Directed acyclic graphs as backbone solution for IOT applications

Outline and Topic Proposal

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1 Scope of Work - 4 Questions

In this section the essence of the proposed work is described by answering four key questions.

What is the problem you want to address in your work? There is no suitable solution for a backbone system for large-scaling, performant and secure IOT usecases where multiple distrusting parties are involved.

Why is it a problem? According to XY there will be more than 30 billion IOT devices by 2025 in many areas of our everyday lives. The concept of IOT is still more theoretical although some usecases are already developed. To accomplish the full potential of the IOT concept a suitable backbone solution must be provided. Different vendors and service providers need a common plattform for connecting their devices, services, buiness logic as well as their customers and a suitable payment solution.

What is the solution you developed in your work? A subset of DLT solutions called DAG (directed acyclic graphs) [1] seems to be suitable for most of the above mentioned IOT usecases. As an intermediate result the big buzzword IOT is defined, seperated into different categories with their own requirements. The selected DAGs are rated and checked for fulfillment. Finally the top three DAGs are evaluated and implemented in an exemplary IOT usecase. Performance tests verify the eralier created requirements. With this work the reader can evaluate DLT solutions (especially DAGs) for their suitability to be an IOT backbone solution as well as distiguish between IOT usecases which can benefit from DAGs and those who cannot.

Why is it a solution? DAGs are suitable as an IOT backbone solution not only because they fullfill (most) of the requirements evaluated for IOT usecases but also promote themself as well-fitted for IOT usecases. Different to blockchain or other DLT solutions they promise high scalability and a greater performance i.e. a high transaction-rate and fast transaction certainty. Their biggest advantage is the asynchroneous processing of newly created transactions as well as the more efficient consensus mechanisms. This work analyzes in detail which properties of DAGs enable their suitability for IOT usecases and which concrete solution implements those properties best. To achive this a theoretical evaluation is executed and afterwards verified by an implementation of a specific IOT usecase adapted for the top three best fitting DAGs. The IOT usecase is selected to represent a specific scope of IOT and does not cover the topic IOT as a whole.

[1] According to the current status: IOTA, Hashgraph, Byteball (OByte), Holochain, etc.

2 Preliminary Table of Contents

In this section the table of contents for the proposed work is described.

1. **Section 1 Introduction** This section introduces the reader in the topics IOT and DLT and the challenges of this work.
    a) **Subsection 1 The future of IOT and its potentail for our everyday lives**
2. **Section 2 Theoretical fundamentals** This section gives the reader a basic understanding of topics required for this work. It is asumed that the reader has a basic understanding of the general IT-related topics.
    a) **Subsection 1 Definitions DLT** Definitions of DLT-related things are done here, may containing: Types of Blockchains, Blockchain vs. DLT vs. DAG, Consensus, Smart-Contracts, (Dis-) Advantages
    b) **Subsection 2 Definitions IOT** Definitions of IOT-related things are done here, may containing: Fog / Cloud / Edge, M2M, Usecases, Digital Twins, IIoT, CIoT, Requirements, Hardware, Connectivity
    c) **Subsection 3**
3. **Section 3 Related Work** This section shows related work and how this work differs from it.
4. **Section 4 Analyzation IOT & DAG ("DAG-IOT")** This section analyzes the advantages and challenges of IOT and DAG
    a) **Subsection 1 IOT Usecases** When is an IOT usecase suitable for DLT?
    b) **Subsection 2 IOT usecase requirements** energy consumption, minimal ressource utilization, low bandwidth, etc.
    c) **Subsection 3 (Dis-) Advantages of DAGs for IOT)** scalability, anonymity, security, updating, trust, etc.
5. **Section 5 Exemplary Usecase** An exemplary usecase is developed in this section.
    a) **Subsection 1 Description**
    b) **Subsection 2 Target audience**
    c) **Subsection 3 Requirements**
    d) **Subsection 4 Design / Architecture**
    e) **Subsection 5 ...**
6. **Section 6 Evaluation** Different DAGs are analyzed and evaluated against the requirements and rated for fulfillment.
    a) **Subsection 1 IOTA**

   b) **Subsection 2 Hashgraph**
   c) **Subsection 3 Byteball**
   d) **Subsection 4 ...**

7. **Section 7 Implementation** The usecase from section 5 is tested on a subset of the evaluated DAGs from section 6
   a) **Subsection 1 Architecture**
   b) **Subsection 2 Hardware**
   c) **Subsection 3 Data structures**
   d) **Subsection 4 Libraries**
   e) **Subsection 5 ...**

8. **Section 8 Tests & Results** In this section the test setup and the results are presented.
   a) **Subsection 1 Test setup**
   b) **Subsection 2 Loadtests**
   c) **Subsection 3 ...**

9. **Section 9 Conclusion & Perspective** In this section a conclusion and a perspective are drawn.

3 Relevant Related Work

In this section, identified related work is described.

[SC18] The authors analyze many blockchain consensus algorithms for their suitability for IOT solutions. The Tangle-consensus algorithm of IOTA seems to fit best as it utilizes a DAG.

[PIH18] The authors present a decision framework for when to use blockchain technology and when not.

[Per+18] The authors analyze DAGs (namely Nxt, IOTA, Orumesh, DagCoin,Byteball, Nano and XDAG, even though some of them are only ERC20-Token) and their advantages over classical blockchain solutions. They do not describe a specific usecase or a concrete application.

References

[Per+18] H. Pervez et al. "A Comparative Analysis of DAG-Based Blockchain Architectures." In: *2018 12th International Conference on Open Source Systems and Technologies (ICOSST)*. Dec. 2018, pp. 27–34. DOI: 10.1109/ICOSST.2018.8632193.

[PIH18] Claus Pahl., Nabil EL Ioini., and Sven Helmer. "A Decision Framework for Blockchain Platforms for IoT and Edge Computing." In: *Proceedings of the 3rd International Conference on Internet of Things, Big Data and Security - Volume 1: IoTBDS,* INSTICC. SciTePress, 2018, pp. 105–113. ISBN: 978-989-758-296-7. DOI: 10.5220/0006688601050113.

[SC18] Mehrdad Salimitari and Mainak Chatterjee. "An Overview of Blockchain and Consensus Protocols for IoT Networks." In: *CoRR* abs/1809.05613 (2018). arXiv: 1809.05613. URL: http://arxiv.org/abs/1809.05613.