# Blockchain Applications and Challenges in Spatial Issues

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Blockchain is a new technology for decentralised consensus on valuable transactions and process tracking without the control of a single third party. In spatial information science, we think blockchain has a promising but yet clear potential.

## Applications of Blockchain in Spatial issues

In general, Blockchain applies for the Byzantine Generals' Problem. The problem requires the consensus (i.e., the agreement on/to do something) of two or more parties without the witness of an observer (i.e., the central agency).

- Issue One: location privacy

  Problem-1: Sending location information to someone p2p without central server?

  - Avoid annoying and irrelevant advertisement, etc. Protect location privacy.
  - Why not use p2p network directly? What's the benefit of Blockchain over P2P network?
  - If using P2P network, what if the spatial interaction causes some accidents/risks? For example, in the case of food delivery, ridesharing, etc, when unknown people meet each other. → Need a 3rd party observer.
  - A potential combined way:

    P2P network sends location info in a private way;

    Blockchain broadcasts the spatial behaviour / interaction without talking about the specific location. (E.g., A is meeting B, but not tell where exactly to meet.)
  - An alternative way:

    Encrypted information in Blockchain: Zcash, Monero?

  Problem-2: Map query without exposing private location?

  - Decentralised map query? How to query a map without going through a central server?
  - Can Blockchain solve this problem at all? How?

- Issue Two: Autonomous vehicle (AV) assignment in an automatic way

  Design an assignment system without central control → Optimisation on a decentralised database (i.e., Blockchain)?

  Pros and cons:

  > Pros: transparent so that no agency will cheat by making passengers take longer detour on purpose; track the trajectory of the vehicle for erroneous behaviours; data open source
  >
  > Cons: passenger privacy issue (?); computation efficiency and confidentiality level → does blockchain suit real-time application?

  Wu et al.'s paper on a peer-to-peer shared ride system design (Wu, Guan, & Winter, 2008) proposed a system where vehicles only negotiate with nearby hosts: short to mid distance (within a certain buffer) communication. Is there a way to optimise the system on the blockchain network?

  Potential solution (not sure if feasible):

  - A person sends a request to each nearby AV, and broadcasts the requests to the blockchain network
  - There can be multiple persons doing the same thing at a similar time
  - Each node (miner) does: mining + optimisation
  - When the optimisation result is returned from a node, the result is broadcast to the network for future tracking

Wu, Y. H., Guan, L. J., & Winter, S. (2008). Peer-to-peer shared ride systems. In *GeoSensor Networks* (pp. 252–270).

- Issue Three: Blockchain and Volunteered Geographic Information (VGI)

  Report errors and malfunction: the data on blockchain is all public and transparent; easy for verification by multiple parties. How to protect location privacy?

  Challenge: Can blockchain leverage data mining to validate the information saved in the distributed database? Blockchain takes a *reality* that is created or is thought to be true by a participant, but that doesn't mean the information input in the database is really *true*. For example, user A claims that a restaurant is at location L1, but in fact the restaurant is at location L2. The consensus in blockchain can be a biased consensus. Therefore, it is necessary to design a mechanism to prove the claimed reality is a truth.

  Potential solution:

  - Blockchain as a public open-source platform to track spatial behaviours and to collect spatial data (by VGI, no matter positive or passive sensing)
  - Data-mining with the collected public data

- Validate whether the claimed realities are true or not

- Issue Four: Location Triggered Events on Smart Contracts

  Location can trigger some transactions/events automatically without human interference. This is based on smart contracts pre-defined and broadcast on the blockchain network. For example, new retailing stores support automatic payment when a customer picks up a product (location-sensible) and walks out of the store (location-triggered). The blockchain system witnesses what the customer bought and whether the customer has enough balance in the bank account. The payment is triggered automatically and can be error-proof (say, wrong charges, etc.)