

The Future of Smart Contracts

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Prelims: Why blockchain and smart contracts?

- The Internet is designed to operate as a peer-to-peer means for mass **communication** and **distribution of content**.
- But as a marketplace for **goods and services**:
The Internet has not fundamentally altered the **basic mechanism** of how individual and corporate parties **transact** their business.

Prelims: Why blockchain and smart contracts?

Most commercial transactions on the Internet are **not peer-to-peer** and still require a **central** or **controlling authority** or other “**trusted**” **intermediary** to conduct the exchange.



Created by Adrien Coquet
from Noun Project

Prelims: Why blockchain and smart contracts?

- The **trusted authority** may be an online retailer or exchange, or a bank or credit card processor, or a title company.
- Critics point out various **issues** with use of a trusted authority model in the **digital domain**: aggregation and concentration of **power**; disclosure to and use of personal **data** by the central authority.

Prelims: Why blockchain and smart contracts?

- **Blockchain** or related **distributed or decentralized ledger** technologies are proposed as the platform for the conduct of **transactions of value** between **peers** - without the **intervention** of a trusted authority.
- In a pure blockchain there is **no central authority** who decides what goes on the blockchain or who holds the sole authorized copy of the transaction.

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Prelims: Why blockchain and smart contracts?

- **Smart contracts** are a form of computer code that automates the execution and enforcement of parts of an agreement.
- Smart contracts are **generally embedded in** and **operate within** a **blockchain** platform.

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■ Blockchain in summary

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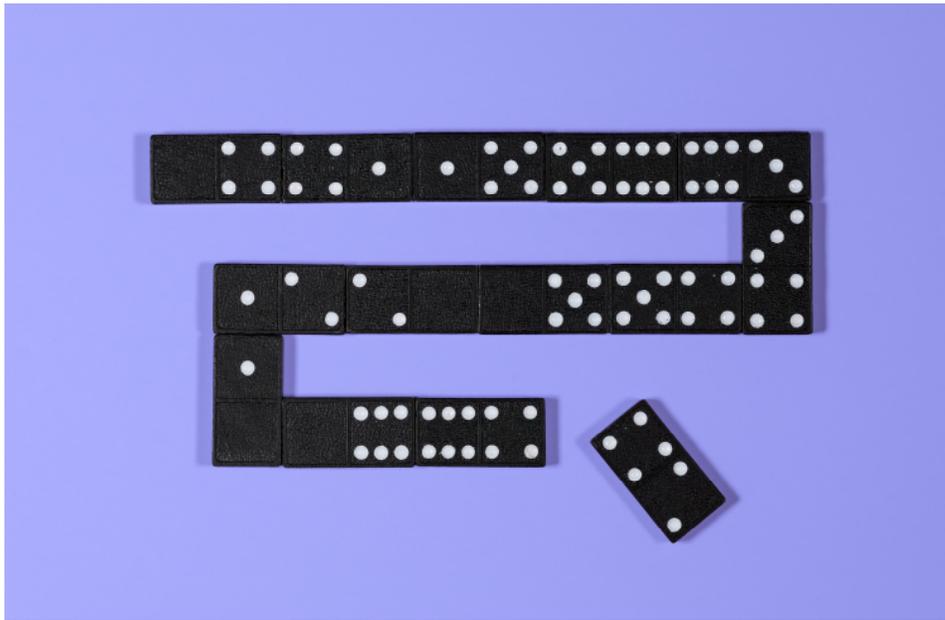
What is a blockchain?



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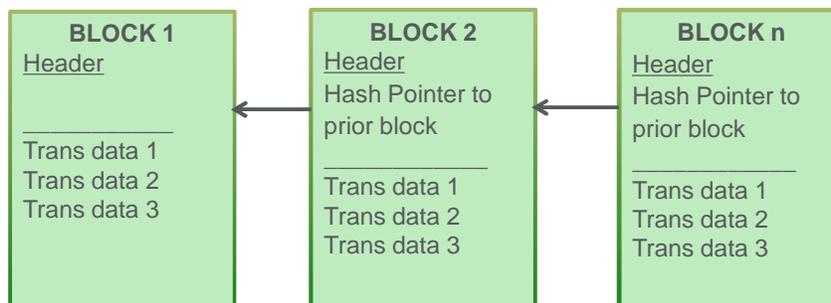
What is a blockchain?

A **blockchain** is

- A software **database** on a computer network maintain in the form of a **digital ledger**.
- Members of the network can enter and record **transactions** and **data** using a linked series of cells known as “**blocks**”.
- Each transaction is subject to a **verification** process before being added to a block.

Blockchain Technology Basics

- The blocks of data of a blockchain are **chained** together in chronological order:



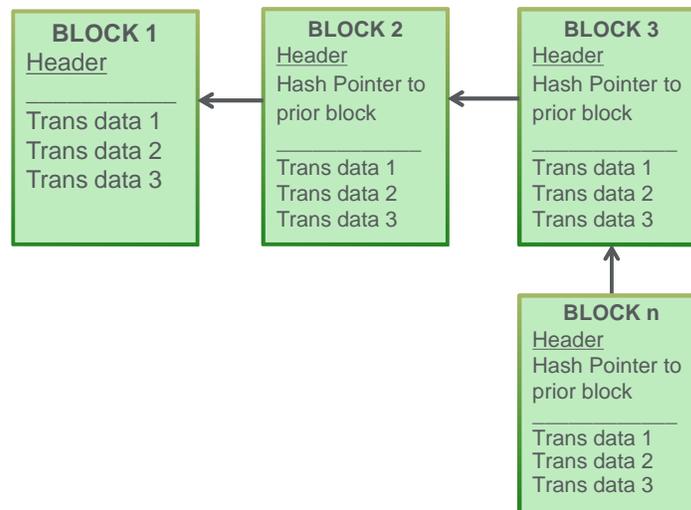
What is a blockchain?

- Each new block of data is connected to the immediately **prior block** by means of a link known as a cryptographic “**hash**”.
- The hash is generated by **mathematical functions** contained on the platform and converts data into a string of values.
- This process **cryptographically locks** the prior blocks ad infinitum. Once locked the data in a block in practice cannot be changed.

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Blockchain Technology Basics



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Blockchain Technology Basics

- Any changes to a transaction instead are **written into new blocks** of data attached to the **end** of the chain.
- In this manner the blockchain is intended to contain a **complete record** of all transactions in the blockchain since the first block.

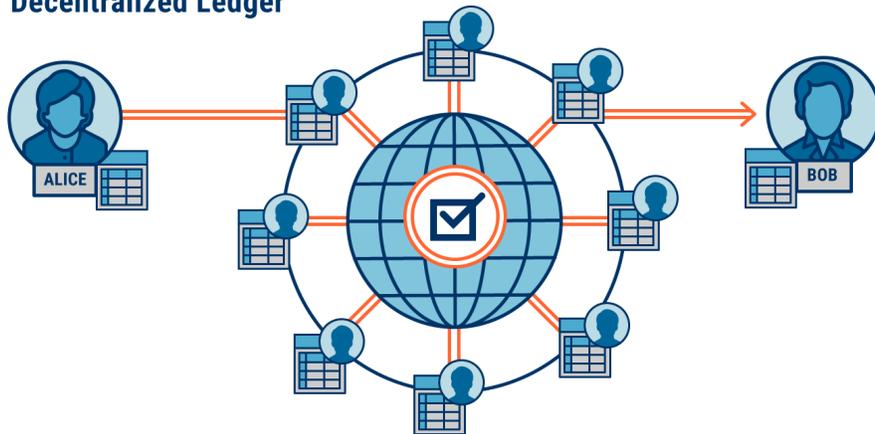
Distributed or Decentralized Ledger

Distribution of the Ledger:

- Copies of the current blockchain digital ledger containing all of the transactions in the **entire** chain are then continuously **updated** and **distributed to every member** in the blockchain network - which can number in tens of thousands.
- Designed to make the blockchain **secure** against **hacking** or **alteration** of the ledger - since at least a majority of **all distributed copies** would have to be altered.

Distributed Ledger Network

Decentralized Ledger



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Blockchain – Main uses

Blockchain has three main categories of potential uses:

- **Peer-to-peer transfer of digital assets** including the creation and exchange of cryptocurrencies - such as Bitcoin.
- Storing and validation of **digital records** such as stocks and land title.
- Creation and execution of **smart contracts**.

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Blockchain – Or mainly useless

Counterpoint: “In some instances, many of its purported use cases (payments, voting, digital ID, etc) amounts to little more than the willingness to add a distributed and encrypted ledger where one was not *really* needed. The technology has been lauded as a viable option to replace legacy systems, which have worked for many decades. But, what if there’s no need for a distributed, decentralized ledger after all?”

<https://thenextweb.com/hardfork/2019/02/07/why-hype-is-killing-blockchain-technology/>

Blockchain – Sceptics

There are **other sceptics:** Wired Magazine had a May 2018 article entitled "*187 Things the Blockchain Is Supposed to Fix*". Wired included the following key Blockchain priorities:

Skynet*

The movie industry's **accounting** practices

Fake news

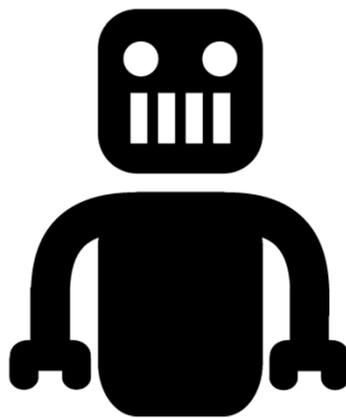
Authenticity in **cannabis** sales

Paying for things with your **face**

*See The Terminator v. Basically Everybody (1984) et seq.

- Smart contracts

What is a smart contract?



What is a smart contract?

- **Blockchain** technology is not **only** a string of static data records stored in blocks.
- It is possible using certain versions of blockchain software to also store **executable computer programs** within the blockchain to perform functions.
- Use of intelligent computing including **AI decision making algorithms** also possible.

What is a smart contract?

Short definition: **Computer code:**

- (1) embedded in a **blockchain** or other **distributed ledger** that
- (2) incorporates all or part of a written **legal agreement**;
- (3) transfers digital assets or vests rights or is otherwise triggered when a set of **pre-defined terms and conditions** are satisfied;
- (4) **without further action** by the parties.

What is a smart contract?

Shorter definition: A form of **robotics** for commercial contracts.



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Smart Contract Examples

- **Example:** Boris and Natasha want to bet on which political party will win the next US Presidential election. Both want to be sure the other will pay.
- Boris and Natasha could enter into a smart contract and transfer the amount of the bet in digital currency into the blockchain.
- The smart contract determines which party has won, and automatically transfers the stakes to the winner.

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Smart Contract Examples: Conditional

- **Example:** (a) Jones transfers **ownership** of securities or other digital assets into the **blockchain**; (b) Smith is required to **pay** \$5X for the assets on a certain date, but \$8X for the assets if Event A occurs prior to that date.
- The smart contract determines **whether** Event A has **occurred**, and then **self-executes** by (1) paying Jones \$5X or \$8X and (2) transferring ownership of the securities to Smith.

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Smart Contract Examples: Auto Lease

Under a smart automobile lease:

- A digital system in the automobile would monitor lease payments by the lessee.
- If the lease payment is late, the car is automatically disabled and will not operate until payment is received.
- If a self-driving or autonomous vehicle, the car theoretically could be programmed to self-repossess by driving itself back to the leasing company.

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Other Smart Contract Use Cases

- **Stocks:** Trading and registration of shares of corporate stock. Several states including Delaware and more recently California have enacted statutes permitting use of blockchain as the official stock ledger.
- **Financial Instruments:** Trading of derivatives or other financial instruments.
- **Trade Finance:** Automated issuance of or substitution for letters of credit, guarantees and trade finance instruments.

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Other Smart Contract Use Cases

- **Clinical Trials:** Automated obtaining and tracking of required patient consents; and secure sharing of personal medical information across institutions.
- **Scientific Research:** Real-time secure sharing of research between institutions to avoid the “silo” effect; automated nondisclosure terms to protect patent and other IP rights; automatic release of grant funds.

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Other Smart Contract Use Cases

Other use cases include:

- Supply agreements
- Supply chain transparency and reporting
- Self-sovereign digital identity.

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BUT: Reality Check

A smart contract generally will **not be an entire agreement** but only those **parts** of the contract that are:

- highly **process-based** and **binary**
- can be represented in executable **computer code**,
and
- can be **usefully automated** in a manner that is more efficient and easier to scale than human processing.

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BUT: Reality Check

- Far better suited to **industrial scale** or **repetitive** forms and transactions rather than "one off" agreements.
- "Smart contracts" thus are not necessarily that **smart** or even **contracts**.*
- While their use is proliferating, many use cases for smart contracts are still in the **theoretical** or early **development** stage.

*See, e.g., Kolber, *Not-So-Smart Blockchain Contracts and Artificial Responsibility*, Stanford Technology Law Review 2018, p. 25.

■ Smart Contract Technology

Building of Smart Contracts

How is a smart contract **constructed** using a blockchain?

Building of Smart Contracts

- There are **competing versions of blockchain software**, similar to competing versions of computer system software such as Microsoft and Apple.
- For example, **Bitcoin** has its own blockchain system for the issuance and transacting of the Bitcoin cryptocurrency as an alternative to fiat currencies such as dollars and Euros.

Ethereum Blockchain System

- The main blockchain platform used for smart contracts currently is **Ethereum**.
- **Ethereum** is a separate open-source, public, blockchain-based distributed computing platform and operating system.
- Ethereum also includes its own cryptocurrency [**ether**] that competes with Bitcoin.



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Our Founder



Vitalik Buterin, Russian-Canadian, born January 31, 1994 (age 25 **now**). University of Waterloo [dropped out]. Invented Ethereum at age 19. Net worth > \$500 Million.

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Ethereum Blockchain System

The **Ethereum platform** contains critical components necessary for smart contracts:

- (1) **Computer code functionality** permitting **self-executing contract terms** to be embedded in the blockchain.
- (2) The ability to perform **computations** within the blockchain.
- (3) The ability to obtain **extrinsic or external data** from outside third parties using functions called “**oracles**”.

Ethereum Blockchain System

- (4) The ability to **combine** this external data with the computer code within the blockchain to perform smart contract functions.
- (5) **Decentralized applications (dApps)** that run on top of the platform to add functions.

Other Initiatives

- Ethereum is owned by no one and is an **open system**. The Ethereum Foundation coordinates improvements.
- The **Enterprise Ethereum Alliance [EEA]** is developing **corporate uses and applications** for the Ethereum blockchain. <https://entethalliance.org>
- Other initiatives include the **Hyperledger** project hosted by the Linux Foundation.

■ Building a smart contract - Steps

Building a Smart Contract: Step 1: Agreement

- Two or more parties must **negotiate** a written legal contract or use a **form contract** from one of the parties or an affiliation group containing their agreement.
- The contract must include specific transactions or other rights and obligations that vest or are executed upon **specified sets** of conditions.

Building a Smart Contract: Step 2: Conditions

The parties **must set**:

- **All of the conditions** to be automated under their agreement
- All **permutations** of each of those conditions
- The **intended result or instruction** in each case.

Building a Smart Contract: Step 2: Conditions

The set conditions can be **internal** to the contract:

- The **manufacture or shipping or delivery** of a product
- A schedule of **due dates** for payments
- **Expiration** of inspection rights or warranties
- A form of **deliverable** or notice by a party.

Building a Smart Contract: Step 2: Conditions

The set conditions can be **external** to the contract:

- Acts or omissions of **third parties**
- Accidents or weather or climate events or other **acts of God**
- Other events of **force majeure**
- Financial or product **market triggers**
- **Changes** in legal or financial status

Building a Smart Contract: Step 3: Coding

- The smart part of a contract must be reduced to **binary machine code**. This requires design logic and the writing and compiling of **computer code** using Solidity or other software language.
- The code must incorporate **all of the set conditions and results**, so that the contract will automatically be performed when those conditions are triggered.

Building a Smart Contract: Step 3: Coding

Key Point:

- A smart contract therefore always has **two versions**: the human language version and the machine code version.

Building a Smart Contract: Step 3: Coding

Written Contract:

- Human language
- All parts of agreement
- Freely modifiable in writing by the parties.
- Subject to interpretation

Smart Version:

- Machine computer code
- Only transactions to be automated
- Embedded into blockchain or other ledger
- Generally immutable.

Building a Smart Contract: Step 4: Blockchain

- The smart contract is then **verified** and **written into** by the blockchain or other distributed ledger network.
- The parties are issued **public and private digital “keys”** to identify themselves as the parties to the contract and the location of the contract on the blockchain.

Building a Smart Contract: Step 5: Execute

- **Execution** of the transaction is triggered:
 - by a message sent by a party validated by its **private key** or
 - by the **objective satisfaction** of external or other **events or conditions** coded into the program.
- The transaction [such as transfer of funds or title] is **automatically performed** pursuant to the smart contract code.

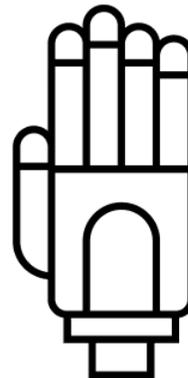
Building a Smart Contract: Step 6: Recording

- The **completed transaction**
[for example: sale of digital currency or assets;
payment of royalties; delivery of shipment]
is verified and written into a **new block** in the
chain.

- Legal issues

Legal Issues

There are very significant **legal and functional challenges** to the use of smart contracts in their **present stage** of development.



Legal Issues - Formation

A. Formation of a Contract

- The formation of a contract requires a bargain in which there is (1) a **manifestation of mutual assent** [generally in the form of an **offer** and **acceptance**] and (2) a form of consideration.
- Parties to a smart contract must evidence **offer and acceptance of the terms** for the contract to be valid.

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Legal Issues - Formation

- The digital **acceptance** by the parties of a smart contract must be by a method evidencing clear **notice** of and **agreement** to the terms of the contract, rather than by **mere implication of assent**.
- Note the various notice and consent issues raised by "**browse-wrap**" contracts for online goods and services.*

*E.g., *Nguyen v. Barnes & Noble, Inc.*, 763 F.3d 1171 (9th Cir. 2014); *Hines v. Overstock.com, Inc.*, 380 F. App'x 22, 24 (2d Cir. 2010).

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Legal Issues - Formation

- There also may be jurisdictions that require a **full human-language version** of an agreement or other documentation be provided to a party to be effective.*

*In the case of China, see, e.g., Run and Ying, Impact of Smart Contracts on Chinese Contract System and Solutions, South China Finance 2018(05), p 95.

Legal Issues - Formation

- What rules apply if a statute requires that the contract be "**written**" or "**in words**" or "**signed**"?
- California Civil Code § 1620: "An express contract is one, the terms of which are stated **in words.**"
- **Statute of frauds** requiring certain contracts to be in **writing** and **signed** by the parties.

Legal Issues - Formation

- Ongoing debates whether current laws are sufficient or whether **additional legislation** is required to validate smart contracts on a blockchain.
- Electronic Signatures in Global and National Commerce Act (“**ESIGN Act**”) and Uniform Electronic Transactions Act (“**UETA**”) and other statutes in several states provide grounds for smart contract recognition and enforcement.

Legal Issues - Formation

- This includes Section 14 of the UETA, which provides that a computer can be an “**electronic agent**”, and a contract can be formed by the interaction of electronic agents of the parties, even if a party was not aware of or reviewed the actions of the agent or terms of the contract.*

* See for example Cal. Civ. Code §§ 1633.2(b), (f), 1633.14.

Legal Issues - Formation

- The European Union is developing its own structure to recognize the **legal authority** of blockchain-based smart contracts. This is a work in process.*
- Under current rules, for a digital signature on a blockchain to be valid, it must be verified by a Trust Services Provider (TSP).

* See EU Regulation 910/2014 on 910/2014, on electronic identification and trust services for electronic transactions in the internal market [eIDAS]. The current state of play is discussed in Legal and Regulatory Framework of Blockchains and Smart Contracts, EU Blockchain Observatory and Forum Report (27/09/2019).

Legal Issues - Coding

B. “Lost in Translation”: Smart Contract Coding

- Written contract terms need to be converted into **computer language** to be embedded as a smart contract in a blockchain. This needs to be done with **complete precision**.
- After a smart contract is added to the blockchain it generally is **immutable** and cannot be changed.

Legal Issues - Coding

- It is essential that legal counsel and its software coding counterparts establish procedures so there are **no gaps or mistakes** as between the two versions.
- Use of a “**sandbox**” to test and validate smart contract code before it is embedded in the blockchain.
- Development and use of **preapproved smart contract templates** limit but cannot eliminate this risk.

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Legal Issues - Coding

- How does the other side **verify** that the smart contract version prepared by a party is the same as the written term sheet or agreement for the transaction?
- Which party is **liable** in the event of coding errors or inconsistencies in the contract?
- How is the contract introduced into **evidence** and proven in court?

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Legal Issues - Coding

- Which is the **controlling** agreement: **human** or **code** version?

Legal Issues - Security

C. Security of Smart Contracts

- At this stage of development, there have been some **security breaches** of enterprise smart contracts coded with the principal software language used for Ethereum - at least when smart contracts are posted on a **public blockchain**.

Legal Issues - Security

- Some companies [including Axoni] are proposing a method called "**formal verification**" to test the correctness and security of smart contracts.
- **Formal verification** is an existing rigorous mathematical method used to "harden" software and hardware logic for military, transportation and cryptography computer programs.

Legal Issues - Irrevocability

D. Irrevocability or Immutability of the Code

- Once the smart contract is embedded into the distributed ledger it is generally irrevocable or immutable, and in accordance with design will be **self-executing**.
- This can be the equivalent of a **transactional doomsday machine**.

Legal Issues - Irrevocability

What happens when there is:

- **Mistake** of law or fact
- **Defects** or **inconsistencies** between the human and digital versions
- Ambiguities or **parol evidence** of additional or different terms
- **Future events**, such as **bankruptcy** or **governmental sanctions** banning a party or the transaction

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Legal Issues - Irrevocability

- Other **changes** in the law
- Issuance of an **injunction** against performance
- **Fraud** in the inducement.
- Under discussion are laws requiring mandatory use of “**kill switches**” or similar mechanisms in smart contracts to **prevent self-execution** in these types of situations.

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Legal Issues - Irrevocability

Plan ahead:

- It may be technically possible to **stop** or terminate by right a smart contract on the Ethereum platform if **self-destruct** or **turn-off** or **modification** functions are built into the contract at the outset.
- This and similar measures of course are inconsistent with the basic objective of **avoiding human agency**.

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Legal Issues - Irrevocability

- It may be possible to create a **central or core smart contract** that is immutable - but **use oracles** to pull in additional or changed terms or values from other subsidiary contracts or sources that can be modified.
- Examples can include **changes** in **payment** terms or **performance** metrics.

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Legal Issues - Privacy

E. Data Protection and Privacy

- There are major issues in data protection and privacy that are **blockchain generic** -
- but directly **impact** the formation and use of smart contracts.

Legal Issues - Privacy

In the case of the EU, the **General Data Protection Regulation** [GDPR] imposes:

- A right of **erasure** [“right to be forgotten”]
- The right to **correct** data
- The right to be **protected** from decisions made only on the basis of **automated data processing**.*

*Note: [Legal and Regulatory Framework of Blockchains and Smart Contracts](#), EU Blockchain Observatory and Forum Report (27/09/2019); [Blockchain and the General Data Protection Regulation](#), European Parliament - EPRS (July 2019).

Legal Issues - Privacy

Under the GDPR:

- Who is the **controller** and who is the **processor** of the data embodied in the smart contract or transaction, especially in fully decentralized permissionless blockchains?
- **Where** is the data held?
- How is personal information on the blockchain **deleted or corrected** if **immutable**?

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Legal Issues - Privacy

- How is the data **anonymized**?
- Is standard **cryptographic hashing** of the data sufficient?
- **Proposed fixes** include:
 - (1) Two-party smart contracts that only disclose information in the event of a **dispute**;
 - (2) **new forms** of cryptographic hashing permitting **edits**;
 - (3) maintaining information **off-chain** or by use of so-called “**pseudonymization**”.

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Legal Issues - Privacy

- Similar issues with the new **California Consumer Privacy Act of 2018 (CCPA)** in effect January 1, 2020 [although the CCPA differs in many material aspects from the GDPR].
- For example, the CCPA provides that consumers covered by the Act must have the **right to require deletion** of personal information in certain cases [Cal. Civ. Code § 1798.105].

Legal Issues- Jurisdiction

F. Jurisdictional Issues

- What is the **location** of the smart contract for jurisdictional purposes?
- Enforceability of smart contracts in **cross-border** transactions when different rules apply in the relevant jurisdictions, including choice of law provisions.

Legal Issues - Extralegal Entities

G. Extralegal Entities

- Virtual organizations known as **Decentralized Autonomous Organizations** (DAOs) can be entirely formed on the blockchain.
- Not **incorporated** or registered under national or local laws.
- Use of **multilateral smart contracts** to establish their **structure** and all **governmental and decision-making functions**.

Legal Issues - Extralegal Entities

- There are **software** platforms such as Aragon [<https://aragon.org>] and Colony [<https://colony.io>] that permit the creation and governance of DAOs.

Legal Issues - Extralegal Entities

There are a host of **issues** presented by DAOs:

- Such organizations are generally **not recognized** as separate and independent entities under current law.
- DAOs may be characterized as **general partnership** or **joint venture** agreements subjecting its individual members to unlimited personal liability.
- Compliance with **securities** and **financial reporting** laws.

Legal Issues - Human Ambiguities

H. Ambiguities of Human Contracts

“**The fault**, dear Brutus, is not in our stars, but in **ourselves....**”

[William Shakespeare, *Julius Caesar*,
Act I, ii, 139-140]

Legal Issues - Human Ambiguities

- There are basic **inherent challenges** in the process of converting from the written contract to the **self-executing** digital one.
- One is the use of **qualifying terms** used continuously to bridge the gap in human language contracts.

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Legal Issues - Human Ambiguities

- Written contracts contain **numerous qualifiers** open to **human** and **contextual** interpretation such as:

good faith
material
fair
reasonable
best efforts
intentional
commercial

customary
satisfactory
personal
workmanlike
circumstances
including but not
limited to

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Legal Issues - Human Ambiguities

- One example is the **force majeure clause** in a contract:

“**Force Majeure.** No failure by a party in the performance of any obligation of this Agreement will be deemed a breach of this Agreement if such failure arises from any cause or causes beyond the reasonable control of the party, including but not limited to the following: acts of God; acts or omissions of any government; _____. The affected Party shall promptly undertake all reasonable efforts necessary to cure such force majeure.”

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Legal Issues - Human Ambiguities

- Another obvious example is application of the **implied covenant of good faith and fair dealing.**
- The covenant of good faith and fair dealing, which is implied in every contract, “precludes each party from engaging in conduct that will deprive the other party of the benefits of their agreement.”

[*Orange County Choppers, Inc. v. Olaes Enterprises, Inc.*, 497 F. Supp. 2d 541, 560 (S.D.N.Y. 2007)].

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Legal Issues - Human Ambiguities

Thus - before the

[dream]

[nightmare]

[fantasy]*

of **fully-autonomous** computable agreements or wide-scale computer-to-computer **autonomous negotiation** of contracts comes true:

*Choose one.

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Legal Issues - Human Ambiguities

- **New logic** and **semantics** that **objectify** and **quantify** concepts such as “materiality” and “reasonableness” must be developed for general application.
- Use of **AI** including **machine learning** to create the necessary logic and predictive algorithms.
- This includes algorithms to identify, rank and standardize **contingencies**.

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Legal Issues - Human Ambiguities

- One proposed partial solution for the **human ambiguity problem** is the open source development of smarter “**wise contracts**” that contain executable code but permit human input.*
- The project proposes universal smart contract templates using **prose objects**.

*CommonAccord Project at www.commonaccord.org. [Hazard and Haapio 2017].

Legal Issues - The “Algorithmic Society”

I. Personalized Default Rules Adaptive Regulation Micro-Directives

- Various proposals to use
 - smart contracts
 - and “**smart legislation**”

to institute **variable standards** of (1) **breach** of contract and (2) **imposition** and **compliance** with laws.

Legal Issues - The “Algorithmic Society”

This includes:

- Use of highly specific **micro sets of facts and circumstances** versus generic rules to direct and control lawful behavior; or
- Variable rules based on the **micro characteristics** of the **specific human actor**.*

*E.g., Casey and Niblett (2107); Porat and Strahilevitz (2012).

Legal Issues - The End Times - Part II

J. Rise of the [Uniform Contracts] Machines

- The **front end complexity** associated with building out smart contracts will accelerate the drive to adopt **uniform contracts** in industries.
- Maximize **interoperability** and **scalability** just as with any other **standard technologies** [see: electric plugs; mobile cellular transmissions; DVDs].

Legal Issues - The End Times - Part II

- **Growing convergence** in standardizing commercial contracts such as non-disclosure agreements [NDAs], supply agreements, online terms and conditions.
- **Certain industries are already there:** ISDA [International Swaps and Derivatives Association] standard agreements for certain financial transactions; NVCA [National Venture Capital Association] model legal documents for startups.

Legal Issues - The End Times - Part II

- It is inevitable that **smart contract and decentralized ledger technologies** will accelerate this convergence to uniform contract terms and standards.

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