

Applied GIS: Web GIS Serving Public Safety in Central Asia

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Abstract

Different mapping technologies for displaying geo-referenced data over the web can be used in different situations. This paper discusses the design, development and implementation of a web-based spatial visualisation tool built from a combination of open source software packages. The online mapping application developed for tracking drug related crime was built on GeoServer – an open-source server written in Java for sharing, processing and editing geospatial data; Apache Server as a web server; PostgreSQL and its extension PostGIS as an object-relational database for location queries to be run in SQL; OpenLayers an open source JavaScript library for displaying map data in web browsers; and finally Drupal, a free, open-source web development platform for online content and user communities. The complex workings of the system are hidden from the user and the automatic rendering design used in this system enables users with no prior knowledge of GIS to visualise their data and immediately gain some understanding of the spatial structure of their data.

1. Drug Problem

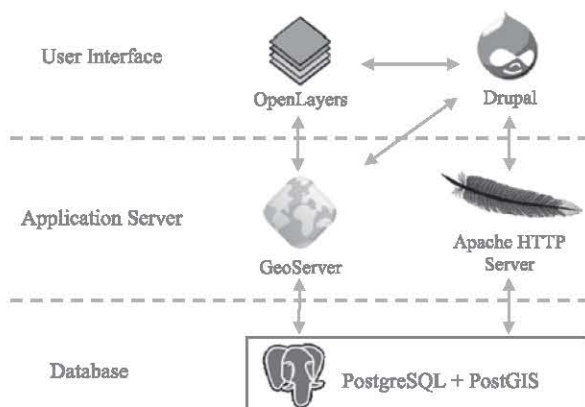
Central Asia as well as the wider region is affected by significant poppy cultivation in Afghanistan (United Nations, 2014) and illicit trafficking of opiates that create multiple challenges for countries in the region and beyond, posing a direct threat to prospects for security, good governance and socio-economic development. The alarming growth in the abuse of illicit drugs in the region creates not only human misery for families and individuals, but also a huge challenge for societies. While illicit drugs are cultivated and produced in Afghanistan, they are trafficked to the destination markets via the territory of its neighbouring countries. Therefore, the Afghan illicit drug trade is a transnational threat with regional and global implications, yielding negative consequences not only in origin and destination countries but in the countries along the trafficking routes as well. Proper use of crime information and optimum use of available resources shall result in improved performance of law enforcement and success in terms of combating smuggling of illicit drugs. Using maps to visualise data can enable quicker interpretation of complex geographical phenomena, identify patterns, and aid in planning the resource allocation for policy and decision making. In the context of law enforcement, mapping provides a visual assessment for investigating the spatial distribution of crime and analysing incident data for trends or hot spots.

This allows law enforcement agencies to understand likely drug smuggling routes as well as to determine the specific patterns of drug related crimes. It is obvious that the more concentrated problematic areas are, the more vulnerable locations exist requiring greater attention. Sharing of spatial information globally can bring better understanding of country level situation. Web-based GIS can be successfully used in sharing statistics on maps or on an advanced level supporting collaborative decision making. Numerous functions are implemented in web mapping. Today Web based GIS platforms within diverse architectures provide point, line, and polygon-based editing as well as tabular database operations conducted via Web browsers. In order to gather up-to-date data for analyses, Web-based systems can answer the questions with accurate and near real-time data input for crime mapping applications. With communication and data sharing defined as underpinning elements that aid in dealing with cross border threats such drug smuggling and organized crime, the United Nations Office on Drugs and Crime in Central Asia set out to improve communication by enabling access and viewing of spatial data and information easily online for expert and non-expert users alike. The goal was to give law enforcement analysts anywhere in the world the ability to look at and analyse regional and global drug smuggling trends in an online environment.

2. Case-Study: Online Mapping of Drug Related Crime

The Drugs Monitoring Platform is a unique global online tool for collecting, monitoring and sharing drug-related data (Drugs Monitoring Platform DMP, 2013). Initiated jointly in 2011 by the Paris Pact Initiative (<https://www.paris-pact.net>), the Afghan Opiate Trade Project of the United Nations Office on Drugs and Crime (UNODC) and the UNODC Regional Office for Central Asia (ROCA), the Drugs Monitoring Platform is operated by ROCA and is the product of UNODC collective efforts to support the global data collection process. The DMP is aimed at helping the international community to address the toll that illicit drug production and trafficking continues to take on all our societies, by providing a global overview and mapping of drug seizure cases, based on the best available data.

Architecture of DMP: The generic layered architecture of web GIS consists of three layers: user interface layer, application layer and database layer. The user interface layer of DMP was designed using Drupal - a free and open source content management system and framework (The Drupal overview, 2015) written in PHP. The clients access the system by interacting with the user interface layer that takes the input and presents the output of the system. The application layer of the system includes OpenLayers powered by GeoServer and implements the functionality of the system, using the database layer to answer the user requests and converting geographic objects from the database layer to cartographic objects to be displayed by the user interface layer. The object-relational database PostgreSQL including its extender PostGIS serves as the database layer for managing spatial data.



In web browsers maps are loaded using mainly the OpenLayers JavaScript library. This library brings interactivity to the maps such as pan, zoom, or querying the map giving users the possibility to actually explore the content of the map and the spatial data displayed on it. In the current stage of development the DMP requested to provide immediate, near real-time information to analyse the illicit trade in opiates, including details on production and trafficking as well as the prevalence of opium poppy cultivation at the provincial and district levels in Afghanistan. This information includes up-to-date drug and precursor seizure information, data on drug seizures worldwide as available to UNODC, details of drug and precursor substance prices, as well as an overview of all data available on the platform by individual country. As of June 2015, over 180,000 drug seizure cases are registered on the Platform. The large amounts of data hosted in DMP was an issue to be addressed, as this could be a problem for the web browser, because it takes longer to load, as well as for people looking at the map (Figure 1). The first problem is caused by the limitations of displaying data by web browsers. The image tiles that make up the map are loaded using JavaScript as the user zooms in and out and moves around the map. The vector overlays displayed on the map (points, lines, and polygons) are added with JavaScript. Even modern web browsers have a point at which they get overwhelmed and become unresponsive because the client cannot handle all of the processing. As a quick and simple solution, DMP tries to limit the number of points rendered to around 300-500 (Figure 2). The spatial clustering methods could be used to lessen the load on the browsers (Li et al., 2011). In DMP clustering was also useful in grouping together a large number of points in close proximity (see Figure 3). Usually this grouping is represented by a different style of marker. This helps the browser by not having to render all the markers or features, thus saving resources. However it should be noted that clustering is done by JavaScript in the browser, so this will not lead to a huge increase in performance. The size of the OpenLayers JavaScript code is over 700 KB, caused by its extreme power and flexibility. Not all maps in DMP need the full functionality of the library. For particular maps in DMP we could squeeze more performance out of the maps by lessening the amount of JavaScript that the client has to download, minimizing the amount of processing on the client side.

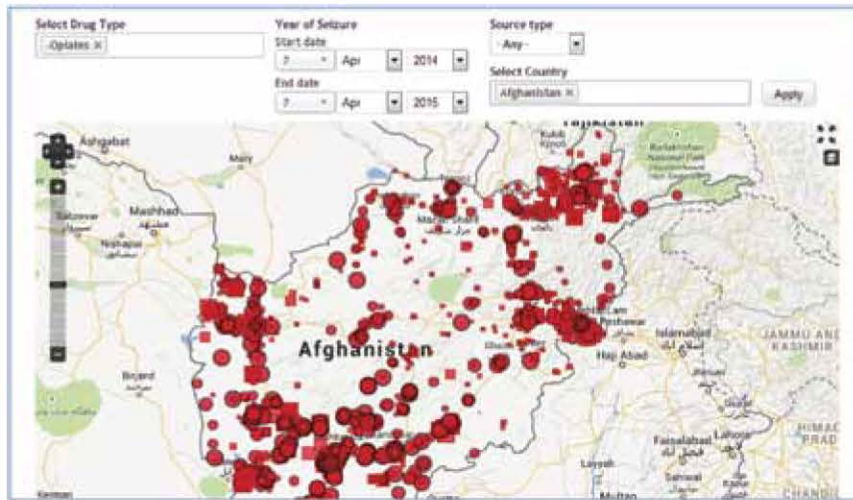


Figure 1: Rendering of over 1000 point data



Figure 2: Global seizures of drugs on the world map

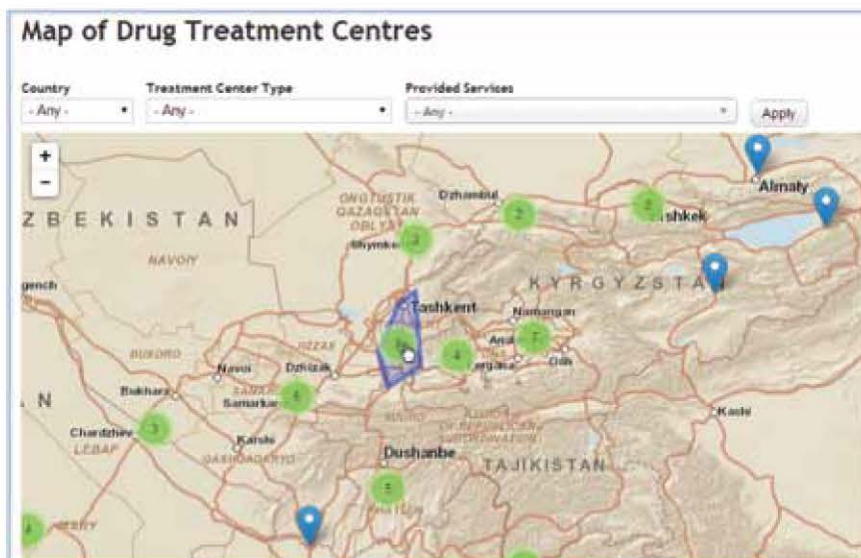


Figure 3: Clustering of locations in proximity

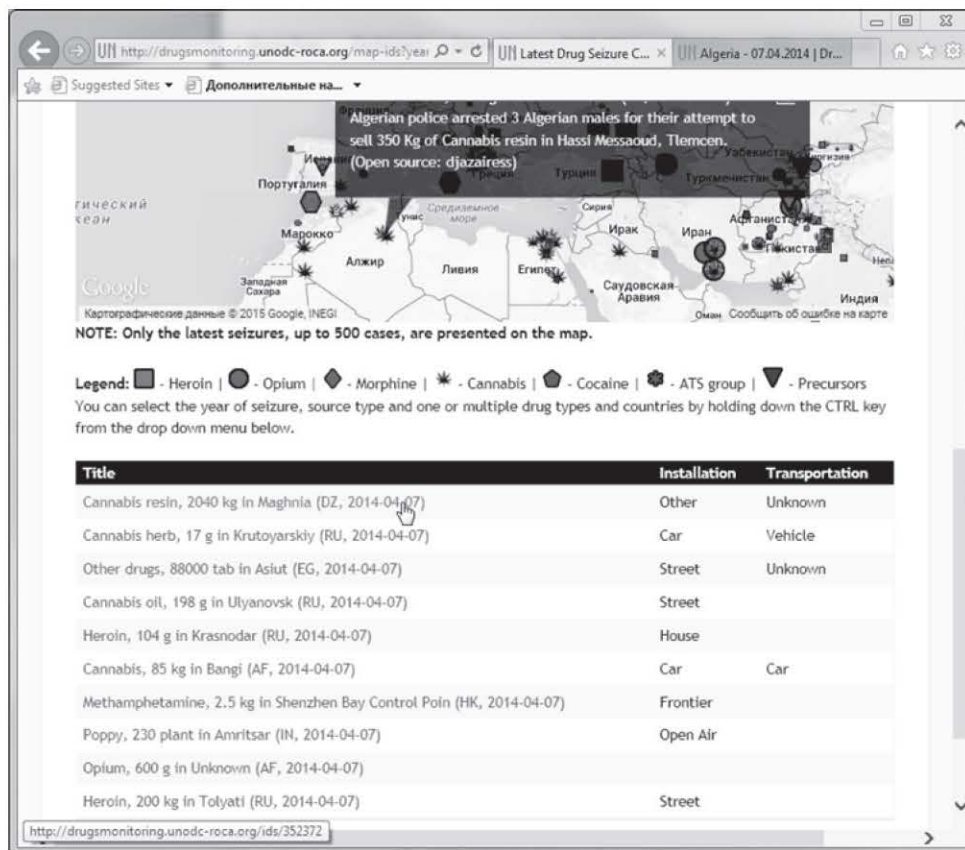


Figure 4. Attaching text based information of geographic data

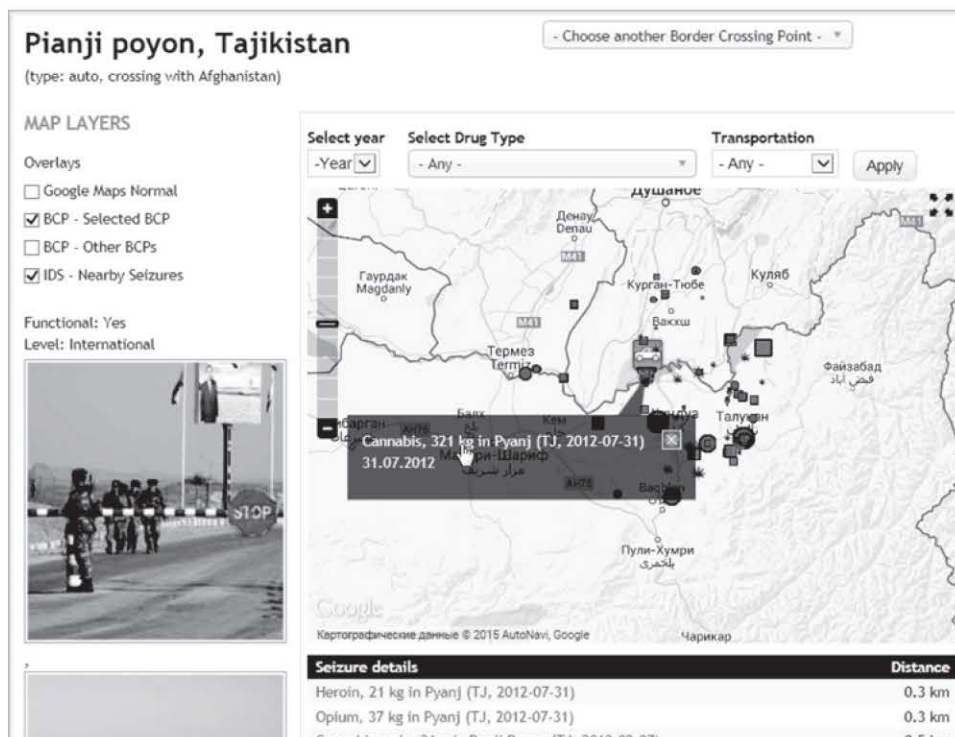


Figure 5: Border Crossing Points (BCP) and proximity search of seizures around selected BCP

Such maps use the lightweight open source Leaflet JavaScript mapping library released by CloudMade. It is worth to mention that there is another alternative for a very lightweight JavaScript API (Murray, 2013) displaying map tiles: Modest Maps JavaScript with 28 KB JavaScript file. The second problem happens when the map is trying to display several pieces of information at the same location, for example, all types of drugs seized in the most problematic areas of smuggling routes. Clustering as discussed above, is one way to deal with this. The other way is to manage what data is displayed and to give users different ways to refine this, for example by filtering seizures by drug types or transportation methods. In some cases a map is not the best interface for geographic data, whether because of the size of the data set or because people cannot access visual information due to a visual impairment. For both accessibility and search engine optimization, it is often worth creating alternative text-based ways of displaying the same data. The content management system of DMP makes this straightforward by providing the possibility to attach the same information as a list or table (see Figure 4). The Drugs Monitoring Platform includes a range of supplementary information relating to the illicit trade in opiates and the work being undertaken to combat it, including details of border crossings, drug treatment centres and counter-narcotics training centres, with a focus on West and Central Asia. This can assist policy makers, operational analysts, researchers and other specialists to undertake further analysis regarding trafficking of opiates (see Figure 5).

3. Results

One of the main outcomes from this development effort was the accumulation of knowledge and skills to build a crime tracking platform based on open-source that could be applied to other agencies or in similar tasks. The complexity and volume of the data and multitude of desired access channels requires a powerful content management framework and flexible web-based geospatial components / modules to deliver a user friendly and performant interface. Another outcome is improved understanding of the illicit drug trade as a result of collation, mapping and sharing of information on this Platform which in turn assisted to strengthen international cooperation in the fight against it. By providing a centralized communications base, this pioneering platform has the capacity to support numerous international and regional organizations and official entities, law enforcement agencies and policymakers.

4. Discussion and Conclusions

Free and Open Source Software (FOSS) can be efficiently used in the development of online spatial applications. The compatibility of FOSSs with Open Geospatial Consortium standards makes them essential, particularly for applications covering wider regions and serving various agencies. Another value is the cost, not the least of the factors for public sector who cannot afford expensive proprietary licenses of commercial GIS packages. We demonstrated an efficient solution for visualization of a large amount of spatial data on the web. The case study of a web mapping solution for tracking drug-related crime data confirmed that FOSS can be used for developing effective and efficient web mapping application. This approach represents another step forward in spatial information management, increasing the capacity of law enforcement agencies to develop similar spatially-aware applications without high up-front investment. It is obvious that the suitability and success of such a platform depends upon the willingness of law enforcement agencies to share relevant information on time. The web as a communication medium has changed maps from static entities on paper to dynamic products of interaction. (Peterson 2008). Another area for further research related to Web GIS is the issues of displaying maps on mobile devices to efficient use of these dynamic products of interaction. More and more people access websites through mobile browsers on tablets and smartphones. It is important to keep the web maps simple, so that information can be seen on small screens and so that the maps load quickly. The latest versions of the APIs for both Google Maps (V3 Maps API) and OpenLayers (v3.4.0) have added many improvements for using maps on mobile devices. These improvements are a base for faster maps, and have added support for touch screens (such as zooming in and out by pinching the screen), and integrated geolocation to show where a user is on the map.

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to data providers around the world; without them, the data in DMP would not be possible.

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