

# PaikkaOppi - a Virtual Learning Environment on Geographic Information for Upper Secondary School

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**Abstract.** PaikkaOppi is a Web-based learning environment, designed to support education related to geographic information on upper secondary school level. It is a Web-based service that integrates geospatial content from several distributed sources and enables its visualization in various ways. The benefits of the learning environment are obvious and are discussed from four different viewpoints: student, teacher, data provider and PaikkaOppi operator. The future development of the system target for instance better support for crowd-sourced information and sharing of content between schools.

**Keywords:** Learning environment, Geospatial web service, GIS education, Open Source, Spatial Data Infrastructures (SDI)

## 1. Introduction

Education related to the cartography and geographic information has a long and interesting history. It goes from traditional map atlases to first cumbersome computer-based applications to more advanced desktop GIS applications and, finally, to computer networks, Web services and advanced browser-based map interfaces.

First simple computerized tools to support map-related education were introduced in the late 1980s. With the development of graphical user interfaces the tools improved considerably and the first real desktop GIS applications were taken into use at the beginning of the 1990s. In those applications both software and data contents were installed locally. This required a substantial level of technical expertise that wasn't available in most of the upper secondary schools.

Introduction of the computer networks generally and the Web in particular starting from the mid 1990s changed the situation fundamentally. The first Web-based map applications were based on static map images that gradually evolved into more interactive applications with the introduction of touch-sensitive areas on the maps that were linked to outside Web resources. The interactive cartography on the Web had begun.

Two developments characterize the subsequent evolution of the Web cartography. On one hand Google and other big Web players emerged as prominent providers of map services. Google Earth and NASA Virtual Earth applications led the introduction of 3D virtual globes as a user interface for all kinds of spatial information. On the other hand national mapping authorities and other public bodies dealing with spatial data started to work on the development of so called National Spatial Data Infrastructures (NSDIs). These were characterized by the provision of more harmonized data content and the use of open, standardized mechanisms in service-based data provision. A prominent example of this development on the European level is the INSPIRE process that aims at the provision of harmonized spatial data for environmental applications across Europe (INSPIRE 2013).

Two other important trends that have significantly eased the map-related education on upper secondary school level include better availability of Open Source tools for geodata management and visualization, and the recent Open Data initiative that has opened many governmental spatial data sets for free use in different fields of society. The development towards open service interfaces, Open Source software and open data greatly benefits schools that struggle with limited budget and personnel resources.

## **2. Development of the Learning Environment**

PaikkaOppi was a four-year project (2008-2012), funded by the Finnish National Board of Education. Regional Council of Southwest Finland coordinated the project. The consortium included two universities, upper secondary schools from two Finnish cities and a private company, Arbonaut Ltd, that was responsible for the technical development and acts currently as the operator of the PaikkaOppi platform. Finnish Geodetic Institute participated in the project as an expert on geospatial Web services and their standardization.

The main result of the PaikkaOppi –project is a Web-based learning environment, designed to support education that somehow relates to geographic information (PaikkaOppi 2012). PaikkaOppi is a Web-based service that integrates geospatial content from several distributed sources and enables

its visualization in various ways (Toivonen & Riihelä 2011). It also supports creation and storing of user-generated content. The other examples of similar Web-based learning environments for geodata-related education include those described by Bakker (2007), Petrovic et al. (2011) and Haeberling et al. (2011).

The technical implementation of the PaikkaOppi service is based on Open Geospatial Consortium's service interface specifications and the use of Open Source applications that support them (OGC 2013). The main interfaces used in the PaikkaOppi implementation include Web Map Service (WMS), Web Feature Service (WFS) and Web Feature Service Transactions (WMS-T).

### **3. Main Actor Roles**

The main roles identified in the context of the PaikkaOppi service are the student, teacher, data provider and PaikkaOppi operator. In the following the PaikkaOppi service is described from the viewpoint of each of these roles.

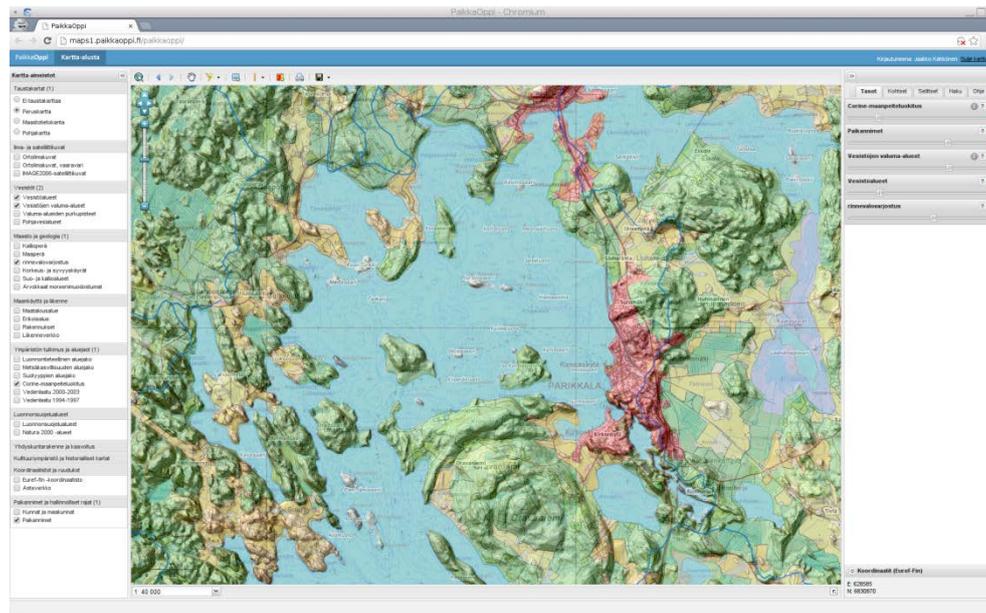
#### **3.1. Student's Viewpoint**

For the student PaikkaOppi is a Web browser-based learning environment. The main component of the user interface is a map view that integrates geospatial content from various different providers. The user interface is designed to be intuitive and easy to use. Being a Web-browser-based application, PaikkaOppi has a low threshold for learning and getting acquainted with by today's students that are accustomed to using Web for various tasks both in school and in leisure time.

The user interface of the PaikkaOppi map view is based on OpenLayers map library. The student can easily compose an interesting map view by combining together content from different sources, accessed via Web from remote service interfaces maintained by the data providers. The student is completely relieved from the complicated issues related to spatial data acquisition, harmonization and integration and can fully focus on using and understanding spatial data in visual form.

The student can freely select, order and scale the available map layers in the PaikkaOppi user interface. The opacity level of individual layers can also be set at will, making it easy for the user to adjust the final map visualization according to the individual preferences. A wiki-based workbook is available for students working on their assignments. The user can also digitize own objects on top of the map and save them for future reference. Multimedia

content, like images or video, can also be connected to the digitized objects. Students can import location information or trajectories into the system from their GPS-enabled mobile devices. Finally the student can share the created content of the workbook with fellow students for instance to be used as a part of a group assignment. An exemplary view of the PaikkaOppi map application is depicted in Figure 1.



**Figure 1.** The map view of the PaikkaOppi learning environment. From the available content layers in the left five themes have been selected (shown on the right) to build an information-rich and illustrative map display. Opacity of the individual layers can be interactively set for the optimal end result.

### 3.2. Teacher's Viewpoint

For the teacher PaikkaOppi is a tool that facilitates introduction of spatial viewpoint to the curriculum in context of various subjects. The teacher does not need to be a spatial data expert or evaluate, select, install and learn to use complicated GIS applications. The only step required for full use of the learning environment is to register into the PaikkaOppi service. The only technical requirement for the school is to have a good Internet connection and a set of computers able to run Web browser-based applications. As there is no need for local installation of specialized software, general purpose computers and even smart phones can be used. As a network service

depending on remote resources, PaikkaOppi also relieves the teachers from the constant cycle of software and data content updates.

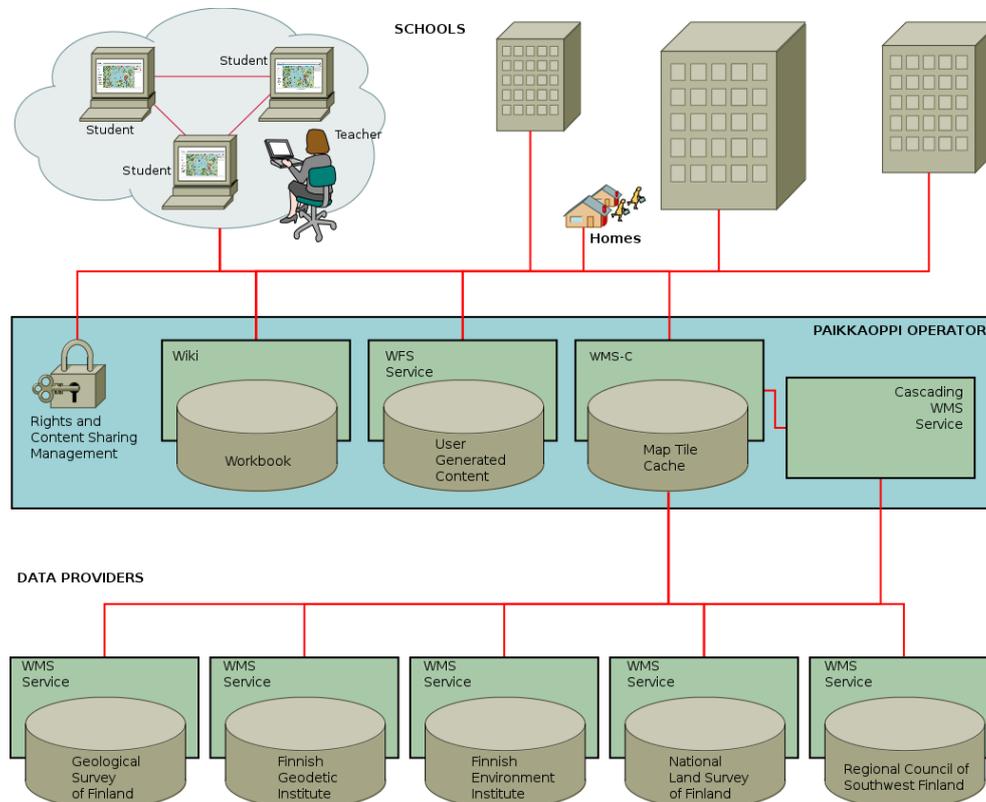
The teacher does not need to acquire geospatial data sets. Content providers just make their access interfaces available to be connected to the PaikkaOppi service and immediately all schools get access to these resources. All the technicalities related to coordinate systems, data encodings and visualization parameters are taken care of by the PaikkaOppi service thus enabling the teacher to focus on the main objective: applying geographic information as a tool for resolving problems in the context of various subjects. The used data sets are always automatically up-to-date as they are accessed directly from the data providers' access interfaces.

All this implies considerable savings for the school in terms of teachers' working hours, hardware acquisitions, software licenses and data purchases. In addition to the pure economic aspects, the PaikkaOppi service can be seen to support curriculum development, facilitate introduction of group learning methods and raise students' awareness of their immediate environment and its protection.

### **3.3. Data Provider's Viewpoint**

One of the main guiding principles of the PaikkaOppi platform is the provision of content via a distributed network service-based architecture (see Figure 2). Schools never need to worry about data management issues or take care of database updating procedures. Data is accessed from the standardized service interfaces set up and managed by data providers. These services are the firm basis of the PaikkaOppi platform, upon which all the other functionalities are built.

From the data provider's viewpoint the use of Web services makes it easy to deliver content. Standardized service interfaces and content encodings simplify the provision of geospatial data to schools. There is no need to support various file formats, as the only requirement is to set up a service implementation that follows standardized access protocols and let the PaikkaOppi operator to connect into this service. Taking into account the high number of upper secondary schools in the country and the consequential diversity in the existing technical solutions, this approach brings significant savings for the spatial data providers.



**Figure 2.** Architectural design of the PaikkaOppi learning environment. From the service interfaces of the data providers on the bottom layer spatial content is requested by the PaikkaOppi operator, cached for better performance and provided as an integrated map display for use in schools.

The service interface standards developed by Open Geospatial Consortium (OGC) are widely adopted in the PaikkaOppi platform. Map visualization is based on the Web Map Service (WMS) interface specification. All content providers support the same access protocol thus making it straightforward for the PaikkaOppi operator to create integrated visualizations. Cache storage is used to speed up interaction in the PaikkaOppi map client application. This cache stores map images on the PaikkaOppi operator's server and delivers them to the client application according to the standardized mechanisms specified in the Web Map Service - Cached (WMS-C) specification. This arrangement also significantly reduces the load on data provider's service platform.

### **3.4. PaikkaOppi Operator's Viewpoint**

The PaikkaOppi operator acts as the service provider for the PaikkaOppi users, i.e. the schools. The operator maintains the Web server that delivers the user interface of the learning environment as a set of Web pages. These include the exercise material available in the PaikkaOppi environment or specifically prepared by a teacher, student's own wiki-based documentation for working on assignments and, most importantly, the map user interface that provides visual access to the spatial content available in the PaikkaOppi platform.

One of the important functions taken care by the PaikkaOppi operator is the management of user rights. Two main user roles are identified and supported in the system, a teacher and a student. The full use of the system requires registration. First the teacher acquires access rights to the platform and can then manage the registration of the students in the class. User information is maintained centrally by the PaikkaOppi operator in the user database. User identities are the basis for the access rights to the system. These include access to spatial content, access to facilities for creating and storing spatial content, access to wiki-based documentation and access to shared user-generated information.

The PaikkaOppi operator also builds and manages the map tile cache that is used for improving the performance of the client application's map display. Map tiles are stored to the cache by requesting the corresponding content from the data providers' services. End users are then supported by these cached tiles. Only when the tiles get out-of-date or are for some reason missing in the cache, the user request goes down to the actual data provider's service. The arrangement reduces network traffic and ensures adequate performance, specifically in demanding classroom situations when several users access the service simultaneously.

The map user interface is based on OpenLayers Java Script library. Project-specific features have been developed on top of this code base during the PaikkaOppi development project. All these codes are stored and maintained in the PaikkaOppi operator's Web server. In addition the operator manages the wiki environment-based workbook, in which the students work on their assignments.

Web Feature Service (WFS) interface provides access to spatial content in the form of Extensible Markup Language (XML) –encoded data. Transactional version of this data access interface (WFS-T) is used to store user-generated content in to the database managed by the PaikkaOppi operator. This content can be accessed, visualized and finally attached as a map im-

age to the documentation that the student compiles using the wiki-based tools available on the PaikkaOppi operator's service platform.

#### **4. Conclusions**

The PaikkaOppi learning environment represents a new approach in the provision of the teaching material for upper secondary school education. Architecturally the platform is based on distributed, Web service-oriented content provision, in which geospatial content is accessed directly from the organization responsible for its capture and management. As such the PaikkaOppi platform demonstrates reuse of generic NSDI content services for educational purposes. Consequently, the students get access to up-to-date information and gain realistic understanding of the existing national geodata resources. The results of the PaikkaOppi project confirm that useful educational tools can be rather easily be built on top of the modern national SDIs.

The PaikkaOppi platform significantly lowers the barrier for introducing geographic information to the upper secondary school curriculum. Digital maps can be now easily used in the context of various subjects, from geography to natural sciences and from history to societal sciences. Complicated software and data acquisition procedures are now replaced with simple Web browser-accessible, ready-to-use service-oriented solutions.

The future improvements of the PaikkaOppi service include for instance better sharing of user-generated content between schools, introduction to crowd-sourced data sets and campaigns for countrywide co-operative data collection. A good example of these could be country-wide observations on the progress of spring time bird migrations.

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