CARbridge, Reduction of System Complexity by Standardisation of the System-Basis-Chips for Automotive Applications

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Abstract

Semiconductor manufacturers continue to integrate functionality into Systems on a chip. Focused target in the automotive area for today are system basis chips. In this context system basis chips are all surrounding components for embedded µ-Controllers, such as: Transceivers, Watch-Dogs, Voltage-Regulators, Sensor-Interfaces, Switches and Diagnosis functions. Because of the lack of a standard, implementations differ and acceptance is missing in the development community. Also the potential evolution of the system CPU+SBC[1] does not happen, because no common target does exist. Therefore major car manufacturers are going to introduce a new standard: ***CARbridge****.*

1. Introduction

On there way to highly integrated systems, the semiconductors industry is searching for potential new areas in the automotive world. Like in the PC industry, the next potentials they identified are the surrounding components and peripherals of the µ-controller. Devices such as transceivers, watch dog, reset functionality, diagnosis, sensor interfaces etc. will be or are already included in SBCs.

Unfortunately those devices are not very successful at the moment, one reason is that in opposite to the PC industry the devices are not standardized. This has various disadvantages:

Additional development effort: Right now a device from manufacturer A is not exchangeable with device B from a different manufacturer. This means that the design of ECU[2] A also differs from ECU B in terms of PCB space, PCB layout, ECU- and software-development.

No second source: Because of the exclusivity of the different implementations, the automotive OEM has no chance for a second source strategy. Not in terms of quality and risk reduction, nor in terms of pricing. Every device needs its own software, so unification under the AUTOSAR [1] standard is impossible too. The similar situation exists for packaging and pinning, what inhibits the exchange of components.

No possibility for a construction kit: Rising complexity does become a major problem for car makers. This is why the development of construction kits is accelerated in different areas: engine, chassis and also in electronics.

The different types of implementation and depth of integration in actual SBCs does not allow the OEMs to develop a construction kit on SBC level. This also avoids that the higher integration level of SBCs is seen as a benefit. Exchangeability is not given and therefore no benefit in comparison to a discrete solution.

Prohibition of the development of a commodity market: When talking about SBCs, we are not talking about a unique selling proposition or an extreme complex element. The SBCs are on the contrary basis elements surrounding the complex CPU. The functionality of these elements differs from manufacturer to manufacturer only in details. But those details are big enough to avoid exchangeability. The ***CARbridge*** standard will help to drive the SBCs to commodity products.

Introduction of a standard software driver: An additional problem is the lack of a standard software driver for SBCs. Due to the number of different implementations it was till now impossible to develop a standard software driver. The addresses

[1] SBC = System Basis Chip
[2] ECU = Electronic Control Unit

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and registers even for a basic functionality vary from device to device.

Standardizing Registers, Addresses, basic functions, diagnosis, and digital interface will allow to have a basic AUTOSAR [1] driver for all ***CARbridge*** devices.

This will reduce the development time and enhance reusability for the car manufacturers. More important than this is, that the complexity will be reduced on the OEM development side. It will be shifted to the people who do know their system best, the semiconductors industry.

Hampering system evolution: When talking to the main semiconductor companies, feedback often is: system evolution is inhibited mostly by the lack of a standard. Big semiconductor companies, which do have µ-Processors and SBCs in their portfolio, complain that there exists no platform, which allows them to bring new ideas into the market without creating a niche solution. They see enhancements on both sides, µ-controller and SBC but fail to improve the system, because it means to implement a unique functionality in both parts. Those devices can then only be connected to their own devices and therefore with a reduced market. The missing standard to introduce new protocols or mechanisms to a wide area of devices does cost them often enough a huge amount of development effort, resources and therefore money.

2. U-Model

To visualize the idea, of integration of the surrounding or companion elements of the µ-controller into one device, the U-model can be used. As one can see, the devices interfacing directly with the CPU are drawn as a "U" surrounding the processor, whereas all other devices do communicate indirectly with the CPU using the parts of the "U".

In a possible first integration step for the coming SBC standard, the voltage regulator, transceivers, watchdog and reset logic will be defined. In comparison to existing SBCs the ***CARbridge*** compliant devices then will be exchangeable in terms of basic functionality, register settings, interfaces, package and pin-out.

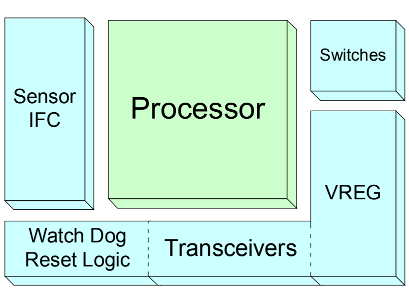

Fig. 1: U-Model and first integration step

Vision of ***CARbridge*** is the OCE (One Chip ECU) where all functions of the ECU are integrated in one chip, potentially including also the µ-controller. Partly this already exists. Major chipmakers developed OCEs e.g. for Mirror- or Door-Applications.

3. *CARbridge* standard

Looking to the PC industry the standard for chip sets is always defined by the µ-Processor. With each CPU a new North- and South-Bridge is defined. The basis functionality always is the same. Memory interface, floppy and hard drive controller, PCI interface and USB-controllers. What makes them exchangeable is not the strictness of the design, the technology or the device-standard, it is the standard of the interfaces. The interface of the CPU is given as well as the definition of the interfaces to the outside world.

In analogy to these bridges the new automotive standard is called ***CARbridge.*** It will be the bridge between the car and the µ-controller.

In the final implementation it will become an open standard, which allows after a defined period all players in the automotive area to participate and to compete in the standards area.

Fig. 2: *CARbridge* Logo

4. Stepwise standardisation, evolution

In actual ECU implementations a mixture of different technologies is used for the different elements. The CPU is normally developed in a CMOS process with very small gate length. The Analogue and High voltage parts are designed in a different CMOS or even a BiCMOS process.

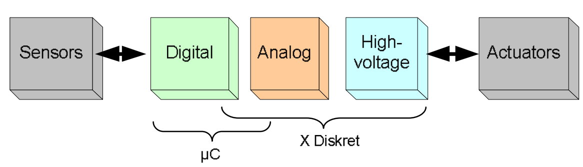

Fig. 3: Discrete solution, mixture of technologies

CARbridge would allow evolving the system in this field, by separating the high integrated CPU technology from the analogue and high voltage technology. (See Fig. 4) Then each element could be manufactured in the best fitting technology.

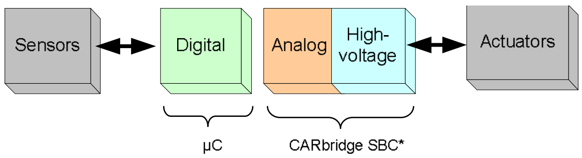

Fig. 4: Integrated solution, separation of technologies

Target of ***CARbridge*** is the step by step integration of the surrounding elements of the µ-controller into one package (as seen in figure 5).

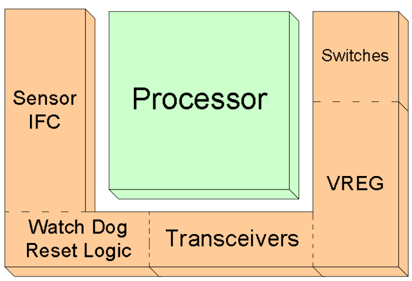

Fig. 5: Integration

Once all parts are integrated in a CARbridge device, the next step would be to reduce the number of interconnects between CPU and SBC. In a final evolution only a few number of connects would be sufficient. A high speed data link and a power link can be sufficient to connect ***CARbridge*** and µ-Processor. Along with that comes a significant reduction in complexity of the PCB and therefore the ECU.

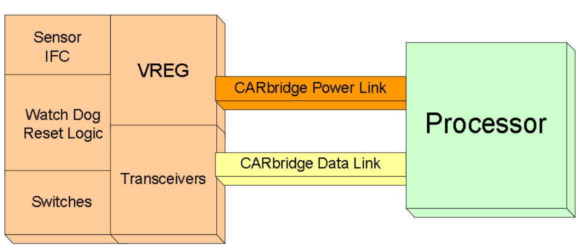

Fig. 6: *CARbridge* Vision

For the car manufacturers it is as important to have a standard and solid definition of all interfaces, as to have a platform to communicate their needs to the semiconductor industries. The trends for outsourcing the development from the car manufacturers to the 1st Tiers took also away the ability to "steer" the semiconductors industry in a direction to fit best their needs.

By defining this standard together with their 1st tiers and semiconductor suppliers a platform will be established to allow all three parties to discuss future devices, and features. Those devices then may become the commodity parts of the future.

5. Content of the standard

Standardisation of the interfaces will be the first step to canalize the development of systems on chip for automotive applications. This specification will be a basic boundary, not a limitation. Even this first small step will be an advantage for all participants, because they then have defined interfaces at hand.

- CARbridge Classes
- Interfaces / SPI
- Package / Pin out
- Register & Address Definition
- Standard SW Driver
- Watchdog
- Reset / Start Up / Wake up
- Clock Generation
- Qualification
- Ambient temperature range
- Power Saving Modes
- Diagnosis functions
- Safety and security Functions
- ESD / EMI
- Voltage Regulator
- Voltage Robustness

Above mentioned points are the inputs from an already defined OEM working team. They are the minimum content of the specification.

6. Main Goals

What are the main goals for this standard from the carmaker point of view?

Standard SW driver: The possibility to have one basis driver for all SBCs, which is also AUTOSAR conform, will reduce the system cost. The car manufacturer can reuse the basic driver for all applications and also the semiconductors companies can reuse this for every ***CARbridge*** device. Only additional functionality has to be implemented on top.

Evolution of the system µ-controller & SBC: The standardisation will also allow future enhancements. The power down modes in the car for example can be extended as in today's laptops and mobile phones, where additional modes with reduced voltage and frequency do exist. Another example is an extended SPI to speed up communication between µ-controller and SBC. In a final implementation this can lead to a system composed of CPU and SBC connected only by a power and a high speed data link.

Although extra wake up states, where the µ-controller only wakes up for a specific amount of time and the data will be send with high speed or burst mode are available. Other key words are: umbrella qualification, EMI and ESD.

Reduced complexity by integrated functionality: Rising system complexity becomes a major problem in car manufacturing. Not only the number of ECUs, but also the network (e.g. data requests in domains) and the functionality of the ECU itself raise system complexity with exponential speed. [2] To have a standardised integrated solution allows the developer to focus on the functions of his ECU and not to take care about the implementation of the functions by the usage of discrete devices.

Moving the complexity from separate pieces to a "black box" simplifies the ECU development as well on OEM side as on 1st Tier side. This is true for the technical, logistical and cost aspects (see Fig.6-9).

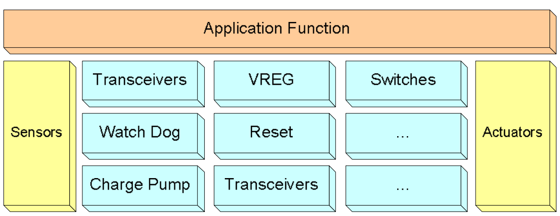

Fig. 7: Current development view of complexity

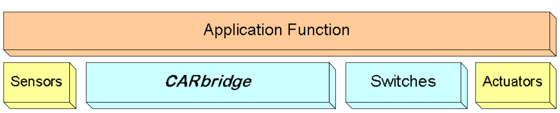

Fig. 8: Reduced complexity with *CARbridge*

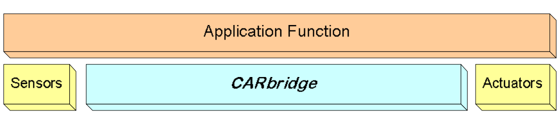

Fig. 9: Final *CARbridge* implementation

Improvement of functional safety in the electronic systems: Major fields for innovation of today's cars are the advanced driver assistance systems (ADAS), e.g. Lane departure warning, Pedestrian Protection System, Adaptive Cruise Control (ACC) or Collision Warning/Detection. With those critical systems the functional safety of the ECUs becomes more and more important. [3] Today the functional safety is not part of the integrated systems. Right now it is often realized with discrete elements.

The integration in the CARbridge standard will be a major step to increases the safety functionality and will reduce the cost and complexity! The standardization in this field allows OEMs overlapping an improvement leap.

Cost reduction: The change from a discrete to an integrated solution may be more expensive on the front loading costs, what means development cost is higher and qualification cost is higher on semiconductor side. But this remains only valid for the first time it will be more than compensated over the lifetime of the product. For further products the developers are able to use existing HW-Library-Parts and SW-Drivers. This will decrease the development time and reduces development resources.

Test coverage, End of Line Test and Qualification shout be a part of the first development steps. This will bring enhanced quality, higher stability, better diagnosis functionality and improved testability

Evolution: Target for the coming standard is to define all interfaces and the communication between the µ-controller and those interfaces. Even if not all interfaces can be included in a first (V1.0) version, the interfaces should be standardized to avoid a number of variants like within the SPI[3] of today.

reduced complexity = improved controllability shortened development time = reduced development cost

Above formulas name the main motivation of ***CARbridge,*** described also by picture 7 to 9.

The major tool to reach this main goal will be, to bring car manufacturers as well as semiconductor manufacturers and 1st Tiers together to define a strong and useful specification for ***CARbridge***.

7. References

[1] AUTOSAR; "AUTOSAR Main Requirements V2.0.1", 26.6.06, AUTOSAR GbR

[2] Dr. G. Reichart, P. Vondracek, Dr. R. Bruckmeier; "Systemarchitektur im Kraftfahrzeug – Status und künftige Anforderungen"; 17.07.2007; Ludwigsburg; BMW Group

[3] Walter Kuffner, „Umsetzung der Anforderung aus der funktionalen Sicherheit in der Fahrwerkselektronik"; 17.07.2007; Ludwigsburg; BMW Group

[3] SPI = Serial Programming Interface