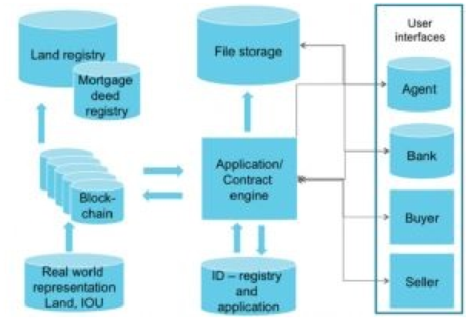
Blockchain in Geospatial Applications



Ian Dowman has written an introduction to blockchain and gives some examples of applications which are relevant to readers of '*Geomatics World*'. The article is based on a piece in '*GIM International*' by Jonas Ellehauge (2016), and also uses a number of other sources.

Many people will find Blockchain a difficult concept, but Wikipedia is a good starting point: *“A blockchain – originally block chain is a continuously growing list of records, called blocks, which are linked and secured using cryptography. Each block typically contains a hash pointer as a link to a previous block, a timestamp and transaction data. By design, blockchains are inherently resistant to modification of the data. A blockchain is "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way." For use as a distributed ledger, a blockchain is typically managed by a peer-to-peer network collectively adhering to a protocol for validating new blocks. Once recorded, the data in any given block cannot be altered retroactively without the alteration of all subsequent blocks, which requires collusion of the network majority.”*

The keypoint here is that blockchains are secure by design and are an example of a distributed computing system with high fault tolerance. This makes blockchains potentially suitable for the recording of events, and other record management activities such as identity management, transaction processing, and documenting provenance.

Benefits

Jonas Ellehauge expands on the characteristics of blockchain:

- **Safer** – because no one controls all the data (known as root privilege in existing databases). Each entry has its own pair of public and private encryption keys and only the holder of the private key can unlock the entry and transfer it to someone else.
- **Immutable** – because each block of entries (added every 1-10 minutes) carries a unique hash ‘fingerprint’ from the previous block. Hence, older blocks cannot be tampered with.
- **Cheaper** – because anyone can set up a node and get paid in digital tokens (e.g. Bitcoin) for hosting a blockchain. This ensures that competition between nodes will minimise the cost of hosting it. It also saves the costs of massive security layers that otherwise apply to servers with sensitive data – this is because of the no-root-privilege security model and, with old entries being immutable, there’s little need to protect them.
- **Resilient** – because there is no single point of failure, there is practically nothing to attack. To compromise a blockchain, you’d have to hack each individual user one by one to get hold of their private encryption keys that give access to that user’s data. Another option is to run over 50% of the nodes, which is virtually impossible and economically impractical.
- **Transparency and accountability** – the fact that existing entries cannot be tampered with makes a blockchain a transparent source of truth and history for your application. The public nature of it makes it easy to hold people accountable for their activities.
- **Control** – the immutable and no-root-privilege character puts each user in full control of his/her own data using the private encryption keys. This leads to real peer-to-peer interaction without any middleman and without an administrator that can deny users access to their data.
- **Trustless** – because each user fully controls his/her own data, users can safely interact without knowing or trusting each other and without any trusted third parties.

A blockchain can be more than a passive registry of entries or transactions. The original Bitcoin blockchain supports limited scripting, allowing for programmable transactions and smart contracts – e.g. where specified criteria must be fulfilled leading to transactions automatically taking place.

Applications

Ellehauge lists some geospatial uses:

1. **Public-good data** such as street maps, parcels, terrain models, aerial footage or sea maps – made publicly available without a central hub that can restrict access to the data; a public record can be kept of changes and contributions.
2. **Internet of things** – autonomous devices & apps. Devices that negotiate with and pay each other, such as drones that negotiate use of air space, self-driving cars that negotiate lane space or pay for road usage, mobile/wearable devices that pay for public transportation; apps similar to Uber and Airbnb that connect clients and providers without a middleman.
3. **Land ownership** - land/real-estate ownership can be registered on a blockchain; corruption is rendered nearly impossible; people in

developing countries can register land ownership themselves using inexpensive mobile devices without the need for slow or expensive overhead costs.

Land Ownership

This is a crucial problem for geospatial surveyors because for the vast majority of people in many developing countries, there is no mapping of parcels or proof of ownership available to the actual landowners. Ellehauge notes that people mostly agree on who owns what in their local communities. These people often have a need for proof of identity and proof of ownership for their justly acquired land to generate wealth, invest in their future, and prevent fraud – while they often face problems with inefficient, expensive or corrupt government services. Ideally, we could build inexpensive, reliable and easy-to-use blockchain-based systems that will enable people to map and register their land together with their neighbours – without involving any government officials, lawyers or other middlemen.

A trial such as the one at the Sweden Land Registry, aims to demonstrate the effectiveness of blockchain at speeding land sale deals. Chavez-Dreyfuss, (Cromaway, 2016) reports that Sweden is conducting tests to put the country's land registry system on blockchain. The country is working on the project with Swedish blockchain company ChromaWay, consulting firm Kairos Future, and telecommunications service provider Telia. Together, they have come up with a framework and technical demonstration on how the Swedish land registry would work on blockchain. This works by creating permanent, public "ledgers" of all transactions that could potentially replace complicated systems such as clearing and settlement, with one simple database. The plan is to put real estate transactions on blockchain once the buyer and seller agree on a deal and a contract is made, from there all the parties involved in the transactions - the banks, government, brokers, buyers, and sellers, are able to track the progress of the deal once it is completed.

In October 2017, one of the first international property transactions was successfully completed using a blockchain based on a smart contract, (Snow, 2017).

Geodesic Grids

It has been suggested to use geodesic grids of discrete cells to register land ownership on a blockchain. Such cells can be shaped, for example, as squares, triangles, pentagons, hexagons, and each cell has a unique identifier.

Although a grid of discrete cells doesn't allow for customised flexible polygons, it has an advantage that each digital token on the blockchain can represent one unique cell in the grid. Hence, whoever owns a particular token, owns the corresponding piece of land. what3words is an example of a geodesic grid.

Open Data

Only in recent years have a few countries in Europe made public map data freely accessible. In the meantime, projects like OpenStreetMap have emerged to meet people's need for open data. Uber and Airbnb are examples of consumer applications that rely on geospatial data and processing. Such autonomous apps may currently have to rely on third parties for their geospatial components – for example Google Maps, Mapbox, or OpenStreetMap. With access to truly publicly distributed data as described above, such apps would be even more reliable and cheaper to run. An autonomous device such as a drone or a self-driving car inherently runs an autonomous application, so these two concepts are heavily intertwined. Again, distributed peer-to-peer apps could cut out the middleman and reliance on third parties for their navigation and other geospatial components.

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