

Innovative EMBEDDED DESIGN drives exciting applications

The design method of embedded system involves many aspects, industry points out key issues and challenges.

SHIKHA NAGPAL

Embedded systems development has been an integral part of the Indian IT-R&D ecosystem growth. Early adopters in the Indian and multinational organizations started their embedded services practice early in their lifecycle driven by the cost advantage and access to a skilled talent pool. During the early 2000s, a plethora of global organizations set up their captive centres in India to drive embedded systems development. The industry also witnessed start-ups in industries such as Telecom, Consumer Electronics, Semiconductors set up their own centres at various locations across India.

With the maturity of this segment, organizations are now leveraging India to drive products, services and business models innovation from India. Access to the India market has also become a key driver for organizations to drive embedded systems R&D locally.

Another interesting trend is a significant growth in the number of indigenous organizations working on their own innovations in Medical Equipment, Consumer Electronics, Telecom and other verticals. Innovations have also started to come out of universities and incubation centres across India. India has now become the undisputed center of electronics innovation. This innovation in electronics design is driving many exciting new devices and applications in a variety of allied

industries, including SoC and embedded software designs for smartphones, tablets/computers, storage, commercial and medical imaging, set-top boxes, displays, wireless communications, and automotive applications. On an average, electronics constitute 35 per cent of an average car's cost. Even the low-cost Tata Nano features a microcontroller to control the engine performance.

"Overall embedded systems market is growing at an estimated CAGR of 5%. However, new domains and applications are emerging continuously, and have a very high growth potential. For example, personal mobile devices market is expected to overtake the PC market this year. Embedded connectivity in Automotive segment is another new high growth area. Energy efficiency in industrial applications is an emerging sector for embedded systems. Military applications, as always, continue to be an area where a lot of pioneering research and innovations happen. All these new applications result in higher operational efficiency of machines and workforce", said Mr. Narayanan Bhattathiripad of Mistral Solutions.

The addressable opportunity in embedded systems development is estimated to be USD 90 billion by 2015. The Indian IT industry, with its traditional strength at managing services and developing software is capable and ideally poised to tap into this large opportunity.

"The embedded system industry has reached quite



Arun Mulpur
PhD Manager,
Industry Marketing –
Communications, Electronics,
and Semiconductors
MathWorks



Edward Tsauro
Field Marketing Director,
APAC,
Atmel Corporation



Guruswamy Ganesh
VP and Country Manager,
Freescale Semiconductor India



Praful Joshi
Business Development Manager,
Wind River India



Suraj Mukundarajan
Director Automotive
Software Development,
Infineon Technologies
India Pvt. Ltd.



Mohamed Saliya.M.A.
Managing Director,
iWave Systems Technologies
Pvt.Ltd.



Narayanan Bhattathiripad
Senior Vice President –
Emerging Business,
Mistral Solutions Pvt. Ltd.



M. K. Mak
Regional Vice President
of Distribution,
Sales and Marketing Operations,
ON Semiconductor

L. Balasubramanian
Director of
Product Applications,
PSoC,
Cypress Semiconductor Corp.

far and is now not only limited to the computing that many would still believe. With the convergence of communications devices, embedded systems have now transformed and have created newer opportunities and challenges to develop and market more powerful, energy efficient processors, peripherals and other accessories", according to Mr. Ganesh, of Freescale Semiconductor.

"Embedded systems are everywhere in every walk of life – from military and space systems to implanted medical systems. In particular, according to a recent Linley Group report, the high-speed embedded processor market segment is expected to cross \$5 billion by 2015 from its current size of about \$3.6 billion. Single-core, single-chip embedded systems of the past two decades are now giving way to multi-core and multi-chip embedded systems. At the heart of these systems is embedded software that implements increasingly complex, high-speed, and math-heavy algorithms", said Mr. Arun Mulpur, MathWorks.

Embedded System Innovations and Trends

Embedded systems are vital to our own existence as can be proven by their widespread use in automotive applications, consumer electronics, telecom, home appliances, comfort and security systems, factory control systems, defense systems, and so on. This view is nowadays indiscriminately shared by everybody, mainly those who live in developed countries, as well as those that are in charge of developing such systems.

The embedded system is comprised of the special hardware and a programmable component which is used to interact with the hardware. It usually includes software, hardware and a special system with certain communication channels. It is generally used as a part of a large system and realized by using the system of chip (SoC). In this way the software provides functions and versatility, the hardware provides the performance. Today embedded systems have been used in every sectors of the industry, from home appliances to the navigator of missiles and spacecrafts. The major building blocks of an embedded system are listed below:

- Microcontrollers / digital signal processors (DSP)
- Integrated chips
- Real time operating system (RTOS) - including board support package and device drivers
- Industry-specific protocols and interfaces

• Printed circuit board assembly

Usually, an embedded system requires mechanical assembly to accommodate all the above components and create a product or a complete embedded device.

In the past, most researching activities in the pc industry were mainly focused on the desktop or laptop pc. But the development of the new technology and social demand has been making companies to shift their sight to environmental intelligent system, which is a kind of embedding system that can sense, obey and react to instructions. As the fast developing of the IC design technology, the central processing unit (CPU) is becoming cheaper and cheaper. Many electronic wares are embedded with CPU and become a so-called embedded systems. Obviously there is a need to change the focus of system research work, that is to change from the general system to the dedicated system and from performance to robustness, usability, safety, auto control, extensibility, function, versatility, cost, size, power saving and manageability. Basically, innovation is a continual process that leads to the introduction of something new and it is a key goal of industry. Apart from software and electronic(digital and analog) components, embedded systems also contain dedicated sensors and actuators, mechanical components, etc, constrained to the design challenges of space, power consumption, cost and weight. Essentially, they differ from the classical IT in several characteristics like: autonomy, flexible networking, default tolerance, restrictions on user interfaces, real time operation, reactivity, restricted resources, etc. "Embedded system design is moving towards integration. System engineers are looking for System-On-Chips (SOC) more than ever – for example, the latest set top box is pretty much powered by a single IC! Proprietary solutions are becoming the rule of the day rather than an exception! Hence semiconductor companies can focus more on innovation and creativity and not worry as much on being compatible with other sources", said by Mr. L. Balasubramanian for Cypress Semiconductor Corp.

According to Mohamed Saliya.M.A., iWave Systems, "High performance, multi core SoCs is the emerging trend these days. With the advent of such high performance and multi core SoCs, the design and development of platform hardware and software is becoming more complex. The application development is emerging to be more and more challenging since the features needed by

the embedded systems users are increasingly complex”.

On the similar phase, Mr. Praful Joshi of Wind River commented, “The current embedded systems are getting more complex in nature. The complexity comes from the requirements from the market that a lot of functionality needs to be built and integrated into devices.

Multi-core and virtualization is the trend being adapted by many in networking, aerospace & defense, industrial markets and other vertical markets such as mobile, automotive have a lot of convergence in terms of applications. Consumers want to have the same experience when they use mobile and when in-car or at-home on TV”.

“There is a sea of opportunities with emerging applications in embedded systems especially in the Automotive and Industrial area. With more and more electronics getting into the car – highly efficient control systems and data processing demands new methodologies to overcome complexity. Safety in the car electronics is becoming a critical aspect that is governed by both Functional Safety and development standards such as ASIL. Hybridization and electric motors demand very high performances from the electronics at extremely low power. These trends also drive battery management technologies. All of these call for an energy efficient embedded systems with precise HW-SW partitioning. Energy efficiency at home drives a lot new application area for well established systems such as motor control. The whole world and emerging economies in particular, will drive the demand for a lot of power-efficient applications into conventional systems. Embedded systems are at the heart of every piece of innovation that generates and saves power for the world”, highlighted by Mr. Suraj Mukundarajan, Infineon Technologies.

The industry must support the emerging trends in embedded systems in order to stay competitive and among the major ones the following were observed:

1. new generations of applications and products with increasing complexity and high demand for functional safety and security, as well as improved autonomy and usability, and interoperability in network;
2. increasing computational power of embedded processors combined with reduced silicon area and energy, as well as improvements in operating platforms and middleware support for efficient development of reliable systems;

3. new embedded system design methodologies to fill the HW-SW productivity gap, in order to match the software productivity to the speed of HW innovation;

4. merging of application sectors like electronics and IT or telecommunication and consumer electronics to provide multifunctional and more attractive products;

5. embedded systems designers are facing tight time-to-market constraints due to the cognitive complexity of current embedded systems, and so there is a need to balance time-to-market with the quality of the designed product.

According to Mr. M. K. Mak, Regional Vice President of Distribution, Sales and Marketing Operations, ON Semiconductor, “India is one of the fastest growing economies. With more and more requirement of intelligence in products and applications, microcontroller demand is bound to increase. The latest design trend is to use MCU in large scale to simplify the design delivering much more value to the consumer”.

To keep up with these trends, the industry is facing new issues and challenges in designing current embedded systems, such as, lifecycle mismatches, skill shortages, low reuse of components, quality concerns, and increased warranty costs.

“Today, end markets are demanding embedded systems that manage to combine higher performance with lower power consumption. That is one major design challenge. In addition, end users are demanding more advanced human-machine interfaces, including interfaces that incorporate graphical displays. End users are also demanding embedded solutions that have a higher level of machine intelligence” said Edward Tsaur of Atmel Corporation.

He adds, “As a key microcontroller supplier, Atmel knows that the market for ARM devices will continue to grow in 2012. New applications and markets are evolving from a range of innovative concepts, including the Internet of Things, Android TV, and Apple TV. However, the entire microcontroller market will also continue to expand, and we will see many more new microcontroller applications. Atmel will continue to release new products and solutions based on new technologies for advance peripherals, IC processing and low power consumption”.

Atmel today offers an extensive range of products based on ARM Cortex™-M3 and Cortex™-M4 processor technology. These have numerous embedded applications, including smart energy;

power conversion; motor control; medical equipment; communications gateways; machine-to-machine (M2M) interfaces; POS terminals; and building and home automation.

The Challenge for Design

It is not only difficult but also very mistakable to design a software for an embedded system which can run smoothly and make fast real time decision. Many of this kind of system are key systems, high robustness, good quality of service and strict power consumption are needed. All these factors make the design company very difficult to figure out embedded systems in different levels according to different using environment. Further, when designing embedded systems the design difficulty exponentially increases as the complexity increases, and the production efficiency of the design engineers are dramatically decreased. So, the design company needs a robust design process which can guarantee correct design or provide means to verify the design, so that all the design schemes satisfy the limitations.

Therefore the design method of embedded system involves many aspects, such as, modeling for the embed system to satisfy the functional or non-functional demands; separating the model into hardware part and software part so as to satisfy the demand for performance; meanwhile the cost, power consumption and other factors shall be optimized. And the model shall be verified and tested from other related aspects. All these challenges shall be properly considered when designing embedded systems.

All EDA suppliers have all issued some embedded system design environment. Many Universities of the World have also developed many design tools for embedded system design, but all these tools are too specific and can be only used in limited specific application environment. In this area there is no single total solution. The only method which is suitable for embedded system design is the point tools based on excellent design methodology. Now, the industry is carrying research work on methodology development and point tools development, because they need to be improved both.

Cypress is in the forefront of research. Mr. L. Balasubramanian highlights, "Embedded design challenges are fast-time-to-market and last minute requirement changes, triggered by competition. Cypress' Programmable System On a Chip (PSoC) is perfectly positioned to address both these

challenges – it provides the system engineer the ability to design his/her system quickly as well as modify it in the last minute to add a feature or two.

Cypress offers plenty of ready-to-use solutions for the embedded systems industry. Cypress PSoC is the choice of market-leading embedded system companies in the following applications: System Management Control, Electronic Bikes, Mobile and Tablet accessories, Battery Charging and more. You can find extensive technical documentation on every solution that we offer on our website".

"Lesser area, faster speed and low power what is required by almost all the new devices that get introduced in the market, thus there is pressure on the engineer to build innovative device that are in sync with this requirement. Apart to this, Design efficiency, time to market and cost optimization are other key challenges that we have in the embedded design industry", mentioned by Mr. Guruswamy Ganesh of Freescale. "We at semiconductor industry understand this and are constantly focusing all our efforts to achieve the same. This is no doubt a challenging task for everyone. Combined with the need to run along the technology advancement, we have to devise new methods to reduce costs to help our partner remain competitive in the marketplace this requires a huge investment in the R&D that we are constantly putting. We have made an investment of more than USD 700million in each year during the last 3 years on our R&D. Today, we have required expertise and experience to overcome these challenges and realize economic value for our customers", he adds.

"Engineering challenges in this space span all aspects of the design flow – from requirements to verification and validation. Discovery of design errors much later in the system development process continues to be the nightmare scenario for embedded engineering teams. Beyond identifying and addressing design errors as early as possible, the engineers must also address the growing complexity of the systems that have a direct impact on the time and resources needed for design as well as for implementation and verification of embedded systems.

Business challenges in embedded system design are familiar but no less formidable – innovation, quality, and time-to-market. Engineering managers have the unenviable task of having to balance projects along these three dimensions while being aware that increasing emphasis on any

one dimension has an inherent negative effect on the other two", said Mr. Arun Mulpur, MathWorks. He says, "At a high-level – connecting design requirements to models; utilizing models as executable specifications to drive the embedded system design flow; and generating efficient code automatically from the models – are the key values that MathWorks products deliver to help address the challenges of embedded system design. These complementary and interconnected concepts are the core of Model-Based Design. Many independent studies have proven that Model-Based Design provides a distinct, quantifiable, and sustainable competitive advantage to companies with 35-40% savings in engineering expenses and time-to-market advantages.

MathWorks provides a complete and comprehensive Model-Based Design environment. MATLAB®, Simulink®, and Stateflow® provide the modeling platform for creating an executable specification and simulating the embedded system and plant models. Simulink Fixed Point™ enables engineers to convert the models to fixed-point if needed and optimize for memory and performance requirements. Embedded Coder™ enables automatic generation of C/C++ code. Certification kits are available for safety-critical applications or standards-compliant code qualification.

Simulink Design Verifier™ and Polyspace® help streamline the verification of the design and the generated code. Built-in project management capabilities and connectivity to requirement specifications provide the necessary infrastructure for handling complex large-scale embedded system designs.

Many of the world's leading aerospace and defense, automotive, communications, computer, electronics, energy production, industrial automation, medical, and semiconductor industries practice Model-Based Design of embedded systems using MathWorks products. More information can be found at www.mathworks.in/embedded-systems.

"The major challenge in the embedded system is not in the programming and algorithms", comments Mr. M. K. Mak, ON Semiconductor. He said, "Today with most of the advanced support given by semiconductor suppliers such as ON Semiconductor, the developer is very comfortable in developing codes. But the real challenge is in interfacing the physical world to the microcontroller such as:

- interfacing various sensor outputs, processing the sensor outputs from millivolt to the proper signal levels required for the microcontroller with impedance matching,
- creating a good and noise immune power supply while facing the challenge of lower supply voltage supplies requirements,
- support on communication protocols such as CAN/LIN, SPI, I2C,
- protection of these devices and systems against ESD, EMI and surges plays a vital role in managing the reliability of the whole system. Also, generation of clocks, managing the jitter and skew of such generated clocks is very important. Distribution of clock and data signals throughout the system with proper fidelity plays a vital role in the system design and implementation.

ON Semiconductor with its portfolio of microcontrollers for embedded systems, is providing an eco-system for the development of such systems with complete portfolio of products to address the functioning of the whole system. According to Mr. Praful of Wind River India, "The big challenge is how to address complexity. Traditional embedded systems were simple in nature of functionality. But now with multi-core and virtualization technologies becoming a need to address those complexities, it is important to have right the operating environments, tools, and solutions. At Wind River, we constantly work with eco-system of our hardware and software partners to make sure that the technology challenges are met and delivered in correct and timely manner. This helps the customers rely upon a trusted partner like Wind River with our new technologies and roadmap so that customers can meet their ultimate challenges in short and long-term. Wind River is the leader in embedded systems, providing solutions to address complexities in all different verticals/domains. In A&D, we provide solution for SWaP (Space, Weight and Power) optimization. In networking, Wind River provides solutions for 4G and beyond. Also in mobile and automotive, we are founder member of OHA, GENIVI and we offer commercial solutions on Android and GENIVI".

Mr. Suraj Mukundarajan, Infineon Technologies India pointed out, "The primary challenges in embedded systems today are complexity, code-size, system performance and power consumption. Power management especially, is becoming the principal challenge to most embedded developers. The notion one-size fits all approach needs to be critically reviewed since the advent of hand-held

applications that should last the distance. Software efficiency has been a major challenge since the mobile phone industry boom. This trend is visible significantly across all application segments now and goes hand in hand with power consumption". "Infineon has energy efficiency, mobility and security as our primary technology drivers. We specialize in highly efficient MCUs for the Automotive embedded electronics with our proprietary TriCore line of products that cater to the powertrain and safety segments of the automotive applications. Infineon has been a technology driver in the automotive sensors applications that have supported several innovative solutions. Our power management devices not only fulfil their primary target – energy efficiency – but also come in various form-factors to suit today's applications." he adds. "Ultra low power designs, low cost, high performance miniaturization and quick time to market are the few challenges still though known for quite some time", commented Mohamed Saliya.M.A, iWave Systems. He further says, "Continuous System on Modules roadmap which meets the high performance requirements and helps to reduce the system design complexity by abstracting all the design challenges into System On Modules (SoMs) and thereby optimizing the Time to market. More focus is on the reusable software component development for addressing the application development challenges". iWave has brought out multiple System On Modules (SoM) with development platforms using ARM9, ARM Cortex A8, ARM Cortex A9 and so on. For more details about our SoMs, please look at www.iwavesystems.com/

According to Mr. Narayanan Bhattathiripad, Mistral Solutions, "The challenges faced in Embedded System design vary widely depending on the end application it is targeted for. These challenges vary from managing hard real time constraints and/or environmental constraints to meeting extremely small packaging requirements, very high reliability and/or cost targets. The main challenge we face in embedded system design for the verticals we operate in is the constant demand of higher computing power for lowest overall system cost. The designer always has to manage the pull between these two orthogonal set of constraints. The semiconductor companies and OS providers are constantly trying to provide the best possible solution to the designer. Still, in almost all the application areas, the demand for advanced features and expectations from the end

users keep growing endlessly. Success comes to the designer who optimizes the design for lowest possible cost and highest possible usability and features.

Another challenge frequently faced by the designer is to keep abreast oneself with the upcoming technologies and developments. As the demand for performance from any embedded system rises constantly, and the technologies get obsolete much faster than probably in any other field, being at the forefront of technological development is of prime importance.

Most of Mistral's activities involve getting a product from a concept to deployment. This gives the designer a complete view of a product from end user's perspective of target price as well as necessary features. At the same time the designer is fully up-to-date with the latest available technologies. This situation helps the designer to optimize the design for the user, so that the end user gets the best possible performance and features at the best price. Partnership with technology leaders and semiconductor companies keep Mistral designers at the forefront of technology all the time. The designers get to work with ICs that are yet to be released in the market and get hands-on with emerging technologies.

Mistral's Product Engineering Services are delivered through a proven development process, designed for embedded product development. The hardware and software teams at Mistral work together in a seamless manner, providing expert product designs covering board and FPGA Designs, BSP and Firmware developments, Embedded Application developments, Integration of 3rd party solutions, Verification & Validation, product prototyping, production coordination and product sustenance services.

Some of the products/designs that Mistral has worked on are available in the international market. These include: head-mounted computers, next-generation in-flight entertainment system, e-book readers, universal remote controls, portable bar code scanner, wearable surveillance system and hands-free car kit, among others. Today, Mistral is a trusted partner for product developers across the world for its expertise and experience in designing feature-rich next-generation products from concept-to-deployment".