Software Engineering For Embedded Systems Chapter 7 Embedded Software Programming And Implementation Guidelines

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Design Approach Embedded System Development Process Computers as Components Software Engineering for Embedded Systems Software Engineering for Embedded Systems Embedded and Real Time System Development: A Software Engineering Perspective *Robert Oshana Inga Harris Bruce Douglass Frank Schirrmeister Robert Oshana Mark Pitchford Jim Trudeau Dr. G Vimala Kumari Mark Kraeling Frank Vahid Jean J. Labrosse Whitson G Waldo Mark Kraeling Steven Frank Barrett Bashir I Morshed Roger Hu Wayne Wolf Erich Styger Gary Stringham Mohammad Ayoub Khan*

an embedded system is a computer system designed for a specific function within a larger system and often has one or more real time computing constraints it is embedded as part of a larger device which can include hardware and mechanical parts this is in stark contrast to a general purpose computer which is designed to be flexible and meet a wide range of end user needs the methods techniques and tools for developing software systems that were successfully applied to general purpose computing are not as readily applicable to embedded computing software systems running on networks of mobile embedded devices must exhibit properties that are not always required of more traditional systems such as near optimal performance robustness distribution dynamism and mobility this chapter will examine the key properties of software systems in the embedded resource constrained mobile and highly distributed world the applicability of mainstream software engineering methods is assessed and techniques e g software design component based development software architecture system integration and test are also discussed in the context of this domain this chapter will overview embedded and real time systems

this chapter introduces the automotive system which is unlike any other characterized by its rigorous planning architecting development testing validation and verification the physical task of writing embedded software for automotive applications versus other application areas is not significantly different from other embedded systems but the key differences are the quality standards which must be followed for any development and test project to write automotive software the engineer needs to understand how and why the systems have evolved into the complex environment it is today they must be aware of the differences and commonalties between the automotive submarkets they must be familiar with the applicable quality standards and why such strict quality controls exist along with how quality is tested and measured all of which are described in

this chapter with examples of the most common practices this chapter introduces various processes to help software engineers write high quality fault tolerant interoperable code such as modeling autocoding and advanced trace and debug assisted by the emergence of the latest autosar and iso26262 standards as well as more traditional standards such as aec obd ii and misra

the software architecture of embedded computing systems is a depiction of the system as a set of structures that aids in the reasoning and understanding of how the system will behave software architecture acts as the blueprint for the system as well as the project developing it the architecture is the primary framework of important embedded system qualities such as performance modifiability and security none of which can be achieved without a unifying architectural vision architecture is an artifact for early analysis to ensure that a design approach will lead to an acceptable system this chapter will discuss the details of these aspects of embedded software architectures

when planning the development of modern embedded systems hardware and software cannot be considered independently over the last two decades chip and system complexity has seen an enormous amount of growth while more and more system functionality has moved from dedicated hardware implementation into software executing on general purposed embedded processors by 2010 the development effort for software had outgrown the development efforts for hardware and the complexity trend continues in favor of software traditional design techniques such as independent hardware and software design are being challenged due to heterogeneous models and applications being integrated to create a complex system on chip using proper techniques of hardware software codesign designers consider the trade offs in the way hardware and software components of a system work together to exhibit a specified behavior given a set of performance goals and technology this chapter will cover these topics

when designing an embedded system special care must be taken when you design the user interface for simple devices simple text command buttons and leds are adequate for more complex systems full graphical user interfaces and touch panels are required user interface design focuses on the following key areas a the design of interfaces

between different software components b the design of interfaces between the software and other nonhuman producers and consumers of information and c the design of the interface between a human and the computer this chapter will focus on the process guidelines human factors and techniques required to design an effective user interface

state of the art techniques and best practices in the development of embedded software apply not only to high integrity devices such as those for safety critical applications like aircraft flight controllers car braking systems or medical devices but also to lesser integrity applications when the need to optimize the effectiveness of the available test time and budget demands that pragmatic decisions should be made to complement this multitude of software test techniques there is a similar plethora of test tools available to automate them these tools are commonplace in the development of safety critical applications but elsewhere not everyone has the budget to buy all or indeed any of them of course the providers of these tools would advocate the purchase of each and every one of them so how can a limited budget best be allocated and where no budget exists how can similar principles be applied to provide confidence that the finished item is of adequate quality in addressing these issues not only are the concepts behind the techniques presented but also some case study software code examples to drill a little deeper and illustrate how some of them are implemented in practice

this chapter explores the unique challenges that limit reuse in embedded systems and strategies to overcome them it explores what limits reuse and traditional approaches to overcome the limitations such as a hardware abstraction layer or an rtos porting layer it does not stop there the shortcomings of layered software drive a desire for highly optimized reusable software components this chapter introduces the component factory concept a mechanism that creates reconfigurable and reusable hardware and rtos agnostic components generated by an expert system

this book aims to provide a broad view of the embedded systems and iot a theoretical approach embedded systems and the internet of things are well known in various engineering fields it provides a logical method of explaining various complicated concepts and stepwise methods to explain important topics each chapter is well supported with the necessary illustrations all the chapters in the book are arranged in a proper sequence that permits each topic to build upon earlier studies embedded systems and

internet of things are an important research area the techniques developed in this area so far require to be summarized appropriately in this book the fundamental theories of these techniques are introduced the brief content of this book is as follows chapter 1 basic of embedded systems chapter 2 embedded firmware chapter 3 real time operating system chapter 4 introduction to internet of things chapter 5 iot protocols chapter 6 iot architecture chapter 7 challenges and applications of iot chapter 8 data analytics for iot chapter 9 iot physical devices and endpoints chapter 10 internet of everything ioe chapter 11 iot applications case studies this book is original in style and method no pains have been spared to make it as compact perfect and reliable as possible every attempt has been made to make the book a unique one in particular this book can be very useful for practitioners and engineers interested in this area hopefully the chapters presented in this book have just done that

this chapter provides some guidelines that are commonly used in embedded software development it starts with principles of programming including readability testability and maintainability the chapter then proceeds with discussing how to start an embedded software project including considerations for hardware file organization and development guidelines the focus then shifts to programming guidelines that are important to any software development project which includes the importance of a syntax coding standard the chapter concludes with descriptions of variables and definitions and how they are typically used in an embedded software project

this book introduces a modern approach to embedded system design presenting software design and hardware design in a unified manner it covers trends and challenges introduces the design and use of single purpose processors hardware and general purpose processors software describes memories and buses illustrates hardware software tradeoffs using a digital camera example and discusses advanced computation models controls systems chip technologies and modern design tools for courses found in ee cs and other engineering departments

real time operating systems rtos are ubiquitous in embedded systems this chapter explains what a real time kernel is and what services it provides the product developer and explains some of the internals of a kernel a kernel is a component of an rtos in this chapter we ll look at task management interrupt handling scheduling context switching time

management resource management message passing priority inversions and much more

this chapter provides information to successfully organize and manage any embedded software project or program it introduces quality systems the osi model of architecting software into stacks several software development models and ways in which teams may be organized and overviews communications managing the constraints of scope schedule costs including resources quality and customer satisfaction fully addresses all the work and activities of any project or program the natural progression of software development from its concept through its life cycle until release is discussed tools are presented for successful planning and execution of resource management risk management problem solving and the traceability of work extending from requirements to respective engineering responses to testing against those software specifications

in this chapter we cover the aspects of developing safety critical software the first part of the chapter covers project planning and the crucial steps that are needed to scope the effort and getting started it offers insights into managing safety critical requirements and how to meet them during the development key strategies for project management are also provided the second part of the chapter goes through an analysis of faults failures and hazards it includes a description of risk analysis the next part of the chapter covers a few safety critical architectures that could be used for an embedded system the final part of the chapter covers software implementation guidelines for safety critical software development

for a second microprocessor course for students enrolled in electrical computer engineering microcontroller courses designed for a senior or graduate level embedded systems design course embedded systems design and applications with the 68hc12 introduces readers to unique issues associated with designing testing integrating and implementing microcontroller microprocessor based embedded systems

this textbook introduces the concept of embedded systems with exercises using arduino uno it is intended for advanced undergraduate and graduate students in computer science computer engineering and electrical engineering programs it contains a balanced discussion on both hardware and software related to embedded systems with a focus

on co design aspects embedded systems have applications in internet of things iot wearables self driving cars smart devices cyberphysical systems drones and robotics the hardware chapter discusses various microcontrollers including popular microcontroller hardware examples sensors amplifiers filters actuators wired and wireless communication topologies schematic and pcb designs and much more the software chapter describes os less programming bitmath polling interrupt timer sleep modes direct memory access shared memory mutex and smart algorithms with lots of c code examples for arduino uno other topics discussed are prototyping testing verification reliability optimization and regulations appropriate for courses on embedded systems microcontrollers and instrumentation this textbook teaches budding embedded system programmers practical skills with fun projects to prepare them for industry products introduces embedded systems for wearables internet of things iot robotics and other smart devices offers a balanced focus on both hardware and software co design of embedded systems includes exercises tutorials and assignments

it is the megatrend in today s digital connected world each and every personal gadget from palmtop smart cellular game set top box to wearable devices is getting thinner lighter shorter smaller and of course low power the global competition and shorter product life cycle post a major challenge to the product development it is getting harder to meet customer s demands on time because customers want the products to be done as early as possible the reason is simple competitions are so high and the technology advances are so fast because the time to market is very short for a new product introduction the development of a new product is often started too hastily no development plan do not follow the golden process flow no thorough reviews incomplete test cases waive bugs etc so engineers and developers have to repeat what they have done to fix things in the end everything takes much longer than it should be a good design flow can reduce time to market meanwhile improve product s quality software development is usually questionable for its poor quality and unreliability buggy code improper interfaces and missing features are almost encountered by the users of most embedded system the embedded system developers are filled with consequence of missed deadlines and huge cost overruns embedded system developers can benefit from high quality design flow by identifying optimal product architecture and executing a high quality design process embedded software development tools are also vitally important for productive development and keeping development in control the purpose of writing this software design process flow is to ensure that by following a high quality process and right set of development tools the developers shall possess the highest quality of products while maintaining a competitive schedule and a lower cost structure book contents chapter 1

introductions define embedded system and development process chapter 2 describe a time task span of the embedded system development process chapter 3 4 5 and 6 each chapter describes the four phases of the design and development process respectively which are plan phase chapter 3 design phase chapter 4 integrated development phase chapter 5 design verification and validation phase chapter 6 the design phase chapter 4 consists of six parallel stages hardware firmware software asic fpga and mechanical not each stage are required in all embedded system design in this book chapter 4 firmware is considered equivalent to software for embedded system development process chapter 4 only deals with software design process other design stages shall be covered by separate contents in additional to development process software design techniques are also discussed in chapter 4 and appendixes appendix 1 gives a template for embedded system development plan appendix 4 to appendix 9 provides coding guidelines and software review checklists appendix 10 to appendix 12 lists few popular ide development tools for the embedded system design audience this book is intentionally written for managers and team leaders who need to guide embedded software design and development process software engineers and new designers who want to optimize software design and development process new graduates and students who want to learn software design and development process interested readers who want to explore software design and development proce

the vast majority of existing computers are embedded in the myriad of intelligent devices and applications not in desktop machines we are witnessing the emergence of a new discipline with its own principles constraints and design processes computers as components is the first book to teach this new discipline it unravels the complexity of these systems and the tools and methods necessary for designing them researchers students and savvy professionals schooled in hardware or software will value the integrated engineering design approach to this fast emerging field demonstrates concepts and techniques using two powerful real world processors as case studies throughout the book the arm processor and the sharc dsp digital signal processor illustrates the major concepts of each chapter with real world design examples such as software modems telephone answering machines and video accelerators teaches the basics of uml unified modeling language and applies it throughout the text to help you visualize stages in the design process illustrates real time operating systems using the posix real time extensions and linux describes performance analysis and optimization of embedded software including the effects of caches

the previous chapter approaches embedded systems from a higher level of abstraction from the system design architecture and how to apply design patterns for the implementation this chapter introduces two fundamental concepts and design patterns in real time systems a the ability to set asynchronous event flags events and b the ability to have things triggered in a timely fashion triggers these two concepts are used both in systems with a real time operating system rtos and in systems not using an rtos the chapter starts with use cases and then develops different ways to implement events and triggers it presents different implementation details and discusses the advantages and disadvantages the sources for both event and trigger implementation are provided at the end of the chapter

this chapter discusses the interface that hardware provides for the embedded software it discusses the registers and interrupts that provide that interface but there is more there are the human aspects of getting the hardware team and the embedded software team to collaborate on the project collaboration is needed during the design phase the co development phase the integration phase and the debugging phase and this chapter discusses those concepts several hardware design aspects are discussed that improve the quality of the product and software design aspects are discussed to help support hardware versions

nowadays embedded and real time systems contain complex software the complexity of embedded systems is increasing and the amount and variety of software in the embedded products are growing this creates a big challenge for embedded and real time software development processes and there is a need to develop separate metrics and benchmarks embedded and real time system development a software engineering perspective concepts methods and principles presents practical as well as conceptual knowledge of the latest tools techniques and methodologies of embedded software engineering and real time systems each chapter includes an in depth investigation regarding the actual or potential role of software engineering tools in the context of the embedded system and real time system the book presents state of the art and future perspectives with industry experts researchers and academicians sharing ideas and experiences including surrounding frontier technologies breakthroughs innovative solutions and applications the book is organized into four parts embedded software development process design patterns and development methodology modelling framework and performance analysis power management and deployment with altogether 12 chapters the book is aiming at i undergraduate students and postgraduate students conducting

research in the areas of embedded software engineering and real time systems ii researchers at universities and other institutions working in these fields and iii practitioners in the r d departments of embedded system it can be used as an advanced reference for a course taught at the postgraduate level in embedded software engineering and real time systems

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