Model-based Development Tool Chain at Volvo Cars

- **Tool chain for function design, prototyping and automatic code generation**

- **MicroAutoBox as the proven in-vehicle solution for prototyping**

- **TargetLink as a reliable code generator for gearshift strategies**

In the development of electronic control units (ECUs) for automatic transmission, Volvo Cars has for the first time used a model-based development concept to develop gearshift strategies, and interlinked the subsequent development steps.

The Challenge: Linking Development Steps

After an ECU's functions have been described as either a written specification or a block diagram, they have to be put into executable code as fast as possible. One important objective is to connect the development steps seamlessly. For example, it is very helpful to developers if they can transfer specification data from the model design straight to the prototyping process or to production code generation. Development tools that guarantee the rapid transfer of ECU functions to other abstract levels are therefore growing in importance.

The main objectives in creating a model-based tool chain were as follows:

- To reduce the number of test vehicles by using more offline simulation

- To reduce the time needed for development by making optimum use of in-house knowledge for ECU design (modeling) and software development

- To allow fast and simple testing of new gearshift strategies

- To avoid communication problems and the ambiguity of function specifications between development steps

- To ensure that specifications are consistent, by running the ECU specification in the form of a model through all the subsequent development steps – offline simulation, prototyping and production code generation

So when we at Volvo Cars were planning the development of gearshift strategies for automatic transmission, it was important to find a model-based concept from which offline simulation, prototyping and production code generation could be performed primarily automatically and with as few technical obstacles as possible. The solution was a combination of several development tools, forming a tool chain that fits the overall development process perfectly:

- MATLAB/Simulink from The MathWorks for model design and VSIM for offline simulation (this is a tool developed by Volvo for offline simulation based on Simulink)
- dSPACE Prototyper with MicroAutoBox for rapid control prototyping
- TargetLink from dSPACE for production code generation

Shift Strategies for Intelligent Shifting at the Right Time

At Volvo Cars, transmission control software is divided into a number of different categories. These include shift strategies, shift quality (for example, adjustment to the specific clutch used), diagnostics, failsafe features, operating system, and a signal database.

The new model-based development process will initially cover the development of shift strategies only. These involve functions that "decide" when the transmission should perform a gearshift. Such functions could include:

- Cruise control: Gearshifts during constant speed driving
- Geartronic: Manual shifting with the automatic transmission gearbox
- Winter: Prevents wheelslip in slippery conditions
- HOT (Hot Oil Temperature): Prevents hardware damage due to overheating
- Quickstep: Detects 'sporty' driving and adjusts shift points to support this

The Development Process

First a model was developed for each function, and then it was verified in offline simulation with VSIM. We then successfully carried out rapid control prototyping with MicroAutoBox from dSPACE. The next step was to convert the model into a TargetLink model. TargetLink was then used to generate the production code and all the calibration information (ASAP file) automatically. In the final step, the production code and all of the handcoded functions were compiled together and loaded to the transmission control module (TCM).

Successful New Strategy

The new development process enabled Volvo Cars to make the following improvements:

- Better control of functionality; modeling gives better overview and structure
- Shorter process from function idea to implemented software
- Fewer logical errors in implemented functionality, better conditions for calibration
- Fewer communication problems and less ambiguity of function specifications; shift strategies are now developed in-house
- Flexibility: Function changes are performed quickly and easily

Tools Must Interlink

The challenge involved in this project was the new model-based workflow in the development of gearshift strategies. The work involved in introducing a new process is often underestimated, as a large number of personnel have to familiarize themselves

with new development tools within a brief period of time. The precondition for this is that all the tools used mesh with one another optimally. The interlinking of Simulink, MicroAutoBox and TargetLink was very satisfactory, and the only point

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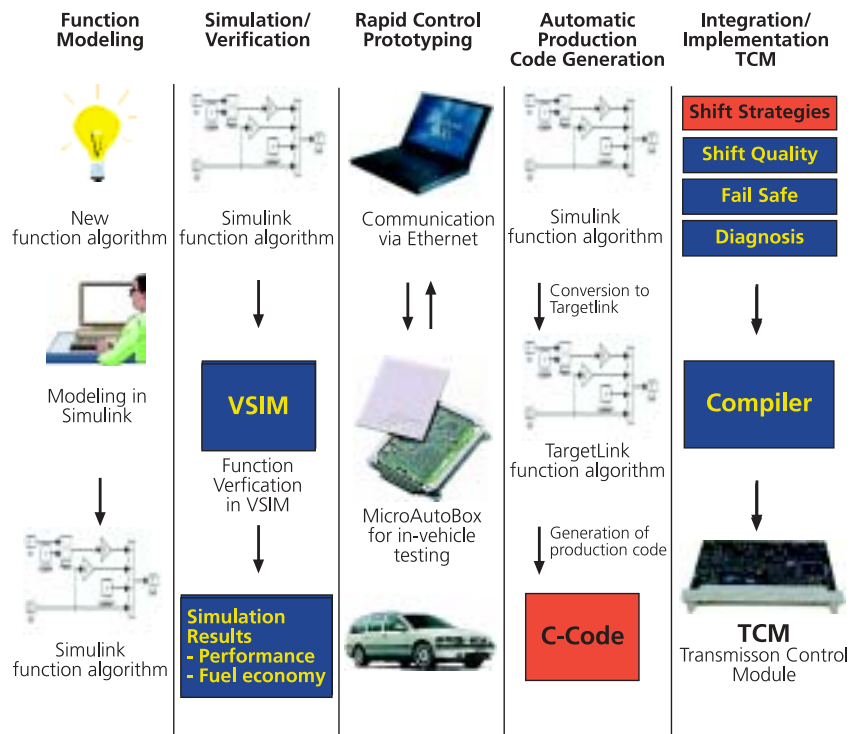
at which a little more time was needed in the start-up phase was in converting the Simulink models to TargetLink models in order to generate the corresponding production code.

On the Way to Completely Automatic Code Generation

Thus, our goal in the future will be to extend the model-based development of functions. Another objective is complete automation of code generation. We intend to make more intensive use of rapid control prototyping to achieve faster and simpler testing of new functions. In addition, we will produce test scripts, including different driving situations, automating the testing process.

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