MAP WHITEBOARD AS COLLABORATION TOOL FOR SMART FARMING ADVISORY SERVICES

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A paper from the Proceedings of the
15th International Conference on Precision Agriculture
June 26-29, 2022
Minneapolis, Minnesota, United States

Abstract.

Precision agriculture, a branch of smart farming, holds great promise for modernization of European agriculture both in terms of environmental sustainability and economic outlook. The vast data archives made available through Copernicus and related infrastructures, combined with a low entry threshold into the domain of AI-technologies has made it possible, if not outright easy, to make meaningful predictions that divides individual agricultural fields into zones where variable rates of fertilizer, irrigation and/or pesticide are required for optimal soil productivity and minimized environmental impact. However, present solutions that control variable rate application hardware such as irrigation, fertilizer application etc. are ‘black box technologies’ to farmers, making predictions that may well be good but that necessarily are not trusted. This limits the uptake of precision agriculture technology and thus also the realization of its promised benefits. The Map Whiteboard concept at the centre of this submission is intended to plug into the “traditional” workflow of variable rate applications and enables agricultural advisors/extension services and farmers to interact, adjust and share an understanding of the estimations made by the ‘black box’, thus increasing the trust in and improving the quality of the prediction models. The vision of the Map Whiteboard innovation was conceived out of a sequence of large-scale collaborative writing efforts using Google Docs. As opposed to traditional offline word processing tools, Google Docs *allows multiple people to edit the same document]—at the same time—allowing all connected clients to see changes made to the document in real-time by synchronising all changes between all connected clients via the server. The ability to work on a shared body of text, avoiding the necessity to integrate fragments from multiple source documents and with multiple styles removed many obstacles associated with traditional document editing. The Map Whiteboard technology seeks to do the same for the traditional use of GIS tools. The overall vision for the technology is that a Map Whiteboard will be to GIS what Google Docs is to word processing. We are now introducing this technology as a tool for collaborative work farmers and advisory services offering them analysis of EO data.*

Keywords.
Collaborative Platform, Precision Agriculture, Copernicus, AI, cloud

INTRODUCTION

Precision farming came to prominence as a scientific concept in the 1990s on the strength of technological advances that enabled variable rate application of irrigation, fertiliser, and pesticides. The practical benefits were demonstrated and well-proved. However, the uptake among farmers was slow and the domain has evolved on the fringes of mainstream agriculture up to and including the present day (Charvát, K., Řezník, T., Lukas, V., Charvát Jr, K., Horáková, Š., Kepka, M., & Šplíchal, M).

Initially, change resistance among an ageing rural farming community was blamed for the slow adoption, but 25 years later, a generation change has taken place in the custodianship of agricultural lands. When the adoption of precision farming practices still remains very limited, it is likely that the problem lies in the communication of, accessibility to and delivery of precision agriculture technology from the scientific community, industrial actors, SMEs and farmers. The combination of Earth Observation technologies, GNSS—one of the key technologies for precision farming—and precision farming itself is discussed as one of the “killer applications” for space technologies.

As underlined also in the conclusions of the EO4AGRI project, farmers (Charvat, K., Safar, V., Kubickova, H., Horakova, S., & Mildorf, T.) are reluctant to pay for services of which they do not grasp the added value and are overwhelmed by the complexity of making technological choices related to what facilities, services, tools, and IT infrastructure to use, in order to improve their farm management systems and also related agrifood services and deal efficiently with the control of their carbon footprint.

Both geospatial infrastructures including COPERNICUS and Location Based Technologies exist today, having reached the maturity stage in terms of specific applications related to many typologies of farming operations. Yet, the concrete uptake of those solutions among farmers is lagging behind, even among the ones that are more technologically aware and prone to innovation. One of the problems highlighted by the conclusions of the EO4AGRI (Charvat, K., Horakova, S., Druml, S., Mayer, W., Safar, V., Kubickova, H., ... & Catucci, A.) project is that farmers do not have the time and training (and often the competences) to deal with the choice of technologies and with the design of solutions that would be usable in their context at an affordable price.

The issue of a structured, aggregated offer of services is partially addressed by the several DIAS (Mitraka, Z., Siachalou, S., Doxani, G., & Patias, P.) (Data and Information Access Services). There are currently five DIAS operating which are co-funded by the European Commission to provide centralized access to Copernicus data and information, as well as to processing tools. However, the DIAS platforms aggregate Copernicus (and other geospatial) services, but still struggle to meet demand, as there is no aggregation on the side of the potential receivers or users of those services. Because the proposed services can be very specific, not easy to find and relatively complex, the chances of seeing demand emerge through a natural process on the side of farmers, are very poor. Within the current context in the EU, it would be unrealistic to think that farmers will soon intensify their usage of Copernicus and geospatial facilities, in the absence of efficient measures designed to accelerate their access to those services and data.(Larson, J. A., Roberts, R. K., English, B. C., Larkin, S. L., Marra, M. C., Martin, S. W., ... & Reeves, J. M.)

Along the value chain, the problem to be solved is situated just before the delivery of data, information, and services to the users (farmers). The flow tends to break in the segments where the farmers are supposed to make technological choices and/or negotiate contracts to access those services. As this does not happen, the potential of those data or services is lost. This qualifies the issue as a typical last mile problem. The project intends to tackle that precise issue, by including in the value chain a layer of trusted intermediation by regionally or nationally rooted organisations that can help to channel their demands or expectations both in terms of technical services and training to be provided and in terms of the fair price to be paid.(Charvat, K., Gnip, P., Gemtou, M., & Vogeltanzova).

Those organizations are typically the FAS (Farmers Advisory Systems) or the Farmers' associations. These are present in all European countries and are in the right position to function as aggregators of demand by farmers in respect of Copernicus and geospatial data and LBS services. Moreover, their presence is capillary, and they enjoy a high level of trust by farmers themselves (Mayer, W. H.).

Our vision is that this is essentially a “last mile” issue. Data is provided continuously, technology and services are available, but they do not reach (not sufficiently, at least) the potential users. In the project's vision, this “last mile” issue can be tackled by aggregating farmers' demand through existing organisations and networks, such as the Farm Advisory Services or farmers' associations. Those organisations (often operating at regional or local level) know their farmers' communities. They provide advice to farmers on several issues, including innovation or access to data and services. They have the capacity to reach farmers in a capillary way and in most cases, they have a relation of mutual trust with the farmers. Most FAS or associations have resources and capacities to understand technology, although they are not necessarily specialised in Copernicus, GNSS and geospatial data, thus possibly need training themselves.

Till now effort has been made to aggregate demand by farmers and channel it through FA. Our intention is aggregating farmers' demand for services and by channeling that demand through local added value chain, data-based services could be designed, integrated and delivered in a much more effective way, to wider communities of users. As a result, the potential contribution of the farming sector to climate change mitigation could be leveraged at an unprecedented level. Our idea is to integrate a number of already approved technologies into a fully operational chain.

We have a number of state-of-the-art technical platforms that are capable of harnessing EO and remote sensing data from a plethora, data from machinery and also other data from different sources for agricultural decision making on a very detailed level. The problem is, how to bring these services to farmers.

But, in its eagerness to provide a sophisticated tool, we have overlooked that they do not have skills necessary for all these tools and do not possess a supercomputer and would be using this tool at the very maximum few times in a year. Thus, utilization of technologies depends on man-in-the-middle services provided by regional and local agricultural advisors who will use the platform on a regular basis as they each serve a multitude of farmers and agricultural businesses. We have a high skills consultant, who will use these tools. Service organizations will conduct high resolution spatial analysis for their client farms - but when the analysis is done, they are required to discuss the results and how to apply them to the specific farm together with the farmer.

Then, the goal of this project is to develop an application, helping a farmer and other players in the agri-food value chain to make proper decisions leading to sustainable production and reducing the losses and energy and chemical production based on evidence decision making.

The evidence comes from data, turned into information. The information then needs to be presented in a clear way, to help understanding of a studied system (knowledge) and objective reasoning (wisdom). [Figure 1](Charvat, K., Horakova, S., Wolfert, S., Holster, H., Schmid, O., Pesonen, L).

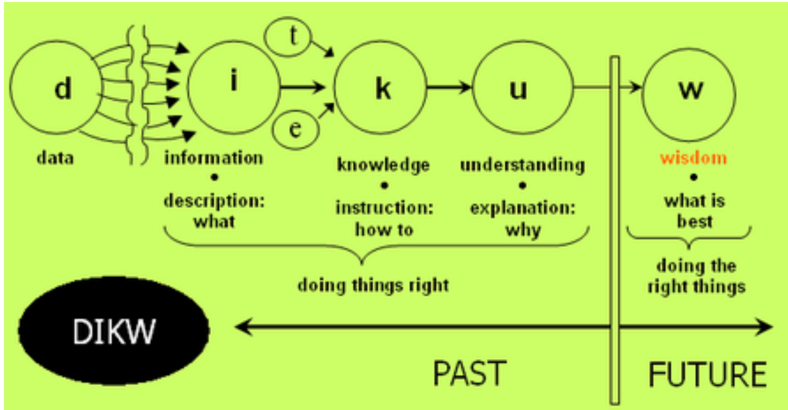

Figure 1: The DIKW process illustrates the challenge of transforming information and knowledge into understanding and wisdom, as required for accelerated uptake of precision farming

The idea of MapWhiteBoard is to develop collaborative technology, which will help to integrate different farming services into one collaborative application and support building wisdom for farmers about how to make the best decision. We need to support them in strategy WWW (When, Where and What).(Jedlička, K., & Charvát, K.)

Collaborative Value Chain for Processing of Satellite Data

Users of Earth observation data in agriculture, a part of the precision farming, can be divided into two groups as:

- data processors - service IT providers, software producers and consultants, and service organizations in the domains including Earth observation, aerial photogrammetry, drone application, phytopathology, agronomy, interpretation of vegetation data from satellite and aerial images, etc.
- consumers of results produced by data processors - farmers, engineering and environmental agricultural companies, agronomists, machinery manufacturers and input providers (fertilizers, chemicals).

Members in both of these groups must collaborate in order to develop all required applications. Then all will benefit from these applications: farmers can make informed decisions regarding their crops and advisors can sell services to farmers and input providers can use weather and soil maps to predict the demand for fertilizer.

Due to its complexity, Earth observation for precision agriculture needs to be supported by a full value-added chain, where a farmer is its final point. See the Figure 2:

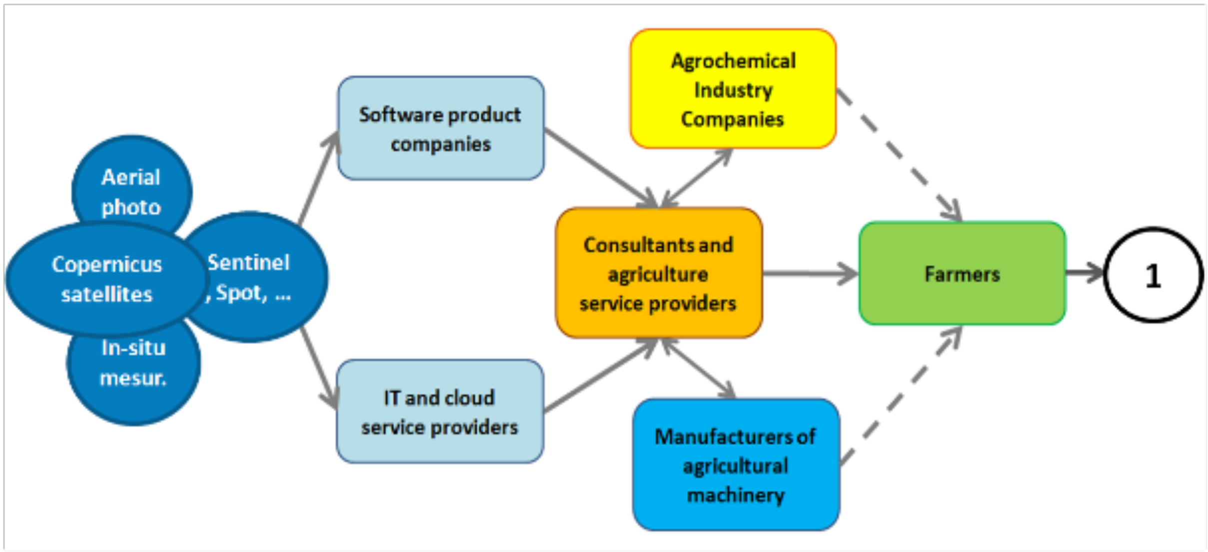

Figure 2 Data Access and Information Services actors

The farm usually concludes a contract with the agriculture service providers for delivering the data from Earth observation and agro-consultancy services. Usually, the order in the preparation period includes:

- data collection of the land site variability.
- detailed analysis of information on a specific plot of land.
- data used for agronomic recommendations.
- crop yield maps.
- monitoring the appearance of disease or damage.
- estimating the extent of disease or damage (loss).
- sensory measurements and exhausted soil.
- validity measurement also on sustainable and long-term factors.
- agronomic information related to sowing, organic fertilization, etc..
- maps of accessible nutrients, soil reaction, sorption complex status.
- plan for using pesticide.
- erosion precaution.

The main purpose of using Earth observation data is to determine the doses of nitrate fertilizers for production fertilization for most plants and especially for cereals, which make up more than 65% of all agricultural areas:

- maps for production fertilizer in the phenophase 30-34 from all fields (A very short time is available to create these maps; practically it is only a few days for the farmer to receive correct, timely and relevant information on the state of the stand and the proposed fertilization process. However, it is not just about doing well-known vegetation index maps but combining this basic mapping information with the actual situation with water saturation and the quantity of previous basic fertilization. Only on the basis of the file of information can make the right conclusions about the benefits of fertilizer applied in heterogeneous fields).
- expert consultation on the application of fertilizers to specific facilities with the supply of experts on fertilizer equipment (liquid and solid fertilizers).
- estimating yield.

During the harvest should be used harvesting equipment sensors revenue associated with GPS localization to determine the degree of correlation with production fertilization maps and against the surface of the differential area, which is given by a square about the width of the cutter bar harvesting machines. Consultants and agriculture service providers offer a hi-tech system of precision farming with some set of services to their clients. Their main benefits are the most efficient use of fertilizers, an increase in land yields and stabilization of production quality (Charvat, K., Safar, V., Kubickova, H., Horakova, S., & Mildorf, T.),(Šafář, V., Charvát, K., Mildorf, T., Crehan, P., Kolitzus, D., Orlickas, T., ... & Kubíčková, H.)

The problem of current solutions is, that this solutions doesn't support real collaborative team work.

MapWhiteBoard

The vision of the Map Whiteboard innovation was born out of a sequence of large-scale collaborative writing efforts using Google Docs. As opposed to traditional offline word processing tools, Google Docs allows multiple people to edit the same document—at the same time—allowing all connected clients to see changes made to the document in real-time by synchronizing all changes between all connected clients via the server. The overall vision for the technology is that a Map Whiteboard will be to GIS what Google Docs is to word processing.

With the increasing adoption of GIS by end-users in non-traditional domains, there has been a shift from desktop to web-based applications, not only for publishing information but also for professional use. That is the second factor that is of importance to the Map Whiteboard concept.

In the present situation, where people are working with "thin clients" that communicate towards the same set of shared services, the potential for collaboration is significantly expanded compared to the setting when everybody worked locally on their computers. Professional Web GIS solutions are typically integrated into web map portals that have highly heterogeneous user interfaces. The capabilities of the software emulate well-known concepts from desktop GIS. The Map Whiteboard seeks to upgrade the manual and linear GIS-workflows that have been inherited from the era when desktop software dominated the field. The technological concept builds on state-of-the-art, as described here, and seeks to exploit some of the capabilities native to web applications, such as the Web Sockets protocol that enables continuous and instantaneous message exchange between multiple connected clients.

An additional dimension to the Map Whiteboard technology is the importance of sharing rather than only sharing data. Spatial data are subject to (mis)interpretation; maps are the means to express these interpretations in a manner suitable for communicating purpose, intent and shared understanding. The Map Whiteboard is not limited to editing a shared dataset. The technology shares the entire map, presenting the data in the context of any background information that may be useful. It allows multiple clients to see the identical map interface and simultaneously draw on it, emulating the widespread use case of sitting around a meeting table looking at a map together, annotating it, pointing at "things", and proposing changes. To realize the vision of the Map Whiteboard technology, it is necessary to make certain behavior of GIS applications interoperable across instances and platforms. The interoperability is limited to the smallest common denominator between different platforms in terms of the types of business objects that are present in each application, what functions they expose and which events they emit.

Collaborative data creation has become increasingly common and has given rise to concepts like user-generated (UGC) and VGI. The interaction process whereby users contribute data is typically based on users working individually towards standard data models using a web form and a map surface. (Charvát, K., Bergheim, R., Bērziņš, R., Zadražil, F., Langovskis, D., Vrobel, J., & Horakova S,)

Technical Background and Description of the process of solution

The map whiteboard library actually consists of a server part and client part which is made to be used as an npm library. The library `hooks` onto existing map libraries such as OpenLayers or aspirationally Leaftlet by listening to the events issued by the map objects (layers, features) and manipulating those objects (adding/removing features, layers). Some of the functionality and configuration needs to be provided by the container application where our library is integrated into. Map information is exchanged between the users with the help of a map composition file which is similar to the OWS standard defined by OGC. It lists the map layers, viewport, projection, styling and metadata. This information is used to reconstruct the whole complex map in the mapping client software.

Server architecture

A docker based environment has been set up to run the components in production . It consists of 2 mongo databases - one for the container application and one for map whiteboard. Similarly, we use 2 Rest API endpoints named ‘polirural-model-builder-api’ and ‘pmb-whiteboard-server’ where the whiteboard-server supports both REST and Websocket protocols. At the top resides an Nginx proxy to ‘rule them all’. The map whiteboard server connects to model-builder-api provided graphql endpoint to validate user sessions and get the current users info. This is used as an alternative to OAUTH2 but conceptually does the same thins. (Figure 3).

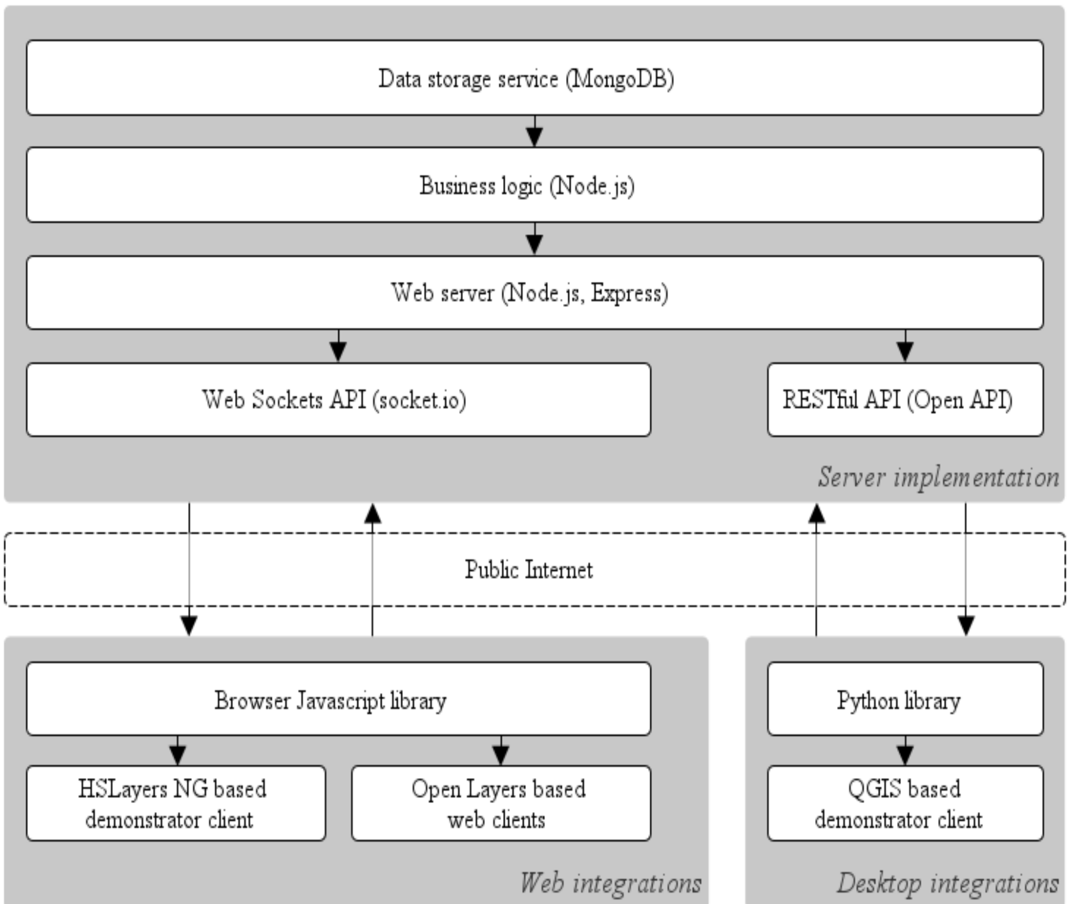

Fig. 3:

Figure 3 Overall architecture of Map Whiteboard technology

Client architecture

On the client-side we have an Angular9 based application, which incorporates a map window component based on HSLayers-ng, which runs Openlayers under the hood, enabling us to integrate the Map whiteboard library using the underlying Openlayers map object.

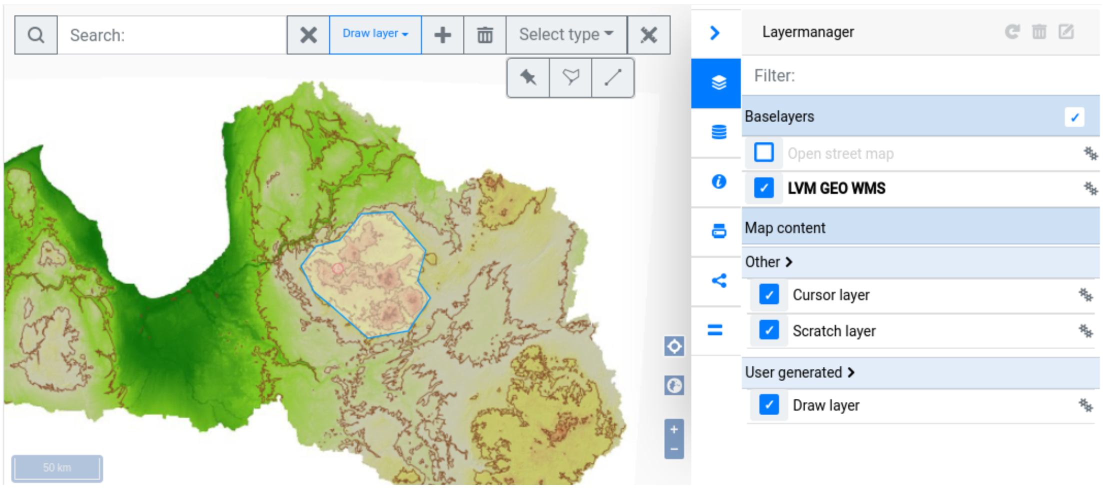

Figure 4 MapWhiteBoard client

Since Hslayers already provides feature drawing functionality we have added to map whiteboard library the possibility to turn off the drawing toolbar not to have duplicate user controls and call the whiteboard libs data synchronization methods directly from JavaScript using hooks in hslayers. Also switching the current edited layer on map whiteboard library from outside needed to be created since the application supports multiple editable vector layers which are done on hslayers side.

Map composition preparation

The map composition creation is still done in the application outside map whiteboard lib with the help of hslayers-ng, because it supports multiple layer types and parameters. The JSON serialize map object or individual layer is then passed to map whiteboard client-side code, which then sends it to the server. This happens at the moment when the user selects a 'Model' in the dropdown list on the top-left corner of the UI. The software then checks if a map composition is linked to the model and creates it in case it doesn't exist. In case it already exists the composition is being queried from the map whiteboard server, and layers are populated on the map including the features. (Figure 5)

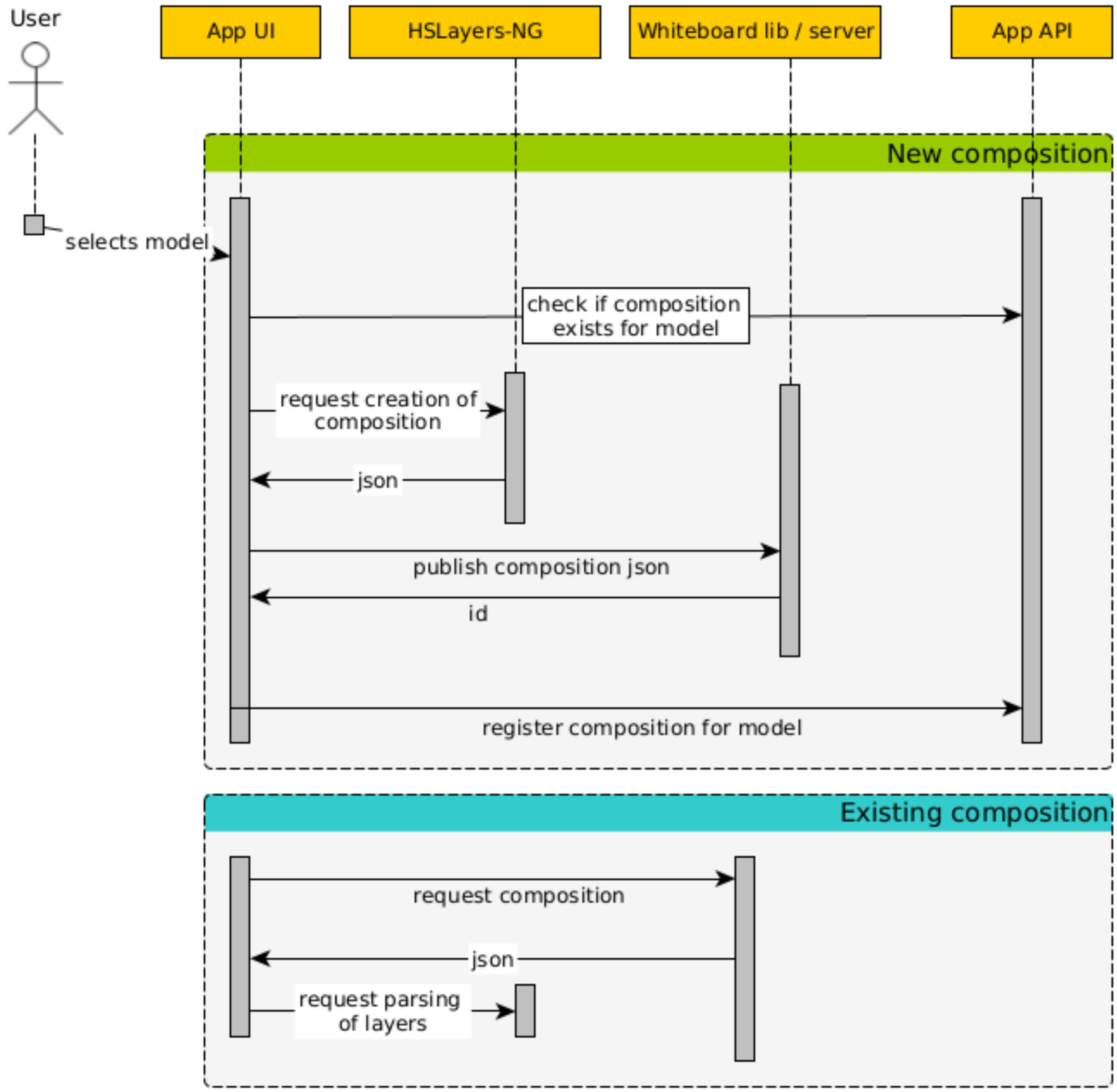

Figure 5 MapWhiteBoard WorkFlow

The uploaded composition is stored on the hard drive, parsed and the title, description and filename of the composition are stored in MongoDB database. Downloading map composition file was developed, and the features are queried for each layer separately or all editable layers at once (parallelly) executing a function in the map-whiteboard client library.

Currently, functionality for editing the composition supports:

- Add new layers either drawable vector or WMS, ArcGIS or vector data loaded from external files
- Listing of editable layers parsed from composition file
- Requesting features for particular layers. Multiple editable layers are now supported
- Listing of my uploaded compositions for the current user
- Granting access (owning) rights to the uploader of composition.

An initial user rights model to keep track of who can access and edit the compositions has been developed. It is email address based and provides the extension of the separate authentication/authorization which the map whiteboard server is integrated with (App API in the

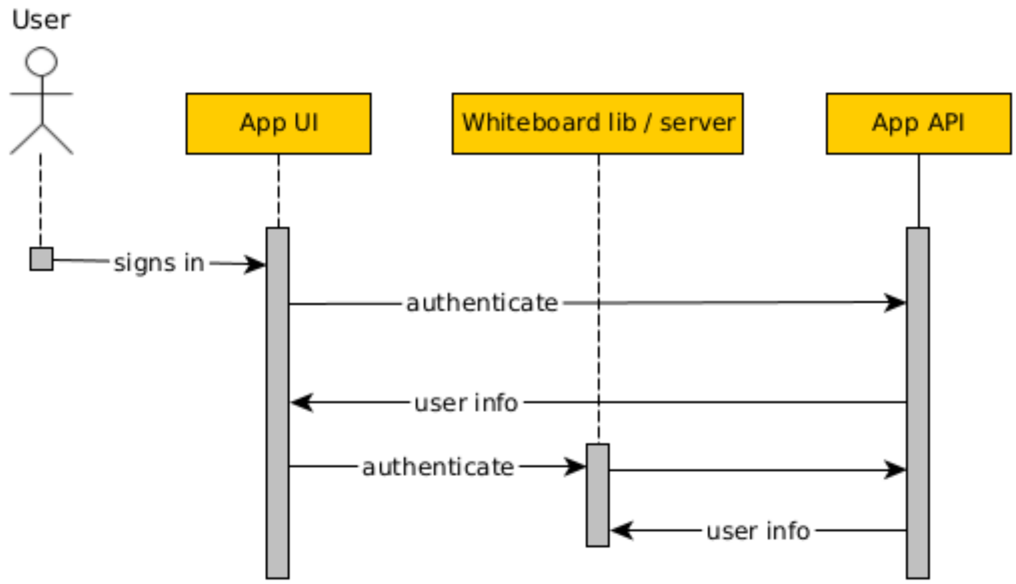

image).

Feature synchronization

Whenever a user draws or edits a feature on his map, it is serialized and sent to the server where it then is propagated to every other user which looks at the same map composition (In our demo the same Model in the dropdown needs to be selected). This is done using Websockets technology which enables near real-time two-way communication between web browsers on distributed networks.

Scenarios

The MapWhiteboard is tested now as an add-on to an application that performs automatic zoning of agricultural fields based on remote sensing data for defining yiled potential and nitrogen application,. The application takes as input a field, automatically acquires satellite imagery time series data, calculates indices such as the NVDI and uses the resulting 4D data to determine zones in the respective field that should be treated differently with respect to fertilisation, irrigation and pesticide application.

The MapWhiteboard component adds value to this scenario in two ways:

1. Users can indicate points that reside within distinct areas of the field
2. Users can modify the resulting zones after auto-classification
3. Users can add recommendations, rates to the individual zones

Yield potential

Yield potential zones are areas with the same yield level within the fields. Yield is the integrator of landscape and climatic variability and therefore provides useful information for identifying management zones. This presents a basic delineation of management zones for site specific crop management, which is usually based on yield maps over the past few years. The presence of complete series of yield maps for all fields is rare, thus remote sensed data are analysed to determine in field variability of crops thru vegetation indices. The abovementioned indices need to be computed from relevant satellite data. Information on farmer's parcels (plots) is the second input since it defines relatively homogenous areas from the crop point of view; one plot parcel usually contains one crop type in one vegetation season. If this was not the case, yield potential cannot be computed for the whole plot parcel. The abovementioned indices are computed as variabilities within each plot.(Řezník, T., Lukas, V., Charvát, K., Charvát Jr, K., Horáková, Š., Křivánek, Z., & Hermana, L.)

Nitrogen applications planning
Applying of Nitrogen during the growing season and recognised that right timing of application of nitrogen has large environmental (water pollution) and economical (losing of nutrients) then site specific farming. Copernicus data is crucial for our idea. The right time for the nitrogen application should be assessed through one or more vegetation indices. Although we have some experience in remote sensing, we do not know which index will provide best performance. Very good results are usually achieved with Sentinel-2 data. On the other hand Sentinel-2 satellites are limited by clouds. For central Europe it is not an exception when there is quite a long cloudy period during spring which makes Sentinel-2 data useless. Therefore we will definitely examine the possibility of using Sentinel-1 radar data. The radar signal penetrates the clouds and collects data day or night. The main disadvantage of the radar signal is the complex pre-processing of the downloaded data and its interpretation.

Conclusion

MapWhiteBoard present not only new technology, but fully new approach for cooperation of advisers, farmers, expects on Remote Sensing and other group dealing with precision farming production. The technology is now developed by international team and tested in different conditions.

Acknowledgements

The paper was prepared on the basis of materials collected by all authors. Work is also contributed with support from the EU projects.
For functional requirements and support in implementing the prototypes:

- PoliRural - Future-Oriented Collaborative Policy Development for Rural Areas and People (Grant agreement ID: 818496)
- DEMETER - EMPOWERING FARMERS (Grant agreement ID: 674973)
- STARGATE - reSilienT fARminG by Adaptive microclimaTe managEment (Grant agreement ID: 818187)
- SIEUSOIL - Sino-EU Soil Observatory for intelligent Land Use Management (Grant agreement ID: 818346)

For the hackathons that have been used as a vessel to carry forward the work:

- Plan4all z.s. (Identification number in the Czech legislation: 03698416)
- SmartAgriHubs - Connecting the dots to unleash the innovation potential for the digital transformation of the European agri-food sector (Grant agreement ID: 818182)

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