Graph property driven information exchange in distributed networks

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Pitch document

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This document is an information document for private investors. It gives a short overview about the project concept for which the grant seeker is looking for funding. If you are interested in supporting the grant seeker, please use the given email address for contact.

1. Project Description

Regarding mathematical models of distributed networks, their characteristics and their belonging algorithms, we can identify mainly three, math orientated, models:

1. Graph theory. Let $G = (V, E)$ be a graph with a finite set of vertices V and edges E between them. We identify vertices, also called nodes, with participants (clients and servers) of the network and edges with communication channels between them, which forms the individual topology of the system. Enhancements of this model by additional consideration of ports (PN model) and bandwidth restrictions (CONGEST model), give more realistic approaches [4].
2. Combinatorial Topology. An extending of graph theory to higher dimensional objects. It represents all possible executions of a distributed algorithm as well as the relations between them, as a single mathematical object, whose properties reflect the solvability of a problem and primary used to study failure-tolerant networks in the context of shared memory and message passing systems [3] [1].
3. Algebraic Structures. A non graph theory based characterisation of object-based distributed systems in terms of algebraic structures. Here, objects represent an abstraction for distinct types of entities, such as humans, accounts, software components or processing units. By the usage of a temporal logic language, they specify local object behaviours by local constraints. During in other models participants interact by asynchronous message communication (receiving, manipulation, sending), here, objects comply with synchronous, event based interaction [2].

Considering this models, we can derive several fundamentals for mathematical distributed network models which we want to put together to a new concept. We will use:

1. All characteristics of participants and network topology are describable by the same mathematical structure (everything is considered to be an 'object').
2. For this we introduce a totally new concept of enhanced graph theory, which we will call 'object based graphs'[2].
3. In this model we examine the design of protocols based on 'graph property changes' on object based dynamical (not static number of vertices and/or edges over time) graphs, instead of message based or event based communication, like it already exists. We call this 'property driven information exchange'.
4. Object based graphs combined with property driven information exchange furthermore seems to give possibilities for data compression, information exchange repectively with less bits as usually.

Benefits of the expected outcome of the proposed research:

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[2] Don't mistake this for 'object graphs' which are used for describing object oriented programming. Our concept doesn't have anything in common with them.

- A new mathematical way of describing distributed networks could give new insides relevant for algorithm development as well as for concepts of network protocols based on object based graph property changes.
- Property driven information exchange shows indications for different approaches regarding important questions for distributed networks like for load balancing and huge interruptions of the network by failures or cyber attacks.
- New data compression approaches are becoming more and more relevant considering technologies like high quality video streaming, blockchains and 5G

After our best knowledge, we couldn't find any hint that this kind of model has already be mentioned and investigated by somebody else, before.

2. Expected research output and publication

First project phase (Duration: 1 year):

- General constraints for objects within the property driven information exchange in distributed networks ($\Rightarrow$ one paper)
- Establishment of enhanced mathematical structures as successor of graphs and hypergraphs, New kind of graphs necessary for describing the mentioned information exchange (in following called 'object based graphs') (first papers already under progress) ($\Rightarrow$ one to three papers)
- Property states of object based dynamical graphs (regarding information exchange) ($\Rightarrow$ one to two papers)
- Data compression given by property driven information exchange on object based dynamical graphs ($\Rightarrow$ one to two papers)

Optional, interesting for further work:

- Connections of the established model to models of physics for general relativity, quantum information and quantum information theory (there seems to exist bridges to physics)

3. Finance

Funding required for:

- Living expenses
- Travel/Conferences
- Publication fees (Open Access)

For the specific amounts, please contact me.

4. Additonal Comments

- Currently, there is a first paper under progress, giving an overview about the basic concept with its main characteristics, to the time of writing this pitch document. I would be happy to give you a bullet point version on demand, if you are interested and need more information.
- Professional and academical references available on request.

References

[1] Armando Castañeda, Pierre Fraigniaud, Ami Paz, Sergio Rajsbaum, Matthieu Roy, and Corentin Travers, *A topological perspective on distributed network algorithms*, Theoretical Computer Science **849** (2021), 121–137.

[2] Carlos Henrique C Duarte, *Mathematical models of object-based distributed systems*, Formal Modeling: Actors, Open Systems, Biological Systems, Springer, 2011, pp. 57–73.

[3] Maurice Herlihy, Dmitry Kozlov, and Sergio Rajsbaum, *Distributed computing through combinatorial topology*, Newnes, 2013.

[4] Juho Hirvonen and Jukka Suomela, *Distributed algorithms 2020*, Aalto University, Finland, 2020, `https://jukkasuomela.fi/da2020/`, `https://jukkasuomela.fi/da2020/da2020.pdf`.