TEN YEARS OF HYDROINFORMATICS CONFERENCES:
A PARTIAL ASSESSMENT, PART 1

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ABSTRACT

This two-part review of the principle strategic problems facing hydroinformatics emphasises the key role of a modern- scientifically-based hydrology in those sociotechnical constructs that have the greatest potential to improve the livelihood of the majority of persons on this planet. The forces that are currently subverting this development are identified and a way of overcoming their negative influences is adumbrated.

INTRODUCTION

Since its first conference, in 1994, hydroinformatics has taken wing to become an indispensable adjunct and support to most major
construction works in the aquatic environment, to be taught in many universities around the world, to have its own major bi-annual conferences and its own Journal of Hydroinformatics sponsored by all three international water associations and to have been accepted generally as a major discipline in its own right. Hydroinformatics started life as a technology, but from 1996 onwards it has been increasingly regarded as a sociotechnology (Abbott, 1996; Thorkilsen and Dynesen, 2001; Jonoski, 2002). Hydroinformatics was initially concerned with hydraulics, including environmental hydraulics, and it is only during the last few years that it has been much concerned with hydrology, and even then with quite faltering steps as compared with the giant strides that it has taken in hydraulics and coastal engineering. Moreover, hydroinformatics has so far had relatively few dealings with the individual sciences which are linked together through hydrology and which constitute its scientific foundations. At the same time, however, applications in hydrology have already provided participations in some of the biggest, multi billion Dollar, projects, such as the Rocky Flats Restoration and the Everglades Restoration projects (e.g. Kaiser Hill, 2001). Further to this again, the sociotechnical applications of hydroinformatics to the most crucial problems of our times, of increasing food production and improving health in sustainable ways, depends most immediately and directly upon a modern-scientific-based hydrology. Hydroinformatics has a vital role to play in doubling the incomes of agrarian communities, accounting for some two billion persons, and reducing deaths from water-borne diseases by at least ten million a year. These are the truly great challenges facing hydroinformatics today.

Thus, on the one hand, the world of applications is now calling ever more urgently for a much more vigorous application of a sociotechnical hydroinformatics with its technical strands constituted largely by a modern-scientifically-based hydrology, while, on the other hand, hydroinformatics is not giving the attention that it should to reifying and strengthening a modern-scientifically-based hydrology. The present two-part paper is mainly given over to this imbalance as a means of reassessing the role of hydroinformatics as a whole. Thus, although this is only a partial assessment, being mainly to do with the relation between hydroinformatics and hydrology, it is intended to address one of the most significant challenges facing hydroinformatics in the immediate future.

In 1996, Abbott and Refsgaard considered the marked discrepancies between those developments in hydrology which could in principle
be catalysed by developments in hydroinformatics but had failed to do so, and developments in those fields, like river engineering, river management and coastal engineering, where already at that time hydroinformatics had triggered major advances. It had by then become clear that only distributed physically-based models could make use of the rapid advances in instrumentation, SCADA systems with real-time data transmission, data assimilation facilities, remotely-sensed data acquisition and interpretation systems, seamless model-GIS interfaces, advances in geodetic surveying incorporating GPS-based position-fixing equipment and cartographic transformation packages, intranetted and extranetted communications systems and the many other such developments that hydroinformatics had already woven together to obtain such massive synergies in other areas. By way of an explanation of this situation, four areas of difficulty were identified by Abbott and Refsgaard (1996, p12) in the applications of such physics-based systems in hydrology, of which the third remains of central importance here:

"The distributed physically-based model codes, as represented by the European Hydrologic System/Système Européen Hyrologique (SHE), constituted a 'quantum jump' in complexity as compared with any other code so far known in hydrology. Moreover it used technologies, such as had been developed in computational hydraulics, with which few hydrologists were familiar. Although the numerical algorithmic problems could be largely overcome through the development of the codes into user-friendly fourth generation modelling systems with well proven algorithms, such as was the case in the MIKE SHE, the problem was then only shifted back to one of comprehending the fully integrated complexity of the physical system that was being modelled together with the constraints that were inherent in the modelling procedures. Very few professional engineers and managers were, and still are, educated and trained with the necessary integrated view of hydrological processes in anything like their real-world physical complexity.

This difficulty is exacerbated by the very nature of hydrology itself, whereby most professional's posses only a limited view of the physical processes involved. Soil physicists, plant physiologists, hydrogeologists and others usually have only a very partial view on the whole system, while there are few organisations that have available both the full range of such specialists and the more broader-ranging professionals that are needed in many situations to exploit the potential of distributed physically-based codes to such a degree that this exploitation is economically justified."
Thus, although the further development of physically-realistic computer-based hydrological modelling systems was seen to devolve upon developments in hydroinformatics, formidable institutional problems were seen already at that time to be blocking these developments in many areas. These institutional problems have become increasingly serious since that time and have now, in their turn, led to serious problems within the hydrologic community itself. These problems appear as a divergence within the community concerning the very nature of hydrologic modelling and practice, and with this the role that hydrology has to play, or indeed can play, in society as a whole. Such divisions strike at the heart of the scientific foundations of hydrology, raising questions concerning its very nature as a discipline based upon the results of modern science. As such, they also raise serious problems for hydroinformatics, and even more generally, they raise questions concerning the scientific foundations of the subject, and indeed whether hydrology, and hydroinformatics more generally, can be maintained on a modern-scientific foundation. In order to discuss this further, however, it is necessary to review the two principal lines of development in hydroinformatics over the last years.

DEVELOPMENTS IN HYDROINFORMATICS

In the seven years that have elapsed since the above-quoted evaluation was written, hydroinformatics has passed through two major transformations which have in turn been quite closely related. The first of these was the realisation that hydroinformatics was something more again than a technology connecting together other technologies and some sciences to provide applications. As the environmental and organic farming movement grew ever more vocal and exercised ever more power at the level of government, hydroinformatics was drawn increasingly into the public debates of the matters that it treated. It had then necessarily to develop new systems, both to provide means for governments to satisfy the engaged populace and to represent the interests of this populace at the level of government. Hydroinformatics became increasingly involved in drafting legislation that would empower the concerned populace as genuine stakeholders in water resources, and this necessitated the development of information and knowledge systems for transforming this
legislated empowerment into real-time, on-line operational realities. Thus, alongside its endeavours to develop and implement measures to assure unprecedented technical developments, hydroinformatics had to develop and implement unprecedented new sociotechnical developments that would provide the concerned populace with entirely new means to intervene in the realisation of the technical works. Thus hydroinformatics became increasingly a sociotechnology. It thus not only treated ongoing technical developments, such as those associated with radio internets, mobile telephony, applications of Java and other communication-enhancing technologies, but it became inseparably involved in the so-called ‘technologies of persuasion’ and other, previously separated, social aspects. It thus entered into a field where the social and the technical were so closely interwoven that no development within the one could proceed at all without a corresponding development in the other, while, consentaneously, entirely new possibilities emerged that would never have become possible if the social and technical developments had not been so woven together by an overarching sociotechnology.

Once again, however, it has to be observed that this sociotechnical development has been greatly retarded by the technocratic mode of thinking of most consultants and many of their clients, whereby projects were and continue to be treated as technical constructs with some ‘social aspects’ appended. These last appendages may be treated by anthropologists and other social scientists, but there has been and there remains little or no sociotechnological expertise to weave these together into constructs in which the social and the technical are brought into synergetic interactions to provide entirely new constructs. As one result, most applications in so-called ‘Third World’ societies have proven to be of only marginal value, if that: consultants and their clients prefer to do what they already know, rather than to invest in the new knowledge that their projects truly require.

This chain of development has been of course in all cases inseparable from the second major development: a change in emphasis in hydroinformatics from computation to communication. The computational development continued, of course, but its products were communicated in new forms directed to satisfying the needs for instantaneous information and supporting knowledge to a totally new kind of non-professional, but highly engaged, public, commonly represented by influential non-government organisations (NGOs). This public, whether as individuals or as
NGOs, needed to know the very precise movements of water, sediments, and other materials not only at the very moment that these were occurring, but also as these would occur in the foreseeable future under existing plans. Only under these circumstances could this public, even if only through its NGOs, be responsibly empowered by legislation to modify, or even stop, ongoing works and management practices if these posed threats to its registered interests. Hydroinformatics thus entered into an ongoing process of ever increasing interaction between long-established representative democratic forms of government and certain new forms of participative democracy, as catalysed by rapidly ongoing developments in the communication technologies.

It is only recently that the consequences of this development for hydroinformatics have become clear. In order to attain to this clarity, however, some further background is required, and in particular how the above developments driven by practice in engineering and management applications, even at their most positive, have departed from more institutionally-driven changes in teaching and academic research. In effect, just as the needs of practice have necessitated an ever greater recourse to the results and methodologies of modern science, the developments in ‘academia’ have to a large extent proceeded in the opposite direction. This is nowhere more evident than in the area of hydrology.

THE PLACE OF MODERN-SCIENTIFIC KNOWLEDGE IN HYDROLOGY

If we define a science conventionally, as a totality established through an interconnection of true propositions, then each science can be regarded as the body of knowledge that is expressed by, or encapsulated in, this totality. When we speak about the physics- and biologically-based sciences upon which hydrology draws for its sustenance, we speak in the spirit of modern science, this being conventionally dated from the Condemnations (of the Seventh of March, 1277), following Duhem (initially, 1913-1917) and most succeeding historians of science (from Gilson, 1938; Copleston, 1953 and Gilson and Böhner, 1954, onwards). These origins of modern science were however from this very beginning traced back to a distinction
in the nature of knowledge that was made already by Plato (Duhem-Brenner, 1997, p24):

“There are three degrees of understanding.

“The lowest degree is that of the knowledge of the senses (αισθησις); it perceives what is born and what dies, that which endlessly changes and passes away; it grasps nothing permanent, nothing that is forever, indeed nothing that can be called true.

“The highest level is that of the pure intelligence (νοησις); the pure intelligence contemplates the eternal and, above all the astral bodies, the sovereign Good.

“Through the union of pure intelligence and the knowledge of the senses there arises a sort of mixed, bastard (λογισµός νόθος) reason which occupies an intermediate position; one species of knowledge that is born of this level is geometry. This knowledge attains to propositions that are precise and permanent; indeed that are true….It prepares the way to participate in the νοησις, which alone reveals the eternal species”.

The ancient Greek science, with astronomical prediction at its head, scarcely progressed beyond Plato’s intermediate level, where each and every astral body had its own laws of motion determined by the god with whom it was identified, and which could be emulated by geometrical constructions, such as in the geometry of homocentric spheres and the astronomy of excentrics and epicycles. It thus corresponded to a polytheistic cosmology. This level of science is often called instrumentalism, since it satisfied itself with reproducing instrumental results for each astral body individually without enquiring into any underlying ‘cause’ that would be true for all such bodies, let alone for all material bodies whatsoever. Plato’s third and highest level of science, however, was concerned with establishing ‘laws of the universe’ such as would apply to all processes in all places at all times, and this only came to realisation when the theologians of the late middle ages recognised this level as the only one appropriate to their one and only God, so that it corresponded to a monotheistic cosmology. This level of science might then be called essentialism. The development of modern science from Buridan’s recognition of the law of conservation of momentum – of impetus – onwards, has been recorded so extensively that no further
commentary on it should be needed here. Similarly, the introduction of empirical, but carefully measured, coefficients into these universal laws in such a way that these coefficients also apply to all processes of a specific kind in all places and at all times, has been greatly advanced over the centuries (See Cunge, 2003, as an example from hydraulics). The ethos of the modern-scientifically-based hydraulic and hydrological modelling systems that follow this tradition can then be described as essentialist, while the regressions to devices that disregard many, if not all, of the productions of the physical, including biological, sciences, such as are being very actively promoted today in academic hydrology, can continue to be described as instrumentalist, in that they are only concerned to reproduce some observed results, and even then only for particular combinations of processes occurring in specific places at specific times, and often further only under specific anterior conditions. As regressions to an earlier era, preceding that of modern science, they have the same concerns as had the ancient Greek astronomers, of saving the appearances (σώζειν τά φαινόμενα) of certain observed phenomena, while disregarding all, or almost all, concern with understanding.

It has been one of the disappointments of hydroinformatics that much excellent work that has been done in data mining technologies has been misused in this way, and not least in the area of hydrology. Indeed in this respect it is still apposite to repeat the observations of Klemes (1986: see Abbott, 1992) on this unfortunate habit of hydrologists of misappropriating techniques borrowed from other disciplines:

"Hydrology, having no solid foundation of its own and moving clumsily along on an assortment of crutches borrowed from different disciplines, has always been an easy victim of this practice. Every mathematical tool has left behind a legacy of misconceptions invariably heralded as scientific breakthroughs. The Fourier analysis, as was pointed out by Yevjevich (in 1968), had seduced the older generation of hydrologists into decomposing hydrologic records into innumerable harmonics in the vain hope that their reconstruction would facilitate prediction of future hydrologic fluctuations (fortunately few computers were available at the time, so that the Fourier fever did not become an epidemic); various statistical methods developed for evaluation of differences in repeatable experiments have been misused to create a scientific analysis of unrepeatable hydrologic events; linear algebra has been used to transform the idea of a unit hydrograph from a crude
but useful approximation of a soundly based concept into a pretentious masquerade of spurious rigour now exercised in the modelling of flood events; time series analysis has been used to remake inadequate 20-year stream flow records into ‘adequate’ 1,000 year records, or even more adequate 10,000 year records; and the illusion of pattern recognition is now being courted in the vain hope that it will lend legitimacy to the unscientific concept of mindless fitting that dominates contemporary hydrologic modelling.

In all these cases, mathematics has been used to redefine a hydrologic problem rather than to solve it.”

From the point of view of practitioners in physics-based hydrologic modelling using all the available resources of supporting modern-scientific disciplines, it seems that many hydrologists continue to go to any length to avoid the hard thinking and mathematical and algorithmic difficulties necessitated by the modern-scientically-based approach. Indeed, in the view of these essentialists, the instrumentalists not only produce only devices that are tied to specific processes acting in specific regions at specific times and often under specific anterior conditions, but in several cases they simultaneously produce a constant stream of disparagement and denigration of the modern-scientific approach, in which quite minor discrepancies and local, passing, difficulties are magnified out of all proportion in order to discredit the efforts of those who persevere along the way of a modern-scientifically based hydrology. Behind this smokescreen of ‘criticism’, in the eyes of the essentialists, the most vacuous so-called ‘theories’ and ‘models’ are advanced as serious alternatives to the modern-scientific approach. Although these tactics have no impact on those who are responsible for major projects that depend upon modern-scientifically-based hydrologic understanding for their real-world success, they do succeed, in the essentialist view, in creating a considerable confusion in the minds of many academic hydrologists and, even more to the point, in the minds of the funding agencies that finance academic activities. Further to this again, and indeed inseparably from it, there arises a confusion of language in which it seems that anything at all can be described as ‘a model’, ‘a theory’, ‘a paradigm’ or indeed as anything else. Judging by the volume of publications issuing from academic hydrologists today, there is more of this, in the essentialist view, spurious computer-based pseudo-modelling than there is any serious, modern-scientifically-based, modelling.
In such a professionally divisive situation, however, it is essential to understand not only the subject itself, and in this case computer-based hydrologic modelling, but also, and inseparably from this, the sociotechnical environment in which the subject is proceeding. No good purpose is served by responding to the negative commentaries directed at physics-based modelling by trading deprecations, denigrations and even insults, but it is necessary instead for the modern-science-, or physics-based, professionals to identify the underlying forces that cause, and even encourage, this conflict. Clearly those who are concerned with modelling for engineering practice do not want to waste too much of their time on refuting these, as they see it, regressions to primitive forms of pre-scientific instrumentalism: they much prefer to persevere further along the path of modern science as this now comes to presence in an era of such greatly extended possibilities for communication. And indeed, as will shortly be explained, it is in just this era that a modern-scientific hydrology can attain to its full potential. In this their instincts are sound, in that it is always unhealthy to dwell too long upon the pathology of a discipline (Barth, 1961). Despite this, however, they, and they especially, should understand the dynamic that is driving these differences that are now mounting up to a confrontatation.

THE ORIGINS OF THE CONFLICT IN HYDROLOGIC MODELLING

The origins of this division can be traced to a change of paradigm in the financing of research in areas like hydrology, a change that has occurred to a lesser extent in companion areas like hydraulics but is evident there also. This change is itself inseparable from the massive bureaucratisation of university education, and indeed of education generally, that has been such a feature of the second half of the twentieth century, whereby the traditional university, which was at the origin of, and provided the ongoing centre of modern science from the twelfth century onwards, has been effectively suppressed. The traditional university was a self-managing, self-organising body whose structure emerged from interactions within its own body and between this and its immediate social environment. Such a structure can be described as an endostructure (Abbott, 2003b). It was largely independent of the state and, especially, of political processes occurring within the state apparatus. Thus, for example, in many European countries professors were appointed by the Crown in order to establish and maintain their independence from political influences. In
engineering, medicine and many other fields besides, the professor was expected to teach and research within the university and to practise his or her discipline outside the university. Most of the great international civil engineering companies of the first half of the twentieth century were developed as a consequence of the synergies thereby released, as the careers of the great hydraulicians of this period bear witness.

The subversion and suppression of this arrangement that occurred in the second half of the twentieth century is a story in itself. It coincided with a 10- to 40-fold increase in student numbers, a large – but never commensurate - flow of money from the state to the universities, a rapid multiplication in the number of these universities with the increased total student intake, a burgeoning administration to supervise this process and a corresponding imposition of hierarchical-bureaucratic organisational structures, constituting *exostructures*, upon the original *endostructures*. The negative consequences of this have been exacerbated by the various attempts, by successive political administrations in most countries, to create a ‘market’ in research, even when this was financed almost entirely through state agencies. Correspondingly, the traditional market mechanisms whereby knowledge passed backwards and forwards between the university and practice were largely dismantled. Instead there arose a competition for university financing that was no longer driven by the needs of practice, but by the needs to satisfy the selection committees of the fund-providing state agencies. Unlike the earlier arrangement, which bred whole new industries, this produced for the most part only a zero-sum game, where projects were acquired primarily to keep university departments operational under an increasingly heavy bureaucratic burden, almost inevitably to the detriment of some other departments elsewhere. In this situation, of a market with no genuine market mechanisms – a pseudo-market in fact – it was inevitable that a competition should arise between the various parts of a discipline like hydrology. Since there could be no real competition between the sciences that contribute to hydrology – glaciologists could scarcely compete with plant physiologists or agronomists with meteorologists – competition became concentrated between the instrumentalists, whereby each proponent of a particular *instrumentalist methodology*, applicable within certain parts of hydrology, endeavoured to promote his or her speciality over all other contenders. The temptation to ‘hype’ one’s wares then became almost irresistible for anyone with
no other sources of funding than those of the state. To the extent that this becomes a ‘competition in ways to save the appearances’, and so a competition in instrumentalisms, so the different methodological sub disciplines come into ‘competition’: those applying probability theory come into ‘competition’ with those promoting fuzzy set theory, those pushing artificial neural networks become ‘competitors’ with those with a penchant for genetic programming, and many other divisions arise between methodological sub disciplines that are, in principle, complimentary. Some of these instrumentalists have indeed joined forces, but then often only in order to oppose distributed, modern-scientifically-based hydrology, which in turn continues to draw most of its inspiration, as well as its financial strength, from engineering practice. It seems to appear to some instrumentalists that if this particular essentialist development could be discredited, then more and alternative sources of financing would become available to the instrumentalist ‘competitors’. From the point of view of an essentialist, modern-scientifically-based hydrology, on the other hand, all of these methodological sub disciplines clearly have something of value to offer, so that there can be no such discrimination: the exaggerations of certain methodological sub-disciplines were and continue to be considered regrettable, but of no longer-term consequence.

This, however, it too facile a position and it has now to be re-evaluated. It has then to be understood that these aberrations in fact arise quite naturally from the fragmentation of hydrological knowledge over so many different ‘competing’ sites, whereby it is usually extremely difficult to assemble the range and depth of knowledge necessary to pursue physically realistic, modern-science-based hydrologic modelling at any one place. The instrumentalist approach accordingly appears as the only way of doing anything ‘competitive’ within the bureaucratic straightjacket that has been imposed upon almost all the universities and other centres of learning. The vital point for a modern-scientifically-based approach is then to understand the true role of the more basic, rather than the methodological, sub-disciplines within the wider scope of hydrology as a whole, as a propædeutic to an investigation of how the present situation can be changed.
REFERENCES
The references that are common to both parts of this paper are given at the end of Part 2. References that pertain specifically to Part 1 only are given below.

Thorkilsen, M., and Dynesen, C., 2001, An owners view of hydroinformatics: its role in realising the bridge and tunnel connection between Denmark and Sweden, J. Hydroinformatics, 03, 2, pp. 105-135.
ABSTRACT

The means for overcoming the present negative influences in hydrology that act as a serious brake upon a sociotechnical hydroinformatics are further developed. The institutional consequences following from the application of these means is further explored. In conclusion, the nature of hydrology, as “a rhetoric waiting for a grammar” of Abbott (1962), is taken up for review.

HYDROLOGY AS A CONJUNCTIVE KNOWLEDGE IN A MULTI-KNOWLEDGE ENVIRONMENT

Multi-knowledge environments are those in which two or more different knowledges have to function simultaneously and interactively in supporting one and the same activity. For this purpose the participating knowledges alone cannot suffice, but a quite other knowledge again is required to connect and coordinate their interactions. Such a knowledge is called a conjunctive knowledge (Abbott, 2003a). Thus, for example, sociotechnology is a conjunctive knowledge that connects and coordinates (or, in
these terms, *conjoins*) interacting social and technical processes, weaving these together to provide knowledge products that are not accessible from the social and technical domains independently. In such cases, the one knowledge is said to be *implected in*, or *implexively contained within*, the other through the intercession of the conjunctive knowledge. Clearly hydrology is also a conjunctive knowledge, weaving together the strands of meteorology, plant physiology, soil physics and other such sciences within its multi-knowledge environment with its intention always directed towards the world of practice, of technology. Within the formalism of Category Theory that provides a means of notating such processes, hydrology provides a mapping, \( f(\text{hydrology}) \), from all possible collections of outputs of a set of modern-scientific knowledges, so that the source of \( f(\text{hydrology}) \), written as \( \Box f(\text{hydrology}) \), is given by:

\[
\Box f(\text{hydrology}) = \{ \Box U(i)(\text{science } i) \}, \tag{1}
\]

into the inputs to all possible technological applications, so that the target of \( f(\text{hydrology}) \) written as \( f(\text{hydrology}) \Box \), is given by:

\[
f(\text{hydrology}) \Box = \{ \Box U(j)(\text{technology } j) \}. \tag{2}
\]

Thus:

\[
f(\text{hydrology}): \{ U(i)(\text{science } i) \Box \} \rightarrow \{ \Box U(j)(\text{technology } j) \} \tag{3}
\]

This structure is not a category in the strict mathematical sense because one and the same set of outputs of the contributing sciences can be applied to more than one technology. It might however be construed as a category if, in such a case, the two or more technologies that share the same ‘knowledge base’ in the contributing sciences are subsumed under one, more general, technology. Thus, for example, the technologies of surface irrigation management and erosion control measures might share the same scientific knowledge base, but might then also be subsumed under the one technology of ‘land use management’.

A category of this general kind then defines a *professional space*, which in this case is of course the professional space of hydrology. The spatial metaphor as usual carries the connotation of an ordering that is
capable of spatialisation. Each of the component conjunctive knowledge that makes up the totality that is hydrology occupies a region in this space. Among the most immediately evident of the axes that may be introduced into this space is one that expresses the degree to which the conjunctive knowledge genuinely coordinates the knowledge which it conjoins, with its origin situated where the one knowledge is completely subordinated to the other knowledge or knowledges, such as arises when the one depends completely upon the other or others. Such a case arises, for example, when a knowledge of evapotranspiration is conjoined with a knowledge of meteorology and a knowledge of plant physiology within the context of a known quantity and distribution in depth of soil water in a given soil type. A second axis may then express the degree of connectivity of two or more knowledges, with its origin at a point of total disjunction between the knowledges, and so at a place where there is no longer any multi-knowledge-component environment at all. A conjunction of glaciology and plant physiology would thus be very close to this origin. These two axes can often be regarded as orthogonal.

Other axes, often envisaged as being orthogonal to the previous two, can be chosen in many ways, depending upon the particular application envisaged. Examples are the extent to which statements arising from the one conjoined knowledge affirm statements arising from the other conjoined language, as a measure of redundancy between these knowledges, the extent to which the one is opposed, as an adversary, to the other, such as is exemplified by modern scientific knowledge being misused to subjugate local, autochthonic, narrative knowledges, and the way, called technically copulation, in which one initially conjoined knowledge may combine with another such knowledge to provide a third knowledge again, as exemplified by geochemistry and environmental hydraulics. Clearly, hydroinformatics provides multi-knowledge environments which may conjoin many and various sciences, technologies, sociotechnologies and other multi-knowledge environments again, directed to specific practical applications.
A POSSIBLE SOLUTION TO THE CURRENT DISJUNCTION

Hydroinformatics, being now at least partially a sociotechnical enterprise, seeks its solutions to what may appear at first sight as social problems through the introduction of new technical means, even as it also seeks the solutions of apparently technical problems in new social/institutional arrangements. Being driven primarily by practice through creative business ventures, it necessarily seeks to solve the present problems by introducing new business arrangements that will catalyse changes in behaviour on the part of those who currently find themselves in conflict. It must then seek to introduce systems that will wean academics away from instrumentalist devices by providing them with working environments in which they can participate as equal partners in the elaboration of much more ambitious and interesting projects than are realisable within the present academic-bureaucratic structures. They must do this, moreover, by providing real-world market remunerations that are superior to those provide by the current pseudo-market through which government funds are presently disbursed. In view of the overwhelmingly technical background of most hydroinformatics’ conferenciers, it will be most apposite to introduce this first on a technical note.

FIFTH GENERATION MODELLING

The structure schematised in Eq. 3, when functioning within a professional space, implies the relevance of a specific modelling architecture, which is called most generally an agent-orientated architecture. Then, in the words of Jonoski (2002, p203):

“What then is the essence of the new approach to conceptualisation that is based on agent-orientation? As a first step, the new approach ‘expands’ the traditional conceptualisation of knowledge domains beyond their descriptions in terms of different objects, with their properties and relations. In fact it ‘replaces’ the basic notion of ‘knowledge domain’ with a much broader notion of an ‘environment’, where
the basic conceptualisation units are not objects, but new kinds of entities called agents. The fundamental property of the agents is that they are embedded in their environment and are able to perceive and affect the environment. In addition to that, in their interaction with the environment they express goal-like behaviour. This is in fact very close to a general definition of an agent. as any entity which operates in some environment (physical, virtual, cyberspace), which posses sensors to perceive this environment, effectors to act on this environment, and goals of its own which may or may not be explicitly represented in the agent itself. In general terms, an agent can be envisaged as a “creator of objects” within a fluctuating content.

“One of the radical changes that this shift in the mode of conceptualisation brings about is that it allows the agents to have their own representation of knowledge domains, which may or may not be part of their own environment. An agent’s environment is therefore not to be confused with a knowledge domain. In some sense, the exclusive role of the (human) observer in the traditional, purely rationalistic, approach, of conceptualising and representing domains in terms of objects, has now been attributed to these new kinds of entities called agents. This is certainly one of the most fundamental changes brought about with the new approach, primarily because it allows for different perspectives (or points of view) between the human observer and the agent, and/or between the different agents themselves.”

Thus, instead of the crude positivism associated with an object orientation, one has a much more flexible and subtle phenomenology associated with an agent orientation. In this approach, an agent can be attributed to, for example, the unsaturated zone in the soil, and this will then be interrogating its environment of precipitation, infiltration, evaporation, transpiration and root water uptake as defined by its position in the professional space in order to decide upon its own most appropriate physical and biological behaviour. Other domain agents will have other ‘concerns’ again, and each agent will be monitoring its own environment within the professional space from its own point of view, corresponding to its own perceptions, as coloured by its own intentions. It is the interaction between these agents with different perceptions corresponding to different intentions that generates an active cooperation between the agents in the representation of the physical system, as each of these does, so to say, ‘what it most wants to do’ within the constraints of its physical and
biological environment. Thus, whereas an object-orientated approach leads to totally managed, fixed hierarchical structures which correspond to exostructures, an agent-orientated approach has the potential to provide emergent, self-managing structures that constitute endostructures (Abbott, 2003b).

It is now appropriate to consider how these considerations lead to new approaches to computer-based hydrological modelling in practice, as a precursor of hydroinformatics systems more generally.

It was considerations of this kind that provided the starting point of a series of studies directed towards the problems of taxonomical complexity (both in its purely technical and in its sociotechnical dimensions) and the communication technologies that were becoming increasingly available and are now already being applied in other fields that present analogous problems. These studies have now resulted in the identification of a new approach to sociotechnical constructs in the water sector, and one that is in no way restricted to numerical modelling, but is much broader in its scope, involving closely interacting associations of people and artefacts whereby synergies are induced between the people and the artefactual components.

The fifth generation paradigm starts out from the observation that the communication aspects of software systems have now become the predominant ones in future developments. This is not to say, of course, that the computational aspects can now be ignored – that is far from being the case – but that the strategic developments must now proceed primarily through communication paradigms. Thus, to take the most familiar example, of the numerical model as a purely technical construct, the main thrust of this development resides in allowing the various computational elements in the model to communicate with one another and with the world outside the model in much more efficient ways. For the sake of simplicity, it is possible to think of the technical components of a fifth generation construct as being one in which software systems generally, with models as just one example, are composed of numerical/communicational components regarded as agents. However, this being in no way only a technical construct, at the same time as these agents are communicating with one another through what can be regarded as a kind of intranet, other, human, agents are communicating about the most appropriate components and combinations of components, sources of data, connections to other hydroinformatics elements and other features of importance to
them through an extranet. Since all the ‘agents’ involved, human and artefactual, then communicate and thereby cooperate by passing messages between them, the resulting architecture is commonly described as a ‘multi-agent, message-passing’ architecture.

Since more general hydroinformatics’ constructs usually involve people as well as such artefacts as instruments, communication networks, computer software, etc., in these cases it is not strictly speaking correct to describe them as ‘systems’ at all, and it is correspondingly not strictly correct to speak of an architecture at all either: as Kant established: “Ich verstehe unter einer Architektonik die Kunst der Systeme”, or in Kemp-Smith’s translation: “By an architectonic I understand the art of constructing systems”. This distinction is essential, because people can be regarded as ‘agents’ in any architecture only in so far as they are regarded very simplistically as ‘repositories of competences’ – as simple predictably-reactive ‘system components’– and not as proactive individuals with truly human behaviours. In practice it is to be expected that people participating in any project will form relations that are constantly shifting with the changing nature of the project itself, so that such structures as do arise are emergent, forming, once again, endostructures. In this sense they are not systematic, but chaotic in the strict sense established in chaos theory – see Abbott and Jonoski (2001) and also Harvey and Han (2002) and the subsequent discussion of Abbott (2003b). This double communication architecture, of people and data, should be applied initially to the elaboration of new hydrologic modelling tools and new hydrologic modelling practices where this approach to modelling is most obviously beneficial. This approach may be expected to be applied, however, to other hydroinformatics products by introducing new communicational linkages and relations between the people, data streams and software and instruments participating in hydroinformatics systems. Since this class of hydroinformatics constructs may be extended indefinitely in its spatial distribution, it can provide the platform for a new kind of cooperation between engineering and management practice, on the one hand, and academia, on the other.

This proposed new system can be characterised as ‘network centred’ as opposed to the previous “desktop-centred” or even earlier “host-centred” systems. This means that the platform for its development and deployment will not be a single machine, but a network of computers. Initially,

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the primary focus will be the utilisation of the internal network of computers which functions as the central, or kernel organisation’s intranet. In principle, the design and implementation of the system should allow for its installation and operation on any other intranet, or even on any single computer if required. However, it will be optimised for operating specifically inside the kernel intranet. Installations on other intranets, although easily possible, cannot be foreseen to include, initially at least, all the additional support which is envisaged with its kernel operation, including its external operation and support for its wide range of users.

The extranet system component will be accessible from anywhere in the world. Although at the moment envisaged as connected to an intranet system operating at the kernel organisation, its ultimate ambition is to allow also for assembling models using computing facilities anywhere in the world. Thus the opportunity is provided to distribute the computing load to the most efficient locations or combinations of locations. This clearly has the potential to become a hybrid between an open source and a proprietary system that would open up new possibilities for academics and others who are at the moment lacking the possibilities to participate in modern-scientifically-based modelling. Such a system then has the required potential to wean away academics from instrumentalist projects and to orientate them instead towards participation in major initiatives in which they can place themselves in process-rich virtual environment.

Clearly these possibilities provide the basis for elaborating new business models. For example, it then becomes possible, and indeed quite simple, to rent or to lease different combinations of functionalities and computing facilities with a greatly enhanced flexibility. Customer service facilities can then also become more broadly web-enabled, drawing upon expertise throughout the kernel organisation and elsewhere again throughout the academic community. Much of this expertise can then be chargeable directly at prearranged rates. The improved level of service which can be anticipated in this way will clearly provide further important competitive advantages. In a certain sense the new paradigm can be seen as one that leads away from modelling systems as products, and moves more towards the provision of integrated modelling systems as services, which can be leased or rented or otherwise made available to any required specifications when needed and delivering reliably, rapidly and at any time. This will provide revenue streams to the academic community which will
promote their autonomy from the state-controlled funding agencies and further provide an invaluable linkage to engineering and management practice that will be an invaluable adjunct to teaching. In this respect, the fifth generation paradigm leads back to the practices of an earlier era, of the traditional university. This new paradigm has a deeper significance again, however, in that the use of its systems can be expected to generate new, emergent ontologies. Ontology, in its broader philosophical sense, has to do with the being of things, while ontical enquiry is concerned primarily with entities and the facts about them. Heidegger (1927, p.12/1962, p.32) reserved the term ‘ontology’ for “that theoretical inquiry which is explicitly devoted to the meaning of entities”, so that what will really be emerging from the use of the system will be the grammar that holds together the rhetoric, expressed in agent terms, of a modern-scientifically-based hydrology. Languages, including even the most formalised of languages, do not appear spontaneously, from a single mind or group of minds cogitating over this language. They arise from the collective discourses of the very many persons in a community going about their everyday activities. The ancient Indus Valley grammarians, for example, discussed and argued for centuries over the fundamentals of Sanskrit grammar and of how the thoughts became letters and words, words and sentences, sentences and paragraphs (e.g. Abbott, 2000). The grammarians formalised what the natural process had long since realised in practice; they did not ‘invent’ it. The actual working of a system of this kind could therefore lead to the identification and ultimately a formalisation of the grammar of hydrology that would provide, to use another Heideggerian expression, a ‘home for its being’. Hydrology has waited much too long already for its grammar; perhaps now it will find it here also.

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