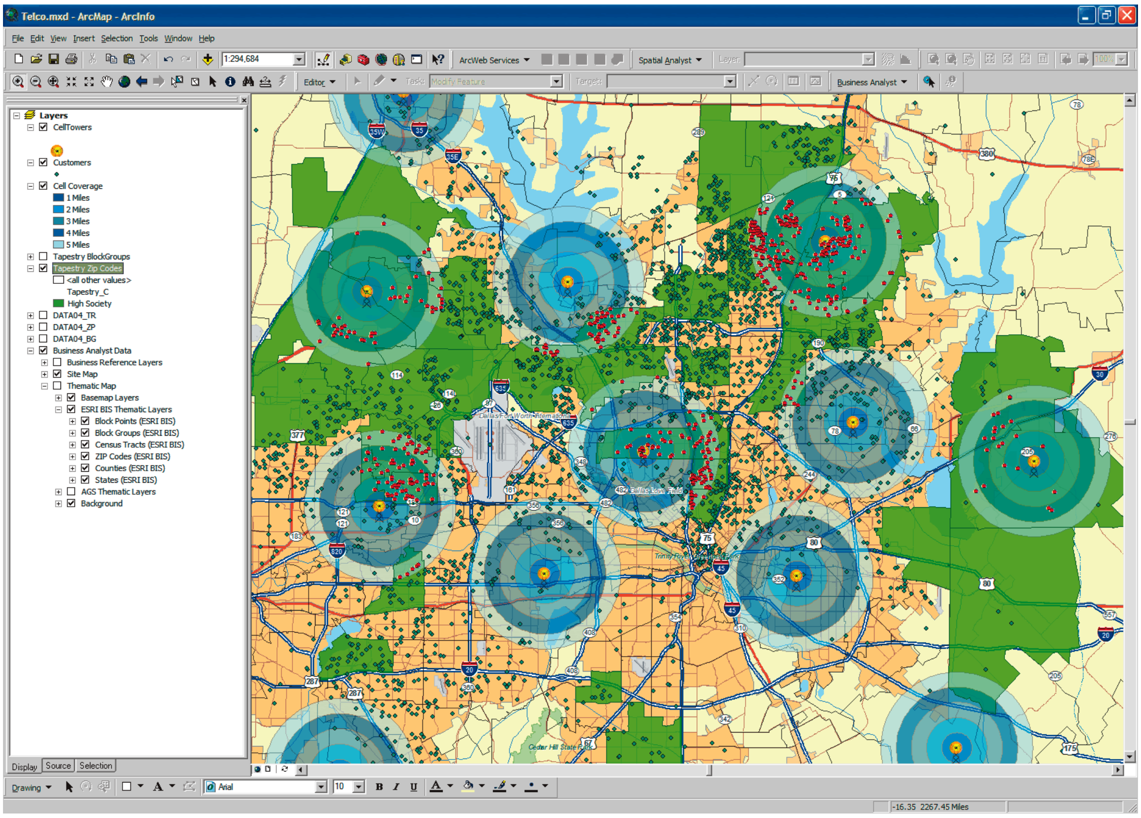

Figure 2. Screenshot of the widely used ArcGIS software [16]

3 Online Mapping Services

3.1 Google

The American company Google has a GIS on which the Google Maps and Google Earth services are built. Google is the most famous GIS and is commonly used in different online services. It uses the WGS83 coordinate system and has its own API for customization. Google Maps is an online native web platform that can be used with a browser or integrated to other clients. Google Earth can be executed by running a browser plugin or by its own application. The biggest difference is that Google Earth supports 3D graphics, such as the entire globe, flyovers and 3D building models. Google Earth also allows data import and customization, while Google Maps requires programming though the API. The most common way of using the API is to set a marker of for example a company's location and share the map as contact information. This map can be integrated into the company's webpage using an iFrame. IFrames can be used with any kind of map and are commonly used in different services where the system is based on a Google map. Google provides roadmaps and quite accurate satellite maps of the entire world. Google has its own Street View mode that provides panoramic photo views of the streets. This service covers several countries entirely for instance Finland, which can be seen in figure 3.

Figure 3. Google Street View [17]

Google’s strength is its popularity while it is connected to other Google services containing a great number of location information of places such as restaurants. Its Map Maker service allows users to add locations, roads and buildings to the service. Especially companies are active on this because that is a marketing asset since Google is the most popular search engine. It also handles traffic and transport information from public transportation to cycling roads, so it is widely used for for example navigation. Google users can add their own places to the service and the API allows making completely customized scenarios. Google’s geocoding is probably the most capable on the market. The Google Maps application comes natively on every Android phone, but it is available also on other platforms. Unlike the web version, the Google Maps application supports 3D views without building textures and navigation.

Based on Google Maps, there are several more professional GIS like systems. One of them is GmapGIS, which is a free web application for drawing shapes, pins and notifications and importing data on a map.

Google also has other similar services for other maps such as moon, space, underwater locations. Google is pretty much a reference technology when it comes to online mapping platforms so the following solutions will be compared to it. [17.]

3.2 Nokia HERE

HERE, formerly Ovi Maps and Nokia Maps, is a web map service provided by Nokia. It is mostly based on the GIS of Navteq which Nokia acquired in 2008. It is much like Google Maps having a web service and a mobile application. Its main features are satellite and roadmaps, traffic information and PrimePlaces service which allows users to add their own places. PrimePlaces is connected to the popular Trip Advisor service, from where it gets data from reviews to opening hours. HERE has an equivalent for Google’s Street View. HERE has its own API for customized scenarios. It has the same kind of 3D features as Google Earth, but it works with WebGL and does not require any plugins. Its 3D city views look even better as figure 4 shows. HERE 3D city maps were made by a company called C3 Technologies. Later Apple acquired the company. Because of impossibility to update these maps with the same technology, Nokia is about to discontinue HERE 3D maps [18].

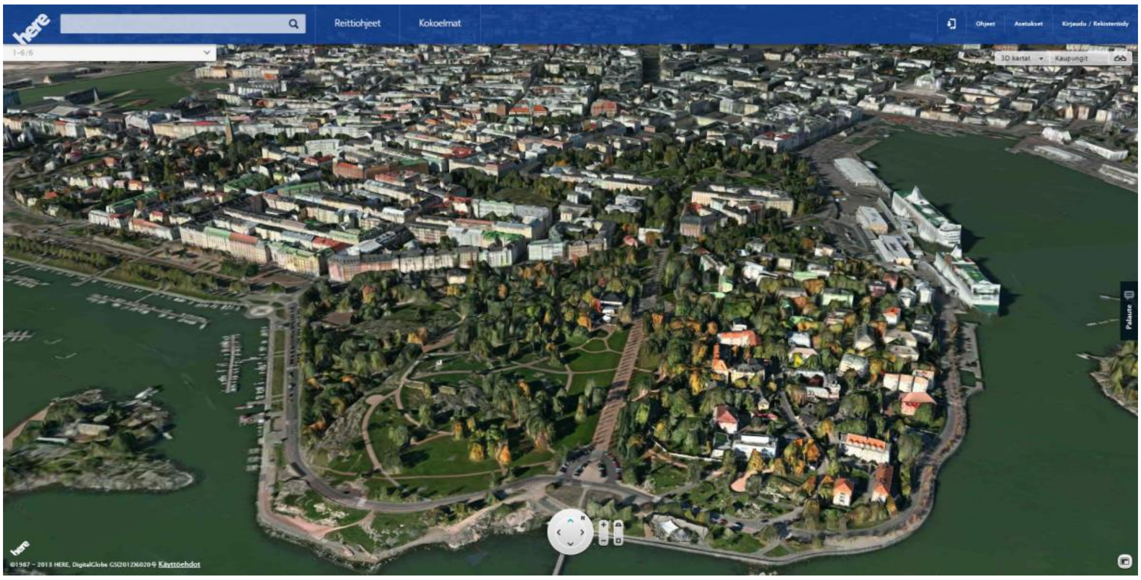

Figure 4. HERE 3D view of Southern Helsinki [19]

HERE Map Creator is a service launched in 2012 which allows users to map their neighborhood. It is meant to be used in areas where specific maps do not exist. [19.]

3.3 Bing Maps

Bing Maps is a web map service provided by Microsoft. It is based on the Microsoft MapPoint platform. It has all the basic features as its competitors. Most of the maps are based on Nokia HERE. It also has the bird view mode that allows watching aerial photos taken from an upper perspective from four different directions. Bing Maps also has its own equivalent to Google's street view, but its coverage is much more limited and it requires the Silverlight plugin. Bing Maps does not have an official application for any platform. Bing Maps allows users to create custom map layers and shapes though an online GUI. It has its own API for customized uses. Facebook uses Bing Maps on its mapping services. [20.]

3.4 Yahoo! Maps

Like Bing, Yahoo! Maps is mostly built on Nokia HERE. Unlike Bing it also shares the HERE street view mode. Yahoo Maps is naturally connected to Yahoo's own services such as Yelp and Flickr to provide more specific information about services including ratings. The Flickr view automatically displays Flickr pictures from the map area. Yahoo Maps has real time weather information provided by The Weather Company. Yahoo Maps also has its own API. [21.]

3.5 MapQuest

MapQuest is an online web mapping service owned by American Online. It is based on an 1980’s maps and routes service and it was set on the internet already in 1996, so it used to have a strong position in the American market. It was acquired by American Online in 2000 and its main purpose was to help American customers in locating services nearby. Later more advanced services have outrun it in several purposes, and outside the United States the service finder for things like airports or gas stations works poorly. It has a road and a quite unspecific satellite view and an API. Otherwise it is pretty simple. [22.]

3.6 OpenStreetMap

OpenStreetMap is a collaborative project to create free editable maps. It was founded in 2004 and now it has more than 2 million registered users. The map is created by using free sources and user collected GPS data and aerial photography. It has a graphical user interface for registered users to add new maps, roads and places. It has a wide range of data about for example activities, restaurants and public transportation. It also has navigation services. [23.]

3.7 Map Service Comparison

By basic features, all the popular online mapping services are suitable for everyday use like locating addresses or finding the best routes. The difference comes when the user wants more usability such as searching for a place by its nickname, more specific views like photos or more customization like embedded customized maps. All of these are so called collaborative mapping services, which means that they are open for user generated content. Table 1 below shows the main differences between these services.

Table 1. Comparison between online mapping services. Data gathered from each service's documentation.

Feature	Google	Nokia HERE	Bing Maps	Yahoo! Maps	MapQuest	Open-StreetMap
Satellite maps	yes	yes	yes	yes	yes	no
Street view	in 85 countries	in 5 countries	in 4 coun-tries with a plugin	HERE	HERE	no
3D view	yes	yes + stereo-scopic	external applica-tion	no	no	no
Direc-tions	yes	yes	yes	yes	yes	yes
Real time naviga-tion	yes	yes	no	no	yes	yes
Mobile applica-tion	yes	yes	no	no	yes	yes
iFrame	yes	Word-Press plugin	yes	no	yes	yes
API	yes	yes	yes	yes	yes	yes

4 Graphical Possibilities of HTML5

Within the last few years of quick development, HTML has got a significant amount of different features to implement visually more impressive pages in an easier way. Some of these features native HTML features, which are nowadays supported by modern browsers. These features include the canvas element and WebGL. Another significant step is the amount of APIs and libraries developed to make web programming more effective. Some of these extensions are cottage coded, but some are managed by massive internet technology companies, by Google leading the way. There is some fight between the standards, but there are main lines where the development is heading to.

Canvas is an HTML element that can be used for drawing graphics. Canvas can be scripted and it is usually done using JavaScript. It can be used to create graphs or animations, edit photos or even modify real time video. Canvas can be used as without any customization as vanilla or through specified libraries. There is a wide selection of libraries for different purposes such as drawing or vectoring [24]. Canvas can also be used in mapping. Embedded Google Maps are done using a canvas element which is automatically created through the API. This is called a server based-canvas [25]. The code in listing 1 shows how this is done.

```
<div id="MapCanvas"></div>
var map = new google.maps.Map(
      document.getElementById("MapCanvas"),
      MapOptions);
```

Listing 1. Code of how Google Maps canvas is created

With canvas maps, it is possible to draw on the map in the same element.

WebGL is a JavaScript API for rendering interactive 2D or 3D graphics in a web browser. It supports GPU acceleration which makes it a powerful tool for complex web graphics. Still it loses in performance to native 3D platforms and too heavy graphics may run poorly on less powerful devices. However it does not require any external libraries loaded into the page and can be run inside a canvas element. It is based on OpenGL and is supported by all modern browsers. There are libraries such as Three.js built for developing WebGL more efficiently. Several 3D globe maps like HERE 3D and WebGL earth run on WebGL. [26.]

JQuery is the most popular JavaScript library. It is designed to make JavaScript simpler. It can be used for example for document manipulation, event handling, animation and Ajax. It is commonly used with other libraries or APIs [27]. Built on JQuery, there is a widget library called JQuery UI. It is a collection of visual elements, effects and themes.

There is a massive selection of other libraries specifically designed for data visualization: D3.js, Dygraphs.js and Raphael.js, to name few.

JavaScript frameworks are used for structuring the application and to help the data manipulation. The MVC (model control view) framework is a common tool for creating rich internet applications (RIA). Specifically web application frameworks (WAF) are designed to support the development of dynamic webpages, applications, services and resources. JavaScript based frameworks are commonly used on dynamic webpages containing data handling. The use of a framework requires only one or a few JavaScript files included in the page. These frameworks are commonly used with other libraries like JQuery. [28.]

A browser plug-in is an external software component that can be installed on the browser. These plug-ins enables functionality that would not normally be available. The most common plug-in is Adobe’s multimedia plug in Flash. Plug-ins are usually in a major role when it comes to arguing about the standards. Companies who have their own plug-ins, for example Microsoft with their Silverlight plug-in, are usually against the development of new native web standards. Lately the popularity of plug-ins has been decreasing after major security vulnerabilities and the lowered support of plugins on mobile platforms.

5 Location Data Visualization Tools for HTML

5.1 Data Types

Data visualized in an HTML application can be stored in several different forms. Basically the rules are the same as in any other web application. It can be in any kind of live database where it can be easily queried and edited from different locations. It can also be included right in the HTML in for example the JSON format where it can be modified only during the session, after it resets after refreshing the page. The form of the data depends on the platform used. Some platforms require the data in a specific form and some platforms supports different data types. Mostly the data types can be translated from one into another very easily so the type does not usually cause problems. The JSON format is the most common type of data, but different tools support different types of data.

5.2 Google Maps and Earth

Google maps provides two APIs. The Embed API is provided for easy non-programmable use, for example adding an embedded navigation information map for a company website. The full JavaScript API contains various kind of tools for data visualization.

Visualization can be done using a data layer. This layer can contain data in different formats such as Google Fusion tables, GeoJSON or KML. The advantage of Fusion tables is that it can be actually hosted by Google and easily managed by the user manually. Otherwise this data can be modified, defined or drawn on using JavaScript. One example of this kind of data is a table that defines state borders and another table that fills them with different colors. The internet is full of complex readymade GeoJSON or KML tables which can illustrate almost anything [29].

Basic graphics that Google Maps provides are simple markers, sized circles and heat maps. All of these can be customized and made interactive. Also the API supports geocoding.

Simple illustrations are well guided and simple to program, but the API offers possibilities to create very complex graphics. For animated and timed graphics are possible but quite clumsy. Moving from location to another smoothly is possible using the panTo() function, but it works only with short distances.

Google Maps API is has been on the market since 2005. It is very popular and well documented.

Google Earth has an API with 3D features, but it was deprecated in December 2014 and it will shut down within a year. The Earth API gave technical potential to even complex 3D visualizations and could be combined with other Google APIs and libraries or external libraries. A service called Data Appeal had a GUI for visualizing data on Google Earth, but after the Earth API will be discontinued soon it will be useless. [30.]

5.3 Power Maps

Power Maps is a location data visualization plugin for Microsoft Office Excel. It was introduced in 2012 and became available as a plugin for Excel 2013 to be integrated with its business-intelligence features. It is designed to be an easy tool for 3D data visualization for Excel users [31]. Figure 5 shows that it has a graphical user interface and it supports all kind of data that is compatible with Excel. The data can be a regular sheet, table, power pivot or an external database. Power Maps itself does not have data filtering or editing tools so it has to be done beforehand in Excel. After that a new “Tour” can be created and the data inserted. Power Maps is built on Bing Maps which are mostly powered by HERE. The map is automatically layered so it can be used from a large globe scale to closer road accurate presentations. The geocoding system works with common addresses and names, but does not contain external places. It has timeline and scene functionalities, so it can represent development of data during a certain time gap and it can be automated to go through different views. It is easy to use and requires no programming skills, but the customization options are very limited for example moving graphics are not supported. It has five different 3D chart types. It also allows to add 2D graphs on the scene. The scene can be presented in the application itself or exported as a picture or video when it becomes more scalable for different uses and platforms like web browsers. It is still not actually an HTML platform. [32.]

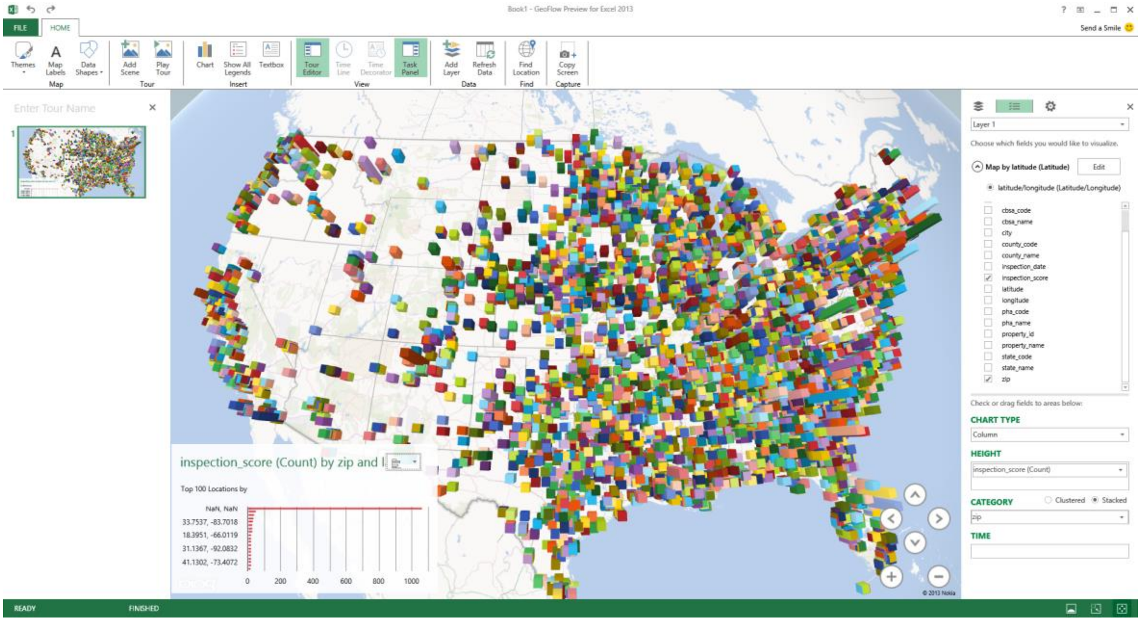

Figure 5. Screenshot of Power Maps' user interface [33]

5.4 CartoDB

CartoDB is a platform specifically designed for data visualization. It has an online GUI which allows users to upload datasets and illustrate the data easily in only a few minutes. Users can upload and store their data online and share their maps. It natively supports various different base maps and more can be added. For developers it provides a platform which is very compatible with other libraries and APIs, so it can be used for very rich maps. One of them is torque which can be seen in figure 6. It allows animated graphics. CartoDB has an inbuilt database system which allows users to host an interactive database which can be updated and manipulated in real time. Regular use of the GUI version with online database is free, but for more features and more data there are various subscription types. [34.]

Figure 6. Visualization of Los Angeles' bus lines done using CartoDB [34]

5.5 MapsData

MapsData is an online easy to use GUI for data visualization. It can import Excel files and visualize them in bubble, cluster, heat map or marker view as figure 7 shows. It supports a few different color themes of OpenStreetMap maps. It is very plain and easy to use, but otherwise it is very limited. MapsData also provides an online converter which does geocoding from file to file. It also has a KML converter which converts location data files like Excel or CSV to KML files. [35.]

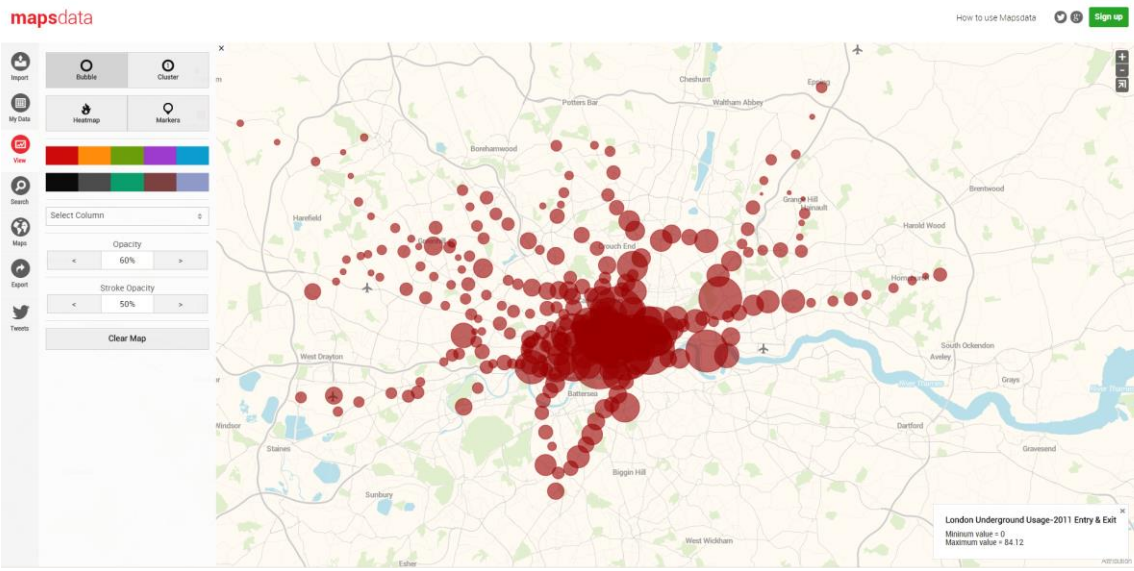

Figure 7. Screenshot of MapsData's graphical user interface [35]

5.6 WebGL Globe

WebGL Globe is an open platform launched by Google's Data Arts Team. It is a simple 3D data visualization platform using WebGL. Its basic features are bar charts which can be seen in figure 8. The Globe can be zoomed in and out and rotated and it can contain several sets of data. Otherwise it is rarely simple and for example the map contains only one graphical layer, but with programming skills it can be improved. The data format has to be in JSON and the location in coordinates, so it does not have any intelligence. Also performance issues with the WebGL 3D can be noticed. [36.]

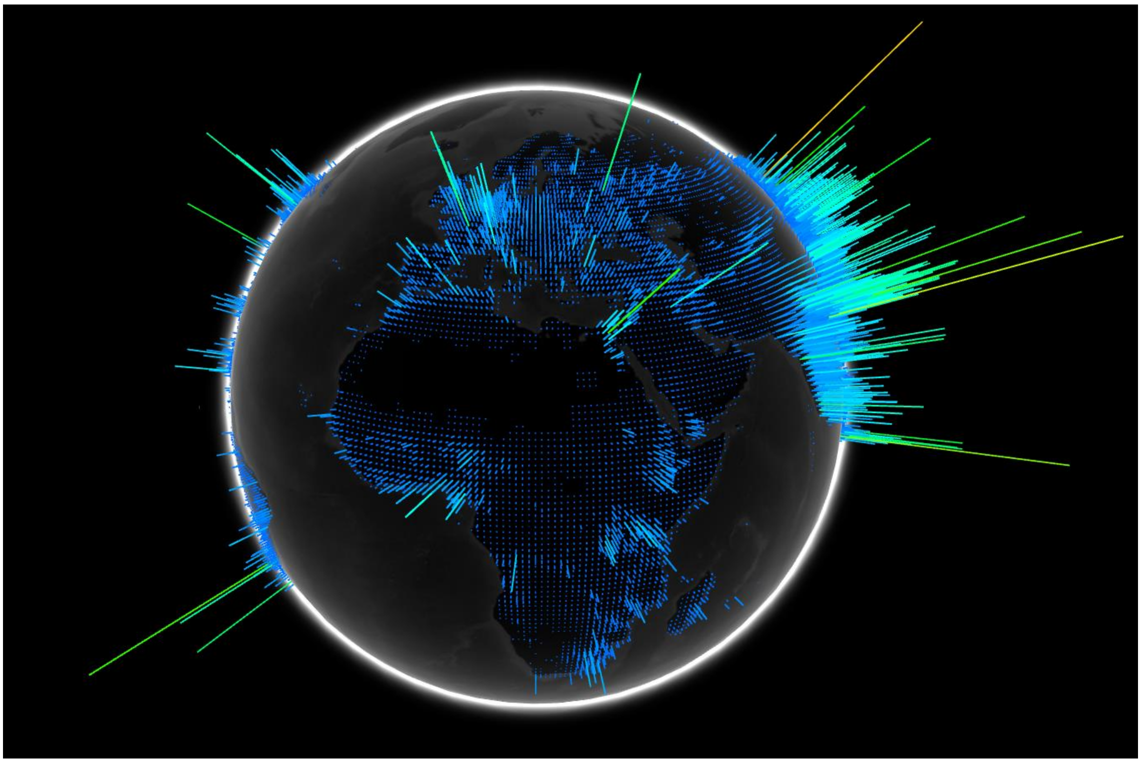

Figure 8. WebGL Globe illustrating the population of the world [36]

5.7 Comparison between Visualization Platforms

Online map data visualization is quite a raw industry so there are not many highly developed or popular tools. The development is going on rapidly and the need for these is real. Technically any map platform with an API allows users to create 2D graphics on the maps. How easy, depends on the API built-in features. The most common platforms that were mentioned in chapter 3 have very much the basic inbuilt features such as regional area painting and heat maps, but they still lose to Google Maps in every aspect so they were not included in this comparison. Figure 9 below shows the structure of a customized map application using an API.

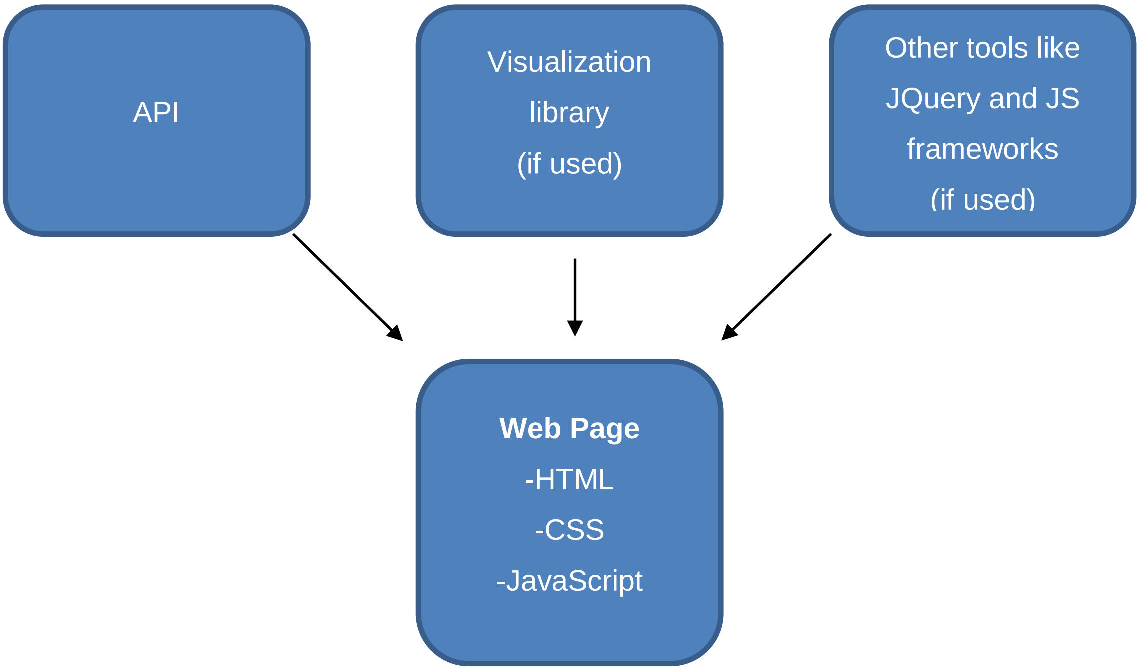

Figure 9. Structure of a custom map application

For a regular user without programming skills the choice would be a platform with a graphical user interface. The growing popularity of CartoDB and its integration with other libraries makes it a comprehensive solution for developers. The demonstrations online show its potential and make it very attractive. Power Maps would probably be the most familiar solution for an average Microsoft Office user, though it does not support HTML natively. The end of Google Earth API and the simplicity of WebGL Globe leaves a niche on the market for a decent 3D solution. CartoDB has some WebGL based 3D visualization using a library called Cesium. It might be the trend.

The slow development of 3D maps is partially caused because of the lack of a 3D web standard. Google Earth is based on a browser plugin which limits the use of the service. Now when WebGL has become more popular, its growth will feed companies and developers to build solutions based on the technology. Maybe Google will also do that. Table 2 below shows the key differences between these platforms. A full screen WebGL visualization still requires a lot of hardware performance.

Table 2. Comparison chart between visualization platforms. Data gathered from each platform's documentation.

Feature	**Google Maps**	**Power Maps**	**CartoDB**	**MapsData**	**WebGL Globe**
Native HTML	yes	no	yes	yes	yes
Interactive handling	yes	no	yes	yes	yes
Map types	all Google	all Bing	almost any	Open-StreetMap	plain single layer
3D globe map	no	yes	with external library	no	yes
Timeline	manual	yes	yes	no	manual
Automatic panning	very limited manual	automatic	manual	no	manual
Zoomable map	yes	yes	yes	yes	no
GUI	no	yes	yes	yes	no
Geocoding	yes	yes	manual	Manual by zip code	no
Data types	GeoJSON, KML, geoRSS, web formats	Excel compatible	csv, KML, gpx, xls, web formats	xls	JSON

6 Nokia Demonstration Application Workflow

6.1 Purpose and Requirements

The practical part of this final year project, was a demonstration application called Numbers from the World. It was invented to demonstrate how global and fast growing the mobile network industry where Nokia is one the biggest companies actually is. This demo's purpose is to illustrate different network KPIs (key performance indicators) around the world. A KPI can be anything from the amount of network users in a country to the average speed of a specific network.

This project was inspired by other same type of illustrations where the user's interest is raised with a showy graphics showing relevant data. In this demo the idea was to create a 3D globe rotating and automatically navigating around the world to show statistics from different countries in each continent by drawing a graph on the map.

Nokia has a big databank of real and calculated usage data of different types of networks and devices world widely. Most of this data covers the years from 2005 to 2017. The main purpose of this demo is to stress the huge growth in the amount of users and data using mobile networks caused by the 3G and 4G boom, and the need to invest in new network hardware and technologies.

The demo can be shown in different marketing uses such as meeting or events. When the project started there was no clear vision of which KPIs and what kind of graph types would be used.

6.2 Platform Chosen

Because the usage data was already in Excel format done with macros, and because the Power Maps plugin was already shown to be impressive in live action, the Power Maps was chosen to be the platform. Power Maps uses Bing Maps, which are powered by Nokia HERE, so it was a suitable platform for Nokia. The use of HERE natively would have been even better, but its unfamiliarity made it challenging. HERE does not have a 3D API either.

When the project started the specific details of the application's functionalities were not clear. The vision of a rotating 3D globe showing that Nokia's network business covers the whole world seemed to be good. Also automated actions on the map were important after the application would most likely to be used also as a gadget to arouse interest in for example events. Perhaps the biggest advantage of Power Maps is the possibility to create automated tours very easily.

The hardware showing the demo would be a computer plugged into a display or a projector so there was no need to think about the compatibility between different types of devices.

6.3 Data Collection

The data itself was in a massive Excel file, which was filtered to different views using macros. Because Power Maps does not have data filtering or editing in itself, to use the data, it was had to be put in separate tables for each category used. This could have been done by using more macros, but because of the heavy performance load of using macros after macros, it was easier to manually copy-paste the data to separate tables. With bigger amounts of data the data management would be in a bigger role, but in this case it was quite simple.

In this use, where the purpose was to follow the development of statistics, every piece of data used had a date. The date could have been in any form, but in this situation the development was followed yearly, so one of the table columns was the year. Excel does not understand year as a date format, so the dates were set to be the first day of each year. The most important column, which is always needed in Power Maps is location. Power Maps geocoding understands several types of location data from coordinates to addresses or entire continents. In this case all the location data was a country name. The only adjustment was to change Korea into South Korea so that Power Maps could understand it. Other columns could contain any kind of numerical data and they could be categorized with names. The names of the columns were not important, as their purpose was just to make reading the data easier. Table 3 illustrates an example of a data table that can be used with Power Maps.

When	Where	Type1	Value1	Type2	Value2
1.1.2013	Finland	Number of 1's	4563	Number of 2's	12
1.1.2014	Finland	Number of 1's	4423	Number of 2's	22
1.1.2015	Finland	Number of 1's	4256	Number of 2's	25

Table 3. Example of a data table that could be used in Power Maps

6.4 Visualization

To run, the Power Maps needs to have at least one table with enough data parameters to add to the map. After that layers can be added. The layers are very similar to layers in any other computer software. For each layer one set of data can be chosen including location, date, value and a category. For the data there are five different ways to illustrate it on the map.

- A stacked column which is a 3D bar graph, where the different data with the same date and location are stacked.
- A clustered column which is similar to the one above, except the graphs for different data are clustered in a row.
- A bubble which is 3D pie chart.
- A heat map where the color changes between blue and red depending on the value
- A region view where the entire area (in this case the country) is painted with a certain color. The opacity depends on the value.

All the graphs are editable (including scale, opacity and thickness) and the color can be changed, except for the heat map. Otherwise the options are limited and this causes issues when the contrast between two graphs is either too big or small. Legends can be used to explain the types of graphs. For the heat map and region view, a color chart showed in figure 10 can be shown, explaining the values of the temperature of the color. Also text boxes and 2D charts based on the data used can be put into the scene, but the options are very limited, so they did not fit this use case. The graph types chosen were the bubble and the region view.

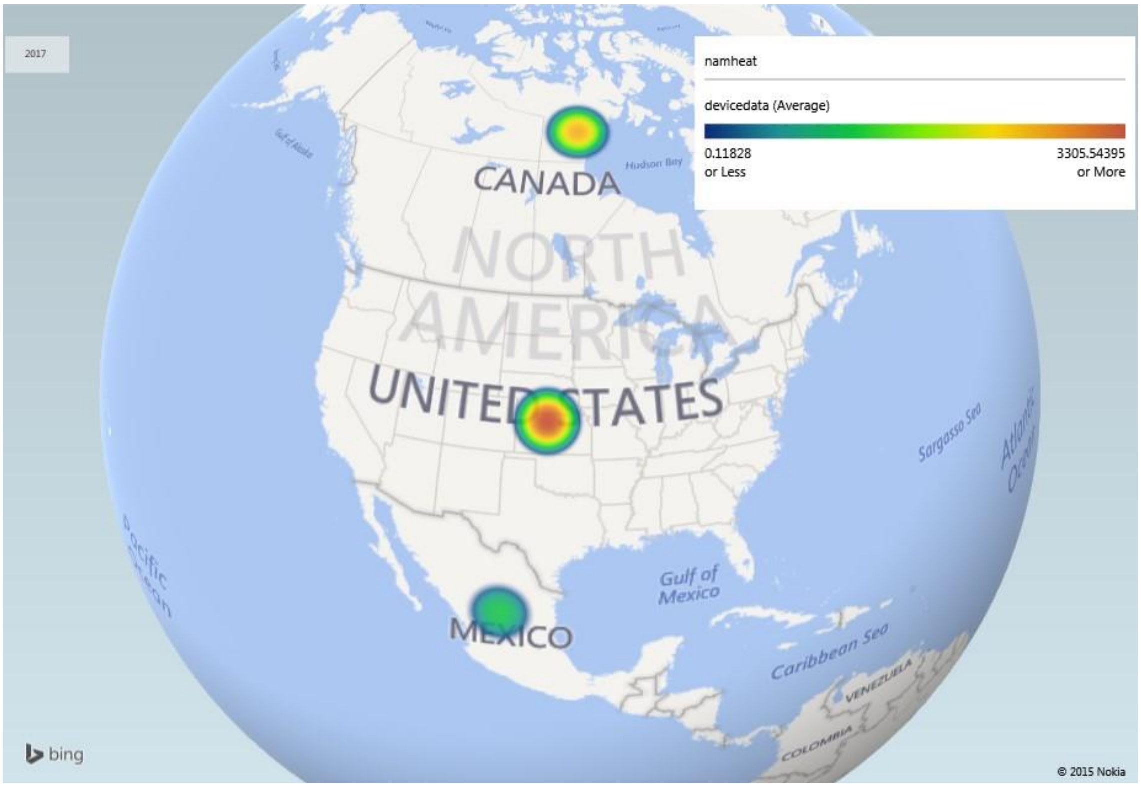

Figure 10. Heat maps which were considered to be used on the default map color theme.

In the beginning there where big issues in using the region view, because selecting too many areas at the same time caused a DirectX error to the preview, which caused a blue screen of death. This error was later fixed with the display adapter driver update, but it took a lot of time to figure it out.

The functionality of a visualization timeline in Power Maps is done by using scenes. New scenes are added like in simple video editors and the location of a scene is selected by manually navigating into a certain point on the map. Also the perspective and zooming can be adjusted. For each scene it is possible to select which layers are in use and which years of the data are being covered. The scene automatically goes through the data timeline in a time which is set as the scene duration. Scenes can be also adjusted to have some automatic movement like flying over in a figure eight or rotating the entire globe. Changing between scenes is automatically done by flying smoothly with a selected speed.

After the tour is done with the right amount of scenes it can be previewed or rendered into a video. The preview mode allows manual navigation on the map, but this stops the timeline so Power Maps cannot provide both timing and navigation at the same time.

This project was done by creating different tours for different areas and rendering them into different video files. Most of the tours had only two scenes, but the introduction view had seven. The video was rendered in full HD resolution and the quality was satisfying except for a couple of rendering glitches with the charts.

6.5 User Interface and Programming

Because of the wish of interaction and the lack of Power Maps legends and other graphics, there were many things still to do. The missing things were done by creating a kind of a video player application running on an HTML platform. The page had a full screen video which was playing the video tours exported from Power Maps. Legends, navigation and other information like graphs were added. Some graphics were added already into the video file and some cosmetic errors were repaired.

All the navigation elements, legends, titles, and graphs and the look and feel were done to fit the Nokia brand guidelines. This meant that the graphs were blue or gray like in figure 11 and the dropdown menu was exactly like in the other demos Nokia has. Power Maps has 12 different map themes and they cannot be customized, so gray and white was selected. The user interface was implemented as minimalistically as possible to give the actual map and graphs more space. The main tour with seven scenes was set to loop automatically. These seven tours and three more were available separately in the menu. Also a functionality for pausing the tour by pressing spacebar was included. Programming was done using plain JavaScript and JQuery without any frameworks. The application was optimized to run on a full HD display with the Chrome browser after it was not going to be in public use. This saved a lot of work in browser and resolution optimization.

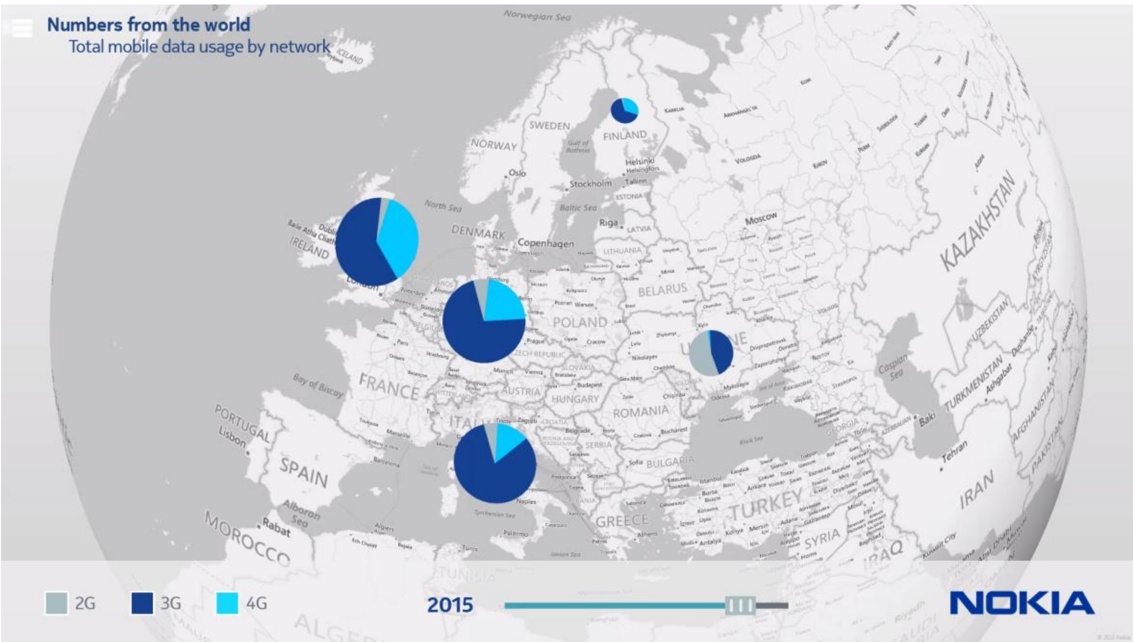

Figure 11. A view from the end product

The end result was a 300 MB HTML folder that could be run from a local computer hard drive. Running it online would require broad network bandwidth. The application can also be programmed to suit mobile devices.

7 Conclusions

Data containing location information is a growing trend and the best way to make use of it is visualization. There have been visualization tools for years, but they have been mostly desktop applications for professional use. Within the last couple of years data visualization has become more usual for common users and common platforms such as HTML. The trend of web applications means that most likely the upcoming visualization solutions for customer use are focused on a web platform. This makes it easy to share visualizations between different types of devices and users.

Simple visualization like point markers and balloons have been available for web mapping platforms for a long time. The big trend of online data visualization has also brought more features to the map APIs.

For simple 2D graphics the current range of visualization tools is satisfying. New platforms specifically designed for visualization with graphical user interfaces have made data visualization possible for regular users without programming skills. For users with programing skills the options are pretty good and integration between common visualization libraries and map platforms has made working with them more effective.

With 3D graphics there is still a way to continue the development. Power Maps, which was introduced by Microsoft only 2 years ago, and smaller projects like WebGL Globe and the combination of CartoDB and Cesium show that there this is something that will be used in the future. For a while there was no 3D standard for web platforms but now it seems that WebGL will be the thing, so it surely attracts more developers.

As a visualization tool Power Maps will probably become popular particularly in business use where the data is already managed with Excel. Power Maps was officially published only less than a year ago so it will most likely gain more features. For now it is quite easy to use if there is some previous experience of some graphical editing software. There are some tutorial videos and a brief documentation online that covers the basics thankfully. There is an online community with professional support, but still the DirectX problem had to be fixed independently.

With the Nokia demo application the decision of the platform was not made purely based on the features and usability, so many difficulties came up within the process and with the need of new kind of visualization features. It was also caused by the loose specifications before the work started.

Still for the 3D visualization, Power Maps was most likely the best platform. CartoDB would have been the most competitive challenger, and if the project started from scratch now, I would have had at least a deeper look into it. With Power Maps, the process from the data into the graphics showing in the browser took a few steps, so if the data would often be updated, the lack of real time data updating and native HTML would be a real disadvantage. In this case since the data is updated very rarely, it did not matter so much.

Every platform compared in this thesis had their own advantages and disadvantages. For the decision of choosing the right platform there are a couple of things to have in mind:

- Scale of the project. For smaller projects it is most likely wisest to choose a familiar platform with the smallest threshold to get into it. With a larger project it may be smarter to spend some time learning new technologies if they are superior in the situation.
- Usage. Every platform has their own strengths so the features wanted should be carefully listed beforehand. For example some platforms are better at handling live data, some platforms are better with animations and some with 3D.
- Technical knowledge. Anything can be implemented by doing enough programming work, but when this is not possible, it should be considered which platform supports the most familiar technologies to work with. Integration with already familiar libraries makes it easier to move from regular data visualization into location data visualization.

Location data visualization is not only used for scientific purposes today but more for everyday purposes. Today it is possible to see map visualization from news pages to bus timetables. The development has been fast and it will continue.

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