Blockerties

The Distributive Design of the Blockchain Technology and its Impact on Urban Form.

Daniel Koehler[1], Anna Galika[2], Junyi Bai[3], Qiuru Pu[4]
[1,2,3,4]The Bartlett School of Architecture, UCL London
[1,2,3,4]{d.koehler|anna.galika.17|junyi.bai.17|q.pu.17}@ucl.ac.uk

This paper aims to link the blockchain technology with property issues and in extend architectural design decisions at the urban scale. In an urban design context, this paper investigates the new potentials of urban form connected to the application of the logic of the blockchain to urban design. With this, the article concentrates on the distributed way of sharing information, with no intent to focus on cryptography issues related to the blockchain. Transferring the blockchain's core concepts of data distribution through ledgers, to patterns of shared and private owned spaces it can lead to what we propose as polyphonic spaces, with overlapping uses. Urban realm, designed as a chain, initiates with the binary condition of private and shared but handles it as a way to interact, through nesting, its initial parts. We think that the blockchain theory is capable of challenging architecture by shifting the weight from individual elements of composition to compound entities (block) that incorporate all the information needed.Please write your abstract here by clicking this paragraph.

Keywords: *Blockchain, Urban Form, Combinatorics, Typology, Mereology, Aggregative Architecture*

Since the beginning of its discursive consideration, one can observe a steadily down-shrinking of a city as an object, as a fabric, as a project, as a composition of parts, to the organization of separated entities. So today, inherent to the postmodern condition, as already suggested by Collin Rowe and Fred Kotter in their book 'Collage City' (Rowe et al, 1978), is to see the city as a fragmental whole, composed by the remnants of the past and other artifacts. By examining a city in this way, we understand that it is a composition of additive and interlinked data assets. The same principle but with a different manifestation is followed in the Archipelago City, proposed by O. M. Ungers. "[...] the city as a whole is formed by the federation of the all these urban entities with different structures, developed in a deliberately antithetic manner" (Ungers, 1983). According to this idea, the city needs to be re-edited to form a series of strategic islands -which are an independent whole with their own center and independent characteristics, and also part of the city. Finally, "a 'loose fit' is proposed between activity and enclosing envelope."

(Allen, 2009). Stan Allen, translating the city to the digital realm, regards the city as composed of many figures, comparable to the blocks of a chain, all of which are loose to each other. The traits of each part will appear in the whole city and interact with each other. In other words, we could discretize the city as a series of parts.

In the realm of digital technologies, blockchain is a newly introduced concept that aspires to become a new foundational technology. Already, the first application of the blockchain theory has changed the way economic transactions are handled (www.forbes.com). Foreseeing this technology to be expanded in other fields, this project speculates on how the blockchain can be spatially applied at an urban scale. While there was already a theoretical background that could architecturally foster technologies that promote parts and discretize city fragments, only now we can start describing and understanding the city and its parts with specific terms, these of a blockchain. The research described in this paper builds on recent interest in combinatorial assemblies and aggregatory architecture (Carpo, 2017) and their scalability to urban design.

The blockchain can be seen as a progression of peer to peer network protocols, like the TCP/IP facilitating the internet (Britto, 2013). Characteristics of blockchain such as the distributed ledger network, anonymous trust system and information untamperability enable the transfer from network economies from the digital to the physical, from online to offline leading to the internet of things. That opens the opportunity to imagine architecture in an unprecedented manner. Seeing the city in the light of the blockchain technology understandings of what privacy, ownership, and share-ability is, are entirely altered. What the blockchain proposes is that each block consists of a private data structure and a shareable entity, that go hand in hand as one entity. In the architectural discourse, this means that each block to exist should have a shared space alongside the private one. This kind of thinking explores new opportunities of reading and designing a new form of urban realm, that can be comparable to what it is already described as a block, a slab or a high-rise, that this time does not prioritize shared or private spaces but takes both at the same time under consideration.

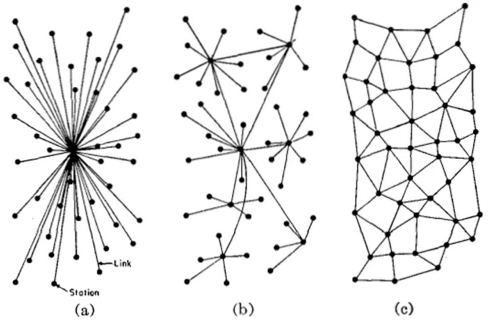


Figure 1
Networks: (a) centralized (b) decentralized (c) distributed. Source: Baran, P. (1964), On distributed communications: Introduction to distributed communications network, The Rand Corporation.

WHAT IS A BLOCKCHAIN?

The blockchain, is a new foundational technology, meaning it has the potential to alter and "establish new foundations for our economic and social systems" (Iansiti,2017). The blockchain technology allows building decentralized databases (see Fig.1) storing a registry of assets and transactions across a peer-to-peer network without the necessity of a third party (www.ibm.com). A blockchain is a distributed electronic ledger□-□a set of records available to all parties on the ledger which is immutable, i.e., cannot be changed, only added to. Any additions to the ledger have to be agreed by all parties using a mathematical proof, and everyone can inspect the ledger. While the block remains unpenetrable -private to only its creator, at the same time, it can be inspected by the whole ledger. There is no assumed trust or faith that the records are correct; they are proven to be accurate by computation by multiple independent parties. Secured through cryptography that transaction history gets locked in the blocks of data that are then cryptographically linked together and secured. As a result, an permanent and unforgeable record is created. And then this record is replicated on every computer that uses

the network. That means, we can create a shared reality across non-trusting entities, and users can monitor and validate the chain for themselves. The blockchain concept prospects that the proprietary and centrally controlled platforms today can be replaced with distributed, open ones; trusted parties replaced with verifiable computation; and inefficient monolithic services replaced with peer-to-peer algorithmic markets.

Due to the application of cryptography in the blockchain, one can use blockchain to create a new relation to contemporary property rights, in which high share-ability and communicable property rights can be achieved. Based on the "partial property rights" concept, real estate sharing and exchange of property rights can be guaranteed. As a result, real estate ownership is no longer immutable -it becomes user-friendly and can be changed through negotiation. Such changes will be recorded in the distributed ledger by blockchain technology as well as updated throughout the whole database. It is foreseeable that to enable such an economic dynamic in a static, physical structure of a building, the pattern of linkage between "assets" must meet specific necessary prerequisites: i.e., it has to possess the capability of distribution. For this reason, we expect that real estate markets based on blockchain technologies will promote and lead to new urban forms. This research intends to identify the characteristics of a building that play a decisive role in this development. The following studies are therefore not to be seen as building proposals, but as a careful linking of computational models of the blockchain with built form.

OBJECT ORIENTED PROGRAMMING AND THE BLOCK.

The blockchain relies upon the object-oriented programming paradigm, where data and execution code is stored in the same place, called an object: the block. The data block uploaded from each transaction contains several pieces of information: timestamp, sender, recipient, transaction cost, and data. The data at the end of the block is used to record the establishment and execution of the smart contract. In the design project, this information contains the circumstances of the use and transaction of different space elements. The information is uploaded to the network for analysis, to calculate the number of connection and disconnection of the block with other blocks. When this information is stored and secured, the object acts like a black box that nothing can alter it but on the same time updates and informs the copies of itself inside the blockchain. So when an object is defined, it is allowed to perform only the way that it is designed, keeping it safe and ensuring the trust between the transactions. The state of the whole blockchain system is only modified when the block is 'sealed' and attached to the chain. Blockchain's object-oriented architecture ensures that the parts inside the system are discrete and accessible at any point of it, but that does not mean that the whole is discrete as well. On the contrary, it remains on purpose a vast, incomprehensible whole. Because the new proposed form is built upon the distributed model, a further crucial aspect of the blockchain logic is now in the spotlight -that of the accessibility. The way a blockchain is structured grants accessibility to every participant of the chain. However, due to the non-trusting parts involved in the transactions, whatever is added has to be agreed on. This, on its premises, leads to a different form of feedback between the building parts. The requirement of accessibility (value, ownership, not necessarily navigation) leads to new notions of share-ability.

Regarding the blockchain, the distributed system means there aren't single nor multiple central storages. Correspondingly, the decentralized city means there isn't a single center, nor multiple clusters with their own center. What distribution proposes is an individualistic approach which handles each object separately with no intent to create a whole. All of the single nodes in the chain contain the data, and this makes them equal with equal rights. Regarding the city, the distributed city means there is no preconceived center or cluster. The relationship of the blocks in the city become peer-to-peer. That

means, the pattern of a city would follow local demands defining the spatial hierarchy, as opposed to bottom-up masterplanning (the third party), resulting in a highly mixed and shareable city.

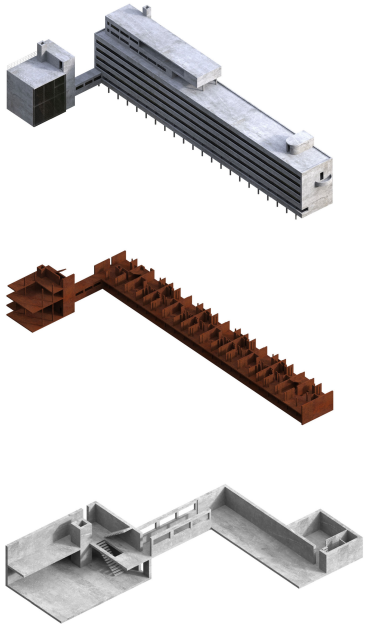


Figure 2
3D model representation of the Narkomfin Building by Moisei Ginzburg and Ignaty Milinis in Moscow, 1928. The extracted block consists of a private and a shared entity and a bridge as their connection.

FROM BUILDING TO BLOCK: DISCRETIZATION OF ARCHITECTURAL PARTS.

Seeing the building as a single blockchain, the mereological extraction process differs a lot than seeing it as a plain architectural composition. While before, a building could be described as columns, floors, façade, or elsewise as structure, navigation, shell, with the blockchain description, elements have a compound meaning. That means that structural elements like walls and columns can be navigational or façade parts. Moreover, the composition of a building does not handle the elements as single layers added on top of each other, but investigates the inherent features of each one and connects them under the scope of cost, circulation and environmental needs. The first step, thus, is to recognize conditions and qualities existing in buildings that can be subtracted from them, yet retaining their connections to the whole but at the same time be independent. What now is the compositional element is the block, which can be self-existent and self-explicable. This mereological description focuses on the closed, as private, and the open, as shared entities as well as their connecting elements (see Fig.2). So, what matters in the extraction is the block from which we can represent the building as a data structure, allowing us to capture all the relevant information that can be then used algorithmically. From the whole, extracting the relevant part and then translating it into a data scheme we can represent the requirements of a building, but this time with the connections that compile with the blockchain thought.

As can be seen in figure 3 and 4 one block can consist of walls, corridors, stairs, roofs, etc. For the sake of defining private and shared space, the standard of private and shared is defined and distinguished by the walls. In a block, there are multiple ways of connection or else navigation inside it. The way to describe the part as data asset follows a cost to connect or elsewise cost to move system ('transaction'). A sequence of space then could be to join corridor - stair - corridor - stair - stair - roof and that would give the cheapest cost of 6. It can be seen that the more private elements require a higher transaction cost, thus making the system more expensive. The private and shared is relative. When it comes to a house, each of the rooms in it becomes private, while the living room, kitchen, and stairs are shared. When it comes to a building, each of apartments in it is private, and the staircase, corridor, and lobby are shared. In an urban scale, we define each of the blocks are private space, while the outside spaces are shared, such as the courtyard, street, plaza, and park4

A multi-objective programming is then used, at first to evaluate the connectivity and in a next level

Figure 3
Block 3. The abstraction of geometrical elements into data scheme of nodes and edges.

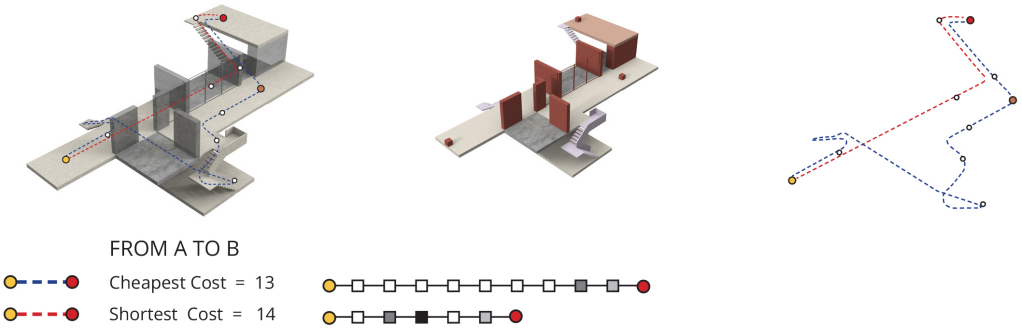
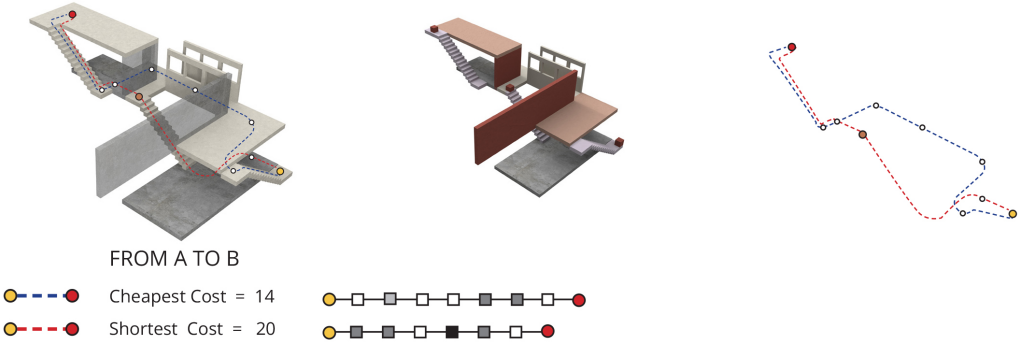


Figure 4
Block . The abstraction of geometrical elements into data scheme of nodes and edges.



to aid decision making through machine learning. There are two cost structures, the first one deals with distance to move from one space to another and the second one gauges the privacy of the elements inside the part. Both systems, as described above, set a starting point and a target to evaluate the efficiency of the part. Afterward, the block definition is sealed, and it only keeps open its connection points. That allows us to examine at the same time a graph definition of large aggregations according to the external connectivity of the element. Each record includes a 'transaction' timestamp, and a block of detailed information is considered a block. The information is all connected and encrypted. Therefore, it is credible and immutable.

INSCRIBING PROPERTY RIGHTS.

With the above mereological descriptions, the question of possession inside an object arises. There is a weird gap between what is owned by what inside an object. Part's rights are based on property rights, so that being in possession of itself is one criterion of having them. In the shared economy described

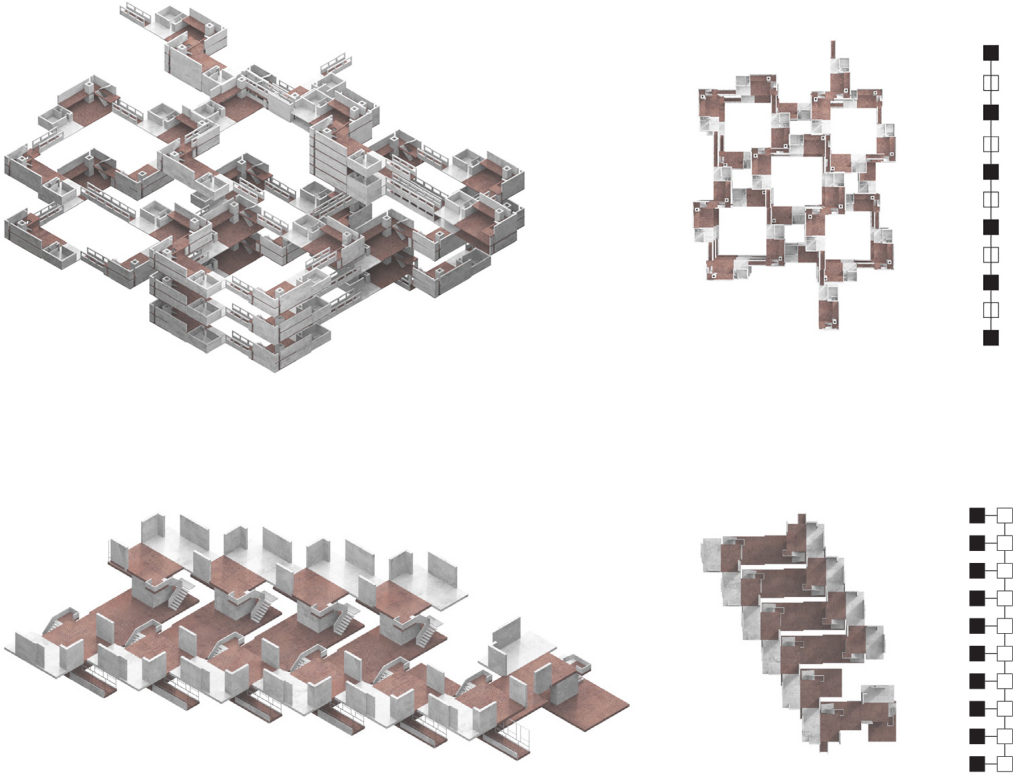


Figure 5
Small aggregation consisted of a block with bridge - private – shared conditions that results in ring figures with courtyards.

Figure 6
Small aggregation consisted of a block with private - shared – bridge conditions that results in a linear system with overlaps.

above with the blockchain example, there exists a shareability of elements inside the object. In that case, there are defined three entities -two of them compiling the third. Concerning ownership, each entity is on possession of itself -even the whole, but each of them own membership in the collection, either extensionally (by the parts that belong to it) or intentionally (by the same shared feature among the elements). Parts are objects in their own right while being parts of larger objects, the ones they are subtracted from. What makes this realization interesting is that the parts are not defined by their relations with other objects, but can consist on their own and also can be detached from the whole.

The property right is "a theoretical socially-enforced power to assign the resource in economics" (Alchian, 2008). The processes of operating property rights include "making decisions and allocating benefits" (Field and Ostrom, 1992). Property rights "emphasise on the collective that can support the claims that people possess resources" (Sauri-Pujol and Bromley, 1992). Actually, property rights "record the relationships between the participants involving and the shared resource" (Demsetz, 2002). Besides, establishing and applying the property rights can impact the effectiveness of benefit allocation and shar-

ing. From the traditional perspective, "the long-term and well-defined property rights drive a sustainable and equitable benefit stream managed by participants, while the indistinct property rights generate evasive benefit distribution" (Ostrom,1992). In the realm of urban design, with the technology of the blockchain, a description of a property is not constrained to the extrusion of a ground. Here, notions of property build and interpret other elements as 'ground.' By 'ground' is here stated the value generation of a plot. Such shared conditions are already part of our built environment; the simplest example is the compartment wall and ceiling between condominiums. One aspect of the research is, therefore, the documentation and extraction of existing property relations other than the plot and the ground. In a further step, defined as states, these relations are tested for their scalability through an assembly model constructed by finite-state-machines. Here, the concept of the blockchain was translated into a reward-policy documented by a graph-data-structure. That allowed the classification of building assemblies and the comparison of blockchains and their value distribution.

As can be seen in figures 5-7 a building arrangement can be composed of the same block, with likewise definition as it was before explained. This time, what defines the sequencing of space is the external connectivity of the block -this means the possibilities of connecting with another block, while at the same time, zooming out and retaining only the private/shared information needed. In this arrangement, it is seen an alternating sequencing of private and shared that can form a building type that is based, for instance, on courtyards.

INVESTIGATION

When the aggregations are understood as city parts, it can be seen how the patterning of private and shared spaces are now not solely defined by their binary definition. Here, shared spaces can take the place of road network infrastructure, or pathways, while at the same time they can be spaces of gathering and form plazas. On the other hand, private entities can have a range of shareability according to the connectivity of the element. What is here proposed is an InterChain (Kruijff et al., 2017), a chain of chains that can define a city structure compiled by different degrees of shared spaces. This aggregatory method is capable of creating polyphonic spaces with inherent features, like navigation, and structural definitions that can on the same time be eligible to diverse readings. That is because of the large-scale effect, that leads to ambiguity but with specific variable design characters.

While forming InterChains, as seen in figures 8-11, what is essential is the large-scale effect that fades the interconnectivity but focuses on the distributed patterns. In this arrangement, there is witnessed two types of patterning, and this stems from the exter-

Figure 7
Small aggregation consisted of a block with open - 3 semi-open and 3 closed conditions that results in a linear system with overlaps.

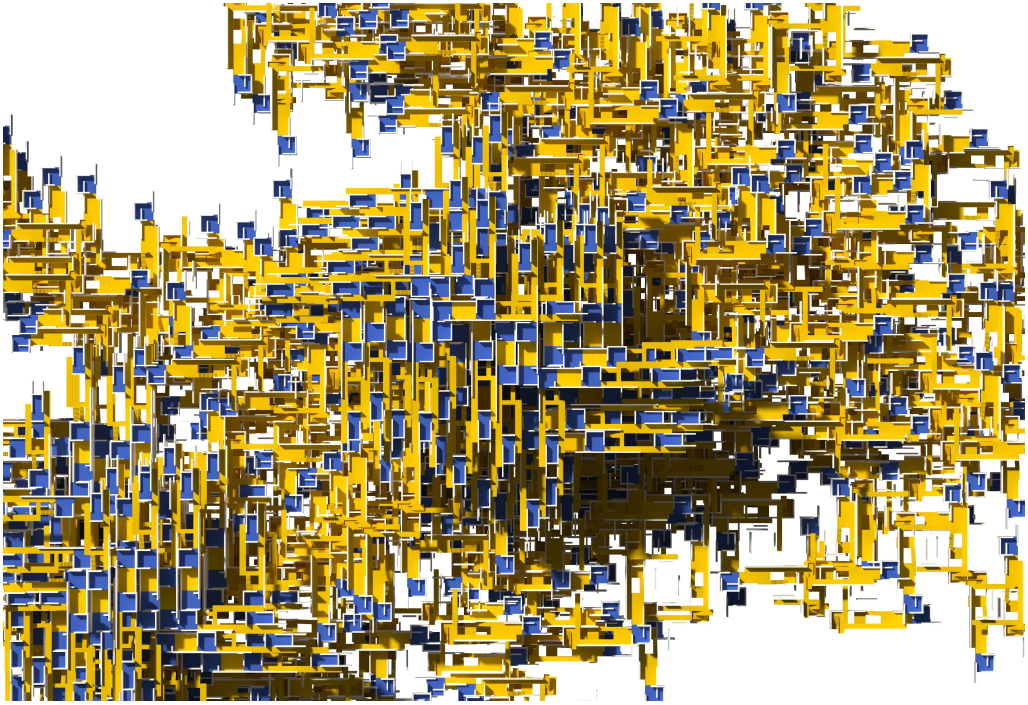


Figure 8
InterChain C3B2, Combination of two chains result is a new interchain with cost 1450.

nal connectivity of the block. While the two forms merge with each other, it can be seen how on the one hand private spaces (blue) can cluster together, while the yellow, navigational space is always connected. On the other hand, the connectivity of the block suggests a more dispersed private space while the prevailing space of the chain is the navigation. Moreover, the share-ability is according to the efficiency and the accessibility of the shared space, which is defined by how many private parts can connect to the shared part. When the shared part connects to the shared part, there is a hierarchical structure created. The share-ability can have a different degree from the highest to the lowest.

OUTLOOK.

The research shown intends to explore the possibilities of spatial sequences through the application of the blockchain theory. Here, as a first introduction of the computational concept to urban design, it was essential for us to point out potential design strategies that are not based on traditional masterplanning. In a further step, closer investigations interlinked with navigation patterns, programmatic distributions, and structural performance will be necessary.

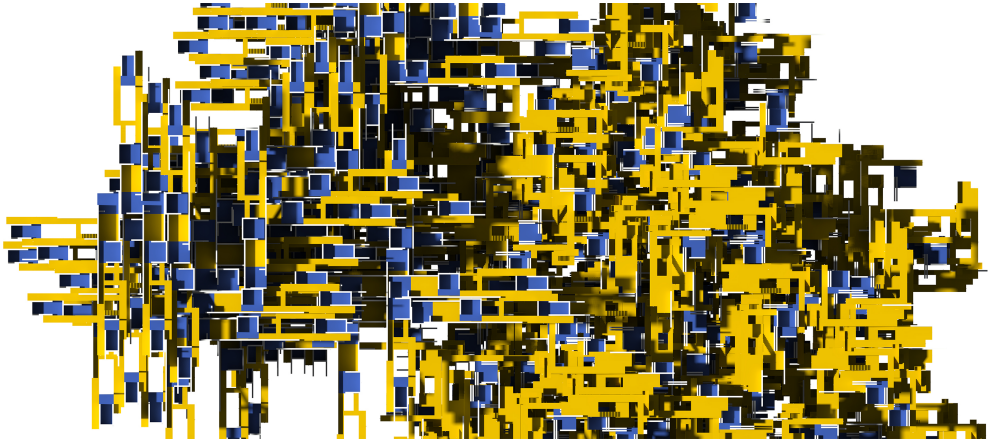


Figure 9
InterChain A3C2, Combination of two chains result is a new interchain with cost 1220.

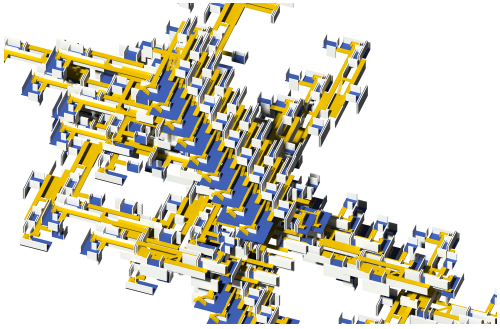


Figure 10
InterChain B6A1, Combination of two chains result is a new interchain with cost 950. (axonometric view)

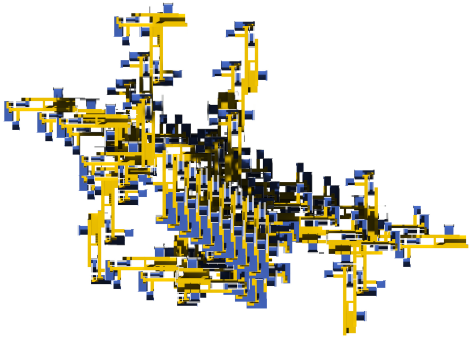


Figure 11
InterChain B6A1, Combination of two chains result is a new interchain with cost 950. (plan view)

REFERENCES

Alchian, A 2008, *Property Rights*, New Palgrave Dictionary of Economics

Allen, S 1977, 'From Object to Field', *AD Architectural Design*, 67, pp. 24-31

Baran, P 1964, *On Distributed Comunications: Introduction to Distributed Communications Network*, The Rand Corporation

Castillo A Britto, J 2013, *Bitcoin, A primer for policymakers*, Mercantus Center, George Manson University

Carpo, M 2017, *The second digital turn: Design beyond intelligence. Writing architecture*, The MIT Press

Catalini, C and Joshua, S 2016, 'Some Simple Economics of the Blockchain', *SSRN Journal*, 10.2139/ssrn.2874598, p. 12

Colin, R and Koetter, F 1978, *Collage City*, MIT Press

Demsetz, H 2002, *Toward a Theory of Property Rights II: The Competition between Private and Collective*, The American Economic Review

Field, B and Ostrom, E 1992, 'Governing the Commons: The Evolution of Institutions for Collective Action', *Land Economics*, 68, p. 354

Haber, S and Stornetta, W 1991, 'How to time-stamp a digital document', *Journal of Cryptology*, 3, pp. 99-111

Ingo, W, Mark, S, Liming, Z, Jan, B, Len, B, Cesare, P and Xiwei, RPX 2017, *A Taxonomy of Blockchain-Based Systems for Architecture Design*, Ph.D. Thesis, USI Lugano

Jose, S 2015 'Block'hood - Developing an Architectural Simulation Video Game', *Proceedings of the 33rd eCAADe Conference*

Karim, R and Iansiti, M 2017, 'The Truth About Blockchain', *Harvard Buisness Review*, 2, p. 12
Klaus, S and Nicholas, N 2018 'Shaping the Fourth Industrial Revolution', *WORLD ECONOMIC FORUM*
H Kruijff, W 2017, *Towards a Blockchain Ontology*, Master's Thesis, Tilburg University
Marullo, F 2015, 'Logistics Takes Command', *Log*, 35, pp. 103-120
Ostrom, E 1992, 'Common-pool resources and institutions: Toward a revised theory', *Handbook of Agricultural Economics*, 2, pp. 1315-1339
Ostrom, E and Schlager, E 1992, *Property-Rights Regimes and Natural Resources: A Conceptual Analysis*, University of Wisconsin Press
Tasca, P 2018, *Taxonomy of Blockchain Technologies. Principles of Identification and Classification*, Master's Thesis, UCL Centre for Blockchain Technologies, University of Zurich
Ungers, OM 1983, *Die Thematisierung der Architektur*, Deutsche Verlags-Anstalt
[1] https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/
[2] https://www.ibm.com/developerworks/cloud/library/cl-blockchain-basics-intro-bluemix-trs/index.html
[3] https://thenextweb.com/contributors/2017/11/28/ultimate-2000-word-plain-english-guide-ethereum/
[4] https://www.coindesk.com/blockchain-land-registry-solution-seeking-problem/
[5] https://www.economist.com/briefing/2015/10/31/the-great-chain-of-being-sure-about-things