KINGDOM OF SAUDI ARABIA
National Science, Technology and Innovation Plan

APPLICATION FORM
Research Project Proposal

ITEM	DESCRIPTION
PLAN	The Second Five - Year Science, Technology and Innovation Plan
PROGRAM	Strategic Technologies
SUB-PROGRAM/ TECHNOLOGY AREA	Information Technology Strategic Priorities
TRACK	Software Engineering and Innovated Systems
SUB-TRACK	System analysis and design
PROJECT TITLE (ENGLISH)	Design and Verification of Safety Critical Systems
PROJECT TITLE (ARABIC)	تصميم والتحقق من أنظمة السلامة الحرجة
PRINCIPAL INVESTIGATOR (ENGLISH)	Aamir Khan
PRINCIPAL INVESTIGATOR (ARABIC)	عامر خان
INSTITUTION	Umm Al-Qura University

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SUBMITTED FOR THE DEADLINE OF	☐ 30th of MARCH ☐ 30th of SEPTEMBER
DATE RECEIVED	
PROJECT CODE	13-INF761-10

CNPSTI Form RE-D1

KINGDOM OF SAUDI ARABIA

National Science, Technology and Innovation Plan

PROJECT INFORMATION

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<tr><th>ITEM</th><th colspan="5">DESCRIPTION</th></tr>
<tr><td>PROJECT TITLE</td><td colspan="5">Design and Verification of Safety Critical Systems</td></tr>
<tr><td>TECHNOLOGY AREA</td><td colspan="5">Information Technology Strategic Priorities</td></tr>
<tr><td>TRACK</td><td colspan="5">Software Engineering and Innovated Systems</td></tr>
<tr><td>SUB-TRACK</td><td colspan="5">System analysis and design</td></tr>
<tr><td>PROJECT TYPE (BASIC, APPLIED,DEVELOPMENT)</td><td colspan="5">APPLIED RESEARCH</td></tr>
<tr><td>PROPOSED TOTAL BUDGET(MAX. TWO MILLIONS SR)</td><td colspan="5">1005000 Saudi Riyals</td></tr>
<tr><td>ESTIMATED DURATION (MAX. 24 MONTHS)</td><td colspan="5">24 Months</td></tr>
<tr><td>PROPOSED STARTING DATE</td><td colspan="5">December /Twenty Thirteen Month / Year</td></tr>
<tr><td rowspan="2"></td><td colspan="5">SENIOR PERSONNEL</td></tr>
<tr><td>No.</td><td>Name</td><td>Research Status</td><td>Role</td><td>Area of Specialization</td></tr>
<tr><td rowspan="8">PROJECT TEAM</td><td>1</td><td>Aamir Khan</td><td>PHD</td><td>PI</td><td>Embbeded Systems</td></tr>
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<tr><td colspan="5">OTHER PERSONNEL</td></tr>
<tr><td>1</td><td colspan="2">1</td><td colspan="2">MS Student (Full time)</td></tr>
<tr><td>2</td><td colspan="2">1</td><td colspan="2">Project Manager</td></tr>
<tr><td>3</td><td colspan="2">2</td><td colspan="2">Other</td></tr>
<tr><td colspan="5">CONSULTANT*</td></tr>
<tr><td colspan="5">*NOTE: a letter of approval from the consultant/s should be attached with the application.</td></tr>
<tr><td rowspan="2">KEYWORDS (MAX. 4)</td><td colspan="3">1. Model Based System Engineering</td><td colspan="2">2. Design Verification</td></tr>
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<tr><td>IS THIS PROJECT BEING SUBMITTED TO ANY OTHER FUNDING INSTITUTION?</td><td colspan="3">NO
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Summary (English):

The complexity of safety critical systems is *exploding* into two interrelated but independently growing directions: architecture heterogeneity and application complexity. On the other hand, time-to-market and design productivity factors are constantly *shrinking*. Consequently, the gap between system complexity and design productivity is constantly increasing. To reduce this gap, Model Based System Engineering Design (MBSE) has shown a lot of potential. However, it still involves a substantial number of design challenges. For example, the abstract model in MBSE captures only the structural aspects of the system under study. The importance of behavioral aspects at higher abstraction level has been realized but never rationalized. Similarly, design verification at higher abstraction level by using the behavioral aspects of the captured model is another challenging task. Furthermore, model transformation of structural as well as behavioral aspects is getting more and more popularity in the scientific community.

In this research project, we will model structural as well as behavioral aspects of the system to ensure design verification at higher abstraction level. Constraints will be represented at the system level modeling in UML and its associated profiles. Consequently, we will be able to embed the assertion based verification techniques in UML-based models. These models will not only be used to model the complex system structures but will also contain the critical information about the safety features of those systems. Once the model is complete (structural as well as behavioral aspects), it will be used to automatically generate the RTL level code skeleton (representing structural model) as well as the assertion constraints (representing constraint properties) to verify the behavior of those system components.

Summary (Arabic):

تعقيد أنظمة السلامة الهامة تشهد اليوم توسعا هائلا في اتجاهين مترابطين مستقلين ولكن متناميين : التغايرية في العمارة وتعقيد التطبيق. من ناحية أخرى الوقت للوصول الى السوق وعوامل انتاجية التصميم تتقلص باستمرار. وبناء على ذلك، فإن الفجوة بين تعقيد النظام وإنتاجية التصميم يتزايد باستمرار. لتخفيض هذه الفجوة، فقد أظهرت تصميم هندسة الأنظمة المبنية على النماذج (MBSE) الكثير من الامكانات. ومع ذلك، فإنه ما زال يشتمل على عدد كبير من تحديات التصميم. على سبيل المثال، فإن النموذج المجرد في MBSE يقيد فقط الجوانب الهيكلية للنظام تحت الدراسة. وقد أدركت أهمية الجوانب السلوكية على مستوى أعلى للتجريد ولكن لم يتم تحقيقه أبدا. كذلك، التحقق من التصميم على مستوى أعلى للتجريد باستخدام الجوانب السلوكية للنموذج آخر هي مهمة صعبة اخرى. وعلاوة على ذلك، تحول نموذج الجوانب الهيكلية وكذلك السلوكية أصبح يكسب شعبية أكثر وأكثر في المجتمع العلمي.

في هذا المشروع البحثي، فإننا نقوم بنمذجة الجوانب الهيكلية فضلا عن الجوانب السلوكية للنظام لضمان التحقق من التصميم في مستوى أعلى للتجريد. وستمثل القيود على مستوى النظام بالنمذجة في UML والملامح المرتبطة به. ونتيجة لذلك، سوف نكون قادرين على تضمين تقنيات تأكيد المبنية على التحقق في النماذج القائمة على .UML هذه النماذج تستخدم ليس فقط لنمذجة هياكل النظام المعقدة ولكنها ستحتوي على المعلومات الهامة حول ميزات الأمان لتلك النظم أيضا. وعندما يكتمل النموذج (الجوانب الهيكلية و السلوكية)، سيتم استخدامها لتوليد هيكل الرموزعلى مستوى RTL تلقائيا، التي تمثل النموذج الهيكلي وكذلك قيود التأكيد التي تمثل خصائص القيد للتحقق من سلوك تلك المكونات للنظام.

INTRODUCTION

Problem Statement:

Safety-critical systems are those systems whose failure could result in loss of life, significant property damage, or damage to the environment [1]. Modeling such systems is a challenging task as these systems are complex and have multi-faceted architecture. By complexity, we mean that such systems are not only huge in magnitude but are also significantly diverse [2]. Such systems frequently exist in telecommunications, defense, and automatic control applications [3] [4] [5].

Traditionally, UML has been used to model software systems [6]. However, it provides support for modeling various types of systems through the use of profile extensions. UML profile for MARTE [7] and UML profile for SysML [8] are leading examples of this trend. Consequently, Model Based System Engineering (MBSE) is the latest trend in system development methodology which focuses on creating and exploiting the abstract representations of systems [9]. The MBSE approach is meant to increase the design productivity by simplifying design process, reuse of standard models, and providing the basis for implementing systems. Various research works have mentioned the use MBSE techniques to improve the productivity [10] [11] [12].

The key feature of MBSE is model transformation [13] [14] in which the abstract model of the system is transformed into an executable model on a specific platform. Model transformation is done using special model transformation languages. Examples of model transformation languages are Kermeta [15], ATL [16], Xpand [17], and MOLA [18].

However, in addition to model transformation, design verification of safety critical systems is equally important to ensure that a system is designed and works as per the specifications [19] [20]. Conventional practices for design verification are simulation, execution of the prototype, and test bench scenarios for the hardware components. An emerging trend in design verification is Assertion Based Verification (ABV) [21] [22] [23] [24] [25] [26] in which designers use assertions to capture specific design intent and, either through simulation, formal verification, or emulation of these assertions, verify that the design correctly implements that intent [27].

To the best of our knowledge, current literature in MBSE generally focuses on modeling the structural aspects of the system and transforms it into executable models. The lack of behavioral aspects in the captured model at higher abstraction level makes design verification a difficult task resulting in reduced design productivity. Complex safety critical must employ thousands of assertions to ensure the safety critical nature of the system. Managing huge number of these low-level verification constraints is not an easy job. Consequently, model should be captured in a holistic way such that it should contain structural as well as behavioral aspects of the system.

Proposed Approach:

In this research project, we propose to model the structural as well as behavioral aspects of the system to ensure design verification at higher abstraction level. Figure 1 shows the complete design flow of our proposed project. We will model both the structural and behavioral aspects of complex safety critical systems in UML using the extension of profiles like SysML and MARTE. Modeling will focus on the electronic sub-systems used in automation and control of complex systems.

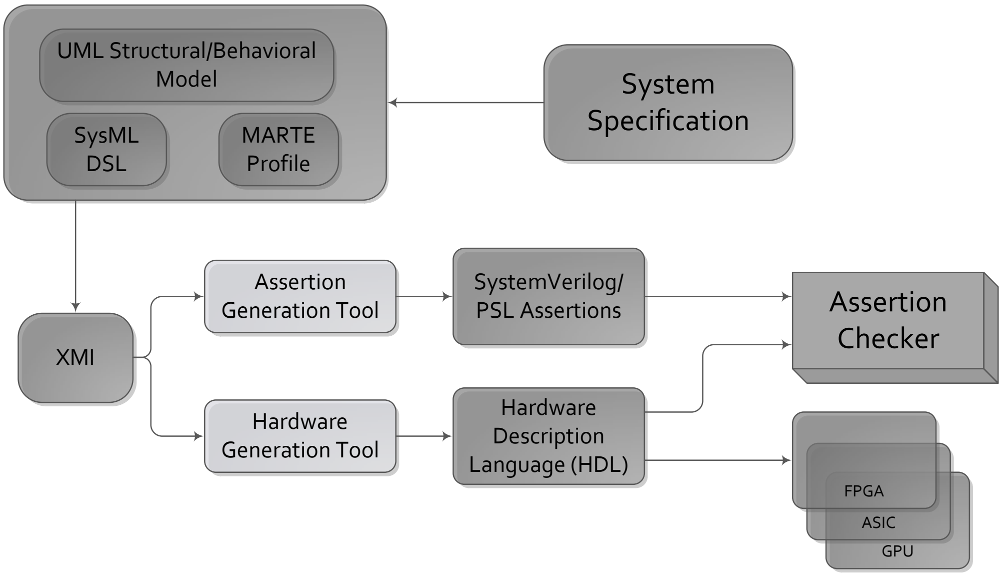

Figure 1: Overall System Design Flow

In this project, we will represent constraints at the system level modeling in UML and its associated profiles. In this manner, we will be able to embed the assertion based verification techniques in UML-based models. These models will not only be used to model the complex system structures but will also contain the critical information about the safety features of those systems.

Once the model is complete (structural as well as behavioral aspects), it will be used to automatically generate the RTL level code skeleton (representing structural model) as well as the assertion constraints (representing constraint properties) to verify the behavior of those system components.

Scientific Significance of the Project:

The innovative points of the project are summarized as:

1. Existing literature on MBSE (See Section 3) *realizes* the importance of behavioral aspects at higher abstraction level but does not *rationalize* the holistic development of models. The proposed approach is the first effort in this regard.
2. Design verification at higher abstraction level by using the behavioral aspects of the captured model is another innovative point of this project.
3. Existing literature transforms the structural aspects only. Model transformation of structural as well as behavioral aspects will be valuable contribution to the scientific community.

Major Steps/Outcomes of the Project:

The major steps/outcomes of this project can be summarized as follows:

1. Theoretical study to identify requirement specifications of captured model
2. Development of a holistic model in structural as well as behavioral aspects

3. Development of a frame work in which we can model as well verify the model
4. Once the model will be captured and verified, it will be prototyped
5. Development of a MBSE laboratory to demonstrate of System Level Design concepts in general, and MBSE concepts in particular to the undergraduate students of Umm Al-Qura University resulting in a variety of innovative students design projects

Relationship with National Plan for Science, Technology and Innovation of KACST:

MBSE is concerned with the design, development, and implementation of systems into a wide range of consumer, industrial, commercial, and military applications. Consequently, the proposed project has a direct relationship with “Information Technology” and “ECP” technology areas.

Future Scope of the Project

In the future, the UML models can be enhanced to include NFP (Non-Functional Properties) of electronic components. Non-functional properties can for example include power consumption, size or heat dissipated by an IC chip. This information is currently not directly utilized in the design of complex electronic circuits. Once we can represent this information at system level design, it can be efficiently used by the design teams at various phases of design process. These modeled NFPs can be used to generate such configuration files which can help us reduce the power consumption of the electronic systems.

PROJECT OBJECTIVES

The proposed research project will deal with the two questions: how can we design complex systems and how the safety of such systems is guaranteed. To deal with these issues, we have three objectives of the project.

- **Embedding structural and behavioral aspects of the system elements on a single unified model**

  We intend to model the complex systems using UML. As UML itself is not adequate enough to model all sorts of systems, profile extensions like SysML and Marte will be used to represent the domain concepts. Finally, we will have a structural model of our case study. To deal with the issues of safety of such systems through design verification, we propose to represent the RTL-level assertions in the UML-based models in the form of constraints. Both the structural and behavioral aspects of the system elements will be embedded on a single unified model. This will be a distinct and valuable contribution to the research community never proposed before.

- **Transforming the unified model and system prototyping**

  A model transformation code will be developed to transform these UML-based models into the implementation code (HDL) and the associated constraints into assertions. This automatically generated code will then be placed on an FPGA or run on a processor based system to verify the system behavior or to robustly model complex systems.

- **Increasing awareness of potential Model Based System Engineering (MBSE) benefits**

  MBSE has many potential benefits for system designers. It can change the way we design systems. Since MBSE is still in its infancy, trained young professional engineers are needed in the very near future. One objective of this project is to establish an educational system design lab to educate and train interested Computer College's students in Umm Al-Qura University on latest technological trends.

PROJECT OBJECTIVES:

1	Embedding structural and behavioral aspects of the system elements on a single unified model
2	Transforming the unified model and system prototyping
3	Increasing awareness of potential Model Based System Engineering (MBSE) benefits

LITERATURE REVIEW

Safety-critical systems exist everywhere around us in the modern environment. Safety-critical embedded systems under-go several certifications to ensure the safety of millions of people depending on such systems. These systems help us to protect from the material or personal loss. In the infrastructures around us we see fire alarms, circuit breakers, and electrical or hydraulic fuses as examples of such systems. In the field of medicine pace-makers, defibrillators, robotic surgery machines are all safety-critical embedded systems. In the transportation we see the extensive use of such systems especially in the avionics, spaceflight industries, and railway signaling systems, where most of the components are so important that they can cause billions of dollars of loss. In our everyday use cars, we see the use of safety critical applications in many car components like ABS (anti-lock braking system), airbags, seat belts and steering systems.

Model is an expression or representation of some system under study [28]. Modeling a system, usually in UML, gives us various advantages like:

- Modeling provides the basis for problem solving
- Modeling helps us to manage complexity of a system by hiding the unnecessary details about the system (also called system abstraction [29]).
- Modeling reduces the chances of making mistakes in our designs.
- Modeling can help us to find more than one solution for our system design.

There are various approaches for system design discussed in detail by Henzinger et al. [30]. They have described the traditional importance given to model-based design approaches for modeling hardware systems. Such models start from a system description in structural fragment of a hardware description language such as VHDL and Verilog and, ideally automatically, derive an implementation that obeys a given set of constraints.

UML is used world-wide for the specification and exchange of system design information. Traditionally, it was used for this purpose in the field of software engineering supported by the use of various CASE (Computer Aided Software Engineering) tools. But currently UML is also extensively used in the EDA (Electronic Design Automation) industry. The complexity of electronic systems in the present times presents the importance of such modeling techniques in ESL (Electronic System Level) design. Situation has aggravated by the use of multi-core processor architectures and the use of SoCs (System-on-Chips) which pack complex electronic structures on a small single chip.

There have been several contributions focusing on the design of electronic systems using UML [31] [32] [19] [33] [34]. In [31], the authors have mentioned that the complexity and the lack of sufficient semantics of UML are its main drawbacks hindering its use for the real engineering applications. Such a deficiency increases the importance of domain specific customizations called profiles for UML. These profiles are used to enhance the existing capabilities of UML making it suitable for modeling designs in a particular domain. Engineering applications can take advantage from the newly introduced extensions like SysML and UML Profile for SoC. Further, the authors emphasize the importance of such DSLs (Domain Specific Languages) by mentioning that the addition of precise semantics to UML allows for the automatic generation of code skeleton, typically C++ or Java, from UML models. In the paper, they have focused on the structural and behavioral modeling in UML.

Huascar Espinoza in [35] also describes the need for combining more than one UML Profiles for the design of embedded systems, mainly due to the complex nature of embedded systems. They have raised several concerns and opportunities regarding the combined use of SysML and Marte profiles.

Many researchers have proposed to use the SysML and Marte profiles for UML to model different sorts of electronic and embedded systems [36] [37] [38] [39] [40] [41]. SysML and Marte have been used together in several other projects like SATURN Project [42] and MeMVaTEx [43]. SATURN is an EU project aimed at a UML/SysML-based approach for hardware/software co-design. It is based on Artisan Studio software [44] and uses an enhanced SysML profile used to generate SystemC and VHDL code. MeMVaTEx is a model-based methodology for expressing requirements and traceability mechanisms during the modeling process. It relies on standards like EAST-ADL2 [45] and UML2 profiles like Marte and SysML.

In 2000, OMG (Object Management Group) [46] which is a leading consortium working for the standardization of the model-based engineering proposed the MDA (Model-Driven Architecture) framework. MDA identifies two types of models: platform independent models (PIMs) and platform specific models (PSMs) [13]. PIMs are the abstract models that we use to represent the system while the PSMs are specific implementations of those models in a target language. So the goal of the MDA approach is not only to specify the abstract PIMs but also to provide a ‘Model Transformation’ [14] to convert this model into PSM executable on a specific platform. Model transformation is done using special model-to-model transformation languages and converts the input model into the output model according to the specifications of the target language. There are various model transformation languages available like Kermeta [15], ATL [16], Xpand [47] [17], and MOLA [18]. Amongst these languages we choose Kermeta for our experiments with the model transformation process.

Once modeled, these systems still face the chances of failures due to software or hardware issues or mere human error. Design verification of a system is a process intended to ensure that a system is designed and works as per the specifications. According to the analysts, about 50% of the design effort for an electronic chip consists of the verification process [19]. In 2001, Andreas Bechtolsheim, Cisco Systems engineering vice president, was quoted in EE Times [20] estimating that design verification still consumes 80% of the overall chip development time.

An assertion is a statement about a specific functional characteristic or property that is expected to hold for a design. For the electronic components, assertions are the executable HDL (Hardware Description Language) code that capture specifications and design intent. This low-level code is usually written in the languages like SystemVerilog [48], PSL (Property Specification Language) [49], or Sugar [50]. This code is executed in parallel to the system under consideration and keeps a check on all the properties of the system to ensure that they work as intended.

On the other side, complex systems like electronic automation systems must employ thousands of assertions to ensure the safety critical nature of the system. Managing huge number of these low-level verification constraints is not an easy job. In our project, we propose to represent these assertion constraints at the system level modeling in UML and its associated profiles. In this manner we will be able to embed the assertion based verification techniques in UML-based models. These models will not only be used to model the complex system structures but will also contain the critical information about the safety features of those systems.

Our Contribution

As discussed, many researchers have proposed different ways to model structural aspects of electronic systems. But our approach is unique in a manner that we propose to embed behavioral properties on our structural models. This holistic approach will let us handle complex systems using a unified model, which in-turn will reduce design effort, cost, and time-to-market.

Specifying SystemVerilog or PSL constraints in UML-based models is a novel and challenging task. As the constraints are closely related to time, we will have special focus on representing time in UML. Frederic in [51] has discussed the use of SysML parametric diagrams along with CCSL (Clock Constraint Specification Language) to represent the laws related to time. CCSL like VSL is a part of Marte and is dedicated to represent the clocks and their relationships. So for now, we consider to use SysML parametric diagrams to model RTL time constraints. As opposed to other constraint languages like OCL, CCSL provides us with the adequate semantics to deal with SystemVerilog assertions. Huascar Espinoza [35] also advocates the use of SysML parametric diagrams and Marte VSL (Value Specification Language) to specify non-causal models with algebraic and time constraint expressions. In another context, another research work in the form of TEPE Language [52] defines a SysML based framework for specifying time-constrained properties. This approach has also utilized the SysML parametric diagrams to specify their models.

The only research work directly targeting the SystemVerilog assertions (SVAs) is from Southern Methodist University [53]. They have considered the example of a traffic light controller implemented in the form of state machines. Then they have coupled the assertions, in the form of properties, with these states. But for representing SVAs, they have only relied on the comments attached to the classes. These comments are retrieved and pasted directly in the SystemVerilog code. So the modeled SystemVerilog assertions are in fact not a part of the model but are included as comments.

So, considering the discussion above, we can use VSL or CCSL to express SVAs in SysML. A related work [54] compares the time semantics of CCSL and PSL. PSL properties are quite similar to SVAs. Referring back to Figure 1, it shows the complete design flow of our proposed project. The design intent is captured from the specification in the form of UML model. UML models are stored in the form of XMI (XML Metadata Interchange) [55] files. Our proposed transformation engine will extract information from the XMI files and will generate the HDL code and the assertions which will run on the dedicated target machines.

Prior Work of the Investigators

The PI and COI-1 have both worked extensively on system level design during their PhDs in France. Dr. Aamir M. Khan worked with the AOSTE project [56] in the famous INRIA research labs. He worked on the UML profile for MARTE during his PhD [57] with some highly valuable research contributions to the research community. During this PhD research work, a modeling framework was proposed based on UML profile for MARTE [58] [59]. This model was then converted through model transformation into low-level IP-Xact [60] code.

Dr. Muhammad Rashid participated in several research projects funded by European Union (Sixth Framework Program) under the thematic area Embedded Systems. In HARTES project [61] [62], the objective was to develop a holistic approach for Reconfigurable real Time Embedded Systems. In MORPHEUS project [63], he worked on the synthesis tools for heterogeneous reconfigurable architectures from logic to system design activities resulting in the development of rapid prototyping tools for reconfigurable architectures. In addition to European Union funded research projects, he worked at Advanced Engineering Research Organization Pakistan and Thomson Research and Development France in the domain of embedded system design.

Form RE -D1-2: APPROACH UTILIZED FOR ACHIEVING OBJECTIVES

OBJECTIVE	APPROACH OF ACHIEVING THE OBJECTIVE
Embedding structural and behavioral aspects of the system elements on a single unified model	Theoretical analysis, structural modeling and assertions-based verification.
Transforming the unified model and system prototyping	Model transformation and system implementation
Increasing awareness of potential Model Based System Engineering (MBSE) benefits	Project Based, Learn by Hands on Projects, workshops and training sessions

Form RE -D1-3: MAPPING OF PHASES AND TASKS TO ACHIEVE OBJECTIVES

OBJECTIVES	PHASES	TASKS
Embedding structural and behavioral aspects of the system elements on a single unified model	1.1. Requirement Specifications	1.1.1. Literature Survey
Embedding structural and behavioral aspects of the system elements on a single unified model	1.1. Requirement Specifications	1.1.2. Industrial Feedback
Embedding structural and behavioral aspects of the system elements on a single unified model	1.1. Requirement Specifications	1.1.3. Requirement Specifications
Embedding structural and behavioral aspects of the system elements on a single unified model	1.1. Requirement Specifications	1.1.4 Project Management including procurement, quality & risk management, planning, scheduling, budgeting, progress monitoring & reporting
Embedding structural and behavioral aspects of the system elements on a single unified model	1.2. Structural Modeling Phase	1.2.1. Selection of Tool A
Embedding structural and behavioral aspects of the system elements on a single unified model	1.2. Structural Modeling Phase	1.2.2. Structural Modeling
Embedding structural and behavioral aspects of the system elements on a single unified model	1.3. Constraints Modeling	1.3.1. Selection of Tool B
Embedding structural and behavioral aspects of the system elements on a single unified model	1.3. Constraints Modeling	1.3.2. Constraint Modeling
Transforming the unified model and system prototyping	2.1. Model Transformation Phase	2.1.1. Selection of Tool C
Transforming the unified model and system prototyping	2.1. Model Transformation Phase	2.1.2. Model Transformation
Transforming the unified model and system prototyping	2.2. System Implementation	2.2.1. Processor-based implementation
Transforming the unified model and system prototyping	2.2. System Implementation	2.2.2. FPGA-based implementation
Increasing awareness of potential Model Based System Engineering (MBSE) benefits	3.1. Lab Preparation	3.1.1. Lab equipment purchasing
Increasing awareness of potential Model Based System Engineering (MBSE) benefits	3.1. Lab Preparation	3.1.2. Lab equipment installation
Increasing awareness of potential Model Based System Engineering (MBSE) benefits	3.2. Training and Projects	3.2.1. Conduct training and workshops
Increasing awareness of potential Model Based System Engineering (MBSE) benefits	3.2. Training and Projects	3.2.2. Supervise student projects

RESEARCH METHODOLOGY

As this research proposal consists of three main objectives, we firstly explain the different phases and tasks for each objective. Then we will describe the overall methodology.

Description of Objectives, Phases and Tasks:

Objective 1 "Embedding structural and behavioral aspects of the system elements on a single unified model"

It will be achieved through theoretical analysis, structural modeling and assertions-based verification. Theoretical analysis is required to generate requirement specifications. One requirement are specified, the structure of the system will be modeled. Finally, properties of the system will be embedded in the structural model to get a unified model. To complete Objective 1, we will have three phases:

- First, "Requirement Specifications" phase will include an extensive survey of existing techniques and feedback from multiple industries in the target domain; identifying key elements that can be used in the design of this project. The outcome of this phase is requirement specifications document.
- Second, considering the requirement specifications of the first phase, we are going to model the structural part of the system in "Structural Modeling Phase". By structural part we mean the components or the interacting parts of the big system. A structural unit can be hierarchical, composed of other smaller units.
- Finally, in "Constraints Modeling" phase, we will represent the RTL-level assertions in the UML-based models in the form of constraints.

Objective 2 "Transforming the unified model and system prototyping"

It will be achieved by model transformation and system implementation. To complete Objective 2, we will have two phases.

- In "Model Transformation Phase", a model transformation code will be developed to transform unified model (output of objective 1) into the implementation code (HDL) and the associated constraints into assertions.
- In "System Implementation" phase, the automatically generated code during "Model Transformation" phase will be placed on an FPGA or run on a processor based system to verify the system behavior.

Objective 3 "Increasing awareness of potential Model Based System Engineering (MBSE) benefits"

The objective will be achieved by engaging undergraduate students in Project-Based learning sessions in the suggested System Design Lab over the potential benefits of MBSE. Training sessions and scientific workshops will be hosted in the lab to increase the awareness of unlimited and potential benefits of MBSE to the community. This objective will have two phases.

- "Lab Preparation" phase includes lab preparation and equipment purchasing. We will focus on establishing a System Design Lab with the latest commercial products available for full engagement from the students.
- In "Training and Projects" phase, PI, CO-1 and RAs will invite students to conduct their graduation projects in the lab with innovative ideas regarding System Level Design. The PI, CO-1 and the RA's will supervise the students of the computer and information systems college in Umm Al-Qura University. The students will also be engaged in hands-on projects on system level design to increase their experience and propose innovative products or enhance existing ones. In addition, the PI, CO-I and the RAs will conduct training sessions and workshops which will be open to all UQU personnel to increase their awareness and knowledge on System Level Design and MBSE.

Description of the Research Methodology used:

The project will start by generating the requirements specifications of the system under study. The knowledge of application domain will be required to generate specifications. The next step will be to model the structural part of the system. By structural part we mean the components or the interacting parts of the big system. These parts can represent units of different sizes from very large to smaller integral ones. A structural unit can be hierarchical, composed of other smaller units.

Modeling of the system will take place in the UML language, as it is a standard language for the modeling of complex industrial level systems. It is widely supported by the third party tool chains and is widely understood by the engineers and researchers. However, as discussed previously in the literature review, the UML itself will not be enough to model a complete system. Some of the profiles for UML will be used to extend the capabilities of UML in expressing the system. SysML and Marte profiles for UML are ideal for the time being but a detailed review will pave the way for the best choice in the future.

Once the structural model will be completed, we will turn our focus on behavior of the system. Many efforts [2] [64] [59] [65] in the past have been made by the research community to represent behavior of a system at abstract levels. Some used the state machines, activity diagrams and use-case diagrams to provide a solution to this issue. However, complete representation of the behavior of a system at a considerably abstract level is still a challenge to the research community.

The authors of this research proposal and some notables from the model-based design community [51] [35] are of the view that instead of focusing on the representation of complete behavior of a system, we shall consider on verification of the system. Verification means we make sure that the system functions as intended in the specifications. At the lower levels like RTL, languages like System Verilog, PSL and Sugar are used to specify the intent of the specifications. Verification engineers write assertions in these languages which have the sole purpose to monitor the events occurring in the system. These assertions match the causes with their respective effects. For a complex system, thousands of such low-level assertions ensure the proper behavior of the system.

Hence, we propose to model these properties (enforced through assertions) of the system in UML using profiles like SysML and Marte. This part of the research project will be huge service to the research community in terms of a novel approach only suggested by the few before. Extensive bibliography will be needed to decide the right tools, profile and mechanism to represent the system properties.

As the behavior of the system is mostly associated with the time issues, we also consider using languages like CCSL (Clock Constraint Specification Language) and VSL (Value Specification Language) along with the UML profiles. These languages CCSL and VSL are used to represent clock expressions. The goal of this part of the project will be to define/identify the techniques to represent the system Verilog (or may be PSL/Sugar) assertions in UML.

There are hundreds of different types of assertions in System Verilog. With the passage of time and effort, we will try to represent as many assertions as possible in the UML. Once we have such representations, then we will be able to embed this information on the structural model components that we have conceived earlier. This way, we will be able to have a single model element to represent both structure and the associated behavior (partial) of a component.

Once the modeling of a system is completed in UML-like languages, we will have a view of the system that focuses on broader aspects or 'the big-picture' of the system. This is a tried and tested approach to deal with complex models. System designer engineers are more comfortable in such designs to make decisions about the system.

But this system level approach is not the only advantage of such a modeling. This whole approach is known as 'design automation' technique. One of the key components of this technique is to automatically generate program code from the system model conceived earlier. The code generation is done through the 'model transformation'. In this, we write a program in a specific language which takes the system model and generates the low-level code in languages like C, C++, Verilog, System Verilog, VHDL, Java etc.

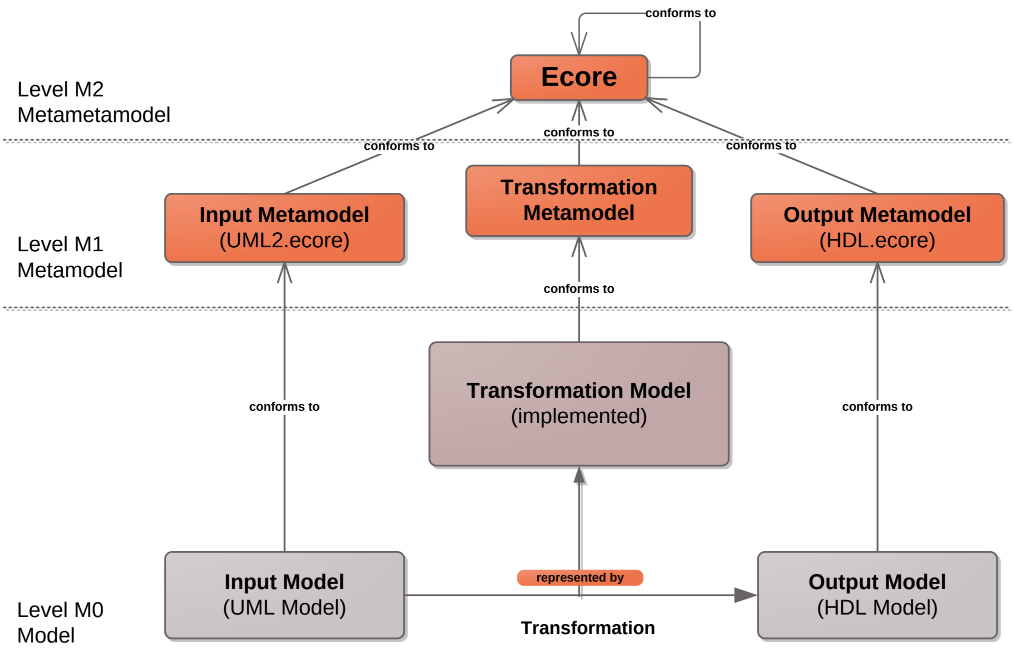

Figure 2: Model-to-Model Transformation Technique

Figure 2 shows the conceptual view of model transformation technique. The input model (which in our case is the UML-based model) is transformed into a target language model using the transformation code written in the specific model transformation language. All the three input, output, and transformation models must conform to their respective language rules/semantics called metamodels. Thus the output metamodel provides the rules to generate the desired HDL code.

Various model transformation languages are available to the research community like ATL, QVT, Xpand, and Kermeta. Currently we consider the Kermeta language to be the best choice for our job but obviously the detailed review will judge the future decisions.

Finally when the whole tool-chain for the model-based system design is complete, we obtain the generated code from our case-study models. To deploy this code into use, the behavioral aspects of the code present in System Verilog like language is placed on an FPGA or run on the CPU. Such a system will take as input the triggering of various events and will be able to generate output signals related to certain events. In the end, this system will work as a sub-system in a bigger 'monitoring unit' to effectively track the correct behavior of the system.

Form RE -D1-4: ROLE AND INVOLVEMENT DURATION OF PROJECT TEAM

TEAM MEMBERS	ROLE	DURATION
SENIOR PERSONNEL:		
Aamir Khan	**PI**	**24 months**
Muhammad Rashid	**CO_I**	**20 months**
OTHER PERSONNEL:		
MS Student (Full time) - 1	**MS Student (Full time)**	**7 months**
RA (MS Holder) (Full-Time) - 1	**Other**	**24 months**
RA (MS Holder) (Full-Time) - 2	**Other**	**20 months**
Project Manager - 1	**Project Manager**	**20 months**

Kingdom of Saudi Arabia
Ministry of Economy And Planning

KINGDOM OF SAUDI ARABIA
National Science, Technology and Innovation Plan

مدينة الملك عبدالعزيز للعلوم والتقنية KACST

FORM RE- D1-5: WORK PLAN AND TIME SCHEDUAL

PHASES & TASKS	INVOLVEMENT	DURATION																							
	Participation	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1.1. Requirement Specifications	**NAME[ROLE]**																								
1.1.1. Literature Survey	Aamir Khan[PI],Muhammad Rashid[CO_I]																								
1.1.2. Industrial Feedback	Aamir Khan[PI],Muhammad Rashid[CO_I]																								
1.1.3. Requirement Specifications	Aamir Khan[PI],Muhammad Rashid[CO_I]																								
1.1.4 Project Management including procurement, quality & risk management, planning, scheduling, budgeting, progress monitoring & reporting	Project Manager - 1[Project Manager]																								
1.2. Structural Modeling Phase	**NAME[ROLE]**																								
1.2.1. Selection of Tool A	Aamir Khan[PI],MS Student (Full time) - 1[MS Student (Full time)],RA (MS Holder) (Full-Time) - 1[Other]																								
1.2.2. Structural Modeling	Aamir Khan[PI],MS Student (Full time) - 1[MS Student (Full time)],RA (MS Holder) (Full-Time) - 1[Other]																								
1.3. Constraints Modeling	**NAME[ROLE]**																								
1.3.1. Selection of Tool B	Aamir Khan[PI],RA (MS Holder) (Full-Time) - 2[Other]																								
1.3.2. Constraint Modeling	Aamir Khan[PI],RA (MS Holder) (Full-Time) - 2[Other]																								
2.1. Model Transformation Phase	**NAME[ROLE]**																								
2.1.1. Selection of Tool C	Aamir Khan[PI],RA (MS Holder) (Full-Time) - 1[Other],RA (MS Holder) (Full-Time) - 2[Other]																								
2.1.2. Model Transformation	Aamir Khan[PI],RA (MS Holder) (Full-Time) - 1[Other],RA (MS Holder) (Full-Time) - 2[Other]																								
2.2. System Implementation	**NAME[ROLE]**																								
2.2.1. Processor-based implementation	Aamir Khan[PI],Muhammad Rashid[CO_I],RA (MS Holder) (Full-Time) - 1[Other]																								
2.2.2. FPGA-based implementation	Aamir Khan[PI],Muhammad Rashid[CO_I],RA (MS Holder) (Full-Time) - 2[Other]																								
3.1. Lab Preparation	**NAME[ROLE]**																								
3.1.1. Lab equipment purchasing	Aamir Khan[PI],Muhammad Rashid[CO_I]																								
3.1.2. Lab equipment installation	Aamir Khan[PI],Muhammad Rashid[CO_I],RA (MS Holder) (Full-Time) - 1[Other],RA (MS Holder) (Full-Time) - 2[Other]																								
3.2. Training and Projects	**NAME[ROLE]**																								
3.2.1. Conduct training and workshops	Aamir Khan[PI],Muhammad Rashid[CO_I],RA (MS Holder) (Full-Time) - 1[Other],RA (MS Holder) (Full-Time) - 2[Other]																								
3.2.2. Supervise student projects	Aamir Khan[PI],Muhammad Rashid[CO_I]																								

FORM RE- D1-6 : RELATIONSHIP TO STRATEGIC FRAMEWORK

PROJECT EXPECTED OUTCOMES	STRATEGIC TECHNOLOGY PROGRAM GOALS										PROJECT OBJECTIVES ACHIEVED
	GOAL 1	GOAL 2	GOAL 3	GOAL 4	GOAL 5	GOAL 6	GOAL 7	GOAL 8	GOAL 9	GOAL 10	
Training of human resource			Y		Y		Y				Increasing awareness of potential Model Based System Engineering (MBSE) benefits, Increasing awareness of potential Model Based System Engineering (MBSE) benefits, Increasing awareness of potential Model Based System Engineering (MBSE) benefits
Model Transformation and implementation	Y	Y	Y		Y		Y				Transforming the unified model and system prototyping, Transforming the unified model and system prototyping, Transforming the unified model and system prototyping, Transforming the unified model and system prototyping
Unified Model for safety critical complex systems	Y	Y	Y		Y		Y				Embedding structural and behavioral aspects of the system elements on a single unified model, Embedding structural and behavioral aspects of the system elements on a single unified model, Embedding structural and behavioral aspects of the system elements on a single unified model, Embedding structural and behavioral aspects of the system elements on a single unified model

GOALS	DESCRIPTION
GOAL1	To support an expanding and innovative KSA IT industry.
GOAL2	To advance IT capabilities to meet critical needs in the Kingdom, in areas such as computer networking, and security.
GOAL3	To develop innovative high quality IT applications to meet specialized needs in the Kingdom, such as for the oil and gas industry, and Islamic applications.
GOAL4	To adapt and localize IT applications for e-services and e-business.
GOAL5	To contribute to the global open source software movement.
GOAL6	To develop world class capabilities in language technologies, especially applied to serve the Arabic Language.
GOAL7	To improve scientific and supercomputing to expand the Kingdom's capabilities in science and engineering through modeling, simulation, and visualization.
GOAL8	Not Applicable for Information Technology Strategic Priorities
GOAL9	Not Applicable for Information Technology Strategic Priorities
GOAL 10	Not Applicable for Information Technology Strategic Priorities

VALUE TO THE KINGDOM

The practical applications of this intended research are immense, as safety critical systems are widespread in our daily lives. We can model variety of complex safety critical systems:

- Petroleum industry and petrochemical plants contain large systems and managing them is a huge task. Assertions can ensure that a particular event when occurred triggers the required actions.
- Hajj activities can be efficiently managed by using model-based approach. Here again the safety can be ensured by the assertion based verification of various system parameters. As a trivial example, an assertion can ensure inside the system that a hazardous condition like stampede or fire is duly responded by the corrective emergency measures.
- Model-based design approach was first adopted by the military equipment manufacturers across Europe and America [66] [67]. So we see great potential of the use of our research outcome in the defense industry like UAV design and other sophisticated military equipment.

This project has many values to The Kingdom of Saudi Arabia. These include but not limited to technological value, educational value, and research and publicity value.

- **Technological Value:** The proposed project is to develop state-of-the-art engineering products by using Model Based System designed for a wide range of consumer, industrial, commercial, and military applications. Acquiring such devices and allowing students, faculty and community to interact with them will open many doors for innovative thinking and enhancements to existing appliances.
- **Educational Value:** The project covers diverse fields such as electrical and modeling, simulation, analysis, performance estimation, digital designing, computer programming and so on. So, students of UQU will get a chance to get hands on experience in the state of the art advanced technologies. The project will enhance the experience and research carrier for the team involved
- **Research and Publicity Value:** The project is divided into different phases and we expect to produce good numbers of research papers from this project which will publicize UQU and NPSTI internationally.

SEE INSTRUCTIONS BEFORE COMPLETING

FORM RE- D1-7: PROPOSED BUDGET(*in Saudi Riyals*)

PROJECT TITLE: Design and Verification of Safety Critical Systems

DURATION: (24) MONTHS

ITEM	CATEGORY	NO.	COMPENSATION	FIRST YEAR		SECOND YEAR		TOTAL
				Months	Budget	Months	Budget	
Manpower								
	Aamir Khan	1	5000	12	60000	12	60000	120000
	MS Student (Full time) - 1	1	5000	7	35000	0	0	35000
	Muhammad Rashid	1	5000	9	45000	11	55000	100000
	Project Manager - 1	1	3000	12	36000	8	24000	60000
	RA (MS Holder) (Full-Time) - 1	1	5000	12	60000	12	60000	120000
	RA (MS Holder) (Full-Time) - 2	1	5000	8	40000	12	60000	100000
Summer Compens.								
Total (including summer compensation)				276000		259000		535000
Equip.& Materials								
	Major equipments (>= 100,000)			0		0		0
	Equipments (< 100,000)			300000		0		300000
	Materials & Supplies			20000		0		20000
Item total				320000		0		320000
Travel								
	Conferences			30000		30000		60000
	Training			0		0		0
	Field trips			0		0		0
	Tickets			0		0		0
Item total				30000		30000		60000
Others								
	Patent registration			0		0		0
	Publications			15000		15000		30000
	Workshop			25000		25000		50000
	Other expenses			10000		0		10000
Item total				50000		40000		90000
Grand Total				676000		329000		1005000

Compensations (including summer compensation)	%	53.23
Equipments & materials	%	31.84
Travel	%	5.97
Others	%	8.96
Grand total	%	100

REFERENCES:

No.	References
1	

Curriculum Vita			السيرة الذاتية		
Name (Arabic)		خان	محمود	عامر	الاسم (عربي)
Name (English)		Khan	Mehmood	Aamir	الاسم (إنجليزي)

P.O. Box	**City**	**Postal Code**	**Country**
56591	Makkah	21955	Saudi Arabia
Tel. No. (Office)	**Telephone No. (Home)**	**Fax No.**	**Mobile No.**
			+966538424719
E-mail (1)	aaakhan@uqu.edu.sa	**E-mail (2)**	jadoon.engr@gmail.com
Academic Title	Assistant Professor	**Others Titles (Specify)**	
Institute/University	**Country**	**College/Directorate**	**Department**
Umm Al-Qura University	Saudi Arabia	Engineering and Islamic Architecture	Electrical Engineering

Nationality	**Date of Birth**	**Country of Birth**
Pakistani	14th January 1982	Pakistan

Languages	English	Urdu	French

Major field	**Specialization field**
Electronics and Computer Engineering	Embedded Systems

Key words which describe your field	System-level Design	Register Transfer-level (RTL)	Software Engineering	Design Verification

Qualifications

Degree	**Date awarded**	**Institute/University**	**Country**
PhD	2010	University of Nice, Sophia-Antipolis	France
MS	2006	University of Nice, Sophia-Antipolis	France
BE	2004	UET Peshawar	Pakistan

Work Experience

Date: From - To	**Position**	**Institute/University**	**Country**
Sept. 2012 – Present	Asst. Professor	Umm Al Qura University	Saudi Arabia
Aug. 2010 – Aug. 2012	Asst. Professor	COMSATS University	Pakistan
July 2004 – Mar 2005	Lecturer	COMSATS University	Pakistan

<table>
<tr><th colspan="3">Curriculum Vita</th><th colspan="3">السيرة الذاتية</th></tr>
<tr><td>Name (Arabic)</td><td></td><td>خان</td><td>محمود</td><td>عامر</td><td>الاسم (عربي)</td></tr>
<tr><td>Name (English)</td><td></td><td>Khan</td><td>Mehmood</td><td>Aamir</td><td>الاسم (إنجليزي)</td></tr>
<tr><th colspan="6">Current Research Interests</th></tr>
<tr><td colspan="6">Design Verification, Software Engineering, SoC Design , FPGA Design & Implementation</td></tr>
<tr><th colspan="6">Honors/Awards</th></tr>
<tr><td colspan="6">
• Designated as HEC Pakistan Approved PhD supervisor in March 2012 entitling to supervise PhD students in Pakistan.
• Awarded with the COMSATS University Research Grant in 2011 for the project titled “Verification and Validation of Embedded System Design”
• Awarded with the partial scholarship for PhD from EGIDE France.
• Awarded with Higher Education Commission (HEC) of Pakistan’s Scholarship for Masters and PhD studies at France for a total duration of four years.
• Won first prize in the National Exhibition on Microcontrollers and Embedded Systems (EMCOT 2004) conducted by the COMSATS Institute of Information Technology (CIIT) Abbottabad, Pakistan.
</td></tr>
<tr><th colspan="6">Workshops</th></tr>
<tr><td colspan="6">
• Virtual Platforms with Synopsys Innovator/Creator Tools‟, 16-20 Nov 2009 at Synopsys, Sophia Antipolis, France.
• EJCP (Advanced Programming Skills for Researchers) workshop in June 2009 at Dinar, France.
• Invited talk at Synchron‟08 workshop on „Synchronous Reactive Systems‟ at Aussois, France in Dec 2008.
• InnovDoc workshop on „Innovation and Industrial Liaison for Doctoral Students‟ in Oct 2008 at Fréjus, France.
• Workshop on „Scientific and Professional Communication in English‟ in Oct 2008 at Sophia-Antipolis, France.
• ICAR workshop on „Construction of Middleware based Distributed Applications‟ in Aug 2008 at Nice, France.
</td></tr>
<tr><th colspan="6">Publications</th></tr>
<tr><td colspan="6">
• Aamir Mehmood Khan, Frederic Mallet, Charles Andre, Robert de Simone, “IP-Xact components with Abstract Time Characterization”, Forum on Specification and Design Languages (FDL’09), Sophia-Antipolis France, September 2009.
• Charles Andre, Frederic Mallet, Aamir Mehmood Khan, Robert de Simone, “Modeling SPIRIT IP-Xact in UML MARTE”, Design Automation and Test in Europe (DATE’08), Munich Germany, March 2008.
</td></tr>
</table>

Curriculum Vita			لسيرة الذاتية		
Name (Arabic)			فاضل الاهي	محمد راشد	**الاسم (عربي)**
Name (English)			Fazal Elahi	Muhammad Rashid	**الاسم (إنجليزي)**

P.O. Box	**City**	**Postal Code**	**Country**
56591	Makkah	21955	Saudi Arabia
Tel. No. (Office)	**Tel. No. (Home)**	**Fax No.**	**Mobile No.**
			00966-580144036
E-mail (1)	mfelahi@uqu.edu.sa	**E-mail (2)**	muhammadrashid.75@gmail.com
Academic Title	Assistant Professor	**Others Titles (Specify)**	
Institute/University	**Country**	**College/Directorate**	**Department**
Umm Al-Qura University	Saudi Arabia	Computer and Information Systems	Computer Engineering

Nationality	**Date of Birth**	**Country of Birth**
Pakistan	5th March 1975	Pakistan

Languages	English	French	Urdu

Major field	**Specialization field**
Electronics & Computer Engineering	Embedded Systems Design

Key words which describe your field	System Engineering	Digital Design	Modeling and Simulation	Engineering Education

Qualifications

Degree	**Date awarded**	**Institute/University**	**Country**
PhD	2009	University of Bretagne Occidental	France
MS	2006	University of Nice Sophia Anti Polis	France
BE	2000	N.W.F.P UET Peshawar	Pakistan

Work Experience

Date: From - To	**Position**	**Institute/University**	**Country**
May 2011 – Current	Assist. Professor	Umm Al Qura University	Saudi Arabia
Jan. 2010 to April 2011	Manager	Adv. Engg. Research Org.	Pakistan
Jan. 2007 to Dec. 2009	R & D Engineer	Thomson R& D	France
July 2000 to June 2005	Ass. Manager	Adv. Engg. Research Org.	Pakistan

Current Research Interests

System Engineering, Digital Design, Engineering Education Research

Honors/Awards

- The abstract of PhD dissertation won the financial awards in the following top events:
  - In IEICE VLD Student Forum at ASP-DAC, Yokohama, Japan, January 2009
  - In EDAA PhD Forum at Design, Automation and Test in Europe (DATE), France, April 2009
- ANRT Award by French Ministry of Research for doctorate industrial research
- Research Funding by Texas Instruments during MS studies in France
- Scholarship by Higher Education Commission Pakistan for Masters leading to PhD studies
- Certificate of Merit for securing silver medal for his engineering studies at UET Peshawar

Participation in Funded Research Projects

- hArtes (holistic approach to reconfigurable real time embedded systems) (2006 to 2009)
  - Sixth Framework Program of the European Union under the thematic area embedded systems
- ANR MoPCoM-SoC (2008-2010)
  - Increasing productivity by reusing software techniques, architectures and/or components
- Morpheus (2008-2010) (FP6 program of the European Union)
  - Design of a fully dynamically reconfigurable heterogeneous architecture

Publications

Journal Publications (First Author):

1. Muhammad Rashid and Imran A. Tasadduq, "Holistic Development of Computer Engineering Curricula by using Y-Chart Methodology", IEEE Transactions on Education, Revision submitted on 20th February 2013.
2. Muhammad Rashid and Bernard Pottier, "Visitor-based Application Analysis Methodology for Early Design Space Exploration", Design Automation for Embedded Systems, Revision submitted on 18th December 2012.
3. Muhammad Rashid and Bernard Pottier, "Application Characterization for Early Design Space Exploration", The Arabian Journal for Science and Engineering, Revision submitted on 5th March 2013.
4. Muhammad Rashid, "Analysis for Parallel Execution without performing hardware software co-simulation", International Journal of Embedded Systems and Applications, Revision submitted on December 2012.
5. Muhammad Rashid, "Formulation of Video Encoding Applications for Heterogeneous Reconfigurable Architectures" International Journal of Computer and Information Technology, vol. 02, no. 01, pp. 86-92, January 2013.

Book(s) (First Author):

1. Muhammad Rashid, "System Level Design: A Holistic Approach, LAP LAMBERT Academic Publishing, ISBN-10: 3844323279, 2010.

Book Chapters (First Author):

1. Muhammad Rashid and Bernard Pottier, "A Multi-Objective Framework for Characterization of Software Specifications", Embedded and Real Time System Development: A Software Engineering Perspective: Concepts, Methods and Principles, Accepted for publication, Probable publication date June 2013.

2. Muhammad Rashid, "An Efficient Cycle Accurate Performance Estimation Model for Hardware Software Co-design", Embedded and Real Time System Development: A Software Engineering Perspective: Concepts, Methods and Principles, Accepted for publication, Probable publication date June 2013.

Conference Proceedings (First Author):

1. Muhammad Rashid, Imran A. Tasadduq, Yousuf I. Zia, Mohammad Al-Turkistany and Saima Rashid, “A Methodology for the Assessment of Pedagogic and Implementation Aspects of Laboratories”, International Conference on Frontiers in Education: Computer Science and Computer Engineering, WORLDCOMP, Las Vegas USA, July 2012.
2. Muhammad Rashid, Imran A. Tasadduq, Yousuf I. Zia, Mohammad Al-Turkistany and Saima Rashid, “Evaluation of Engineering Laboratories”, IEEE International Conference on Education and e-Learning Innovations (ICEELI), pp. 1-6, Tunisia, July 2012.
3. Muhammad Rashid, Fabrizio Ferrandi and Koen Bertels, “HARTES Design Flow for Heterogeneous Platforms”, Proceedings of the 10th International Symposium on Quality of Electronic Design (ISQED’09), pp.330--338, Santa Clara, CA, USA, March 2009.
4. Muhammad Rashid and Bernard Pottier, “Application Capturing and Performance Estimation in a Holistic Design Environment”, Proceedings of the 16th IEEE International Conference on the Engineering of Computer Based Systems, pp. 21--30, CA, USA, April 2009.
5. Muhammad Rashid, Fabrice Urban and Bernard Pottier, “A Transformation Methodology for Capturing Data Flow Specification”, Proceedings of the IASTED Conference on Parallel and Distributed Computing and Networks, pp. 220–225, Innsbruck, Austria, February 2009.
6. Muhammad Rashid, “Design Space Exploration in Heterogeneous Embedded Systems”, IEICE VLD Student Forum at Asia and South Pacific Design Automation Conference (ASPDAC), Yokohama, Japan, January 2009.
7. Muhammad Rashid, “Design Space Exploration in Heterogeneous Embedded Systems”, EDAA PhD Forum at Design, Automation and Test in Europe (DATE), France, April 2009.
8. Muhammad Rashid, Damien Picard and Bernard Pottier , “Application Analysis for Parallel Processing”, In Proceedings of the 11th Euro Micro Conference on Digital System Design, Architectures, Methods and Tools (DSD’08), pp. 633--640, Parma, Italy, September 2008
9. Muhammad Rashid, Loudvic Apvrille and Renaud Pacalet, “Application Specific Processors for Multimedia Applications”, Proceedings of the 11th IEEE International Conference on Computational Science and Engineering, pp. 109-116, Brazil, July 2008
10. Muhammad Rashid, Loudvic Apvrille and Renaud Pacalet, “Evaluation of ASIPs Design with LISATek”, In Embedded Computer Systems: Architectures, Modeling, and Simulation, Springer, Lecture Notes in Computer Science, volume 5114/2008, pp. 177-186, July 2008.
11. Muhammad Rashid, Jean-Christophe Le Lann and Koen Bertels, “Video Encoding Analysis for Parallel Execution on Reconfigurable Architectures”, 6th Symposium on Design, Analysis, and Simulation of Distributed Systems, Edinburgh, UK, June 2008.
12. Muhammad Rashid., Thierry Goubier and Bernard Pottier, “A High Level Generic Application Analysis Methodology for Early Design Space Exploration”, International Workshop on Design and Architectures for Signal and Image Processing, France, 2007.
13. Muhammad Rashid, “A High Level Design based on Performance Estimation Methodology for Reconfigurable Architectures”, 4th International Workshop on Reconfigurable Communication Centric System-on-Chips (ReCoSoC’08), Barcelona, Spain, July 2008.

BRAINS FOR INNOVATIVE RESEARCH DEVELOPMENT & STRATEGIC STUDIES (BIRDS) FOUNDATION

In recognition of successful completion of course of study

And satisfactory fulfillment of the prescribed requirements

Mr. Maher Jamil Alahmadi

Is hereby awarded

CERTIFICATE IN PROJECT MANAGEMENT

On this 30th day of January, 2013

Noman Hashmi

Noman Ahmed Shah, PMP
Executive Director

Serial: SA/313/120

Manpower Justification:

As this project is more software engineering oriented, the main cost of the budget is on the human resources and licenses for the commercial softwares to achieve the objectives of this proposal. The PI and the CO-I will work together on the research tasks. Two full-time research assistants will be needed to perform the modeling and then the model transformation tasks. The MS student will focus on the system level design issues. One project manager is needed to handle paperwork, workshop arrangements and for coordination between the team members.

Graduate Student Justification:

The MS student hired in the project will work on the system level design issues. This work will contribute as the graduate level thesis for the student. Currently the Umm-al-Qura University does not have a graduate program, so we will try to hire the student from other universities especially looking for the research thesis in the field of software engineering.

Traveling and Others Justification:

During both the years, we intend to frequently publish our research work at journals and selected conferences. Our focus will be on the conferences as the feedback from the research community is quick. Feedback will be important in shaping our design methodology as per the language standards used. Similarly by the end of the project tenure, we target to publish the complete work in reputed ISI or SCOPUS indexed journals. As this proposed research is quite novel, the UQU library lacks any book or other material on the relevant topics. So we have allocated a small amount for the purchasing of required books/articles (mentioned under the 'other expenses').

Once the lab is established, workshops and training sessions will be needed to educate the students and the project team members about the cutting-edge research work going on in this field.

Equipment Justification:

As this proposal is submitted for the first time, there is no current or pending funding for this project. However, space for the proposed project lab will be available at the Umm Al-Qura University (UQU). Training and workshop classrooms can also be arranged with the university. The undergraduate students participating in the laboratory sessions and design projects are available as part of the academic program of both the college of engineering and Islamic architecture and college of computer and information systems.

For the equipment, we are demanding two types of resources; one for the lab establishment and other for the research project. Hardware material like PCs, FPGA kits, Oscilloscopes, function generators, power supplies, UPS, multimeters, networking equipment are all required to establish a small lab where students can be trained to design and model at system level. Moreover, the office furniture cost also adds to this budget for the lab.

For the research project, we require equipment like high-end computing machines, laptops, monitors etc. High-end computing machines will be required to perform selective modeling tasks, as the modeling softwares are usually very bulky and processor power consuming. Laptops are required for the project full-time members for the data collection during their field visits. Printers, scanners and other consumables will be used during both phases of the research project.

Another important cost added to the budget is of the licenses for the commercial softwares. Modeling softwares like MagicDraw [68], Rational Software Architect (RSA) [69] or Enterprise Architect [70] will be used design UML and SysML models. Simulation softwares like ModelSim [71], QuestaSim [72] or VCS [73] will be used to program and simulate the SystemVerilog or PSL code. These software tools are generally expensive and consist of complete tool suites bundling the simulator engine with a complete development environment. The software licenses will be shared by both the research project and the design lab. Details of the hardware/software equipment are shown in the table.

All prices are in Saudi Riyals

Item	Quantity	Price	Total
Equipments (<= 100,000)			
High-end Computing Machines	2	7,000	14,000
Desktop Computers	5	3,000	15,000
Laptops	4	3,500	14,000
Monitor Screens	4	2,000	8,000
Docking Stations	4	1,000	4,000
FPGA Design Kits	5	5,000	25,000
Oscilloscopes	3	5,000	15,000
Multimeters	3	2,000	6,000
Uninterrupted Power Supply	2	1,000	2,000
Function Generator	1	5,000	5,000
Power Supplies	4	3,000	12,000
Accessories (Cables, Networking Equipment etc.)	1	30,000	30,000
Lab Material (Tables, Chairs, Shelves, Storage Units etc.)	1	30,000	30,000
Modeling Softwares (with 2yrs License)	5	10,000	50,000
Simulation Softwares (with 2yrs License)	5	10,000	50,000
Synthesis Software (with 2yrs License)	2	10,000	20,000
Sub total			300,000
Materials & Supplies			
Printers	2	4,500	9,000
Consumables	1	10,000	10,000
Scanner	1	1000	1000
Sub total			20,000
Grand Total			**320,000**

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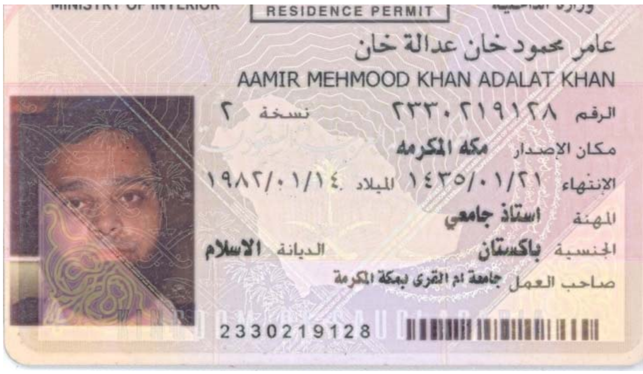
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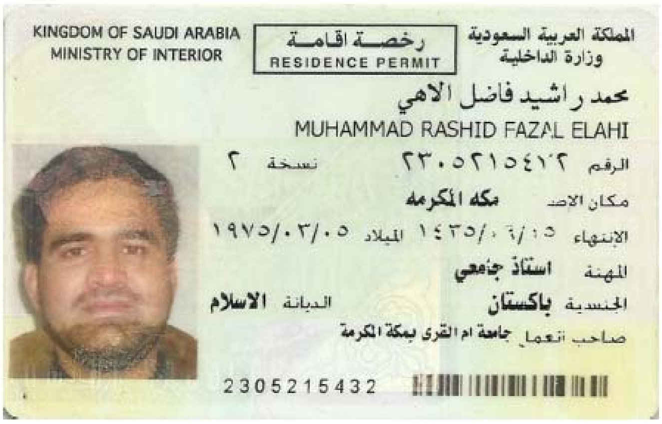
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