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TRUSTED IOT ALLIANCE – SMART E-MOBILITY CHALLENGE

February 2020

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EXECUTIVE SUMMARY

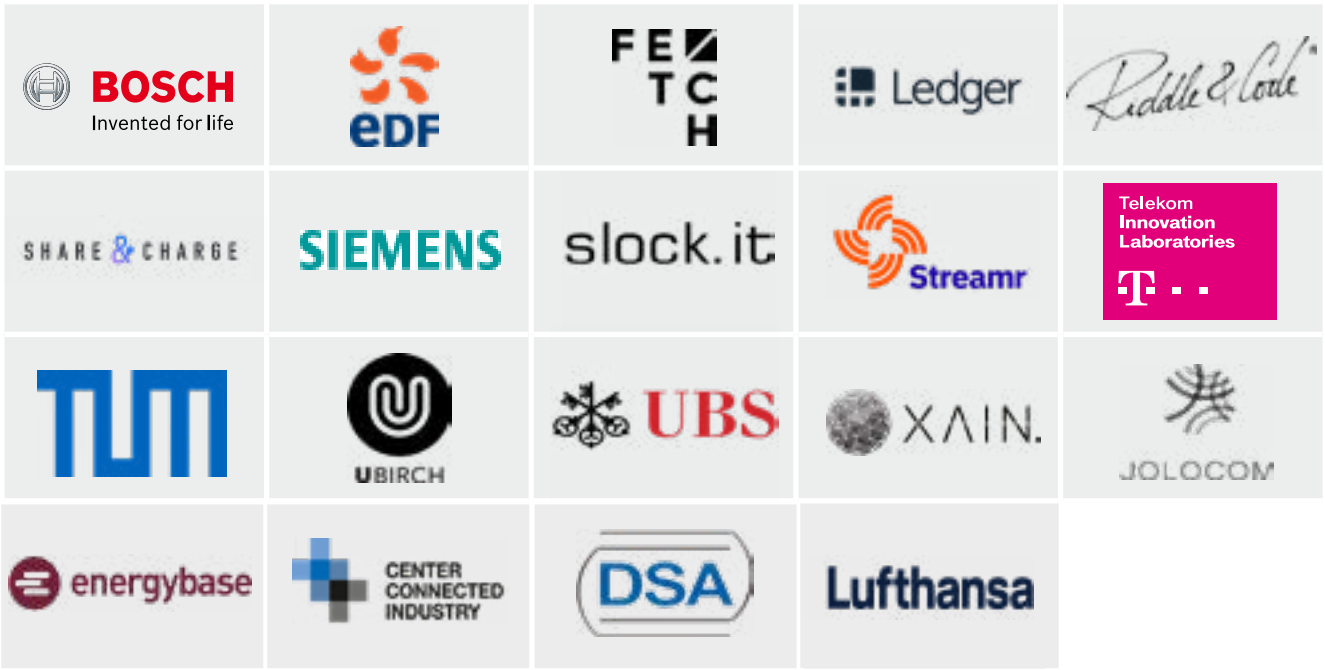
The Smart E-Mobility Challenge was a competition run by the Trusted IoT Alliance (TIoTA), the open-software consortium created in 2017 to support the creation of a secure, scalable, interoperable, and trusted Internet of Things (IoT) ecosystem. TIoTA's members are engaged with this ecosystem -- a group of companies involved with IoT devices, hardware, platforms, applications, and various services.

The E-Mobility Challenge was conceived to advance the development and commercial adoption of technologies in the e-mobility marketplace. The challenge leveraged the existing e-mobility ecosystem in Europe and the TIoTA Standard Framework as a basis for participants to design their solutions.

The primary electric vehicle (EV) selected for the challenge was a Jaguar I-PACE, provided by Bosch. Participants were invited to work on the I-PACE, but were allowed to submit challenge entries for any EV.

The highlight of the challenge was the PACE Tour. During the tour the Jaguar I-PACE travelled to numerous European cities including Barcelona, Stuttgart, Zurich, Munich, and finally ending the tour in Berlin for Bosch Connected World where the competition winners were announced. Competitors were given access to the Jaguar to work on their

FIGURE 1 2019 Smart E-Mobility Challenge Participants



solutions and conduct hackathons throughout the tour.

MachNation, a co-sponsor of the challenge, and a group of judges evaluated a total of ten challenge submissions from start-ups and solution providers. Figure 1 lists the challenge participants.

Based on the scoring of challenge submissions, judges awarded first place to the submission for My Easy Charge to a team made up of members from Fetch.AI, T-Labs, Share & Charge, and Bosch.

The second-place award for the Machine Witness use case went to participants from Streamr, Riddle&Code, and Bosch.

Finally, the third place for Decentralized Open Urban Mobility Ecosystem was awarded to a solution provided by participant members from T-Labs, Riddle&Code, and Jolocom.

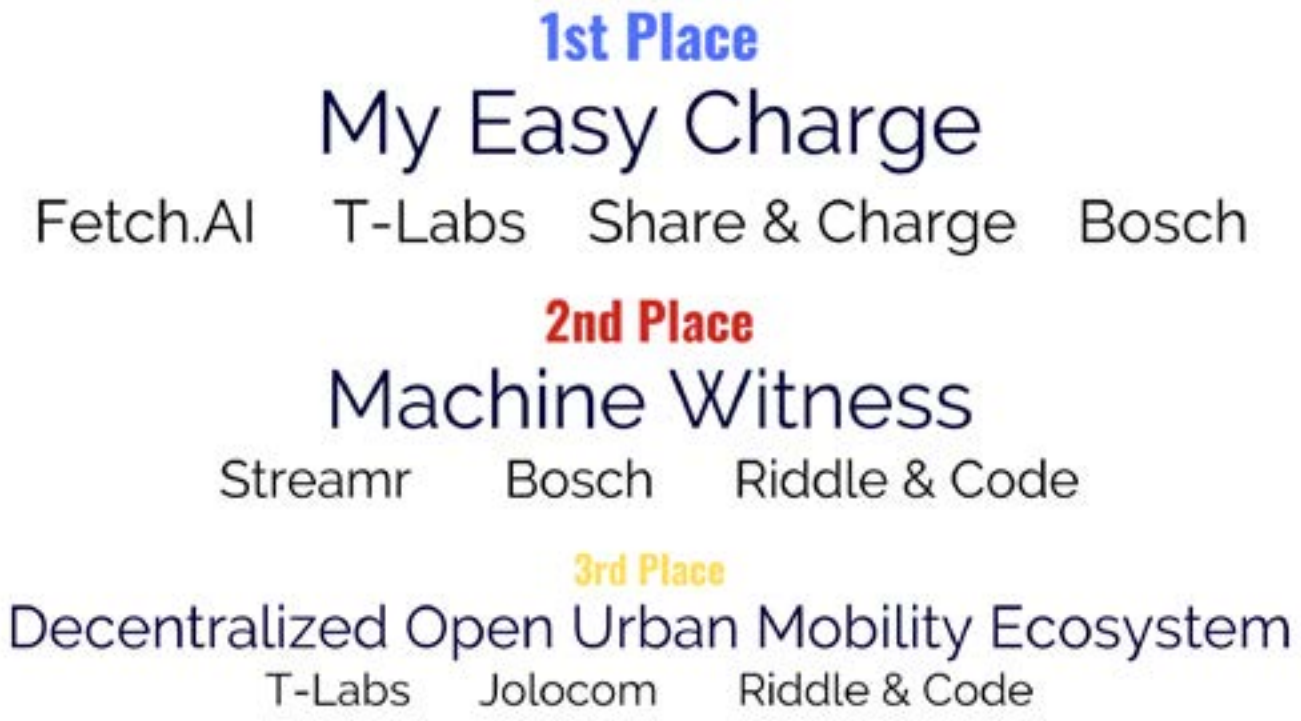
Recognition for collaboration were also awarded for two submissions - one for the Enabling Reliable Power Grid Optimization use case submission to a team comprised of members from Diagnotics Systems Applications (DSA), Center Connected Industry (CCI), EnergyBase, and UBirch, and the other for the submission on Autonomous Car Infrastructure Communication from Siemens and Bosch.

THE CHALLENGE: AN OVERVIEW

The challenge began in 1Q 2019, judging took place in 2Q 2019, and the winners were presented with their awards in May 2019, at Bosch Connected World in Berlin.

Overall, the challenge consisted of six key stakeholders:

1. Organizers. TIoTA was the primary organizer of the challenge. On January 3, 2020, TIoTA joined forces with the Industrial Internet



Consortium (IIC) and TIoTA challenges now fall under the IIC. MachNation, a global independent IoT research and testing firm is both an organizer and co-producer of the challenge. Organizers are responsible for the overall management of the challenge, including partner acquisition, marketing, and event coordination.

2. Principal. Bosch is the principal for the E-Mobility Challenge and in this capacity Bosch was responsible for defining Challenge submission requirements and technology parameters. Bosch awarded the Challenge winners the opportunity to build out their submission in a proof-of-concept (PoC) with Bosch's facilities and resources.

3. Technology Partners. Technology partners provide relevant technology components to assist start ups and solution providers in the creation of their PoCs if chosen for further development. Technology partners also provide overall technology guidance and support to the challenge stakeholders. Bosch, as a technology partner, furnished the Jaguar EV for the E-Mobility Challenge.

4. Advisory Committee. The advisory committee is comprised of representatives from the organizers, the principal, and other invited guests. The advisory committee collaboratively determines challenge test environments and use cases, secures technology partners for sponsorships, picks a research firm to write up challenge results and winning solutions, establishes challenge rules and guidelines, and determines the jury, evaluation criteria, and prizes.

5. Jury. The challenge jury is comprised of members from the six key stakeholders. The jury is responsible for evaluating submissions for the judging criteria, as well as issuing scores and awards.

6. Contestants. The contestants are comprised of start-ups and solution providers that submit their proposals, in accordance to technical and business model requirements, to the challenge jury. Proposals are evaluated against the challenge criteria and relevance to the technology partners' pre-selected use cases. If selected as challenge winners, start-ups and solution providers will have the opportunity to propose a PoC to the members of TIoTA and the challenge sponsors.

CHALLENGE USE-CASES

Participants were asked to develop technology solutions to address specific e-mobility use cases while leveraging the existing e-mobility ecosystem and the Trusted IoT Framework. Challenge participants were required to design and implement their software and hardware systems on an EV, the charger network, and in the cloud.

Technology partners identified 10 potential use cases to address challenges in the e-mobility marketplace:

1. **Smart Charging**. The smart charging use case addresses some of the major pain points for today's EV customers, namely, locating charging stations and paying for electricity. Consumers today require a variety of apps and RFID scanners to find EV charging station locations, prices, route planning, and more. An entry for the

smart charging use case will provide a solution that helps the EV discover charging stations, pay for electricity, discover additional services, and receive a single invoice.

> One of the major consumer attractions to EVs are the integration possibilities with existing smart-home technology.

2. **Crypto HW/SW**. Distributed ledger technology (DLT) is changing the way we conduct financial transactions over open networks. This use case addresses the software and hardware components that could connect an EV to a distributed network to negotiate prices and conduct financial transactions for charging or other services. For a more in-depth analysis on DLT and its uses in the broader IoT ecosystem, MachNation has published Distributed Ledger Technology: 7 Benefits for IoT Applications.

3. **Distributed Data Marketplace**. Data marketplaces connect buyers and sellers of data over a network of distributed ledgers, such as the exchange of cryptocurrencies over a blockchain network. This use case concerns the methods by which EVs would conduct machine-to-machine (M2M) transactions for goods and services, such as electricity at a charging station, as well as the sharing and selling anonymized data associated with EV changing.

4. **FOTA/SOTA.** The firmware over-the-air (FOTA)/software over-the-air (SOTA) use case concerns the connectivity protocols and methods by which the EV's internal software and firmware capabilities can be updated wirelessly.

5. **Ride-Sharing**. The ride-sharing use case concerns the potential applications for e-mobility technology in the ride-sharing economy. Examples of potential solution entries could focus around ride-hailing software for smart vehicles, hardware to facilitate easy transactions between service provider and customer, or even smart route planning and traffic detection technology to reduce stress on the traffic grid.

6. **Smart Home Integration**. One of the major consumer attractions to EVs are the integration possibilities within existing smart home technology. The smart home integration use case concerns the development of applications that connect the user's EV to the smart home ecosystem.

7. **Seamless IoT Access**. A seamless IoT access use case allows smart products to be easily and readily accessible from a central secure location. Possible applications for this use case could include developing applications that enable connected EV control or monitoring functionality from a home dashboard.

8. **Track & Trace**. Track and trace is defined as the process of monitoring past and current

location or status data of a connected asset. In the context of e-mobility, applications for this use case could be relevant in fleet management, ride-sharing, and consumer applications.

9. **Machine Witness**. Machine witness is a term to describe the multiple interconnected systems and sensors that gather and transmit data from a smart asset like an EV. A machine witness use case describes an ecosystem in which environmental and traffic data is collected and transmitted to a public database for applications. Applications like Waze have already begun to implement this method of crowd-sourced data for transportation; currently, however, data must be entered manually by users. A proposal for a machine witness solution will describe the architecture of the connected systems and databases that carry out this function independent of the operator.

10. **Secure, Attest, Authenticate**. One of the consistent challenges in the IoT space, let alone blockchain, is the lack of end to end security. A challenge submission for the secure, attest, authenticate use case will describe an architecture for embedded trust systems that enable verification in all stages of the transaction over the blockchain network, from silicon/sensor end-points to the cloud.

Challenge contestants were allowed to submit one or more proposals for these use cases, although most participants submitted only one proposal that fit within one or more use cases.

METHODOLOGY

Challenge participants submitted their proposals to TIoTA as a PowerPoint-style file. Participants were also allowed to submit supplementary materials including architecture diagrams and online videos to support their proposals.

The challenge participants were asked to submit proposals that met the following 7 guidelines. TIoTA provided these guidelines to help focus participants proposals and their technical submissions..

1. **Meeting customer requirements**. How is the proposal addressing the use cases and pain-points identified for this challenge?

2. **Shortening time-to-money**. How does the proposal, if built-out to production scale, lend itself to a rapid time-to-money (TTM)?

3. **Decentralization**. How does the proposal contribute to the technological design of a decentralized ecosystem by proposing and building common infrastructure operation (e.g., DLT, multiparty computation), software and hardware architectures, standards, reusable components, etc.?

4. **Multi-domains**. How does the proposal integrate disparate domains along the way? (e.g., lodging, food, commerce, energy, public sector, etc.)

5. **Industry engagement**. Over the last 12 months, how have the team and the team's members participated in industry-related

marketing and technology activities, including industry hackathons, challenge-related activities in Europe, and trade shows.

6. **Community contributions**. How has the team contributed to help building the TIoTA Challenge Community? How has the team contributed towards helping advance the TIoTA Reference Architecture?

7. **Coopetition**. How does the proposal support cooperation within an IoT and distributed ledger community that might be comprised of companies that traditionally compete?

CHARACTERISTICS OF A LEADING SMART E-MOBILITY CHALLENGE SUBMISSION

Challenge submissions were evaluated on 7 high-level criteria as the key characteristics of a leading solution for e-mobility. Below, we discuss these 7 in more detail.

- **Interoperability -** TIoTA was focused on developing innovations that enhance and progress established technologies, not create market disruption for the sake of disruption. Leading submissions for smart e-mobility focused on interoperability within existing ecosystems and being a viable multi-domain solution that has mechanisms in place for easy integrations.

- **Ease of Use -** Leading solutions leveraged standards in software and hardware components to create an easy-to-use solution that contributed to the larger framework of a trusted IoT ecosystem. System compatibility for the service provider and front-end productization for the end user were key attributes to consider in a leading solution.

- **Single Invoice -** There are a number of applications and disparate services that comprise the broader e-mobility marketplace. A leading proposal considered the billing aspects of their solution for the end user and endeavor to integrate these services on a unified billing platform. Services and products such as maintenance, location tracking, monitoring, and electricity should be available for payment on a single invoice.

- **Marketplace -** In consumer use cases, e-mobility solutions will intersect with many other industries throughout their lifecycle. Leading e-mobility proposals considered how the proposals fit within connected marketplaces such as lodging, food, and commerce. They also considered competition from other products within these markets and potential differentiators.

- **Participation -** Leading proposals were created with collaborative, multi-vendor architectures. In an effort to promote engagement with the broader IoT and e-mobility community a best-in-class solution helps advance the TIoTA Standard Framework through challenge event participation and cooperation.

- **Time-to-Money -** Leading proposals considered software/hardware technology standards, internal service provider expertise required for implementation, level of solution productization, and potential cost savings of the solution. All of these characteristics will lead to shorter time-to-money from solution design, testing, and development.

- **Importance -** For a proposal to be considered a leading solution for e-mobility it had to be innovative and progress the capabilities of the market. A leading solution differentiated itself from what is currently available by driving technology forward in a way that will be impactful to the ecosystem and ultimately deliver enhanced value to the market.

Judges met to discuss the proposals and the scoring. Overall scores for challenge submissions in each of the judging categories is illustrated in Figure 2. Detailed information on the challenge winners is located in the subsequent section.

FIGURE 2 Overall Scores for Challenge Submissions

TEAM NAME	TEAM COMPANIES	INTER-OPERABILITY	EASE OF USE	SINGLE INVOICE	MARKETPLACE	PARTICIPATION	TIME TO MONEY	IMPORTANCE
Machine Witness	Streamr, Bosch, Riddle&Code	◒	◒	◒	◒	●	◒	○
Data Sharing & Monetization	XAIN, Streamr	◒	◒	◒	◒	◒	●	◒
Trustworthy Odometer	T-Labs, G+D, UBirch	◒	◒	◒	◒	◒	●	●
Decentralized Open Urban Mobility Ecosystem	T-Labs, Riddle&Code, Jolocom	◒	●	◒	◒	●	◒	○
My Easy Charge	Fetch.AI	◒	◒	◒	●	●	●	●
Autonomous Car Infrastructure Communication	Siemens and Bosch	◒	●	●	◒	◒	◒	◒
Enabling Reliable Power Grid Optimization	DSA, CCI, EnergyBase, UBirch	◒	◒	◒	◒	◒	◒	◒
Enabling Trustworthy Damage Detection	Lufthansa, UBirch	-	-	-	-	-	●	●

Below Average ○ Average ◒ Above Average ●

Judges included representatives from Zublin, TÜV SÜD, Bosch, MachNation, TIoTA and Liebherr.

MY EASY CHARGE

Fetch.AI, T-Labs, Share & Charge, Bosch

Summary

The first-place proposal was submitted as a collaboration between Fetch.AI, Telekom Innovation Laboratories (T-Labs), Share & Charge, and Bosch. My Easy Charge is a solution that addresses interoperability gaps between the consumer's EV and service provider charging stations. The solution is comprised of three technology layers: the backend/cloud interface for the utility provider, a DLT middle-layer for negotiating and processing transactions between the end user and utility company, and the frontend components that run in the field. The proposal offers a solution that locates and selects a charge point based on individual user profiles, negotiates and processes the financial transaction via DLT, and automates the billing process.

Highlights

This proposal utilizes widely adopted, multi-domain, peer-to-peer (P2P) communication protocols that can scale with the growing market. The free-to-use Open Charge Point Interface protocol (OCPI) is a widely adopted communication standard for EV charge points and mobility service providers. By leveraging OCPI as the communication protocol for the P2P message broker between an EV and charging points, My Easy Charge is positioned as a rapidly deployable and scalable solution. In addition, this communication agnostic approach minimizes service provider lock-in for the consumer.

The Fetch.AI agent uses artificial intelligence-based algorithms to learn behaviors and provide user personalization. Agents running on a consumer's EV collect data on user actions to organize services and knowledge in the DLT layer. The algorithm enables cross-domain interoperability by establishing links that allow for a more productized and efficient experience. Furthermore, the capabilities of the AI will scale with the solution. This kind of functionality is comparable to the "Recommendation" section in services like Netflix that will deliver content based on past actions.

High levels of transaction automation reduce costs to mobility service providers. Transactions that occur on a DLT network are validated by other user nodes (i.e. P2P) to confirm the validity of the transaction. By operating in a shared P2P economy, as changes to the database are processed including financial transactions, each participant node on the network uses its own processing power to validate each request. With potentially hundreds or thousands of connected nodes contributing compute power to assist processing requests, this has significant

cost-saving implications for companies spending large money to maintain, update, and secure a centralized service.

Challenges

Personal data storage presents GDPR compliance issues in EU countries. The introduction of the Global Data Protection Regulations (GDPR) for European Union countries places strict guidelines around the consumer controls of personal information within public systems. The My Easy Charge solution architecture, particularly the Bosch hardware on which the location, financial, behavior, and other. data would be stored, will have to take great steps to stay in regulatory compliance. Compliance issues may also vary by country and will have to be closely monitored across borders and markets.

There are vulnerabilities inherent to DLT networks that have the potential to disrupt the distributed ecosystem. Distributed networks are architecturally more secure from outside disruptions due to the lack of a single point of network vulnerability. Responsibility is shared across nodes (users) with no one point of failure or compromise. However, in order to maintain a fair and sustainable market, My Easy Charge will need to ensure that a majority of nodes are not under the control of dominating forces in the decentralized economy. In a decentralized network the ability to control changes to the ledger is distributed evenly across its user base, yet, as is the case with all DLT networks, should a single actor, or actors gain control of the majority of available nodes the authority of the network is compromised. This is most commonly referred to as a "51% attack" and is a concern for all networks utilizing a distributed architecture.

Artificial intelligence for user personalization could affect agent policies in machine-to-machine (M2M) communication. Policies between machine agents determine the parameters and appropriate triggers for actions between devices. Normally, policies are set in the software and updated via SOTA/FOTA mechanisms. However, because My Easy Charge has also incorporated AI-based algorithms to personalize the user experience to learn common geographic locations, buying preferences, and activity trends, it has the potential to alter agent policies when negotiating transactions via the DLT, locating a preferred charging station, and more. Steps will need to be taken to ensure that the AI component of the solution does not alter fundamental device agent scripts without proper workflows. Doing so would increase risks of unwanted or unpredictable interactions between machines.

MACHINE WITNESS

Streamr, Bosch, Riddle & Code

Summary

The machine witness proposal by Streamr, Riddle & Code, and Bosch is a solution for utilizing EVs as a data source for aggregate data collection and reporting on real-time traffic conditions. This solution proposes a low-latency P2P network with consensus methods of data validation for collecting and transmitting information for use by road-side units, government agencies, commercial consumers, and more. Monetization is achieved through a crowdsourced eco-system of data providers and data consumers via a distributed network. Sensors connected via the Bosch Automated Linux Edge Node (ALEN) are pushed to Streamr hardware nodes and visualized in real-time on Streamr canvases. Riddle & Code developed specific hardware and software cryptosecurity solutions to meet the specifications of the challenge criteria and secure wallets on the blockchain network.

Highlights

Monetization incentives encourage users to participate. Through this method of crowdsourced data provisioning, users are able to utilize otherwise unused CPU power in their EV to collect and transmit data for use in the cloud platform. EVs at rest and during charging may act as a data collection point through data extraction to API connected gateways within range of the P2P network. This mutually beneficial relationship between data sellers and buyers promotes a self-sustaining marketplace for real-time intelligence.

A leading proposal for the machine witness usecase has the potential to improve public safety and industrial efficiencies. MachNation believes that the machine witness use case will become particularly relevant as the marketplace for autonomous vehicles continues to progress. This challenge submission's architecture provides a basis for increased public safety through: improved incident response times, condition reporting, advanced alerts, and more. Additionally, there are a number of industrial applications for road-side construction, traffic routing, and grid management.

Legacy vehicles can join the network by accessing the mobile application and installing Streamr hardware nodes. One of the major strengths of this machine witness proposal is the non-restrictive design. Due to the Android-available application and mobile Streamr hardware node, users with legacy vehicles are able to participate in the solution without using an EV. This enables easy adoption and rapid TTM for service providers interested in implementing this solution in existing markets.

Challenges

Data is unreliable without a sufficiently scaled deployment. Operating under the consensus validation model requires a majority of reporting nodes (i.e., EVs) to agree on the data being reported. However, without a sufficient volume of data collection, the data becomes statistically unreliable. This solution may face challenges in providing valid reporting without a sizeable adoption rate.

Malicious nodes may tamper with the overall integrity of the network. As with any distributed or centralized system, there are vulnerabilities to consider. Particular to this solution is the potential of falsified data corrupting or skewing the real-time data to the end users. To combat this, a device reputation system has been implemented to establish the trust of each reporting device. However, this too is not without its security flaws. The solution may face challenges addressing data integrity on the network without a robust security and reporting mechanism to identify false data.

Lack of existing mobile network infrastructure could limit connectivity between nodes and gateway data-collection points. This solution is highly dependent on the existence of an already established mobile network across a wide geographical range. P2P connections via cellular protocols are generally short-range, and require a mobile network to communicate. Weak connections will limit the ability for nodes to collect data from sensors or transmit to the gateway. This proposal may face challenges in implementing its solution in geographical areas with weak or low coverage.

DECENTRALIZED OPEN URBAN MOBILITY ECOSYSTEM

T-Labs, Jolocom, Riddle&Code

Summary

The Decentralized Open Urban Mobility Ecosystem, a collaborative proposal by Riddle & Code, Jolocom, and T-Labs, is a solution for enabling efficient operation and cryptographically secured payment methods for service providers in the ride-sharing economy. The Open Urban Mobility backend application is a reference architecture that provides a standard for mobility service providers that allows users to login with self-sovereign identities (SSI), locate services, and make secure payments via a blockchain.

Highlights

T-Labs Stax feeless blockchain micro-transactions enables new business models for the ride-sharing economy. Large-scale ride-sharing companies like Uber or Lyft generally require a minimum fee for services to remain profitable over conventional payment methods due to transaction fees. Blockchain technology enables the processing of micro-transactions with minimum to zero fees associated as transactions are processed on a P2P network. This method of transaction processing enables new short-distance ride-sharing businesses to operate profitably without driving up prices to compensate for fees.

The standard framework enables coopetition and development of a common ecosystem. The Decentralized Open Urban Mobility Ecosystem acts as a toolkit for competing companies to build upon one another and engage in constructive competition. The potential reduction in development costs and ROI may ultimately benefit the user experience.

Secure authentication is made possible through Jolocom and self-sovereign identities (SSI). User identities are protected via an open-source protocol that allows them to digitally interact anonymously. SSI authentication is becoming increasingly relevant within IoT and connected systems as a means to secure and manage personal data. This has particular implications within EU nations that fall under GDPR compliance restrictions.

Challenges

Lack of data governance and regulatory controls. It is unclear how the DLT-agnostic blockchain would adhere to data privacy regulations. While all data moving across blockchain networks is cryptographically secured, a ledger on a DLT network is immutable and persistent, with no clear data ownership. This solution may face regulatory challenges as DLTs transacting personal data are being collected on the T-Labs blockchain ecosystem.

The prevailing competitive culture in the ride-sharing marketplace does not encourage coopetition. While all participants in an open ecosystem have an opportunity to benefit from engaging in coopetition to advance their industry, this solution may face unwilling participants within current corporate cultures. As this solution was designed as a framework to which others could contribute, it is only a viable innovation with the proper support.

The solution has unclear monetization mechanisms. While easier access to a blockchain network and mobile application may provide value to service providers and ultimately consumers, it is unclear how this proposal is monetized by the solution providers. T-Labs Stax is often described as a "Blockchain as a Distributed Service". This might imply that T-Labs or a related service provider charges a subscription fee for deploying a DLT within the T-Labs ecosystem, however this is not explicitly stated in the proposal, nor would it necessarily receive market acceptance.

MachNation is the exclusively dedicated to testing and benchmarking Internet of Things (IoT) platforms, middleware, and services. MachNation owns and runs MachNation IoT Test Environment (MIT-E), the industry's only independent, hands-on, benchmarking lab for IoT platforms. MachNation testers, developers, and analysts provide guidance to industrial enterprises, the world's leading IT vendors, and communication service providers. MachNation participates in many of the world's most exclusive IoT events and contributes regularly to leading IoT and business press.

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