HYDRO-TECH – AN INTEGRATED DECISION SUPPORT SYSTEM FOR SUSTAINABLE IRRIGATION MANAGEMENT: (II) SOFTWARE AND HARDWARE ARCHITECTURE

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Introduction

In southern EU Member States, 'sustainable' water management in agriculture is a major issue and there is an increasing need to develop and test appropriate **'decision support systems' (DSS)** to further support the on-farm decision process. The application of new technologies to the **control and automation of irrigation** is becoming a very relevant issue in the last decade, due to a number of factors (McCarthy *et al.*, 2011; Romero *et al.*, 2012; Zapata *et al.*, 2012). The 'HydroTech' project is developed in the Apulia Region (Italy) by a temporary association of local business companies (Sysman, DyrectaLab) and research institutions (IAM-B, ISPA-CNR), with the aim to further develop an integrated decision support system (**HT-DSS**) and to bring available modern technologies at the level of farm application.

Among other objectives, the project aims to: i) test the **applicability of HT-DSS at farm level**, in relation to its effectiveness and reliability, fast and simply information transfer; ii) design 'simple and practical' **user-friendly applications**, by considering also the end-user feedbacks; iii) test the plug-and-play **on-field devices** interconnected through a cloud network. A general description of the software and hardware architecture of the HT-DSS is here reported, while in a companion paper (Todorovic *et al*., 2013, this issue) the main algorithms and the on-going experimental activity at farm level are described.

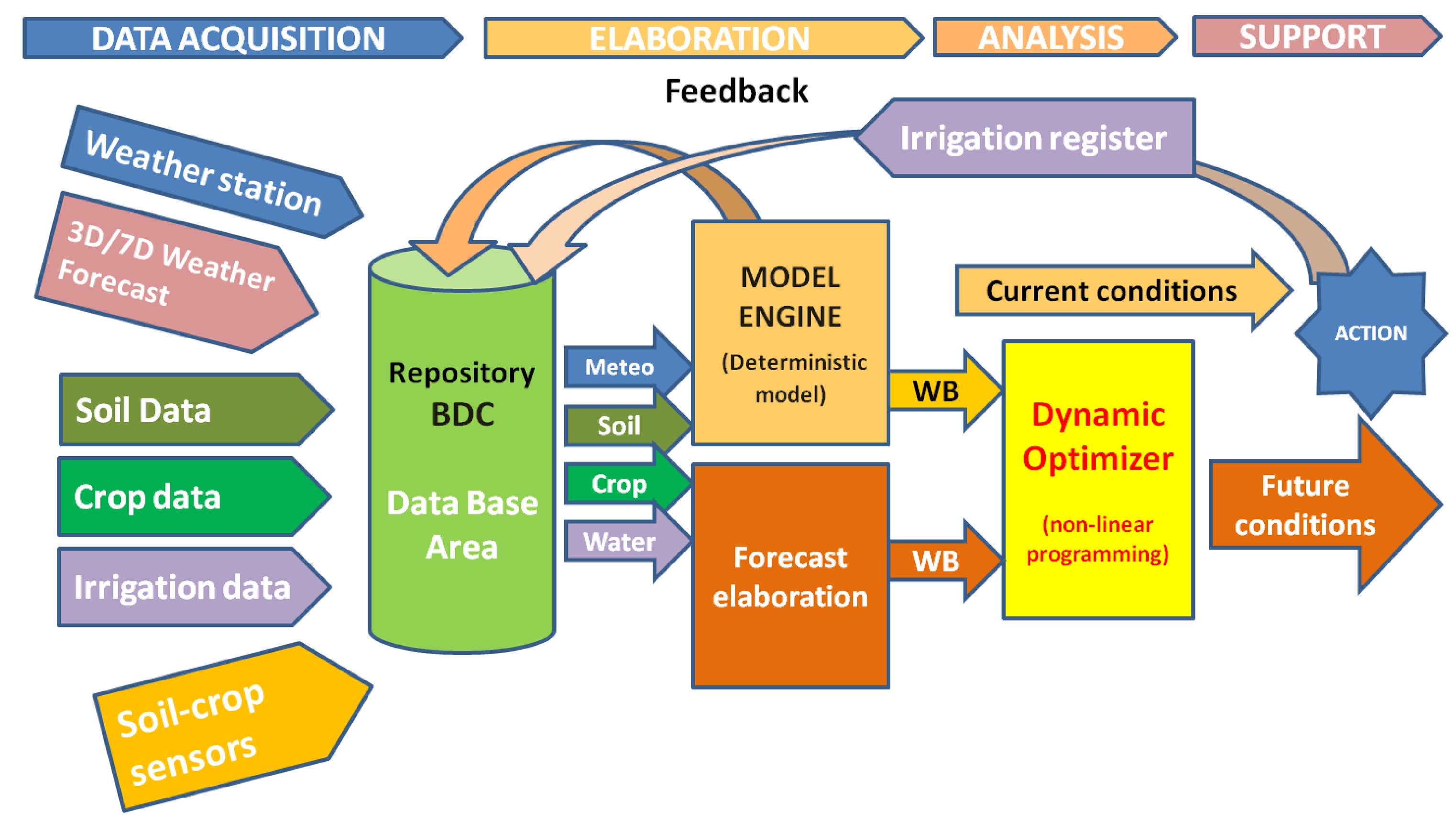

Fig. 1. Data Flow scheme. Multiple data source streams are stored into DB and aggregated in order to obtain the optimal solution for the irrigation/fertirrigation scenario.

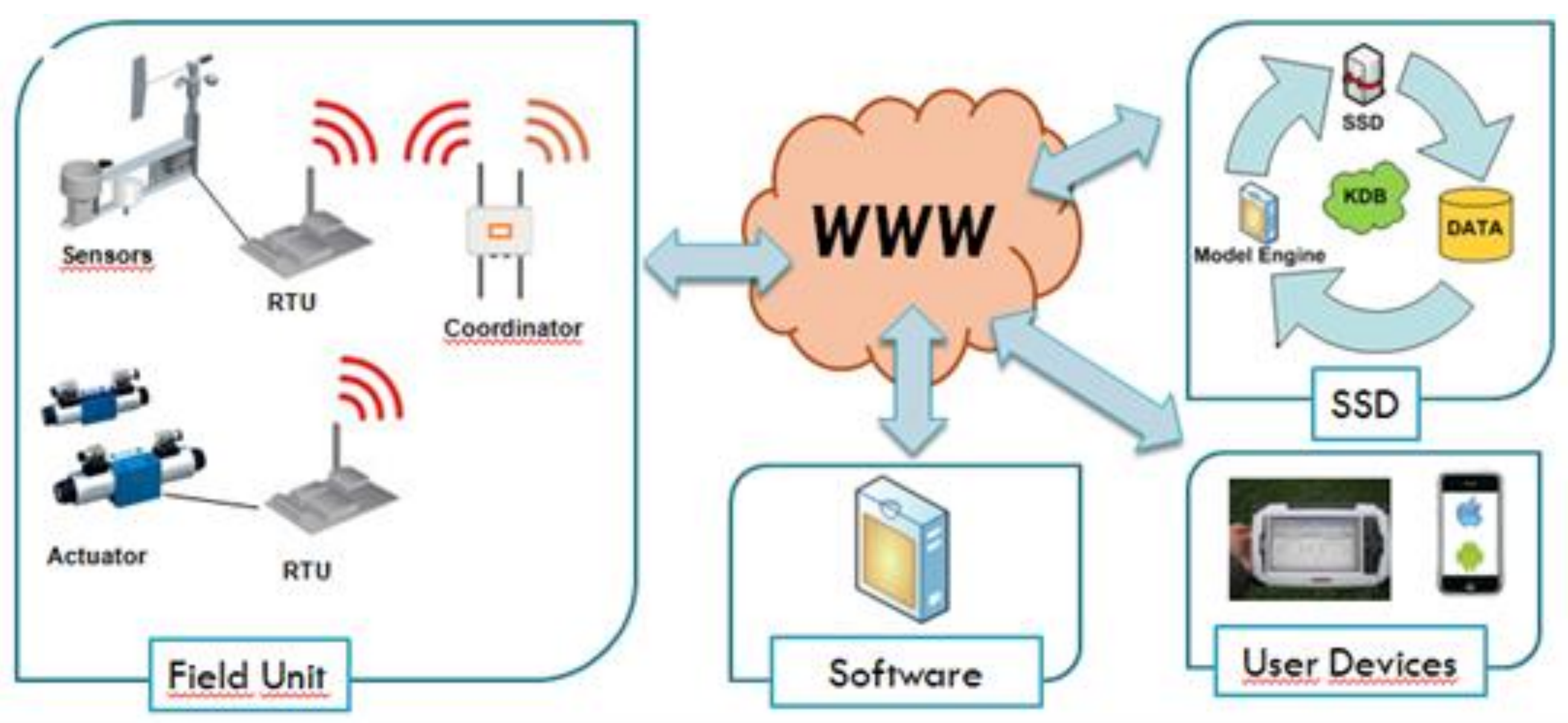

Fig. 2 – General scheme and main components of the HydroTech architecture.

General scheme and Hardware components

The HT-DSS information system integrates **multiple data sources** in order to collect all information useful for the irrigation and fertilization support, such as information on farm and irrigation units, weather forecast and measured data and crop-soil data. In Fig. 1, the data flow scheme is represented. In general terms, the system consists of the following main components (Fig. 2): the 'Field Unit', the 'HydroTech Information System' (HDC, HydroTech Data Cloud) with DSS Dynamic Optimizer, and the 'Software' and 'User Devices' for the technology transfer.

The '**Field Unit**' is composed of: 'sensor' devices, connected to a microcontroller (SENS); 'actuator' devices, connected to a microcontroller (ACT); a 'coordinator', which is aware of the whole configuration and logics to be respected. Each sensor/actuator station is equipped with Li-Ion rechargeable battery and a solar panel in order to have the highest installation facility. The coordinator is a Linux mesh router provided with moderate computation and storage capabilities, integrating 2 different communication interfaces: ZigBee (to transfer data from/to SENS and ACT stations) and 3G/GPRS (from/to the cloud system).

The Information system and main Software components

In Fig. 3, a general overview of the '**HydroTech Information System**' is given, to represent the main communication and elaboration flows of data and information. The 'Grib Data Manager', 'WS Data Manager' and 'Ground Data Manager' packages process all input data and store it into a central remote database. The 'Model Engine' is the system core and can be executed 'on-demand' (or 'stand-alone') if the user interacts with the system to update field data and observations, or 'services' (or 'auto-run') if the model engine automatically calculates the specific plan.

The Model Engine consists of different **software modules**: FIELD WATER BALANCE, calculating the crop water balance using measured and forecast meteorological data; FERTILIZATION, to support fertilization activities calculating the correct amount of different fertilizers to provide for each crop; DATA QUALITY CONTROL; DYNAMIC OPTIMIZER, supporting the user to design a specific irrigation strategy according to farmer objectives and constraints; ANDROID & WEB PAGE, responsible of the interaction between users and the system using internet devices (mobile, web) through Web Service functionality; JAVA, desktop interface of HT-DSS, interacting through TCP/IP protocol.

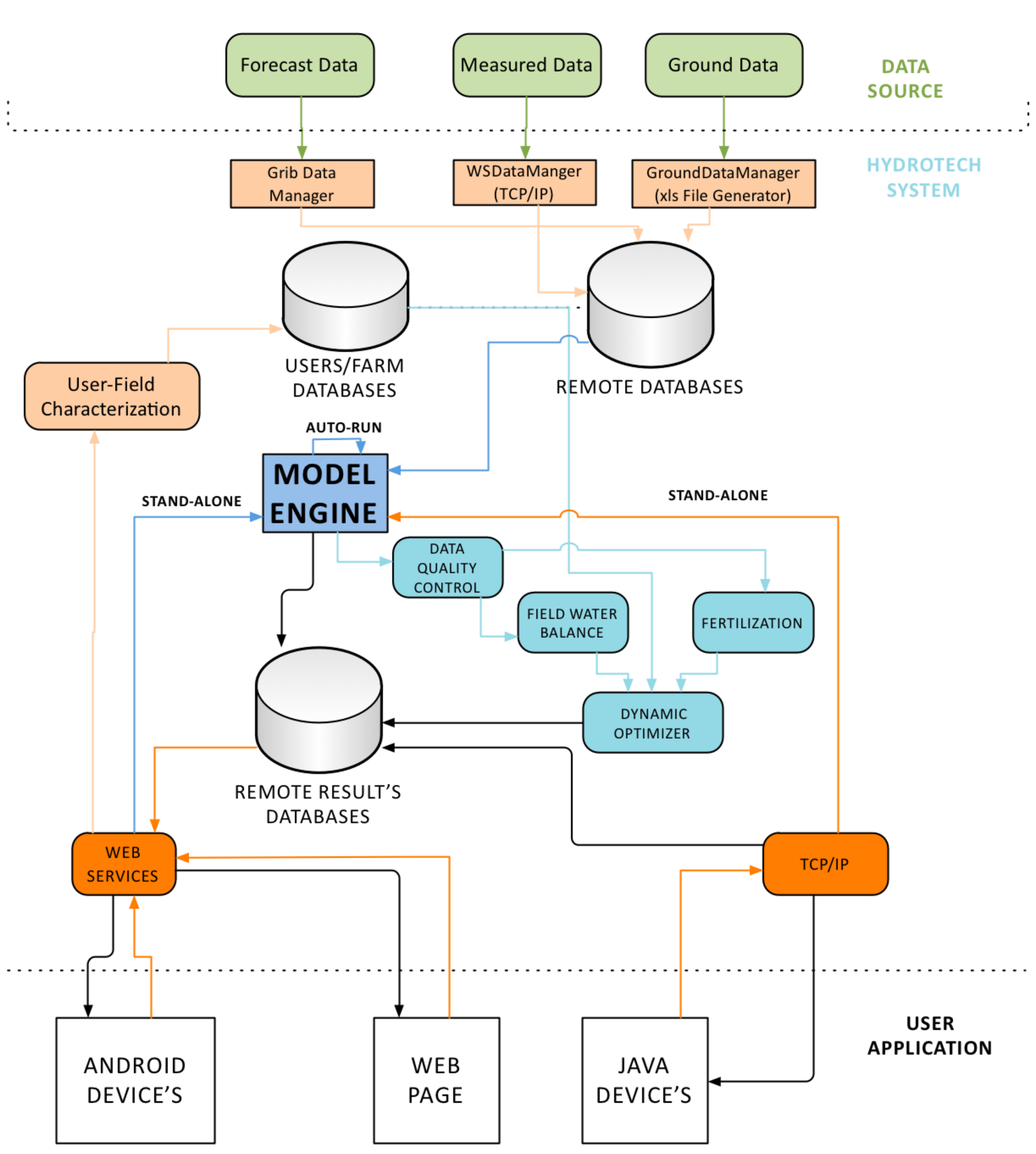

Fig. 3– Data communication and elaboration: general scheme of the HydroTech Information System.

On-field technology transfer

The expected interaction between the end-user and the information system is related to three main actions, to be undertaken under an ergonomic graphical interface: 'data entry', 'consultation of results' and 'start of remote procedures'. According to this requirements, the system is designed according to a 'three-tier' architecture characterized by a 'user interface' layer, a 'web-service', an 'application and data-storage' layer. The '**user interface**' layer allows the fruition of the system through personal computers and smartphones/tablets from the latest generation, and is implemented as a web-application (PHP, HTML/Javascript, AJAX) for web browsers and as a mobile-application for Android devices. The rendering of the graphical interface is suitably decoupled from the remote content processing through **asynchronous HTTP requests** to the web-service, allowing user interactions while waiting for responses. The web-application implements asynchronous data exchange with AJAX technologies, showing pleasing animations and status messages during data transmission, **minimizing the waiting time** in the transitions between pages. The mobile-application implements asynchronous data exchange using a third-party HTTP class, managing the communication with the web-service in a separate process from the graphical interface, avoiding misleading and improper deadlock conditions during the execution of the app. The mobile-application is predisposed to the distribution of **push notifications** that may, for example, alert the user on the update in weather data (Fig. 4).

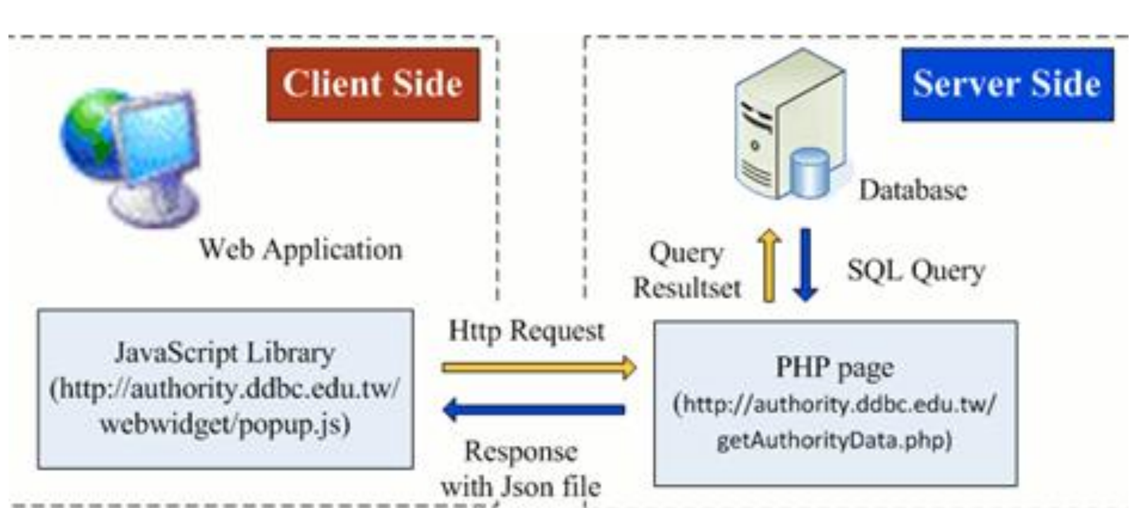

Fig. 5. Communication scheme between client and server through web services.

Fig. 4. Example of MOBILE Android application: a) suggestion of the next irrigation (day, amount), with the level of current and projected 3-days changes in soil water content; b) the seasonal trend of soil water depletion, with respect to the RAW threshold, together with the graph of rainfall and irrigations; c) meteorological variables; d) daily trend of soil water content at different depths as recorded by soil moisture sensors.

The '**web-service**' layer exposes the remote methods required for each interaction with the application-layer and the data-storage layer, and is implemented in PHP according to an **RPC-style paradigm**. The web-service responds with JSON objects to remote calls, if eligible (Fig. 5). The web-application and the mobile-application takes advantage of the web-service as an interface to information and commands inside the information system, for which it constitutes an **universal level of abstraction**, open to the implementation of new user interfaces (such as a mobile-application for IOs and future data mining tools). The insertion of new inputs performed by the end-user (such as the insertion of a new irrigation) or performed at system level (such as an update in weather data) results in the **loss of validity for the latest solution found**: every time this condition occurs during the consultation phase, the calculation of a new solution is automatically launched without **user interaction**.

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Regione Puglia

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