Blockchain Security

A survey of Techniques and Research Directions

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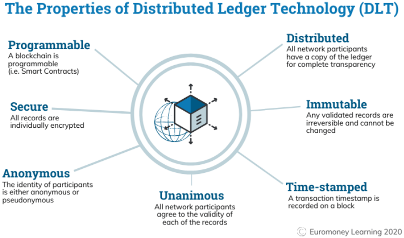
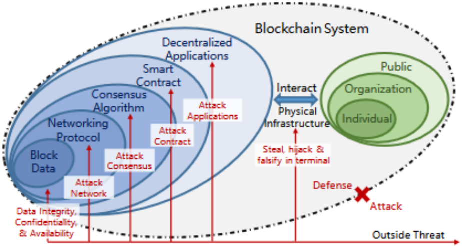
Introduction

- Blockchain
  - Data blocks chained sequentially according to chronological order
  - Distributed ledger; infeasible to tamper with
- Applications
  - Cryptocurrencies
  - Smart contracts
  - Non-Fungible Tokens (NFTs)



Introduction

- Blockchain Security
  - Threat Types
    - Internal or Peripheral
    - Malevolent or Unintentional
  - Threats are addressed by
    - Detection
    - Prevention
    - Appropriate Response
- Today's research is too technical; limited real-life considerations



Related Work

- Lin and Liao (DOI: 10.6633/IJNS.201709.19(5).01)
  - A review of blockchain security issues in terms of majority attack, data scale, etc.
  - Problem – not comprehensive enough
- Li et al. (DOI: 10.1016/j.future.2017.08.020)
  - Blockchain attacks and their real-life counterparts
  - Problem – neglects business application scenarios
- Joshi et al. (DOI: 10.3934/mfc.2018007)
  - Consensus protocols from the aspect of data security and privacy
  - Problem – Misses other aspects such as smart contracts
- Pattern: security is not considered holistically

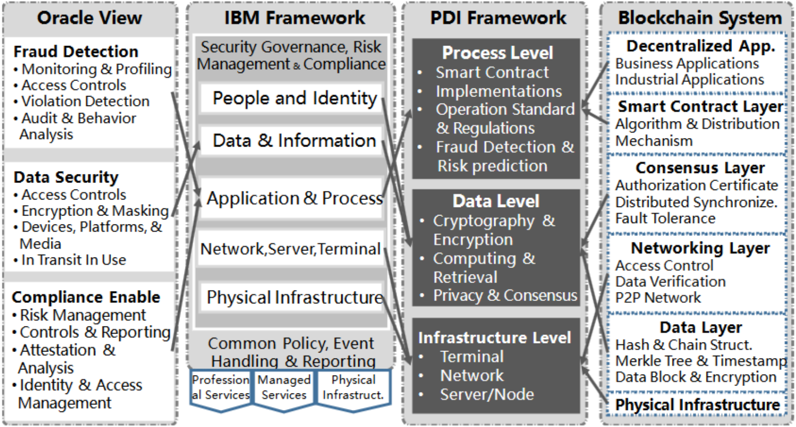
Objective and Approach

- Objective – survey blockchain security challenges in light of different parts of system
- Approach – View blockchain security in terms of
  - Process level
  - Data level
  - Infrastructure level
- The Process-Data-Infrastructure framework – PDI

Overview of Existing Security Frameworks

- Security Conceptual View – Oracle View of Security
  - Data Security
  - Fraud Prevention
  - Compliance Enablement
- Security Reference Architecture – IBM Framework
  - Holistic view of security
  - Includes business, technology, and service
- How does the PDI framework compare?

PDI VS Existing Frameworks



Process Security In Blockchain

- Requires practitioner to agree on and enforce set of secure policies
- Complicated due to multiple tasks and governance
- Aspects of process security
  - Smart Contract
    - Business Level
    - Virtual Machine Level
    - Contract Code Level
  - Implementing Scenarios
  - Standards and regulations
  - Fraud detection and risk management

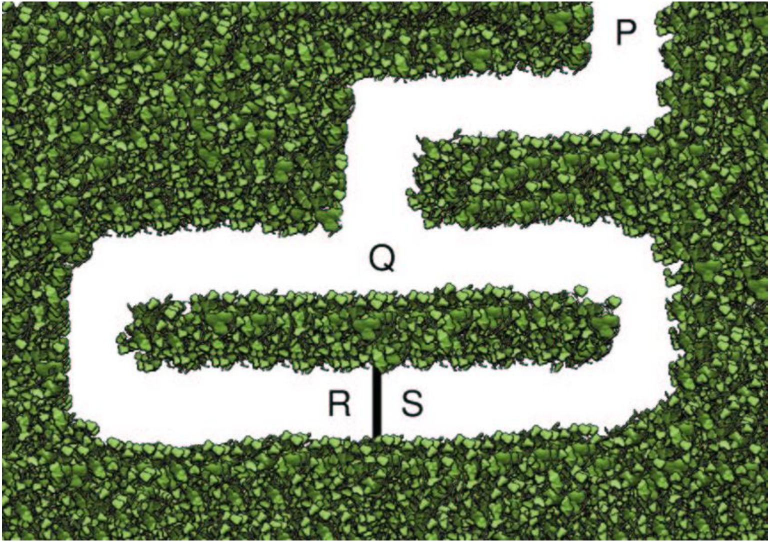
Security of Smart Contracts

- Programs automatically executed on distributed networks
- No external trusted third-party; mutual distrust
- Need to execute *correctly* and be protected against *malevolence*
- Issues on the level of
  - Business (unauthorized access, malicious infection, unpredictable state)
  - Virtual Machine (stack size limit, randomness generation, time constraints)
  - Code (call to the unknown, gasless send, deadlocked state)
- To combat such issues, analysis of smart contracts bytecode and semantics is necessary
- Tools such as Securify could help

Implementation Security of Blockchain

- Internet of Things
  - Goal – full autonomous data processing and exchange
  - Challenges – Transactions per second, privacy violation, DoS
  - Possible solution – Robust identification and authentication of devices
- Shared economy
  - Goal – Enforce demander-supplier agreements
  - Challenges – Privacy violation of parties of interest
  - Possible solution – Zero-knowledge proof

Zero-knowledge Proof - Ali Baba's Cave



Operation Standards and Regulations

- Blockchain technical challenges
  - Scalability, performance, and interoperability
- Blockchain management challenges
  - Integration with complex institutional, regulatory, social, economic, and physical systems
- Standardization of blockchain technologies is key in solving such issues
- However, standardization may stifle progress and introduce new risks

Operation Standards and Regulations

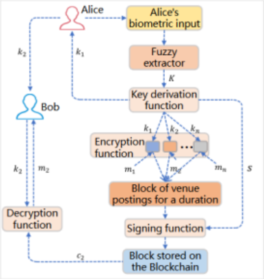
Type	Group/Content
World Wide Web Consortium (W3C)	Credentials Community Group, Digital Verification Community Group, Blockchain Community Group, Verifiable Claims Working Group, Interledger Community Group, Web Ledger Protocol
ISO TC 307	Joint ISO/TC 307 - ISO/IEC JTC 1/SC 27
Standards Australia	Roadmap for Blockchain Standards
International Telecommunications Union	Focus Group on DLT (FG DLT)
IEEE	Blockchain and DLT
SWIFT	Blockchain and DLT
European Union	General Data Protection Regulation (GDPR)
China Electronics Standardization Institute	Reference architecture of blockchain

Fraud Detection and Prevention

- Types of fraud that affect blockchain
  - Objective fraud
  - Subjective fraud
  - Rating fraud
- Fraud detection and prevention via
  - Preventative control (risk prediction)
  - Detective control (detection of existing fraud / attacks)

Access Control in Blockchains

- Access Control in Blockchain
  - In research, access control is achieved by
    - Smart Contract
    - Attribute-Based Encryption (ABE) schema (CP-ABE)
  - Challenge – ABE schema requires mutability for revocation; blockchains are immutable
  - Solution – Fine-grained control; access is given per-item
  - Example: hybrid fine-grained access control model proposed by Adams (DOI: https://doi.org/10.1002/spy2.97)



Computation Techniques on Encrypted Data in Blockchains

- Computing techniques on encrypted blockchain data
  - Homomorphic encryption
    - Working on data while it's still encrypted
  - Secure multi-party computation
    - Work on joint input together while keeping each node's input secure
  - Trusted computing
    - Offload computation to other participants while still ensuring validity of result

Questions

The floor is open for questions