



# Blockchain Application Design and Development, and the Case of Programmable Money



CLOSER'21 Keynote

Prof. Dr. Ingo Weber | April 2021

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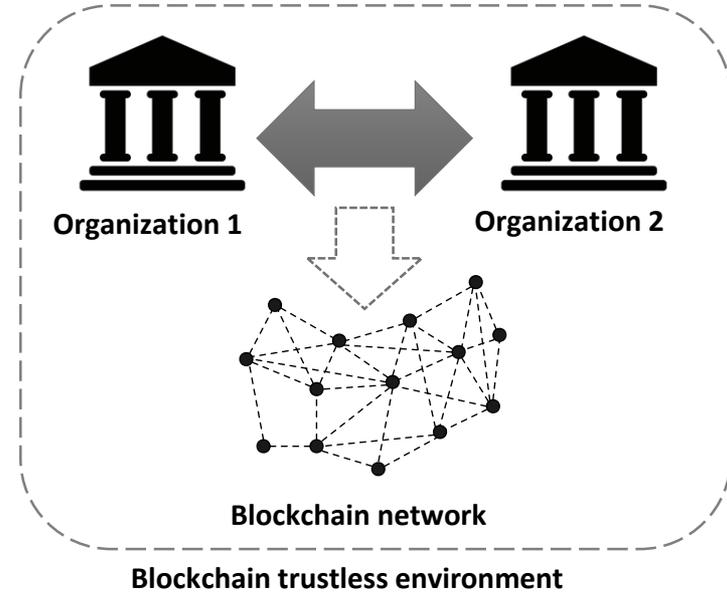
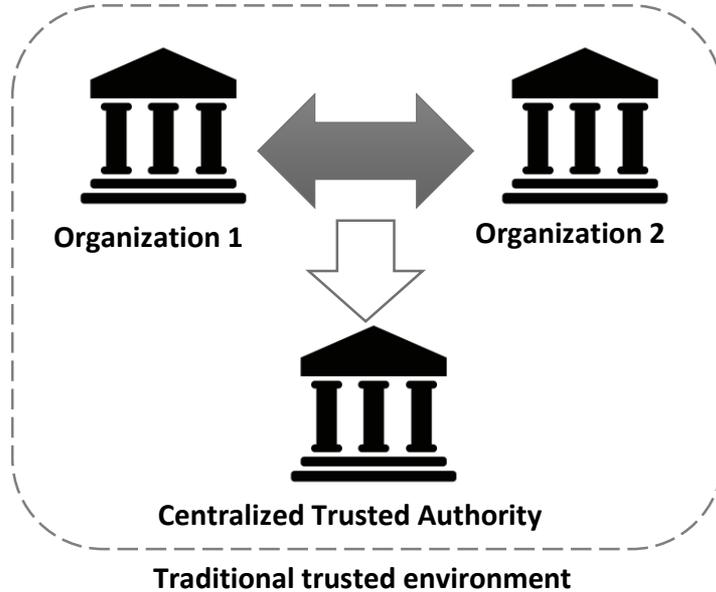
- Blockchain basics and terminology
- Designing and developing blockchain applications
  - Architecture & design
  - Model-driven engineering
- Blockchain and Services:
  - Integrating Blockchain-based Applications with Services
  - Blockchain-as-a-Service
  - Service-orientation vs. Smart Contracts
- Programmable money
- Blockchain adoption



# Preliminaries and Definitions



# Blockchain – replacing centralized trusted authority



# Blockchain 2<sup>nd</sup> gen – Smart Contracts

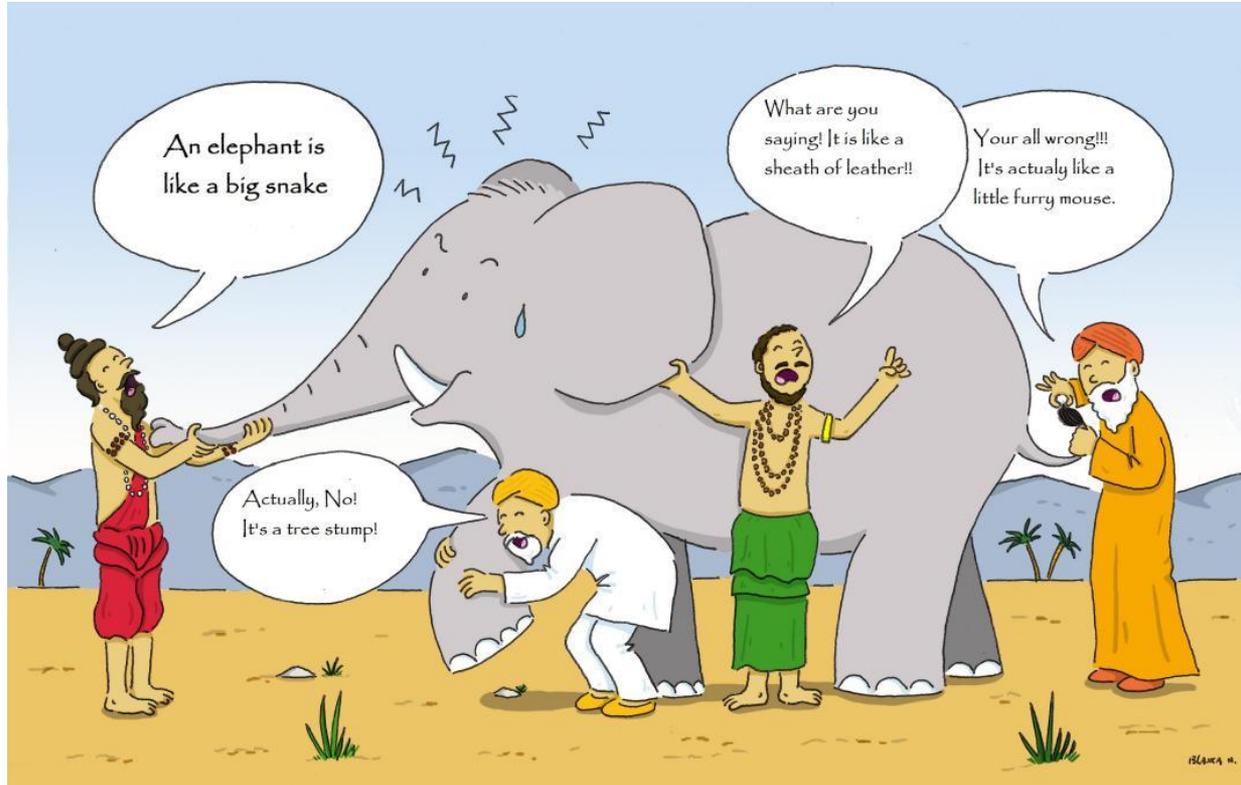
- 1<sup>st</sup> gen blockchains: transactions are financial transfers
- Now Blockchain ledger can do that, and store/transact any kind of data
- Blockchain can deploy and execute programs: Smart Contracts
  - User-defined code, deployed on and executed by whole network
  - Can enact decisions on complex business conditions
  - Can hold and transfer assets, managed by the contract itself
  - Ethereum: pay per assembler-level instruction



# So what?

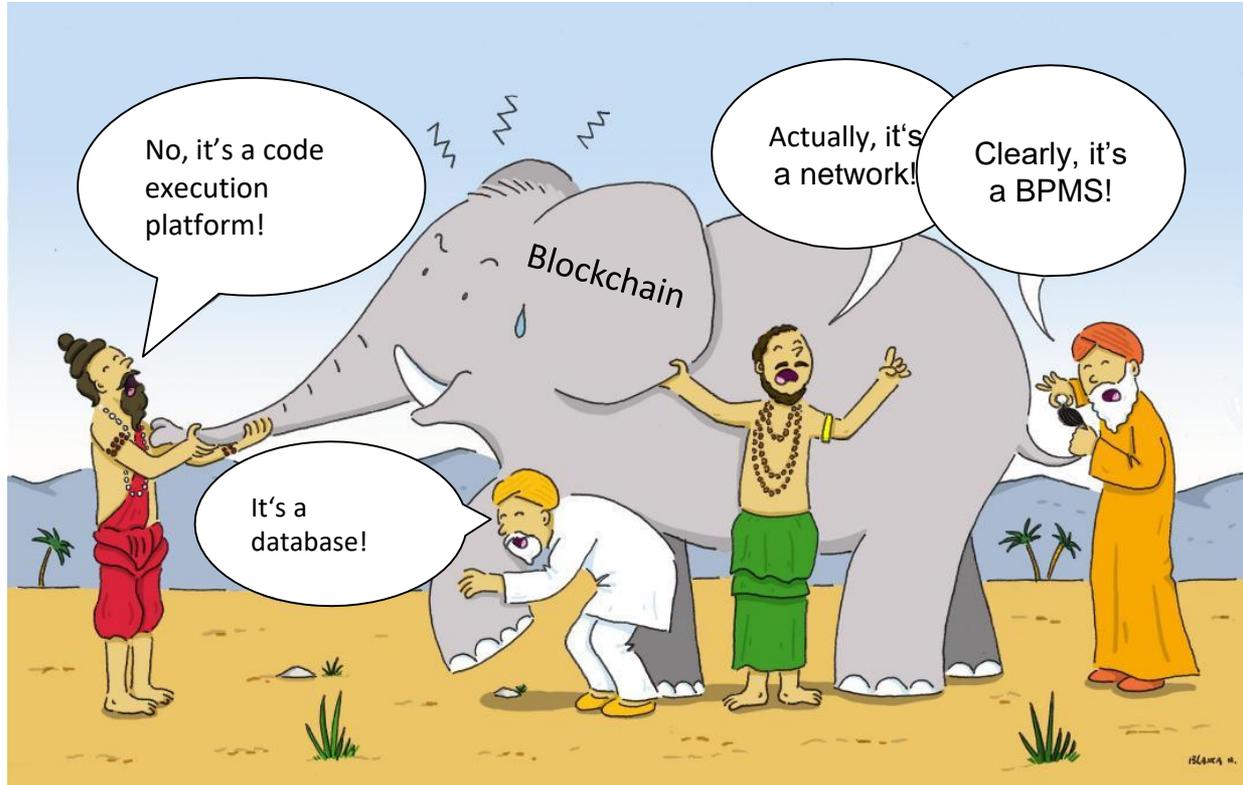
- Well, blockchains are exciting because they can be used as a new foundation for re-imagining systems:
  - Neutral infrastructure for processing transactions and executing programs
  - Potentially interesting for innovation at **all touch-points** between organizations or individuals
  - **Blockchain applications have the potential to disrupt the fabric of society, industry, and government**
- Blockchains can also be used as a technology platform to handle hard issues of data replication and system state synchronization with high integrity.

# What is a blockchain?



Parable of the blind men and the elephant, see e.g., <https://wildequus.org/2014/05/07/sufi-story-blind-men-elephant/> (source of figure)

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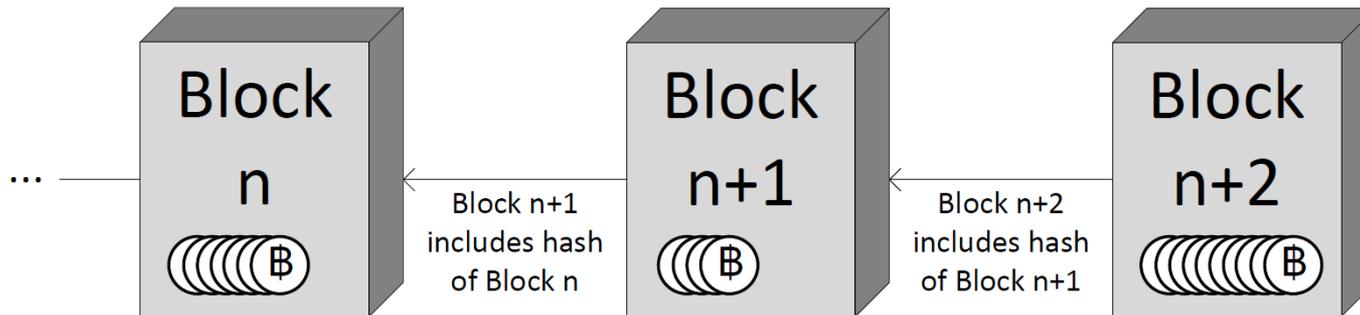
# Defining Blockchain (1)

- **Distributed Ledger**

- An “append-only” transaction store distributed across machines (*immutability*)
- A new transaction might reverse a previous transaction, but both remain part of the ledger

- **Blockchain**

- A distributed ledger structured into a linked list of blocks
- Each block contains an ordered set of transactions
- Use cryptographic hashes to secure the link from a block to its predecessor



# Defining Blockchain (2)

- A **Blockchain System** consists of
  - A blockchain network of nodes
  - A blockchain data structure
    - For the ledger replicated across the blockchain network
    - Full nodes hold a full replica of the ledger
  - A network protocol
    - Defines rights, responsibilities, and means of communication, verification, validation, and consensus across the nodes in the blockchain network
    - Includes ensuring authorisation and authentication of new transactions, mechanisms for appending new blocks, incentive mechanisms

# Defining Blockchain (3)

- A **Public Blockchain** is a blockchain system with the following characteristics:
  - Has an open network
    - Nodes can join and leave without requiring permission from anyone
  - All full nodes can verify new transactions and blocks
  - Incentive mechanism to ensure the correct operation
    - Valid transactions are processed and included in the ledger and invalid transactions are rejected
- A **Blockchain Platform** is the technology needed to operate a blockchain
  - Blockchain client software for processing nodes
  - The local data store
  - Alternative clients to access the blockchain network

- **Smart contracts**

- Programs deployed as data and executed in transactions on the blockchain
- Blockchain can be a computational platform (more than a simple distributed database)
- Code is deterministic and immutable once deployed
- Can invoke other smart contracts
- Can hold and transfer digital assets

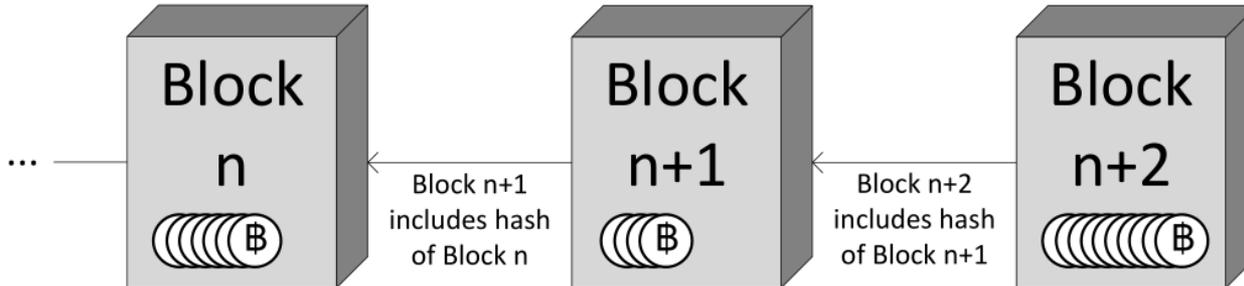
- **Decentralized applications or dapps**

- Main functionality is implemented through smart contracts
- Backend is executed in a decentralized environment
- Frontend can be hosted as a web site on a centralized server
  - Interact with its backend through an API
- Could use decentralized data storage such as IPFS
- “State of the dapps” is a directory recorded on blockchain:  
<https://www.stateofthedapps.com/>

# Blockchain defined (1/4)

## Verbatim from the Book

- **Definition 1 (Distributed Ledger).** A Distributed Ledger is an *append-only store of transactions* which is distributed across many machines.
- **Definition 2 (Blockchain (Concept)).** A Blockchain is a *distributed ledger* that is structured into a *linked list of blocks*. Each block contains an ordered set of transactions. Typical solutions use cryptographic hashes to secure the link from a block to its predecessor.



- **Definition 3 (Blockchain System).** A Blockchain System consists of:
  - a *blockchain network* of machines, also called *nodes*;
  - a *blockchain data structure*, for the ledger that is replicated across the blockchain network. Nodes that hold a full replica of this ledger are referred to as *full nodes*;
  - a network *protocol* that defines rights, responsibilities, and means of communication, verification, validation, and consensus across the nodes in the network. This includes ensuring *authorization and authentication* of new transactions, mechanisms for appending new blocks, incentive mechanisms (if needed), and similar aspects.

- **Definition 4 (Public Blockchain).** A Public Blockchain is a *blockchain system* that has the following characteristics:
  - it has an *open network* where nodes can join and leave as they please without requiring permission from anyone;
  - all full nodes in the network can *verify each new piece of data* added to the data structure, including blocks, transactions, and effects of transactions; and
  - its protocol includes an *incentive mechanism* that aims to ensure the correct operation of the blockchain system including that valid transactions are processed and included in the ledger, and that invalid transactions are rejected.

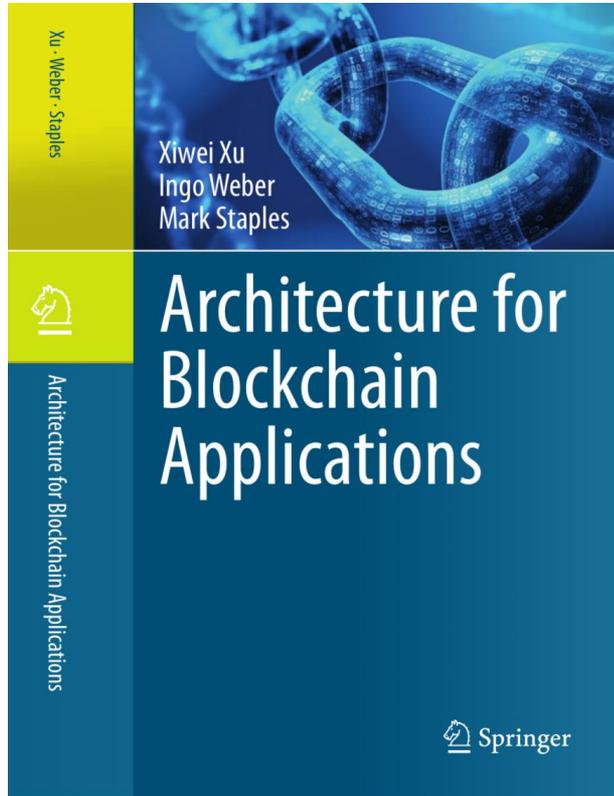
# Blockchain defined (4/4)

## Verbatim from the Book

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- **Definition 5 (Blockchain Platform).** A blockchain platform is the *technology needed to operate a blockchain*. This comprises the blockchain client software for processing nodes, the local data store for nodes, and any alternative clients to access the blockchain network.
- **Definition 6 (Smart Contract).** Smart contracts are *programs* deployed as data in the blockchain ledger, and executed in transactions on the blockchain. Smart contracts can *hold and transfer digital assets* managed by the blockchain, and can invoke other smart contracts stored on the blockchain. Smart contract code is *deterministic and immutable* once deployed.
- **Definition 7 (dapp).** A decentralized application or dapp is a software system that is designed to provide its main functionality through smart contracts.

# Book: Architecture for Blockchain Applications



*Xiwei Xu, Ingo Weber, Mark Staples.  
Architecture for Blockchain Applications.  
Springer, 2019. [1]*

➔ Includes the definitions from the previous slides

- **Cryptocurrencies**

- ‘Baked in’ to the core platform of public blockchains -base currency of blockchains
- Symbiotic relationship
  - Blockchain keeps track of the ownership of portions of that currency, e.g. Alice owned 2 Ether, transferred 1 Ether to Bob, offered 0.01 Ether to miner
  - Cryptocurrency enables the incentive mechanism for blockchain operations

- **Digital tokens**

- Created and exchanged using smart contracts
- Represent assets
  - Fungible asset: individual units are interchangeable, e.g. company share, gold
  - Non-fungible asset: represents a unique asset, e.g. cryptokitties, car title

- **Not all applications are the same:**

- Transferring coins / tokens vs. tracking movement of physical goods
- Core difference: where is the default version of the truth, on or off-chain?



# Designing and Developing Blockchain Applications



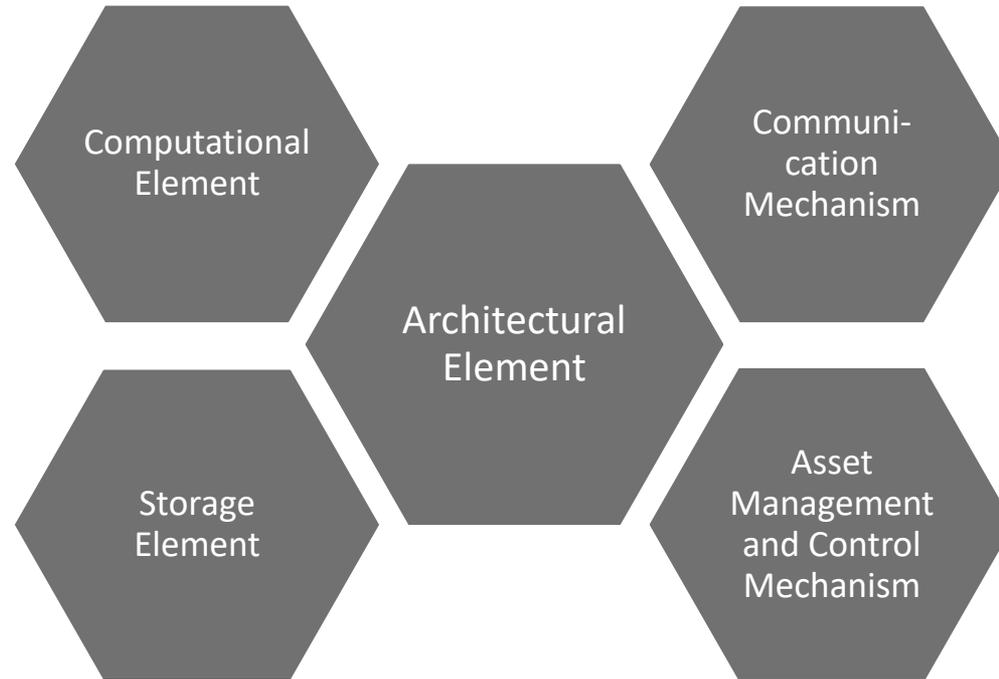
- **Many interesting applications for Blockchain**
    - Basically of interest in most lack-of-trust settings where a distributed application can coordinate multiple parties
    - Examples:
      - Supply chains
      - Handling of titles, e.g., land, water, vehicles
      - Identity
    - Many startups and initiatives from enterprises / governments
  - **... but also many challenges**
    - When to use blockchain
    - Trade-offs in architecture
      - Downsides: cost, latency, confidentiality
      - What to handle on-chain, what off-chain?
-

# Work with my former and my new teams

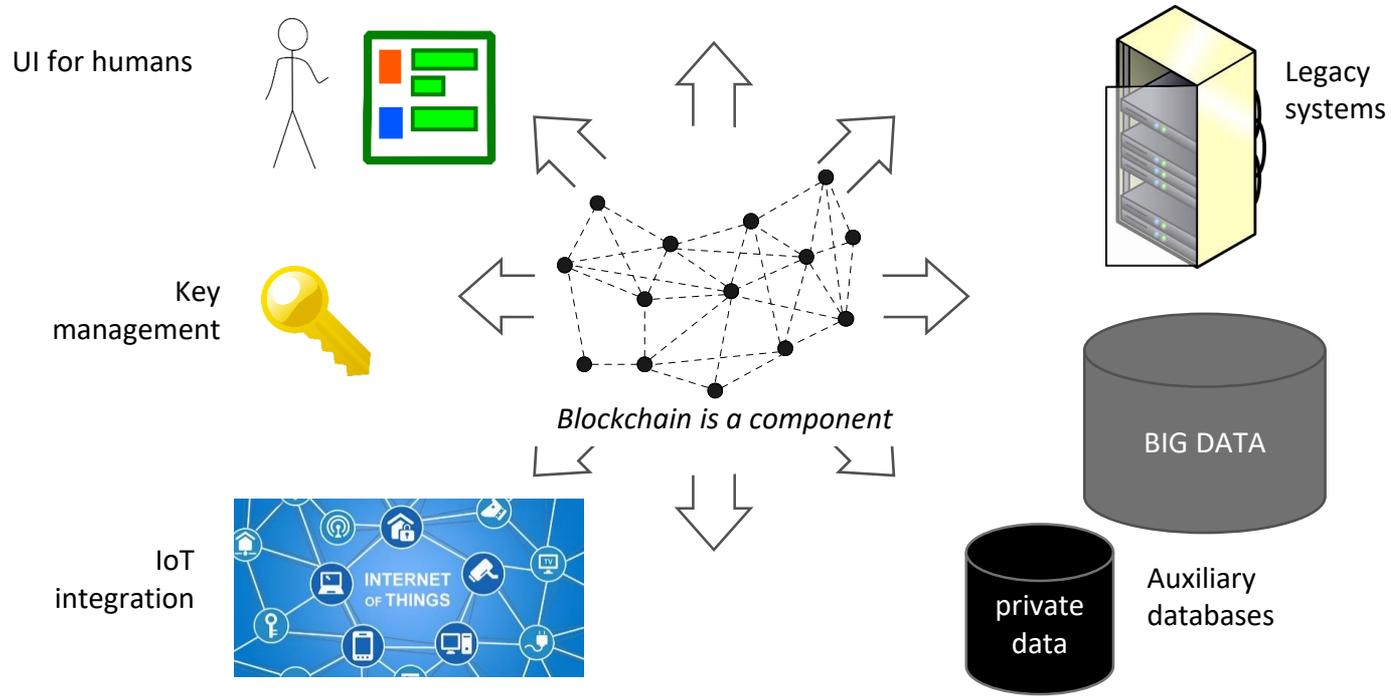
- Architecting applications on Blockchain:
    - Book [1]
    - Taxonomy and design process [5]
    - “Cost of Distrust”: how much more expensive is blockchain? [7]
      - On some blockchains, cost and throughput are tightly linked
    - Availability analysis from viewpoint of dapps [11]
    - Latency: simulation under changes [12]
    - Multi-tenant applications on blockchain [13]
  - Model-driven development of smart contracts
    - Business process execution (including the tools *Caterpillar* [6] and *Lorikeet* [10])
    - Model-based generation of code for data structures, non-fungible and fungible tokens, and UI components
    - Data extraction and analytics, e.g. Process Mining on blockchain data [3,4]
  - Blockchain Patterns – reusable experience & inspiration [14,15]
    - <https://research.csiro.au/blockchainpatterns/>
  - ...
-

# Functions blockchain can provide in an application architecture

- Blockchain as...



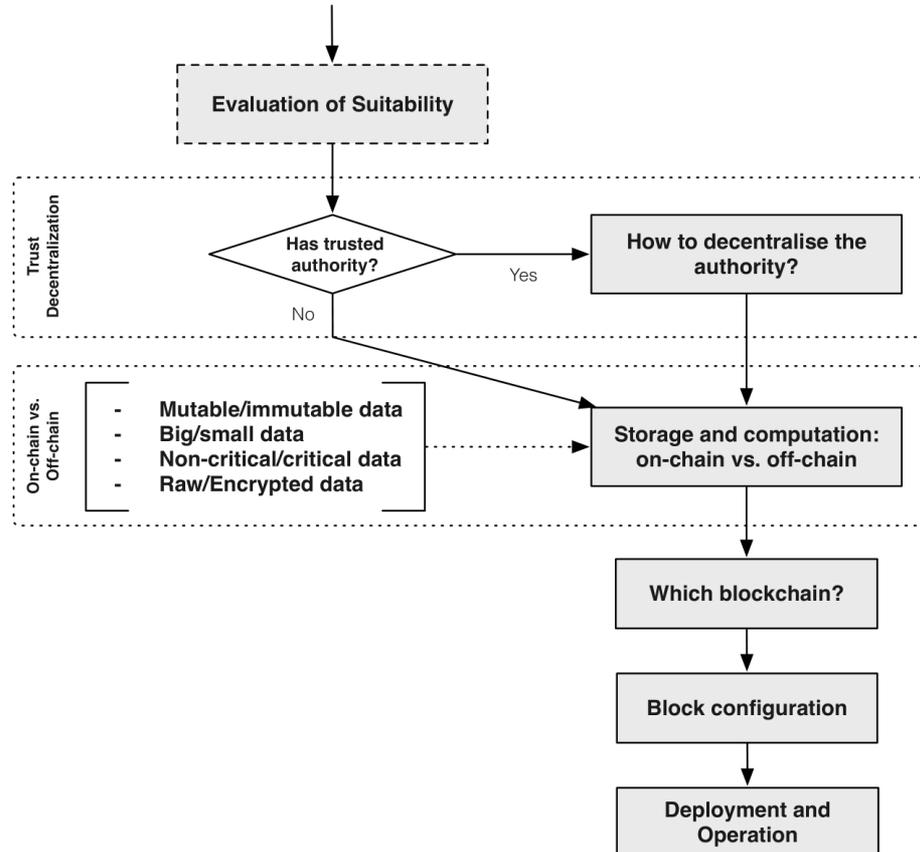
# Blockchains are Not Stand-Alone Systems



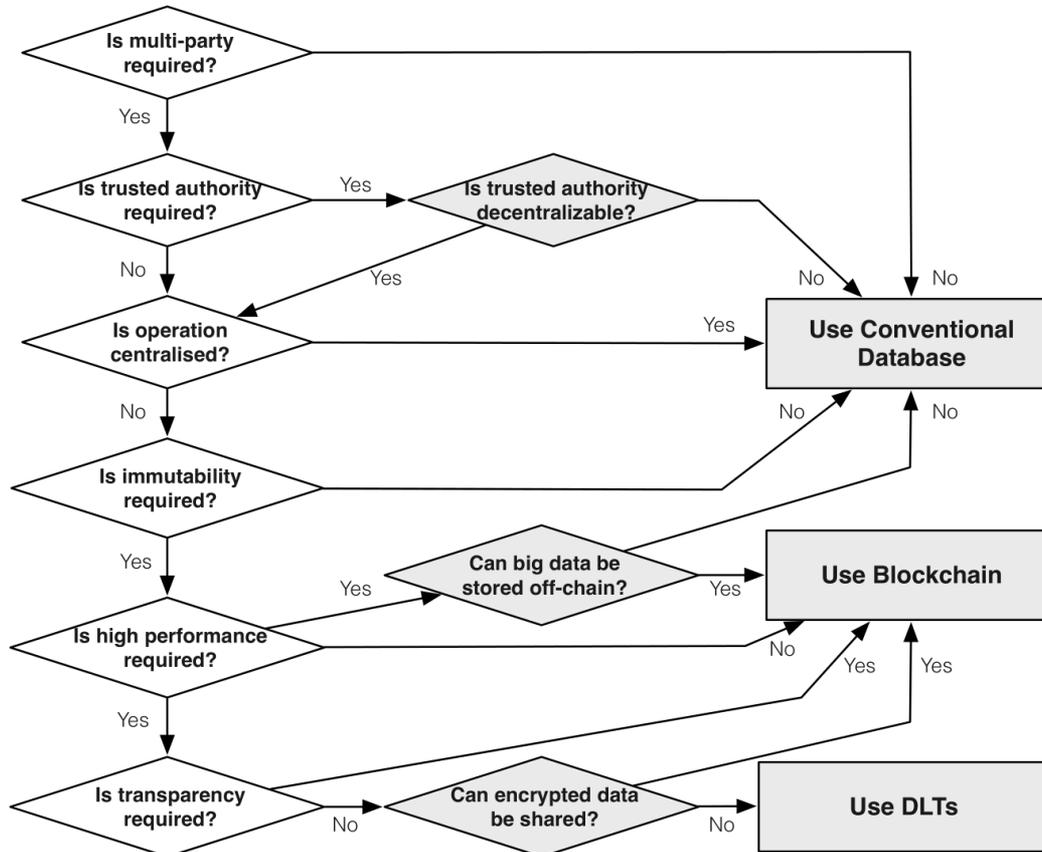
# Non-Functional Trade-Offs

- Compared to conventional database & script engines, blockchains have:
    - (-) Confidentiality, Privacy
    - (+) Integrity, Non-repudiation
    - (+ read/ - write) Availability
    - (-) Modifiability
    - (-) Throughput / Scalability / Big Data
    - (+ read/ - write) Latency
- } Security: combination of CIA properties

# Design process



# Evaluation of Suitability





# Designing and Developing Blockchain Applications: Model-driven Engineering for Blockchain Applications



- Model-driven engineering (MDE):
  - A methodology for using models at various levels of abstraction and for different purposes during software development
  - Low-level models: production code can be directly derived from the models
  - High-level models: means of communication between business owners and developers implementing a system
  - Intermediate levels can support model-based system analysis or system management tools
  - Any level: generate a code skeleton or early version of the code
  - Can cover static structures (like data models) or dynamic behavior (activity sequences)
- Advantages in the blockchain context:
  - Code generation can implement best practices and well-tested building blocks
    - Code can adhere to blockchain “standards” (like ERC-20, ERC-721, ...)
  - Models can be independent of specific blockchain technologies or platforms
  - Models are often easier to understand than code – particularly useful in communicating with business partners about smart contracts
    - Facilitates building trust

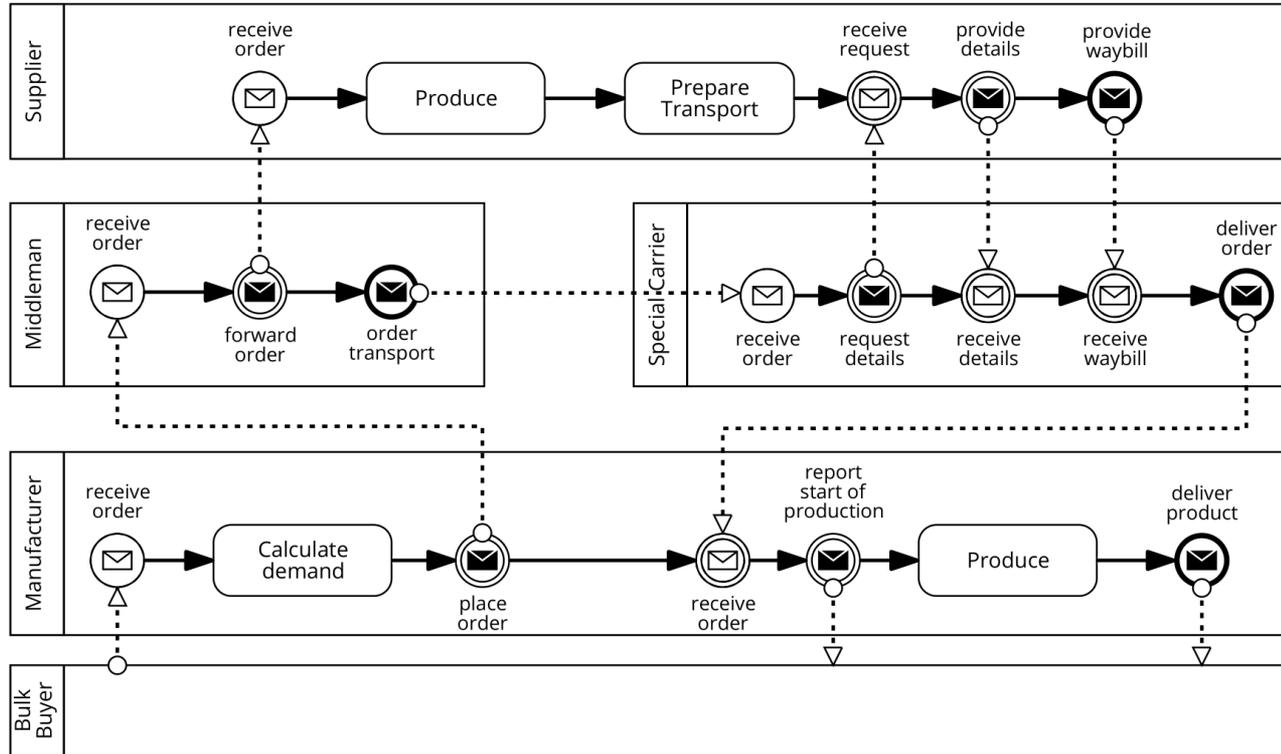
# MDE for data structures and tokens

- Approach:
    - Model data structure (variables, types) – not for fungible tokens
    - Model relationships to other types / tokens
    - Select features

→ Code is generated – deploy or customize
  - Feature examples:
    - Fungible tokens:
      - Can be minted? Burnt? By whom?
    - Non-fungible tokens
      - Include standard method(s) for sale
      - One contract for all tokens or one per token?
  - Code generated is compliant with standards
    - interface syntax and semantics
-

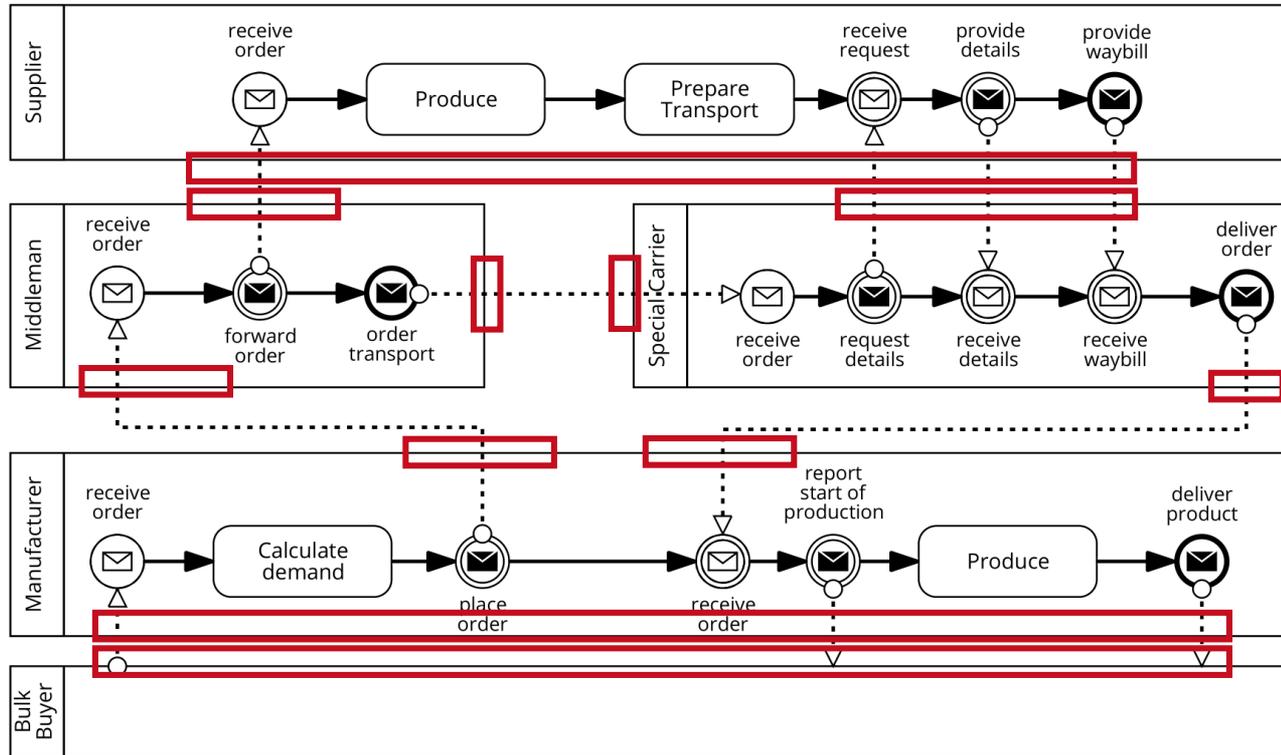
- Integration of business processes across organizations:  
a key driver of productivity gains
- Collaborative process execution
  - Doable when there is trust – supply chains can be tightly integrated
  - Problematic when involved organizations have a **lack of trust** in each other
    - if 3+ parties should collaborate, where to execute the process that ties them together?
  - Common situation in “coopetition”

# Motivation: example



- Issues:
- Knowing the status, tracking correct execution
  - Handling payments
  - Resolving conflicts

# Motivation: example



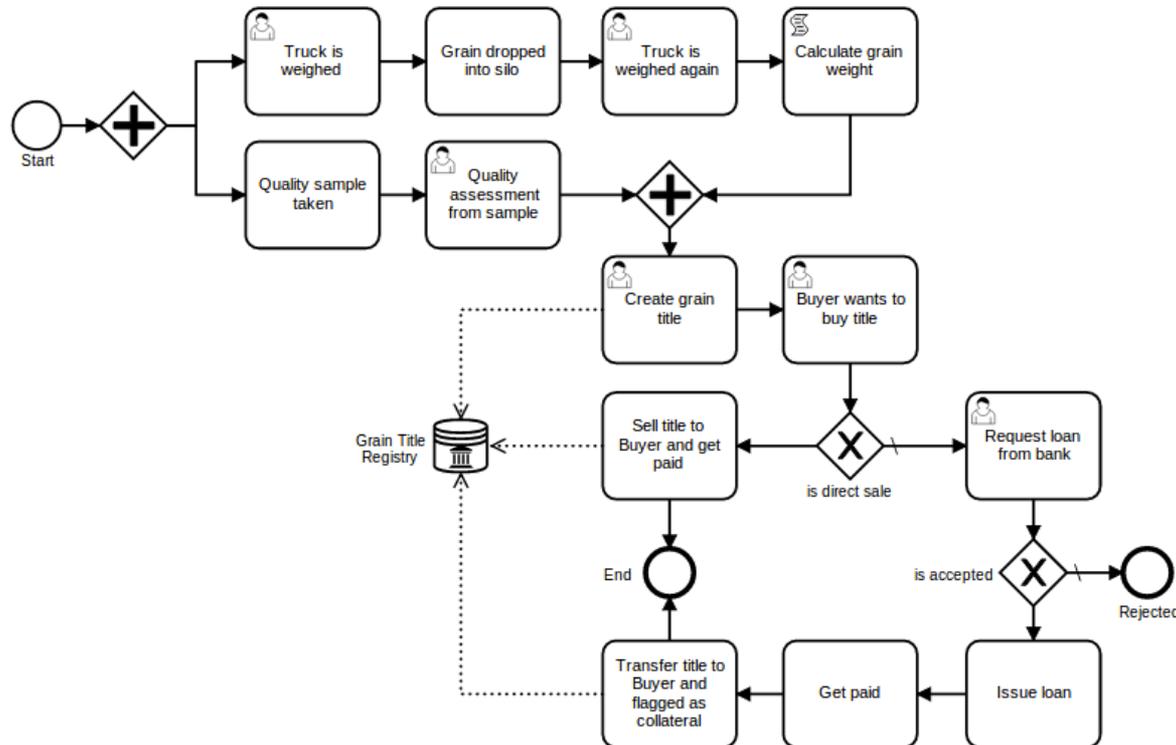
Service Interface

- Issues:
- Knowing the status, tracking correct execution
  - Handling payments
  - Resolving conflicts

# Approach in a nutshell [2]

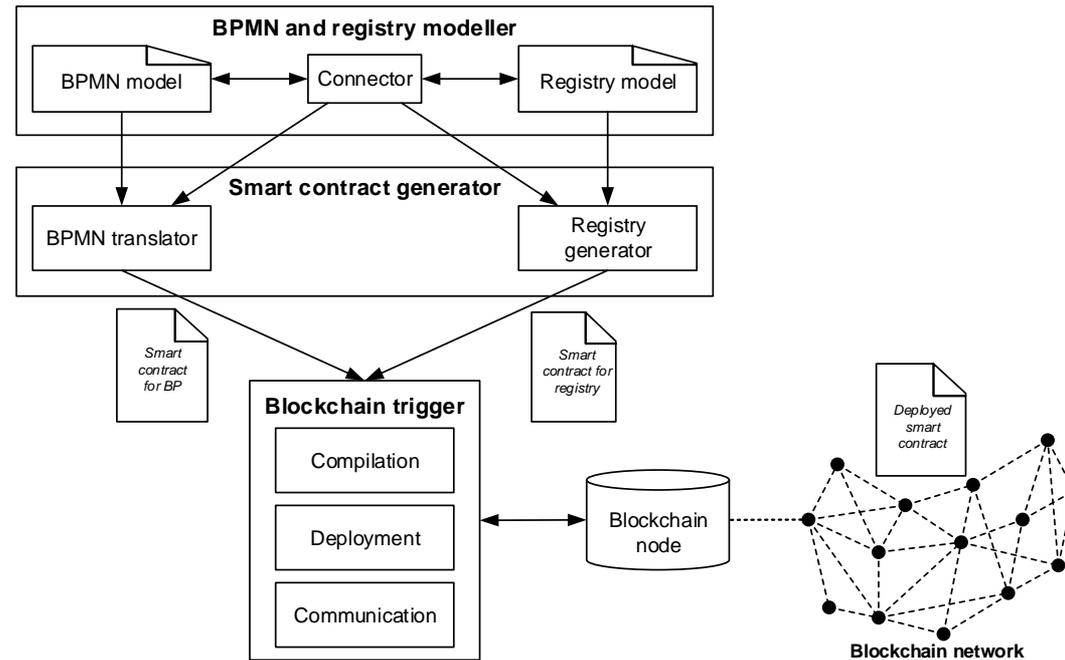
- Goal: implement collaborative business processes as smart contracts
  - Translate (enriched) BPMN to smart contract code
  - Triggers act as bridge between Enterprise world and blockchain
  - Smart contract provides:
    - Independent, global process monitoring
    - Conformance checking and process enforcement: only expected messages are accepted, only from the respective role
    - Automatic payments & escrow
    - Data transformation
    - Encryption
- Processes can make use of data / token contracts
  - Process activity to hand over title to a car / shipment / grain / ..., e.g., in exchange for fungible tokens

# Combining process and data/token models



# Data61 tool: Lorikeet [10]

- Lorikeet: automatic generate smart contracts from BPMN models/registry data schema



# Design time for fungible tokens

DATA 61  Lorikeet Home Design Ethereum connectivity: Error  

### Edit ERC20 Token Design

Compile Smart Contract Save & Close Cancel

Does the token require details?  
 Details  
 No Details

Name   
What the token will be called

Symbol

Decimals

Is the token mintable?  
 Mintable  
 Not Mintable

Is the token burnable?  
 Burnable  
 Not Burnable

How will the token be initially distributed?

Account   
Account to distribute allocation to

Allocation   
How much this account will be allocated

Add

### Smart Contract Output

Source Code ▾

```
pragma solidity ^ 0.4 .24;

/**
 * @title SafeMath
 * @dev Math operations with safety checks that revert on error
 */
library SafeMath {

    /**
     * @dev Multiplies two numbers, reverts on overflow.
     */
    function mul(uint256 a, uint256 b) internal pure returns(uint256) {
        // Gas optimization: this is cheaper than requiring 'a' not being zero, but the
        // benefit is lost if 'b' is also tested.
        // See: https://github.com/OpenZeppelin/openzeppelin-solidity/pull/522
        if (a == 0) {
            return 0;
        }

        uint256 c = a * b;
        require(c / a == b);

        return c;
    }

    /**
     * @dev Integer division of two numbers truncating the quotient, reverts on division by 0
     */
    function div(uint256 a, uint256 b) internal pure returns(uint256) {
        require(b > 0); // Solidity only automatically asserts when dividing by 0
        uint256 c = a / b;
        // assert(a == b * c + a % b); // There is no case in which this doesn't hold

        return c;
    }

    /**
     * @dev Subtracts two numbers, reverts on overflow (i.e. if subtrahend is greater than
     */
    function sub(uint256 a, uint256 b) internal pure returns(uint256) {
```

Buidl 61. Commit SHA: 9172290fb0f4ba57d521932bbfae1730dbccde

# Design time for data models / non-fungible tokens

DATA 61  Lorikeet Home Design Ethereum connectivity: Error  

### Edit Registry Design

**Compile Smart Contract** **Save & Close** **Cancel**

Digital Asset Name:   
The digital assets to be registered on the blockchain.

Registry Type:  Single  Distributed  
All records held in a single registry smart contract.

Record ID Data Type:   
Unique ID identifying each registry record.

### Record Attributes

New Attribute:    
 Allow updates to this attribute **Add Attribute**

Data Type	Attribute Name
uint	z-ID 

### Foreign Keys

Referenced Registry:   
Create a reference from an attribute in this registry to the record ID(s) of this or another registry.

Foreign Key Attribute:    
 Many-to-One  Many-to-Many **Add Foreign Key**

### Smart Contract Output

Source Code

```
pragma solidity ^ 0.4 .21;

// COMP6452-students registry smart contract.
contract COMP6452 - studentsRegistry {

    enum RecordStates {
        NON_EXISTING,
        ACTIVE
    }

    // Data structure containing basic fields/attributes of a registry record.
    struct RecordAttributes {
        // Define record attributes here...
        uint z - ID;
    }

    // Data structure representing a single registry record.
    struct Record {
        // Record owner can be an external Ethereum account,
        // or a smart contract representing a user group or Organisation.
        address owner;

        RecordStates state;
        RecordAttributes attrs;
    }

    mapping(address => Record) records;
    address[] all_record_ids;

    // Admin of registry.
    address public registry_admin;

    // Registry constructor.
    function COMP6452 - studentsRegistry() public {
        // The user deploying the registry contract will be the registry admin.
        registry_admin = msg.sender;
    }

    // ===== CONTRACT EVENTS =====
```

Build 61. Commit SHA: 9172290fb80f4ba57d521932bfae1730dbccde

# Design time for process models

Demo video: <https://drive.google.com/file/d/1rpy-oHbDVkXa6u4Fn73wSX8rINn1sv3U/view>

DATA 61 Lorikeet Home Design Manage Welcome 0x180d34b876DAa90057B2Ec345E82E2B1E9a4A082 Log Out

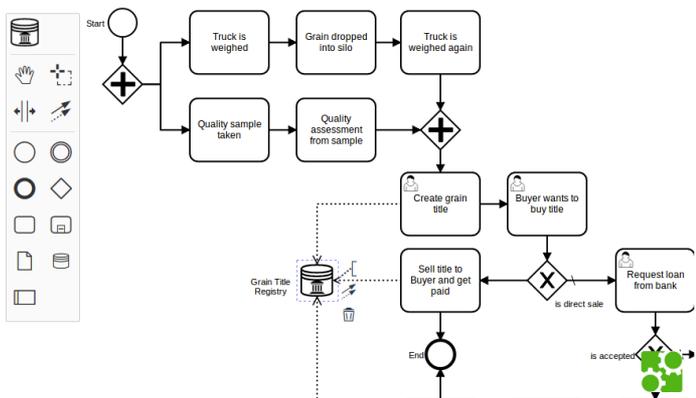
### Edit BPMN Design

Compile Save & Close Cancel

**Business Process Name**  
GrainSupplyChain

Use Petri-Net Method

Save Model Source XML



**RegistryReference\_03z5ksr**

General Listeners Extensions Registry Reference

**General**

**Id**  
RegistryReference\_03z5ksr

### Smart Contract Output

Solidity Code

```
// ----- REGISTRY INTERFACES
contract GrainTitleRegistry {
    function record_create(uint weight) returns(uint record_id);

    function record_transfer_ownership(uint record_id, address buyer_address, bool is_collateral);
}

// -----

contract ProcessMonitor {
    //uint preconditions = 0x000;

    function getPreconditions(uint instanceID, internal returns(uint);

    function setPreconditions(uint instanceID, uint preconditions) internal;
    event taskCompleted(uint indexed instanceID, string taskName);

    // ----- PROCESS VARIABLES
    bool isLoanAccepted;
    bool isDirectSale;
    bytes32 titleID;
    address buyerAddress;
    // -----

    // ----- REGISTRY CONTRACT ADDRESSES
    address addressOfGrainTitleRegistry = 0x11D6fd252649f869349CAdf4E2df3E17c85398f0;
    // -----

    function ProcessMonitor() {
        //
        //
        //
    }

    function Issue_loan(uint256 instanceID) returns(bool) {
        uint preconditions = getPreconditions(instanceID);

        if ((preconditions & (0x2 | 0x10000) == (0x2 | 0x10000))) {
            step(instanceID, preconditions & uint(~0x2) | 0x40);
            taskCompleted(instanceID, "Issue_loan");
            return true;
        }
    }
}
```

# Runtime View of Process Instances

The image displays three screenshots of process models and a log of messages sent during execution. The process models are for the 1st Level Support Agent, 2nd Level Support Agent, and Key Account Manager. The log shows the sequence of messages sent, including block numbers, transaction hashes, and URLs.

**1st Level Support Agent Process Model:** The process starts with a start node, followed by a task 'Customer Has a Problem' (Key Account Manager). This leads to a decision node 'Ask 1st level support' (1st level support agent). From there, it branches into two paths: one leading to 'Ask 2nd level support' (1st level support agent) and another to 'Provide feedback for 1st level support' (1st level support agent). The 'Ask 2nd level support' path leads to 'Ask developer' (Software developer) and 'Provide feedback for 2nd level support' (1st level support agent). The 'Provide feedback for 1st level support' path leads to 'Provide feedback for 1st level support' (1st level support agent). Both paths converge at a decision node 'Provide feedback for account manager' (Key Account Manager), which leads to 'Explain solution' (1st level support agent) and finally 'Key Account Manager'.

**2nd Level Support Agent Process Model:** The process starts with a start node, followed by a task 'Customer Has a Problem' (Key Account Manager). This leads to a decision node 'Ask 1st level support' (1st level support agent). From there, it branches into two paths: one leading to 'Ask 2nd level support' (1st level support agent) and another to 'Provide feedback for 1st level support' (1st level support agent). The 'Ask 2nd level support' path leads to 'Ask developer' (Software developer) and 'Provide feedback for 2nd level support' (1st level support agent). The 'Provide feedback for 1st level support' path leads to 'Provide feedback for 1st level support' (1st level support agent). Both paths converge at a decision node 'Provide feedback for account manager' (Key Account Manager), which leads to 'Explain solution' (1st level support agent) and finally 'Key Account Manager'.

**Key Account Manager Process Model:** The process starts with a start node, followed by a task 'Customer Has a Problem' (Key Account Manager). This leads to a decision node 'Ask 1st level support' (1st level support agent). From there, it branches into two paths: one leading to 'Ask 2nd level support' (1st level support agent) and another to 'Provide feedback for 1st level support' (1st level support agent). The 'Ask 2nd level support' path leads to 'Ask developer' (Software developer) and 'Provide feedback for 2nd level support' (1st level support agent). The 'Provide feedback for 1st level support' path leads to 'Provide feedback for 1st level support' (1st level support agent). Both paths converge at a decision node 'Provide feedback for account manager' (Key Account Manager), which leads to 'Explain solution' (1st level support agent) and finally 'Key Account Manager'.

**Log of Messages Sent:**

```
Message sent: Customer_has_a_Problem
Block Number: 483262
Tx Hash: 0xb4f5e1c5b4b2d189b428cfff5bd8bdec180d9e7fd5235b883f23c6139564a319
Message sent: Get_problem_description
http://203.143.170.105:8081/activity/exec?procInstID=0x5c095e139af14113cc49a8cf0220029d9f653720&log=Get_problem_description
Block Number: 483284
Tx Hash: 0x7a05c1153c94e34abbc8adb8ca4d9a0487f9f26eabf66d2e15552dc3559bb3a1
Message sent: Ask_1st_level_support
http://203.143.170.105:8082/activity/exec?procInstID=0x5c095e139af14113cc49a8cf0220029d9f653720&log=Ask_1st_level_support
Block Number: 483296
Tx Hash: 0x9ced8e5460c2eb9380be2a1a45cd38d29ee749d798cb54146eda42c5e2c53ce
Message sent: Provide_feedback_for_account_manager
http://203.143.170.105:8082/activity/exec?procInstID=0x5c095e139af14113cc49a8cf0220029d9f653720&log=Provide_feedback_for_account_manager
Block Number: 483306
Tx Hash: 0x1c75c8b1a04e7321465c1809b917f8f2950a1a88700d8126212e14c0e440230f
Message sent: Provide_feedback_for_1st_level_support
http://203.143.170.105:8083/activity/exec?procInstID=0x5c095e139af14113cc49a8cf0220029d9f653720&log=Provide_feedback_for_1st_level_support
Block Number: 483315
Tx Hash: 0xc6d1afd652a8a2d3a0c09309668553485e95b17ae498c0395f30485f43b897a
```

# General remarks about developing blockchain applications

---

- Code is immutable!
  - Consequences:
    - Follow **all** security best practices
    - Test heavily
    - Do code reviews
    - Build in features for updating as needed and acceptable for the user base
      - Governance for updates, e.g.: updates will become active only after 1 week / 1 month, ...
    - Understand all (relevant) parts of the blockchain system – if you get it wrong, there is no safety net
    - Design includes potentially hard trade-offs between confidentiality and transparency, though patterns exist for resolving parts of those
-



# Integrating Blockchain-based Applications with Services



# Related keynote paper:



Search  Me... 

[Australian Symposium on Service Research and Innovation](#)  
... ASSRI 2018, ASSRI 2018: [Service Research and Innovation](#) pp 13-21  
[| Cite as](#)

## Blockchain and Services – Exploring the Links

Keynote Paper

Authors Authors and affiliations

Ingo Weber 

Conference paper  
First Online: 06 October 2019

 103  
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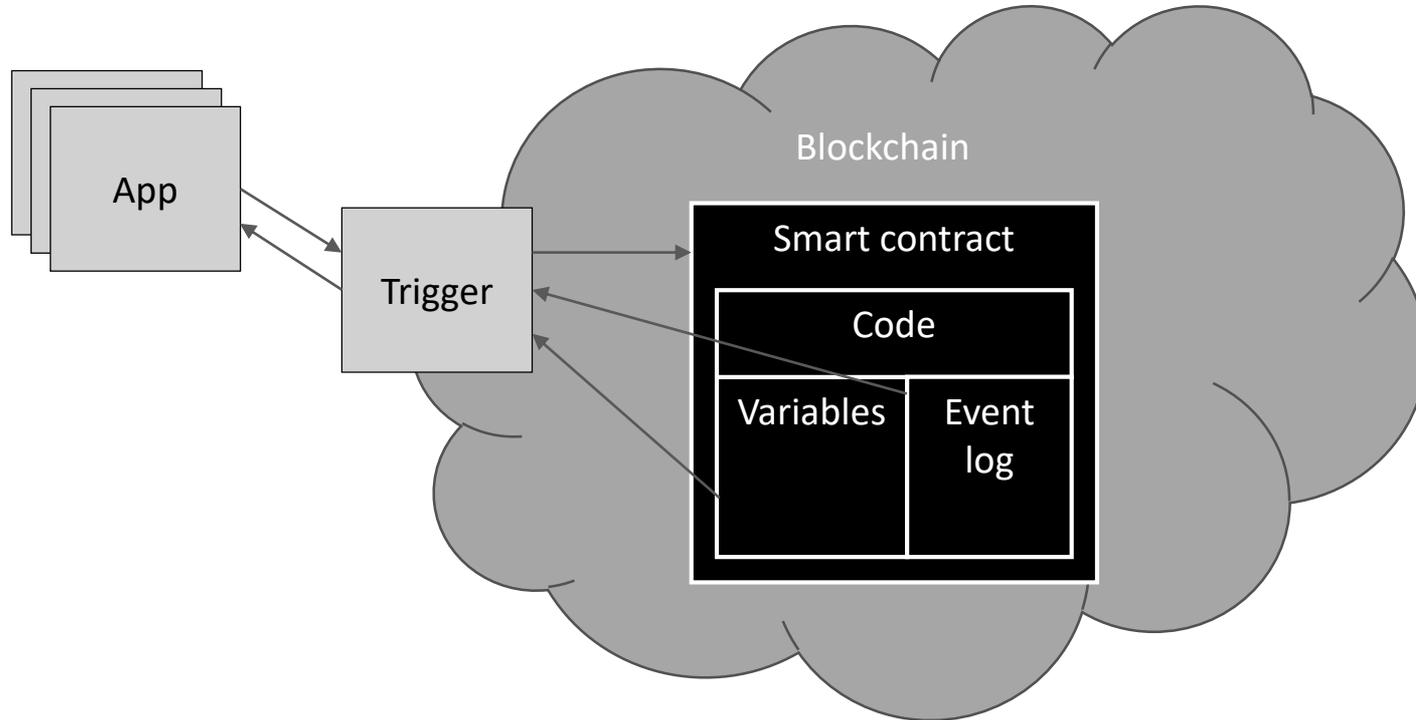
Part of the [Lecture Notes in Business Information Processing](#) book series (LNBIP, volume 367)

Ingo Weber. Blockchain and services - exploring the links: Keynote paper. In *ASSRI'18: Australian Symposium on Service Research and Innovation*, pages 13-21, October 2019. [9]

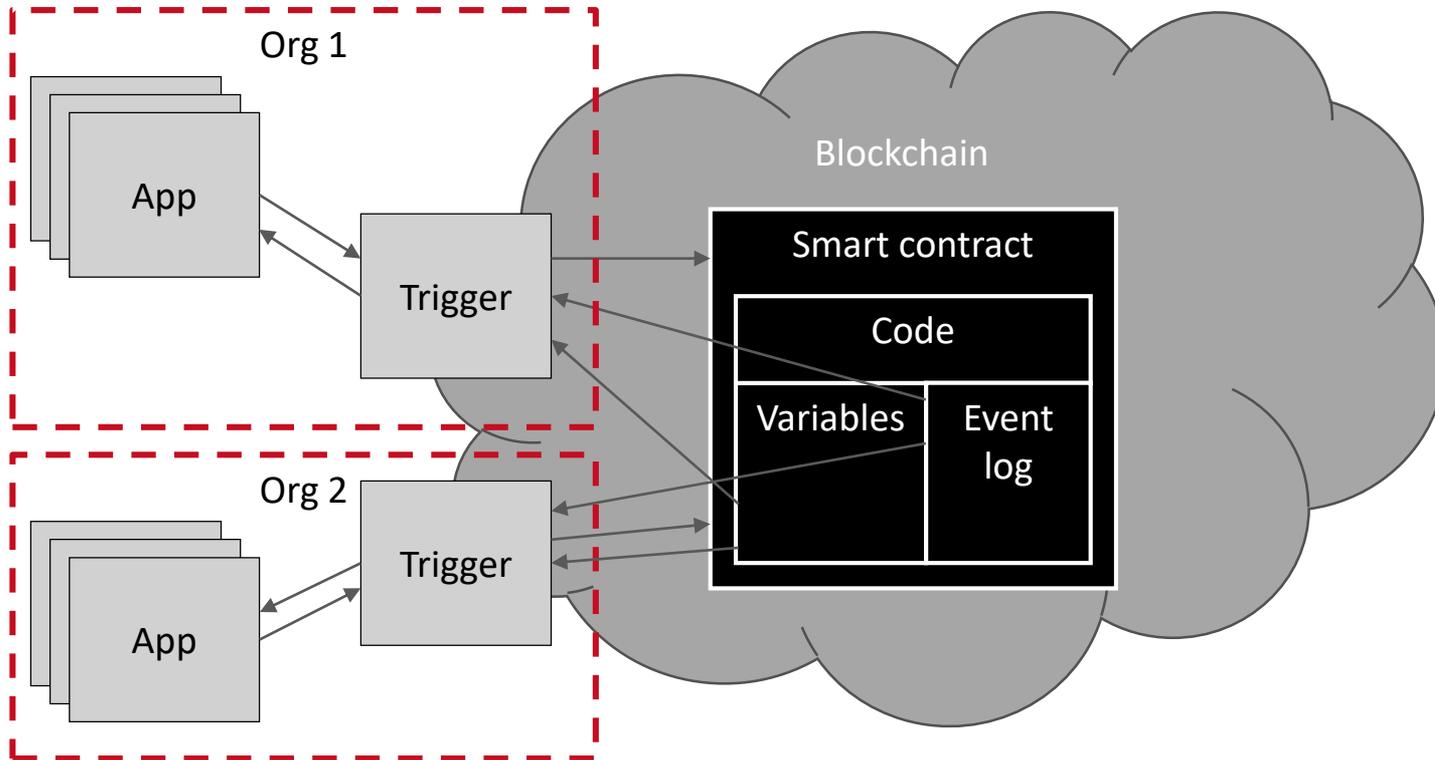
# Blockchain is a closed-world system

- To interact with smart contracts on blockchain, need to:
  - Write: create and broadcast a blockchain transaction (BCTX) for each method call
  - Read: monitor smart contract variable values and/or event logs to see updates
- The outside world speaks Services
  - REST / SOAP-WSDL / JSON RPC
- How to bridge between the two worlds?
  - Recurring problem
  - Our solution: a *Trigger* component as bridge

# Trigger as bridge between blockchain and services



# Decentralization



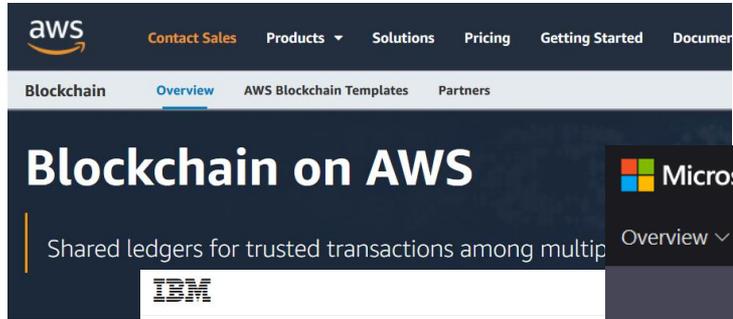


# Blockchain-as-a-Service

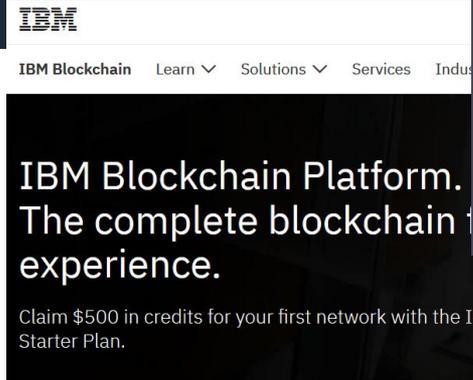


- Blockchain is a relatively new technology with steep learning curve
  - Gartner survey: “23 percent of [relevant surveyed] CIOs said that blockchain requires the most new skills to implement of any technology area, while 18 percent said that blockchain skills are the most difficult to find.”
- aaS offers can bootstrap that learning phase to a degree
  - Pre-made templates
  - Management tools
    - IDEs
    - Monitoring tools
    - ...

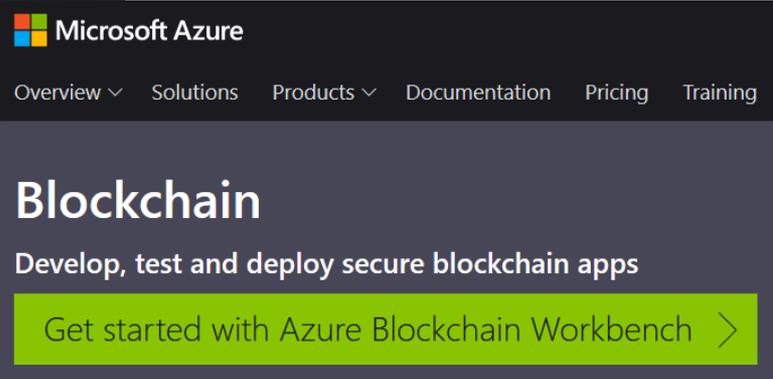
# Commercial Offers



The screenshot shows the AWS Blockchain on AWS page. The header includes the AWS logo and navigation links: Contact Sales, Products, Solutions, Pricing, Getting Started, and Documents. The main heading is "Blockchain on AWS" with a sub-heading "Shared ledgers for trusted transactions among multiple parties".



The screenshot shows the IBM Blockchain Platform page. The header includes the IBM logo and navigation links: IBM Blockchain, Learn, Solutions, Services, and Industries. The main heading is "IBM Blockchain Platform. The complete blockchain experience." with a sub-heading "Claim \$500 in credits for your first network with the IBM Blockchain Platform Starter Plan."

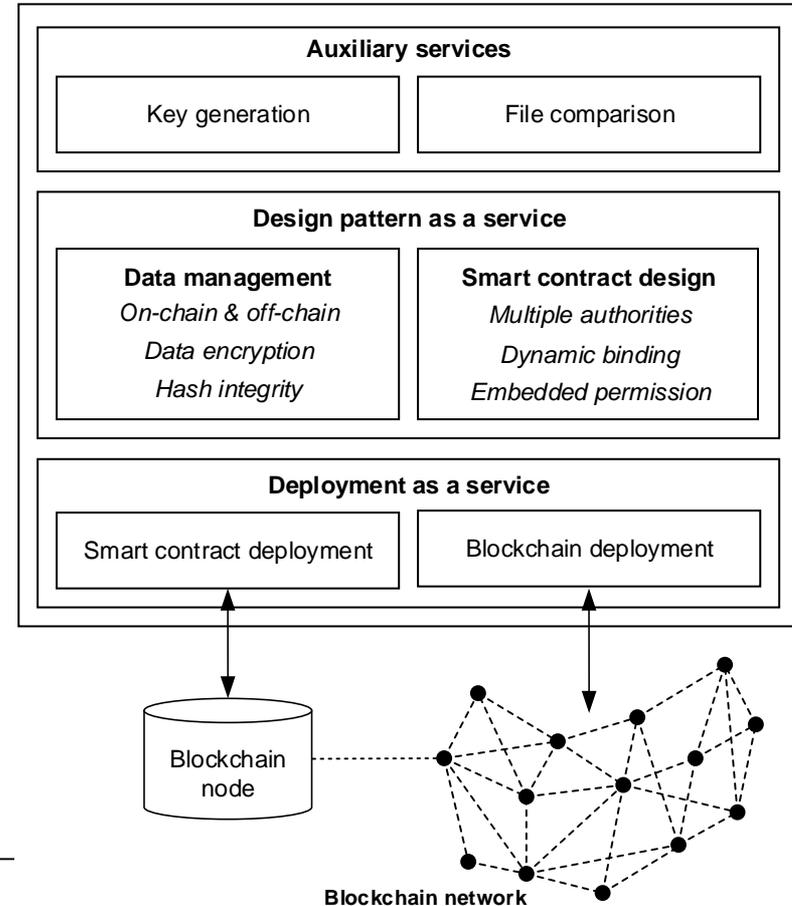


The screenshot shows the Microsoft Azure Blockchain page. The header includes the Microsoft Azure logo and navigation links: Overview, Solutions, Products, Documentation, Pricing, and Training. The main heading is "Blockchain" with a sub-heading "Develop, test and deploy secure blockchain apps". A prominent green button says "Get started with Azure Blockchain Workbench".

- But: what if all nodes are using the same provider?
  - Decentralization?

# Unified approach: uBaaS [8]

- Deployment as a service
  - Includes a blockchain deployment service and a smart contract deployment service
  - Platform agnostic to avoid lock-in to specific cloud platforms
- Design patterns as a service
  - Common data management services and smart contract design services
  - Based on a design pattern to better leverage the unique properties of blockchain (i.e. immutability and data integrity, transparency) and address the limitations (i.e. privacy and scalability)

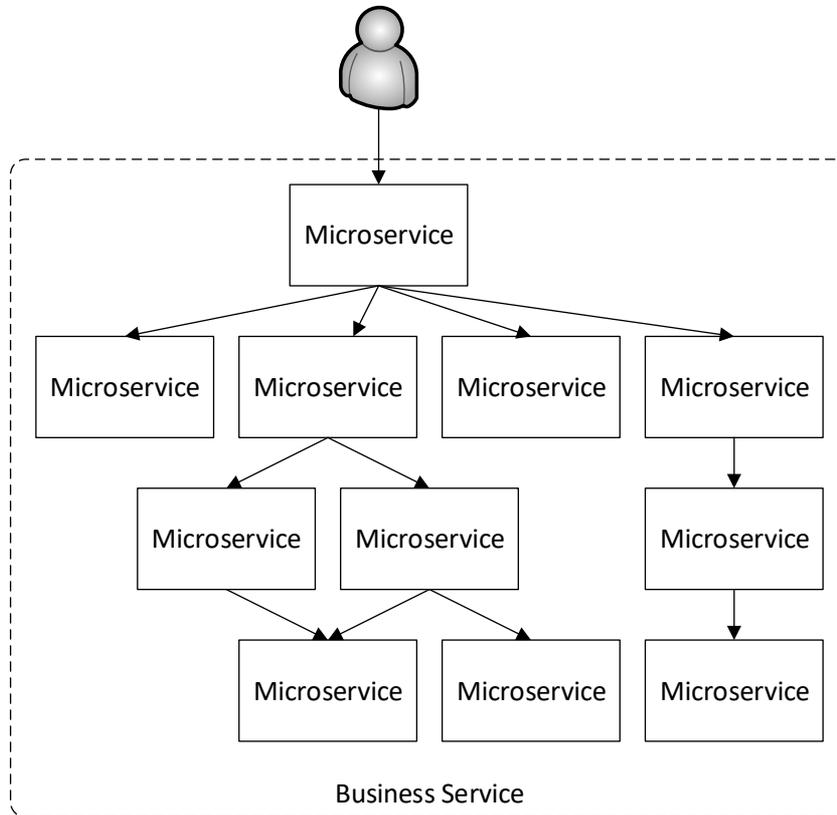




# Service-orientation vs. Smart Contracts



# Microservice Architecture



- Each user request is satisfied by some sequence of services
- Most services are not externally available
- Each service communicates with other services through service interfaces
- Service depth may be 70, e.g., LinkedIn

# Smart Contracts as Services?

- Analogy:
  - Smart contract code  $\approx$  Java Class
  - Deployed smart contract  $\approx$  Java Object, but with some properties
    - Defined interface
    - Standard way to invoke
    - Callable by anyone (who can send transactions to the blockchain)

→ Similar to Web service!
- Some design principles can apply

# Service-Orientation Design Principles

- ✗ **Standardized Service Contract:** the public interfaces of a services make use of contract design standards. (Contract: WSDL in WS\*)
- ✓ **Service Loose Coupling:** to impose low burdens on service consumers (coupling ~ degree of dependency)
- ✗ **Service Abstraction:** “to hide as much of the underlying details of a service as possible”
- ~ **Service Reusability:** services contain agnostic logic and “can be positioned as reusable enterprise resources”
- ✓ **Service Autonomy:** to provide reliable and consistent results, a service has to have strong control over its underlying environment
- ✗ **Service Statelessness:** services should be “designed to remain stateful only when required.”
- ✗ **Service Discoverability:** “services are supplemented with communicative meta data by which they can be effectively discovered and interpreted.”
- ~ **Service Composability:** “services are effective composition participants, regardless of the size and complexity of the composition.”
- ✗ **Fundamental requirement – interoperability of services:** “...stating that services must be interoperable is just about as evident as stating that services must exist.”

# Microservice Principles

- ✓ Small, focused functionality
  - ✓ Split of responsibility
  - ~ Full-stack & independently updatable without downtime
  - ✗ Stateless
- 
- While some design principles for Microservice Architectures apply, others do not
    - Updates *can* be independent
    - But reliance on the *inability* of anyone to update without agreement / governance is one source of trust in a smart contract



## Selected Applications & Adoption



# Selected Blockchain Projects

- Australian Securities Exchange:
  - Settlement of trades to be sped up from 2-3 days to minutes, freeing up billions of \$\$
  - In industry engagement, revision based on feedback and testing ongoing
  - Go-live of the blockchain system planned for 2021 / 2022
- Modum.io:
  - Ensure drugs do not exceed a temperature threshold
    - Tamper-proof IoT device & blockchain storage of data
  - Otherwise: use refrigeration trucks, 4-8x pricier
- Lygon.io
  - Joint initiative by Australian Banks
  - Platform for blockchain-based bank guarantees for commercial property leases
    - “Before Lygon, issuing a paper bank guarantee took up to a month. Today, Lygon achieves same-day issuance.”
  - Digital bearer instrument



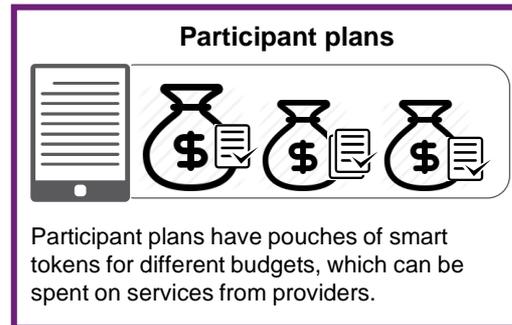
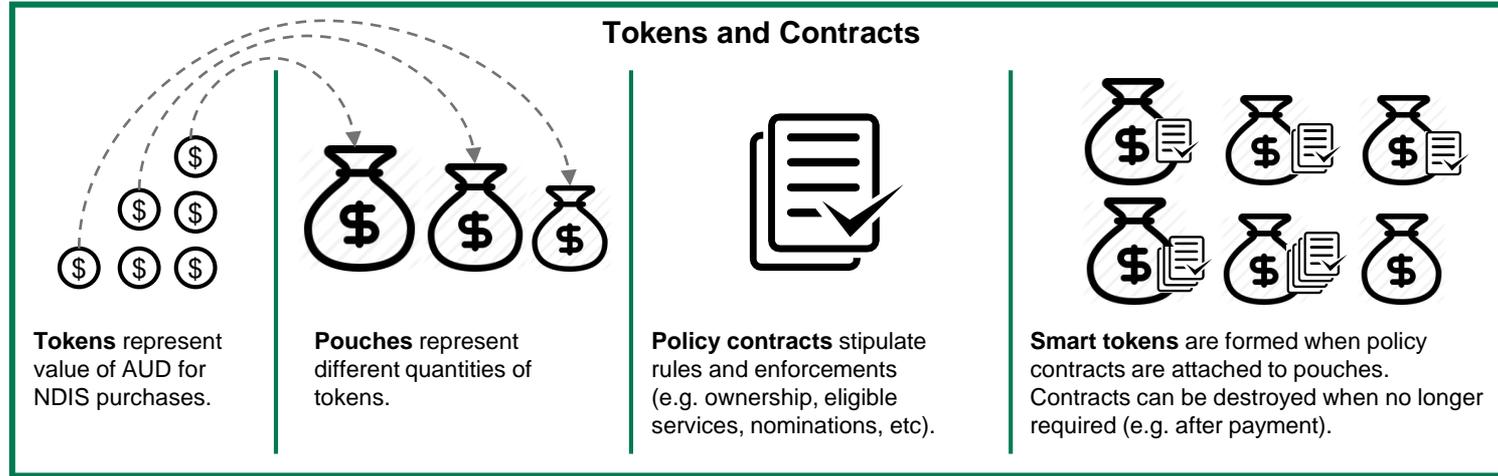
Picture source: modum.io

# Programmable Money [16]: core idea

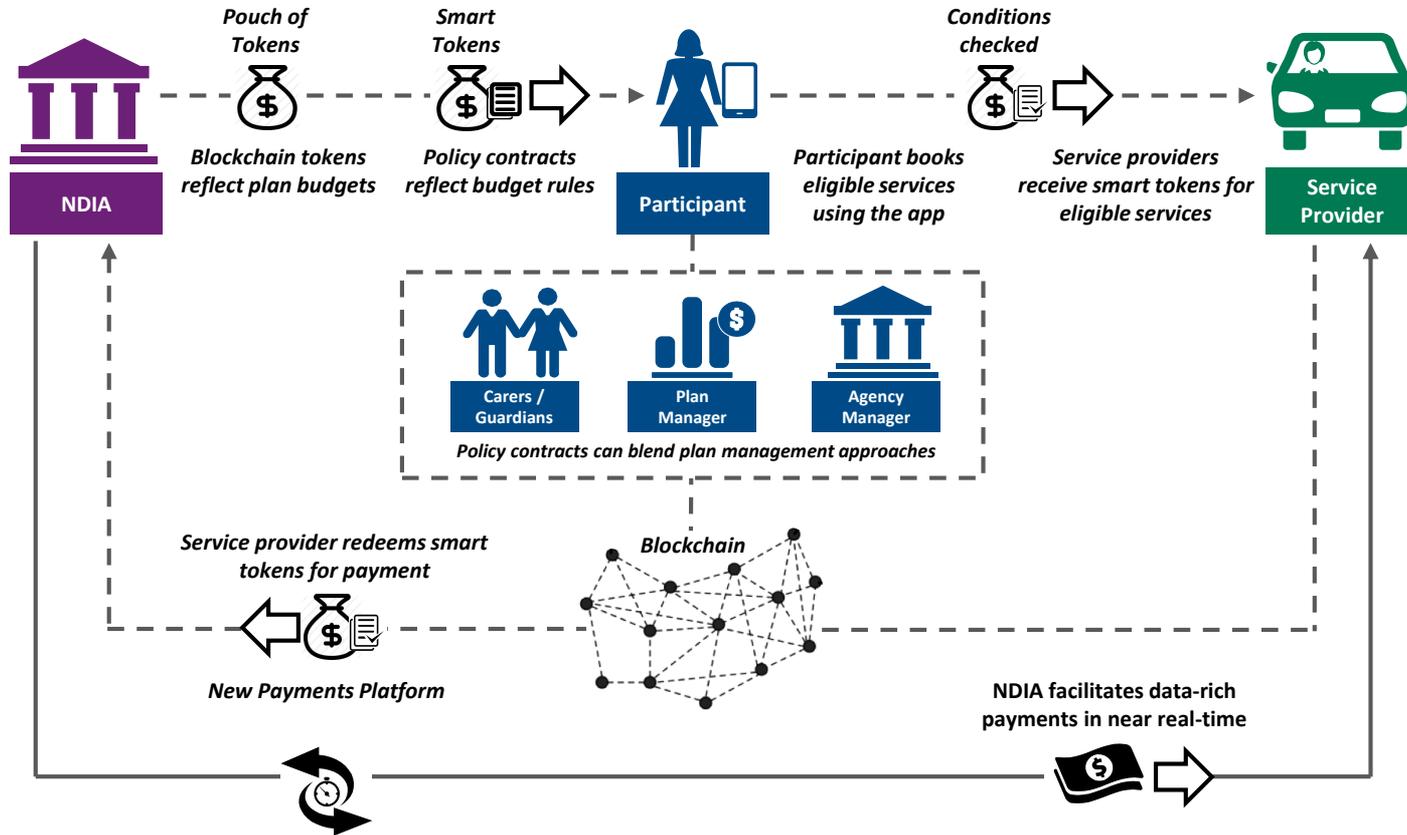
- Conditional payments: the transfer money only when predefined rules hold.
  - Examples: welfare payments, employee expenses, insurance payouts, ...
- Traditionally: conditions are checked (manually) in reimbursement or pre-approval/audit processes
  - Violation of policies: no reimbursement (or similar)
- Programmable money: next-generation conditional payments, on decentralized ledger / blockchain.
- In our programmable money project: programmed policies are not attached to accounts, but instead to money itself!
  - Policies here specify under which conditions money may be spent
  - When you try to spend money, the **money itself checks** automatically if a payment adheres to the policies
    - no uncertainty whether you will get reimbursed (and other benefits)

# Programmable Money (“making money smart”)

Use case: National Disability Insurance Scheme (NDIS)



# Programmable Money: our NDIS proof of concept



# Programmable Money: further notes

- Many more details contained in the keynote paper  
Ingo Weber and Mark Staples. *Programmable money: Next-generation conditional payments using blockchain - keynote paper*. In CLOSER'21: International Conference on Cloud Computing and Services Science, April 2021.
- Including lessons learnt and some open questions, for programmable money and development of blockchain apps in general. Examples:
  - How to present the policies in a way that the users can understand them?
  - How to horizontally scale components that create and submit transactions on behalf of a single party?

# Selected blockchain adoption examples

## Blockchain Stories

 <p>Article</p> <h3>Introducing the Boost token</h3> <p>A New Tool to Encourage Positive Impact</p> <p><a href="#">Read the story</a></p>	 <p>Link</p> <h3>Tackling Real World Issues</h3> <p>Hackers at ETH New York Build Apps Geared Toward Social Change</p> <p><a href="#">Visit the site</a></p>	 <p>Link</p> <h3>Blockchain to Improve Education</h3> <p>UNICEF Explores Blockchain to Improve Internet for 'Every School' in Kyrgyzstan</p> <p><a href="#">Visit the site</a></p>	 <p>Link</p> <h3>Exploring the Potential of Blockchain for Good</h3> <p>6 emerging market blockchain startups will receive up to \$100,000 to develop an open source prototype.</p> <p><a href="#">Visit the site</a></p>
 <p>Article</p> <h3>Introducing Blockchain to Young People</h3> <p>From "what is blockchain" to "this</p>	 <p>Article</p> <h3>Redesigning Impact Bounties for collaborative solutions</h3>	 <p>Article</p> <h3>Building for Financial Inclusion in Bangkok</h3> <p>The fifth installation in the SURGE</p>	 <p>Link</p> <h3>Un-chained: Experiments and Learnings in Crypto at UNICEF</h3>

<https://www.unicef.org/innovation/blockchain>



Blockchain Products Solutions Services Learn Explore More



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## New York launches blockchain-powered COVID-19 vaccination passport

Ne pa: pre rec: TECH 10 APRIL 2021 Steve Kaaru

## Blockchain-based COVID-19 vaccine passports coming to South Korea

South Korea has become the latest country to announce the launch of a COVID-19 vaccination passport powered by blockchain technology. The passport will roll out later this month to allow a faster return to normalcy.

- Blockchain basics and terminology
- Designing and developing blockchain applications
  - Architecture & design
  - Model-driven engineering
- Blockchain and Services:
  - Integrating Blockchain-based Applications with Services
  - Blockchain-as-a-Service
  - Service-orientation vs. Smart Contracts
- Programmable money
- Blockchain adoption



# Blockchain Application Design and Development, and the Case of Programmable Money



CLOSER'21 Keynote

Prof. Dr. Ingo Weber | April 2021

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