Research Plan

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1 Academic Background

I am currently working at the Urgench branch of Tashkent University of Information Technologies (TUIT). Simultaneously, I am enrolled as a PhD student at TUIT and doing my PhD research in the field of Software Engineering.

After finishing my bachelors study in 2013 and masters study in 2015, I have continued working at TUIT Urgench branch as a junior lecturer. I give lectures on the subjects of "Web Application Development", "Software Architectures, Designing and Development", "Embedded Software Systems", which are strongly related to the research area of my interest. During these teaching activities, I worked on several projects as a software architect, database designer and developer in the framework of the "e-Cardio" project developed for the Cardiology Center in Khorezm (Uzbekistan) in 2015-2017 years. Besides, I took a part in development of the "InfoSecurity" project as a developer in 2016. By participating in these projects, I have expanded my knowledge in the Software Engineering field. Teaching and developing activities strengthened both my theoretical and practical knowledge in Software Engineering.

2 Existing Collaborations Between Partner Institutes

Initial contacts between the partner institutes have been started by scholarships, starting in 2011 in the framework of the TARGET project of Erasmus Mundus. In 2014, a memorandum of understanding between University of Oldenburg and TUIT was signed, to establish a formal framework for future cooperation. Motivated by recent efforts to establish a software engineering institute at TUIT, Dr. Bakhtiyorjon Akbaraliev and Oybek Allamov, visited the software engineering group for the 2014/2015 winter term. This stay was used to exchange and transfer knowledge in software engineering research and teaching.

To extend existing cooperations, the parter institutes have submitted a collaboration project proposal entitled **"Smart Modeling"** to the BMBF call

(BMBF Bekanntmachung: "Richtlinien zur Förderung der Wissenschaftlich-Technische Zusammenarbeit mit der Republik Usbekistan: Vorhabenbeschreibung") in 2016. The project proposal is initially received a positive notification from the grant provider. The existing memorandum of understanding was also extended in 2017, accordingly. Furthermore, the both universities together with other partners have submitted another project proposal in the field of **"Smart City"** to another BMBF call (Bekanntmachung: Richtlinie zur Förderung von Vernetzungs- und Sondierungsreisen deutscher Hochschulen und Forschungseinrichtungen ("Travelling Conferences") zum Aufbau von Kooperationen mit Partnern im Südkaukasus, Zentralasien und der Mongolei, Bundesanzeiger vom 05.09.2017) in 2017.

I am very keen to develop and expand existing cooperation between the Tashkent University of Information Technologies and the Carl von Ossietzky University of Oldenburg. The potential research fields consist of smart modeling, smart cities based on IoT and model-driven IoT. In the framework of the smart modeling collaboration project, I am currently participating as supervisor in the joint seminar on smart modeling. Among others, I am supervising the presentations of the Uzbek students including Dilshod Jumaboev and Jakhongir Sobirov in bi-national teams. The smart modeling seminar includes topics like model-driven software development for IoT and Domain-specific Languages for Smart Home Configurations.

3 Motivation and Goals

Today's technological advancements leading to an increasingly interconnected world. We are using smarter devices and services in our everyday life. Internet of things (IoT) has become the new technological trend today. Therefore, I have chosen model-driven IoT as my PhD research area. I am currently working in the PhD topic entitled "Model-driven Internet of Things".

German universities, and particularly, Software Engineering Group at University of Oldenburg is one of the leading institutions in the field of software engineering and its model-driven aspects. Therefore, I want to do my PhD research in the Software Engineering Group at the University of Oldenburg. I am interested in the scientific works of this department, as long as they are in my interests. Additionally, both the University of Oldenburg and TUIT have signed a "Memorandum of Understanding" to setup and strengthen partnership and cooperation in Software Engineering and it's application areas.

I plan to expand my knowledge in the field of software engineering while visiting University of Oldenburg. In particular, to strengthen the theoretical knowledge of the foundations of modeling, model-driven software architectures, version-control systems, service-oriented architectures, micro-service architectures and modeling. These areas are the main foundations for the research field of model-driven IoT.

In the framework of my thesis, model-driven concepts (meta-model) dedicated especially to development of IoT systems will be described and tool sup-

port will be developed as well as the results will be validated in real-world applications. Moreover, I plan to publish the scientific results of my research in different conferences and workshops, as well as discuss my research topic with various experts and scientists in the relevant field. And yet, if possible, I would like to establish contacts with German companies working in this field.

At the same time, I want to participate in current projects of Software Engineering group as a visitor. Participation in these projects will help me to enrich my practical skills in Software Engineering.

4 PhD Thesis

Internet Of Things. The Internet of the present day is enriched with a huge amount of various devices and micro services. These devices and services operate for different purposes, yet work together to achieve common goals. The various types of sensors, actuators and devices are being developed to provide a range of services. These sensors and devices have created a new technological trend today. This trend has been named the "Internet of Things".

In the framework of IoT, more and more devices are equipped with network connectivity to autonomously provide "smarter" services, forming the Internet of Things (IoT). Applications are wide-ranging, and have variously been termed "Smart X", including Smart Homes, Smart Factories (Industry 4.0), Smart Government, Smart City, Smart Grid, Smart Traffic Control, and many more.

Smart technologies employ sensors and actors to increase the efficiency of services and processes, including environmental sustainability, energy efficiency, mobility, health care, safety, and security. ICT helps to optimize the processes, while IoT provides the platform for managing a multitude of small sensor, actor devices, communication protocols and home servers.

The concept of smart technologies arises from the need to manage, automate, optimize and explore all aspects of daily life that could be improved and optimized by information technologies. The software paradigm IoT, being a core concept behind smart smart technologies, is largely perceived as a collection of interconnected "things" within smart technologies.

Model-Driven Engineering. The IoT-based smart applications are realized by interconnected systems of heterogeneous hardware, software, and embedded systems: these cyber-physical systems introduce new levels of complexity, requiring appropriate engineering methodologies to support formally rigorous software and systems development. **Model-Driven Engineering (MDE)** provides fitting foundations and is considered as an enabling technology for advancing smart technology applications.

MDE is the modern day approach of software system development which supports well-suited abstraction concepts for development activities. It intends to improve the productivity of the design and development, maintenance activities, and communication among various actors and stakeholders of a system. As the main concept in MDE, models are well-suited for designing, developing and producing large-scale software projects. MDE brings several main benefits

such as a productivity boost, models become a single point of truth. Models are the main artifacts in MDE. They are well-suited for designing, developing and producing large software systems. Software models are the documentation and implementation of software systems.

MDE Applied: Model-Driven IoT. There are several domain-specific MDE approaches and tools for developing IoT-based architectures and applications. However, research in model-driven IoT is in its early stages and extended research in the field is required. MDE is not fully utilized for developing model-driven IoT approaches. This proposal focuses on the field of model-driven IoT for smart systems. Its objectives are manifold: (1) studying the state of the art in model-driven IoT, (2) extended research in model-driven IoT focusing on smart technologies, (3) applying MDE concepts to develop software architectures and platforms for IoT-based systems.

The **core objectives** of this my research are manifold:

- **Studying The State of Art.** This research initially intends to study the state of the art in model-driven IoT approaches in order to identify the MDE tools and approaches dedicated especially to develop the IoT-based smart systems. As long as these tools are open-source and their underlying concepts can be further developed and extended.

- **Research.** The most important, challenging and long-running part of this research focuses on extended research in model-driven IoT focusing on the smart technologies. This research aims to utilize the full potential of MDE in developing advanced model-driven IoT systems, applications and architectures. This research helps to improve development and maintenance of IoT-based systems by applying modern model-driven engineering trends.

  For the general development of IoT systems, only initial and prototypical approaches currently exist. However, a comprehensive, widely applicable research is not yet available. In the scope of my dissertation, I plan to develop such a model-driven language for developing IoT systems. The main intention of applying for the contact scholarship is to enrich my rather theoretical work in Uzbekistan on the model-driven development of IoT systems with application-oriented case studies. For this purpose, the status of the model-driven development for the realization of IoT systems in Germany will be surveyed and compared with the activities in Uzbekistan.

  The Software Engineering Group at the University of Oldenburg works in the intensive development and application of modeling languages, which are used to describe, implement and further develop large software systems. Current activities of the group includes the development of sensor-based environmental information systems, in which the "things" (environmental) sensors and appropriate actuators via the "Internet" in IoT systems are summarized. Likewise, extensive experience in the development and application of such domain-specific languages and the associated

tool support e.g. on collaborative modeling and integration of modeling languages.

- **Application and Validation.** IoT is widely used in automation of daily life activities. It is the main foundational concept in building smart technologies such as smart cities, smart cars, smart grid, smart traffic control and Industry 4.0. Model-Engineering is also widely applied in developing big size software systems. Software systems for IoT can be very huge raising necessity for MDE. The main application areas of model-driven IoT are smart technologies like smart cities, smart cars, and many more. For example, we can utilize model-driven languages to describe, analyze, maintain and evolve IoT-based smart systems. Model-driven engineering makes IoT systems easy to develop, maintain and sustain. It can save development time and effort, and reduce complexity by providing automatic code generation. Automatic code generation also reduces the risk of errors, which leads to the quality improvement. Besides, it gives the opportunity to concentrate on adding more value. This research further focuses on applying model-driven IoT approaches to real-world applications as the proof of concept. This activity addresses to practical applications of model-driven IoT. I will study the current state of the art of IoT development in Germany to compare it to Uzbekistan.
- **Cooperation with companies.** During the my research stay, I intend to get acquainted with the activity at companies operating in Germany, particularly in Oldenburg, in the field of IoT. As known [`http://www.oldenburg.de/de/startseite/buergerservice/aktuelles/smart-city.html`], Oldenburg city administration is working in the field of smart city development. Furthermore, the existing collaborations between the University of Oldenburg and Tashkent University of Information Technologies focus on smart modeling and smart city subjects together with several industrial companies and the City Administration of Oldenburg.

5 Work and Time Plan

I intend to apply for six months research stay in Oldenburg. During this research stay, I will to pursue concrete work and time plan as follows:

- **1st month:** In the beginning of my research stay, I would like to familiarize myself with the existing infrastructure and working environment in the Software Engineering Group. In this phase, as I am already familiar with the general concepts of Model-Driven Engineering, I will continue extended literature review in the field of model-driven Internet of Things approaches.
- **2nd and 3rd months:** I will continue literature study in Model-Driven IoT to review and identify the research challenges. Meanwhile, I will learn how to write scientific papers. From this phase, I am planning to visit

companies working in the field of model-driven IoT in Oldenburg and study their activities. At companies, I mostly focus on practical applications of model-driven IoT and compare them to the practical applications in Uzbekistan. I will learn how to improve IoT development and maintenance using new model-driven technologies.

- **4th month:** I will begin to write a scientific paper for publishing in a conference and workshop. It will mainly focus on practical and industrial applications of model-driven IoT. Because, the research in Uzbekistan focuses strongly on the mathematical and theoretical foundations of scientific field. I would like to combine these strong practical applications and my theoretical knowledge.

- **5th month:** The research findings till this time will be documented in some chapters my combining practical applications and theoretical knowledge. These research findings will mostly fit into the motivation, literature study, evaluation chapters of my thesis.

- **6th month:** In the final phase of my research stay, I will finalize documentation of my research stay, eventually complete a report about my stay which will contribute to my further research and scientific activities. In the end of my research stay, I would like to give a presentation in the group to discuss what I have achieved from the research stay.

Moreover, I am very keen on learning German language. I want to learn German from the first month of the stay among native speakers and continue learning during my stay in the language center of University of Oldenburg. Along the activities above, I will seek for developing contacts with other researchers and PhD students to discuss my topic.

6 Necessity of Funding

To develop my scientific work and establish strong ties with the department, I would like to visit the University of Oldenburg and closer get acquainted with my supervisor and Software Engineering group. This research stay will not be paid by TUIT. I need a funding to finance my research stay in Software Engineering group. The joint contact scholarship for foreign doctoral students by DAAD will be the best aid for me to achieve plans and results in this proposal. Because I have no other source of financial support except my own budget, it would be very helpful for my research stay in Oldenburg and develop closer cooperations with the research colleagues and to discuss further scientific activities with Prof. Andreas Winter in Oldenburg.