## Aigang

# Blockchain protocol for digital insurance

## Insurance for Internet-of-Things using DAO and smart contracts

**Release 0.2sha**

**Updates from Release 0.1 (2017 May):**

- **New sections: 6.** Investing in DAO Insurance and Token Model **7.** Peer to peer investment platform **8.** Device data tracking and claim process **9.** Aigang Protocol Showcase: Functional Battery Insurance for Smartphones **10.** Insurance Pricing simulation with Machine Learning
- **Updated sections: 12.** Roadmap

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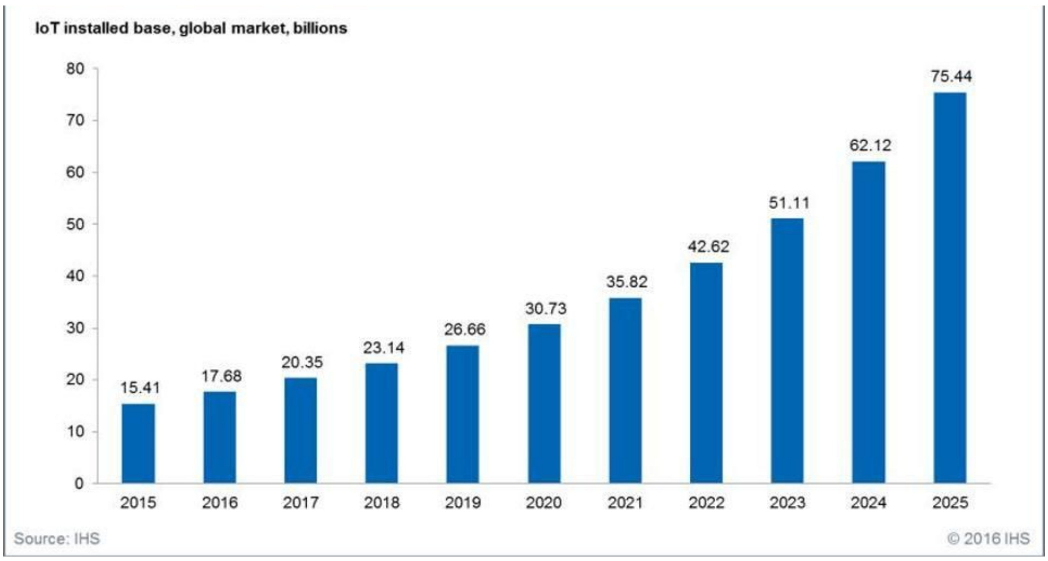
# 1. Executive summary

The blockchain is a decentralised database that maintains a continuously growing list of ordered records. The blockchain was first used in 2009 as the basis for the digital currency Bitcoin. Since then the technology has evolved drastically. Now it is one of the cutting-edge innovations even named the greatest revolution since the Internet. The main advantages of the blockchain technology underpinning its success are disintermediation (no central agent is required to approve transactions), immutability (all transactions cannot be altered or deleted), reliability (database is replicated on a large network of servers and does not have a central point of failure) and transparency (changes to public blockchains are publicly viewable by all parties).

The second generation of blockchain (referred to as "Blockchain 2.0") [1] provides a platform for smart contracts which embed software code that contains defined rules and can execute code based on those rules. This enables a formation of a Decentralised Autonomous Organisation (DAO) which functions without human employees. This greatly extends the potential applications beyond digital currencies especially in the financial industry. The blockchain has just scratched the surface of the global insurance industry transformation. As potential fields of application in insurance considered today are new methods for distribution and payment, increased effectiveness in pricing, claims handling and fraud detection, reinsurance, reducing administrative costs and new products and services for growth, such as the Internet of Things (IoT).

The IoT is a fast growing phenomenon which is projected to grow to 75 billion objects by 2025. This provides an emerging market for automated insurance as those devices could detect the broken part and initiate the claim themselves, e.g. smartphone after crash could detect not functioning microphone, drone could detect its broken accelerometer or Amazon Echo could detect broken glass in the office. This paper discusses the framework for incorporating insurance for IoT as a DAO powered by smart contracts in a blockchain. It discusses the main aspects of the insurance DAO smart contract, namely Policy, Pricing, Claims and Profit Distribution.

Figure 1. "The IoT market growth" [2]



The growing adoption of IoT products in developed and developing economies, value-added services for insurance industries, cost reduction of premium policies and automation are the main drivers for global IoT adoption in the industry. According to the report "IoT Insurance Market - Global Forecast to 2022" conducted by MarketsandMarkets, the global IoT insurance market is expected to be worth USD 42.76 Billion by 2022, growing at a CAGR of 65.89% between 2016 and 2022 [4]. The IoT will have a huge impact on various markets: e.g. automotive, transportation, agriculture, consumer electronics. Global positioning systems, in-built sensors and other detectors would increase the need for blockchain technologies in the insurance industry as those systems can gather valuable data, interpret it and perform needed actions autonomously. For instance, the growing usage of drones and Wi-Fi enabled devices in China, India and Japan [5] opens up new possibilities to insure the devices themselves and the environment they are in based on the gathered data.

# 2. Smart Policy

In standard wording, it is important to consider appropriate exclusions that would limit the coverage. The implementation of the Bitcoin, blockchain was the first ever solution to the double spending problem. In the same way the blockchain can ensure the uniqueness and validity of the insurance policies and provide the offer and acceptance property which is essential for a contract to be legally binding.

With Blockchain 2.0 further benefits arise if insurance operations such as underwriting and claims handling can be automated by the rules embedded in the smart contract. The blockchain could then be used to automatically sign new policies, evaluate provided data of damage, trigger the repair process and claim payment. In order to achieve that the insurance cover has to be standardised as much as possible.

The traditional insurance policy is the document which governs the relationship between the insured and the insurer. It sets out the rights and obligations of both parties and the rules for making transactions. Similarly, the Smart Policy would form the basis of the insurance DAO but by including software algorithms it would also automatically govern and perform its operations such as; issuing new policies, handling claims, distributing profits, etc.

Conventional insurance policy consists of two parts – standard wording and a schedule. Standard wording is the same for all policyholders and describes the cover provided as well as rules, rights and obligations of the parties. Of particular importance are the terms and conditions under which an insurer is liable to pay insurance claims and must be carefully worded to cover all possible circumstances under which payment will and will not be made. The cover is usually split into perils, some of which can be included by default others can be optional.

Sample perils for the IoT would be:

- Extended Warranty (replacement or repair of the device beyond the standard warranty period provided by the manufacturer).
- Product Liability (damage to the insured, insured’s property or third parties caused by

malfunction of the device).
- Damage by Third Parties (damage to the device, insured, insured's property or other parties caused by malicious actions of third parties such as hackers).

Provided and enable automated verification by software algorithms. Examples of situations where payment should be avoided include:
- Policyholder has an advantage by possessing more information about the likelihood of a claim
- Claim event is under the control of the policyholder
- Claim event would be difficult to verify
- Loss can be considered as depreciation

Without appropriate exclusions the probability of a claim being filed or inaccurate risk assessment would be very high. Exclusions can also be used when the risk is covered by a third party, such as the manufacturer who guarantees repair or replacement within the standard warranty period.

The second part of the policy form is the schedule, which may vary between policyholders. The schedule may include:

- Details of insured object
- Excess or deductible
- Sum insured
- Optional covers
- Premium and payment schedule

If wider cover is to be provided than can be handled by automated algorithms, part of the business could be reinsured. For example, the part to be ceded to the reinsurer could be determined by peril (e.g. retaining property damage claims and ceding liability) or by size, e.g. retaining smaller claims and ceding claims above retention limit.

In addition to standard wording and the schedule the Smart Policy would virtually include a third part consisting of the software algorithms executing all the operations of the insurance DAO.

# 3. Smart Pricing

Underwriting of an insurance contract normally consists of the following steps:

- Assessing whether the risk can be accepted
- Setting the conditions
- Setting the premium

In our case the first step should be straightforward since the insurance product can be bundled with the IoT device by default or acceptance can be verified by checking a list of required conditions and device data which can be performed with help of software within the device, machine learning algorithms (based on historical data) and smart contracts. If required, the blockchain could receive (using Oracle's) data from external data sources to retrieve needed extra information. The second point is also straightforward since policy terms and conditions should be standardised for all policies. So in this part we focus on premium calculation, which can be split into two parts – Risk Premium and Office Premium.

## 3.1. Risk Premium

The risk premium is the pure cost of claims, which is not known in advance and has to be estimated using mathematical techniques. At start up the risk premium will have to be based on assumptions or benchmarks available from reinsurers or the market. Once the blockchain is in operation data from its own claims experience can be used to determine the risk premium. The data can be represented as:

$$\boldsymbol{X} = \begin{pmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m1} & x_{m1} & \cdots & x_{mn} \end{pmatrix} \text{ and } \boldsymbol{Y} = \begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ \vdots \\ y_m \end{pmatrix} \quad (1)$$

***X*** is the matrix of predictors potentially to be used as rating factors. $\boldsymbol{x_{ij}}$ is the data element representing the value of j[th] characteristic of the i[th] policy. ***Y*** is the vector representing the dependent variable we wish to predict for pricing, e.g. number of claims or claim amount. $\boldsymbol{y_i}$ is the data element representing the value of the variable for the i[th] policy.

Evaluation methods for the risk premium range from simple approaches like average burning cost (claim amount per unit of exposure) to predictive modelling like GLM (Generalised Linear Model) which is widely used by general insurers. The aim of the model is to identify the factors which have the most impact on the amount of risk taken. It can be represented by the following equation:

$$\boldsymbol{Y} = \boldsymbol{g}^{-1}(\boldsymbol{X}\beta) = \boldsymbol{g}^{-1}(\beta_0 + \beta_1 \boldsymbol{x}_1 + \beta_2 \boldsymbol{x}_2 + \ldots + \beta_{\boldsymbol{n}} \boldsymbol{x_n}) \quad (2)$$

where ***Y*** is the dependent variable, **X*β*** is the linear predictor (a linear combination of unknown parameters ***β***) and ***g*** is the link function allowing for non-linear relationship. ***X*** and ***Y*** are the data matrixes from (1) and the model estimates the ***β*** coefficients which are then used to predict ***Y*** when pricing future policies. Machine learning techniques can be potentially employed to automate this process.

The model is deployed by expressing the Risk Premium as follows:

$$\boldsymbol{Risk\ Premium} = \boldsymbol{Base\ Premium} \times \beta_1 \times \beta_2 \times \ldots \times \beta_{\boldsymbol{n}} \quad (3)$$

where ***Base Premium*** is a constant and $\beta_1,\ \beta_2,\ \ldots,\ \beta_{\boldsymbol{n}}$ are coefficients looked up depending on factor values for a particular policy.

## 3.2. Office Premium

Office Premium includes Risk Premium and loadings for expenses. Calculation of the expense loading component is straightforward as it simply adds all the assumed expenses to be loaded on top of the risk premium. Final premium can then be calculated as follows:

$$\textbf{\textit{Office Premium}} = \frac{\textbf{\textit{Risk Premium}} + \sum_{i=1}^{n} M_i}{1 - \sum_{i=1}^{m} P_i} \quad (4)$$

Where $M_1, M_2, \ldots, M_n$ would be loadings expressed as fixed monetary amounts and $P_1, P_2, \ldots, P_m$ loadings expressed as percentages of Office Premium, such as:

- Reinsurance cost
- Claim handling costs
- Other administration costs
- Commission (if policy is sold through an intermediary)
- Cost of capital (to generate return to shareholders)

Another important component in price calculation is the measure of exposure, i.e. the unit of cover for which we are calculating the price. Assuming that usual duration of the policy would be one year and risk would be evenly distributed throughout the year, the price could be calculated for one year of cover. If in some cases a different cover period would be required the premium can be adjusted proportionally:

$$\textbf{\textit{Short Term Premium}} = \textbf{\textit{Annual Premium}} \times e$$

and $e = \frac{\textit{days of policy duration}}{365{,}25}$

$$(5)$$

In case of premature policy cancellation the premium for the remaining period can be calculated similarly and returned to the policyholder.

# 4. Smart Claims

There are several options for the basis on which policies can be written:

- Claims Occurring Basis (claim event date must be within policy duration period for the claim to be valid)
- Claims Made Basis (claim should be notified within policy duration period for the claim to

be valid)

In traditional insurance both options have their advantages and disadvantages and the basis is chosen depending on the cover provided. For example, in some insurance classes the claim event date may not be known or difficult to verify which makes a claims occurring basis hard to apply and a claims made basis can be more practical. In the case of the insurance DAO it should also depend on the cover provided but since claim event detection and notification will be automated the difference between the two approaches may be less relevant than in traditional insurance.

Usually a claim process consists of the following stages:

(1) **Claim Event**. Occurrence of the actual damage event. In traditional insurance the duty to detect the event lies on the insured person who may not be aware of the claim event yet and notices it only after some time, which creates delay. In the insurance DAO it would be possible to automate event detection, e.g. autonomous vehicle crash or device malfunction could be automatically detected and pushed to the blockchain network.

(2) **Notification**. Insured person notifies the insurance company of the claim event. Again the insured may not report the claim to the insurer at the same moment if he has a more important business to deal with or feels that the claim is too small and not important. In the insurance DAO notification would be instantaneous for the cases where the claim event is detected automatically. In some cases it may still rely on the policyholder but the following procedures should be triggered automatically in any case.

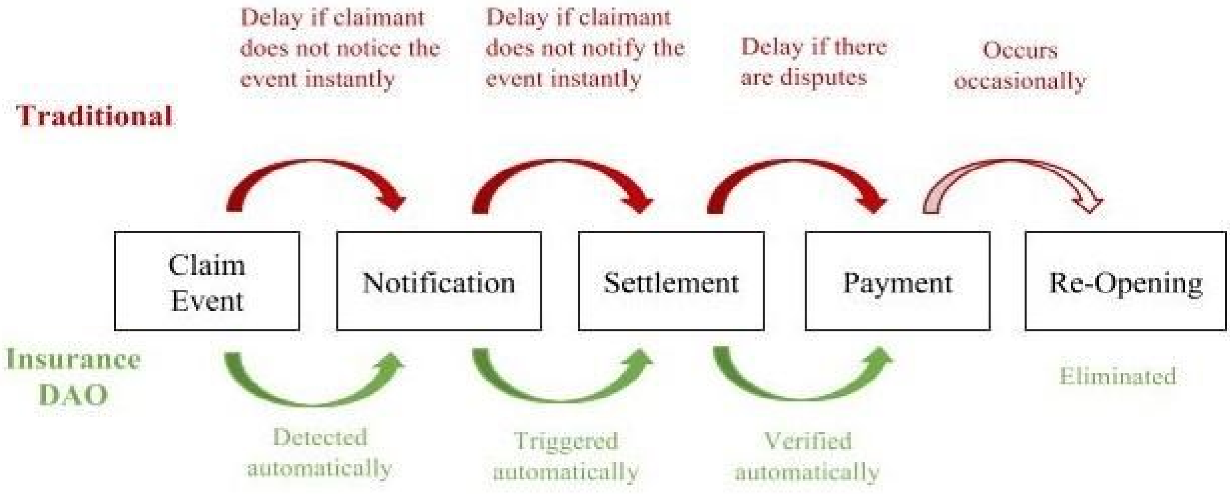
(3) **Settlement**. Verification of claim validity and details required to determine the claim amount. In traditional insurance this stage relies heavily on human factors. Various conditions can be interpreted subjectively and cause disputes which may lead to court. If the insurance cover can be standardised in such a way that claims can be validated automatically by the software within the IoT device and third party integrations, claims settlement can be fully objective and autonomous in the insurance DAO.

(4) **Payment**. In most cases this is the final stage of the claims process. It can be either actual payment or replacement of the damaged item. In an insurance DAO the software code can make the money transfer or trigger the repair process automatically.

(5) **Re-Opening**. Occurs occasionally if new information comes to light which requires adjustment of the settled claim. Re-opening of a claim inherently indicates a dispute or complexity of the claim so in the case of the insurance DAO the process should be optimised in such a way that reopening is not possible or such claims are ceded to a reinsurer.

Data sources could connect to the blockchain (using oracles) if required to verify claim validity or other details at any stage.

Figure 2. Traditional vs. DAO claim process.




In traditional insurance stages (1), (2) and (3) are prone to significant delays which can take from weeks to months or years. These delays create the need for the traditional insurance company to hold reserves (estimates for the claims that are not yet reported or fully settled) which involve complex calculations and create uncertainty in the company's financial result.

In the case of the insurance DAO the process should be simplified and automated so that occurrence of a claim event can be automatically identified triggering the subsequent processes handled automatically by software embedded in the smart contract. Ideally we should be able to jump to the payment phase instantly or if there are cases where the algorithm detects that the claim is more complex and cannot be handled instantly they could be ceded automatically to the reinsurer for further processing.

# 5. Profit Distribution

The simplified P&L for a smart contract DAO could be represented as follows:

| | |
|---|---|
| | Premiums Earned |
| - | Claims Paid |
| - | Reinsurance Costs |
| - | Expenses Paid |
| = | **Total Profit** |

Full insurance company P&L has two more parts – changes in claims reserves and investment income. Claim reserves arise due to delays in various stages of the claims process. As noted in the claims section this paper assumes that the claims process can be automated to such extent that reserves can be ignored.

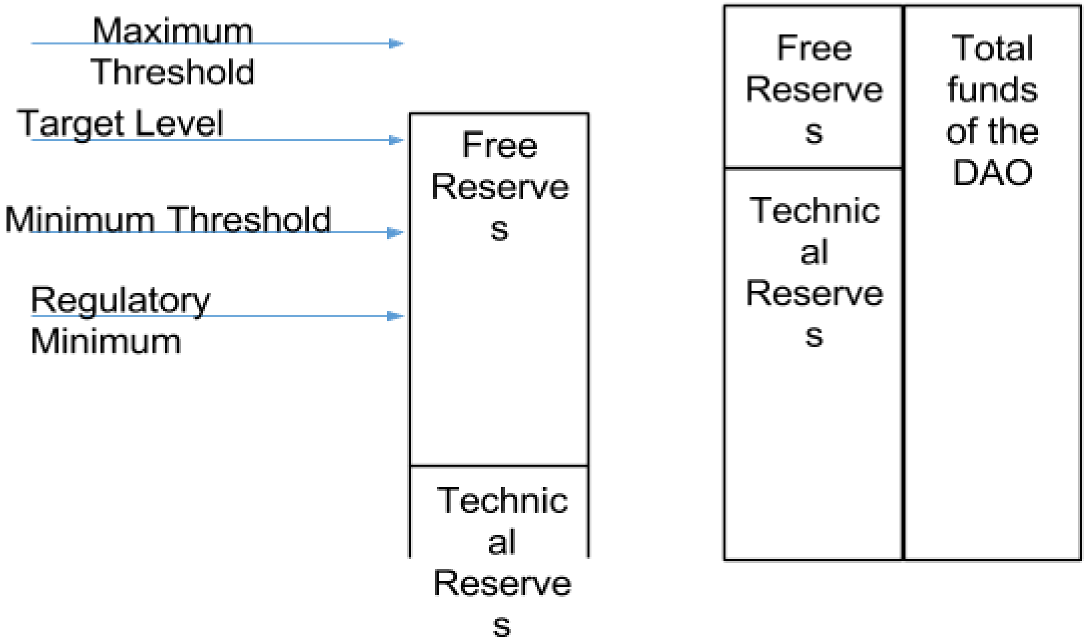
Investment income arises because insurance premiums are collected in advance and claims are paid out later thus creating a cashflow which can be invested to generate extra return. In such case the P&L should also include investment income which is added to the pure underwriting result above to get the total profit attributable to shareholders. In the case of the insurance DAO this may be seen as an unnecessary complication introducing additional risks related to investment and liquidity.

At any point in time the total funds available to the DAO can be divided into two parts:

> Technical Reserves – amount required to pay claims for unexpired policies and expenses. This represents the DAO's liabilities to policyholders and other parties.
>
> Free Reserves – amount above technical reserves which is used when technical reserves turn out to be insufficient. This is the shareholder capital.

P&L is calculated assuming some accounting period (e.g. a year) in which case the profit would be released from the technical reserves and transferred to the free reserves at the end of the period. In the case of the insurance DAO this would happen continuously. The blockchain would always know the capital position by continuously updating the values of the technical reserves and the free reserves.

To ensure solvency of the insurance DAO the free reserves must be maintained to be no less than a certain level, e.g. under the Solvency II regime in Europe the required level is such that the probability of default (when technical reserves plus free reserves are insufficient to meet the liabilities) would not be higher than 0.5%. Normally, companies hold free reserves well above the regulatory minimum, which is defined by a target level, e.g. 200% of the regulatory minimum.




Under normal circumstances the level of free reserves would fluctuate around the target level. This can be managed by setting the Minimum Threshold and Maximum Threshold levels.

If the free reserves decrease to breach the minimum threshold additional capital can be raised by issuing shareholder tokens through the investment platform. Alternatively the capital position can be improved by issuing debt capital. Also the system can be programmed to cease issuing new policies in such an event until the target capital level is restored.

If the free reserves breach the maximum threshold the excess capital can be distributed as dividends to shareholders bringing the free reserves down to target level, i.e.

$$\boldsymbol{Total\ Dividend} = \boldsymbol{Maximum\ Threshold} - \boldsymbol{Target\ Level} \tag{6}$$

The dividend would be distributed to the shareholders in proportion to their holding:

$$\pi_i = \frac{\textit{Shares held by investor } i}{\textit{Total shares}} \tag{7}$$

$$Total\ Dividend\ (TD) \times \boldsymbol{\pi} \rightarrow \begin{pmatrix} TD \times \pi_1 \\ TD \times \pi_2 \\ \vdots \\ TD \times \pi_n \end{pmatrix} \rightarrow \begin{pmatrix} d_1 \\ d_2 \\ \vdots \\ d_n \end{pmatrix} \tag{8}$$

The risk carried by the shareholders (the fluctuations in the level of free reserves) can be reduced through reinsurance arrangements.

# 6. Investing in DAO Insurance and Token Model

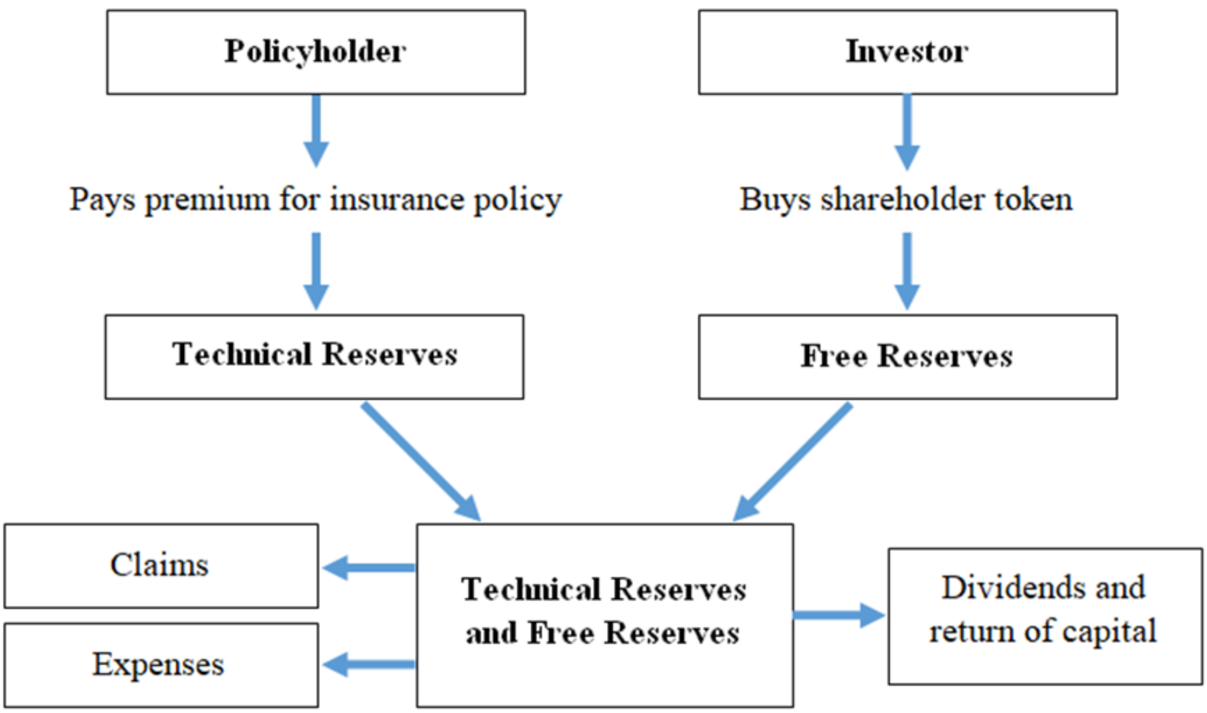
This section provides an explanation and simplified example how the proposed framework will work in practice as a peer to peer insurance platform with two profiles – policyholder and investor.

Insurance will be organised in separate pools. Each pool will represent an issue of some insurance product for a certain predefined amount of premium, e.g. $1,000,000 premium from phone battery insurance. Investors will be able to diversify their portfolio by investing in pools of different products with different risk levels and potential profit, e.g. phone battery, drone, smart car, etc.

Policyholders pay premiums and receive claims in case of damage but they carry no risk for the performance of the pool as a whole. As premiums broadly represent the cost of average expected outcome relying only on collected premiums would mean a 50% probability of loss.

Investors provide additional funds which are required in case experience is different than expected. They carry the risk and for that receive a return. The amount of funds required from investors is set such that the probability of loss is low, e.g. 0.5%.

Each pool will function according to the following scheme:




Let’s take for example a $1,000,000 pool for phone battery insurance (e.g. 100,000 policies $10 each).

If target level of free reserves is 20% of premium then investors need to provide $200,000. To gather these funds 200,000 shareholder tokens are issued through the investor platform with $1 nominal. When the funds are collected the pool can start to issue policies.

Every insurance product at a different time will represent separate pool. The issued token will represent the USD value of that pool, as insurance statistical models cannot be calculated and won't work with volatile currencies. Everytime new pool is created, investors are invited to send their investments directly to specialized smart contract and get tokens in return. Ownership of these various Aigang platform issued tokens represents your right to claim profits from the pool at the profit sharing period and claim invested amount after the whole pool insurance period ends.

Assuming for simplicity that all policies have a duration of one year and start at once. Also assume that after half a year free reserves reach a certain threshold which triggers release of free reserves above target level. In reality this calculation will be performed continuously and release of free reserves can happen at any time depending on portfolio performance.

Let's say that premiums were set according to the following assumptions:

80% loss ratio
18% expense ratio
2% cost of capital (targeting 10% return of $200,000 invested capital which gives 2% of $1,000,000 premium)
Actual claims and expenses turned out as expected

After half a year $500,000 of premium will be earned and remaining $500,000 held as technical reserves. Also half of claims and expenses will be paid. If 2% cost of capital was loaded in the premium and experience was as expected 10% return can be paid as dividends. Additionally only $500,000 of premium is remaining to be earned and only $100,000 capital is required to support this pool, so remaining $100,000 of capital can also be returned to investors resulting in $110.000 funds returned.

After one year all policies have expired and remaining free reserves are returned to shareholders.

| | | |
|---|---|---|
| **Invested amount** | **$200,000** | **$1 per share** |
| **Premiums paid by policyholders** | **$1,000,000** | |
| **Funds at outset** | **$1,200,000** | |
| Claims during half year | ($400,000) | |
| Expenses during half year | ($90,000) | |
| **Funds at half year** | **$710,000** | |
| ***Unearned premiums (Technical Reserve)*** | ***$500,000*** | |
| ***Free Reserve*** | ***$210,000*** | |
| ***Target Free Reserve*** | ***$100,000*** | |
| Funds returned to investors | ($110,000) | $0.55 per share |
| **Funds after distribution** | **$600,000** | |
| Claims during half year | ($400,000) | |
| Expenses during half year | ($90,000) | |
| **Funds at end of year** | **$110,000** | |
| Funds returned to investors | ($110,000) | $0.55 per share |
| Total funds returned to investors | $220,000 | $1.1 per share |
| Return | 10% | |

In reality not all policies will be issued at once, so the duration of the pool before all free reserves are released will be longer than one year.

A secondary market will be available for investors who wish to trade their tokens earlier. All insurance investors will have their tokens assigned to their wallet. As soon as all funds for the pool are collected, tokens become tradeable. Meaning that in case they need money earlier, or they do not want to take risk, they can sell their tokens to others investors directly on the price they agree. This enables people to invest in various insurance products reserves and not get stuck, but be able anytime to sell its tokens directly via blockchain without any intermediary.

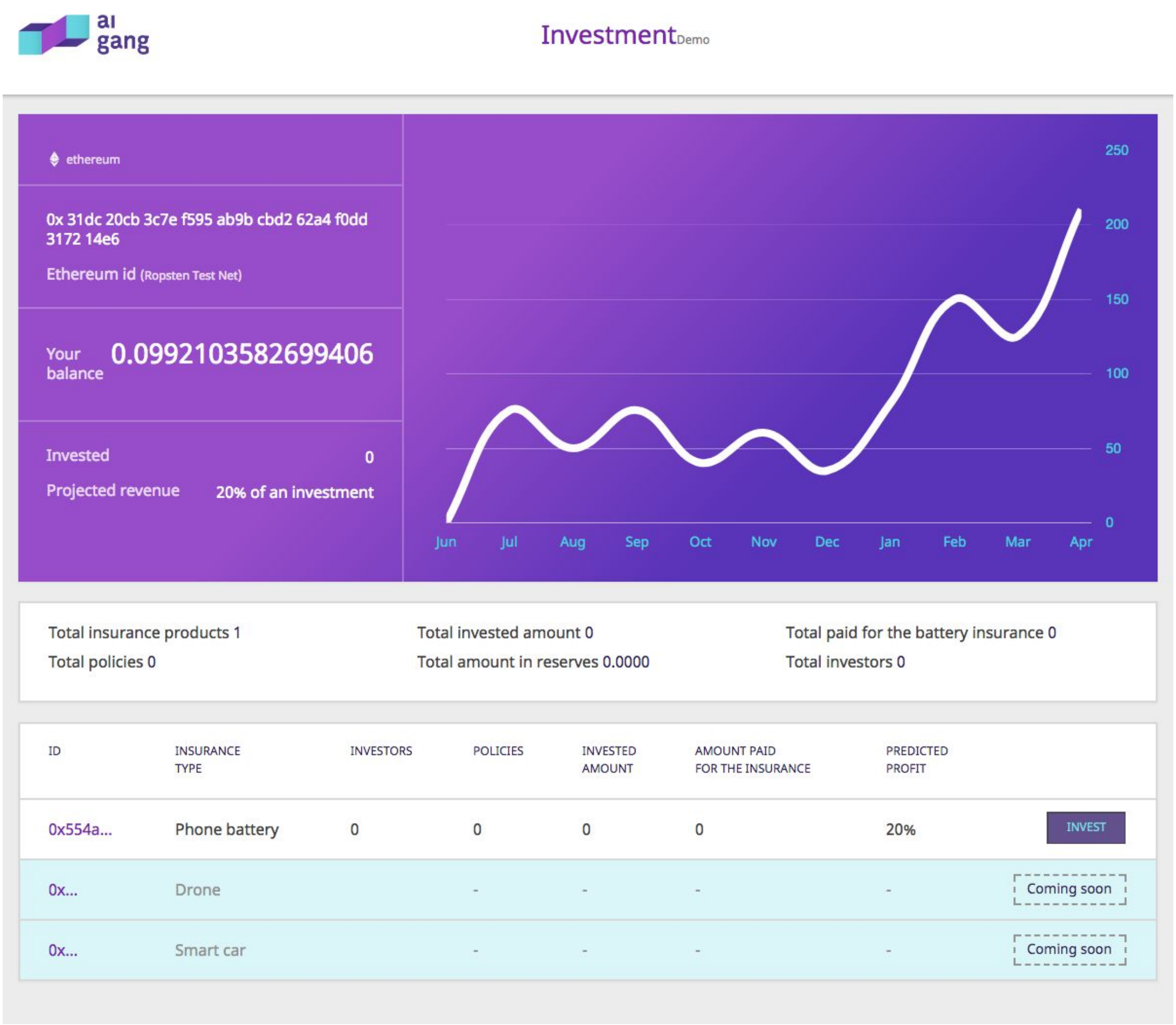
Combining the proposed peer to peer framework and the secondary market for investors creates a new asset class which was previously available only for large investors investing in traditional insurance companies. This can transform insurance in a similar way as peer to peer online platforms transformed the investments from retail investors into consumer and business loans.

# 7. Peer to peer investment platform

The peer to peer investment platform will be developed by Aigang team. The key targets for this platform is:

1. Perform calculation and build statistical models for needed reserves and risk assessment.
2. Tokenize the reserves.
3. List all insurance product pools with assessed risk, predicted profit, etc.
4. Enable investors purchase tokens for various insurance product pools.
5. Display whole investor profile: funds, projected profits, risk and the status of each pool.
6. Enable secondary market trading.
7. Collect and monitor premiums, process claims and payouts.

This platform will be the core of our protocol, as it will enable full peer to peer insurance vision. It will cover many complex insurance parts and will help us to automate the whole process. Early alpha can be accessed here - [http://insurer.aigang.network/insurer.html](http://insurer.aigang.network/insurer.html)



# 8. Device data tracking and claim process

Current insurance industry lacks accurate data about the devices they insure. Everything is based on trust of people and some general lookup of the damaged item. This leads to a huge frauds in the whole industry. Based on Insurance Information Institute calculations, property/casualty fraud amounted to about $34 billion each year. [3] And this amount is increasing as more and more expensive items are being insured. Here we saw a huge untapped potential to build a completely new insurance category for IoT devices based on the data they gather. The software will be built for devices or product makers API's will be used to retrieve data about the device state. The whole process could be divided into 3 parts:

1. Data collection and monitoring. We will constantly monitor IoT device health and its surroundings based on sensors in the device. The data will be pulled to our backend servers for storing and processing. This will enable our algorithms to have a historical view of the device and act accordingly on the actual data.
2. Event triggering. In case of an accident, device will automatically register the event or if that's not possible (limited by device software), policyholder will trigger the event manually.
3. Data validation. On the event, our system will pull the data from device and gather the state and sensor data at the time of the event and register the claim.

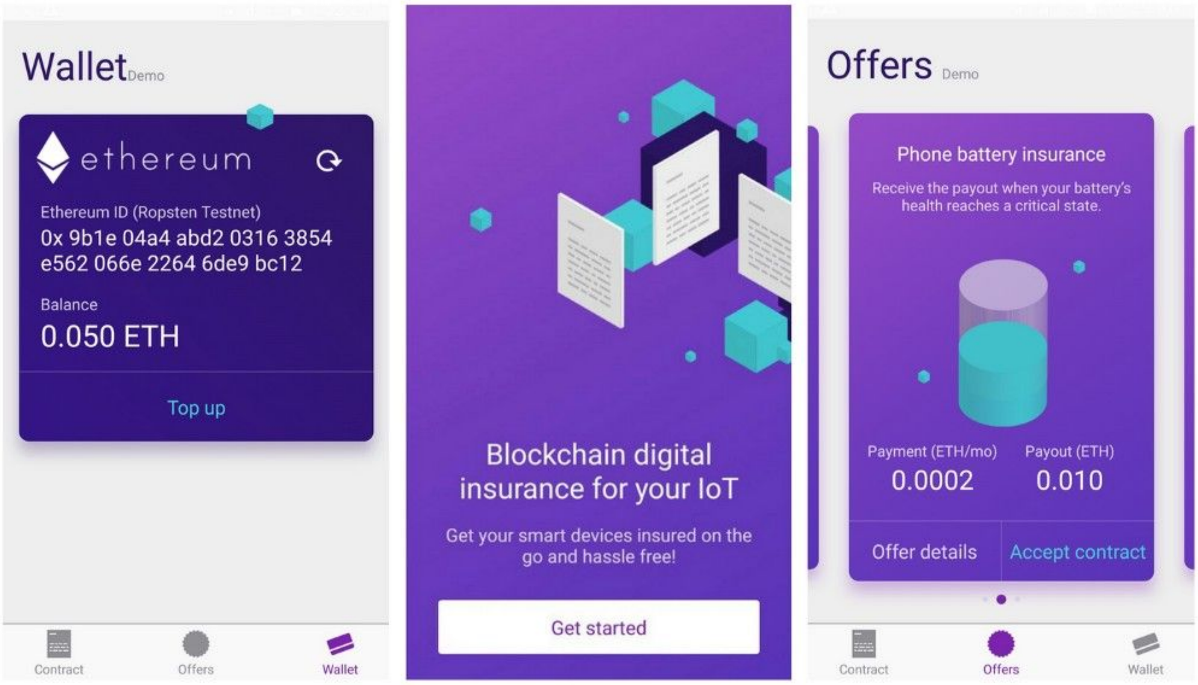
Using historical data, machine learning and the data at the time of the event, our algorithms will be able to detect the damage, calculate the payout and finalize the claim. We completely understand that there are possibilities for hacking, providing fake data and technical limitations in case devices are completely dead. Therefore, we believe, that our system will minimize the risk of frauds using historical data of the device which is hard to be tampered, and statistical models that will make insurance profitable for investors. In the beginning there will be a need to have a support team which would solve edge cases, monitor frauds till the protocol can be moved to fully autonomous insurance driven by AI and blockchain.

# 9. Aigang Protocol Showcase: Functional Battery Insurance for Smartphones

For a showcase of blockchain protocol for digital insurance, we selected the one of the most common IoT devices - smartphone. Nowadays, they offer a variety of built in sensors that could be accessed by a software. One of the most common technical issue, smartphone owners face, is battery malfunction. And manufacturers offering shorter warranty periods, force the owners to replace the their phone batteries. This lead Aigang to build its MVP (minimum viable product) and solve this issue by offering such insurance. Since it is possible to understand the state of the battery by accessing the smartphones sensors, the gradual degradation can be detected and risk could be assessed based on the real-time data. Once the battery reaches a critical stake (a certain threshold set) the payout is automatically processed and executed by smart contracts.

It is possible to fully automate such a process by storing it on blockchain using smart contracts and validate payouts. Judging the current state of the battery, Aigang assesses different risk levels with different payment plans. If the smartphone already requires a new battery - it does not allow to insure that device. This solidifies a process that can be fair to both parties - insurer and insuree. Currently, MVP functions on Ethereum Testnet and only accepts payments through Ropsten Testnet. However, it is planned to transfer to Ethereum Mainnet and allow the commercial use of such insurance.

This is how the Aigang MVP looks like to the end user.



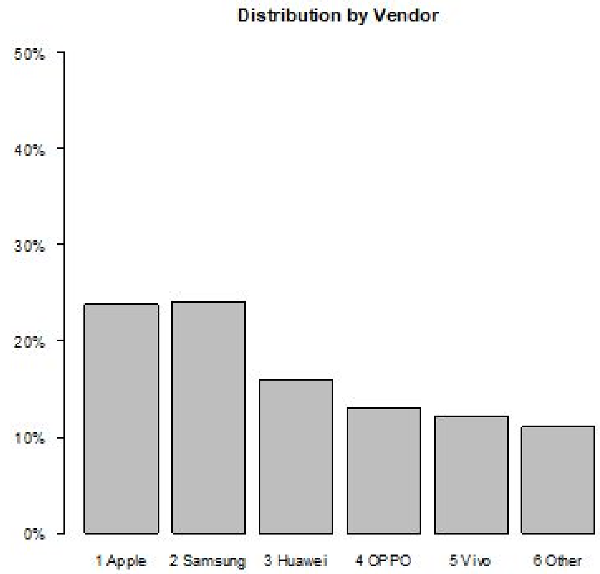

# 10. Insurance Pricing simulation with Machine Learning

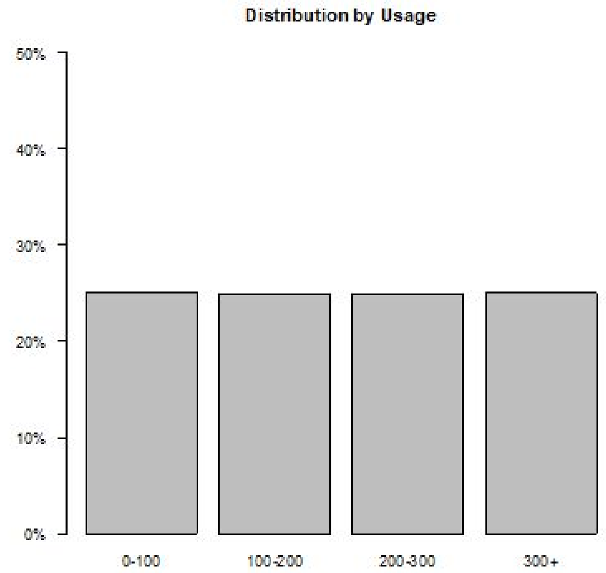
Together with other conditions that will be embedded in the smart contract to govern risk selection pricing will be key in ensuring the profitability of the portfolio and appropriate return to investors. It is important not only to set the appropriate average level of price, but also make sure that the pricing structure captures the significant risk factors of each individual policy. The risk of policies available to insure in the market will not be the same. There will be policies with higher and lower probabilities of claim.

The key function of pricing is to protect the portfolio from adverse changes in the mix of risk factors (the proportion of worse risks increasing). In other words this is called selection against the insurer or anti-selection. Anti-selection can obviously occur in a competitive market where one insurer with better pricing structure selects against the other insurer. But even being the only player in the market does not protect from anti-selection because it can also occur as selection not to insure at all. If offered price is the same for everyone it will appear too high for people with better risk and attractive for people with worse risk so the insurer ends up insuring only worse risks.

Machine learning techniques are used to capture the significant risk factors for pricing. To illustrate the concept for the purposes of this white paper we will use artificial data generated in R. For simplicity let's assume that there are only two risk factors – Vendor and Usage (again following the example of smartphone battery insurance). In reality machine learning deals with much higher number of risk factors which can also be related with each other through complex interactions.

Let's assume that the market of smartphone battery insurance policies potentially to be incepted is distributed as follows by Vendor and Usage:




Furthermore, let's assume that the risk differs as follows:

- Batteries of more established brands (Apple, Samsung, Huawei) are 20% less likely to fail than other brands.
- Compared to newer batteries (0-100 charge cycles), batteries charged 100-200, 200-300 and 300+ cycles are 10%, 20% and 30% more likely to fail respectively.

Please note that the numbers are only assumptions for the illustrative purpose of this white paper and may not be true in reality.

Artificial data exhibiting these features is generated by treating the above assumptions as GLM (Generalised Linear Model) coefficients and then reverse engineering the GLM. Machine learning seeks to identify risk factors by learning from the data and distinguishing significant patterns from the random noise. Applying this process from the other end we can produce artificial data exhibiting the above features, i.e. putting random noise on top of the pattern described above.

By applying the GLM coefficients each policy in the dataset is assigned an average claims frequency $\lambda_i$ which depends on Vendor and Usage as described above. Random number of claims $\boldsymbol{Y_i}$ is then generated for each policy:

$$Y_i \sim Pois(\lambda_i)$$

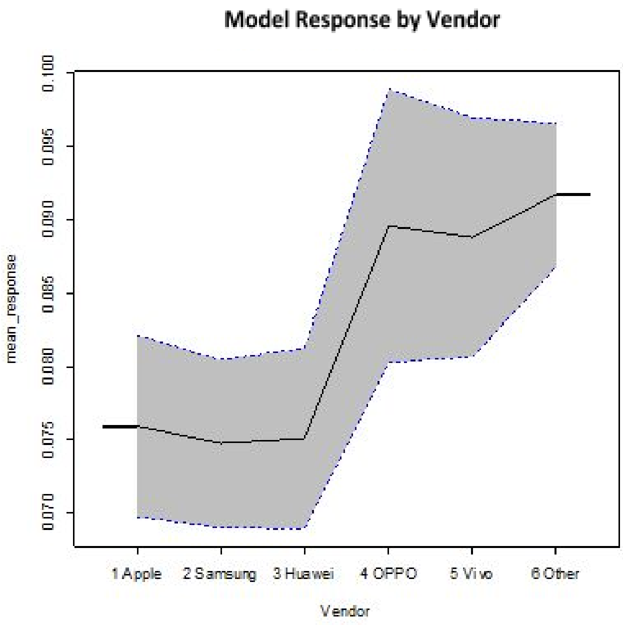
We can now apply machine learning on this data. In any function estimation problem we wish to find a regression function ***f(x)***, that minimizes the expectation of some loss function ***Ψ(y, f)***:

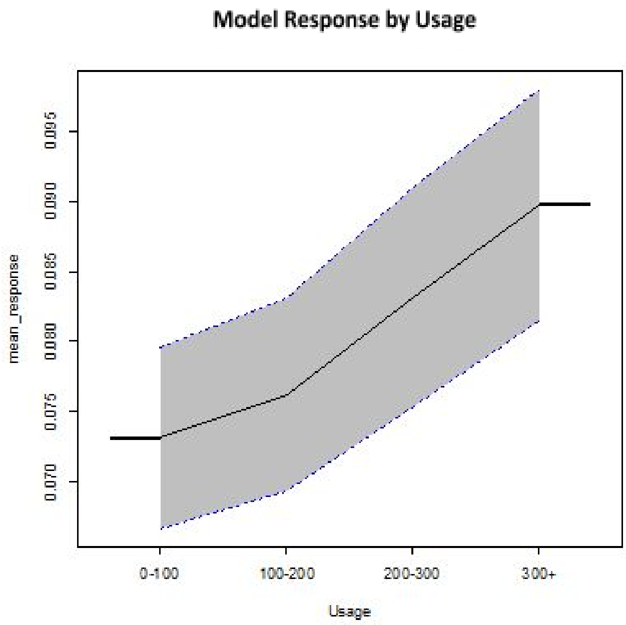
$$\hat{f}(x) = argmin_{f(x)} E_{y,x} \Psi(y, f(x))$$

There is a wide variety of machine learning algorithms developed to do that. GLM is just one of these algorithms which is widely used in general insurance pricing. For this example let's choose a different algorithm called GBM (Gradient Booster Machine) which is also used in modern pricing. The output of GBM algorithm from the H2O package widely used by machine learning community is presented below.

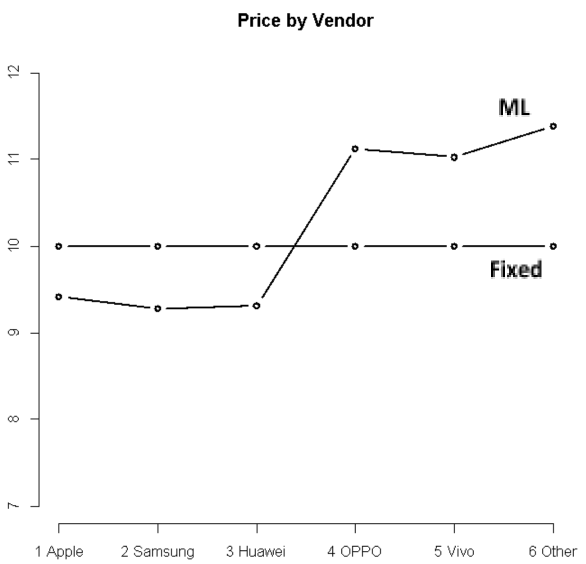
```
Model Details:
==============

H2ORegressionModel: gbm
Model Key:  GBM_model_R_1500798425455_7
Model Summary: 
   number_of_trees  number_of_internal_trees  model_size_in_bytes  min_depth  max_depth  mean_depth
min_leaves max_leaves
1               20                        20                 5626          2          5    4.00000
4          16
  mean_leaves
1    10.70000

H2ORegressionMetrics: gbm
** Reported on training data. **

MSE:  0.0803715
RMSE:  0.2834987
MAE:  0.1484591
RMSLE:  0.1921301
Mean Residual Deviance :  0.0803715

Scoring History: 
            timestamp   duration number_of_trees training_rmse training_mae training_deviance
1 2017-07-23 12:29:17  0.047 sec               0       0.28372      0.14866           0.08050
2 2017-07-23 12:29:17  0.140 sec               1       0.28368      0.14864           0.08047
3 2017-07-23 12:29:17  0.249 sec               2       0.28364      0.14862           0.08045
4 2017-07-23 12:29:17  0.343 sec               3       0.28362      0.14860           0.08044
5 2017-07-23 12:29:17  0.421 sec               4       0.28359      0.14858           0.08042

---
             timestamp   duration number_of_trees training_rmse training_mae training_deviance
16 2017-07-23 12:29:18  1.139 sec              15       0.28350      0.14848           0.08037
17 2017-07-23 12:29:18  1.201 sec              16       0.28350      0.14847           0.08037
18 2017-07-23 12:29:18  1.263 sec              17       0.28350      0.14847           0.08037
19 2017-07-23 12:29:18  1.310 sec              18       0.28350      0.14846           0.08037
20 2017-07-23 12:29:18  1.357 sec              19       0.28350      0.14846           0.08037
21 2017-07-23 12:29:18  1.419 sec              20       0.28350      0.14846           0.08037

Variable Importances: (Extract with `h2o.varimp`) 
=================================================

Variable Importances: 
  variable relative_importance scaled_importance percentage
1   Vendor           74.634300          1.000000   0.558408
2    Usage           59.021095          0.790804   0.441592
```

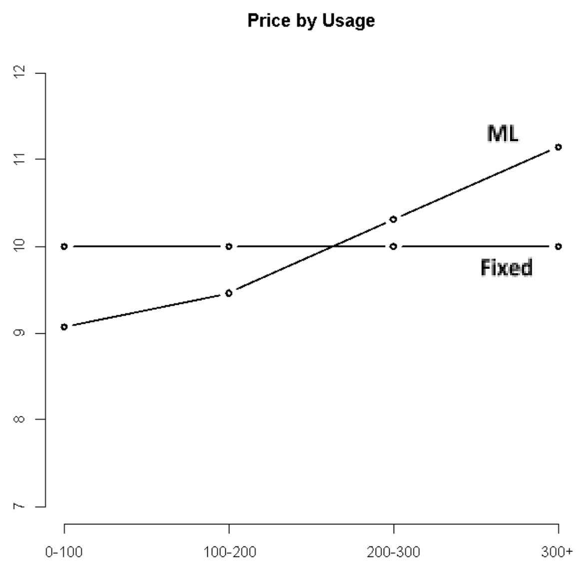
GBM is one of the most powerful machine learning algorithms which produces a prediction model in the form of an ensemble of weak prediction models, typically decision trees. In the following graphs we observe that it captured the risk features in our data as expected:



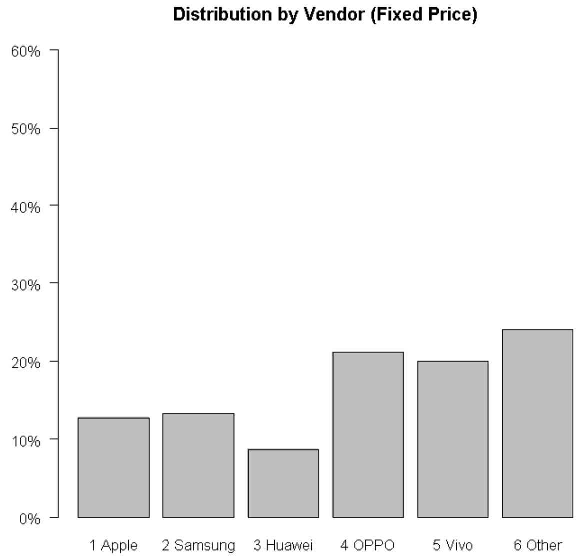



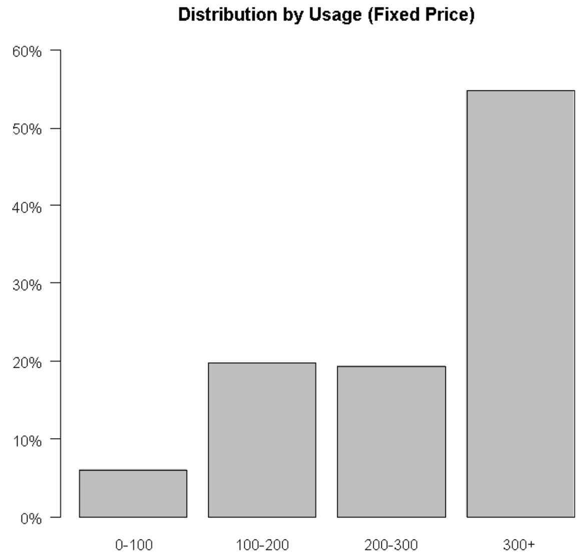

Let us now compare the performance of two competing portfolios – one offering the price derived from machine learning (ML) vs. fixed price for all policies.



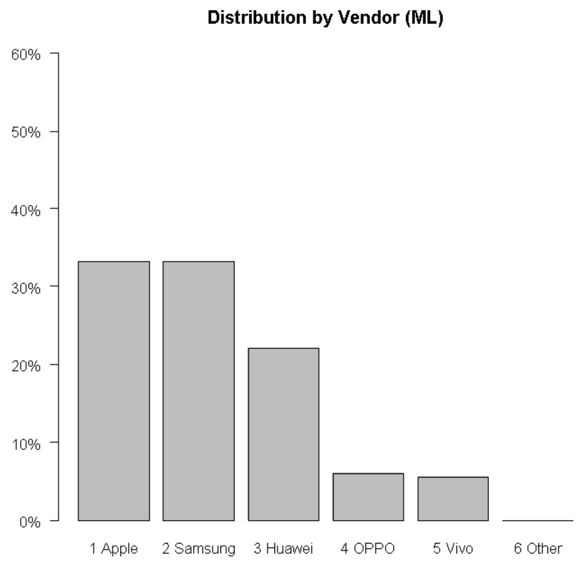



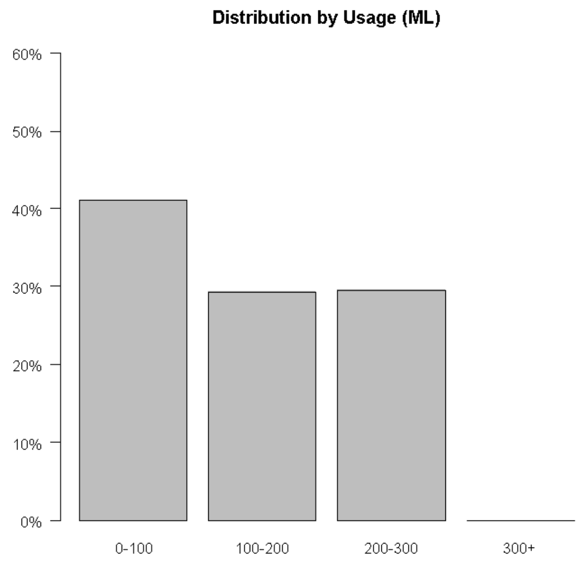

Assuming each policy is incepted by the portfolio offering lower price the portfolio attracted by fixed price would be as follows:




As expected the fixed price portfolio attracted a higher proportion of less established brands and more used batteries which are worse risks. On the opposite the ML portfolio attracted more policies of established bands and less used batteries:



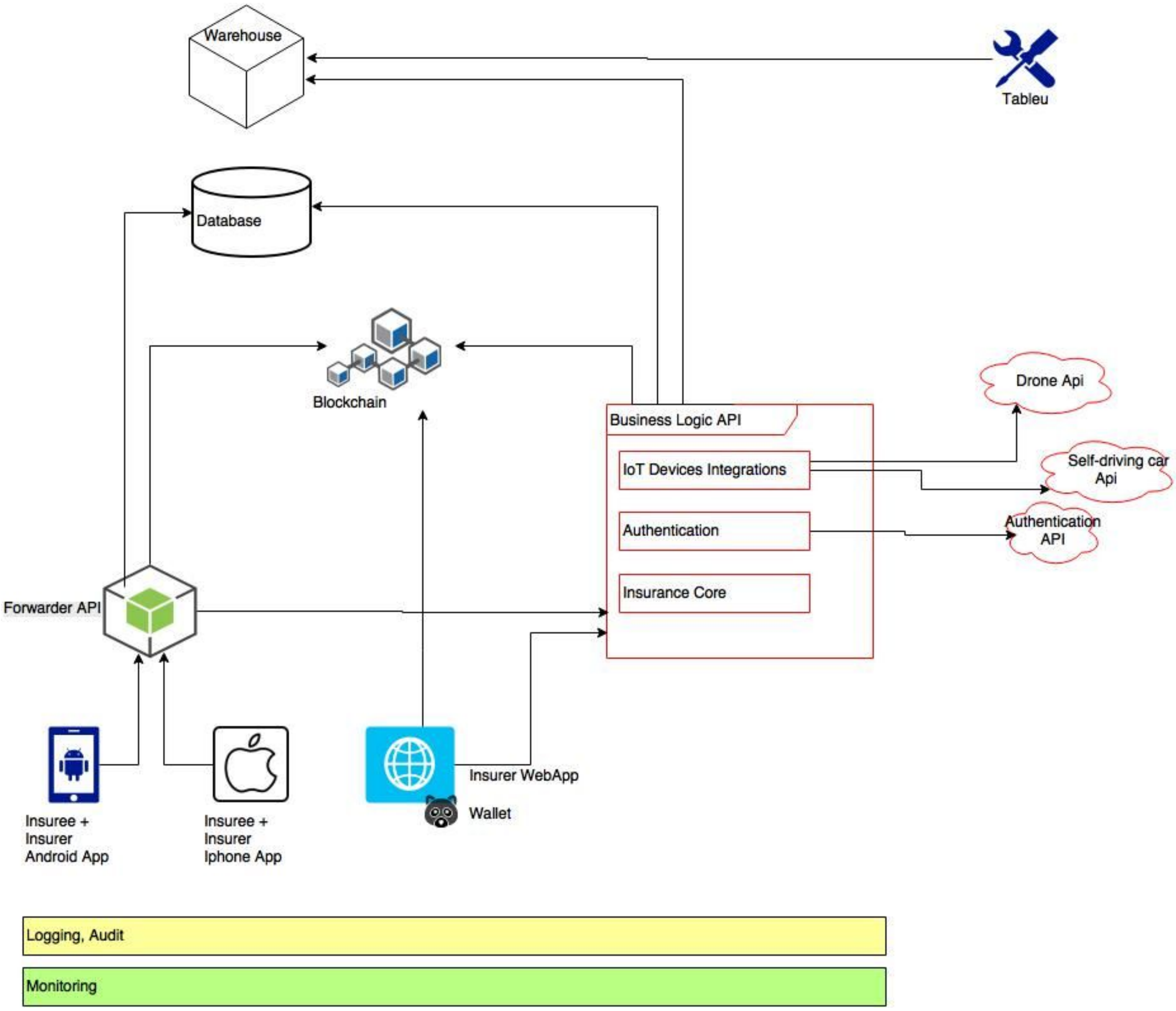

Simulated loss ratios were as follows:

Market portfolio: 80.6%
Fixed price portfolio: 90.6%
ML portfolio: 79.2%

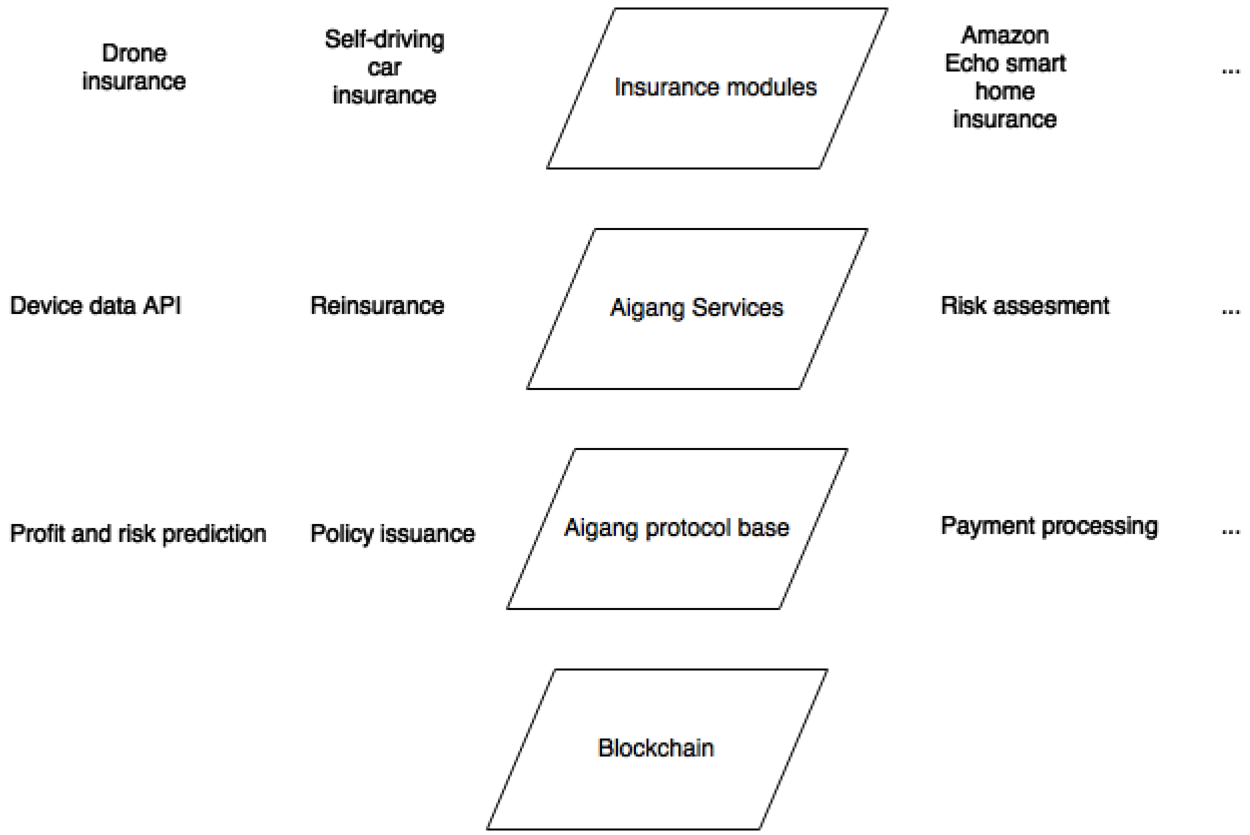
ML portfolio selects against the fixed price and attracts all the better than average risks thus experiencing 10 p.p. better loss ratio.

# 11. Architecture of the protocol

Based on our vision, we proposed architectural model of whole protocol and platform we aim to build. It contains many parts, and will require decent amount of time to build it. However, the main reason for that is ability to make fully autonomous insurance. The scheme below represents platform architecture.




The technical goal of our team is not to build all of the insurance products for various devices ourselves. We aim to build a protocol on a blockchain which would enable community, companies, developers build insurance modules themselves, using our infrastructure. That's how we see the future of blockchain insurance protocol. The scheme below represents layers of our system.




## 12. Roadmap

- **Phase 1**: MVP development v1.0. Ethereum blockchain smart contracts for policy issuing, risk assessment, claim processing. User interface for the insuree to manage all insured devices. Smart device tracking software use case development for issuing claims automatically. Blockchain environment: Ethereum Testnet. **Completed** (Demo apps can be downloaded from here - https://aigang.network/#section-downloadapp).
- **Phase 2**: MVP development v2.0. Ethereum blockchain smart contracts update for profit calculations, reserves formation and tokenization of it. User interface for the investor to manage portfolio of investments and invest into insurance product pools. Backend infrastructure for off-chain data collection and calculation. Blockchain environment: Ethereum Testnet. **In progress** (Early alpha can be accessed here - http://insurer.aigang.network/insurer.html).
- **Phase 3**: Beta version. Release for several developed insurance products. Opening beta version of the platform for investors and people to insure. Reinsurers integration. Blockchain environment: Ethereum Mainnet.
- **Phase 4**: Release v1.0. Stable and functioning software for several insurance products. Opening platform for module developers and introducing new insurance products. Blockchain environment: TBA.
- **Phase 5**: Release v2.0. Fully automated Insurance Protocol with insurance products

(modules) for people to insure and investors to fund.  Blockchain environment: TBA.

## 13. Leadership & Core Team

**Augustas Staras, Business development**
https://www.linkedin.com/in/augustasstaras/

Augustas has 10+ years experience in creating, growing & managing online and consumer businesses. He works in the emerging digital finance industry and has co-founded a peer-to-peer lending and investment platform with 15K+ users. He also works with blockchain projects, helping them achieve fundraising objectives.

**Lukas Kairys, Smart contract developer**
https://www.linkedin.com/in/lkairys/
https://github.com/LukasKairys

Lukas has experience as technical founder at startups, where he learned his ropes by working on software development and product management. He completed his Bachelor in Computer Sciences with a deep dive in the Ethereum blockchain, creating a prototype for an electronic voting system with smart contracts as a basis for voting.

**Aidas Ignatavicius, Chief Actuary**

Aidas has 10+ years experience working as an Actuary for a leading insurance company in Europe. His responsibilities include designing, validating and testing various pricing models for insurance products and policies. He has an MSc in Mathematics and spends his time to become a fully accredited actuary at the Institute and Faculty of Actuaries, UK.

**Reda Markeviciute, Insurance Product & Policy**
https://www.linkedin.com/in/redamarkeviciute/

Reda has more than 10 years experience in various finance, digital and marketplace businesses. She previously worked as a product manager and an actuary at SEB Life Insurance, one of the biggest insurance companies in Scandinavia and the Baltics. She has experience in product management, fundraising & business development. Also, an avid traveller!

**Jonas Matkevicius, Marketing Manager**
https://www.linkedin.com/in/jonasmatkevicius/

Jonas is a certified inbound marketer with a deep passion to process automation. Experienced in

SEO, content marketing & inbound leads generation. He has a BSc in International Business. He worked as a marketing manager in a sales consultancy startup. He has also cofounded a few startups and was chosen as one of the few to participate in EUXCEL 2015 startup scrum.

**Darius Devenas, Full Stack Developer**
https://www.linkedin.com/in/darius-devenas/

Darius has 8+ years experience in enterprise software solutions. He works as a Senior Software Engineer in Adform - reporting platform for media agencies, trading desks and advertisers. He builds reliable platforms for critical business processes. He is responsible for Aigang security.

**Mindaugas Jucius**
https://www.linkedin.com/in/mindaugas-jucius-915929bb/

Software developer with a huge passion to iOS architecture. Graduate in Computer Software Engineering. He helped to build application that has over 15 million users. Has experience working on grand scale projects and establishing Point of Sale systems.

**Naglis Zemaitis**
https://www.linkedin.com/in/naglis-%C5%BEemaitis-22826993/

Cofounder of mobile applications and design company. Built secure and intuitive Android applications for banks, massive festivals and other business projects. He also has a BSc in Computer Software Engineering.

# 14. Competitive landscape

- Friendsurance (friendsurance.com), Lemonade (lemonade.com), P2P protect (tongjubao.com/en), Trov (https://www.trov.com/) - Centralized insurance brokers, returning part of premium to policyholders who did not submit any claims. Acts as a third party broker or insurance company. No automation.
- Dynamisapp (dynamisapp.com), Teambrella (teambrella.com) - peer to peer based insurance solutions implemented on the blockchain. Requires policyholders to act as evaluators. Does not eliminate the human factor.
- Rainvow (rainvow.org) - automated solution to insure against various weather conditions implemented on the blockchain. Focused on a very narrow use case and acts as an insurance company itself.
- Etherisc (etherisc.com) - blockchain peer to peer insurance solution. Team focuses on insurance using external data (weather, flight delays, etc.) to validate claims and issue payouts. Aigang's vision is fully automated insurance for IoT devices using its sensors and software.
- Gnosis (gnosis.pm) - blockchain based prediction market. Plans to use prediction for insurance pricing calculation and claims processing. Gnosis could act as a module on our protocol to create new insurance products with its community and algorithms.