Decentralise Indexing in Common Data Environments for Collective Actions in Urban Design: A Blockchain Proposal

Provides Ng[1,2]

[1] Bartlett School of Architecture University College London 22 Gordon St, London WC1H 0QB, United Kingdom
[2] School of Architecture, The Chinese University of Hong Kong, Hong Kong

Abstract

While crowdfunding and crowdsourcing has much potential for the decentralisation of architectural production, there are immense challenges in formulating mass consensus mechanisms. The urgency is to rethink the relationship between how data is controlled and communicated and the consequential value circularity within a common data environment. This investigation concerns the design of an architectural system that enables participatory processes and collective input. It first unpacks the urgency as both a form of technical and socioeconomic engineering, introducing the idea of 21e8—decentralised indexing as system infrastructure. Then, it illustrates the idea through a series of strategic diagrams, comprising 1) an OSI model from physical to user layer, 2) a tech stack between blockchain, BIM, and AI, 3) and data flow from the indexing infrastructure to various modelling interfaces. Afterwards, it demonstrates how architectural information can be indexed and a voting mechanism that ranks contents, with all data transactions mined immutably with blockchain. Subsequently, it shows an ongoing experiment of urban remapping, where AI/BIM collaborate to increase and evaluate options within the system. Finally, this paper concludes by discussing how decentralised indexing may help to promote a peer-to-peer, data-for-data, compute-for-compute environment - a computational data market.

Keywords

Blockchain, BIM, AI, Participatory Design System, 21e8

1. Decentralised Indexing

Within any distributed system, difficulty in consensus increases as the size of the community scales up [8]. The advancement of distributive technologies challenges design production to evolve: from singular authorship to a participatory one that comprehends data from huge amounts of sources — both expert-oriented and from general users [12]. In particular, user ratings and opinions are of great value, not only in our attention economy, but also in participatory urban processes. Means by which we crowd-evaluate data sources assist the comprehension of common preferences for the building of a common well.

In the attention economy, Google remains a dominant player; its centrality is both the reason for its success and its downfall: it provides a single access point to digital information for convenience; at the same time, its proprietary Page [14] Rank indexes information according to content linkage and user attention, but it is being operated in a centralised manner that leaves users with little to no control over where the value of their attention goes [15]. Equally important, is the form by which the value is realised, such as being able to understand the value in a piece of information and rank them.

Indexing is the organisation of data according to a specific schema to make information more accessible; in a database, indexing helps to structure data in a way that improves retrieval

WCDCC 2025: First Workshop on Computational Design and Computer-aided Creativity 2025, 23 June, 2025, Campinas, BR
[1*] Corresponding author.
provides.ism@gmail.com, provides.ng.19@ucl.ac.uk (P. Ng)
0000-0001-6975-4642 (P. Ng)

operations [2]. Google's search model provides some clues on how we may crowdsource and crowdfund projects by realising and capturing value in user attention, but to decentralise indexing is a matter of system design. The peer-to-peer (p2p) dynamic within a decentralised system frames the system design problem as both a technical and a socioeconomic engineering challenge.

To contextualise this within our built environment discipline, individual designers should be able to directly contribute content to a Common Data Environment (CDE) and harness value in their work input via indexing operations. Such value can be realised through search and query: which results should come up first according to a specified parameter? Embedding participatory processes within indexing operation means users may consciously and directly influence how information is ranked within a CDE, as opposed to being passively harvested as behavioural patterns. This highlights the key to value circularity in collective indexing, where blockchain provides prospects as a distributed ledger that records a list of information consensus.

Along these lines, the study investigates two interrelated questions: How can value be transacted from p2p amongst a network of architectural content-contributors via decentralised indexing? Consequently, how can value be captured and realised within such data transactions and in what form?

2. Proof-of-Architectural-Work (PoAW)

Prior research demonstrates blockchain's technical potential for construction collaboration but reveals critical governance gaps in value capture and stakeholder alignment. Tezel et al. [19] systematically established frameworks for blockchain in construction, analyzing permissioned versus permissionless implementations to enable diverse public-private partnerships. Further, Hunhevicz and Hall [5] advanced smart contract protocols with reward-punishment mechanisms to calibrate project execution, while Pschetz et al. [17] demonstrated blockchain's utility for peer-to-peer value exchange through automated energy markets. However, these technical advances contrast sharply with The DAO's governance failure [6] in real world developments, where purely financial stake-based consensus attracted speculative investment— highlighting the need for mechanisms prioritizing domain-specific value over profit.

Building on these efforts, this research hopes to advance the Proof-of-Work (PoW) mechanism to a Proof-of-Architectural-Work (PoAW), where the system goal shifts from maximising financial profit to improving built environment quality with the help of Building Information Modelling (BIM) and Artificial Intelligence (AI). BIM manages a comprehensive 3D model of a building's physical and functional components throughout its entire lifecycle, from design to construction; while AI has the potential to diversify design through generative algorithms [12]. However, there is a lack of investigation into how these technologies can help crowdsource design between a network of individuals who have limited resources and means to lower market entry costs. By focusing on content production as idea seeds that may accumulate its incrementality within the system and compete until maturity for design implementation, this study aims to displace the need for large-sum contracts with micro-value transactions. Through decentralised indexing operations, the outcome would propose a negotiation system, where money is not the primary medium of exchange—value would be realised directly as data or compute, evaluated through a voting mechanism. This may help to mitigate risks of financial speculation in crowdfunding built environments, especially in the prevention of 'bad' voting in DAOs.

'21e8' is a blockchain concept that pioneers a "computational data market", which are competitive ecosystems that combine algorithmic content creation with distributed data exchange to displace ad-based ranking and recommender systems [1]. 21e8 is being introduced in this study as a universal index within a CDE, looking at how it may benefit architectural content production.

The decentralised index functions as a decision-making framework to assist variety, circularity, and self-organisation of creators and contents. By combining information and attention through proof-of-work, nodes within a network can p2p exchange not just data, but their computational power as values.

Design production as sets of decision-making processes can be thought of as iterative information feedback, where the realisation of the design is the reaching of an equilibrium in a game, in which all players have no reason to deviate from their chosen strategy [10]. Design concepts and challenges can be seeded in a CDE, where multiple players can compete and contribute options and evolutions of solvers. Each iteration of the design can be feedback as input and voted up by nodes in the network to form an index of values.

Once the contribution reaches a stability, an equilibrium, the output would be a design that went through natural selection within the network and reached a maturity framed by user preferences [12]. Such votes can be backed by values in forms of data, compute (e.g. data storage or processing), or monetary (tokens), which become resources that feedback to the content-creator in supporting further contributions. And because every vote takes a minute charge of value, it means the user not only has rights, but also responsibility to give back to the system, which may help them to build consciousness around their decisions.

3. Blockchain + BIM + AI

The architecture of a system that facilitates distributive design production should crowdsource intelligence of humans and machines alike. Today's AI can be understood as rule/agent-based and Machine Learning (ML) systems. The latter achieves intelligence with machines that define their own rules based on available data, transcending design from causation to correlations, from small to big data. This may help us to develop a statistical understanding towards our environment; also, increasing options in a system to crowdsource feedback for more democratic digital practices; also, to relieve and automate repetitive computational processes.

This research is interested in a particular type of ML, where Wiener's [20] feedback and von Neumann's [11] minimax strategy (an equilibrium in a game) formed part of the basis. In this sense, the 21e8 approach to collective intelligence is, at the same time, the formulation of a distributed artificial intelligence.

If AI is to maximise choices in a system: increasing information entropy, then BIM is to rationalise choices in a system: minimising information entropy. This stabilises a system where entropy increases globally but decreases locally—Schrodinger's [18] definition of intelligence. BIM helps to interface between a scattered supply-chain and evaluate architectural information using simulation strategies as a frame of reference for users to vote on design options. In this sense, ML, which is based on big data, and BIM simulation, which is based on Newtonian physics, may calibrate each other to relieve symptoms of 'bad' voting.

The sharing of intellectual labour and properties requires data to stay immutable and distributed so as to provide transparency, where blockchain can be useful. Together, they provide prospects in designing a system that is not only intelligent, but is able to aggregate different forms of intelligence to reproduce itself as a system. This requires beyond a mere stack integration of these technologies, to the design of their interconnection and communication.

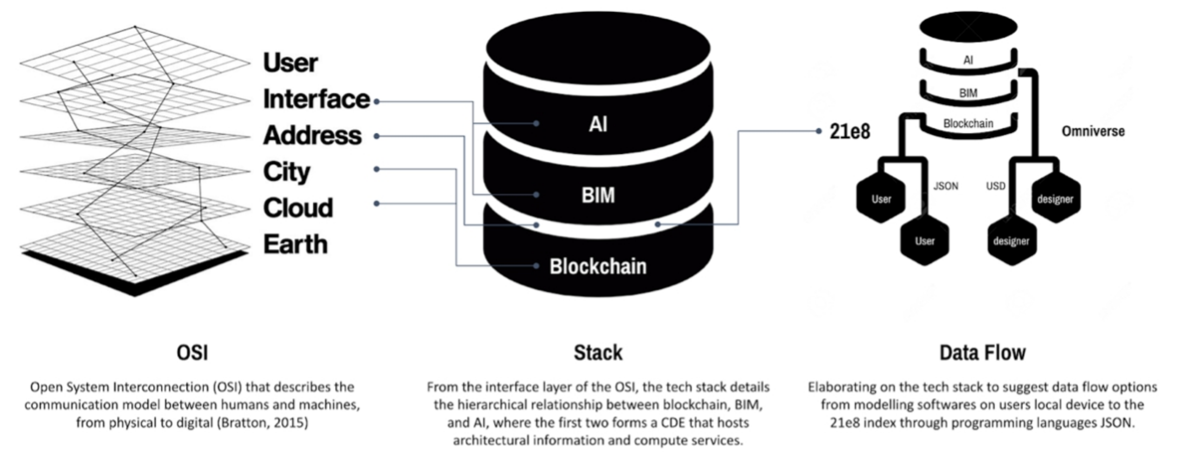

Figure 1: From OSI and tech stack, explaining the role of 21e8 in managing data flow.

3.1. The Stack

The Open Systems Interconnection (OSI) model is 'a conceptual model that characterises and standardises communication functions of a telecommunication or computing system without regard to its underlying internal structure and technology' [16]. This 7-layer application networking model was developed by International Organization for Standardization (ISO) [9]. It has been applied by Bratton (2015) as a reference model for political and design theory to include a network of individuals, organisations, and their governance within a system, all entities taken as users.

Ng [12] imagined an Urban OSI model that visually communicates how different layers correspond to the deployment stack, showing data communication between infrastructural services, operation system services, protocols, and users, orienting them from physical medium to social engineering. The city, address, and interface layers are respectively where blockchain, BIM, and AI integrate. With a blockchain ledger as the backend supporting a CDE, which hosts architectural information and compute services, the API gateway bridges data exchange between various applications. Layer 3 typified different modelling software, from computer graphics to BIM, and their communication through Omniverse for in-situ visualisation and Tensorflow options as custom framework for AI. Omniverse calls itself a multi-GPU platform because it is able to translate 3D data between a distributed network in real-time using a universal programming language. As such, 21e8 becomes a multi-database open-source infrastructure.

Figure 2 shows how different softwares may form a collaborative content-creation environment via the 21e8 index, recording input from multiple sources. As the proposed system is technically distributed, it contains no files centrally, but a 'yellow page' that records all content contributions. Contents can be pulled to a user's local device upon request for p2p transactions.

The index records users' query or vote through downloading a JSON file on the local device, forming a network of distributed databases. JSON is a programming language, chosen for its 'open standard file and data interchange format that uses human-readable text to store and transmit data objects' [7]. The rising 3D data format glTF developed by Khronos Group is based on JSON—in other words, an open source format suitable for the proposed system. With the Unreal Engine as an example—a prominent real-time 3D software that supports JSON structures—which can be installed with a 21e8 plugin and Omniverse connector. The former pushes a record of the file with JSON onto the universal index for users to search and vote, the latter pushes 3D data onto other modelling softwares for design collaboration using Universal Scene Description (USD) [4].

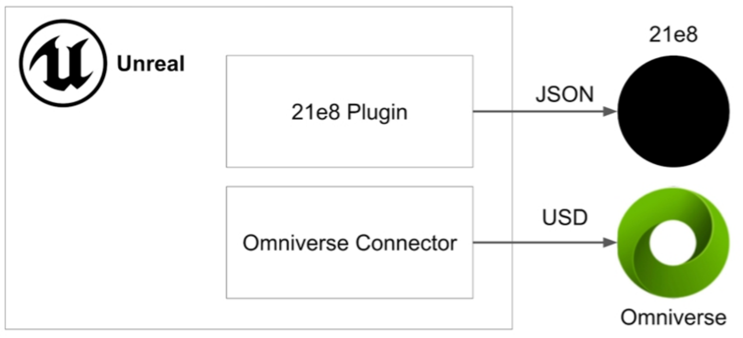

Figure 2: The plugin pushes JSON files to the index, recording user votes. With Unreal as interface, the Omniverse connector updates geometries between various modelling softwares in real-time.

3.2. Users Interaction: Voting, Indexing, and Giving Back

Architectural information can be broadcasted, voted, and mined on 21e8, enabling user rating on information objects for indexing, ranking and searching purposes.

First, a search function within CDEs. Links are ranked according to the amount of votes. Figure 3 is a working demo illustrating a query for ‘ark.page’, the first link received the most votes—6 votes represented as 6 green boxes next to the link, thus being assigned with the highest value amongst all searches. The vote action puts users in a conscious position of their data contribution. In comparison to Google’s proprietary search index, users have no access to the reason behind certain searches being ranked as the best results. For instance, large platforms like Twitter naturally have the highest score for content linkage, it will always occupy the top search results. Whereas 21e8 applies PoW to create a custom bias over the content through voting mechanics—users can invest a few clicks to influence the index structure by which the content is ranked. This is how an information object is turned into a digital asset, which is a database record of all transactions and users who have invested computing power, creating network effects.

With each vote, a JSON file is being downloaded on the user’s local computer to contribute storage and computing power to the network. This secures one’s vote without exposing one’s search history, forming a network of immutable distributed ledgers and decentralising the overall system. The option of creating a shared index among multiple parties or publishing transactions on a public or consortium blockchain can be enabled on request.

Figure 4 contains an example JSON recording the 1) search query ‘provides Ng’, 2) retrieved url, 3) cryptographic hash code (the identity of the data), 4) assigned index value, and 5) target index ‘21e8’. This helps to build different ways of investing compute power in a computational data market, relieving symptoms of data licensing.

Second, a content broadcast function. Imagine BIM’s CDE working like a social media platform where designers as content-contributors are able to broadcast their work in the hope of harnessing network effects. The hashtag function helps users to place their content under a certain query or topic so as to enable search optimization. In Facebook, content-contributors have the option of purchasing ads to get their content ranked up on the platform; whereas the 21e8 index provides a more straightforward means for content broadcast without having to go through third party intermediaries. Figure 3 illustrates how one can navigate the topic ‘omniverse demo chair’ and broadcast one’s content underneath using the mine button and anchor it to the index. If one wishes to rank the content up, one would only have to invest a few clicks and computing power to vote it up.

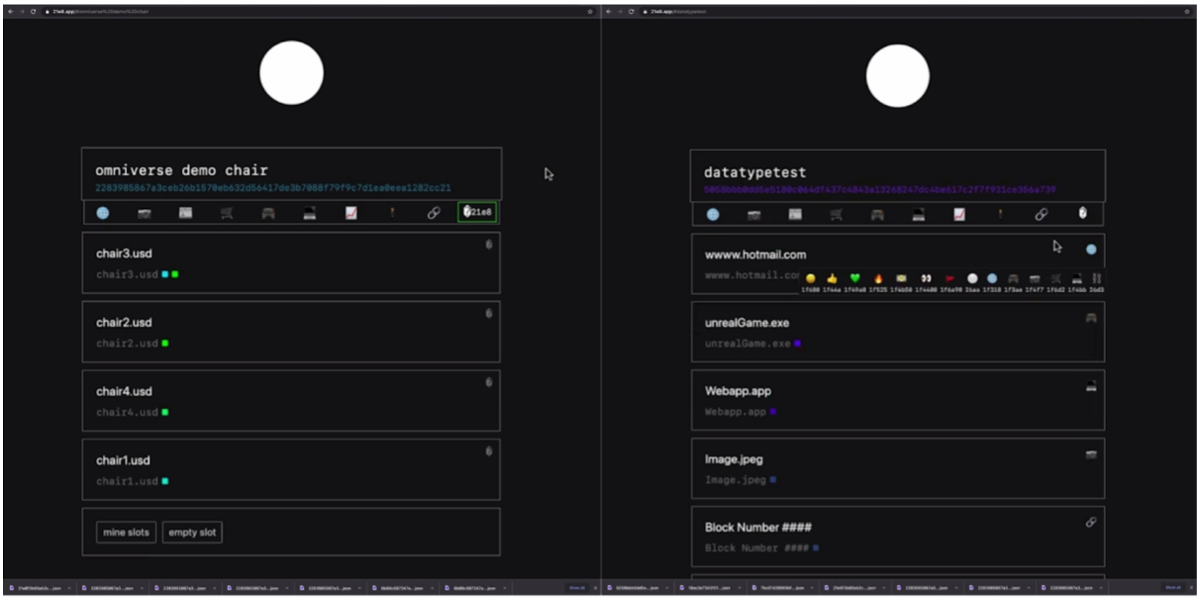

Figure 3: (a) A demo of how content is being mined and broadcasted on 21e8. (b) data type test.

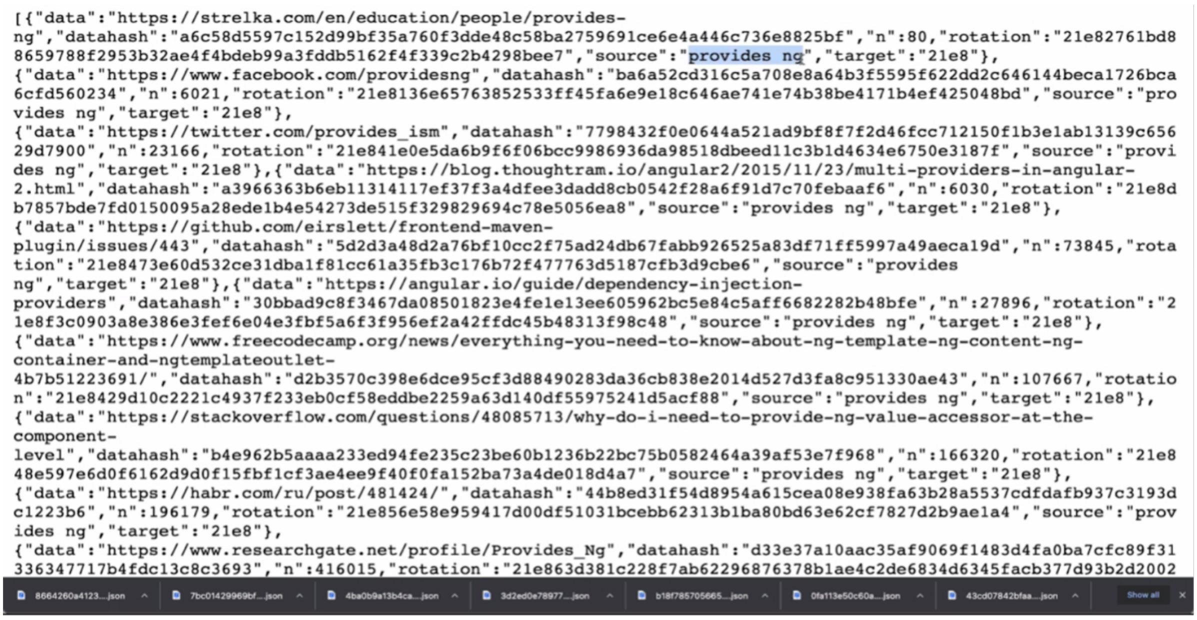
[{"data":"https://strelka.com/en/education/people/provides-ng","datahash":"a6c58d5597c152d99bf35a760f3dde48c58ba2759691ce6e4a446c736e8825bf","n":80,"rotation":"21e82761bd88659788f2953b32ae4f4bdeb99a3fddb5162f4f339c2b4298bee7","source":"provides ng","target":"21e8"},
{"data":"https://www.facebook.com/providesng","datahash":"ba6a52cd316c5a708e8a64b3f5595f622dd2c646144beca1726bca6cfd560234","n":6021,"rotation":"21e8136e65763852533ff45fa6e9e18c646ae741e74b38be4171b4ef425048bd","source":"provides ng","target":"21e8"},
{"data":"https://twitter.com/provides_ism","datahash":"7798432f0e0644a521ad9bf8f7f2d46fcc712150f1b3e1ab13139c65629d7900","n":23166,"rotation":"21e841e0e5da6b9f6f06bcc9986936da98518dbeed11c3b1d4634e6750e3187f","source":"provides ng","target":"21e8"},{"data":"https://blog.thoughtram.io/angular2/2015/11/23/multi-providers-in-angular-2.html","datahash":"a3966363b6eb11314117ef37f3a4dfee3dadd8cb0542f28a6f91d7c70febaaf6","n":6030,"rotation":"21e8db7857bde7fd0150095a28ede1b4e54273de515f329829694c78e5056ea8","source":"provides ng","target":"21e8"},
{"data":"https://github.com/eirslett/frontend-maven-plugin/issues/443","datahash":"5d2d3a48d2a76bf10cc2f75ad24db67fabb926525a83df71ff5997a49aeca19d","n":73845,"rotation":"21e8473e60d532ce31dba1f81cc61a35fb3c176b72f477763d5187cfb3d9cbe6","source":"provides ng","target":"21e8"},{"data":"https://angular.io/guide/dependency-injection-providers","datahash":"30bbad9c8f3467da08501823e4fe1e13ee605962bc5e84c5aff6682282b48bfe","n":27896,"rotation":"21e8f3c0903a8e386e3fef6e04e3fbf5a6f3f956ef2a42ffdc45b48313f98c48","source":"provides ng","target":"21e8"},
{"data":"https://www.freecodecamp.org/news/everything-you-need-to-know-about-ng-template-ng-content-ng-container-and-ngtemplateoutlet-4b7b51223691/","datahash":"d2b3570c398e6dce95cf3d88490283da36cb838e2014d527d3fa8c951330ae43","n":107667,"rotation":"21e8429d10c2221c4937f233eb0cf58eddbe2259a63d140df55975241d5acf88","source":"provides ng","target":"21e8"},
{"data":"https://stackoverflow.com/questions/48085713/why-do-i-need-to-provide-ng-value-accessor-at-the-component-level","datahash":"b4e962b5aaaa233ed94fe235c23be60b1236b22bc75b0582464a39af53e7f968","n":166320,"rotation":"21e848e597e6d0f6162d9d0f15fbf1cf3ae4ee9f40f0fa152ba73a4de018d4a7","source":"provides ng","target":"21e8"},
{"data":"https://habr.com/ru/post/481424/","datahash":"44b8ed31f54d8954a615cea08e938fa63b28a5537cdfdafb937c3193dc1223b6","n":196179,"rotation":"21e856e58e959417d00df51031bcebb62313b1ba80bd63e62cf7827d2b9ae1a4","source":"provides ng","target":"21e8"},
{"data":"https://www.researchgate.net/profile/Provides_Ng","datahash":"d33e37a10aac35af9069f1483d4fa0ba7cfc89f31336347717b4fdc13c8c3693","n":416015,"rotation":"21e863d381c228f7ab62296876378b1ae4c2de6834d6345facb377d93b2d2002

Figure 4: A JSON file, recording votes and transactions on the local desktop, forming a network of distributed databases, where users volunteer their storage capacity with each vote on the index.

This creates a microeconomy around indexing that transacts computational value, which is realised when the compute is being put to use. Currently, this demo version only mines URLs onto the index. Further tests have to be carried out to expand data types, as illustrated in Figure 3, including executable files (.exe) for building compute services, application files (.app), image files (.jpeg) and so on, are currently undergoing preliminary tests.

3.3. Use Case Development: Participatory Urban Planning

In order to demonstrate the larger social implication of decentralised indexing, here tabulates a sketch of potential participatory urban planning processes that can happen on 21e8, taking Hung Shui Kiu (HSK) New Development Planning (NDA) in Hong Kong (HK) as an example.

Currently, the NDA planning process takes place in a centralised manner that has difficulties in comprehending and crowdsourcing opinions from citizens. The master plan is directly formulated by the government which becomes statutory after a 3 weeks period of public consultation; the communication is unidirectional. Figure 5 provides a high-level system overview and visualises user interactions.

The overall system goal is for planners to crowdsource ideas and comprehend views from both experts and general users. Designers and citizens can contribute graphs and urban data (e.g. street maps, etc.) for the AI to output urban planning options, which will be evaluated using BIM and anchored on 21e8. Users can then vote on these options to rank them on the index. Content contributors would be rewarded with data / compute / tokens according to received votes. All information would be mined and hashed via blockchain. Planners can then rationalise and consolidate options into a conceptual plan and feedback on the index for citizens to go through a second round of voting.

The output will then be iterated until it reaches an equilibrium in the voting process into a master plan that can then become statutory. Implementation of the plan can be traced-and-tracked and monitored through the BIM system to coordinate with a supply-chain of contractors, all processes indexed and published on 21e8 to enhance efficiency and transparency.

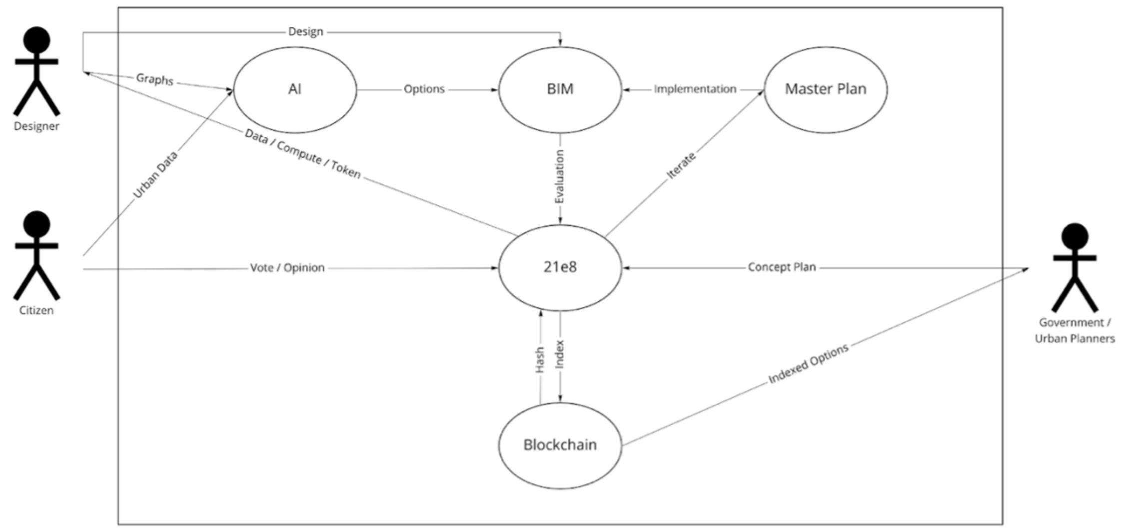

Figure 5: Proposed use case on participatory urban planning processes.

3.4. Urban Remapping with StyleTransfer AI

The following test demonstrates how AI may help in diversifying urban planning options, using various graphs to analyse the relationship of interacting nodes in HSK NDA, which is undergoing revitalisation with Transit-Oriented Development (TOD) strategies. The network analysis visualises existing urban density using StyleTransfer AI. Compared with HKSAR's plan, which shows a clear functional division of the NDA into land fragments to tender out to developers, this study's tests demonstrate how different plots may form various complex webs between existing low-rise and village houses, bridging them into central transit and other function hubs, synthesising urban fabrics and their communities.

The network analysis rationalises the urban fabric with topologies extracted from 1) e8 graph, 2) random graph, 3) small world graph and 4) preferential attachment graph, showing how transit hubs can be embedded in the area while giving consideration to the existing complexity of the fabric. The blue dots show the centrality of the network; while the e8 root system offers a way to label functionality into each node with various colour labelling. The colour can be used as a semantic label by assigning centrality and functionality values to be plugged into BIM for analysis, and act as a datum to evaluate NDA plans in terms of how the area would network itself, which is the next step of the project.

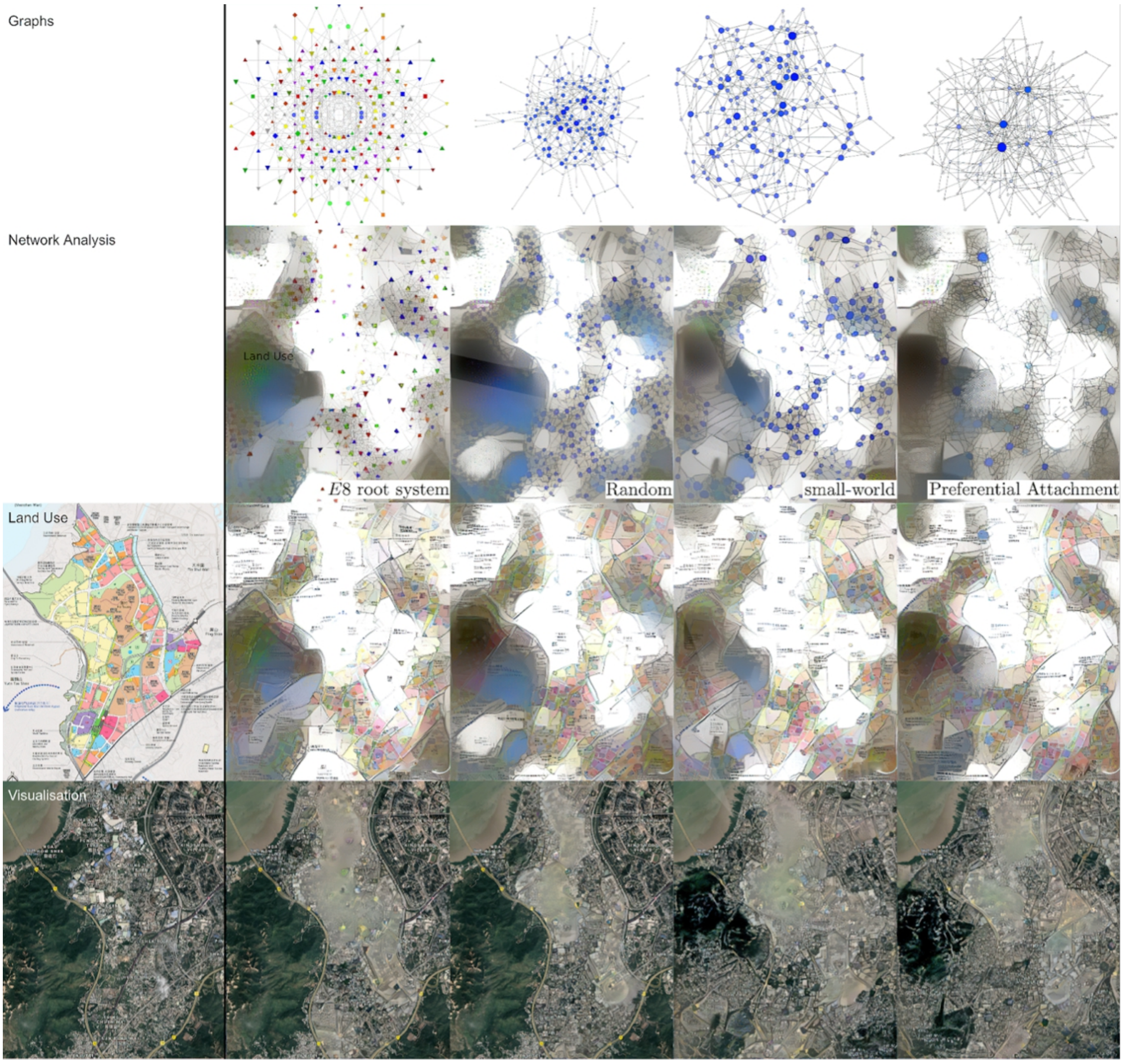

Figure 6: Visualisation and analysis of existing urban density and connection using StyleTransfer ML. Remapping with various graphs to facilitate options for plasticity.

From these tests, a brief summary on how 21e8 can help to improve the pipeline based on crowdsourcing and crowd-indexing. First, upscaling resolution, which was largely influenced by the lack of open source data in the area. Second, crowdsourcing graphs can facilitate a larger range of options and variety in decision making and forming better evaluation metrics. Third, decentralised indexing can help to expand the labelling beyond functionality to other urban utilities, including power grid, sewage system, public facilities, etc., which are currently unavailable data. Fourth, crowdsourcing opinions from local inhabitants and stakeholders for participatory planning (e.g. infrastructural support, functional hubs, community services, etc.).

4. Discussions

Reflecting on the experiment, the core function of the decentralised index replaces proprietary search algorithms with a community-driven, blockchain-anchored method for ranking content in a

CDE. Contextualising it in urban design, the index couples with AI-BIM Interaction, where AI diversifies design options while BIM evaluates feasibility. Together, they calibrate decision-making in participatory systems. The key components are as follows.

Content Contribution & Anchoring: Creators submit architectural data (BIM components, graphs, codes, etc.) to the CDE. Content is cryptographically hashed and "mined" onto the blockchain index via JSON files, creating an immutable record.

Voting & Ranking: Users vote on content relevance/quality (e.g., design options), each vote is a JSON file record on the voter's local device (decentralized storage), consumes minimal compute resources (e.g., storage, processing), and increase the content's index value, determining its search ranking.

Value Circularity: Votes act as microtransactions of value (data, compute, or tokens). Top-ranked creators earn rewards (compute/tokens) to incentivise quality contributions. Users "pay" with compute resources with each vote to prevent free-riding and "bad votes".

Consensus & Security: Blockchain immutably records all transactions. No central server: Index is built from distributed JSON files across users' devices. Content hashes ensure data integrity; votes are cryptographically signed.

AI as "Option Generator" (Entropy Maximizer):

- Input: Crowdsourced urban data (e.g., ideas, graphs, votes).
- Process: Uses ML (e.g., StyleTransfer, GANs) to
  - Generate diverse design variants (e.g., urban layouts).
  - Analyze complex relationships (e.g., density, connectivity via graph topologies).
- Output: Multiple design options with semantic labels (e.g., functional zoning, centrality scores).

BIM as "Option Evaluator" (Entropy Minimizer):

- Input: AI-generated options + physics-based constraints (e.g., structural, environmental).
- Process: Simulates real-world performance (e.g., energy use, spatial conflicts); provides quantifiable metrics for user evaluation (e.g., cost, carbon footprint).
- Output: Rationalized options ready for voting on 21e8.

Calibration Loop: AI Diversifies → BIM Rationalizes → Users Vote → Iterative Feedback Loop. Together, BIM's physics-based simulations ground ML's statistical predictions, reducing speculative and low-quality input/output.

Future technical integration should test two components. First, the data bridge between AI/BIM tools connected via APIs and Omniverse using USD format. This would enable real-time 3D data synchronisation from AI-generated graphs to the BIM simulation environment. Second, with 21e8 as Mediator, this experiment only tested hosts ranked options for voting. Next step should include rewards for creators of high-voted AI/BIM content with compute/resources.

The following points should be considered before further implementation. First, Decentralized Indexing does not equal Traditional Databases as there would be no central database; instead, an Index is a distributed network of JSON files on the communities' local devices. Also, it is not a system for file storage: 21e8 stores content metadata (hashes, votes), while actual data remains peer-to-peer.

Second, AI-BIM users are not Competitors in such a system, instead, They Complement each other. AI users' role is to expand solution space (e.g., 10 urban layout variants from a single idea seed contributed by creators). While BIM users are validators who narrow down options via simulated constraints. This bridges big data patterns with Newtonian physics to diversify balanced options.

Third, it is important to note that this system, while decentralised, possesses a certain level of centrality based on such evidence-driven mechanisms to create informed decisions.

Finally, and most importantly, PoAW is not a Proof-of-Stake. There will be no financial speculation as "Work" is a piece of contribution in the form of design content/compute. Also, this decentralised system has the goal to enhance built environment quality, not profit maximization. This create a computational market that circulate values beyond monetary:

- Data-for-data: Contributors trade datasets (e.g., open street maps for BIM analytics).
- Compute-for-compute: Each voting action contributes minute local resources (e.g., CPU for ML training).

The use case clarified these key conceptual ambiguities through processes of citizens crowdsourcing, BIM evaluation, expert voting, to iterating options until consensus (Nash equilibrium). This synergy enables scalable, transparent participatory design while mitigating centralization risks and "bad voting"—a core issue in many decentralised autonomous organisations.

5. Conclusion

The proposed decentralized index transforms Common Data Environments (CDE) into a self-organizing, p2p computational market where Ranking is democratized via blockchain-anchored voting and value flows as data/compute (not just money). This Eliminates central gatekeepers (e.g., Google, Facebook) to create content ranks that truly reflect collective preferences beyond corporate/advertising interests. Further, the AI-BIM interaction creates a calibrated feedback loop, where AI users explore possibilities and BIM users ground decisions in reality considerations. Rewarded via 21e8's incentive layer for improving built-environment outcomes, This enables users to retain control over their data/compute resources while creating validated options and mitigate "bad voting".

Through considering the integration between blockchain, BIM, and AI from both technical and socioeconomic perspectives, this study discussed how such forms of system design might prompt changes around architectural production. It elaborated on the idea of a computational data market and how it may aggregate the intelligence of both humans and machines, and continuously reproduce itself as a collective system. This tackled an urgent problem in large scale information systems—the ability to index and rank information, a consensus mechanism to validate work and content contribution. From these arguments, the study proposes the application of the 21e8 infrastructure.

Overall, the investigation exemplified how the system might work at three levels: a system design of the technologies and their communication, a user interaction design, and a presentation of data output from ML. On the technical side, it positioned blockchain as the shared data layer to be integrated with BIM's CDE, using JSON to store transactions on local desktops. On a conceptual level, it innovates creator/diversifier/validator roles: BIM evaluates content as a frame of reference and interfaces communication between a network of scattered actors, while AI algorithms are compute services that learn from crowd contributions to diversify design options. Along these lines, the study offered means to large-scale human-machine interactions, bridges proprietary and crowdsource efforts, automating decentralised indexing from real-time data streams.

Acknowledgements

This project emerged from a partnership with Mark Wilcox, a great friend who has truly inspired me throughout my journey to decentralisation. Also, I must thank Prof. Mario Carpo for his mentorship during my postgraduate study, who provided great support and guidance in bridging digital theory with design applications. Finally, many of these ideas first came to my mind when I was with the Strelka Institute, a stimulating arena under the direction of Prof. Benjamin Bratton.

Declaration on Generative AI

During the preparation of this work, the author used ChatGPT for grammar and spelling checks. After using this tool, the author reviewed and edited the content as necessary and takes full responsibility for the content of the publication.

References

[1] 21e8. (2022). The magic number company. https://21e8.nz/

[2] Brin, S., & Page, L. (1998). The anatomy of a large-scale hypertextual web search engine.

[3] HKSAR. (2019). Plan making. https://www.info.gov.hk/tpb/en/plan_making/participate.html

[4] Hummel, M., & van Kooten, K. (2019). Leveraging NVIDIA Omniverse for In Situ Visualization.

[5] Hunhevicz, J. J., & Hall, D. M. (2020). Do you need a blockchain in construction?

[6] Jentzsch, C. (2016). Decentralized autonomous organization to automate governance. White paper.

[7] JSON. (n.d.). Introducing json. JSON. https://wwwJSON.org/json-en.html

[8] Li, J., et al. (2003). On the feasibility of peer-to-peer web indexing and search. In International Workshop on Peer-to-Peer Systems (pp. 207-215). Springer, Berlin, Heidelberg.

[9] Microsoft. (2021). Windows Network Architecture and the OSI model.

[10] Nash Jr, J. F. (2008). The agencies method for modeling coalitions and cooperation in games.

[11] Neumann, J. von, & Morgenstern, O. (1944). Theory of games and Economic Behavior.

[12] NG, P. (2021). 21E8: Coupling Generative Adversarial Neural Networks (GANS) with Blockchain Applications in Building Information Modelling (BIM) Systems. CAADRIA

[13] NVIDIA. (2022). Omniverse™ platform. https://developer.nvidia.com/nvidia-omniverse-platform

[14] Page, L., Brin, S., Motwani, R., & Winograd, T. (1999). The PageRank citation ranking. .

[15] Pasquinelli, M. (2009). Google's PageRank algorithm: A diagram of cognitive capitalism and the rentier of the common intellect. Deep search: The politics of search beyond Google, 152-162.

[16] PennState. (n.d.). The OSI model. https://psu.pb.unizin.org/ist110/chapter/2-3-the-osi-model/

[17] Pschetz, L., Pothong, K., & Speed, C. (2019). Autonomous distributed energy systems

[18] Schrödinger Erwin. (1944). What is life?

[19] Tezel, A., et al. (2020). Preparing construction supply chains for blockchain technology

[20] Wiener, N. (1948). Cybernetics: Control and communication in the animal and the Machine. Wiley.