A New Approach – Connected Cockpit Multi-domain Controller

AUTHORS

Dipl.-Des. (FH)
Gert-Dieter Tuzar, M.F.A. (Univ.)
is Principal Designer HMI in the Design Experience Europe department at Visteon Electronics Germany GmbH in Kerpen (Germany).

Dipl.-Ing. Harald Schöpp
is Executive Director in the Infotainment, Connectivity and Cockpit Domain Controllers department at Visteon Electronics Germany GmbH in Karlsruhe (Germany).

With increasing demands on networking technologies and processing power, driver information, infotainment and connectivity need to be managed more efficiently. Changing the view of traditional infotainment systems, Visteon joins these domains in its industry-first SmartCore – a one chip, multi-domain controller featuring a single integrated, seamless human-machine interface (HMI). The solution allows multiple domains to run side-by-side on a scalable hardware with different operating systems, greatly reducing system complexity.

SYSTEM ADVANTAGES

Visteon's new SmartCore concept offers significant and unique advantages over traditional, heterogeneous infotainment and driver information systems. Different operating systems can run independently, side-by-side, on individual cores of a multicore silicon chip. The solution combines several levels of information – ranging from safety critical vehicle data to personal information from the cloud – on one single chip for the first time.

Traditionally, different electrical domains such as driver information, infotainment, driver assistance and cloud connectivity have their own hardware – single or multiple electronic control units (ECUs) – that are connected via bus systems like CAN or Most. SmartCore fuses together these previously discrete ECUs within a single multicore silicon chip. Each core typically has a different operating system allowing the vast majority of software from the existing discrete units to be reused.

The seamless SmartCore HMI also allows free compositing of audio, video and graphics content from different domains to multiple display outputs and audio zones – another industry first.

SYSTEM SECURITY

SmartCore's cloud-based connectivity is secure and designed to protect the user's privacy. The system incorporates mechanisms that guarantee a seamless handover from full cloud support to fully-embedded mode if there is no cloud connection. If there is an issue – for example a malicious application consuming all processor power or a virus trying to stall the system – all system-relevant and safety-critical features remain operational. This is only possible with a solid firewall architecture – an intrinsic feature of the system platform.

ERGONOMIC ASPECTS

Incorporating new and additional options for drivers to interact with the system's HMI, while maintaining their focus on the road ahead, is challenging. HMI developers have to balance the technical potential with growing consumer demand for more features to ensure stringent automotive ergonomic requirements are maintained.

To meet today's expectation for a fully-connected driving experience; Visteon applied its user-centric HMI design approach which actively integrates user testing into the platform development process. SmartCore's HMI concept was drafted, continuously prototyped by HMI designers and tested globally. Usability and acceptance tests were carried out and analysed by Visteon. New insights, described further here, were directly updated and implemented in subsequent HMI releases. From a usability viewpoint, cognitive requirements such as simplicity, efficiency and intuitiveness have to be met. In spite of SmartCore's huge technical potential, focus remained on ease-of-use.

In addition to a flat system hierarchy, the system takes advantage of already-established interaction mapping from consumer electronics, featuring touch screens and touch pads using multi-gesture inputs. User interaction expectations regarding system behaviour were mapped based on available input modalities. Touch screen and touch pad HMI is offered in a symmetrical way, allowing the user to choose the favourite input device to control the functionality on the centre information display (CID). Only the instrument cluster display (ICD), as a domain, features a single and separated input device on the steering wheel. The symmetrical HMI design on the system level – and especially on the application level – helps to meet interaction consistency goals between the ICD and CID allowing the user to choose which device is best for him.

The graphical user interface (GUI) and its behavioural aspects have also been taken into account. For instance, the legal requirements for legibility, size and contrast of an automotive GUI are significantly different from consumer devices. When using SmartCore's touch screen, all touch targets on screen are designed to intelligently read the user's touch input (by finger) to avoid potential errors, for example unintentional activation of close-by functions. The legal requirements for interruptibility of tasks were also taken into account when designing the HMI and its animated behaviour.

HMI CONCEPT – DISPLAYS AND INPUT MODALITIES

SmartCore is a platform that can be offered at different levels in terms of information output technologies, types of software applications and types of control devices. At the lower end, the platform can feature an instrument cluster system only. At the higher end, it can incorporate several displays including infotainment, head-up and rear seat displays as well as tablets. For platform capability demonstration purposes, Visteon is using a high-end configuration example.

A fully digital 12.3" colour thin film transistor (TFT) display was selected as the ICD. The steering wheel hosts two input fields for controlling the ICD HMI, **FIGURE 1**. The input devices on the left side of the steering wheel offer full access to the functions. The input on the right side offers dedicated hard key access to specific infotainment functions such as volume control, push-to-talk for voice control and mute.

Above the ICD, a full colour 1.8" TFT head-up display (combiner HUD) presents concise driving-related information such as navigation or speed within the

FIGURE 1 Demonstrator steering wheel – the left input device offers full access to the functions, the right input device is dedicated to specific infotainment functions

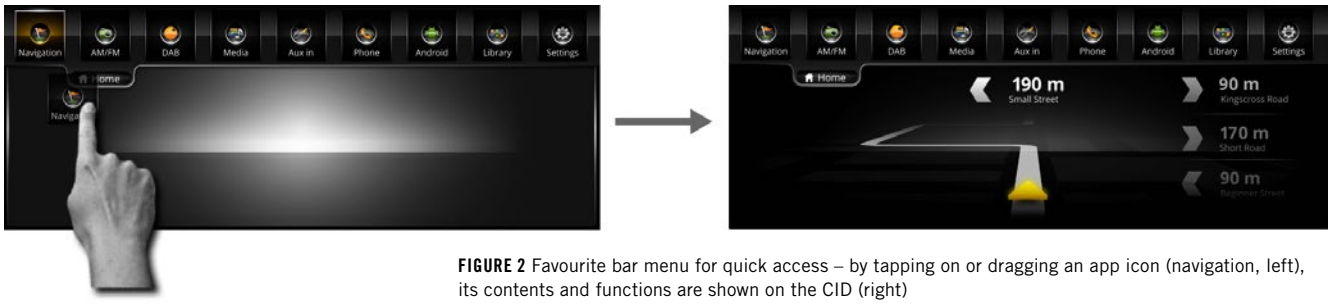

FIGURE 2 Favourite bar menu for quick access – by tapping on or dragging an app icon (navigation, left), its contents and functions are shown on the CID (right)

driver's line of sight. Direct menu interaction with the HUD is not considered for this prototype. In order to maintain the highest ergonomic and safety standards for the presentation and visualisation of information, only OEM-certified applications can be displayed on the HUD.

HMI KEY FEATURES

SmartCore is an application-based cockpit domain controller that allows the user to change and grow the vehicle's feature set over its entire lifetime. Users will be able to purchase applications (apps) via an OEM-certified app store on the platform. These apps are stored in an easily-accessible library from where users can decide which apps are visible.

The app-based system will not have a limited feature set. The strategy is to prioritise the growing amount of features via "favourites' management". Up to nine apps can be clustered in a row. Tapping on the menu, content is listed in a pull down menu on top of the CID, **FIGURE 2**.

From the quick bar menu, the user can decide if none, one, or two applications are displayed on the CID. This feature is called "population", **FIGURE 3** and can be executed by drag-and-drop from the quick bar menu on the touch screen or by using the multi controller. Application size and content automatically adapts to the available display area – depending on the number of active apps. The user can choose to change the position by the switch of a button.

Each application that is visible on the display can also be turned off; this is known as "de-population", **FIGURE 4**. This action can be executed on the touch screen by a simple finger swipe over the app area or by using a dedicated functional area on the multi controller. If two apps are visible on the CID and one gets closed, the visible app will automatically resize to full screen layout.

Application instances can be distributed from CID on ICD and HUD – called application extension. **FIGURE 5** shows the ability to extend apps from the CID to the ICD and HUD. SmartCore can feature up to four interactive applications on different displays in parallel. The information visualisation of one app changes according to its spatial location within the cockpit. The abstraction level of information grows heads-down to heads-up in order to reduce the risk of driver distraction;
for example the HUD provides concise and reduced visualisation of information.

The ability to interact with up to four applications in one system requires a new focused control approach. Compared to conventional information systems, SmartCore features a system focus that can be placed over each application, **FIGURE 6**. To activate an application, the consumer simply validates the selected app and continues interacting with the app as normal, since the focus is now within the app.

ACCEPTANCE TESTING

Visteon conducted early consumer and market testing in North America and China to gauge user acceptance of the system and to identify regional and cultural differences in perception and expectations. Research in Europe is still pending. In the survey potential target groups in different segments evaluated SmartCore's key features that are information extension onto other displays, multiple domains, display interaction and GUI style.

Enlarging applications using a simple finger swipe was overwhelmingly appreciated in both regions, especially in North America where customisation is considered a key element of the user experience and satisfaction. 98 % of North American respondents gave a positive or very positive reaction to this feature.

The ability to interact with up to two applications in parallel on the CID was also highly appreciated in both regions (population). Three quarters of the respondents in China liked this feature compared to 91 % in North America.

The interaction with the display was rated differently in the two regions.

FIGURE 3 Population with two applications

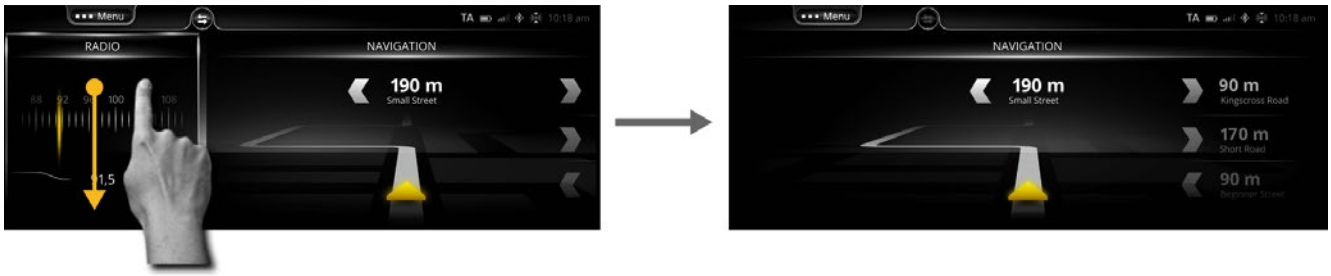

FIGURE 4 Depopulation via a simple finger swipe gesture over the app area

North American consumers wanted more flexibility in managing the displayed content and therefore valued the fact that they could interact with multiple devices. Chinese consumers did not appreciate the value of the multi-functional HMIs as much, generally preferring fixed input displays.

The biggest variance in perception was the reaction to the GUI styling. In China, 75 % of the respondents appreciated the styling; male participants to a higher degree. In North America, there was no visible gender difference. Here, 68 % of consumers gave a positive or very positive reaction to the style, with the highest level of acceptance found in the youngest age group.

OUTLOOK AND POTENTIAL

With the SmartCore HMI, Visteon offers a high potential information system. For future autonomous driving applications, Visteon expects an even more complex array of infotainment products to cater for consumer demand.

For driver information technology, contact analogue HUDs will become part of the architecture allowing information to be presented and mapped directly to the outside world. Stimulated by the way – and where – information is shown, new interaction input modalities such as 3D gesture control and eye tracking will add a new dimension to conventional solutions.

The presentation of information is experiencing a transition from pure 2D and 2.5D to rendered 3D objects. Dynamic 3D picture composers and HMI development tool chains have to be set up to support these new requirements.

Connected services, applications and functions will assist drivers in their daily-connected life and driving experience. The SmartCore connected cockpit domain controller is a unique solution contributing to the evolution of the passenger car as a platform for connected services.

FIGURE 5 Radio app extension from CID (left) to ICD or HUD (right)

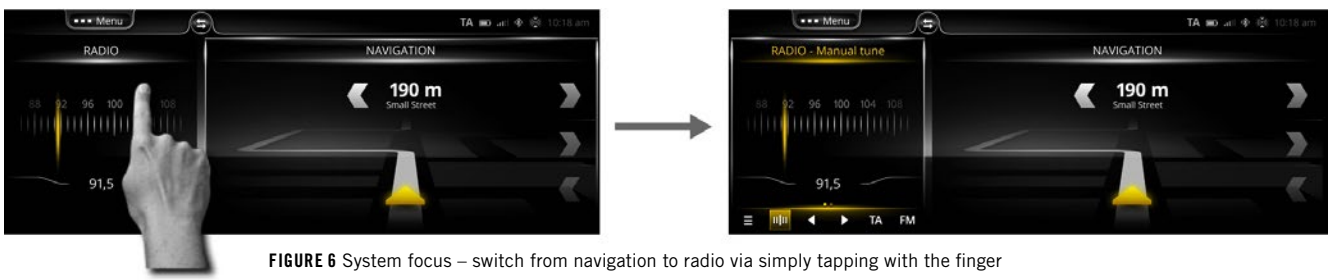

FIGURE 6 System focus – switch from navigation to radio via simply tapping with the finger