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CLOUD Computing and Water Resources Planning and Management

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Abstract : The development in Water Resources Planning and Management in terms of automation/software/ hardware has witnessed remarkable growth in the recent decades. The Industry has now several Commercially Off The Shelf software (COTS) solution available which are GIS based, web based, integrated with real time devices i.e telemetry. Such technologies can provide a significant contribution in the description of water resources and their management related to it. Keeping this view in mind, collaboration is required by integrating data, tools and expertise in the field of hydrological modelling, with the aim to organize and make available an operational service for the entire region/users, constantly updated, balanced and refined, which simulate the hydrological budget and related processes. Cloud computing has emerged as powerful technology for processing and analysis capabilities across platforms/system for the water resource application including voluminous data handling and adaptability and scalability & seamless integration. Cloud computing, through its multi layered user-friendly web portal, updated quality data, model inputs, visualization and processing tools & technology will benefit to support the analysis and assessment of water resources and their effective management.

Key words: Cloud Computing, GIS, web, portal, Telemetry, COTS (commercially off the shelf), SAP, ERP, SCADA, SaaS, IaaS, PaaS

INTRODUCTION

The management of water as a natural resource is one of the central challenges of our genera-tion, and how we act today has consequences for all future generations. System states and changes must be traceable, and decisions must be based on facts for future verifiability. Our starting point is to transfer the natural world and its dynamics into a world of data points which can be recalled, transferred, validated and stored in periodic intervals. These points reflect system states, and form the basis for analyses and forecasts. The technology is called Time Series Management, and it provides the backbone of key services for water indus-try data processing.

Technological development in water resources planning and management, as in other sphere of the applications, is linked with the IT development. India has witnessed the development of Hydrological Information System in Client Server Technology during the Hydrology project phase-I and several vertical application and development during Hydrological Project- Phase-II like web based water information services, real time data collection and monitoring of water levels & quality, decision support system, integration with SAP/ ERP / SCADA etc.

Cloud computing is another IT development around the corner and most technology companies are offering the products and solution including "Software As A Service" suitable for the Water Resources planning and management. This paper discusses how Cloud Computing can be an efficient tool for the effective water resources planning and management. (Water Resources Planning & Management Software As A Service 'WRM SaaS')

The automation at the water resources departments facilitate everyday operations

handling mass data, enhancing performance and effi-ciency of use combined with one another in order to guarantee reliability and realise full automation potential. These challenges can only be met through the best hydrological and IT knowledge and intensive practical experi-ence. The development of WRM SaaS is to be designed with the vision to manage large amounts of time-series data useful in the various water industry including hydro power, water resources and wastewater industries and environmental data management etc.

The major component for water resources planning and management software (WRM SaaS) as service shall include Data Acquisition, Data Management, Data Analysis, Modelling and Simulation and Automated Task Scheduling etc.

WHAT IS CLOUD COMPUTING?

Cloud computing is a general term for anything that involves delivering hosted services over the Internet. Cloud computing allows users and businesses to use applications without installation and access their personal files at any computer or platform / client with internet access. This technology allows for much more efficient computing by centralizing storage, memory, processing and bandwidth (Fig.1).

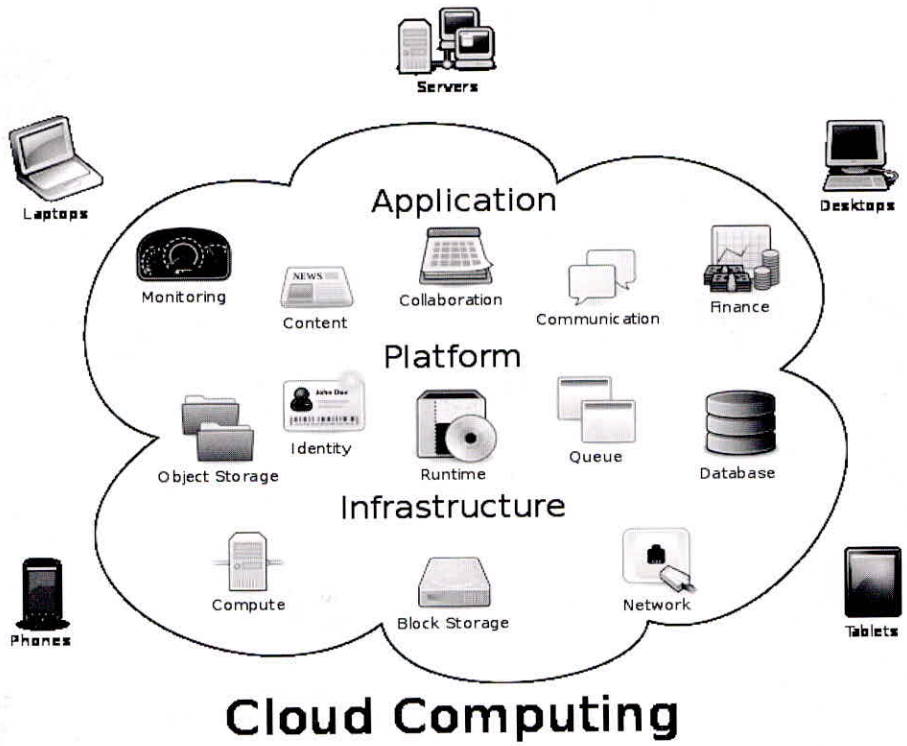


Fig.1. Cloud Computing

WHY CLOUD?

- **Reduced cost:** Cloud computing can reduce both capital expense (CapEx) and operating expense (OpEx) costs because resources are only acquired when needed and are only paid for when used.
- **Refined usage of personnel:** Using cloud computing frees valuable personnel allowing them to focus on delivering value rather than maintaining hardware and software.
- **Robust scalability:** Cloud computing allows for immediate scaling, either up or down, at any time without long-term commitment.

CLOUD BASED SERVICE DELIVERY (CBSD)

"*Any service that is provided via the cloud*". Cloud application services or "Software as a Service (SaaS)" deliver software as a service over the Internet, eliminating the need to install and run the application on the customer's own computers and simplifying maintenance and support (Fig.2).

DEPLOYMENT MODELS

The cloud model promotes availability and is composed of five essential characteristics, three service models and four deployment models (Fig.3).

Public cloud

A public cloud is one based on the standard cloud computing model, in which a service provider makes resources, such as applications and storage, available to the general public over the Internet. Public cloud services may be free or offered on a pay-per-usage model.

Community cloud

Community cloud shares infrastructure between several organizations from a specific community with common concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third-party and hosted internally or externally. The costs are spread over fewer users than a public cloud (but more than a private cloud), so only some of the benefits of cloud computing are realized.

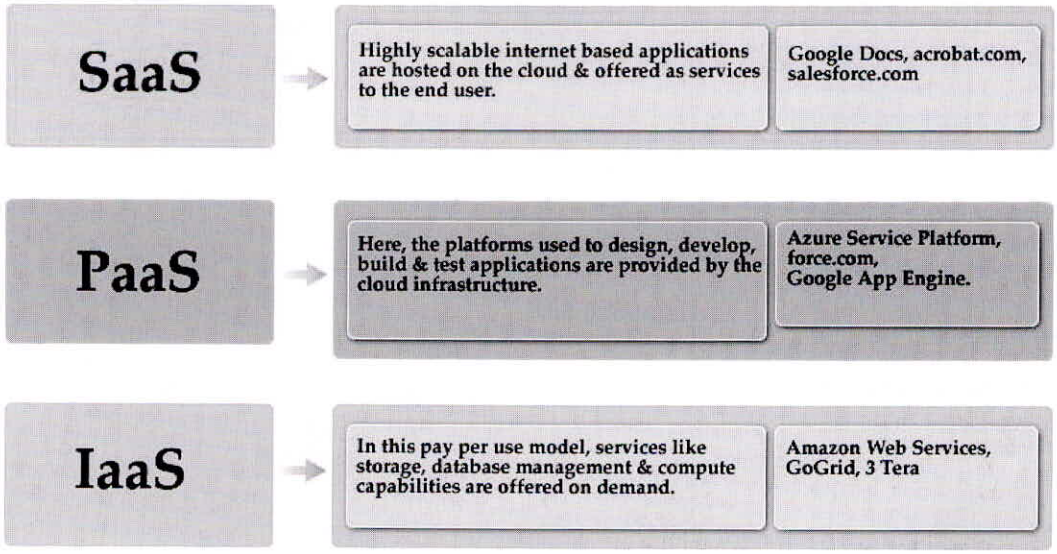


Fig.2. Cloud computing layers embedded in the "as a Service" components

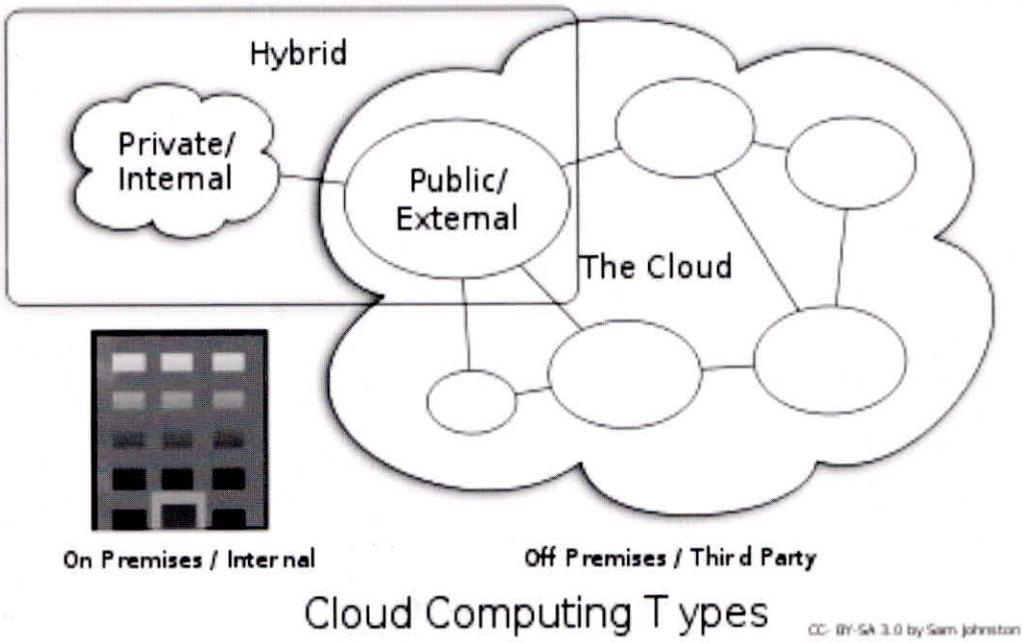


Fig.3. Different Types of Cloud computing

Hybrid cloud

Hybrid cloud is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together, offering the benefits of multiple deployment models. It can also be defined as multiple cloud systems that are connected in a way that allows programs and data to be moved easily from one deployment system to another.

Private cloud

Private cloud is infrastructure operated solely for a single organization, whether managed internally or by a third-party and hosted internally or externally.

On-premise Private Cloud: On-premise private clouds, also known as internal clouds are hosted within one s own data center. This model provides a more standardized process and protection, but is limited in aspects of size and scalability. IT departments would also need to incur the capital and operational costs for the physical resources. This is best suited for applications which require complete control and configurability of the infrastructure and security.

Externally hosted Private Cloud: This type of private cloud is hosted externally with a cloud provider, where the provider facilitates an exclusive cloud environment with full guarantee of privacy. This is best suited for enterprises that don t prefer a public cloud due to sharing of physical resources.

WATER RESOURCES PLANNING AND MANAGEMENT -"SOFTWARE AS A SERVICES" (WRM SAAS)

This paper discusses the deployment of Water Resources Planning and management software's

functionalities as a service over the internet. Instead going for costly license purchases, software is simply leased for a particular range of usage. Users are given the individually required functions and the desired degree of support without having to pay for software components not actually being used. The WRM SaaS are available in the industry and can be considered to be implemented at Data Centre for the allowing the access to variety of users.

In addition, WRM SaaS can also be deployed much faster than licensed purchases across organisations, eliminating need of client-side pre-installation tasks and physical installations which are no longer required. This means that WRM SaaS can be made available quickly. Furthermore the concept provides users with maximum flexibility without the need for long-term commitment. The software is leased and deployed on demand for particular projects only. Due to its flexible and manageable 'pay per user' pricing structure, WRM SaaS shall be applicable even for smaller users like universities, research institutes, and engineering companies all over the world, who need a professional and reliable software system for intensive processing of internal as well as external data.

WRM SaaS as a Service can provide the user with a comprehensive hydrological work station. In addition, it also offers the rating curve for the collection of flow measurement data from regular and irregular sections. Complex tasks in accordance with the stage-fall method, discharge hysteresis etc can be solved.

Typically WRM SaaS can be used in following application:

Meteorology

- Management of all relevant parameters (e.g. precipitation, air pressure/emperature/ humidity, wind, evaporation)
- Rainstorm evaluation
- Spatial interpolation and areal precipi-tation

Hydrological

- Process heterogeneous measuring networks (gauge, ultrasonic, back-up systems)
- Manufacturer-independent parallel data polling
- Flow measurement and rating curves Groundwater
- Management of all relevant parameters (e.g. dip measurement, absolute/rela-tive water level, flow capacities/rates)
- Compare measuring data with surface water and precipitation
- Hydrogeological data

Flooding

- Information and alarm management
- Automatic measuring network
- monitoring
- Notification templates
- Various media (email, fax, telephone, SMS, GSM)

Water quality

- EU water framework directive
- Import sampling point data from Excel and LIMS
- Threshold and comparison lists
- Graphical presentation of quality data for the general public

Further fields of application

- Flow measurement
- Rating curves
- Reservoirs
- Urban hydrology
- River catchment management

WRM-SAAS: GLOBAL ARCHITECTURE

The Global Architecture can be explained with above diagram (Fig.4). The WRM SaaS can be deployed for any users dealing with daily work involve managing measuring water networks, data capture or evalua-tion. It is very useful for the hydrological measur-ing networks or in the fields of meteorology, groundwater monitoring, flood forecasting and alarming, water quality control, urban hydrology, reservoir operation or dam safety. The WRM SaaS therefore has got capability to serve in variety of department and user agencies, and being hosted either in Public/ private or Hybrid Cloud. In every field of application, this unique technology converts the complexity of hydrological data and tasks into pure efficien-cy, making less workload to the Scientist Community and increase in the quality information.

The software shall be able to capture the data, process and archive it. The time series engine powers all desirable data processing operations in WRM SaaS viz checks and corrections, aggregations, analyses, and forecasts. It shall form the processing module of WRM SaaS, uniting all functional logic in a single component. It shall be capable of rapidly creat-ing plainly understandable and directly useful results in clear graphs, tables and appropri-ately formatted reports. Particularly careful thought has gone into the user interface for the its presentation module. Time series and meta data are maintained securely in a central database, managed by the persistency module. Data access from remote workstations is subject to user management control, security and safety data and application.

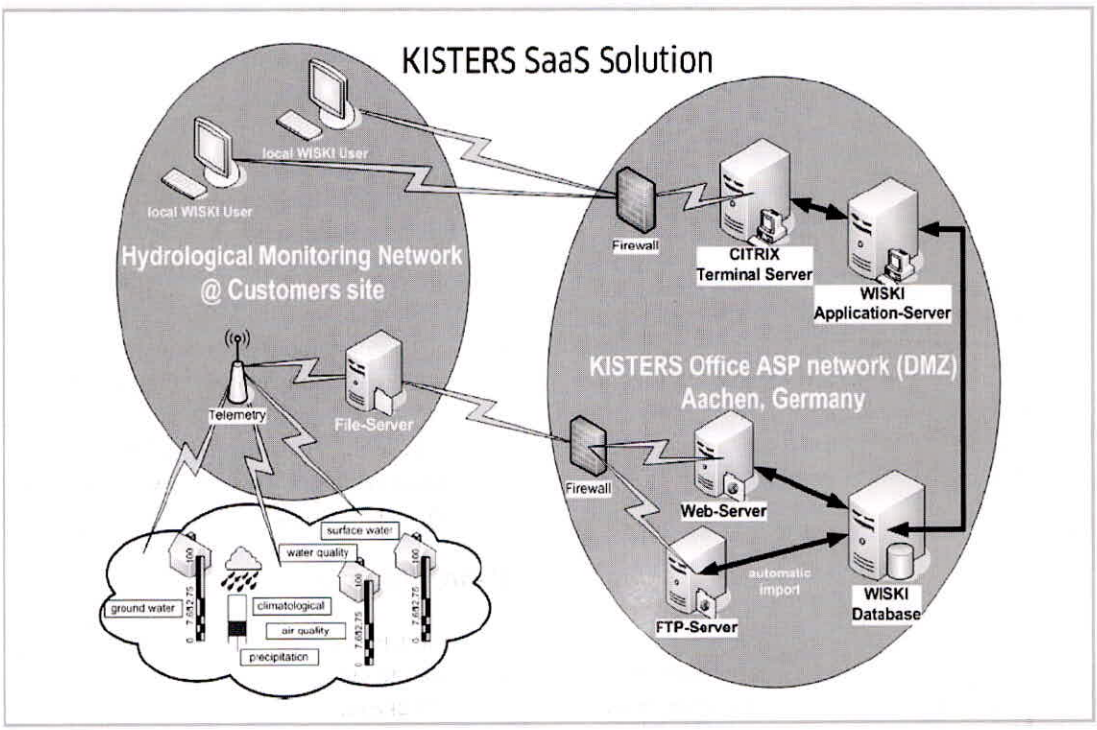
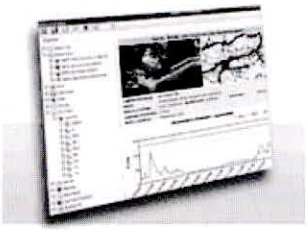
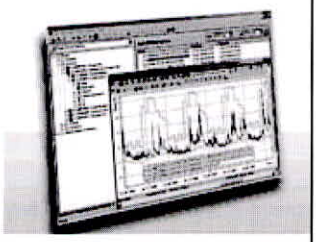


Fig.4. Global Acchitecture of WRM-SaaS

		
Data loggers and sensors Water level, flow, precipitation, etc. **Telemetry** Telephone, mobile, satellite, internet, etc. **External data sources** Control systems, GIS, databases, internet **File import** Flow measurement devices Current meters, sensors, ADCP **Manual capture** PDAs and handhelds, web interfaces **Historical data** Lists, archives, files, gauge charts		**Reports, lists, yearbooks** **Data forwarding and export** **Clear data display and processing in graphs and tables** **Data validation and quality management** **Alarm management** **Statistics, measurement values and trend analyses** **Internet communication**

The few advantages WRMSaaS can be summarised as below:

1. High-performance data management system with broad application flexibility and unlimited scalability combined with security and reli-ability,
2. state-of-the-art technology and a future proof design
3. No costly license purchase for variety of users, industry and research and scientific communities.
4. Integration with varied data acquisition devices (full automation) and scalability.
5. Option of Private/Public and Hybrid Cloud

DATA MANAGEMENT

On the order of 20 percent of the budget allocated for the monitoring program should be reserved for data management and data analysis activities. Failure to plan for these costs can result in the loss of information due to inadequate data preservation and limited analysis of the monitoring data that are collected.

Collecting Data is Expensive - It costs lot of money to run an average monitoring station for a year. It is important to protect this investment. Data is valuable - Reliable data is essential to manage water resources effectively. It is important to get the most out of your data.

Data Management - To get the most out of your data you need a system in place to provide quick and easy access to all of your data. For small amounts of data you could use Excel. When you have to deal with large amounts of data you may encounter special problems that need a specialized solution.

Managing large amounts of Data-

Some common problems with managing large amounts of data are:

- consolidating data from different sources
- combining different types of data
- keeping all of your data online and accessible
- analysing data quickly
- integrating different systems
- assessing the quality of your data

A good data management system must address following:

- Provide quick and easy access to all of your data- The database shall store data efficiently reducing the amount of storage required and improving the speed at which it can be processed. It should keep tens of thousands of station years of data on a local hard disk and analyse a year of continuous data
- Consolidate data from different sources- import data from a variety of sources including any data logger, digitized charts, telemetry systems and spreadsheets.
- Consolidate different types of data- to combine your time-series data, water quality data; groundwater bore information and geographical information into a single integrated archive.
- Provide facilities for editing and reviewing data- data would always be clean and accurate but in reality data needs to be reviewed after it is collected and often edited
- Allow you to assess the quality of your data via WRM SaaS
- Make it easy to publish data from your archive through Web
- Store other information related to your data- supporting information including Station Details, Rating Tables and Shifts, Gauging Measurements, Instruments, Cross-Sections, Variable Descriptions, Variable Conversions, Data Quality Descriptions etc.
- Integrate with other systems.

FUNCTIONS OF WRM SAAS

Measuring network management

The hierarchical data model can be configured which means even complex hydrological networks can be represented with clarity.

Data and time series

The diversity of data and a flexible range of applications at point of time and location are made available to variety of users. The interpreted data and interpolatable or not – terms such as these are few functionality one can expect from WRM SaaS. Data validation and correction is carried out comfortably using graphs and tables, and aggregations and evaluations take place auto-matically based on the current data stock.

Calculations and evaluations

One can constitute powerful and adjustable algorithms for data calculation and analysis. Create and register specific automatic calculations, data validations and corrections with software. Analyse the data using statistical methods and create statistics, data exports and reports as necessary.

User management

The User Administration Concept allows to securely control data access through flexible and highly configurable roles and rights. External access is also subject to the full control.

The Explorer

The Explorer facilitates simple navigation through individual data structures and defini-tions of your own data trees. You can access graphs, tables, reports and evaluations directly, key lists and meta data management are com-pletely integrated, and external data sources such as websites can be tied in directly.

Reporting

Individualised and customer-specific reports are the requirement of any system. A range of standard reports can be generated immediately. Modi-fications and custom reports can be created quickly and easily.

Data transfer and telemetry

The comprehensive import and export functionality for time series/recorded value data and meta data is important component of the WRM SaaS. All time series data imports can take place on a continuous and automatic basis or also manually. The telemetry system, consisting of special hard-ware and software for communication tasks, is the requirement for remote data transfer.

Data Quality Code System

It is not just Data but Quality Data that is important. The role of Quality Code System assists to turn data into information. It can manage data quality based on definable quality flags, and remarks and comments.

Flow measurement/rating curves

An application can be integrated to work on regular and irregular cross-sections with current me-ter, sensor and tracer data. rating curve editor, which will offer a diverse range of rating curve types and analysis methods. Fulfil international standards (e.g. ISO, USGS, British and Indian Standards). Complex tasks according to the stage-fall method, discharge hysteresis, USGS stage/date shifts or various backwater methods can be solved easily.

THE WRM WEB

The WRM web can be used to share information on internet. The Web GIS application will support the accessibility of GIS/ maps, time series graphs and tables, meta data, data ex-ports and reports – WRM Web publishes data including flood information and alarms. Different solu-tions for intranets, closed user groups and the general public can also be made integrated with the WRM SaaS.

CONCLUSION

For the effective water resources planning and management, several COTS products & solutions requires are needed including the customization such as large database handling, storage and retrieval, processing and analysis. The client server and web based technology have proven to be milestone development in the water resources, however there is gap across various organization/ users and in public domain for the fullest implementation of the application.

The cloud computing in water resources planning and management is need of the hour for wide application of computing and storage resources, distributed over a wide geographical domain, available from fast and secure networks, providing software as a services, applications and advanced GIS tools.

WRM SaaS is a solution that can process a very large amount of information without adding to each client user's processing cost. It is based on an integrated and collaborative approach where the complexity of the technology is transparent to the user, and interdisciplinary working groups and skills can be enhanced.
WRM SaaS can be applicable for the various users of Meteorology, Hydrology, groundwater, floods, water quality, flow measurement, rating curves, reservoirs, urban hydrology, river catchment management etc.

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