# Towards Smarter, Efficient and Trusted Insurance Marketplaces through Computable Contracts

## 1. Context

Many industries[1] and national governments[2] have started utilizing Distributed Ledger Technology (DLT) with significant investments. More specifically, DLTs have been prototyped in different use cases. These use cases include digital currencies[3], cross-border payments, syndicated lending, know your customer (KYC)[4], insurance marketplaces[5], voting platforms to secure votes[6, 7], Internet of Things applications[8], supply chain management[9], autonomous vehicles[10], and smart cities (including the various components therein, such as smart energy, smart transportation, and smart health care)[11].

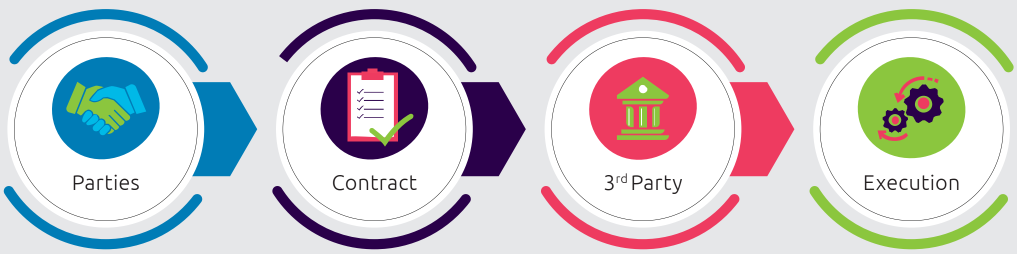
Furthermore, several industry giants are behind some of the on-going or proposed DLT deployments. IBM Food Trust[12] was tapped by Walmart to trace lettuce among other products. TradeLens[13] is a platform that has attracted four of the five prominent shipping lines, including Maersk, to share shipping data. In the financial industry, NASDAQ widely invested in DLT to reduce costs in shares management and created a partnership with Chain (http://chain.com) to develop a protocol for financial networks to store information on shares issued or exchanged[14].

DLT uses a digital signature mechanism to sign a message broadcast to the network and a ledger to keep the records immutable, which guarantees the integrity, authenticity, and reliability of transactions made. Bitcoin, the poster child of DLTs, was initially intended to transfer currency between two mutually distrusting parties. However, the bitcoin currency's popularity led to more features, which inspired the development of programs that govern the rules of transactions on the platform. Bitcoin features a scripting language that includes basic arithmetic, logical, and crypto operations (e.g., hashing and verification of digital signatures)[15]. More expressive logic needed for complex applications such as insurance policies has rarely been implemented and deployed in the Bitcoin ledger. However, many have recognized the potential for DLT to record transactions involving different types of information or even store and run programs beyond the Bitcoin transactions.

Computable Contracts, i.e., programs that self-execute based on predefined conditions without relying on a trusted authority, was first introduced by Nick Szabo in the pre-blockchain world in 1996[16] and popularized in the DLT ecosystem by Vitalik Buterin in Ethereum[17]. Applications in Ethereum are written in a programming language such as Solidity[18], which is far superior in terms of the features offered compared to Bitcoin's scripting language. Both users and contracts can store money (ether) and send/receive ether to other contracts or other users.

Computable contracts are executed via code, and cannot be easily tampered, unlike traditional paper contracts.  With the rise of DLT, computable contracts have found renewed prominence. We examine the applications of computable contracts in the insurance industry, current challenges, and the way forward for enterprises in integrating computable contracts to achieve greater transparency and higher process efficiencies.

## Traditional Contract




## Smart Contract

## 2. Will Computable Contracts Govern the Future of Insurance Marketplaces?

We survey and develop a point of view on applying computable contracts in the insurance space, where application of DLT has been investigated[19]. Computable contracts can be written to provide insurance on the occurrence of adverse events, which are digitally provable. Some other examples include automatically processing insurance claims according to agreed terms[20] and payments on delivery for postal companies[21]. Even though the insurance industry's adoption is yet to mature, several noteworthy insurance applications implemented on DLTs using computable contracts utilize the following themes:

1. Parametric, monitored by observable parameters,
2. Personal, for personal risk aided by monitoring devices,
3. Peer-to-peer insurance.

Some additional details and examples for each follow.

### Parametric Insurance

Parametric insurance compensates a policyholder with a predefined payment when agreed-upon parameters are met. The very nature of parametric insurance makes it the perfect-fit use case for computable contracts. For example, suppose the risk is correlated to parameters that are due to catastrophic natural events that could result in a loss or a series of losses. In that case, computable contracts can trigger payouts as and when the set thresholds are met. Other examples include insurance policy for flight delays- if a flight is delayed or canceled, the insured traveler will automatically obtain a refund. AXA insurance group rolled out their parametric insurance program called 'fizzy' which was a computable contract-based insurance scheme that triggered automatic payments in case of flight delays by more than 2 hours [22]. The computable contract in this case is connected to global air traffic databases. Among the different types of such insurance products offered by Etherisc (https://etherisc.com)[23], their insurance policy for flight delays is the most popular product. Other computable contract-based parametric insurance product offerings include the following:
(1) hurricane protection (payout if the winds in the insured's area exceed a certain pre-determined amount)[24], (2) crypto wallet insurance (protection against the risk of theft and attacks of hackers on wallets)[25], and (3) collateral protection for crypto-backed Loans (payout if the value of the collateral provided by the borrower drops by 90% or more)[26]. Furthermore, they have prototyped crop insurance (payouts triggered by drought or flood events reported by government agencies)[27] and social insurance[28].

## Personal Insurance

An on-demand insurance scenario is envisaged by utilizing a portable electronic device installed onboard, and a complimentary mobile app[20]. This solution augments traditional insurance practices to lower policy modification costs and reduce fraud. The electronic device records properties such as the GPS location, the number of passengers in the vehicle, and whether they are wearing seatbelts measured by sensors. The mobile application is used to take photos of the car for an insurance-claim worthy event, which are then checked by the insurance staff during the claims process to assess the vehicle's state before coverage activation. The Dynamis project (http://www.dynamisapp.com) provides peer-to-peer unemployment insurances ("social capital") based on a user's LinkedIn profile data. They aim to combine computable contracts and peers' social network to double-verify policy applicants' employment status. The computable contract automates the underwriting of policies and claims handling, combined with approvals and corroboration from other policyholders, who serve as voters or evaluators[29].

## Peer -to-peer Insurance

A group of people known to each other in the real world can get together to provide reimbursement to an insurance claim that is voted by peers. This idea was popularized in Teambrella (https://teambrella.com). Participants in Teambrella have a Bitcoin wallet, which is locked using multi-party-signature. The money can only be spent if both the insured team member and a pre-determined number of semi-randomly selected teammates sign for it. This process is facilitated through a round of voting after a reimbursement claim is made. After the initial voting round, the median of all votes is taken. The team's offer to the claimant is typically the median value decided by the team during the voting process. The claimant can then decide to either take the offer, leave it, or perhaps provide the team with more information and ask for a re-vote. Another peer-to-peer insurance idea is popularized by Lemonade (https://www.lemonade.com), which combines AI and DLT to offer insurance to renters and homeowners. The Lemonade protocol requires a fixed fee from each participant every month. It allocates the rest towards future claims and attempts to eliminate bias from submitting and paying claims by pooling customers by the charity they choose upon sign up. Unlike other applications that rely on a parametric occurrence like an extreme weather event to trigger, Lemonade relies on AI-based algorithms to establish claim legitimacy. The behavioral traits of customers not wanting to take money away from their chosen cause dissuades them from exaggerating the cause of loss[30].

### Decentralized Autonomous Organizations (DAO) for Insurance?

DLT could be used to build DAOs that support computable contracts for the implementation of peer-to-peer insurance. In these on-demand insurances, a hub communicating with different sensors could be used to dynamically activate coverage, detect damages, automatically ask for intervention/refunds. There are services such as 'insPeer' (https://www.f6s.com/inspeer) and 'Friendsurance' (https://www.friendsurance.com) that offer both B2C and B2B insurance policies in the traditional insurance markets. Without relying on an intermediary, such policies can be implemented using computable contracts and deployed on the ledger. Insurer groups can manage themselves by allowing the creation of DAOs using computable contracts, where the rules of operation are coded irrefutably and deployed on all the nodes in the network.

## 2.1. Potential Use Cases across Insurance Value Chain

Although the initial enthusiasm around DLT has waned due to slow adoption, the insurance industry will benefit from the thoughtful application of computable contracts across the value chain. Computable contracts can improve transparency, accelerate the claims process, prevent fraud, improve process efficiencies, and enhance the overall customer experience. Some of the potential industry application innovations are outlined below.


**Product: Usage-Based Insurance**

Computable contracts could boost pay-per-use insurance policies, relying on the IoT sensors for automatic underwriting. Travel insurance premiums could be collected if customers' GPS coordinates (collected by their smartphone) confirm they are abroad. Similarly, computable contracts can revitalize existing subscription models for car insurance premiums on the basis when customers drive--Pay As You Drive (PAYD) or how they drive--Pay How You Drive (PHYD). These innovations will create significant cost savings for the customers, making such insurance policies extremely attractive.

**Distribution: Insurance Marketplace**

DLT platforms can serve as trusted and secure marketplaces to improve the efficiency in the quotation process involving brokers and agents, especially for complex corporate risks. The current corporate risk quotation is inefficient due to the exchange of fragmented information involving many manual processes. With DLT platforms, a broker and an insurer can bilaterally negotiate the insurance of a commercial property. Customers can benefit from such DLT-enabled platforms to seamlessly compare different policies and interact with insurers and brokers on a need-to-know basis.

**Risk Management: Underwriting**

Computable contracts can improve the underwriting efficiency and transparency, resulting in accurate risk scores and premium calculations. Computable contracts can connect with external databases (oracles) to improve the accuracy in the underwriting process. In peer-to-peer insurance, computable contracts can automate the risk assessment process through the network based on voting.

**Claims: Automatic Settlement**

With computable contracts, the policyholder will not need to contact the insurer to notify a loss. Especially in the case of parametric insurance, where complex data from multiple sources might need to be verified, computable contracts can verify the incident through trusted and secure off-chain data sources or oracles. Further, computable contracts can automate verification and reconciliation. While providing increased transparency to customers, insurers can also ensure that claim payout happens only when pre-defined conditions are met.

**Customer Experience: Privacy and Trust**

One of the key advantages DLT can deliver is a trusted platform for data exchange. For health insurance, DLT and computable contracts could be the ideal way to share sensitive data with multiple stakeholders in an accountable manner. With an increase in data breaches and cyber-attacks, customers become increasingly skeptical about sharing personal data with insurers. With DLT, insurers can win the customer's trust and offer personalized products and services to improve customer experience.

### Detecting Fraud

One of the key challenges threatening the insurance industry is fraudulent claims. Applying computable contracts to insurance products can help insurers better manage risk and eliminate fraud. DLT can prevent, detect, and counter fraudulent claims. For example, a DLT-based insurance product can facilitate the recording of details of precious stones such as diamonds that allow insurers to reliably check previous claims that have been made on the stones. Furthermore, insurers can prevent 'crash for cash' auto insurance claims. These claims are when drivers deliberately stage an accident, where claims are made against multiple policies held by different insurers, which is difficult to detect unless data is shared cross-industry in the traditional insurance landscape.

### Micro-insurance in emerging markets

Micro-insurance schemes may not have been viable in certain situations because of human-intensive administrative processes and high fees for small payments. Due to the low handling costs of computable contracts, underwriting and claims handling can be automated based on defined rules and reliable data sources in micro-insurance schemes in emerging markets. Payouts to insured farmers can be triggered when verified oracles report drought conditions or any other persistently adverse conditions with weather data coupled with sensors.

### Reinsurance

Reinsurance involves data exchange between customers, agents/brokers, insurers, and reinsurers. DLT and computable contracts can modernize data transfer, reduce administrative efforts, and automate premium payments from insurers to reinsurers. Further, in cases where multiple reinsurers are involved, computable contracts can bring in transparency.

## 3. Solving the Computable Contracts Puzzle

The "blockchain" was seen as a panacea for a while[31]. But many experts have now claimed that DLT is overhyped[32] or applied to use cases that could be addressed with already-mastered technologies[33]. However, there is a glimmer of hope in the insurance space, wherein computable contracts and DLT-integration can yield significant benefits for both the business and the customer. Yet, few grey areas need to be addressed for adoption at scale. In this section, we look at the different parts of the computable contracts puzzle, solving which will aid insurers in their enterprise readiness for technology adoption.


### 3.1. Technology: Maturity and Readiness

**Platforms:** The fragmented nature of the DLT space is a significant hindrance to industry adoption. As of July 2020, on coindesk.com, there are twelve different distributed ledger platforms that one can deploy a computable contract on. These platforms in alphabetical order include Bitcoin, Codius, Counterparty, DAML, Dogeparty, Ethereum, Lisk, Monax, Rootstock, Symbiont, Stellar, and Tezos. The proliferation of such platforms is good for competitive innovation, but this makes implementers in various industries very nervous when deciding to pick the right platform. In the absence of proven benchmarks, insurers find it difficult to formulate a mechanism to assess these platforms.

**Transaction Speed:** "Blockchain fatigue" is settling in the industry primarily due to the sluggish speed at which the transactions are confirmed[31]. Adding information to the ledger is slow due to the consensus process required to commit transactions to the ledger. According to http://etherscan.io/chart/blocktime, Ethereum requires 15 seconds to create a block of information, a smaller though still significant amount of time. While DLT platforms have moved ahead from 'proof-of-work' to 'proof-of-stake' and other forms, like 'proof-of-authority' and 'delegated proof-of-stake,' there is still wide skepticism around DLT viability for large-scale applications. However, in the insurance space, a little delay is acceptable as the transparent and auditable nature of the transaction is more beneficial than the transaction speed.

**Bugs:** While applying DLTs can be extremely beneficial for technological innovation, the consequences of unsafe computable contracts can be catastrophic. Once the computable contracts are deployed, it is like launching a rocket ship; computable contracts cannot be easily modified after deployment, and even to do so provisions have to be made at the time of deployment. Because the code is publicly available and computable contracts become autonomous entities once they are created and deployed on the ledger, they could be exploited by nefarious individuals. Apart from intentional malicious attacks, computable contracts can be riddled with many bugs as developing the computable contracts is a human endeavor. To remove any code bugs and recover from code exploits, developers must create new computable contracts and transfer all data and pointers from the old to the new ones, as witnessed by the unfortunate hacking of the Decentralized Autonomous Organization (DAO) contract[34] (where an attacker managed to pull $60M from a crowd-funding platform). To mitigate such risks and other vulnerabilities[35], business leaders must anticipate hacks and be prepared to handle them swiftly.

**Rensselaer Scales**

To protect decentralized applications from unforeseen situations due to the bugs and exploits that are only evident at a later point, the Rensselaer-led research effort on "Smart Contracts Augmented with LEarning and Semantics (SCALES)" (https://idea.rpi.edu/research/projects/scales) has several thrusts on smart contract bugs. The project aims to characterize unforeseen issues in computable contracts before they are deployed, detect any problems while the contract is on the ledger, and finally, if there are any issues, dynamically devise methods to fix or augment the contract without any expensive re-deployments. In particular, the application of the human-in-the-loop voting mechanism to strengthen computable contracts seems to be a promising direction[36] in non-mission-critical applications where the speed of the transactions is not a significant factor for the effectiveness of the system. The SCALES research work can be applied to the insurance space to predict, detect, and fix bugs in computable contracts without expensive re-deployments.

## 3.2. Use Case: Compelling Business Case and ROI

Even if the technology may be ready, there may not be enough business traction or customer enthusiasm, as evidenced by AXA dropping its DLT-based flight insurance product 'fizzy' due to low adoption[37]. Computable contracts are not a solution to all the world's problems. Insurers need to decide which use cases make business sense to pursue. Computable contract-based solutions are most-suited for transactions where multiple parties are involved, and the conditions can be pre-defined.

Another exciting aspect is how computable contracts can complement other technologies such as IoT to create new business models and value propositions. The insurance industry has already witnessed an IoT wave with data-driven models taking center stage for personalized services across different lines of businesses. IoT applications can be seen in personal, health, life, and commercial insurance models[38], and computable contracts can be deployed to offer insurance through these connected devices.

New technology adoption will significantly depend on cost alignment to business models and revenue streams that flow into ROI. While cloud services like Blockchain-as-a-Service (BaaS) have lowered the entry barrier to build computable contract based DLT networks, there still needs to be considerations around commercialization and maintenance costs. Insurers need to carefully assess potential use cases on associated costs and benefits before implementing them at scale.

## 3.3. Culture: Talent and Skillsets

A significant hindrance to DLT adoption is the workforce's lack of skills to implement the technology[31]. Further, culture of the insurance business could be an impediment to new technology adoption like DLT. Being a traditional business, only lately has insurance embarked on the digital journey and will require cognizant efforts to make the most of advancements in DLT. Gartner expects that "through 2021, 90% of the enterprise blockchain implementations will require replacement within 18 months to remain competitive and secure, and to avoid obsolescence"[39]. Therefore, the workspace must be ready to learn new technologies and swiftly adapt to any disruptive changes, and the failure to do so would be detrimental to the company. For example, FidentiaX (https://www.fidentiax.com) was purported to be the world's first marketplace for tradeable insurance policies, where users could buy, sell, or store their insurance policies on the company's blockchain. However, according to a Harvard Business Case Study, the company is yet to provide the insurance product to its customers, partly due to a tardy development team[40].

As DLT is a technology that is being updated at a rapid pace, the workforce must be adept at learning them swiftly. The workforce must be prepared to move on to new technology as the current technology is becoming obsolete, or in some cases, even before the present technology is thought to be outdated. This rapid churn in the worker skill set can be very costly and challenging in the traditional mindset of skills development. Training programs that incorporate core computer science fundamentals such as data structures, cryptography, peer to peer networks, and other less explored topics, such as working with large open-source software projects, and having the expertise to evaluate new tools and techniques quickly is a necessity in this ever-evolving space. We believe higher education institutions have a significant role to play by offering degree programs and certifications aligned with the industry needs that provide a skilled workforce equipped with substantial business and software development skills and ready to take on the challenge of staying relevant.

## 3.4. Ecosystem: Integration to Technology and Business Ecosystem

DLT, by its very nature, operates on network effect. To leverage the best outcome, insurers will need to have buy-ins from the larger technology and business ecosystem- including partners, vendors, agents, and customers.

**Single vs. Consortia Approach:** DLT is a step towards decentralization, and the value-add from decentralized networks arises from the collaboration between several entities. Consortia have become a popular means for enterprises to work together on DLT-enabled platforms to derive shared value. The key dilemma for insurers is whether to approach DLT independently or be a participant to a consortium.

**Reliance on External Inputs:** Many insurance products implementing computable contracts may need to acquire data from outside the DLT, e.g., sensors or external websites or APIs. However, computable contracts do not allow querying external sources, as doing so breaks the determinism of computations with different nodes, possibly receiving different results for the same query. Consequently, data required by a computable contract should be first injected in the ledger. For this purpose, they rely on oracles- off-chain services taking data from the real world and pushing them to the ledger. Oracles are the interface between computable contracts and the outside but require a stable reputation system or governance mechanism and need to be as robust as the ledger itself, in order not to become the weakest part of the process. Technically, oracles are just contracts, and as such, their state can be updated and queried by sending them transactions. Some of the most common oracles are Provable (https://provable.xyz) and Chainlink (https://chain.link). These oracles can be readily incorporated with insurance products.

## 3.5. Adoption: Enterprise Integration and Governance

**Data Migration Issues:** The need and challenge of data migration are evident in businesses from upgrades, partnerships, mergers, and acquisitions. Database migration and enterprise application integration would remain relevant for migration in the DLT context. However, as enterprise information systems and business process management systems start to adopt DLT platforms, the innovation in this space is happening at a break-neck pace. There are inherent incompatibilities in platforms, modes of hosting, and DLT properties such as consistency, immutability, transparency, and openness. As innovations in this space proliferate, businesses may be interested in adopting new platforms with better performance (i.e., higher throughput, lower latency, or faster finality), new features, low transaction fees compared to the incumbent platforms, bug fixes, security, and governance. Therefore, the applications that rely on computable contracts will eventually need to migrate from one DLT instance to another to remain competitive and secure and enhance the business process, performance, cost efficiency, privacy, and regulatory compliance. Data migration challenges should not be an afterthought, as that will undoubtedly incur costs that could have been avoided with careful planning. A set of models for safeguarding data[41] could be adopted in DLT-based insurance products to tackle the challenges associated with data management and data migration.

## 3.6. Regulations: Security and Compliance

Insurance being a highly regulated business, security and compliance are two key areas for insurers to consider when adopting new technology. Insurers need to consider whether they are compliant with the legal and regulatory norms and whether the computable contract is legally binding and enforceable dependent on the jurisdictions.

**Scams:** With the proliferation of ICO scams[42, 43], investors of enterprises innovating in DLT-based insurance may be further nervous about investments into insurance products that could vanish into thin air. “BeeToken,” which was offered by a decentralized home-sharing platform for crypto-enthusiasts, was intended to let users book homes using the token and provide insurance to the homeowners using a computable contract. The company behind BeeToken, “BeesNest,” did a token sale to help fund the development of blockchain-backed insurance. However, the token sale was subjected to a phishing scam[44]. Therefore, businesses must take excellent precautions to ensure that their solutions are not subjected to traditional cyber-security exploits as the recourses in the decentralized applications can be tricky due to the nature of the engagement.

## 4. The Way Forward: Short-to-medium term Solutions

To reap the benefits of computable contracts, enterprises must craft out a careful adoption and integration strategy, considering legacy modernization and technology standardization. Businesses could employ the techniques outlined below to realize the goals mentioned above in the near term.

**Scaling and Integration**

One deterrent for enterprise grade adoption of computable contract is the execution speed in a blockchain environment, limited by consensus mechanisms. As proof-of-work consumes significant time and cost, enterprises need to adopt new, efficient methods to govern computable contracts through proof-of-authority (PoA) or delegated proof-of-stake (DPoS) mechanisms. The integrity of computable contract also relies on the reliability of oracles. Computable contract by themselves do not have the ability to determine the authenticity of data retrieved from oracles. This trust conflict between oracle and computable contract can be solved by mechanisms to verify the accuracy of information being fed to the computable contract and ensure data privacy[45].

**Shadow Ledgers**

In traditional database systems, when the system is being upgraded or moved to a newer, more efficient system, it is customary to operate both the systems in tandem for some time to verify that the outputs of the more modern system matches the tried and tested outputs of the legacy system, and also to recover from any issues from the newer system. A DLT system that records data alongside existing systems, allowing clients to test the “cryptographic waters,” is becoming a common choice in the industry and is already championed in IBM’s DLT product offering[46]. Such careful approaches might be useful not only for recovering from errors but also in incrementally training the workforce.

**Technology Standardization**

A lack of standards and proven, successfully applied reference implementations indicates that the technology is still in its infancy. Therefore, to realize sustainable benefits from an open or, at least to some extent, shared and distributed system, standards are critical. Consortia comprising technology experts, startups, regulators, and other market participants is crucial in identifying the challenges around DLT’s open and decentralized nature. Among these challenges are technical limitations as well as the market, legal/regulatory (who is regulated in the absence of an intermediary or cross-border solution?), and operational requirements regarding, for example, data protection and standardization.

While consortiums may not always work as intended, as evidenced by the Facebook Libra cryptocurrency[47], a body of experts to consult on best practices in computable contract adoption, and usage in the industry will be precious. The Blockchain Insurance Industry Initiative (B3i) (https://b3i.tech) is a startup comprising a cohort of insurers formed to explore the usefulness of DLTs in the insurance industry. While they have support from many industry partners in the insurance space, the technical output of this initiative is not publicly accessible.

## 5. Role of Center for Risks and Advances in Financial Technologies (CRAFT)

Rensselaer Polytechnic Institute has partnered with Capgemini on a strategic initiative to establish a US National Science Foundation (NSF) funded research Center for Risks and Advances in Financial Technologies (CRAFT). This Rensselaer-led multi-university and multi-disciplinary Industry-University Cooperative Research Center (IUCRC) will focus on cyber and financial technologies innovations, challenges and opportunities. Within this scope, the center will support DLT based insurance space in three areas:

1. Provide education and training
2. Define and implement a research agenda
3. Enable standards and policy guidance in engagement with government and industry partners.

As was discussed earlier, there is a need for a standards body in this space to guide businesses in adopting DLTs in the muddy waters of technological and regulatory churn. Insurers could take the lead in this space guided by CRAFT, benefitting from the academic research and expertise of Rensselaer and industry knowledge and capabilities of Capgemini.

## 6. Summary

Without question, computable contract-based insurance policies undersigned on a transparent world-viewable medium such as the ledger in the DLT are invaluable. In the insurance space, especially, these computable contracts will need to work with data possibly coming from other domains (medical reports, police reports) coordinated through trustworthy oracles that will act as a trigger for the contract execution and help identify fraud during insurance claims processing. Since the oracle is a special-purpose contract, it can be queried from other contracts without consistency issues for better risk assessment, pricing, and mitigation. All these transactions are recorded on the ledger. Since they are owned by neither insurers nor the insured, the transaction records cannot be corrupted or manipulated. In some cases, the self-executing ability of computable contracts could speed up claims processing (clients would receive their money even before they claim it because a computable contract could automatically trigger a reimbursement as soon as a given event occurs) and reduce human effort.

There are many process optimizations compared to traditional insurance scenarios as well. Unlike the coverage changes recorded with a formal modification to the contract made in the presence of the insurer in traditional policies, with the utilization of DLTs, costs could be cut since customers may directly modify coverage by interacting with the computable contract based decentralized application. Some startups have ventured into the parametric insurance space while others are working on DLT-based peer-to-peer risk transfer protocols. At its core, the semi-autonomous nature of the policy creation and execution using computable contracts is the winning formula for the next generation of insurance products and services. Specific features that would need to be codified in computable contracts include the type of risk, data and method for risk assessment, claims and payout mechanisms, surplus redistribution, etc. Furthermore, near-real-time adaptive pricing, on-demand insurance, and hybrid insurance products for the sharing economy are being explored by multiple startups leveraging big data, AI, IoT, and DLTs.

Recent incidents have shown that in a DLT ecosystem, new types of attacks are coming to existence. These are far less understood and, therefore, less mitigated as those occurring in conventional software architectures. Therefore, today's technology may not be future proof. Companies that plan to adopt DLTs may feel that they are aiming at moving targets, especially given the fragmented nature of the DLTs. However, some of the recent research efforts conducted at Rensselaer and many other research institutions on augmenting computable contracts may be the answer to this problem.

Furthermore, we note that data self-sovereignty and the tokenization of assets will require defined industry standards and safeguards. Since a large part of the risk in computable contracts will reside with the information provider (oracle), there will be a need to define "safe oracles" and other technical standards on DLT components. An industry-academia based consortium could help in this standardization effort.

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## About the Authors

### Oshani Seneviratne

Oshani Seneviratne is the Director of Health Data Research at the Institute for Data Exploration and Applications (IDEA) at the Rensselaer Polytechnic Institute. At Rensselaer IDEA, Oshani co-leads the Smart Contracts Augmented with Learning and Semantics project and is involved in the Health Empowerment through Analytics and Learning and Semantics research center. She has extensive experience in decentralized systems, knowledge representation, provenance, and policy-based systems.

### Aparna Gupta

Aparna Gupta is a quantitative Finance Expert and Director of the Center for Financial Studies in the Lally School of Management at Rensselaer Polytechnic Institute. She has worked on several US National Science Foundation, US Department of Energy funded research projects in financial innovations for risk management. Currently, she is working to establish a multi-university multi-disciplinary NSF-funded research center on risks and advances in financial technologies.

### Muhammed Ahmed

Muhammed Ahmed is a Technology and Innovation Consultant with Capgemini. Ahmed leads strategic initiatives around emerging technologies and business transformation for Financial Services Strategic Business Unit in Capgemini. He acts as an advisor to banking and insurance clients on their transformation journey, preparing them to be future ready. His interest areas include Blockchain, Internet of Things and Quantum Computing. Prior to joining Capgemini, he completed his MBA from Indian Institute of Management, Calcutta.

## Contributors

**Amit Choudhary**

EVP, Chief Operating Officer, Financial Services Strategic Business Unit, Capgemini

**Sudhir Pai**

EVP, Chief Technology and Innovation Officer, Financial Services Strategic Business Unit, Capgemini

**Seth Rachlin**

EVP, Chief Innovation Officer, Global Insurance Practices, Capgemini

**Kiran Boosam**

Vice President, Insurance GTM, Capgemini

**Sivakumar Nuti**

EVP, Global Delivery Executive, Insurance, Capgemini

**Manuel Sevilla**

Vice President, Chief Digital Officer, Business Services, Capgemini

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