WHAT IS A BLOCKCHAIN AND HOW IS IT RELEVANT FOR GEOSPATIAL APPLICATIONS?

Blockchain in Geospatial Applications

A blockchain is an immutable trustless registry of entries, hosted on an open distributed network of computers (called nodes). It is potentially safer and cheaper than traditional centralised databases, is resilient to attacks, enhances transparency and accountability and puts people in control of their own data. Blockchain technology is already being used in some geospatial applications, as explained here.

(By Jonas Ellehauge, awesome map tools, Norway)

As an immutable registry for transactions of digital tokens, blockchain is suitable for geospatial applications involving data that is sensitive or a public good, autonomous devices and smart contracts.

Use Cases

Here are some geospatial use cases:

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; contributors to the map are rewarded with tokens; a public record can be kept of changes and contributions.
2. **IoT – 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 overheads.

The use cases are discussed further below. I have given a few short talks about this topic at various conferences, most recently at the international FOSS4G conference in Bonn, Germany, 2016.

Public-good data

Open Data is Still Centralised Data

Over the past two decades, I have seen how ‘public-good’ geospatial data has generally become much easier to get hold of, having originally been very inaccessible to most people. Gradually, the software to display and process the data became cheaper or even free, but the data itself – data that people had already paid for through their taxes – remained inaccessible. Some national mapping institutions and cadastres began distributing the data via the internet, although mostly with a price tag. Only in recent years have a few countries in Europe made public map data freely accessible. In the meantime, projects like OpenStreetMap have emerged in order to meet people’s need for open data. It is hardly a surprise, then, that a myriad of new apps, mock-ups and business cases emerge in a region shortly after data is made available to the public there.

Truly Public Open Data

One of the reasons that this data has remained inaccessible for so long is that it is collected and distributed through a centralised organisation. A small group of people manage enormous repositories of geospatial data and can restrict or grant access to it. As I see it, this is where blockchain and related technologies like IPFS can enable people to build systems where the data is inherently public, no one controls it, anyone can access it, and anyone can review the full history of contributions to the data.

Would it be free of charge to use data from such a system? Who would pay for it? I guess time will tell which business model is the most sustainable in that respect. OpenStreetMap is free to use, it is immensely popular and yet people gladly contribute to it – so who pays the cost for OSM? Bear in mind that there's no such thing as 'free data'. For example, the 'free' open data in Denmark today is paid for through taxes. So, even if it would cost a little to use the blockchain-based data, that wouldn't be so different from now – just that no one would be able to restrict access to the data, plus the open nature of competing nodes and contributors will minimise the costs.

Autonomous Devices & Apps

Uber and Airbnb are examples of consumer applications that rely on geospatial data and processing. They represent a centralised approach where the middleman owns and controls the data and charges a significant fee for connecting clients and providers with each other. If such apps were replaced by distributed peer-to-peer systems, they could be cheaper and give their users full control of their data. There is already such an alternative to Uber called Arcade.City. A peer-to-peer market app like OpenBazar may also benefit from geospatial components with regards to e.g. search and logistics. Such autonomous apps may currently have to rely on third parties for their geospatial components – e.g. Google Maps, Mapbox, OpenStreetMap, etc. 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. There's no doubt that self-navigating cars and drones will be a growing market in the near future. Uber and Tesla have big ambitions regarding cars, drones are being designed for delivery of consumer products (Amazon), and drone-based emergency response (drone defibrillator) and imaging (automatic selfie drone 'Lily') applications are emerging. Again, distributed peer-to-peer apps could cut out the middleman and reliance on third parties for their navigation and other geospatial components.

Land Ownership

What is Property?

After some years in the GIS software industry, I realised that a very large part of my work revolved around cadastres/parcels and other administrative borders plus technical base maps featuring roads, buildings, etc. In view of my background in physical geography I thought that was pretty boring stuff and I dreamt about creating maps and applications that involved temperatures, wind, currents, salinity, terrain models, etc., because it felt more 'real'. I gradually realised that something about administrative data was nagging me – as if it didn't actually represent reality.

Lately, I have taken an interest in philosophy about human interaction, voluntary association and self-ownership. It turns out that property is a moral, philosophical concept of assets acquired through voluntary transactions or homesteading. This perspective stretches at least as far back as John Locke in the 17th century. Such justly acquired property is reality, whereas law, governance services and computer code are systems that attempt to model reality. When such systems don't fit reality, the system is wrong and should be dismissed, possibly adjusted or replaced.

Land Ownership

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. Christiaan Lemmen, an expert on cadastres, has experience from field work to map parcels in developing countries such as Nigeria, Liberia, etc., where corruption can be a big challenge within land administration. In his experience, however, 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 in order 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.

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, e.g. as squares, triangles, pentagons, hexagons, etc., and each cell has a unique identifier. In a traditional cadastral system, parcels are represented with flexible polygons, which allows users to register any possible shape of a parcel. Although a grid of discrete cells doesn't allow such flexible polygons, it has an advantage in this case: each digital token on the blockchain (let's call it a 'Landcoin') can represent one unique cell in the grid. Hence, whoever owns a particular Landcoin owns the corresponding piece of land. Owning such a Landcoin means possessing the private encryption key that controls it – which is how other cryptocurrencies work.

In order to represent complex and high-resolution geometries, it is preferable to use a grid which is infinitely sub-divisible so that ever-smaller triangles, hexagons or squares, etc., can be tied together to represent any piece of land. A digital token can also be infinitely sub-divisible. For comparison, the smallest unit of a Bitcoin is currently a 100-millionth – aka a 'Satoshi'. If needed, the core software could be upgraded to support even smaller units.

Examples of some geodesic grids:

- Octahedral Quaternary Triangular Mesh – triangles
- Geoshash – squares
- what3words – squares, proprietary
- GEOHEX – hexagons

What is a Blockchain?

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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' of 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 or Ether) 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's practically nothing to attack. In order to compromise a blockchain, you'd have to hack each individual user one by one in order to get hold of their private encryption keys that give access to that user's data only. 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.

Smart Contracts and DAPPs

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. Possibly the most popular alternative to Bitcoin is Ethereum, which is a multi-purpose blockchain with a so-called 'Turing complete' programming interface, which allows developers to create virtually any imaginable application on this platform. Such applications are referred to as decentralised autonomous applications (DAPPs) and are virtually impossible for third parties to stop or censor.

[1] IFPS

IPFS is a distributed file system and web protocol, which can complement or even replace HTTP. Instead of referring to files by their location on a host or IP address, it refers to files by their content. This means that when requested, IPFS will return the content from the nearest possible or even multiple computers rather than from a central server. That could be on the computer next to you, on your local network or somewhere in the neighbourhood.

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Jonas Ellehauge is an expert on geospatial software, GIS and web development, enthusiastic about open source, Linux and UI/UX. Ellehauge is passionate about science, philosophy, entrepreneurship, economy and communication. His background in physical geography provides extensive knowledge of spatial analyses and spatial problem solving.