

Index

A

Academic scores, 93
Accreditation authority, 102
AddedNode message, 126
Advanced Message Queuing Protocol (AMQP), 15
Agricultural Produce Market Committee, 336
Amazon, 306
Analytics, 118
Apache License version 2.0., 127, 132
Application layer

- blockchain transcript, 55
- effective individual learning, 56
- learning certificates, 56
- monitoring and tracing, 57
- quality education, 55
- shared ledger, 56
- teaching resource management, 56

Applications, 137, 138, 147, 149, 152, 157
Artificial Intelligence, 153
Asymmetric encryption, 140
Authorized networks card (ANC), 123
Average Variance Extracted (AVE), 25

B

Banking systems, 212
Big data, 15, 266, 276
Bi-model business model, 331
Biomarker data, 138
Bioterrorism, 152
Bitcoin, 142, 161, 166, 203, 254, 267, 268, 271, 319

Blockchain, 2, 5, 7, 73, 74, 83, 84, 87, 88, 109, 161, 181–185, 201, 203, 204, 207, 208, 210, 261, 340
advantages, 209, 314
application, 89, 91, 220, 256, 315
ARK technology, 90
assumption, 98
attributes of security, 313
certificates and caliber, 92
chained architecture, 316, 317
challenges

- operational cost, 196
- scalability, 196
- security risk, 196
- storage, 196

conceptualized, 90
consensus protocols, 95
consent rules, 207
contact tracking, 223
cost, 324
courses and degrees, 92
cryptography, 206
customs, 320
database, 209, 223
data integrity and anonymity, 313
decentralization and storing data, 314
decentralized solutions, 97
development of, 311
digital data, 207
digital marketing

- Big Data and, 274
- brands in, 272
- customers' behaviour, 273

- Blockchain (*cont.*)
 - disintermediation, 272
 - research methodology, 276
 - theoretical framework, 275
 - transparency and credibility, 285
 - digital signatures, 75
 - disadvantages, 209
 - distributed database, 115, 116
 - distributed record (*see* Distributed record)
 - education, 87, 192
 - education and knowledge, 93
 - education sector, 211
 - educational program, 91
 - EduCTX, 90
 - EHR management system, 221
 - feature, 192, 205, 221
 - financial services, 194
 - generation, 205
 - goals, 88
 - Google Doc, 255
 - governance and control, 87
 - government schemes, 193
 - in higher education
 - Blockcerts, 18
 - EduCTX, 18
 - KAUST, 19
 - KMI, 18
 - MIT Media Lab, 18
 - international institutes, 88
 - investment phase, 75
 - marketing campaigns, 88
 - mathematical algorithm, 207
 - mining, 206
 - network, 75, 210
 - nodes, 206
 - online language learning system, 90
 - permissioned and permissionless
 - blockchain, 318
 - permissionless and permissioned
 - blockchain, 317
 - port authority function, 320
 - power generation, 211
 - record verification, 116
 - regulatory authority, 311
 - resource-extraction phase, 75
 - retirement phase, 75
 - rigidity, 325
 - rural logistics, 336
 - security, 325
 - smart contract, 97, 192, 206
 - application of, 250, 258
 - blockchain-based survey structure, 253
 - design and implementation, 259
 - Ethereum Platform, 252
 - experimental setup, 260, 261
 - online review/ranking, 250
 - permissioned smart contracts, 258
 - public smart contracts, 257
 - ReviewChain, 251
 - system architecture, 254
 - third-party application, 251
 - transaction, 252, 262
 - trustworthy transactions and agreements, 249
 - types of, 257
 - vulnerability analysis, 260
 - speed of computation, 325
 - speed of process, 324
 - survival game concept, 76
 - Timestamp, 96
 - tourism, 193
 - transaction, 205, 208
 - transforming healthcare, 185
 - data access control, 189
 - drug, 190
 - interoperability, 188
 - payment, 190
 - privacy, 189
 - security, 189
 - transparency, 188
 - universal data sharing, 189
 - user awareness and security, 28
- Blockchain 3.0, 175
- Blockchain adoption, 304
- Blockchain Adoption Framework Factors, 22
- Blockchain-based distributed record, 114
 - architectural approach
 - cloud-based architecture, 121
 - concepts, 121, 123
 - cooperative behavior, 120
 - data transmissions, 120
 - deployment, 120
 - GW/MA stores, 123
 - LocalRecord* class, 122
 - localresources component, 120
 - measurements gateway architecture, 120
 - Merkle tree, 123
 - passive behavior, 121
 - ReceiverLocalResources, 121, 122
 - score per node, 122
 - SenderLocalResources, 121, 122
 - URL, 121
 - behavioral description
 - AddedNode* message, 126
 - BPMN diagram, 124, 125
 - Merkle tree, 126
 - snapshot operation/consolidating, 125
 - transaction, 126

- BPMN diagrams, 119
 - low-cost IoT-based devices, 119
- Blockchain-based solution, 195
- Blockchain-based systems, 6
- Blockchain-based technologies, 174
- Blockchain-enabled smart rural logistics, 337
- Blockchain hashing, 162
- Blockchain layered framework
 - architecture, 55
 - bitcoin cryptocurrency transactions, 54
 - deployment, 54
 - management layer, 57
 - network layer, 57
 - service layer, 57
- Blockchain network, 17, 165
 - public, 166
 - types, 17, 166
- Blockchain revolution, 6
- Blockchain survival game, 84
- Blockchain systems, 20
- Blockchain technologies, 5, 8, 9, 11, 12, 14, 20, 168, 202, 210, 211, 220, 222
 - application, 43, 46
 - applications, educational sector, 62–65
 - authenticity of transactions, 137
 - block header hash and node, 142
 - blockchain development service projects, 303, 304
 - budget, 67
 - business applications, 58
 - centralized health systems, 138
 - challenges, 155
 - characteristics, 139
 - cloud network, 58
 - computer science and technology, 43
 - contract management services
 - applications and start-ups, 303
 - crowd-funding services
 - applications and start-ups, 301
 - digital identity services, 301
 - crypto currency services
 - application and start-ups, 300
 - asset management services, 300
 - implication and start-ups, 300
 - cryptocurrency, 44
 - cryptographic sealing, 140
 - decentralization, 137, 139
 - definition, 48, 49
 - degree certificates, 59–61
 - development, 143
 - digital certification, 46
 - digital currencies, 137
 - digital signature, 46
 - digital transactions, 47
 - distributed ledger, 139
 - education sector, 44, 45
 - education system
 - activities, 51
 - distributed (decentralized) system, 54
 - encrypted security, 53
 - permanent transactions, 53
 - prompt verification, 52
 - proof of work, 52
 - quality, 50
 - resilient, 51
 - tamper-proof storage and management, 52, 53
 - transparency, 53
 - educational applications, 67, 68
 - educational organizations, 65
 - encrypted token, 47
 - Ethereum, 46, 48
 - evolution, 44
 - financial services
 - applications and start-ups, 302
 - flow of information, 137, 138
 - gas limit, 48
 - Gem Health Network, 138
 - genesis block, 140
 - hash block, 140
 - health care (*see* Health care system)
 - hybrid blockchain, 141
 - IBM prediction, 138
 - information/data block, 140
 - legality, 156
 - nontechnical factors, 66, 67
 - organizations, 67
 - payment channel, 47
 - peer-to-peer network policy, 45
 - private (*see* Private blockchain)
 - private network model, 142
 - public (*see* Public blockchain)
 - public feature, 141
 - scalability, 156
 - security, 155, 156
 - service sectors, 45
 - shared ledgers, 47
 - solidity, 48
 - storage problems, 156
 - structures, 141
 - technological challenges, 65, 66
 - threats, 154, 155
 - time frame, 45
 - transactions/payments, 142
 - types of methodology, 46
- Block-hash record, 76, 77
- Bluetooth, 219

BPMN (Business Process Model and Notation) diagrams, 114
 BPMN diagram, 124, 125, 129, 130
 BriefPD, 119
 Brilliant agreements, 256
 Broadcast nodes, 207
 Bronze Token, 99
 Business model

- constituents of, 292
- development of, 293
- influence of blockchain
 - channels, 297
 - cost structure, 299
 - customer relationship, 297
 - customer segment, 296
 - key resources and activities, 298
 - revenue streams, 297
 - value proposition, 296
- private blockchains, 295
- public blockchain, 294
- sub-segments of, 293
- technological advancements and innovations, 294

 Business Model, 292
 Business Model Canvas (BMC), 293
 Business process, 293
 Business to business (B2B), 271, 307
 Business to consumer (B2C), 265

C

Campus systems, 15
 Cell phone tracking technology, 216
 Centralization, 144
 Centralized health systems, 138
 Centre-and State-level university, 101
 Certification Authority, 102
 Certification systems, 27
 CINCAMIMIS, 119
 CINCAMIPD, 119
 CINCAMIPD/SSA, 119
 Client software, 140
 Clinical trials, 138
 Cloud-based architecture, 121
 Cloud-based layers, 118
 Cloud-based perspective, 118
 Cloud-based services, 263
 Cloud computing technology, 14
 Community level, 152, 153
 Complementary modelling approach, 2
 Complete client, 142
 Computational energy, 95
 Confidentiality, 45, 46, 53, 61, 182
 Consensus process, 166, 167

Consumer interface, 292
 Contact tracing, 213
 Contact tracing management procedure, 214
 Cooperative behavior, 120
 Counterfeit pharmaceutical goods, 198
 Covid-19, 202, 213, 215
 Cronbach's alpha values, 25
 Cryptocurrencies, 204, 212, 234
 Cryptogenic algorithms, 138
 Cryptographic hashing, 140
 Cryptographic sealing, 140
 Cryptography, 75, 163, 206
 CryptSubmit, 20
 Customer–brand partnerships, 265
 Customer-centric approach, 265
 Customers and business (B2C), 271
 Customs, 320
 Cybersecurity, 153, 154

D

dApp, 262
 Data analytics, 281
 Data breaches, 266
 Data collection techniques, 339
 Data distributions, 131
 Data gathering, 118
 Data integrity, 11, 181
 Data protection, 219
 Data security, 182, 313
 Data Services, 118
 Data Stream Processing Strategy (DSPS), 114, 117–119
 Data transmissions, 120
 Data visualization, 176
 Decentralised applications for smart certificates (DASC), 2

- actors, 28
- certificate, 33
- conceptual infrastructure, 29
- credentials data, 29
- future implementation, 30
- high-level conceptual infrastructure, 30
- prototype, 32
- sharing certificate, 31
- structure and functionality, 28
- survey, 29

 Decentralised technology, 6
 Decentralization, 87, 91, 94, 139, 338
 Decentralized database, 137
 Decentralized technology, 137
 Decision criteria, 117
 Device management, 118
 Diamond Tokens, 99

- Digital contact tracing, 217
 - Digital credentialing systems, 19
 - data storage, 22
 - demographic characteristics, 24
 - framework, 22
 - HEIs, 19
 - influential factors
 - efficient, 23
 - privacy and security, 23
 - social influence, 23
 - trust, 22
 - prospective employers, 25
 - questionnaire, 23, 24
 - Saudi, 21
 - Digital currencies, 137, 142
 - Digitalization, 140, 141, 168, 176
 - Digital marketing, 265
 - Big Data, 281, 282
 - Big Data and, 274
 - Big Data and Streamlining Data Access, 278
 - brands in, 272
 - customers' behaviour, 273
 - data sharing and data quality, 278
 - disintermediation, 272
 - impact of, 279, 280
 - predictive analysis, 278
 - PwC's Global Blockchain Survey Result Analysis, 283, 284
 - research methodology, 276
 - theoretical framework, 275
 - transparency and trust in, 277
 - trust and fraud prevention, 277
 - Digital technologies, 137, 217, 218
 - Discrete simulation, 132
 - Disease surveillance, 152, 153
 - Distinctive engineering options
 - arrangements, 262
 - Distributed and digital disease information
 - storage, 115
 - Distributed database, 116
 - Distributed information collecting system, 115
 - Distributed ledger, 139, 204
 - business networks, 162
 - EHR, 163
 - IOTA, 163
 - MAM, 163
 - Distributed ledger technology (DLT), 267
 - Distributed record
 - aims and approaches, 116
 - different distributed databases, 113
 - distributed and digital disease information storage, 115
 - distributed database, 115
 - EHR, 116
 - MA (*see* Measurement Adapters (MA)) metadata, 115
 - modification/incorporation, 113
 - stakeholders, 115
 - Drug traceability, 151
- E**
- e-commerce, 261, 312
 - Education system, 88
 - Educational materials, 73
 - EHR databases, 175
 - Electronic Health Record (EHR), 116, 138, 163, 174, 220
 - Electronic Medical Record (EMR), 149, 165
 - Emerging technologies, 265, 269
 - EnsorsementDetails* class, 122
 - Enterprise Resource Planning (ERP), 335
 - Ethereum, 91, 254, 255, 316, 319, 323–325
 - and Blockchain-based systems, 324
 - Ethereum cryptocurrency, 181
 - European Credit Transfer and Accumulation System (ECTS), 18, 90
 - Existing healthcare models, 237
 - clinical trials, 238
 - deployment challenges, 244
 - apoptosis challenge, 244
 - multiple medical schools, 245
 - technology life span, 244
 - design challenges, 242–244
 - device tracking, 238
 - drug tracking, 238
 - healthcare data interchange, 237
 - nationwide interoperability and beyond, 238
 - Experimental design, 118
- F**
- Fake information, 152
 - Farming, 78
 - Fee-based technologies, 270
 - Financial sector, 212
 - Financial services, 194
 - Fishing, 78
 - Fowchart system, 73
 - Fuzzy-ANPTOPSIS method, 169
- G**
- Game simulation data, 83
 - Game simulation resources
 - blockchain, 79
 - dice roller, 79

Game simulation resources (*cont.*)

- fishing, 80
- genesis block, 80
- initialization, 80
- PoS dice roll, 80

Gamification, 74

Ganache GUI, 323

Gateways (GW) acting, 120

Gem Health Network, 138

Genesis block, 94, 140

Geographical Informational System (GIS), 153

Global Positioning System (GPS), 218

GMLPoint class, 127

Gold Tokens, 99

GPS tracker, 326

Granularity, 335

H

Hash block, 140

Hash calculators, 79

Hash ID, 151

Hashing verification, 94

Health care system

- applications, 137
- blockchain, 154
- clinical trials, 149, 150
- cybersecurity, 153, 154
- disease surveillance, 152, 153
- domain applications, 146, 147
- drug traceability, 151
- in domains, 142, 143
- in maintenance, 142
- medical data management, 149
- organization related, 148
- patient related, 147, 148
- precision medicine, 153
- storage, 138
- workers, 138

Healthcare 4.0, 175

Healthcare industry, 190

Healthcare insurance model, 238

Beveridge model, 238

Bismarck model, 239

national health insurance model, 239

Healthcare sector, 169

- applications, 174
- blockchain, 170
- blockchain-based solutions, 176
- digital transformation, 169
- machine-readable code, 171
- MoD, 172
- open-ended loop, 171

RPM, 172

stakeholders, 171

teledermatology, 173

TMIS, 172

Healthcare services, 168

Healthcare surgical services, 173

Healthcare surveillance, 152

Healthcare system

- healthcare records, 190
- medical records, 191
- supply chain, 191
- users actual data, 191
- users control, 190

Healthcare tracking devices, 164

Healthcare use cases

- EHR, 197
- healthcare staff, 197
- IBM, 198
- IoT devices, 197

Hellinger distance, 131

Higher education institutions (HEIs), 17, 21

Higher education processes, 19

Higher energy consumption, 146

Humanity, 203

Hunting, 78

Hybrid blockchain, 141

Hyper ledger fabric and Hyper ledger Besu architecture, 151

Hyperledger fabric, 317, 325

I

IBM blockchain, 314

IBM prediction, 138

Identity and Access Management system (IAM), 144

Immutability, 163

Immutable records

- EHR, 164
- immutability, 163
- Med Rec, 164

Indian administrative structure, 91

Information and communication technology (ICT), 1

Information/data block, 140

Information technology, 231

Infrastructure management, 292

Innovations, 325

Integrated Vehicle Tracking System, 343

Integrity, 183

International courier services, 312

International trading, 312

Internet, 266

Internet of Healthy Things (IoHT), 168, 170

Internet of Things (IoT), 3, 114
 architecture, 4
 blockchain, 5
 communication, 4
 service applications, 4
 technological perspective, 4
 Internet of Things (IoT) devices, 164
 Internet of Things (IoT) technologies, 306
 IPFS, 259

J

Java-based implementation
 density curves, 132
 experimental design, 129–130
 Hellinger distance, 131
 library organization, 127–129
 memory consumption, 130, 131
 scope and limitations, 132
 snapshot operation, 130, 131
 Spring Boot 2.5.0 framework, 126
 violin chart, 131, 132

K

King Abdullah University of Science and
 Technology (KAUST), 19
 Knowledge management, 118
 Knowledge Media Institute (KMI), 18

L

Learning machine, 88
 Legal opportunities and challenges, 239
 PDPB, 241
 protect data privacy in India, 240
 stakeholders, 241
 Legality, 156
 Lelantos, 313
 Lesser security, 145
 LocalOrganizedItem class, 127
 LocalRecord class, 122
 LocalRecordController, 127
 LocalResources, 122
 Location-based contact tracing, 218
 Logistics, 191, 312
 Logistics value chain, 311
 Low-cost IoT-based devices, 119

M

MacBook Pro, 130
 Management, 57, 139, 146, 148, 150, 151,
 153, 156, 157

Martech, 265
 Masked authenticated messaging
 (MAM), 163
 Measurement adapters (MA)
 blockchain-based distributed record, 114
 concept's attribute, 113
 data heterogeneity, 114
 DSPS, 114, 117–119
 frameworks, 114
 and gateway, 121
 identified and characterized, 114
 IoT, 114
 java-based implementation, 126–132
 measurement project, 114
 monitoring field, 114
 NUR, 114
 wireless sensor network, 115
 Measurement Project Definition (MPD),
 117, 118
 Measurements gateway architecture,
 118, 120
 Medical data, 182
 Medical data management, 149
 Medical-on-demand (MoD) service, 172
 MedRec, 139
 Memory consumption, 130, 131
 Merkle tree, 115, 120, 123, 126, 142
 Message Queue Telemetry (MQTT), 15
 Metadata, 142
 Metrics, 117
 Microservices, 129
 Microsoft, 306
 Ministry of Education (MoE), 21
 MIT Media Lab, 88
 Mobile apps, 272
 Mobile cloud computing technologies, 173
 MOOCs, 20

N

Network layer, 57
 Node configuration, 128
 Node Unified Record (NUR), 114
 NodeStatistic class, 127
 Non-governing bodies, 152
 NRChainApplication class, 128

O

Online educational technology, 20
 Online information, 250
 Online product feedback, 250
 Online purchase, 266
 Online reviews, 250

P

Partnerships, 298
 Patent and intellectual property, 108
 Pearson's correlation test, 25
 Permissioned smart contracts, 258
 Personal data protection bill (PDPB), 241
 Pharmaceutical supply chain, 151
 Positive COVID-19 test, 221
 Post Student's Certificate, 32
 Precision medicine, 153
 Privacy, 43, 45, 46, 53, 64, 66, 68
 Private blockchains, 295

- demerits
 - centralization, 144
 - lesser security, 145
 - trust building, 144
- merits
 - scalability, 144
 - speed, 144

 Private keys, 140
 Private network model, 142
 Probability sampling method, 338
 Project definition, 119
 Proof-of-Work (PoW), 125, 141, 208
 Proposed cryptocurrency model, 267
 Proposed model, 109
 Protected Health Information (PHI), 164, 169
 Public blockchain, 294

- disadvantages
 - higher energy consumption, 146
 - reduced transaction rates, 146
 - scalability, 146
- merits
 - security, 145
 - transparency, 145
 - trustworthy, 145

 Public smart contracts, 257

Q

Quality education, 89
 Quantitative analysis, 29
 Quantitative close-ended questionnaire survey, 339

R

Raspberry Pi, 120
 Ready Mixed Concrete, 336
 Real-time data collecting systems, 114
 ReceiverLocalResources, 121, 122
 Record tracking, 188
 Record verification, 116
 Regulatory management, 138
 Remote patient monitoring (RPM), 172

Research design, 338
 Reserve Bank of India (RBI), 240
 REST (REpresentational State Transfer) services, 128
 RestController, 127
 ReviewChain, 251, 253, 255
 Reviewers, 259
 Rural logistics

- agricultural inputs and consumer products, 330
- blockchain in, 336
- collaboration index, 344
- customer service, 332
- digital interventions in, 341
- digital transformation, 334
- environmental regulations, 334
- lack of actionable data, 335
- lack of awareness, 333
- lack of education, 334
- limited granularity of data, 335
- management intervention, 331
- planning and risk management, 333
- policy intervention, 331
- product cost, 335
- program intervention, 331
- road infrastructure, 342, 343
- supplier relationship, 334
- supply chain, 330
- transportation cost, 333

S

Saudi higher education system, 21
 Scalability, 144, 146, 156
 Scenarios/entity states, 119
 Score per node, 122
 Scratch-note section

- activity of players, 77
- block-hash record, 77
- dice roll, 76
- disruptions phase, 79
- ground activities, 78
- player locations, 78
- player positions, 77
- probability, 76
- resource-extraction activity, 78
- retirement phase, 79

 Security, 145, 155, 156, 161, 162
 Security services, 183
 SenderLocalResources, 121, 122
 Service layer, 57
 Service provider, 259
 Severe Acute Respiratory Syndrome -2 (SARS CoV-2), 152
 Shipment process, 312

- Silver Tokens, 99
 - Simulation data, 80
 - Smart campus
 - application layer, 15
 - architecture, 12
 - business strategy, 15
 - cellular/mobile communication
 - technology, 14
 - centralised architecture, 10
 - communication, 13
 - data layer, 15
 - framework, 13
 - framework-based IoT architecture, 8
 - IEEE 802.11, 14
 - information service, 7
 - IoT architecture, 7
 - IoT gateway, 14
 - privacy, 10
 - scalability, 11
 - security, 10
 - sensors, 13
 - single point of failure, 10
 - system structure, 14
 - three-tier structure, 7
 - Smart campus concept
 - definition, 3
 - physical learning resources, 3
 - Smart contract, 95, 102, 164, 181, 315
 - phases and challenges, 164, 165
 - Snapshot operation, 129–131
 - Social media marketing, 270
 - Soft skill assessment, 108
 - Spearman's correlation coefficient, 27
 - Spring Boot 2.5.0 framework, 126, 127
 - SpringBootApplication profile, 127
 - Stakeholders' Current State vs. Future State, 343
 - statip* package, 131
 - Strategic approach, 293
 - Supply chain, 210
 - Supply chain costs, 335
 - Supply chain management, 89, 313, 335
 - Survival game, 74
- T**
- Technological revolution, 203
 - Technology and Law, 232–237
 - blockchain technology, 233
 - crossroads with law, 234, 235, 237
 - Cryptographic Hash Function, 233
 - Distributed Ledger Technology, 233
 - Telecare Medical Information Systems (TMIS), 172
 - Timestamps, 147
 - Token calculation flowchart, 100
 - Tokens, 272
 - Tourism industry, 193
 - Transaction rates, 146
 - Transactions, 201
 - Transactions per second (TPS), 144, 146
 - Transparency, 145
 - Transportation, 321
 - Tribal areas, 330
 - TripAdvisor, 250
 - Trust, 43, 49, 58, 67
 - Trust Authority (TA), 101
 - Trust building, 144
 - Trustworthy, 145
- U**
- Uniform Resource Locator (URL), 121
 - Urban economy, 312
- V**
- Value creation, 293
 - Vehicle tracking system, 342
 - Vocational training, 109
- W**
- Warehousing, 332
 - WeChat app, 216
 - Winning contact tracing models, 216
 - Wireless sensor network, 115