## Handbook of Blockchain Law

### A Guide to Understanding and Resolving the Legal Challenges of Blockchain Technology

Edited by Matthias Artzt Thomas Richter

Wolters Kluwer

Editors		v
Contributors		vii
Foreword		
Sandra Ro		xxix
Preface		xxxi
List of Abbrev	viations	xxxiii
Chapter 1		
Understanding	-	
Jake van der l		1
§1.01 Introduction		
§1.02 Core Concepts		
[A]	1 0	2 3
	How Computers Encode Data	3 4
[C] [D]	How Computers Store LargeNumbers	4
[D]	Computer Programming [1] Variables	0 6
	[2] Control Structures	0 7
	[3] Data Structures	8
	[a] The Array	9
	[b] The Linked List	9
	[4] Syntax	10
	[5] From Program Code to Machine Code	10
§1.03 The Ma	thematics of Blockchain	11
[A]	The Hash Function	11
[B]	The Cryptographic Hash Function	13
	[1] The 'Always the Same' Property	13

	[2] The 'Digital Signature' Property	13
	[3] The 'No Reverse Engineering' Property	14
	[C] The Hash List	15
	[D] The Merkle Tree	16
	[E] Public-Private Key Encryption	17
§1.04	Database Concepts	20
	[A] Database Operations	22
	[B] A Transaction Log Distinguished from a Database	22
	[C] Database Transactions: The ACID Properties	23
§1.05	Networking Fundamentals	24
	[A] P2P Networks	24
§1.06	Core Blockchain Functionality	25
	[A] Tying Blocks Together to Prevent Tampering	26
	[B] Adding a Time Cost	27
	[1] The Nonce	28
	[2] The Probabilities of Generating a Particular Hash Value 28	
	[a] Randomness	28
	[b] Sample Space	28
	[3] Not Replacing Generated Events	29
	[4] A Cryptographic Hash Function Behaves Like a Random	
	Variable	30
	[5] Requiring a Hash Value Below a Certain Value	31
	[C] The Proof of Work Process	31
§1.07	Transactions on the Bitcoin Blockchain	32
	[A] Bitcoin Scripting	33
	[B] Entitlement Tracking	33
	[C] The UTXO Database	34
§1.08	The Distributed Blockchain	34
	[A] The Bitcoin Network	34
	[B] The Memory Pool	36
	[C] Adding a Mined Block	36
	[D] The Double Spending Problem	37
	[E] The Mining Reward	38
	[F] Mining Pools	38
	[G] The 51% Attack	39
§1.09	Blockchain Forks	40
	[A] The Soft Fork	40
	[B] The Hard Fork	40
§1.10	Blockchain as a Platform	41
	[A] Ethereum	41
	[1] Gas: LimitingHow Long a Program Can Run	42
	[2] An Ethereum Transaction	43
	[3] Ethereum Transaction Account Types	44
	[a] The EOA	44
	[b] The Contract Account	44

		[4] The Ethereum Virtual Machine	44
§1.11 S	Smart C	Contracts	45
	[A]	Programming Smart Contracts	46
	[B]	Oracles	46
	[C]	Decentralized Applications	47
§1.12 T	Fokens	on the Blockchain	48
	[A]	The ERC-20 Token Standard	48
	[B]	Crowdfunding on the Blockchain	49
		[1] Initial Coin Offerings	49
		[2] Token Generation Events	50
		[3] Initial Exchange Offerings	51
		[4] Security Token Offerings	51
		[5] A Note on Token Fungibility	51
§1.13 I	Bitcoin	and Ethereum Governance	52
	[A]	The Bitcoin Governance Process	52
		[1] Bitcoin Improvement Proposals	53
		[2] Segwit	54
	[B]	Ethereum Governance	55
	[C]	Off-Chain and On-Chain Governances	55
§1.14		ing Beyond Ethereum	55
	[A]	Public (Permissionless) Blockchains	56
	[B]		56
	[C]	Distributed Ledger Technologies	56
§1.15		ibuted System Consensus Theory	57
	[A]	• •	57
		The FLP Impossibility Result	57
	[C]	*	58
01.1.4		[1] The CAP Theorem	58
§1.160		DLT and Consensus Approaches	59
	[A]	•	59
		[1] Ripple	60
	(15.1	[2] Stellar	62
	[B]	Proof of Stake-Based Networks	62
		[1] Peercoin	62
	[C]	Delegated Proof of Stake-Based Networks	63
		[1] BitShares	64
	[D]	Directed Acyclic Graph-Based Networks	64
		[1] Graph Basics	64
		[2] Using a DAG as a Ledger	65
81 17	Enter	[3] IOTA	66 67
§1.17		rprise Blockchain Platforms	67 67
	[A]	Hyperledger	67 68
		[1] Fabric	68
		[2] Sawtooth	68
		[3] Proof of Elapsed Time Consensus	68

	[4] Transaction Families	70
§1.18 Scaling	the Blockchain	70
[A]	Sharding	70
[B]	Sidechains	71
	[1] The Lightning Network	72
[C]	Multilayer Blockchains	74
§1.19 Blockch	ain as a Service	75
Further Reading	ıg	75
Chapter 2		

Blockchain an	d Info	rmation Security	
Dave Hirsch			77
§2.01 Risks and Vulnerabilities			78
[A]	Priva	te Keys: A Single Point of Failure	81
	[1]	Lost Private Keys Typically Means a Total Loss of Bitcoins	
		Held at the Associated Public Key Address	81
		[a] Legal Implications of Lost Private Keys	83
		[b] Policy Considerations	84
	[2]	Death: Risks Associated with Digital Asset Inheritance	85
		[a] Legal Implications of Dying Without a Plan to	
		Transfer Private Keys	86
		[b] Policy Implications	86
	[3]	Stolen Keys: Beware of Hacking, Malware, and	
		Man-in-the-Middle Attacks	86
		[a] Legal Implications	89
		[b] Policy Considerations	90
	[4]	Compromised Keys: Digital Assets Are Only as Secure as	
		the Keys That Control Them	90
		[a] Legal Implications	92
		[b] Policy Implications	92
	[5]	Kidnapping Seeking Digital Assets: The Intersection of	
		Physical and Information Security	93
		[a] Legal Implications of Kidnapping for Ransom	96
		[b] Policy Implications	97
	[6]	SIM Swapping: Exploiting Vulnerabilities in Digital	
		Identities	98
		[a] Legal Implications of SIM Swaps	102
		[b] Policy Implications	103
[B]	-	tal Asset Exchanges and Third-Party Services: Different	
	Role	es, Different Risks	103
	[1]	Digital Asset Exchanges: Hacks Happen	104
		[a] Legal Implications	106
		[b] Policy Implications	107

[2] Reliance on Third Parties: Exit Scams Happen108[a] Legal Implications110

		[b] Policy Implications	111
		[3] Third-Party Exploits: Trust Misplaced	112
		[a] Legal Implications	115
		[b] Policy Implications	116
§2.02	Tools	and Methods to Address Risks	118
	[Al I	ndividual Options for Protecting Digital Assets	118
		[1] Paper Wallets	118
		[2] Hardware Wallets	119
		[3] Multi-sig Wallets	120
	[B]	Outsourcing Security: Custodians	120
Further	Readin	ng	120
Ch a pt e			
		egulation	
Thoma			123
§3.01 I		g Blockchain for Regulation Purposes	123
	[A]	Background: The 'Legal Factor'	123
	[B]	The Meaning of 'Blockchain' in the Context of Regulation	125
		[1] The Relevance of a Legal Definition	125
		[2] Various Organizational Forms of Blockchains	126
		[3] Legal Relevance of the Blockchain Protocol	129
		[4] Inherent Characteristics of Blockchains and Their Legal	
		Implications	131
	101	[5] Summary	132
	[C]	The Meaning of Regulation' in the Context of Blockchain	133
		[1] Which Kind of Regulation Can Be Relevant for	100
		Blockchains?	133
		<ul> <li>[2] Which Legal Subjects Can Be Relevant for Blockchains? 135</li> <li>[3] 'Code <i>Is</i> Law' and 'Code <i>As</i> Law'</li> </ul>	126
		<ul><li>[3] 'Code <i>Is</i> Law' and 'Code <i>As</i> Law'</li><li>[4] Summary</li></ul>	136 138
§3.02	Dogu	latory Challenges	138
§3.02	[A]	Decentralization as Key Challenge	139
	[A]	Jurisdiction	139
	[D]	Anonymity	140
§3.03		latory Concepts	141
30.00	[A]	The Regulatory Principle of Technology Neutrality	142
	[B]	Regulating the Use Case Versus Regulating the Technology	144
		Regulatory Sandboxing	145
§3.04		latory Actors	146
30101	[A]	Governments and Law Makers	146
	[B]	Regulatory Authorities and Enforcement Agencies	147
	[C]	Courts	147
	[D]	International and European Bodies and National Banks	148
§3.05		essees of Regulation	149
-	[A]	Addressing 'the Blockchain' as Subject of Regulation	149

		[1]	Legal Personality of the Blockchain	149
		[2]	The Malta Innovative Technology Arrangements and	
			Services Act 2018	150
		[3]	Decentralized AutonomousOrganizations as a New	
			Corporate Form	150
		[4]	Summary	152
	[B]	Add	ressing Blockchain Actors as Subjects of Regulation	152
		[1]	Validation Nodes ('Nodes')	152
		[2]	Mining Nodes ('Miners')	154
		[3]	Blockchain Users	154
		[4]	Coders	155
§3.06	Exan	nples o	of SpecificBlockchain Regulation	155
	[A]	Unite	ed States	155
	IB]	Outsi	ide of the US	159
	[C]	Defi	nition and Summary	160
§3.07	Outle	ook: F	inancialServicesPrudential Regulation	160
§3.08	Sum	mary		161
Further	Read	ling		161
Ch a pt e	r 4			
· · · · ·		nd Sma	art Contracts	

Dioene	inann an		
Philip T	Trillmic	ch, Matthias Goetz & Chris Ewing	163
§4.01	Term	inology and Characteristics: What Is a Smart Contract?	163
	[A]	History of the Term 'Smart Contract'	163
	[B]	Technical Characteristics of a 'Smart Contract'	164
	[C]	Terminology	165
		[1] The Meaning of the Term'Smart'in Smart Contract	165
		[2] What Does the Term 'Contract' Mean in Smart Contract?	165
		[3] The Attempt to Develop a Definition	166
	[D]	Characteristics of 'Smart Contracts' as an Application of a	
		Blockchain	167
§4.02	Fields	s of Application	169
	[A]	Legal Profession	169
	[B]	Insurance Industry	170
	[C]	Music Industry/Media industry	171
	[D]	Energy Supply Industry	173
	[E]	Internet of Things	174
	[F]	Sharing Economy	175
§4.03	Contr	act Law Issues	176
	[A]	Applicable Law Versus 'Code in Law'	176
	[B]	Formation of a Smart Contract	177
		[1] Contracting Parties	177
		[2] Form Requirements	178
		[3] Offer and Acceptance	181
	[C]	Regulatory Issues and Smart Contracts	182

	[D]	Consumer-Protection Laws and Smart Contracts [1] EU Directive 2011/83/EU	182 182
		[1] EO Directive 2017/85/EO [2] Unfair Standard Terms	182
	[E]	Interpretation of Smart Contracts and Their Terms	185
	[E]	Performance and Remedies	184
§4.04	Outlo		188
84.04	[A]	Benefits, Opportunities and Limitations of Smart Contracts	188
	[A]	Use of Smart Contracts in the Future	100
Further			191
Ch a pt	er 5		
-		nd Data Privacy	
		t, Lothar Determann & William Long	193
		ction and Executive Summary	193
		al Data in the Context of the GDPR	194
	[A]	Definition of Personal Data in the Context of a Blockchain	194
		[1] Public Keys	195
		[2] Transactional Data	197
	[B]	How Is Personal Data Processed on a Blockchain?	198
	[C]	Application of the GDPR to the Blockchain	199
§5.03 ]	Identify	ying Controllers and Processors in a Blockchain Environment	
	unde	or the GDPR	201
	[A]	Definition of Controller and Processor	201
	[B]	LegalStatus of Participants of a Blockchain Network	201
		[1] Static Number of Roles and Responsibilities	201
		[2] Miners	203
		[3] Nodes	205
		[4] Wallets	206
		[5] Users of a Blockchain	206
		[6] Developer of Smart Contracts	208
		[7] Oracles	209
		[8] Governance Bodies and Joint-/Co-controllership	210
	[C]	Frictions Between Controllership and Obligations under the	
		GDPR	211
§5.04	Legal H	Basis and Consent under the GDPR	212
	[A]	Contractual Necessity	214
	[B]	Consent	214
	[C]	Legitimate Interest	216
	[D]	Compliance with a Legal Obligation	217
	[E]	Special Categories of Personal Data	218
§5.05		y of Data Processing on a Blockchain in the Context of the	
	GDF		218
	[A]	Personal Data Versus Anonymous Data	218
	[B]	Particular Security Techniques	218
		[1] Encryption	219

		[2] Hashing	219
		[3] Multi-layered Blockchains	220
		[4] Storing Personal Data Off-Chain	220
	[C]	Principles of Purpose Limitation and Data Minimization	221
		[1] Purpose Limitation	221
		[2] Data Minimization	223
		[3] Evaluation in the Light of the Principles of Purpose	
		Limitation and Data Minimization: Multi-layered	
		Blockchains Versus Off-Chain Storage	223
	[D]	Recommendation for Security Measures in a Blockchain	
		Environment	225
	[E]	Implications in the Case of Security Breaches	225
§5.06 E	Data Su	bject Rights under the GDPR	226
	[A]	How Do Data Subject Rights Apply to the Blockchain?	226
	[B]	Rightto Access Personal Data	227
	[C]	Rightto Rectification	228
	[D]	Rightto Erasure	229
		[1] What Does Erasure Mean?	229
		[2] The Techniques to Erase Data	230
		[3] Public Keys/Identifiers of Blockchain Users	232
§5.07 A	Accoun	tability Principles under the GDPR	233
	[A]	Lawfulness, Fairness and Transparency	234
	[B]	Purpose Limitation, Data Minimization and Storage Limitation	235
	[C]	Use of Data Privacy Impact Assessment	236
	[D]	Data Protection by Design and Default	237
	[E]	Record of Processing Activities	240
	[F]	Appointment of a DPO	240
§5.08	Intern	national Data Transfers on a Blockchain under the GDPR	241
§5.09	Outlo		243
§5.10	Block	cchain and US Privacy Law	243
	[A]	US Privacy Law Versus EU Data Protection Regulation	244
	[B]	Federal and State Law	249
	[C]	Diverse Terminology	249
	[D]	General and Specific US Privacy Laws applied to Blockchain	250
		[1] General US Privacy Laws	250
		[2] Specific US Privacy Laws	252
	[E]	Blockchain and CCPA	255
		[1] Scope of CCPA	256
		[2] Which Blockchain Participants Must Comply with CCPA? 2	257
		[3] CCPA Compliance Obligations	258
		[4] Data Access and Deletion Rights	261
		[5] Sanctions and Remedies	262
Further	r Read	ing	264

Chapter 6		
Capital Mark	ets	
Michael Juen	emann	265
§6.01 Capital	Markets and Blockchain	
Michael Juen	emann	265
[A]	What Makes a Token a Security?	265
[B]	Blockchain Finality	268
[C]	Special Requirements for Prospectuses	271
[D]	Regulatory Specifics for Organized Trade	273
§6.02 Capita	l Markets and Blockchain: Country Report - Austria	
Johannes Fre	ank & Philipp Kinsky	275
[A]	What Makes a Token a Security?	276
[B]	Blockchain Finality	277
[C]	Special Requirements for Prospectuses	278
[D]	Regulatory Specifics for Organized Trade	278
§6.03 Capita	l Markets and Blockchain: Country Report - Belarus	
Klim Stashev	rsky & Mikhail Khodasevich.	280
[A]	What Makes a Token a Security?	280
[B]	Blockchain Finality	281
[C]	Special Requirements for Prospectus	282
[D]	Regulatory Specifics for Organized Trade	284
§6.04 Capita	l Markets and Blockchain: Country Report - Estonia	
Kirsti Pent		286
[A]	What Makes a Token a Security?	286
[B]	Blockchain Finality	290
[C]	Special Requirements for Prospectus	291
[D]		292
§6.05 Capita	l Markets and Blockchain: Country Report - Finland	
Mika Puurur	ien	293
[A]	What Makes a Token a Security?	294
	Blockchain Finality	296
	Special Requirements for Prospectus	297
[D]	Regulatory Specifics for OrganizedTrade	299
[E]	Conclusion	300
_	al Markets and Blockchain: Country Report - France	
Bertrand Le	vy	300
[A]	What Makes a Token a Security?	300
[B]	5	301
[C]		303
[D]		305
-	al Markets and Blockchain: Country Report - Germany	
Michael Jue		306
[A]	5	306
[B]		308
[C]	Special Requirements for Prospectus	310

[D]	Regulatory Specifics for Organized Trade	312
§6.08 Capital 1	Markets and Blockchain: Country Report - Italy	
Stefano Febbi		314
[A]	What Makes a Token a Security?	314
[B]	Blockchain Finality	316
[C]	Special Requirements for Prospectuses	316
[D]	Regulatory Specifics for Organized Trade	318
§6.09 Capital	Markets and Blockchain: Country Report - Liechtenstein	
Johannes Diir		321
[A]	What Makes a Token a Security?	323
[B]	Special Requirements for a Prospectus	324
[C]	Blockchain Finality	325
[D]	Regulatory Specifics for Organized Trade	328
§6.10 Capital	Markets and Blockchain: Country Report - Poland	
Aleksandra Wi	idziewicz	329
[A]	What Makes a Token a Security?	329
[B]	Blockchain Finality	331
[C]	Special Requirements for Prospectus	332
[D]	Regulatory Specifics for Organized Trade	332
§6.11 Capital	Markets and Blockchain: Country Report - Spain	
Jose Luis Lore	ente Howell	334
[A]	What Makes a Token a Security?	334
[B]	Blockchain Finality	337
[C]	Special Requirements for Prospectus	337
[D]	Special Requirements for Organized Trade	338
§6.12 Capital	Markets and Blockchain: Country Report - Switzerland	
Olivier Favre	& Fabio Elsener	340
[A]	What Makes a Token a Security?	341
[B]	Blockchain Finality	342
	[1] Payment Tokens and Utility Tokens Without Claims	342
	[2] Asset Tokens and Utility Tokens Conferring Claims	342
	[3] Developments: DLT Rights	343
[C]	Regulatory Specifics for Organized Trade	344
	[1] Payment Tokens and Utility Tokens	344
	[2] Asset Tokens	345
	[3] Developments: Introduction of DLT Trading Facility	346
§6.13 Capital	Markets and Blockchain: Country Report - Singapore	
Kim Kit Ow		347
[A]	What Makes a Token a Security?	347
[B]	Blockchain Finality	348
[C]	Special Requirements for Prospectus	350
[D]	Regulatory Specifics for Organized Trade	352
[E]	Conclusion	353
§6.14 Capital	Markets and Blockchain: Country Report - Canada	
Daniel Fuke d	& Mike Stephens	353

	[A] What Makes a Takan a Sagurity	251	
	[A] What Makes a Token a Security	354	
	[B] Crypto Winter	356	
	[C] Special Requirements for Prospectus	357	
	[D] Regulatory Specifics for Organized Trade	358	
	[1] Registration Request and Oversight	358	
	[2] Regulatory Gaps	358	
	[3] Enforcement	358	
	[E] Conclusion	360	
§6.15 C	apital Markets and Blockchain: Country Report - USA		
James Gatto			
	[A] What Makes a Token a Security?	360	
	[1] US SEC	361	
	[2] The Commodities Futures Trading Commission	362	
	[3] The Financial Crimes Enforcement Network	363	
	[4] FINRA	365	
	[5] The IRS	365	
	[6] State Laws	365	
Further Reading			
1 01 0101		366	
Ch a pt e	r 7		
-	nain and Intellectual Property		
	s Holzwarth-Rochford	369	
	Introduction	369	
§7.01 §7.02	Trademark	371	
37.02	[A] Definition	371	
	[B] Duration	371	
	[C] Territory	371	
	[D] Goods and Services	372	
	[E] Types of Trademarks	372	
	[F] Registration Process	373	
	[G] Post Registration	374	
	[H] Enforcement	374	
	[I] Examples and Practical Hints	375	
§7.03	Designs	376	
	[A] Definition	376	
	[B] Duration/Territory	376	
	[C] Registration/Invalidity Procedures/Protection Requirements	378	
	[D] Enforcement	379	
	[E] Examples and Practical Hints	380	
§7.04	Copyright	381	
	[A] Definition	381	
	[B] Rights Given by Copyright, Duration and Practical Hints	381	
§7.05	Open Source	382	
§7.06	Patents/Utility Models	385	
	[A] Definition/Content of Patent Application	385	

	[B]	Rights Provided by a Patent	385
	[C]	Territory	386
		[1] European Patents/Planned European Unitary Patent	387
		[2] Further Regional Patents European Patents/Planned	
		European Unitary Patent	389
	[D]	Protection Requirements EPO	389
		[1] Novelty/Grace Period	389
		[2] Priority	390
		[3] International Patent Applications	391
		[4] Exclusion from Patentability	392
		[5] Assessing Patentability of CII: Examples of	
		Blockchain-Related EP Patents	393
		[6] Opposition Procedure	396
		[7] Enablement	397
	[E]	Protection Requirements USPTO: Examples of	
		Blockchain-Related US Patents	398
	[F]	Practical Hints Protection by Patents	401
		[1] Strategic Considerations	401
		[2] Observation/Surveillance of Third-Party Rights	401
		[3] Transfer of Rights	402
		[a] German Act on Employee Inventions	403
	[G]	Utility Models	404
		[1] Background	404
		[2] Registration Procedure: Branching Off	405
		[3] Protection Requirements/Duration	406
		[4] Protectable Subject Matter	407
		[5] Summary of Pros and Cons of Utility Models	407
§7.07 Tra	ade Se	ecret	408
	[A]	General Background	408
	[B]	Legal Basis: Definition	409
	[C]	Practical Aspects	410
Further F	Readir	ıg	413
Ch a pt er	8		

115
115
116
116
418
119
21
422
424
424
1

[A	] Introduction of Concepts	424		
[B	] Big Data	426		
	[1] Mandating Data Access	427		
	[2] Policing Data Sharing and Pooling	429		
[C	] Online Platforms	430		
	[1] Most Favoured Nations	431		
	[2] Multi-homing	431		
	[3] Interoperability	431		
	[4] Transparency	432		
	[5] Leveraging	432		
	[6] Self-Preferencing	432		
[D	D] Article 102 TFEU and Blockchain	432		
[E	Appropriate Safeguards	433		
§8.04 Merg	434			
[A	Introduction to Concepts	434		
[B	Full-Function Joint Ventures	435		
IC	C] Gun-Jumping	436		
[[	D] Merger Control and Blockchain	437		
[E	[] Appropriate Safeguards	442		
Further Re	443			
Bibliograp	445			
Electronic References				
Table of Cases				
Index		479		