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# 40 years of evolution in science-based tools for flood and water management

Hydrolink

# 40 YEARS OF EVOLUTION IN SCIENCE-BASED TOOLS FOR FLOOD AND WATER MANAGEMENT

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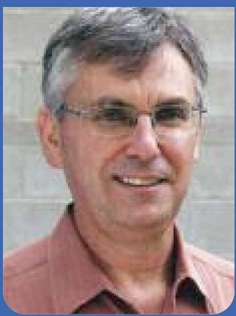

***Dr. Robert Carr*** **is Deputy CEO of eWater Ltd Australia with specialist technical skills in Hydrologic and Hydraulic Modeling including flood-plain and water management, waste-water and bulk water supply investigations and design. Robert graduated from Civil Engineering from the University of Queensland in 1980 and MSc and PhD from Iowa State University USA in 1982 and 1985 respectively. Robert has worked in Australia, New Zealand, Singapore, Thailand and North America and been involved in projects and research for more than 25 years mainly across Asia and North America. His present role at eWater involves transitioning from a cooperative research centre (CRC) which has developed models to express Australia's unique capability in water sharing policy into a self-managed independent modelling centre focussed on the tools and associated communities of practice.**

Finding the balance between managing floods, water security and environmental flows at physical scales from local urban to transboundary river basins has become a real concern for policy makers in recent years, particularly when climate change and megacity growth are brought into the conversation. Computer-based modelling systems are considered by many technical experts to be a reliable method of analysis to support decisions in water management, but with the science and engineering methods underpinning these models constantly shifting, decision and policy makers have tended to use other methods to reach consensus.

Further, the emergence of proprietary software modelling platforms has to some extent constrained functionality and created a timing lag between new knowledge and mainstream adoption that weakens the credibility of models to represent truly integrated planning based on latest science. This paper explores ideas around new combinations of community-based model development in combination with business models which may offer a new paradigm for integrated water resources planning.

### Models as Decision Support Systems - What Happened to Artificial Intelligence?

What we commonly refer to as computational modelling can be traced back to developments in computational hydraulics in the 1960's and 70's. Abbott (1991) identified several generations of modelling from the first use of computers to solve analytical equations to the final (5th) generation which was foreseen to involve artificial intelligence (AI) to bring these by now highly sophisticated numerical tools into the realm of decision-makers. While it could be argued that by the early 1990's that Abbot's third generation of generalised modelling systems was well underway and the 4th of data integration was largely foreseeable as a natural progression, the 5th generation was still somewhat 'out there' and held great promise. However looking from where we are today some 20 years later after Abbot's paper, the merging of advanced hydrological and hydraulic models with AI technologies has largely failed to deliver on the promise for a number of reasons.

- The underpinning science is still not complete. New methods are constantly being developed and new science developed which causes any decision to be subject to question if not able to adapt. We are living in a world of a deluge of information (Attwood, 2009) which implies that models also need to adapt quickly to retain the trust of the public and policy-makers.
- Decision makers perceive the world differently from model developers and indeed those who apply the codes to solve real-world problems. Models need to adapt to decision makers perception and compare approaches rather than be locked into one or two methods. Rule-based approaches do not represent reality, where decisions are ultimately made on the basis of complex hierarchies of influences.

- Some AI Tools (artificial neural networks, genetic algorithms, chaos theory, model trees, fuzzy logic, intelligent agents etc) were found to require a significant amount of tailoring and judgement to ensure that optimisation outcomes were practical. Some techniques have been found to be useful in tradeoff analysis to help decision makers visually appreciate the implications of choice but the vision of generalised AI linkages between water models and AI has largely stalled in practice.
- In an attempt to define more and more detail through more detailed theoretical process descriptions, models have become very data intensive despite inconsistencies in the quality of the underlying data sets. Different models require different types and density of data due to the level of conceptualization of the model. Models have generally been 'out in front' of the underlying data sets and while some models delve into considerable detail in conceptualizing physical processes, the data and process knowledge required to support those models is prohibitively expensive to collect and maintain. The true cost of these models is not in the software itself, but in the investment in data and human knowledge required to operate and maintain them. There is a tendency to develop models to reflect the scale of the data rather than the scale of decision or supporting science. All these factors lead to models that are slow, over-parameterized and unsuited to AI applications and have unfortunately become largely Data Support Systems rather than Decision Support Systems.

The conclusion is that after 40 years of modelling platform development, best available science coupled with Human Intelligence remains the best combination and clearly an adaptable flexible platform is required to facilitate the process in a way that appeals to decision makers rather than replace them with AI.

So the challenge is to find a way of connecting the various communities that interact with models together in such a way that supports the concept that water is a public good necessary for life, is self-sustaining from a business perspective and innovative to the extent that new knowledge can be integrated and mainstreamed with minimal delays.

**Innovation Management via Open Source Variants**

There are many challenges to developing and maintaining water management models given the requirements for constant innovation: Innovation is made even more difficult because the basic IT platforms won't stop moving. For example new computer hardware and operating systems appear regularly, and programming languages are constantly under revision as new standards are developed. Data storage systems, Geographical Information Systems, SCADA and Web-based sources of information are also constantly changing as those fields progress and improve their own technologies and approaches.

Users have become accustomed to working with sophisticated packages with intuitive interfaces and there is an expectation that water management tools will follow a similar development path even though this may not represent fundamentally new science and knowledge. It is uneconomic to constantly implement new science before some level of mainstreaming already exists, but mainstreaming cannot occur unless new science is tested in real world applications.

This paradox is the fundamental reason why proprietary systems lag the public research innovation front and is further compounded by the need for the self-validating proprietary software organisations to be conservative in their approach to new methods.

Open Source is a development method for software that has the promise to deliver reliable, flexible, high quality products at relatively low cost compared to other approaches. There are several variations on the theme ranging from essentially public domain to commercial groups which may approach vendor lock-in models by offering limited access to proprietary systems. Open Source conceptually is ideally suited to the concept of a platform that encourages innovation and comparison of methods, leading to rapid mainstreaming of new knowledge without the time lags associated with proprietary systems. As an innovation platform it has the further benefit of distributed peer review and transparency of process (www.opensource.org).

### Innovation Opportunities in Business Models

We find ourselves in a challenging funding environment where the sponsors of research demand that the link between research and practical outcomes is made clear and a pathway to mainstreaming is considered. It is also increasingly important to appeal to the widest possible range of stakeholders to rapidly deploy the outcomes of research. The challenge is to find a business model that self-supports the research mission but at the same time provides financial stability and a sense of moral purpose and direction in an increasingly global commercial business environment.

A Business Model can be defined generically as describing "*the rationale of how an organization creates, delivers, and captures value (economic, social, or other forms of value)* (Osterwalder, 2010). In the context of the above, any business model which has at its core the improved understanding of a public good element such as water needs to have at its an element of 'Free'. In this context (Oserwalder, 2010) a 'Free' business model does not necessarily mean that there are no revenue streams for the organization, it means that *"at least one substantial customer segment is able to continuously benefit from a free-of-charge offer"*. One configuration of business model which could support sustainable open innovation around a public good element such as advances in policy-driven water management tools is described below:

1 **Community.** The core values acknowledge that the community is working towards improving our ability to manage water for the benefit of the public good. The Community Business Model relies on user loyalty, social networking and user-generated content to deliver innovation and his heavily reliant on the :network effect", "crowdsourcing" and other approaches to generating content and knowledge. This model is also attractive to advertisers because it is a place where conversations are taking place between potential consumers. Wikipedia™ and Facebook™ are examples of communities.

2 **Membership.** The membership model can be used to reinforce the theme of community through a subscription fee which is applied on the basis of the ability to pay. Such a model removes many of the elements of commercial negotiation because unlimited access to a set of tools and forums is contained within the subscription (all you can eat model) Users may be charged a periodic fee to subscribe, while knowing that some other users are offered the same access but without a fee due to their special status. In the membership model, subscription fees are incurred irrespective of actual usage rates and subscription and advertising models are frequently combined. Some level of advertising is often permitted within the membership model because it supports the community (also integrated advertising/product listing). An example of this business model is online newspapers.

One business model pattern which offers an opportunity to combine Community and Membership offerings is known as "Freemium" (Osterwalder, 2010). The Freemium model can be adapted to combine some free content with "premium" (i.e., subscriber- or member-only) content. Advertising and product listing can be brought into the business model where it supports the community and is understood to be there to lower the cost of membership, particularly for those members who have little access to funds. Such approaches are common for example in social media, a good example being the forum hosting site ning.com™ where the basic services are provided with advertising, the user pays for additional functionality and removal of advertising.

The Freemium business model offers the opportunity to apply a commercial open source approach with open innovation as an engagement model and has a number of benefits towards achieving the goal of a financially sustainable independent enterprise. Freemium can be tailored to create and capture value by providing a collaboration environment for those partners who are of a similar mission and vision, and are prepared to join as members of the community. It is attractive to external parties who can benefit from shared ideas or assets. It also allows "Outside In" innovation by adopting external contributions through two-way conversations (a kind of Knowledge broker role) and ultimately fosters a true Community of Practice around the public good water management mission.

### Conclusion

In response to the ever-increasing deluge of literature and innovation in Integrated Water Resource Management, the need for transparency of process and best practice scientific foundation for decisions is driving new paradigms in how to structure modelling frameworks, communicate with stakeholders and fund the necessary research and maintenance of a community of practice. If successful, these new combinations can deliver the necessary linking of sophisticated modelling with human intelligence and deliver the next generation of water modelling advances.

### References

[1] Abbott, M B (1991) Hydroinformatics: Information technology and the aquatic environment. Avebury Technical, Aldershot, UK, p 145
[2] Attwood, T.K. (2009) Calling International Rescue: knowledge lost in literature and data landslide! Biochem J. 2009 December 15; 424(Pt 3): 317–333.
[3] A. Osterwalder, Yves Pigneur, Alan Smith (2010) Business Model Generation' John Wiley and Sons, Inc New Jersey