

Blockchain- Edge Computing Systematic Literature Review

General Topic: Edge Computing and Blockchain

Studied Perspectives: In this systematic literature review (SLR), we study the following perspectives:

1. **Blockchain Advancing Edge Computing (Perspective 0):** Exploring how blockchain technology can enhance the capabilities and functionalities of edge computing.
2. **Edge Computing Advancing Blockchain (Perspective 1):** Investigating how edge computing can improve the efficiency, scalability, and performance of blockchain systems.
3. **Mutual Benefits of Edge Computing and Blockchain (Perspective 2):** Examining how the integration of edge computing and blockchain technology can create synergies that benefit both domains.

The following shows the systematic framework used to structure, plan, and conduct research, i.e., methodology. This methodology outlines the steps and criteria used to identify, select, evaluate, and synthesize relevant research papers. The records of bibliographic information for the studied papers are available in the file ReviewedRecords.xlsx, which includes separate sheets detailing the results of each step in the process. The following list details the specific steps taken in our SLR methodology:

1. Formulate a Candidate Search Query: Develop an initial search query based on the Systematic Literature Review (SLR) topic.
2. Refine the Search Query: Execute the candidate search query on various databases, analyze the results, and iteratively refine the search query and scope.
3. Finalize Search Parameters: Determine the final search query, databases, and scope (see Table 1 for details).
4. Collect Relevant Papers: Use the final search query to gather papers and their bibliometric data from the selected databases.
5. Merge Data and Remove Deduplicate: Combine the collected papers and bibliometric data into a single dataset, removing any duplicates.
6. Filter Predatory Papers: Exclude predatory papers using reputable lists Such as <https://beallslst.net/>
7. Illustrate Preliminary Results: Present the results from steps 2 to 6 in tables or plots.
8. Screen Papers: Apply exclusion criteria to the downloaded papers and bibliometric data (criteria listed in Table 2).
9. Cross-Validate Exclusion Criteria: Have different reviewers cross-validate the exclusion criteria.
10. Identify Survey/Review Papers: Mark survey and review papers for a separate study.
11. Remove Short Papers: Eliminate short papers that are extended elsewhere through a systematic and manual decision-making process.
12. Illustrate Screening Results: Present the results from steps 8 to 11 in tables or plots.
13. Develop Taxonomy: Build study dimensions towards a taxonomy based on Nickerson et al.'s method for taxonomy development in information systems.
14. Review and Extract Dimensions: Review the papers and extract study dimensions (see Table 3, 4).
15. Unify and Encode Dimensions: Standardize the values of dimensions and introduce encodings.
16. Cross-Validate Dimensions and Encodings: Validate the dimensions and encodings with reviewers.
17. First Round of Feature Extraction: Perform the first review round of feature extraction.
18. Repeat Feature Extraction: Conduct a second round of feature extraction.
19. Analyze the Feature Dataset: Apply descriptive statistics, statistical tests, and machine learning techniques to analyze the dataset of study dimensions.
20. Write the SLR Paper: Compile and write the SLR paper based on the findings.

Table 1. Query and Search Date Bases

Search query specification	
Data Bases	<ul style="list-style-type: none"> - Scopus - Web of Science - Science Direct
Search Query	("distributed ledger" OR "distributed-ledger" OR "DLT" OR "blockchain" OR "smart contract" OR "consensus" OR "crypto" OR "Web3" OR "dApp") AND ("edge" OR "fog" OR "edge-to-cloud") AND ("computing" OR "system" OR "network" OR algorithm)
Search Scope	Title OR Abstract OR Keywords
Search Limits/Exclusions Criteria	<ul style="list-style-type: none"> - Time period: 2015-2022 - Language: English - Publication type: Journal and conference papers excluding editorials, letters, book chapters, etc.
Information Recorded for Papers	<ul style="list-style-type: none"> - Paper text - Bibtext entry with standardized bib entry and the following: <ul style="list-style-type: none"> o Title o Abstract o Authors o Other information that the data base provides

Table 2. Exclusion Criteria

Exclusion procedure	
Exclusion criteria applied to steps 5-11 of the methodology.	<p>First set of ineligibility criteria applied systematically:</p> <ul style="list-style-type: none"> - Papers not written in English. - Short papers (<=4 pages), glossaries, extended abstracts, tutorial, book chapters, poster papers, position/retrospective papers - Survey/review papers - Papers published in predatory and non-peer-reviewed conferences/journals - Papers that are older/shorter papers that are extended elsewhere <p>Second group of exclusion criteria applied manually in two stages outlined below:</p> <ul style="list-style-type: none"> - Publication type: Exclusion of articles categorized as reviews or surveys, ensuring inclusion of original research papers: Survey/Review/SLR paper (1), Research paper (0) - Relevance: Determination of whether the paper aligns with one or both study perspectives: BC2EC (1), EC2BC (2), ECBC (3), None (4) - Results: Evaluation of whether the study contains an assessment or proof of concept (0) or not (1). - Application domain: Examination to ensure the study focuses on software (0) rather than only hardware applications (1). - Papers that are older/shorter papers that are extended elsewhere.
Two stages of manual screening	<ul style="list-style-type: none"> - Title/Abstract screening: This is when the titles and abstracts of each article are scanned to mark obviously irrelevant studies. At this stage some papers may remain undecided. - Full text screening: Here we review the full text of a paper and carefully examine its compliance with the inclusion criteria.
Reviewer	<ul style="list-style-type: none"> - With two independent reviewers - Has a good knowledge of the topic - Has a thorough understanding of the exclusion criteria developed in our protocol - Screen independently to avoid influencing each other
Regular discussion meetings	<ul style="list-style-type: none"> - To reassure of the classification of papers in correct category

Table 3. Study Dimensions

<p>Study Dimensions</p> <ul style="list-style-type: none"> ■ If a dimension is not mentioned in a paper, fill that dimension with "None". ■ If there are multiple items for a dimension, they should be formatted as follows: for D5, use "AL (matching) [1], MO (inference) [2]". Items are separated by commas, explanations are in parentheses, and the perspective (BC2EC [0], EC2BC [1], ECBC [2]) is encoded in brackets. 	<ol style="list-style-type: none"> 1. D1: METH: [0 1] The paper is a methodological one or makes a methodological contribution. Yes: 1, No: 0 2. D2: APPL [CODING]: The studies application scenario or study. Examples: smart transportation, smart home, smart city, smart grid, smart healthcare, industrial, e-government, sustainability, etc. 3. D3: PROB [CODING]: The core challenges that this paper addresses at a high level. Examples: fault-tolerance, security, privacy, resource management, scalability, resilience, etc. 4. D4: CONT [CODING]: What are the contributions of this paper. Examples: model, framework, algorithm, findings/insights, benchmark/measurements, software artifact, dataset, etc. 5. D5: AIME [CODING>EDGE[0]] [BLOC[1]] [BOTH[2]]: What AI, learning or optimization technique is used in the paper. Examples: supervised learning methods (neural networks, etc.), unsupervised methods (clustering, etc.), reinforcement learning, federated learning, optimization heuristics, etc. NOTE: Add information about whether AI method is centralized or decentralized, adaptive, etc. 6. D6: SECU [CODING>EDGE[0]] [BLOC[1]] [BOTH[2]]: The paper studies a security mechanism for blockchain or edge computing or both. Examples: authentication, access control (confidentiality), etc. 7. D7: PRIV [CODING>EDGE[0]] [BLOC[1]] [BOTH[2]]: The paper studies a privacy mechanism for blockchain or edge computing or both. Examples: differential privacy, homomorphic encryption, anonymity, etc. 8. D8: ALLO [CODING>EDGE[0]] [BLOC[1]] [BOTH[2]]: The paper studies a resource allocation/management problem for blockchain or edge computing or both. Examples: load-balancing, offloading, service placements, trading, etc. 9. D9: METR [CODING>EDGE[0]] [BLOC[1]] [BOTH[2]]: The paper makes measurements for resource allocation/management, AI and optimization as well as for performance evaluations and comparisons. Examples: economical cost, transaction costs/throughput, latency, quality of service, load-balance, energy consumption, carbon footprint, etc. 10. D11: TECH [CODING>EDGE[0]] [BLOC[1]] [BOTH[2]]: The paper contributes or uses technology such as 5G, 6G, Zigbee, WiFi, Bluetooth, specific ledgers, etc. 11. D12: TRLE¹ [0 1 ... 9] The Technology Readiness Level of the contributed solution. In case of non-relevance, the code "0" should be used. 12. D13: OPEND [LINKS]: Links to open data repositories contributed 13. D14: OPENS [LINKS]: Links to open-source software repositories contributed 14. D15: SUST² [CODING>EDGE[0]] [BLOC[1]] [BOTH[2]]: The paper studies sustainability aspects such as energy consumption, carbon footprint, equality, resilience, etc. 15. D16: UNSD [0, 1, ..., 17]: The sustainable development goal of United Nations in which the paper solution contributes. In case of non-relevance, the code "0" should be used. 16. D17: COMM [CODING>EDGE[0]] [BLOC[1]] [BOTH[2]]: The paper studies/contributes a communication protocol or communication algorithm. 17. D18: EVAL [CODING]: The paper uses one or more evaluation methods. Examples: theoretical method (theorem proofs), data analysis, simulation, implementation and system testing, human experimentation, model checking, etc. 18. D19: BLOC [CODING]: The paper studies or uses a certain blockchain system or distributed ledger. Examples: Ethereum, Bitcoin, etc. 19. D20: CONS [CODING]: The paper contributes, studies or relies on a certain consensus algorithm. It can be derived implicitly from D19. Examples: PBTF, SIEVE, Script, DPoS, ePoW, Trust-based, Ripple, etc. 20. D21: PERM [0 1]: The paper contributes, studies or relies on a permissioned (0) or permissionless (1) blockchain system. It can be derived implicitly from D19.
--	---

¹ <https://www.ukri.org/councils/stfc/guidance-for-applicants/check-if-youre-eligible-for-funding/eligibility-of-technology-readiness-levels-trl/>

² <https://sdgs.un.org/goals>

	<p>21. D22: TYPE [0/1/2/4]: The paper contributes, studies or relies on a blockchain type. It can be public (0), private (1), hybrid (2), consortium (4).</p> <p>22. D23: CHAI [0/1]: The paper contributes, studies or relies on a blockchain that is: off chain (0) or on chain (1) data storage</p> <p>23. D24: REWA³ [0/1/2/3]: The paper contributes to a reward/incentive model. It can be: Monetary, reputation, hybrid, multi –dimension. Hybrid means using both monetary and reputation, multi-dimensional means using multiple values/currencies for incentives, e.g., a token combining carbon emissions, reputation, etc.</p>
--	--

Table 4. Attributes of Design Dimensions

Dimension [Num. Attributes]	User-friendly Code	Machine- readable Code	Comments
1.METH [2]	NonMethodological Methodological	0 1	
2.APPL [20]	VideoStreaming HealthCare SmartEnergy IIoT IoT SmartCity WeatherForecast Drones CrowdSourcing MobileComputing 5G 6G SmartTransport SupplyChain ECommerce SmartFarm SmartWater Surveillance SmartCameras SmartHome	VSS HCA SEN IIT IOT SCI WEF IOD CSO MCO 5G 6G ITS SCH ECO SAG SWA SUR SCA SHO	<p>Crowdsourcing: Crowdsensing</p> <p>Surveillance: structural health monitoring, public safety</p> <p>Smart city: structural health monitoring</p> <p>Smart energy: V2G</p> <p>Intelligent Transportation: V2G, maritime wireless communication network</p> <p>Drones Robotic</p> <p>IoT cyber physical system</p> <p>ITS: maritime transport systems</p> <p>HCA: Wireless body area networks</p> <p>Industrial IoT: smart factory</p>
3.PROB [14]	DataSharing DataTrading Performance Trust Privacy Security Transparency Reliability Scalability Incentivization Programmability Experimentation DataProvenance DataRecovery	DS DT PF TR PR SE TP RL SC IC PG EX DP DR	<p>Performance: accuracy, efficiency and speed of execution. response time, throughput, resource utilization, data compression and decompression, Storage efficiency</p> <p>High availability of the computing system or application, Storage reduction, Communication, computation cost bandwidth, data transmission time.</p> <p>Security: includes Integrity, Non-repudiation, Authenticity, Confidentiality</p> <p>Experimentation: Simulation environment (methodological paper), Design A cross-reality environments that help fuse the real and the virtual in networked human-avatar/robot collectives, Resource monitoring tools</p> <p>data recovery: backup, recovery</p>
4.CONT [10]	Model Framework Platform Architecture Methodology	MO FR PL AR ME	<p>Architecture: Block format</p> <p>Software artifact: smart contract, middleware</p> <p>Protocol: consensus protocol</p>

³ <https://ieeexplore.ieee.org/iel7/6287639/9668973/09825658.pdf>

	Algorithm Protocol SoftwareArtifact Service Mechanism	AL PR SA SE MS	
5.AIME [8]	Reinforcement Federated Unsupervised Supervised Heuristic Metaheuristic Matching Reasoning	REL FEL USL SUL HEU MET MAT FUZ	Whether the algorithm is studied, presented, or used, all are coded in the same way. Reinforcement learning: Deep RL Heuristic includes greedy approaches
6.SECU [12]	Authentication Encryption AccessControl Verifiability TrustManagement Credibility Integrity Availability Immutability Confidentiality Authorization NonRepudiation	ATH ENC ACC VRF TRM CRB INT AVL IMT CON AUT NRD	
7. PRIV [13]	Anonymity DiffPrivacy OPRF Encryption PSI HomoEncryption RingSignature ZeroKnowlProof Pseudonymity BlindSignature SecretSharing AutoEncoder HybridIdentity	ANM DFP OSF ENC PSI HME RNG ZKP PSA BLS SSH AEC HID	DFP: Differential privacy OPRF: Oblivious Pseudorandom Function Ring signatures: privacy-preserving multiparty Computation, threshold ring signatures Homomorphic encryption: privacy-preserving multiparty Computation Secret sharing: adaptive threshold signature PSI: Private set intersection ZKP: Zero-knowledge proof
8.ALLO [7]	Trading Offloading Balancing Placement Scaling Scheduling Matching	TRD OFD LBL SPL ASL SCH MTC	Trading: data/resource trading Autoscaling: scaling up/down the resources
9.METR [40-->28]	CompDelay Throughput SecurityVulner Latency GasConsumption UtilSocialWelfare ConvergeSpeed CommCost CompCost Accuracy PowerConsumption EnergyConsumption CommUtil CompUtil StorageUtil	DLY TRP SVL LTY GSC USW CSP CMC CPC ACC PWC ENC CMU CPU STU	HV, STE, IGD, and HAR evaluate the performance of optimization algorithms. Accuracy, precision, and F1-score evaluate the performance of ML algorithms. Throughput: Data processing speed, cache hit rate (check it deeper) Security Vulnerability: Every metric that measures system security such as malicious attackers' success probability and security degree. Privacy: Every metric that measures system privacy such as privacy level, privacy leakage, etc. Winning rate: success rate of miners in auction Computational utilization: success rate of offloading, balance for the number of subtasks processed by the VM Storage utilization: memory utilization, balance for the number of subtasks processed by the VM, cache hit rate (check it deeper) Utility social welfare: Revenue, number of cooperators (cooperative game) with diff values of reward. Availability: success rate of backup/recovery

	Reliability Availability Precision Recall F1Score StorageCost FailureCost Privacy LinesOfCode Reputation WinningRate Scalability Jitter	RLB AVA PRC RCL F1S STC COF PRV LOC RPT WRT SCL JTR	Reliability: system failure rate, number of inconsistencies (chain versions/forks)
11.TECH [73-->72]	IPFS RFID CellularNet MEC Docker InfluxDB 5G 6G WiFi Bluetooth Zigbee ANT NFC IntelSGX SDN NFV LightNet ETHTestnet Redis OpenStack CouchDB Kafka BigchainDB GoETH RaspberryPi Cassandra Nodejs Mininet REST Arduino NodeRED iFogSim Brain4Net EdisonSoC Wireshark Jolinar GPS Contiki OPNET GMapAPI Chainlink NS3 Postman BlackPill HealthShield JMeter OpenThread Avispa Onos	IPF RFD HNT MEC DKR IFD 5G 6G WFI BLT ZBE ANT NFC SGX SDN NFV LNK REN RDS OPS CDB KFK BCD GEM RPI CAS NJS MNT RST ARD NRD IFS BRN IES WSK JLR GPS CKI OPN GMP CLK NS3 PSM BPL eHS AJM OTN AVA ONS	<p>NFC: Near field communication refers to a set of short-range wireless technologies</p> <p>SDN: Software defined Networking is an approach for flexible networking</p> <p>NFV: Network Function Virtualization is a way to virtualize network services</p> <p>ANT is a proprietary (but open access) multicast wireless sensor network technology</p> <p>Raspberry Pi: Nano Pi, LattePanda, Orange Pi</p> <p>Wi-Fi: WSN</p> <p>Cellular network: heterogeneous cellular network (HetNet)</p> <p>Ropsten Etherscan includes Rinkeby and RETH, TESTRPC</p> <p>Bluetooth: Blue- tooth Low Energy v4.2 (BLE)</p> <p>IntelSGX : Intel's Software Guard Extensions</p> <p>Contiki is an operating system for networked, memory-constrained systems with a focus on low-power wireless Internet of Things (IoT) devices.</p> <p>The Intel Edison is a computer-on-module that was offered by Intel as a development system for wearable devices and Internet of Things devices.</p> <p>Wireshark is a free and open-source packet analyzer.</p> <p>The Intel Edison is a computer-on-module that was offered by Intel as a development system for wearable devices and Internet of Things devices.</p> <p>The Google Maps API is one of those clever bits of Google technology that helps you take the power of Google Maps and put it directly on your own site.</p> <p>OPNET Network simulator is a tool to simulate the behavior and performance of any type of network.</p> <p>Chainlink is a decentralized blockchain oracle network built on Ethereum.</p> <p>Postman is an API platform for building and using APIs.</p> <p>The Black Pill development board is bare-bones development board featuring the powerful microcontroller STM32F401RCTB.</p> <p>The Apache JMeter application is open-source software, a 100% pure Java application designed to load test functional behavior and measure performance.</p> <p>OpenThread released by Google is an open-source implementation of Thread.</p> <p>OpenThread implements all Thread networking layers (IPv6, 6LoWPAN, IEEE 802.15.4 with MAC security, Mesh Link Establishment, Mesh Routing) and device roles, as well as Border Router support.</p> <p>AVISPA stands for Automated Validation of Internet Security Protocols and Applications, tool for the automated validation of Internet security-sensitive protocols and applications.</p> <p>ONOS: Open Network Operating System is the leading open source SDN controller for building next-generation SDN/NFV solutions.</p> <p>Non-Orthogonal Multiple Access Techniques in Emerging Wireless Systems. Non-orthogonal multiple access (NOMA) is one of the most promising radio access techniques in next-generation wireless communications.</p> <p>Compared to OFDMA where only one user is supported over a particular sub-channel, in NOMA multiple users can be supported over a sub-channel.</p> <p>The technology where a Radio Frequency (RF) signal is transmitted through a fiber optic network after the light signal is modulated by RF signal is known as Radio over Fiber or RoF.</p> <p>SQLite is a database engine written in the C programming language.</p>

	Prometheus NOMA RoF SQLite FreeStyleLib OrbitDB Ganache OneSwarm RemixIDE JetXavNx CIDDS PostgreSQL OMNet SQL MySQL SUMO K8S LevelDB JMTSim FoBSim JetsonNano ZooKeeper Caliper	PRS NMA ROF SQL AFL ODB GNC OSW RMX UAV CID PSL OMN SQL MSQ SUM KUB LVD JMT FOS NVD ZKP HLC	<p>The FreeStyle Libre system measures glucose levels through a small sensor.</p> <p>OrbitDB is a serverless, distributed, peer-to-peer database.</p> <p>Ganache is a personal blockchain for rapid Ethereum and Filecoin distributed application development.</p> <p>OneSwarm is a P2P file sharing service that protects your privacy.</p> <p>Remix IDE is a no-setup tool with a GUI for developing smart contracts.</p> <p>NVIDIA Jetson Xavier NX brings supercomputer performance to the edge in a small form factor system-on-module (SOM).</p> <p>CIDDS (Coburg Intrusion Detection Data Sets) is a concept to create evaluation data sets for anomaly-based network intrusion detection systems.</p> <p>OMNeT++ is a modular, component-based C++ simulation library and framework, primarily for building network simulators.</p> <p>JSIM: the simulation module of the Java Modelling Tools (JMT), an open-source fully portable Java suite for capacity planning studies. FoBSim: an extensible open-source simulation tool for integrated fog-blockchain systems.</p> <p>The Jetson Nano module is a small AI computer that has the performance and power efficiency needed to run modern AI workloads, multiple neural networks in parallel, and process data from several high-resolution sensors simultaneously.</p> <p>Caliper: Hyper ledger Caliper benchmark tool</p>
12. TRLE [10]		0 1 2 3 4 5 6 7 8 9	
13. OPEND	Link to proposed dataset		
14. OPENS	Link to proposed open software		
15. SUST [17]	NoPoverty ZeroHunger HealthWellbeing EducationQuality GenderEquality WaterSanitation Energy WorkEconomic IndustryStructure ReducedInequality SustainableCity ResponsibleConsProd ClimateAction LifeBelowWater LifeOnLand PeaceJustice GlobalPartnership	NPR (1) ZHU (2) GHW (3) EDU (4) GEW (5) CES (6) ACE (7) DWE (8) IND (9) IAC (10) SCC (11) RPC (12) CLA (13) LBW (14) LOL (15) PJI (16) GPS (17)	<p>QualityEducation: Education, e-learning, certificate validation</p> <p>Genderequality includes empower women</p> <p>WaterSanitation: Clean water and sanitation</p> <p>Energy: Affordable and clean energy, smart grid</p> <p>WorkEconomic: Decent work, Economic growth</p> <p>IndustryInfrastructure: Industry innovation and infrastructure, fault tolerance, security, resilience</p> <p>ReduceInequality: Reduce inequality among countries</p> <p>SustainableCities: Sustainable cities and communities, infrastructure applied to city like mobility</p> <p>ResponsibleConsProd: Responsible consumption and production, energy efficiency</p> <p>Lifeonland includes degradation of soil</p> <p>PeaceJustice: Peace, justice, accountable & strong institutions</p>
16. UNSD [18]		0 1 2 3 4 5	

		6 7 8 9 10 11 12 13 14 15 16 17	
17.COMM [20]	MQTT VANET TLS M2M CAN OFDM SoAP CoAP STEP IE1609.2 IE802.11 RTS gRPC WiMAX IE802.15 LTE-A OpenFlow LoRa OPC IE802.15.6	MQT VNT TLS M2M CAN OFD SAP CAP SCL IE2 WFI RTS GRC WMX IE5 LTA OFW LOR OPC IE5	<p>CAN: A controller area network (CAN) bus is a high-integrity serial bus system for networking intelligent devices.</p> <p>M2M systems use point-to-point communications between machines, sensors and hardware over cellular or wired networks</p> <p>TLS: tls/ssl</p> <p>LTE-A: LTA, LTE-A</p> <p>VANET: vehicular ad hoc network/v2v</p> <p>OFDM: Orthogonal frequency division multiplexing is a modulation technique that is used in several applications ranging from cellular systems (3GLTE, WiMAX), wireless local area networks (LANs), digital audio radio, underwater communications, and even optical light modulation.</p> <p>OFDMA: Orthogonal frequency-division multiple access</p> <p>STEP: Service and Topology Exchange Protocol (STEP) provides a way to achieve service availability through a central repository. STEP helps network administrators easily design and scale existing or new networks and provides insight into the service availability across the whole network.</p> <p>3GPP: The 3rd Generation Partnership Project is an umbrella term for several standards organizations which develop mobile telecommunications protocols.</p> <p>GRC includes Remote procedural call-gRPC, WEB3J</p> <p>OPC is an industrial communication standard that enables data exchange between multi-vendor devices and control applications without proprietary restrictions.</p> <p>OpenFlow, an open-source standard supported by many vendors, is the first software defined networking (SDN) control protocol.</p> <p>LoRa is a physical proprietary radio communication technique.</p> <p>gRPC is a robust open-source RPC (Remote Procedure Call) framework used to build scalable and fast APIs.</p> <p>RTS/CTS (request to send / clear to send) is the optional mechanism used by the 802.11 wireless networking protocol to reduce frame collisions introduced by the hidden node problem.</p>
18. EVAL [4]	Implementation Simulation Testbed FormalVerification	PIM SIM TES FVE	<p>PIM a realization of a certain method or idea to demonstrate its feasibility or verify that some concept or theory has practical potential.</p> <p>FVE: Model Checking.</p>
19.BLOC [18]	HLG Ethereum Bitcoin Monero RecordChain MicroChain Cosmos FISCO Tangle TrustChain IOTA MultiChain NaiveChain EOSChain LiTiChain XuperChain VeChain	HLG ETH BTC MNR RCC MCR CSM FSC TNG TRC IOC MLC NVC EOS LCH XPC VCH	<p>Hyperledger: Hyperledger Sawtooth</p> <p>Rapidchain is a high-performance blockchain network forked from Ethereum, with a key focus on enhancing transaction speed.</p> <p>FISCO BCOS is the first safe and controllable enterprise-level financial consortium blockchain platform open source by domestic enterprises.</p> <p>RecordChain is a novel blockchain architecture called Recordchain to handle big data among distributed edge nodes.</p> <p>NaiveChain The NaiveChain was created for demonstration and learning purposes. Since it does not have a “mining” algorithm (PoS of PoW) it cannot be used in a public network. It nonetheless implements the basic features for a functioning blockchain.</p> <p>EOS/ EOS.IO is a blockchain platform to develop industrial-scale decentralized applications.</p> <p>Monero Monero is a cryptocurrency which uses a blockchain with privacy-enhancing technologies to obfuscate transactions to achieve anonymity and fungibility.</p> <p>LiTiChain Blockchain of finite-lifetime blocks with applications to Edge-IoT.</p> <p>XuperChain: A blockchain system that supports smart contracts parallelization.</p>

			<p>VeChain Thor VechainThor blockchain is the leading enterprise-grade, Layer-1 blockchain, spearheading the sustainability revolution with a low-carbon, highly scalable smart contract platform. It is intended to serve as the foundation for a sustainable and scalable blockchain ecosystem.</p> <p>Cosmos is a unique blockchain ecosystem. Its focus on interoperability sets it apart from so many other networks, each with complicated ways to send assets between them. Instead, this ecosystem has interoperability at its heart, allowing its users to swap between chains practically seamlessly.</p>
20. CONS [28-->25]	ProofOfWork BFT ABFT FABPaxos RAFT RPCA ProofOfStake ProofOfAuthority ProofOfElapsedTime CollectiveSign ProofOfSpace ProofOfPUF ProofOfCredit ProofOfQDB VoteConsensus ProofOfReputation ProofOfCollaboration ProofOfTrust ProofOfExistence ProofOfLearning ProofOfEfficiency Tendermint ProofOfService ProofOfUsefulWork Solo	PoW BFT ABA FAB RFT RIP PoS PoA PET CSC PSP PPU PoC PoQ VCF PoR PCL PoT PoE PoL PEF TDM PSR PUW SOL	<p>PoS: Proof of Coin, delegated proof of stake: DelegateConsen is a blockchain consensus mechanism where network users vote and elect delegates to validate the next block [POS+BFT].</p> <p>PoC: calculates the credit value of each participant, and the user with low credit cannot participate in consensus.</p> <p>Proof of efficiency: proof of utility</p> <p>Proof of service: proof of good service</p> <p>Proof of Existence: proof of location</p> <p>BFT: LS-PBFT, PBFT</p> <p>The proof of authority (PoA) consensus mechanism is fundamentally an improved PoS consensus that controls identity as the system of stake rather than token staking.</p> <p>POW: time oriented PoW</p> <p>The consensus framework, based on Proof-of-PUF (PoP), aims to guarantee authentication of the devices and the miner with a rapid verification process compared to existing Blockchain consensus algorithms.</p> <p>HotStuff is a Byzantine fault tolerant (BFT) consensus which achieves both linear view change and responsiveness.</p> <p>Tendermint is a consensus algorithm that forms the foundation of the Cosmos network. It is a Byzantine Fault Tolerant (BFT) consensus algorithm that provides fast and secure transactions.</p> <p>Proof of service: The algorithm is based on the concept of committees that are re-elected for signing each block. The committee is formed using a system of reputation which depends on the initial stake and quality of masternode work (the masternode is always online and proposes only true blocks). integrates PoS and BPFT for permission-less networks.</p> <p>ProofOfQDB: lightweight feeless consensus algorithm named Poof of Quality of Service based DAGs-to-Blockchain (PoQDB)</p> <p>PoET: Proof of Elapsed Time</p> <p>Collective Signature Based Consensus</p> <p>PoE: Proof of Existence: The road network exploits the advantage of using private blockchain and offers transparent platform for access control without the intervention of any third-party coordinator. Whenever an access request is placed at a RSU, it first checks the existence of such a transaction in the blockchain. In one way, it avoids redundant transactions to be stored into the blockchain, on the other way, it ensures that only the authorized applications are accessing the concerned data. This is how the mutual conflict of accessing data among multiple service providers can be resolved while maintaining the desired privacy parameters for vehicular data at the same time [2344].</p> <p>VoteBasedCons: Voting-based consensus mechanisms are democratic by nature, achieving consensus on transactions and key network decisions by counting the number of votes cast by nodes on the network.</p> <p>Ripple Protocol Consensus Algorithm (RPCA) [1298] checks the consensus about the ledger with the connected nodes every few seconds.</p> <p>Proof-of-Space (PoS) is similar to Proof of Work (PoW) excepting instead of storage and computation is used. PoS is used for mining devices in the network using their available space of hard drive for deciding mining rights and transaction validation</p> <p>Solo is a simple, non-production consensus mechanism intended for development and testing purposes. It is not crash fault-tolerant and should not be used in production</p>
21.PERM [2]	Permissioned Permissionless	0 1	
22.TYPE [4]	Public Private Hybrid Consortium	0 1 2 3	

23.CHAI [3]	OffChain	0	
	OnChain	1	
	Both	2	
24.REWA [4]	Monetary	0	
	Reputation	1	
	Hybrid	2	
	MultiDimension	3	