Toward implementation of 'self-owned car ecosystem'

Discussion document for NuNet ⇌ Nature2.0 session

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Below is the figure visually describing the three layers of the envisioned 'self-owned car ecosystem'[1] as could be implemented using SingularityNET, NuNet and OfferNet technology ecosystems. This conceptual image is used for providing further elaborations and ideas.

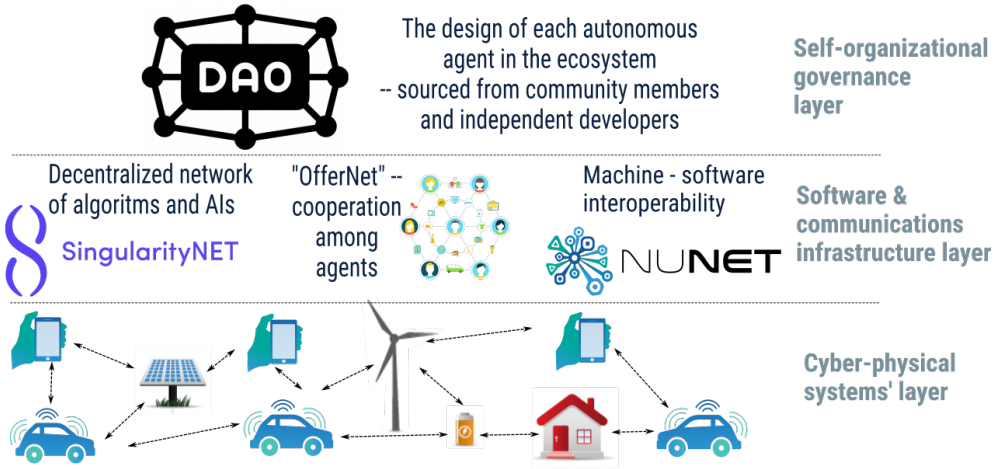

Figure 1: Three layers of 'self-owned car ecosystem' DAO using NuNet and SingularityNET technologies:
(1) *Cyber-physical system's layer* is composed of hardware agents with computing and communication capabilities enabling the ecosystem to be grounded in physical reality;
(2) *Software & communications infrastructure layer* implements computing, communication and algorithmic / AI logic;
(3) *Self-organizational governance layer* is where decentralized autonomous organizations self-organize and guide the ecosytem's behavior.

An important property of this architecture is that the three layers are fairly decoupled from each other, therefore components developed at, say top and middle layer, can be used for different cyber-phyiscal systems, as explained in more detail below.

[1]The idea has been formulated with close connection to blockchain and Bictoin, but I believe that the use of blockchain technology, while conceptually may be useful, is not the most important part of such ecosystem, therefore calling it 'self-owned cars on blockchain' is somewhat inaccurate. Therefore the concept is called 'self-owned cars' ecosystem' for the lack of a better name.

"Self-owned cars' ecosystem" use case

This use-case / idea (see video presentations [2] [3] [4]) considers the following:

1. A (decentralized) fleet of autonomous cars:
   - they are autonomous in the sense that they can drive themselves using self-driving technology (something in the spirit of Tesla Robotaxi),
   - however, they are also autonomous agents that are not legally controlled/owned by any other agent – so represent a type of truly autonomous robots (see EU recommendations on Civil Law Rules on Robotics for the first attempts to define legal status of autonomous robots);
   - the fleet is decentralized in the sense that there is no single central agency (like Uber/Lyft, etc.) that directs and controls its operations. Rather, the fleet self-organizes based on the bottom level coordination of autonomous agents;
   - the more futuristic version of the idea involves infrastructure where autonomous agents could self-maintain themselves;
2. Cars are electric, which implies their relation to energy distribution system:
   - cars observe the status of their batteries and autonomously charge themselves when needed;
   - they will necessarily need a charging infrastructure and ability to interface with it (technically as well as economically);
3. The integration with electricity distribution infrastructure is deeper than just charging batteries:
   - autonomous electric cars can become part of decentralized energy distribution and production infrastructure – Enernet – where they could 'drive energy around', exchange energy with houses, other cars and smart devices in the context of energy microgrids, etc.;
4. Last but not least, there are many extensions to the idea if implemented as general infrastructure of collaboration between autonomous robots. This comes from realization that the whole envisioned ecosystem consists of three layers which can be decoupled and combined in many different ways (see Figure 1).
   - self-owned/driving car ecosystem could perform additional functions, e.g. delivery services, wifi connectivity, monitoring of the neighborhoods, registering pollution levels, etc. (as implemented by different logic at the *self-organizational governance layer* of Figure 1);

[2] Jan-Peter Doomernik — Why are We Building and Connecting Self-Owned Machines on the Blockchain?; November 8, 2017
[3] Building the Unimaginable — Jan-Peter Doomernik — TEDxErasmusUniversityRotterdam; Jan 8, 2019
[4] Mike Hearn: Autonomous agents, self driving cars and Bitcoin; Turing Festival 2013

- the infrastructure could generally include any other type of autonomous robots, including unmanned areal vehicles, humanoids, etc. (as allowed by *software & communication infrastructure layer* of Figure 1).
- the same basic infrastructure could be used for implementing a *Matternet*[5], smart city solutions, general IoT systems, decentralized computing infrastructures, energy distribution networks, smart grids, microgrids, etc.

At the core, the ecosystem of self-owned cars transporting humans and energy as a part of critical infrastructure is a DAO – decentralized autonomous organization. These notions were ideated by many people and are well summarized in [6] – something that can be considered consider a conceptual reasons behind Ethereum blockchain as a world computer implementation.

NuNet platform

NuNet is building a global economy of decentralized computing, which is both a world computer and a computing resources' sharing ecosystem. Following the concept of radical decentralization, NuNet technically implements autonomy of each agent, resource and computing process in the global decentralized network, where no global state is automatically knowable to any actor or observer within the network. Note the difference from blockchain technology, which enforces global state of the system. NuNet platform will allow autonomous agents (computers, mobile phones, algorithms, AIs, data stores, IoT devices, self-driving cars, etc.) to (self)organize into fluid and ad-hoc workflows of arbitrarily many hierarchical levels. However, NuNet will not implement or restrict the functionality of algorithms, or nature and scale of workflows / DAOs that will emerge out of cooperation – but will be strictly limited to enabling resource sharing between autonomous agents in secure and efficient manner. In this sense, NuNet team will need assistance and cooperation with other teams for implementing or prototyping the cyber-physical system's layer of the 'self-owned cars' ecosystem'.

Since NuNet is a platform, conceived for interrelating different layers and ecosystems, any use-case should necessarily involve an interrelation with other technological layers – see NuNet's conceptual architecture in Figure 2 below and note similarities to the architecture of "self-owned cars' ecosystem" in Figure 1 above.

[5] *Matternet* is a distributed system of design, production and delivery of manufactured material goods (hardware in the broad sense) supported by DIY and Makers movements.
[6] Vitalik Buterin (May 6, 2014))*DAOs, DACs, DAs and More: An Incomplete Terminology Guide*

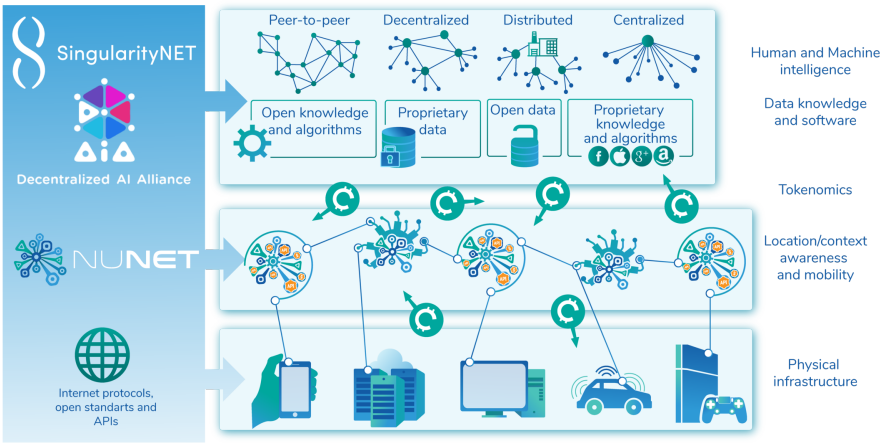

Figure 2: NuNet is a technical and business layer relating algorithms and data of different frameworks with the computing and storage resources of heterogeneous hardware devices.

In short, NuNet is an interoperability layer between software and hardware resources that could be owned or controlled by different agents – or "self-owned" for that matter. Therefore, an actual use case implementation involving operation of NuNet will also involve hardware resources (storage, computing, autonomous robots, etc.), computing frameworks (currently NuNet is implementing interoperability with SingularityNET) and computational logic (AI's, algorithms and actual data) – so will need to show integration between these. For the achievement of full functionality of NuNet, the conceptual and technical framework of alternative economy of resource sharing – OfferNet – would be necessary. OfferNet is a somewhat separate, but highly relevant research and development project.

NuNet team is building the platform in an iterative fashion, selecting progressively more complex use cases and advancing platform's functionality as required by them – e.g. see the first demo application. Self-driving cars use case is another application of the NuNet platform which requires considerably more advanced integration. The following section starts to detail how NuNet would approach collaboration around "self-owned cars' ecosystem" use-case introduced above.

NuNet platform for "self-owned cars' ecosystem" in the context of Nature2.0

Here is the preliminary list of functionalities needed for self-owned cars' ecosystem, the aspects that can be enabled by NuNet, as well as additional collaborations and integrations needed. Obviously, this list is not exhaustive and detailed enough, but

could be the basis to start thinking about hacking towards prototype / simulation.

1. **Cyber-physical systems' descriptions** In order to prototype a cyber-physical systems' network (ecosystem), first of all we have to define and describe what kind of cyber-physical systems will be part of it (e.g. self-driving cars, charging stations, energy sources (solar panels, wind turbines...), houses, electricity meters, standalone batteries...). The list is open-ended therefore the framework should enable any newly developed cyber-physical system to freely join the ecosystem. In the real world, the descriptions of the cyber-physical systems will be grounded in their physical implementation, but any realistic roadmap would necessarily have to include some sort of simulation framework for testing, where these systems will have to be abstractly described;

2. **Simulation framework** No-one will do actual system deployment on real cyber-physical systems and real world without first simulating everything, even if such cyber-physical systems existed. However, with fast development of autonomous driving solutions, a number of simulation frameworks, including open-source ones, are being available for hacking (e.g. Carla, MADRaS, Voyager Deepdrive). These, including solutions for digital twins, 3D mapping, etc. may be used for building a simulation environment. The Driving adoption of living labs challenge of 2020 Odyssey Hackathon / Momentum, which is "looking to provide a 3D virtual twin of the city (The Hague) and online participation methods as building blocks, as well as direct links with experts on self-sovereign identity and decentralized data exchanges" looks like an ideal partner here.

3. **Algorithms and AI guiding cyber-physical systems** Operation of every cyber-physical system is based on the diverse set of algorithms and AI engines driving their behavior. NuNet is a part of SingularityNET ecosystem and therefore first of all implements deployment of SingularityNET's daemons (while in the long term not limited to that). However, SingularityNET is an open ecosystem itself, where algorithms are provided by community members. Any more complex algorithms and engines beyond basic prototypes will have to be sourced from the community and cannot be expected to be fully provided by NuNet team. The best course of action with respect to this aspect is to find a suitable partner.

4. **Dynamic software modules' deployment to cyber-physical systems.** One of the main functionalities of NuNet Platform is the ability to deploy any AI or generic algorithm to any hardware (given, of course, that all of them are 'NuNet enabled'). NuNet team would prototype this aspect of the system;

5. **Access to cyber-physical system's hardware state and sharing information between systems.** NuNet Platform is envisioned to provide low level secure access of software algorithms to cyber-physical systems' hardware states (e.g. sensor information, battery levels, physical location, etc.) and, most importantly, share this information with other cyber-physical systems in the network in order to enable resource sharing collaboration between them. NuNet team will prototope / hack on this aspect.

6. **Resource sharing collaboration between cyber-physical systems** is the foundation of the 'self-owned car ecosystem' and its operation. The alternative economy of resource sharing is the subject of open-source OfferNet project within SingularityNET ecosystem, introduced above (also see project's documentation on its GitHub page). OfferNet implementation is envisioned to become an integral part of SingularityNET and NuNet ecosystem, but needs considerable research and development efforts, resource and time for achieving fruition (see the current list of OfferNet's open R&D problems / features to consider). In the context of "self-owned cars' ecosystem", OfferNet implementation will provide:

6.a) *The logic of inter-operation among AIs and algorithms running on different machines*;

6.b) *Searching and matching demands & offers (inputs & outputs) among cyber-physical systems*;

6.c) *Operation of ad-hoc sub-networks of cyber-physical systems as self-organizing service meshes grounded in physical reality*;

6.d) *Tokenomic/economic mechanism for enabling exchanges of value (i.e. resources) among cyber-physical systems.* Note, that strictly speaking, only this aspect of the system may need a blockchain related solution;

6.e) *Gateway / integration to the 'fiat' monetary systems of the current economic reality.*

7. **Self-sovereign identity** Every cyber-physical system, software container and AI algorithm operating within the ecosystem, will necessarily have to have a network identity. Most probably, a solution of self-sovereign identity, preferably in collaboration with the corresponding track of 2020 Odyssey Hackathon / Momentum, will be needed for that.

8. **Human-machine interface.** A realistic system, as well as realistic simulation, will have to include a human-machine interface at least for implementing Uber/Lyft mobile app functionality – for enabling humans to post their traveling requests which the system would solve. However, since the system will be decentralized, the human-machine interface should not be a single app, but rather an API that would allow any apps / reservation systems to interface with it.

Further discussion

The full scale of 'self-owning car ecosystem' wildly exceeds the scope of Odyssey Hackathon / Momentum 2020 or NuNet team's short term capabilities. However, it is a fascinating opening for conceiving and starting to build the backbone of the system for growing fur-

ther within Odyssey Open Innovation multiyear program and attracting collaborations from different stakeholders. Furthermore, the same system, at least its 'software and communications infrastructure layer' could be used in scenarios involving other critical infrastructures and stakeholders. As hopefully is clear by now, NuNet's long term strategy is geared towards creating such a general platform. It should be discussed, however, which components could be reasonably hacked upon during the 2020 Odyssey Hackathon / Momentum in order to bootstrap the initiative.