INFORMATION TECHNOLOGY - ENABLED WATER RESOURCES TECHNOLOGY AND MANAGEMENT

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Abstract *As the 20th century came to a close, we were standing at the confluence of three powerful technological forces: computers, telecommunication, and electronic entertainment. This digital convergence is altering the world's economic landscape rapidly and radically. This development has led to the emergence of Information Technology (IT), also referred to as Information and Communication Technology (ICT). Its influence is now all pervading and is felt in every walk of life. IT has been enabling activities in other engineering disciplines, either by the way of improving the manner in which things could be done or by making possible new activities. While civil engineering in general has been quick to assimilate such developments into its methods, techniques and procedures, water resources technology and management have also been significantly impacted by the developments in IT. The prospects are even more exciting and highly promising. In this paper, an overview of selected developments and the outlook for the near future are dealt with.*

INTRODUCTION

The book by Bugliarello and Gunther (1947) was one of the earliest to summarize the role and potential of computers as digital machines in enhancing the way water resources engineering was practiced in the early sixties of the 20th century. Since then computer based modelling has been occupying centre stage in research and development work in this area, even though professional practice has been lagging behind in assimilating these in a significant manner.

The developments in computer hardware and software have been closely spawning newer ways of dealing with water resources and environmental problems over the past four decades. Starting with methods to exploit the huge main frame computers, the revolution has led to prospects and notable practices of many new applications in all the phases of life-cycle of water resources projects, including planning, conflict resolution, design, project construction management, operation and maintenance and even decommissioning. Since water resources projects, by their very nature, cover a large spatial area and as the processes involved are dynamic; condition-sensing, monitoring, telemetering have been essential component activities. Huge data collection, storage and processing, both off-line and on-line have been natural requirements. In these activities any new developments in sensor-technology, and communication technology were being closely followed and availed. The most recent significant phenomenon is the emergence of the internet and World Wide Web and these are now offering exciting possibilities. Thus, the water resources (research) community has been busy developing many applications, based on the various advances in computer science.

Such advances include Artificial Intelligence, Expert Systems and Decision Support Systems. Under the umbrella of 'Soft Computing', approaches based on Fuzzy Logic, Artificial Neural Networks, and Evolutionary Computing have obtained great patronage by almost all branches of engineering including water resources engineering. Interesting possibilities using Parallel and Distributed processing methodologies are also being actively pursued. An account of these developments has been collectively presented by Nagesh Kumar and Barai (2000).

As regards data generation, transmission and capture, from the humble beginnings of manual recording of sensor-readings, into simple data bases, the transformation has been through automatic data collection, wireless transmission into relational, and object oriented data bases, which then flowered into information systems. The emergence of Geographic Information System along with Remote Sensing Technology, especially satellite-based, has brought in a new era in water resources engineering and management activities. Currently, multimedia potential and Web-based methodologies offer very interesting possibilities in training, condition monitoring and controlling multi unit water resources systems in more efficient and environment –friendly manner. The concept of "Virtual Engineering" would be very appropriate for water resources and environmental systems too.

In the subsequent paragraphs, we consider selected developments and glance at the state-of-the art in some of them.

WATER DISTRIBUTION SYSTEMS

The water resources industry is one of the first to recognize the benefits of availing computer technologies. Since the 1970s, computers have been used in the urban water supply and distribution system. Computer usage has been in the form of Supervisory Control and Data Acquisition (SCADA), Geographic Information System (GIS) and Relational Data Base Management System (RDBMS) to store asset data, to ensure efficient operations, to respond effectively to emergencies, to plan and execute corrective and preventive maintenance activities and besides these for commercial acts like customer billing and public relation. There exist a number of urban systems that have installed central control rooms which receive very large amount of telemetry data as part of the operational management.

An Existing System

The United Water IDAHO (Cameron et al, 1999) has successfully integrated GIS, SCADA and Network Analysis System (NAS). The linking of SCADA and NAS facilitates monitoring of the hydraulics throughout the system and helps in deciding pumping strategies guided by pressure and water quality scenario. The GIS manages the asset database and graphics display. The SCADA system receives data from local stations and concentrates into vital information for system control. The NAS simulates the water quantity and quality variations resulting from operational decisions. This facilitates the system operator to have a complete overview of the network and to investigate the consequences of different operating actions prior to selecting the best course of action.

With the help of French Company SAFEGE, the integration as shown in Fig.1 has been carried out for the city of Boise. The resulting integrated system is quite sophisticated and is called as Piccolo Real Time. In 1996 the system's capabilities were limited to on-line snapshot simulations and it has since been extended to on-line extended-period simulation. The IT enabled system (Cameron et al, 1999) is found to be very helpful in the following ways:

(i) As an *automatic super sensor*, that provides the operator an instant view of the networks in terms of pressure, flow and quality;

(ii) As a *training simulator* for training the operators in better management of the network by displaying the consequences virtually in real-time as affected by pumping strategies and various valve operations;

(iii) As a *super-automation* for extended period operations; and

(iv) As a *crisis-assistant* that helps in managing critical situations by detecting hydraulics malfunctions through alerts of deviation from acceptable reservoir level and/or pressure condition over the network.

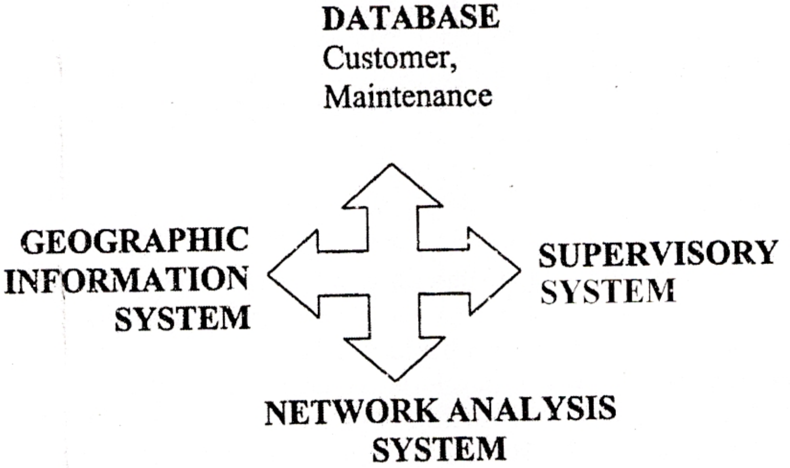

Fig. 1 Integrated database for water distribution system

A System Under Development

Morris (1999) explains the issues of an effective integrated operation for water network control. The computer hardware, software and telemetry system should be based on the best available entities. Building the integrated system should be made up of 'open product' so as to avoid getting struck up with proprietary product. Figure 2 gives a list of issues that should be decided before real design work commences.

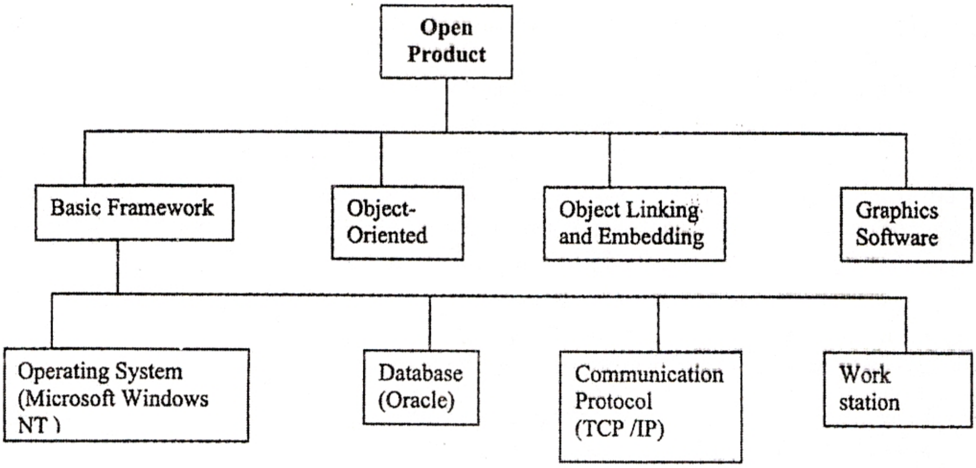

Fig. 2 Open products components

FLOOD FORECASTING AND CONTROL

Schultz (2000) discusses in a comprehensive manner the potential of modern data types in managing water resources system. As one of the applications, real-time assessment and forecasting of flood and its control are dealt with in the frame work of using appropriate computer systems, software, data acquisition and telemetry systems. A typical example of the use of real-time flood control in a river basin is shown in the Fig. 3.

An Existing System

(a) The flood forecasting system described by Schultz was customised for a portion of the Danube River. In real-time the area rainfall measurement is achieved with the aid of ground-based weather data. First, a measured radar echo (active micro-wave) is transformed into areas rainfall and then into a flood hydrograph forecast for the near future with the aid of distributed system rainfall-runoff model. The dams or flood protection reservoirs can be operated based on the forecast results. For this purpose, it is necessary to have available spatially distributed, real-time rainfall intensities as well as a rainfall forecast for the next several hours. From the radar images, the rainfall intensities in time and space can be derived and using distributed rainfall-runoff model the runoff hydrograph can be obtained. The quantitative perception forecast will give forecast for next several hours.

(b) An interactive flood forecasting and flood routing simulation model for Gandhi Sagar Reservoir has been developed, which is based on an on-line acquisition of recorded and forecasted rainfall data. The use of ArcInfo, the popular GIS package, for the Gandhi Sagar Catchment system has been very well demonstrated.

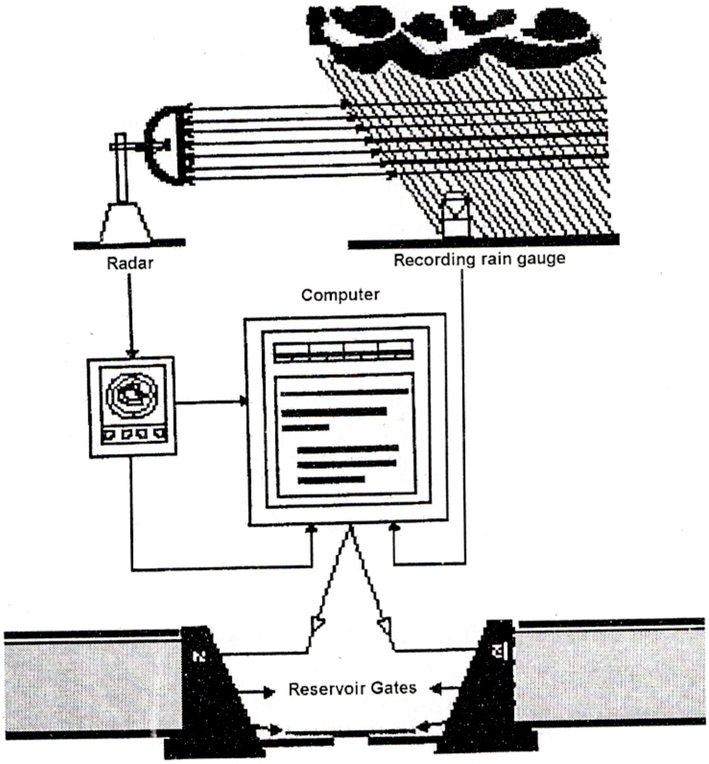

Fig. 3 Reservoir operation based on real-time flood forecasts with the radar rainfall-measurements (Shultz, 2000)

A System Under Development

Under the Hydrometeorological monitoring program, supported by the World Bank, the supply installation, testing, and commissioning of two INSAT satellite based Hydrometeorological Data Acquisition Network was carried out in 1998 by Sutron Inc, one network each in the Chambal River basin and in the Narmada basin. The networks include Data Collection Platforms (DCPs), sensors, a Digital Direct Readout Ground Stations (DDRGS), system software and training for the personnel of Engineering Department dealing with the Chambal River Basin. The project enables collection of data for flood forecasting and warning systems for dams located on the Chambal River upstream of Kota, based on real-time data collection from remote sites through sensors and satellite based data communication system.

DISTRIBUTED INFRASTRUCTURE MODELLING

The development and adaptation of Internet have made drastic improvements in the development of distributed information management and control systems. The client/server paradigm of the Internet has enabled a number of important innovations in the way that Decision Support System (DSS) can be designed and implemented. In conventional decision support system, it depends on single or predefined source of data. But in Internet, the hardware and software need not be confined to predefined location. Because of these innovations, the communications infrastructure provided by the Internet becomes a robust and reliable vehicle for supporting distributed infrastructure modelling. Herein implied is a decision support environment in which models, data, and users for a given application need not to be collocated in time or space.

Wallace et al. (2001) have adopted the distributed modelling system that incorporated extended Internet functionally in managing the coastal infrastructure. In Coastal Infrastructure Modelling System (CIMS), using boundary condition information obtained from real-time data sensors the surface water velocities in sections of Lake Michigan was evaluated. The data was collected through the USGS stream flow sensor, a NOAA water surface elevation sensor and a NOAA wind and wave buoy. The manager response is sent to the controlling server. The output, hydrodynamic analysis data, are formatted to suit GIS and the visualization tasks are performed.

SCADA Versus Distributed Infrastructure Monitoring System

Conventional distributed infrastructure monitoring system is based on SCADA, in which a controlling computer hosts the application software (DSS) and it directly controls data sources from different locations using different connection technologies. Its general structure is shown in Fig. 4. Use of this system, including use of associated data sources, is confined to a single user or application at any one time and this is suitable to application that has low tolerance for failure.

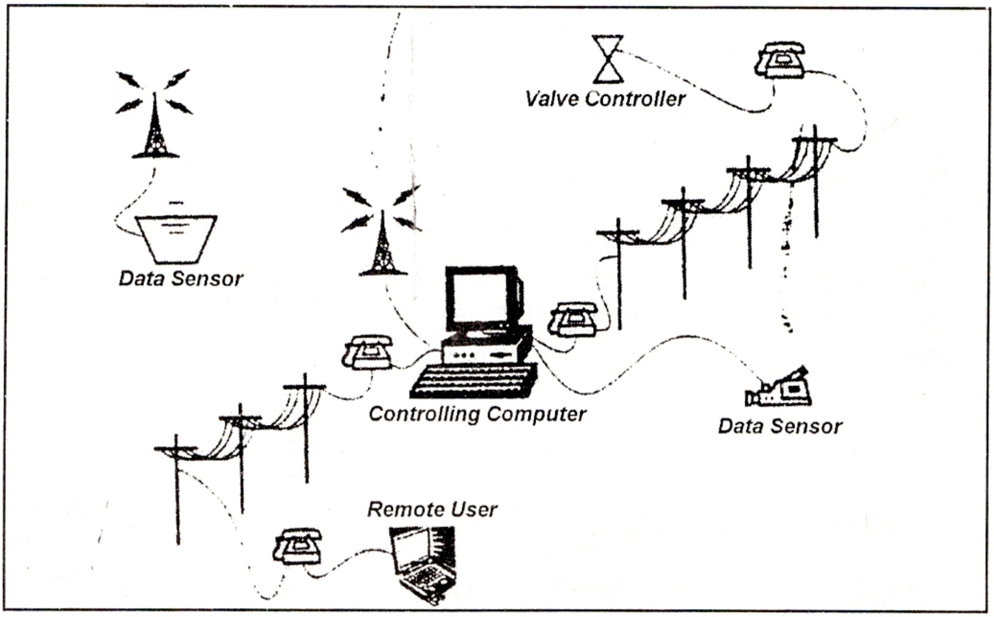

Fig. 4 General structure of SCADA (Wallace, 2001)

In distributed infrastructure modelling the communication between processes is connectionless as shown in Fig. 5. Client/server communication protocols allow access to remote services. (Cameron et al., 1999). This approach holds great promise in the near future for water resources engineers.

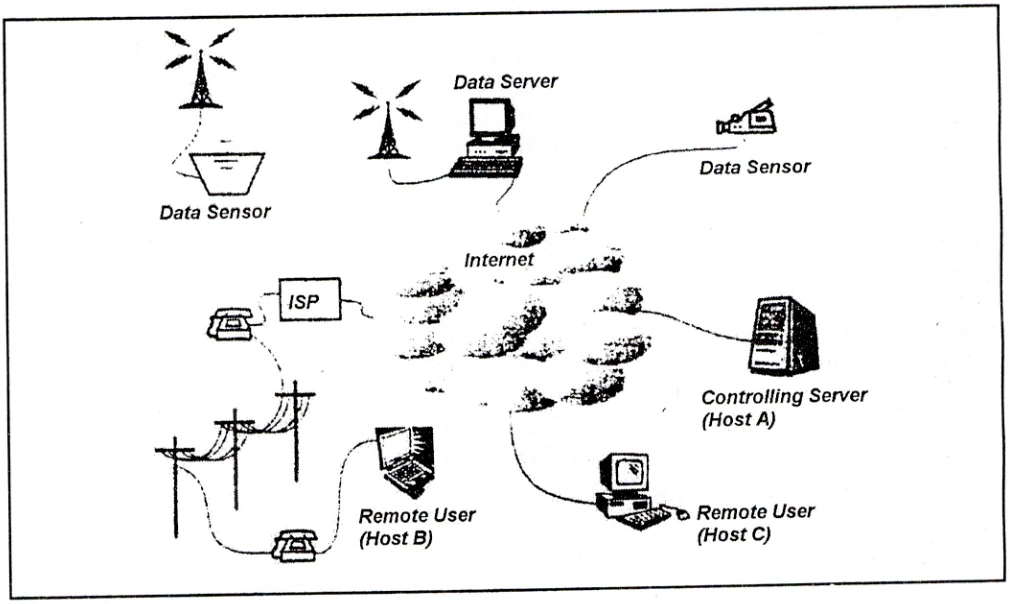

Fig. 5 General structure of connectionless client/server computing architecture (Wallace, 2001)

Proposed System

An interesting proposal for a National Spatial Data Infrastructure has been reported by Narayanan (2001), which envisages a grandiose integration of data bases from at least ten National agencies, including the satellite systems under IRS and INSAT. The agencies that are expected to participate and contribute to this effort include the Survey of India (SoI), National Remote Sensing Agency (NRSA), Forest Survey of India (FSI), Geological Survey of India (GIS), Central Ground Water Board (CGWB), Ministry of Water Resources (MoWR) and agencies preparing soil maps, urban maps and other cadastral maps. This would go a long way in improving the planning and operational management of water systems in our country.

OUTLOOK

There seems to be a lot of wisdom in the expression "IT *in* everything, but IT *is not* everything". When judiciously identified and innovatively adopted, Information Technology can be of significant advantage in improving water resources technology and management.

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INDIAN NATIONAL COMMITTEE ON HYDROLOGY (INCOH)

(IHP National Committee of India for UNESCO)

Constituted by the Ministry of Water Resources in 1982

INCOH Publications

Publication of Jalvigyan Sameeksha Journal

To disseminate information and promote hydrological research in the country, INCOH brings out the bi-annual Journal '*Jalvigyan Sameeksha*' (Hydrology Review Journal). The papers published in the Journal are by invitation only. The Journal is widely circulated to all organisations and agencies dealing with water sector.

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IHP-VI activities

India is actively participating in the IHP-VI activities and has chalked out a detailed program in accordance with IHP-VI themes towards preparation of reports, taking up research studies, organisation of seminars/symposia at national and regional level, promotion of hydrological education in the country, establishing nodal point for implementation of G-WADI program of IHP, UNESCO, for arid and semi-arid regions of South and Central Asia, and HELP basin program for India. It is envisaged to participate in all the relevant and feasible programs identified under the various focal areas of IHP-VI as given below.

India's participation in IHP-VI programs

Focal Area	Integrated assessment of water resources in the context of global land based activities and climate change
Focal Area	Extreme events in land and water resources
Focal Area	Dry lands
Focal Area	Public awareness raising on water interactions
Focal Area	Continuing education and training for selected target groups

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