Innovation Reports

D-MINT
(ITEA 2 ~ 06014)

Turning an academic testing discipline into an industrial reality

ESNA
(ITEA ~ 05023)

Developing effective business applications for wireless sensor networks

TWINS
(ITEA ~ 05004)

Optimising hardware/software co-design for software-intensive systems development

D-MINT
(ITEA 2 – 06014)

Colin Willcock, Nokia Siemens Networks, Germany

Turning an academic testing discipline into an industrial reality

The D-MINT project has turned the academic discipline of model-based testing into an industrial reality to cut the cost of producing complex software systems. Demonstrators in industrial domains from street lighting to mobile phones clearly showed how such an approach can close the productivity gap in the cost-effective development of quality software. The resulting techniques are already being exploited in product development by several major European industries.

Quality is crucial to continuing European competitiveness. This requires a wide cross-section of software-intensive industries across many sectors to invest in and be the best at the development of complex software systems. Europe is challenged on hardware costs as it continues to be undercut by Asia. However, software is playing a greater and greater role in key industrial products. Half of the components in today's cars depend on software. And software is now the bottleneck in telecommunications as much of the hardware has become standard off-the-shelf components.

While the key to future European success lies in cost-effective and efficient development of complex software systems, 40 to 60% of the overall costs of turning that software into a real product lie in testing. The ITEA 2 D-MINT project set out to develop a more efficient and more effective approach to testing complex software systems using a model-based approach.

In classical software testing, product and testing software are written in parallel. However, that involves the same level of complexity on the test side as on the product side. Moreover, the degree of reuse is virtually zero as the two sets of software are completely separate.

HIGHER LEVELS OF ABSTRACTION

Working at higher levels of abstraction with models rather than actual code makes it possible to reuse some of these models as the specification is in more general terms. In addition to this reuse, another real advantage is that the modelling paradigm causes developers to actually think more at the beginning about what is being specified.

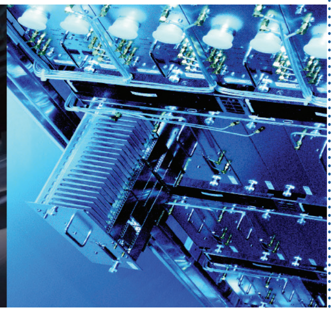
This means that more effort is invested in the initial specification phase and, because this is early in the development process, it is possible to actually save much time and effort because errors are detected far earlier. In other words, the classic advantages of model-based software development are also brought across to the testing side.

Model-based testing is not new, it has been investigated by academics for over 20 years. But this approach is not being used systematically and pervasively in industry as there was a large gap between the academic work and industrial reality. While the academic approach is fine for thousands of lines of code and hundreds of states, a mobile phone needs software with millions of lines of code and 10,000 parameters.

D-MINT set out to resolve the problems and to turn an academic discipline into an industrial reality, with the necessary methodology, tools and training material to enable this approach to be used more widely.

The typical academic model-based approach applies the same language and tools throughout and therefore makes the tool integration very straight-forward. However, in the real 'industrial' world we do not have just one specification language, just one tool and just one level of abstraction. The basic requirements specification may be written in DOORS, the electrical system specified in MATLAB and software in UML – completely different specification languages with different semantics, different tool chains and different actual levels of abstraction.



One of the key innovations in D-MINT was the ability to extract the information from various different levels and various different abstractions of models and put that together into a single model-based testing framework.

ADVANTAGES ACROSS INDUSTRY

The new methodologies were found to offer many advantages when applied at an industrial scale and with industrial quality. Model-based testing was demonstrated successfully across a very wide range of domains in six separate industrial sectors. Applications ranged from street lighting control to video-conference units, from telecommunications to automotive control systems and from industrial engineering to machine tools.

Moreover, these techniques were used in real product development and real advantages were obtained in all the applications.

That all domains showed the same advantages gives great confidence that what has been developed is generically useful. This means that the results are not confined to specific areas such as mobile phones or automotive control units but can be applied to a very wide range of other industrial software developments.

Despite operating in so many different industrial domains, the results of the project were remarkable homogenous. The case studies indicated that adaptation efforts to model-based testing – such as initial training and integration into existing test processes – are high but are a one-off activity. They also showed that this approach is particularly beneficial for testing activities with several iterations.

The demonstrators involved parallel developments using classical and model-based testing approaches for direct comparison. Analysis of the real costs involved in time and investments across all the consortium members showed that not only could direct test costs be reduced by 15% using model-based testing, but that test coverage could be improved by 10%. This translates into an overall improvement of some 20 to 25% in test costs.

FAST EXPLOITATION POSSIBLE

While these figures may appear somewhat modest compared with some European projects, they can be backed up in real industrial cases with real figures and are more than sufficient to justify use of model-based testing. One result is that three tool vendors have already put their products on the market: iXtronics Toolbox, Testing Tech TTmodeler and Conformiq Qtronic.

Even more convincingly, several of the industrial partners are already starting to use the D-MINT techniques in their product development. Major industrial engineering company ABB has decided to use D-MINT results for the next version of its Softstarter control products as this approach proved significantly better than its current technology. And carmaker Daimler intends to use D-MINT technology for ECU software testing in the medium term.

Perhaps most impressive has been the case of Estonian ICT specialist ELIKO which has used D-MINT technology and tools for a street lighting control card that is now widely employed in Estonia.

The new board incorporates a GSM modem and a battery. The hardware had already been developed and the software for the CPU tested when the customer completely revised the specifications. The high cost of the lithium battery and the manpower required to change it led to a desire to save energy on the board when external power was not available and the battery voltage level has decreased to a level that can cause damage to the battery. This completely altered all the requirements at the top level. Using classical testing, it would have been necessary to start again with three man-months of effort to get back to the current situation. Using model-based testing, working at a higher level of abstraction, ELIKO, working together with tool provider Elvior, was able to re-factor the models and generate the test cases needed with only ten days of effort.

In fact, after comparing the first iteration of the control board against classical software development, the effort for both approaches had proved to be about the same – not providing an overwhelming case for a switch. However, most of the effort with model-based testing was in the initial training – this learning phase should not be necessary in subsequent use. And this is exactly what happened with the radical redesign of the board.

So ELIKO validated that, when changes are made, D-MINT model-based testing is not just more efficient, but the greater the change, the more the improvement obtained.

More information:
www.d-mint.org