MIKE FLOOD WATCH – Managing Real-Time Forecasting

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Abstract

The human and economic losses caused by floods worldwide have increased dramatically over the recent decades. Experience has shown, however, that the losses can be significantly reduced if ample warning is given. The time available from heavy rainfall or snowmelt begins till the flood occurs is often short, so it is important that the forecast calculation and warning dissemination is carried out as quickly as possible. DHI has developed flood forecasting systems for more than 20 years and has continuously aimed at improving the applied models and software. Recently, a new generation of the GIS-based MIKE FLOOD WATCH has been released. This is a robust forecast management system, which automatically collects all required data and information, performs data checking, runs forecast models and issues forecasts and early warnings. The paper describes the system and provides an example of a recent application in Bangkok.

Introduction

Twenty years have passed since the first DHI flood forecasting system became operational. This was in Maithon, India, where the MIKE 11 models even today provide accurate forecasts of inflow to the reservoirs. Flow forecasting systems have been established in more than 20 countries worldwide since then, and DHI has continuously developed and refined the applied software to meet various challenges and client demands. The main objectives of this development have been:

- The forecast procedure must be **fast**, and should therefore be as automatic as possible**.** The procedure includes collection of data and weather forecasts information, data checking, calculation of forecasts, presentation of results, and issue of warnings when required.
- The results must be **accurate**, as minor differences can have major impact, e.g. whether the water level is expected to be above or below the level of embankments
- The system must be **reliable**, as important decisions on evacuation or changed dam operations are taken on the basis of the forecasts. The user must be able to count on the system to produce forecasts under any condition and with a consistent accuracy.
- The issued information and warnings must be **meaningful** and to the point, so that appropriate emergency action is taken. It may be necessary to provide different information to different target groups.

In addition to strengthening the forecast accuracy, see e.g. Madsen et al 2003, a significant effort has been made over the years to meet these objectives. Focus has been on developing a flood forecasting management system - the MIKE FLOOD WATCH, see e.g. Ammentorp et al. 1998, which is further described in the following.

System Description

MIKE FLOOD WATCH is a decision support system for real-time forecasting that integrates data management, monitoring, forecast modelling tools and dissemination methodologies in a single, user-friendly environment (ESRI ArcMap GIS). Operationally, it can run automatically, manually or as a combination. Moreover, it can be customized using built-in Visual Basic scripting facilities.

The system can be used to manage and examine data imported in real-time from a range of external sources, including point observations and grid-based data from weather models and radar and satellite imagery (refer Figure 1). The user can specify quality control procedures for each data stream and link to common commercial database engines. The system supports a range of modelling tools from different suppliers, including 1D and 2D hydrological and hydraulic forecast engines and models with an environmental focus.

The system includes a scenario management tool that makes it possible to carry out comparative assessments, get immediate answers and respond accordingly. The user can identify key information and customize the flow and the presentation of this information. User-defined information such as vital forecast results and observations can be disseminated either manually, as part of a scheduled task or on an event-driven basis. Typical dissemination tasks include the following:

- Scheduled uploading of observed and forecasted time series and key results to a web server
- Scheduled notification of flood managers by e-mail or SMS, typically key forecast results
- Event driven notification of flood managers, typically in the early stages of a coming flood

The MIKE FLOOD WATCH system has been installed in numerous countries worldwide to meet specific client needs. The system is typically used by regional and local river basin authorities to provide real-time forecasts in areas prone to flooding and to issue early, potentially life saving, warnings to flood response managers and the vulnerable population. Typical applications include:

- Real-time monitoring and decision support
- Real-time flood forecasting and warning
- Control of dams, reservoirs and hydraulic structures
- Dissemination of real-time flood data, flood maps and flood response actions
- Water resource and environmental monitoring
- Long term forecasting

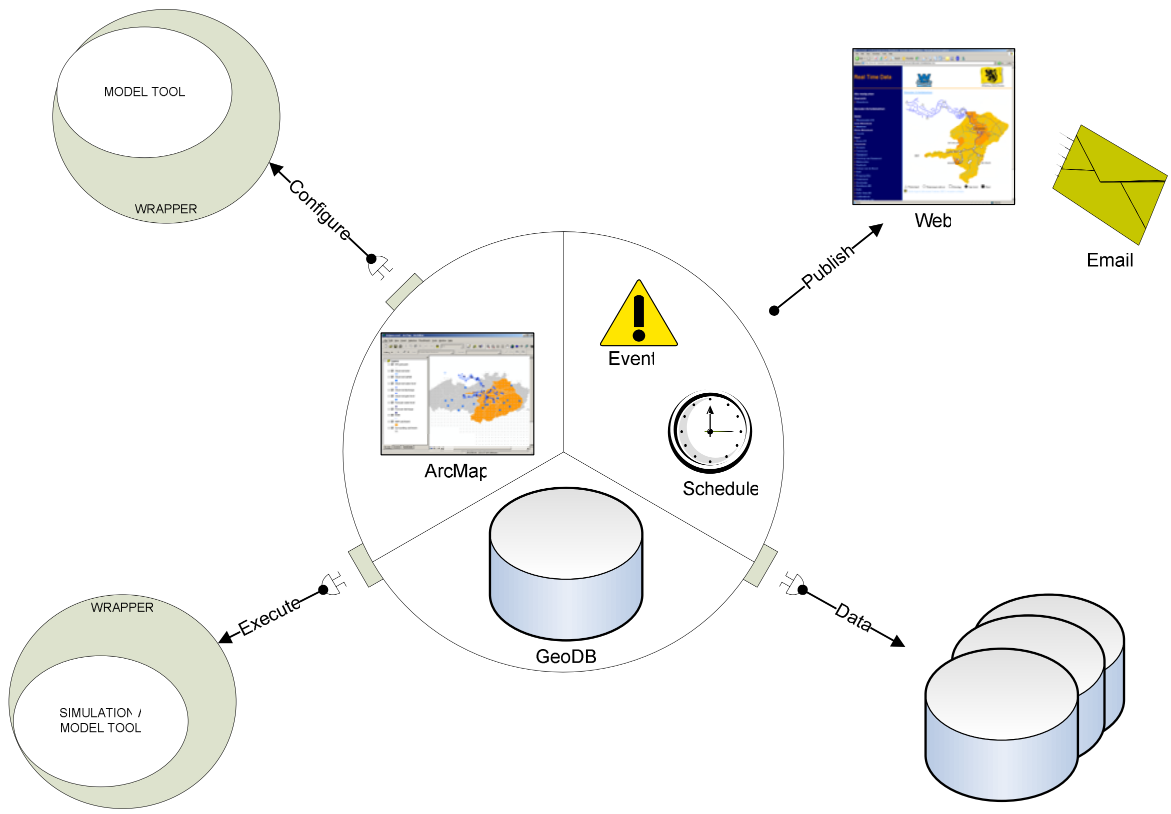

Figure 1 Conceptual system layout

Applications

Different examples of application may be found in the list of references. Here, we will focus on the city of Bangkok, which is prone to flooding. In the monsoon season, May - October, the surface runoff associated with heavy showers causes inundation of inhabited villages located in the vicinity of the khlongs (canals).

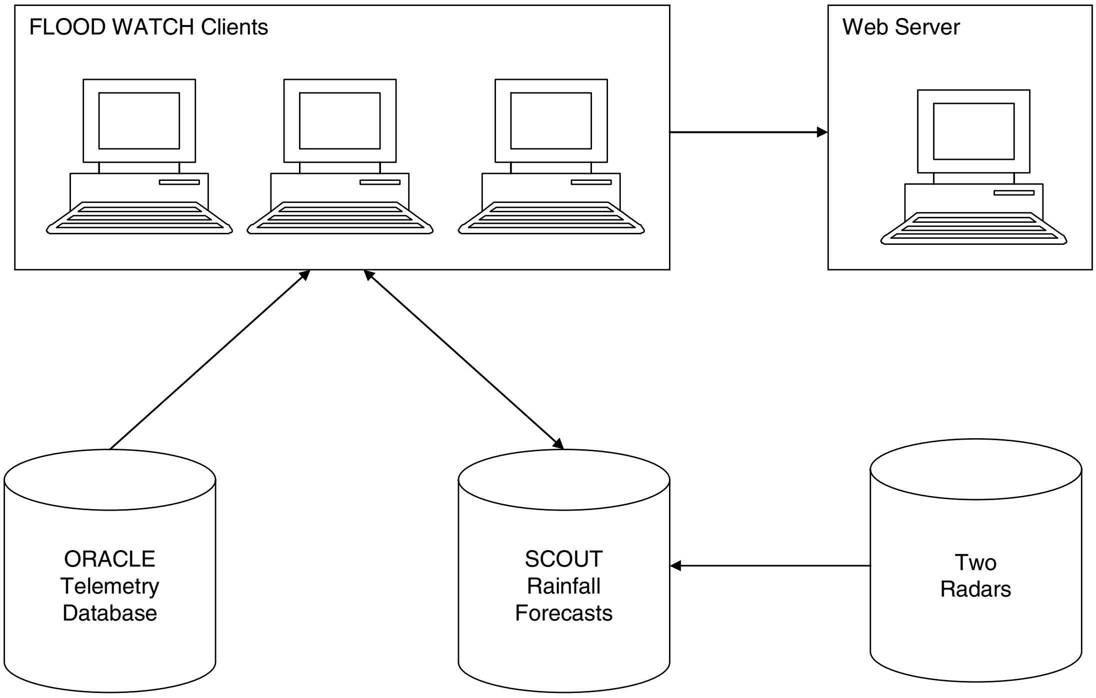

Figure 2 Hardware set up

In 2004-2005, DHI Water & Environment was commissioned by TEAM Consulting Engineers of Thailand to install a real-time flood forecasting system for the Bangkok Metropolitan Administration (BMA) to provide fast and accurate flood forecasts in Bangkok and issue early warnings to BMA flood managers and the population.

In order to meet this objective, a cluster of three FLOOD WATCH forecast PCs was installed on site to safeguard the redundancy of the system and facilitate flood mitigation assessments during periods of heavy rainfall (refer Figure 2).

Real-time telemetry data stored in an ORACLE database is passed to the FLOOD WATCH cluster every 15 minutes to keep the forecast system updated. The telemetry database comprises of point observations at 110 rainfall stations, 105 water level stations and five discharge stations. Prior to insertion into the FLOOD WATCH database, the data is subjected to rigorous quality assurance and processing.

In addition to point based observations, grid based rainfall forecasts are imported from the SCOUT rainfall forecasting system. Using point based rainfall observations and rainfall images acquired by two radars in Bangkok, the SCOUT system issues a short term rainfall forecast, which is subsequently used by the flood forecasting model.

In the operational mode, flood forecasts are issued automatically every three hours, with a hindcast period of three hours and a forecast period of six hours. The flood forecasting model comprises of the following modules:

- An urban rainfall-runoff module (RR)
- A hydraulic river module (HD)
- A flood forecasting module (FF)

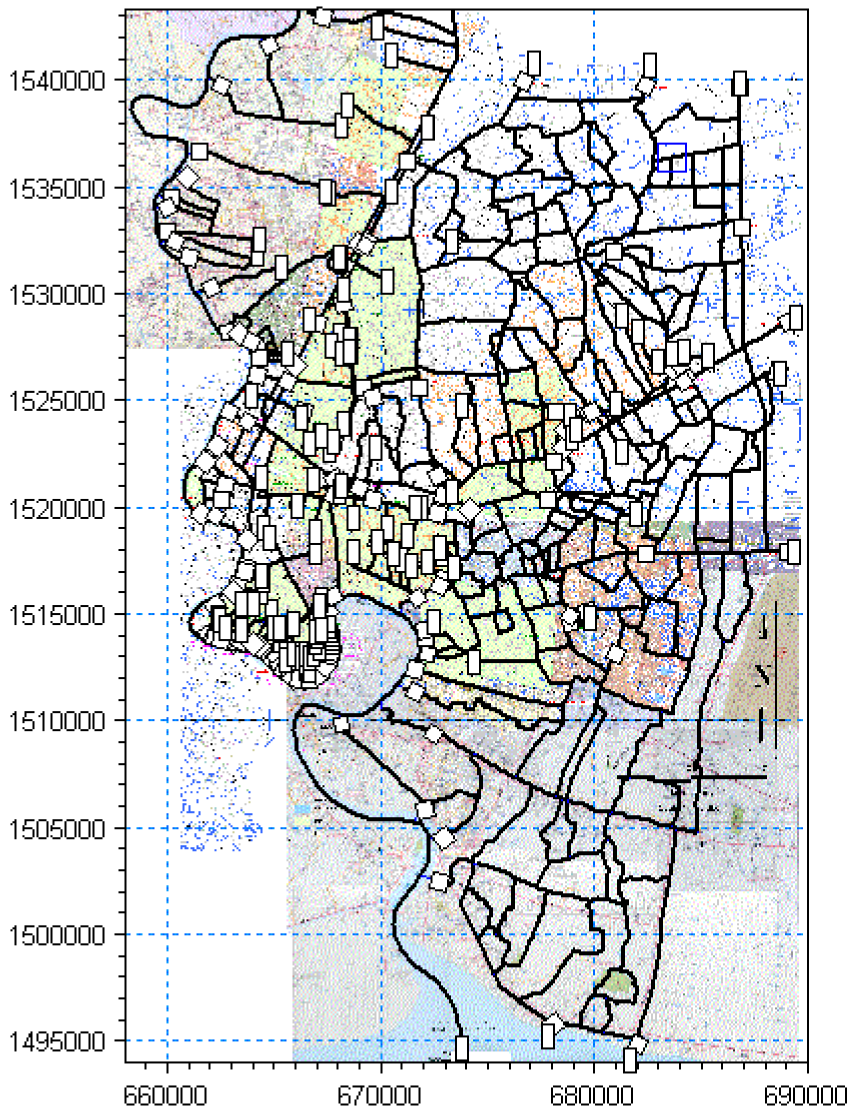

Figure 3 Forecast model. Legend: ▯ hydraulic boundary; ◇ hydraulic structure

An overview of the schematised model is given in Figure 3. The RR model is used to simulate the surface runoff in the area, wich covers about 650 km^2, while the HD module is used to simulate the discharge and water level of more than 400 khlongs in the city, including the dynamic operation of more than 200 hydraulic structures, notably pumps and gates (Figure 4).

An updating module, which is based on a data assimilation framework incorporated into MIKE 11 (Madsen et al., 2003), is used to match observed and simulated water levels in the hindcast period (i.e. prior to the time of the forecast) and enhance the simulated results in the forecast period (i.e. after the time of the forecast). A total of 67 update locations have been inserted into the hydraulic model, typically on each side of the main pumps and gates.

The pumps and gates of the khlongs play an important role in protecting the city against urban flooding, which is normally a result of one of the following:

1. A storm surge in the Gulf of Thailand combined with a high tidal water level
2. Severe rainfall in the area, which causes rapid (surface) runoff to the khlongs

A number of gates and pumps have been constructed at locations where the main khlongs discharge into the Chaophraya River, cf Figure 4. During periods of extreme water levels in the Chaophraya River (Item 1 above), the pumps and gates are used to seal off the vulnerable villages from the floodwater in the Chaophraya River, whereas in periods of severe rainfall over the city (Item 2 above), the pumps are used to provide flood alleviation in the villages.

In addition to serving as a flood protection scheme, the pumps are used during low flow conditions to flush the khlongs, hence reducing sedimentation and increasing water quality. As such, the structures serve a number of purposes, all of which are taken into account when deciding upon a given structure operation strategy.

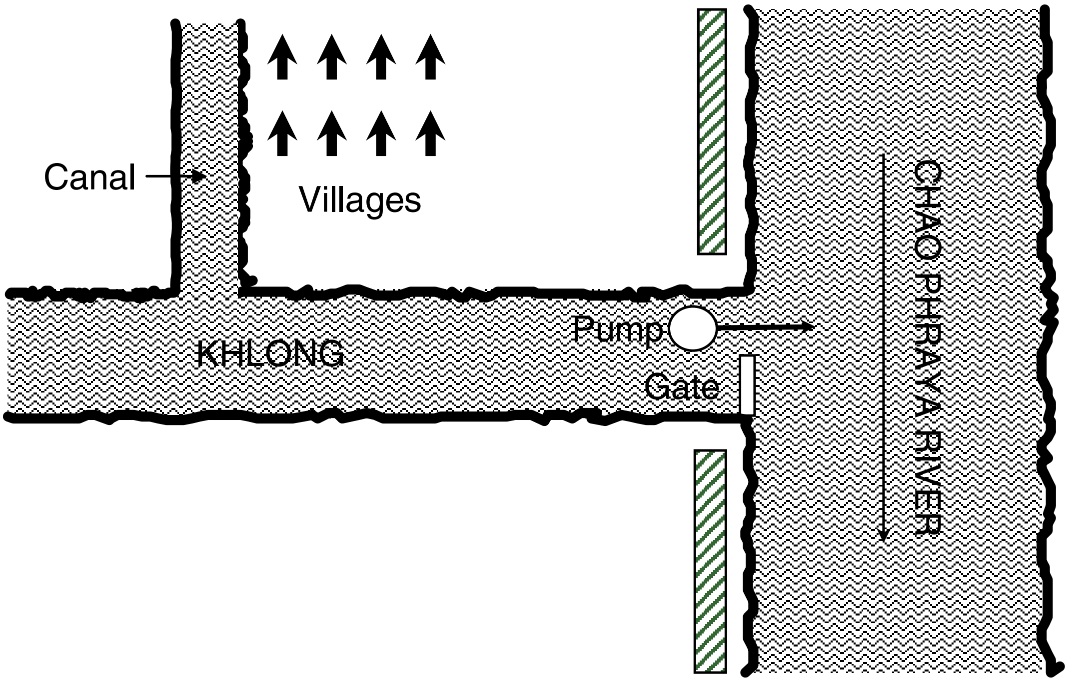

Figure 4 Typical layout of hydraulic structures in the centre of Bangkok

Owing to the fact that the BMA operates a large number of hydraulic structures, each with different objectives, it is difficult and indeed not feasible to set these manually. Consequently, the MIKE FLOOD WATCH system was configured to decide upon an appropriate structure operation strategy using a predefined set of rules for each hydraulic structure (Figure 5) and the current physical state of the system. Consequently, the system serves actively as a decision support tool assisting the flood managers in their effort to reduce the impact of a coming flood.

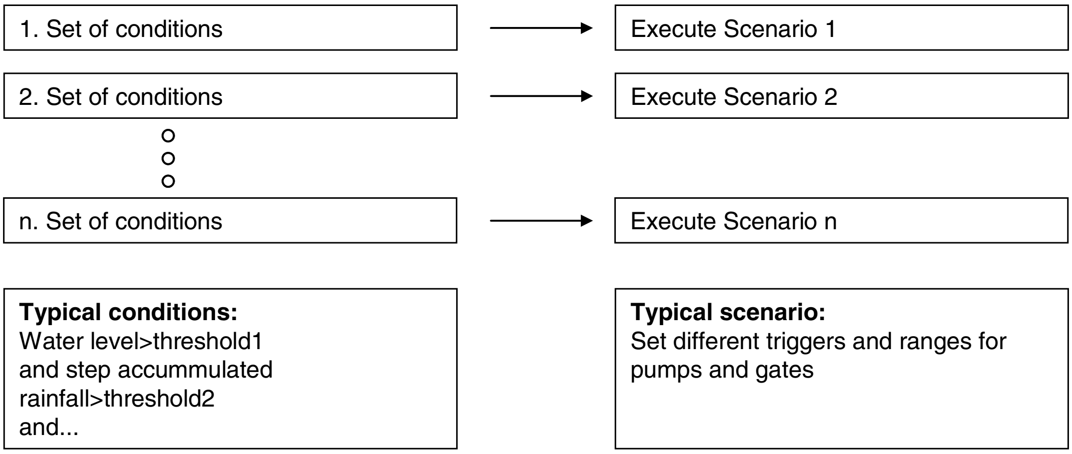

Figure 5 Selection and execution of appropriate flood forecasting model scenario based on a set of physical conditions in the hydrological and hydraulic system

Conclusions

A flood forecasting and warning system consists of a number of elements, which all play an important part in the chain of actions from the first weather forecast indicating heavy rain or snowmelt to the time when emergency action is initiated. The chain must be strong and the actions fast.

A sad example of a missing link in the chain was seen in December 2004. Although a tsunami warning system did not exist, there were a few people in the world who actually knew what might happen, one or two hours before the disaster struck. The problem was, however, that no lines for disseminating such information had been defined.

MIKE FLOOD WATCH has been developed to control all the elements of a forecasting and warning system automatically, from data collection to dissemination of warnings. It has proven to work fast and efficiently, making as much time as possible available for saving people and property.

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