



## Intelligent and Adaptable Grid-based Flood Monitoring and Warning

Flooding is a growing problem in the UK which has a significant effect on residents, businesses and commuters in flood-prone areas. The cost of damage correlates closely with the warning time given before a flood event, which makes flood monitoring and prediction critical to minimizing the cost. Grid computing is being used to reduce these problems.

Current approaches to flood monitoring (e.g. in river valleys) involve statically deploying depth and ultrasound-based flow sensors across flood-prone areas, and feeding the collected data to hydrologists off-site as input to Grid-based computational models which predict flooding trends. At Lancaster University, we believe that there is considerable scope for improvement in such scenarios. In particular, we are investigating selectively shifting the execution of prediction models to the sensor network itself, which thus acts as a 'mini-grid'. Computations organised in this way not only provide more timely flood warnings, but also help to dynamically adapt the wireless sensor network (WSN) and thus optimise it for current or predicted environmental conditions. For example, the network can employ a low power, low throughput organisation in quiescent conditions, and switch to a high power, high throughput organisation when flooding is imminent.

To achieve this vision we have developed a sensor network framework based on an appropriate combination of software and hardware. The software

consists of our component-based runtime reconfigurable GridKit middleware.



Figure 1: model used to demonstrate GridStix functionality

This provides flexible networking support, service binding, resource discovery, resource management, and security. Our hardware platform uses the linux-based Gumstix embedded computing platform [1]. We call the combined hardware and software framework 'GridStix'. This is capable of integrating with remote fixed-network Grids such as NW-GRID for computationally intensive flood modelling purposes, and also capable of performing on-site flood modeling. This combination yields significant benefits, for example, local computation can be used to provide timely warnings to local stakeholders, and a combination of local and remote computation can inform

adaptation of the sensor network to maintain optimal performance in changing environmental conditions. Fully predictive models can then be run on the NW-GRID using input which has been collected and uploaded in real time.

Figure 1 shows a model used to demonstrate GridStix technology. This has been shown at a number of workshops and demonstrates, in real time, the overlay network topology being maintained by the GridStix nodes.



Figure 2: GridStix deployment at Cow Bridge

The first deployment site is at Cow Bridge, on the River Ribble in the Yorkshire Dales. This site is prone to flooding for much of the year and thus offers good potential for evaluating the

system under real-world conditions. Flooding affects the nearby village of Long Preston, which thus additionally presents us with a motivation for evaluating warning systems for local stakeholders.

Traditional flood monitoring approaches impose a rigid separation between the on-site WSN used to collect data, and the off-site computational Grid which is used to analyze this data. Our GridStix approach provides more on-site "intelligence" with next generation Grid middleware used to realize our goals.

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[1] Gumstix <http://www.gumstix.com>

[2] D. Hughes, P. Greenwood, G. Blair, G. Coulson, F. Pappenberger, P. Smith and K. Beven. *An Intelligent and Adaptable Grid-based Flood Monitoring and Warning System*. UK e-Science All Hands Conference (Nottingham, September 2006) paper 639

