LOWCOMOTE ESR4 MONTHLY REPORT
Period March 2021.

1. Literature

Alfred Åkesson, Görel Hedin, Niklas Fors, Rene Schöne, and Johannes Mey. 2020. Runtime modeling and analysis of IoT systems. In Proceedings of the 23rd ACM/IEEE MODELS '20. Association for Computing Machinery, New York, NY, USA, Article 40, 1–5. DOI:https://doi.org/10.1145/3417990.3421397

- ***Url***: *Runtime modeling and analysis of IoT systems*
- ***Motivation***: *This paper introduces an easy way to model and performs IoT components dependability analysis using textual RAGs language.*
- ***Summary***: *DSL that can be good at specifying IoT system component connectors explicitly can facilitate the analysis mechanism. A high-level analysis is preferred. The paper proposes the use of Relational Reference Attribute Grammars (RAGs) for modeling and analysis of IoT systems. Relational RAGs are the abstract syntax of a conceptual model of a system that takes into account components relationships. The authors developed a runtime model composed of components and connectors. Components are to provide services which connectors are there to facilitate message exchanges which are then used for analysis. The authors presented a simple running example of an IoT system to communicate health measurements to the physician. The authors then present a divide dependable Analysis algorithm to analyze message transaction dependability to the devices which take into account the number of devices required to perform a given send/receive action.*
- ***Opinions***: *This paper presents a simple domain-specific language to model and analyze IoT component dependability. The authors describe how the system can be designed graphically and represented textually using Relational Reference Attribute Grammars to facilitate the analysis. In my opinion, this paper presents a starting point to understand how IoT systems dependability analysis can be performed. Even though the modeling approach is easily expandable and self-explanatory but the analysis technique presented seems to be poor considering how ordinary dependability analysis is performed. Taking into account device number and presence in all IoT design scenarios doesn't guarantee satisfaction when making design-level decision making, but it is a very good start.*

Huang, Jiwei & Li, Songyuan & Chen, Ying & Chen, Junliang. (2018). Performance modeling and analysis for IoT services. International Journal of Web and Grid Services. 14. 146. 10.1504/IJWGS.2018.090742.

- ***Url***: *(PDF) Performance modeling and analysis for IoT services*
- ***Motivation***: *I choose this paper to understand how performance analysis can be conducted on IoT systems.*

- ***Summary***: *The paper proposes a modeling approach and mathematical performance analysis techniques for IoT services to tackle the task scheduling and resource management problems in IoT. The authors presented a model to be used when formulating a system and later developed a performance analysis approach based on different metrics proposed for design and optimization purposes. The IoT service model has been represented as a series of atomic requests queued for execution while an IoT system has been represented by a relational connection of atomic models. Based on service arrival rates and service layer, the authors established a mathematical model to analyze the performance of such connected services.*
- ***Opinion:*** *This paper presents a mathematical model to perform a performance analysis of the IoT system based on required/provided service execution rates. In my opinion, the author's approach gives a very detailed mathematical description of how performance analysis can be conducted on IoT services. Though it might look a bit complex to implement in real code but once implemented it can be efficient for performance analysis in CHESSIoT.*

Modekurthy, Venkata & Ismail, Dali & Rahman, Mahbubur & Saifullah, Abusayeed. (2018). A Utilization-Based Approach for Schedulability Analysis in Wireless Control Systems. 49-58. 10.1109/ICII.2018.00014.

- ***Url***: *(PDF) A Utilization-Based Approach for Schedulability Analysis in Wireless Control Systems*
- ***Motivation***: *I choose to read this paper to understand the possible techniques involved in schedulability analysis of different IoT scenarios.*
- ***Summary***: *This paper presents a schedulability analysis technique based on utilization bound for multi-hop, multi-channel industrial WSN. This paper highlights the unsuitability of classical schedulability analysis techniques which are based on worst case delay on IIoT (currently used by CHESS). In IIoT the frequent checking is required due to channel/link/node failures and changes to the node operating conditions are inevitable. To solve such a problem, the authors determined a schedulable flow by comparing its utilization with the maximum utilization of all flows in the network. Finally, the authors presented a validation simulating examples considering different network architecture.*
- ***Opinion:*** *This paper presents a multi-channel schedulability analysis for IoT systems based on usability aspects. Different mathematical representations of resource utilization flow have been used to deduce schedulability analysis equations. In my view, understanding all the mathematical representation of schedulability analysis techniques is a bit out of my scope and may require extra effort and time to understand but the conceptual level of how the process is conducted is very important.*

M. Gonzalez Harbour, J. J. Gutierrez Garcia, J. C. Palencia Gutierrez and J. M. Drake Moyano, "MAST: Modeling and analysis suite for real-time applications," Proceedings 13th Euromicro Conference on Real-Time Systems, Delft, Netherlands, 2001, pp. 125-134, DOI: 10.1109/EMRTS.2001.934015.

- ***Url***: *MAST: Modeling and analysis suite for real-time applications*
- ***Motivation***: *I choose to read this paper as it gives an overview of the MAST tool used by CHESS for Schedulability analysis.*
- ***Summary***: *This paper presents the MAST tool, a timing analysis tool used for schedulability analysis relying on the system's component timing requirements. The tool parser converts the ASCII description of the system into a data structure that is used by the analysis tools. The analysis is done by performing different kinds of worst-case schedulability analysis techniques to produce a set of results on the timing behavior of the system. The schedulability conclusion is made by comparing the result provided by the tool with the timing requirements provided by the user. The MAST language for describing systems is defined using a custom definition of processing resources, scheduling servers, sharing resources, operation, events, and transactions.*
- ***Opinions:*** *The MAST tool is a very mature tool for performing schedulability analysis for real-time systems by performing timing checks on models. In the paper, a use case has been presented and its corresponding MAST model. In my opinion, while MAST relies on timing constraints to perform the analysis, from the previous paper, it is highlighted that IoT systems activities are more dynamic and unpredictable. This can be due to different unprecedented environmental constraints. We can not also forget the fact that the event deadlocks can happen in the middle of the process for instance in case of a failed processing resource. It would be good if this is also addressed in MAST.*

Very important papers to read:

- P. Iyenghar and E. Pulvermueller, "**A Model-Driven Workflow for Energy-Aware Scheduling Analysis of IoT-Enabled Use Cases**," in IEEE Internet of Things Journal, vol. 5, no. 6, pp. 4914-4925, Dec. 2018, DOI: 10.1109/JIOT.2018.2879746. **[UNFINISHED]**
- P. Iyenghar, A. Noyer and E. Pulvermueller, **"Early model-driven timing validation of IoT-compliant use cases"** 2017 IEEE 15th International Conference on Industrial Informatics (INDIN), Emden, Germany, 2017, pp. 19-25, DOI: 10.1109/INDIN.2017.8104740.
- S. Sicari, A. Rizzardi, A. Coen-Porisini and C. Cappiello, "**An NFP Model for Internet of Things applications**" 2014 IEEE 10th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob), Larnaca, Cyprus, 2014, pp. 265-272, DOI: 10.1109/WiMOB.2014.6962181.

- M. Hagner, A. Aniculaesei and U. Goltz, "**UML-Based Analysis of Power Consumption for Real-Time Embedded Systems**" 2011IEEE 10th International Conference on Trust, Security and Privacy in Computing and Communications, Changsha, China, 2011, pp. 1196-1201, DOI: 10.1109/TrustCom.2011.161.

2. Activities

· *What you have been doing this period*

- This month, I performed different activities on the CHESSIoT extension development platform. The main activities are the following:
  - Made CHESSIoT component compliant with End-2-end response time and Schedulability analysis provided by CHESS (this needs to be improved).
  - Created different exemplary CHESSIoT models for modeling purposes but especially one on Industrial IoT safety use-case to be featured in CHESSIoT paper.
  - Worked on CHESSIoT2ThingML model transformation focusing on generating components state machines.
  - Explored CHESS model2model transformation chain for future extension and better understanding.

- Finished working on the GeoMQTT paper ready to be submitted.
- Successfully presented my work to the IMT research team.
- Started preliminary collaboration with ESR10 for secondment preparation.
- Working on the CHESSIoT paper which can be accessed through this link.
- Presented my research status to my supervising team.
- Got my driving license :-)

· *What you did not achieve (report them in the next period)*

- Achieve the CHESSIoT paper intended level as I set last month.

3. Potential blockers

- No

4. Action items for the next period

- Learn how the services of the local eclipse native plugins can be exposed to the cloud.

- Continue the development of the CHESSIoT tool by exploring the possible transformation of the extended CHESSIoT model.
- Work on chess2thingml model transformation.
- Look at how new elements extended by CHESSIoT can play a part in the schedulability analysis of CHESS models.
- Explore MAST analysis tool capability in the IoT domain.
- Continue working on the CHESSIoT paper with tentative submission this month(main focus)
- Submit MQTT5 paper.
- Continue the preparatory collaboration with the ESR10 collaboration from IMT Atlantique.
- Attend the 5th Lowcomote research meeting event.