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Blockchain at the Edge: The Nexus of Capturing New Value in 5G

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INTRODUCTION

5G is poised to transform mobile into a general purpose technology [1], just like the printing press, the steam engine or electricity, which promises to impact entire industries and economies profoundly, triggering transformative changes and elevating the living standards of people around the world. 5G is meant to be the foundation of our digital society, providing high speed, high bandwidth and low latency connections, as well as connectivity to the 15 billion Internet of Things devices expected online by 2022 [2]. Compared to previous generations of communications networks, 5G marks a distinctive shift from merely improving the technical aspects of communications to supporting a wide array of new services and applications. Indeed, one of the main objectives of 5G is to open up new business opportunities in very different market sectors, called verticals, such as automotive and transportation, healthcare, media and entertainment, energy, smart cities and smart factories. In a sense, 5G is business driven, as these heterogeneous business verticals rely upon 5G connectivity for their actual implementation and deployment.

VALUE CREATION DOES NOT IMPLY VALUE CAPTURE

Mobile data traffic has exploded in the last decade, growing 1800x in the decade 2006-2016 [2]. To a large extent, however, network operators have not succeeded so far to monetize this growth and the massive amount of data flowing through their networks. One of the reasons for this was the value shift that occurred during the same time period in the mobile sector, moving the value away from connectivity services to content, from the network infrastructure to the web services and apps running on top of it, and which have largely benefited platform companies and over the-top (OTT) players [3] but not mobile network operators (MNOs). In fact, in the past decade, operators were instrumental to the creation of value in the telecommunications ecosystem, namely by improving their 3G/4G networks, providing faster connections and larger

bandwidths, and enabling new web services and apps to run on top of their networks, yet at the same time they failed to capture (i.e. monetize) the value that they contributed in creating.

5G brings a new exciting opportunity for MNOs, as different types of applications and traffic will be served by their network. This multiplicity of services and applications will fundamentally redefine the value framework in 5G networks and beyond, especially as machine-centric communications will be supported in 5G [4] and vertical industries start playing a bigger role in 5G. The implications of this change are profound as the entire value chain in the sector is redefined and the economic opportunity grows to become huge. Estimates evaluate that the global 5G value chain alone will generate $3.5 trillions in output in 2035 and $12 trillions of global economic activity, including related industry sectors and verticals [1].

5G and Edge Computing at the Backbone of New Value Creation

With the advent of 5G, the economic value is again shifting back to the network itself, and the services that it will enable. New value creation will be driven by ubiquitous massively distributed access [5] on the radio access side, and by software on the core network side [6], where distributed edge clouds will play a pivotal role. It will be up to operators to make the most of this opportunity and extract the most out of this newly created value.

The distributed cloud or multi-access edge computing (MEC) [7] aims at providing cloud computing capabilities within or close to the radio access network, which is achieved by co-locating local computing servers with base stations or access points, or at least deploying the MEC servers in their close vicinity. By shortening the physical distance between the locations where the data or the computation is consumed (the mobile device) and where it is stored or provided (the MEC server), edge computing allows for delays lower than 5ms and permits to overcome the fundamental physical limitation, namely the propagation delay, that besets cloud communications and processing.

Edge computing permits a paradigm shift towards a more local and distributed network where services are at the centre of the system design. The edge cloud provides an efficient platform where mobile edge applications run as virtual machines on top of a virtualization infrastructure, serving new services and applications close to the mobile device and in turn enabling new business models. This is ultimately the real novelty of 5G and its congenital reason to exist, and which distils the real added value brought about by 5G: its capability of creating new business opportunities and unlocking new value creation.

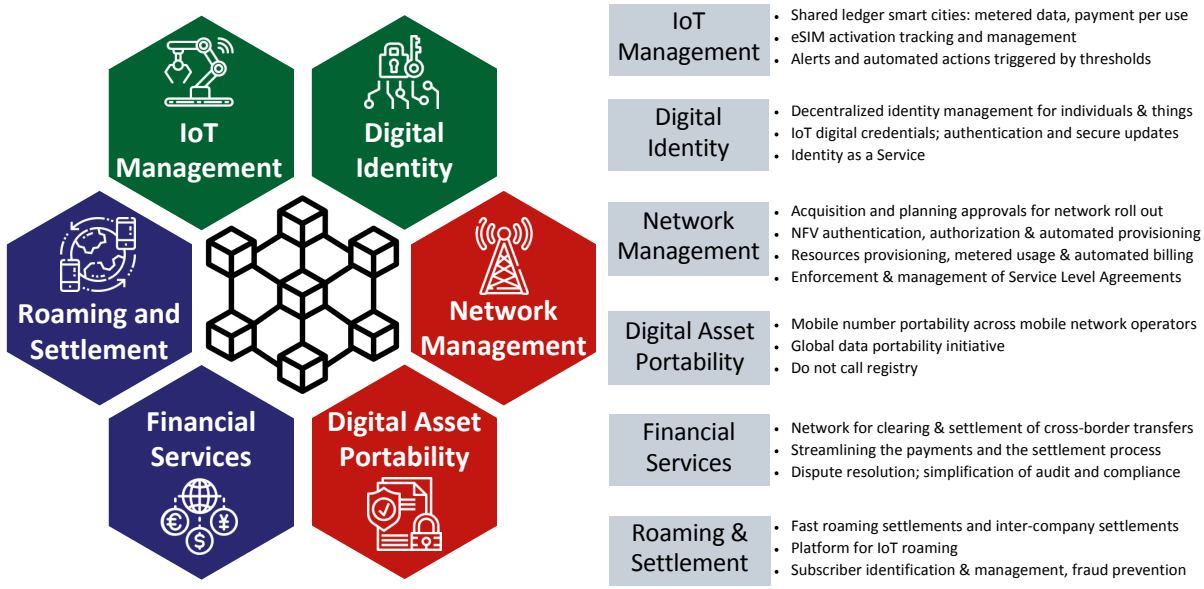

Fig. 1: Blockchain use-cases currently being discussed for 5G.

Blockchain as the Nexus of Capturing New Value in 5G

Value creation is, however, just one element of a successful business model, the other two being value delivery (not addressed here) and value capture [8]. 5G and its service-based architecture puts MNOs in a privileged position to capture the new value created through their networks. On the other hand, blockchain or distributed ledger technology (DLT), provides the ideal platform to do that in a seamless and autonomous fashion. Blockchain permits to automatically record events and transactions, and bundle them into blocks which are cryptographically secure, creating an immutable ledger that is shared among the different parties involved [9].

The advantages of implementing a DLT solution at the 5G edge are manifold. For instance, sharing data in a secure and transparent manner permits to reduce disputes across the different parties, and the shared ledger provided by the blockchain can be used to automate transactions and accounting. Additionally, the blockchain creates a secure record of identities not only of people but also (and especially) of things, assets, sensors and machines. Any interaction that occur with an asset can then be recorded onto the secure ledger, which in turn can be used for asset tracking, for metering or simply as a secure log. Finally, distributed ledgers offer the potential to simplify 5G highly complex and dynamic networks, for instance in respect to the provision of rules to access networks, and for authentication of devices onto these networks.

Some interesting applications and use-cases of DLT systems that are currently being discussed for 5G are shown in Figure 1.

Blockchain and MEC go hand in hand as they are both distributed by definition, and the edge cloud is the ideal place to implement DLT, given its vantage within the network, exactly where services are provided to the mobile device. For instance, a blockchain implemented at the edge can manage authentication for IoT networks, which are often fragmented into a myriad of protocols, simultaneously solving the scalability and security issues of centralized architectures. Furthermore, a DLT at the edge provides an effective platform to monetize the applications that run on the edge cloud. Applications can be billed in real time based on the precise amount of resources –communications, computing, caching [10], or a combination of these– that they use.

A high-level layered architecture for implementing blockchain systems within the edge cloud is shown in Figure 2. The business logic layer provides a higher level interface with the blockchain network layer, providing a stratum that connects the business world with the blockchain layer and abstracting the inner parameters of the DLT in use. This layer also provides an interface for managing the read/write permissions of each application to interact with the ledger. For instance, an application managing the authentication of IoT sensors may only be allowed to check (*read*) an identity from the blockchain, whereas an asset tracking application may also be able to update (*write*) the current status of an asset.

The business logic layer can also calculate the precise amount of resources that an application has consumed, and communicate this information to the business system layer, which in turn generates the billing details and forwards them to the (legacy) Business Support System (BSS)

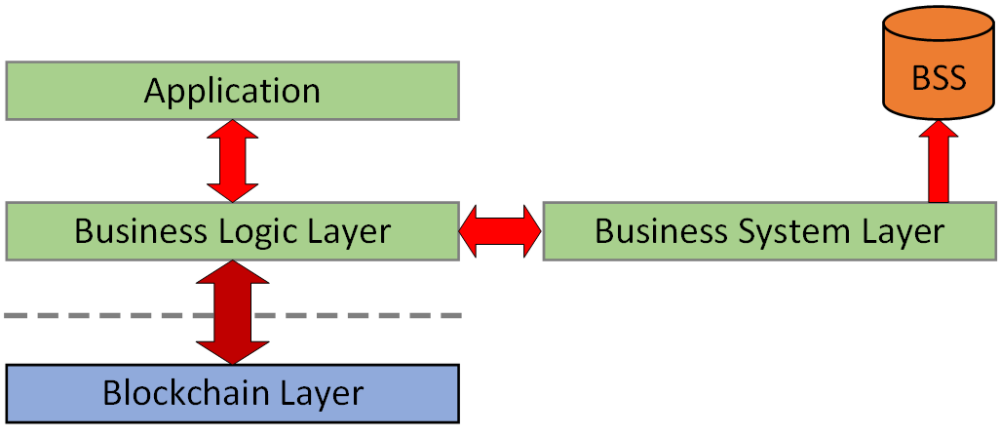

Fig. 2: Layered Blockchain Edge Architecture.

of the network provider. The unit price of each resource may also be stored securely on the ledger and asked/pulled via the business logic. As blockchain platforms for communications systems become mature, the BSS itself may disappear and its functionalities integrated within the business logic layer of the DLT. Finally, the blockchain layer deals with all functionalities of the DLT at the block level [9], from keeping the system state consistent across peers, performing validity checks of new transactions committed to the ledger, and ensuring the immutability of past transactions.

The separation between the business logic and the blockchain layer also allows for a greater flexibility with respect to the deployment. Each layer may be a virtualized entity that is accessed via specified APIs, thus the blockchain network layer can run either on the edge cloud itself or somewhere else within the core network. This layered architecture also supports hierarchical implementations, where different blockchain layers run in different physical parts of the network.

CONCLUSION

5G propels mobile technology into the exclusive group of general purpose technologies that have marked the evolution of our history, and unlocks a $12 trillion business opportunity. 5G brings yet another value shift in the mobile communications value chain, shifting once again the economic value back to the network and its software. In the same way that edge computing is the nexus of creating new value in 5G, blockchain is the fulcrum of capturing that new value.

REFERENCES

[1] IHS Economics and IHS Technology, "The 5G economy: How 5G will contribute to the global economy," Jan. 2017.

[2] Cisco, "Cisco Visual Networking Index Forecast and Trends 2017-2022," Cisco White Paper, Feb. 2019.

[3] M. Van Alstyne, "Platform Shift: How New Business Models Are Changing the Shape of Industry'," MIT Sloan CIO Symposium, May 2015.

[4] C. Bockelmann et al., "Towards massive connectivity support for scalable mMTC communications in 5G networks," IEEE Access, vol. 6, pp. 28969-28992, May 2018.

[5] H. Q. Ngo et al., "Cell-free massive MIMO versus small cells," IEEE Transactions on Wireless Communications, vol. 16, no. 3, pp. 1834-1850, Mar. 2017.

[6] M. Weldon, "The Future X Network: A Bell Labs Perspective," CRC Press, Mar. 2016.

[7] ETSI GS MEC 003, "Mobile Edge Computing (MEC); Framework and Reference Architecture," v2.1.1, Jan. 2019.

[8] D. J. Teece, "Business models, business strategy and innovation," Elsevier Long Range Planning, vol. 43, no. 2-3, pp. 172-194, Apr. 2010.

[9] F. Miatton, "The Blockchain Recipe," preprint, 2020.

[10] H. Liu, Z. Chen, L. Qian, "The Three Primary Colors of Mobile Systems," IEEE Communications Magazine, vol. 54, no. 9, pp. 15-21, Sep. 2016.