

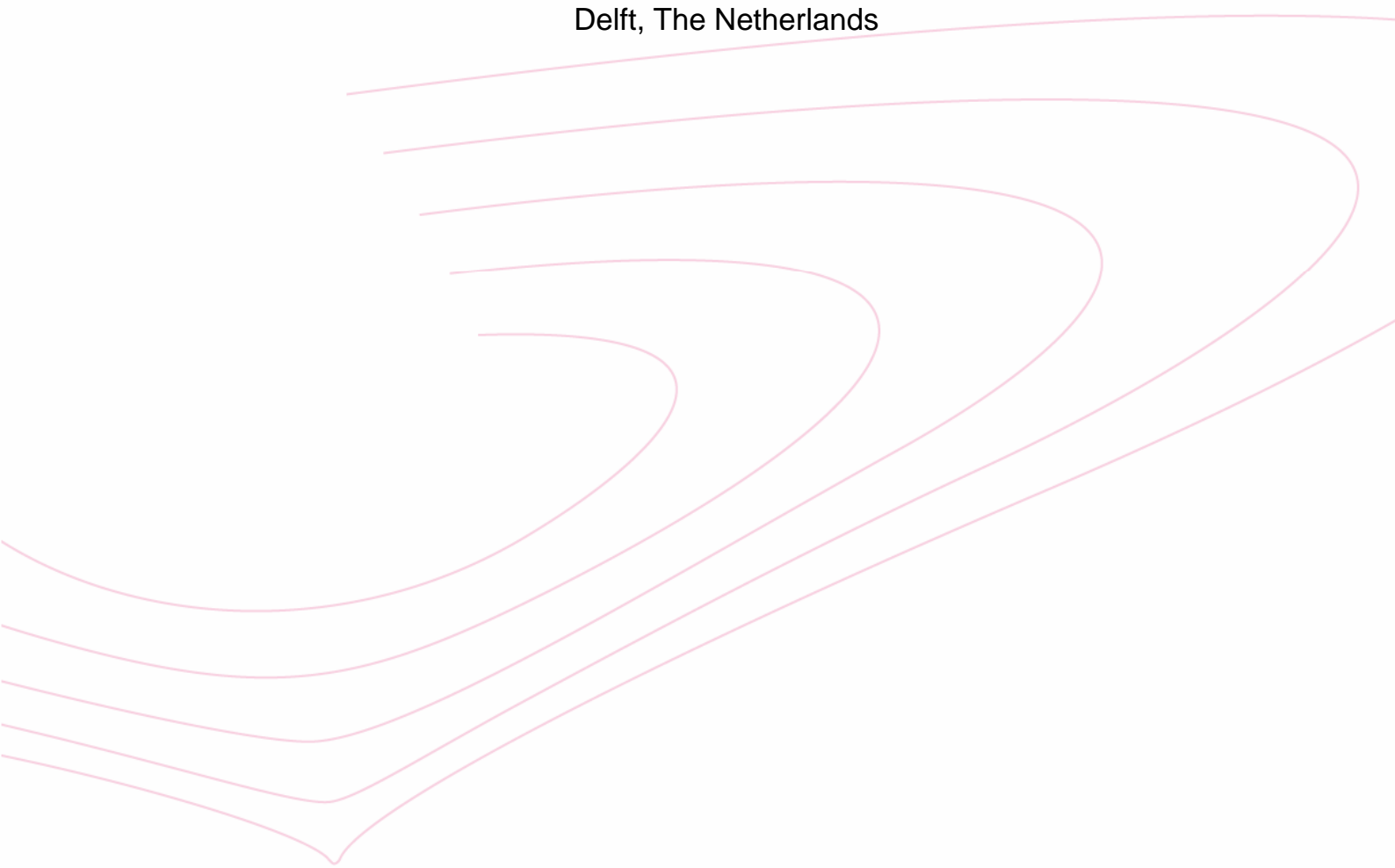


INFORMATION AND COMMUNICATIONS SYSTEMS

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Discussion Draft Paper
for the session on
Information and Communication Systems

Wednesday, 13 June 2007
Delft, The Netherlands



Introduction

The information and communication technologies (ICTs) revolution is an event of paramount importance for human society. Because of it, we are seeing an exponential growth and analysis of information affecting every area of society and communications that result in the death of distance and opportunities for understanding better the perceptions of others. Whereas the ubiquitous personal computer was originally conceived as a calculation machine, it is now pre-eminently a communications device with powerful calculation facilities. In fact, we have a melting pot of communications devices: mobile phones, hand held organisers, palm tops (PDAs), as well as PCs/laptops, with capabilities to send and receive emails, exchange documents, explore the Internet, receive podcasts, interrogate databases, join in videoconferences, work collaboratively, and so on. New devices are becoming available along with a rapid growth in services provided. Given the ferment in the technologies and services, what are the implications for the water sector?

Undoubtedly, the ICTs have fuelled better management of water-based systems. Through remote sensing and on-the-ground monitoring networks, we have the capability to harvest a huge amount of information on individual systems and to archive and analyse it in geographic information systems (GIS). Where we couple such monitoring with modelling, we enhance our ability to derive further significant information in real time, such as for forecasting, design, and compliance with standards. Modelling itself has advanced rapidly since the introduction of computers: physically based modelling, data driven modelling, intelligent agent modelling, systems modelling, and so on. The marriage of data acquisition and modelling brings closer the digital catchment or city, that is, when we have a judicious balance between data acquisition direct from the real world with modelling used essentially to interpolate (in time as well as space) in order to maximise the information available on which to optimise the performance of a water based system. However, perhaps more importantly still, besides this emphasis on information processing there is the communication and interaction with stakeholders concerned with a given aquatic system. The communication facilities now make it possible for all to get involved in the decision making process, to bring local knowledge to bear, in order to cultivate ownership of systems that serve a particular community. This is a knowledge modelling task whereby the flow of knowledge from the multi-disciplinary interpretation of data acquired from the real world, through modelling, to support for decision making lubricates the problem diagnosis (symptom alert, symptom identification, causal scenarios definition, preferred scenario selection), treatment (design, implementation) and review (monitoring, maintenance) process. The knowledge systems that result take advantage of the artificial intelligence technologies that are available; some of them are traditional like databases, spreadsheets, geographic information systems and digital terrain models; others include 3D modelling, scene modelling and even expert systems. Animation capabilities are increasingly realistic, and full virtual reality is now potentially available in any field. This has considerable impact on the attractiveness of the knowledge system, where the user has to be intuitively comfortable with the man machine interface, and where two or more people need to work together simultaneously at a distance. Also available are ICTs for brain storming in groups, voting and consensus decision making, mind mapping, etc.

A significant technology that has extensive repercussions for integrated water management is (global) optimisation. This opens up opportunities for refining designs, minimising costs and risks, determining unknown parameters, maximising benefits, and so on. Increasingly more and more complex problems are being submitted for optimisation, such as the design of sewerage rehabilitation for minimum flood frequency and receiving water impact from overflows. In turn greater demands are made on computing power. This particular problem performed for a 10 year time series for example, definitely requires parallel processing for a sizeable sewerage network. Such processing is of course commonplace among meteorologists using global circulation of the atmosphere models for, among other purposes, rainfall forecasting. Global circulation models are refined locally on local area models. There is increasing need to bring together meteorologists with hydrologists to improve the science and modelling of their mutual processes.

The forecasting of rainfall is fraught with difficulty because the dynamics of the atmosphere is a chaotic system, which means that the outcomes of any modelling exercise are divergent dependent on very small changes in the initial conditions. ICTs offer a range of possibilities to improve rainfall monitoring and forecasting, and these are vital as input to flood forecasting in rivers and to coastal surges, especially in semi-enclosed seas. The forecasting of droughts in connection with observed phenomena such as the El Nino, South Atlantic Oscillation Index, snowfall patterns, dust storms, etc is a growing field of study. A purpose of forecasting is to provide adequate warning to society. In turn this is part of the management of the consequences of extreme phenomena or hazards. There is a considerable range of possible management facilities to choose from, whether structural or non-structural. The trick is to get the right mix of facilities for the given situation. Modelling, quantifying risk and uncertainty, optimising performance, linking through to monitoring and remote sensing systems feeding decision support facilities, all have to be integrated to produce safe and reliable warnings.

The Internet and World Wide Web are symptomatic of the emerging systems that arise out of the application of ICTs. Both networks are surprising in their development for they are unregulated. As such they exemplify what can be done with networks that truly meet an acceptable paradigm for the way of working, even if there was no plan for it. In this sense the networks are really emergent. An analysis of such networks concludes that they belong to the class of 'small world' networks. For example, it is interesting that with the WWW it is possible to show that any two (hypertext) documents are linked through about 19 separate sub links (clicks). Increasingly search engines are having difficulty in scanning the whole of the WWW space: the best cover about 30%. Additional issues to do with Internet concern its vulnerability to those who seek to disturb or harm individual processors through viruses or clog the recipients' mail boxes with spam.

There are many other technologies that have been introduced to influence human behaviour. Five years ago we began to use collaborative platforms to facilitate groups of users who wanted to work more closely together at a distance, such as communities of (good) practice. Various facilities including document management, common agendas, news lists, and so on were available. Blogging has since become popular along with a whole range of entrepreneurial services for communicating (Skype), sharing video clips, downloading music, etc. Many of these tools add to the

information and communication overload. There is urgent need for better facilities to enable individuals and groups to cope better with such overload.

Far reaching changes are taking place in the development of operating systems and software codes for tools and modelling. The dominance of Microsoft in terms of Windows has brought enormous benefits to having a commonly accepted operating environment, but there is as ever an underlying unease with the monopoly held by Microsoft and the awareness that there are better systems available. This has led to the emergence of Linux as open source software, with its promotion by companies like IBM, but even more significantly by China, as a competitor to the Windows family. Although we will continue to pay heavily for the leading software products, their high cost puts them out of the reach of organisations in developing countries, and academia in particular is unable to work with the source code of such products. In this sense academic research into the more sophisticated modelling is thwarted. It is no surprise therefore that open source products such as SWAT (Soil and Water Analysis Tool), OpenGIS, OpenCFD etc are being promoted and enthusiastically taken up by academics and practitioners. The fact that it is generally the younger generation that strongly advocates and supports the open source movement implies radical consequences for the water sector as these people take on management responsibilities. Undoubtedly the movement will profoundly affect the business side of the water sector, and lead to new ways of providing services and therefore doing business.

The emergence of the open source movement raises issues of legal constraints concerned with ICTs, such as copyright and patents. These instruments attempt to safeguard inventions and the publication of such things as music, logos, ideas, processes and concepts. The underlying notion of knowledge as property stems from the desire to create wealth and limits the free exchange of knowledge. Indeed, Abbott (2006) claims that the legalisation of knowledge is producing a state of indifference among knowledge creators by inhibiting innovation, something that can only be overcome by liberalising knowledge and refusing to control it through legal instruments. In particular, anarchistic structures are needed to liberalise the generation and dissemination of knowledge.

So far as handling knowledge is concerned ICTs are making data, information and knowledge for particular water domains accessible to all interested parties. Increasingly, such water information systems not only provide access to the information they contain, but invite contributions from knowledgeable people. A model for such a system is Wikipedia, which is a multilingual, web-based, free content encyclopedia written collaboratively by volunteers from all around the world. Anyone is welcome to add information, cross-references or citations. The advantage of such a system is that it benefits all contributors who can rightly feel that they 'own' the content. Provided editorial checks are in place to ensure the quality and consistency of the content then the reputation of such a system can but grow.

Finally, we should not forget that administrative aspects of managing water undertakings require extensive use information and communication technologies, for infrastructure, financial and human resource management, forward planning, marketing and sales, and so on. These tools are of course common to a wide range of

organisations, sectors and industries. Other tools that can be highlighted for the water sector include conflict resolution facilities (games, role plays), asset management systems (underground pipe distribution and drainage systems), environmental impact assessment aids, on-line education tools, Internet-based reporting and payment by customers, etc.

Some issues:

What are relevant advanced ICTs for developing countries?

What is the role of digital catchments and cities in water management?

How can we best use web-based advice systems to help different sections of the public?

What opportunities are there to develop new web-based business processes?

What is the role of OpenMI and open source software?

How can remote sensing and integrated monitoring systems help water managers?

What are the new monitoring technologies?

How can we take best advantage of new remote sensing technologies?

What part should 3D, scene and animation modelling play in our presentation of information?

How can we use ICTs to improve urban water asset management?

What is the role of optimisation in water management?

What is the future of data driven and agent modelling in water management?

How can ICTs support (human) networks?

What is the role of ICTs in learning and distance education?

Do rule-based expert systems have any future?

What is the role of knowledge based systems in water management?

How could a Wikipedia-type water information system be set up?

How can ICTs service virtual working environments?

Are anarchistic membership structures with a sympathetic leadership better for creative knowledge generation than hierarchical structures?

Do legal instruments, such as copyright and patents, encourage or limit knowledge generation and sharing?

