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AIOT Dev Summit

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IoTeX

End-to-End Security with Arm-Based Edge Devices & IoTeX Blockchain

Xinxin Fan and Raullen Chai

December 3, 2019

The Internet of Trusted Things

IoTeX | Blockchain, Secure Hardware, & Data Services

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Part I: Pebble Tracker Overview

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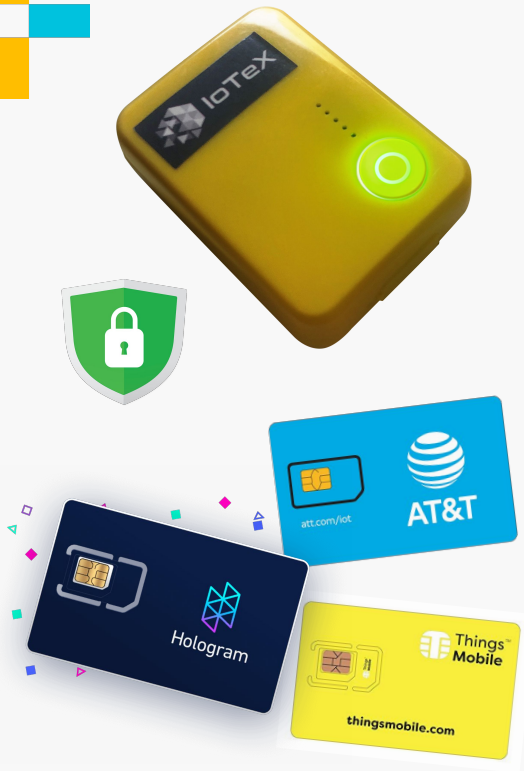
What is Pebble Tracker?

- An “Out-of-the-Box” trusted smart GPS tracker prototyping kit with 4G connectivity and sensor technologies
- Build around the latest low-power nRF9160 System-in-Package (SiP)
- Support LET-M and NB-IoT in bands from 700 MHz to 2.2 GHz
- Support worldwide operation with IoT SIM cards
- Come with environmental and motion sensors for version 1
- Add a light sensor and a buzzer for version 2
- SoC platform security with Arm TrustZone and CryptoCell
- Include an asset tracking and decentralized data authorization demo application
- Open-source development tools and SDK from Nordic



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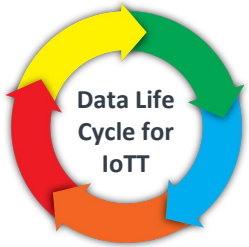
Why Are We Building Pebble Tracker?

Internet of Trusted Things (IoTT)

- Data collection
- Data in transit
- Data at rest
- Data processing
- Data retention



Pebble tracker is an ideal smart device for realizing the IoTT security reference architecture developed by IoTeX

- Secure IoT device
- IoT cloud
- Blockchain

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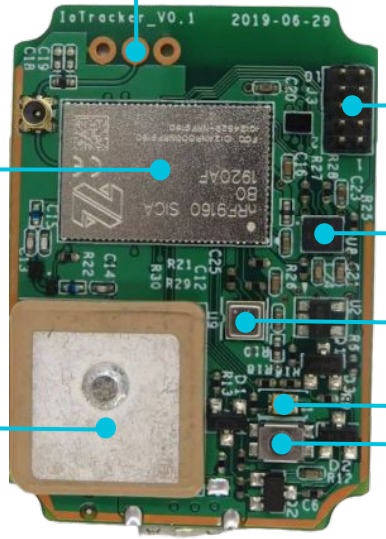
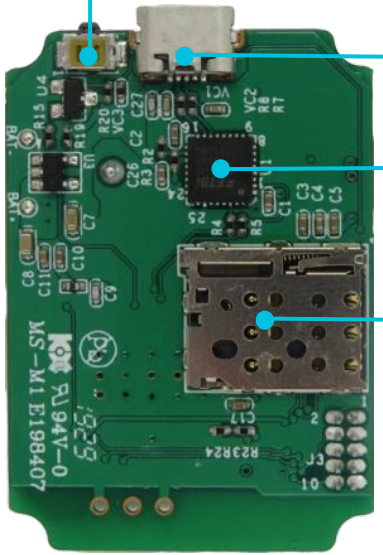
Pebble Tracker Hardware





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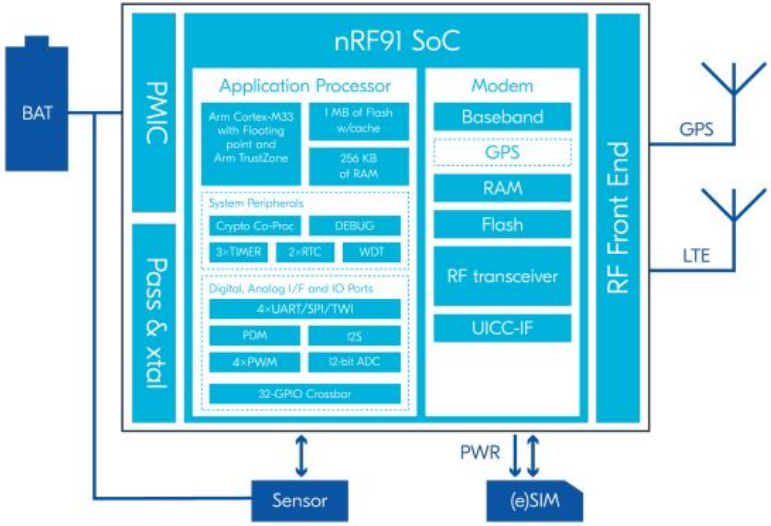
nRF9160 System-in-Package (SiP)

Key Features

- Full integrated SiP for low-power cellular IoT applications
- Arm Cortex-M33 processor
- Multimode LTE-M/NB-IoT modem with integrated RFFE
- Built-in GPS
- Single variant certified for global operations
- 10x16x1 mm LGA package



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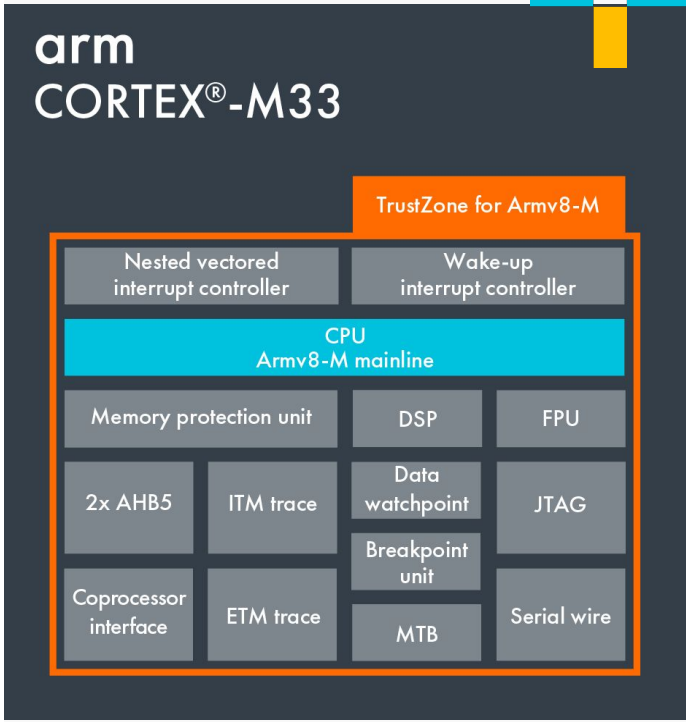
Arm Cortex-M33 Processor

- 32-bit processor running at 64 MHz
- Trusted execution environment with Arm TrustZone
- Arm CryptoCell 310 for application layer security
- 1 MB Flash & 256 KB RAM
- 4 x SPI/URAT/TWI
- PDM, I2S, PWM, ADC
- Automated power and clock management
- FPU offering up to 10x performance over software
- MPU for enhanced memory protection
- 32 GPIOs



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TrustZone for Armv8-M

- Isolate secure and non-secure executions
- Isolate trusted and non-trusted resources

Applications:
- User applications
- RTOS
- Device drivers
- Protocol stacks

Normal Resources:
- General peripherals

Normal world
- Non secure app
- Non secure RTOS

Secure world
- Secure app/libs
- Secure RTOS

TrustZone

Secure software:
- Secure boot
- Crypto libraries
- Authentication
- RTOS support APIs

Secure Resources:
- Secure storages
- Crypto accelerators
- TRNG

Root-of-Trust

Always on

Control interface

Security resources	Asymmetric crypto	Symmetric crypto	Data interface

CryptoCell augments TrustZone by providing a range of security subsystems

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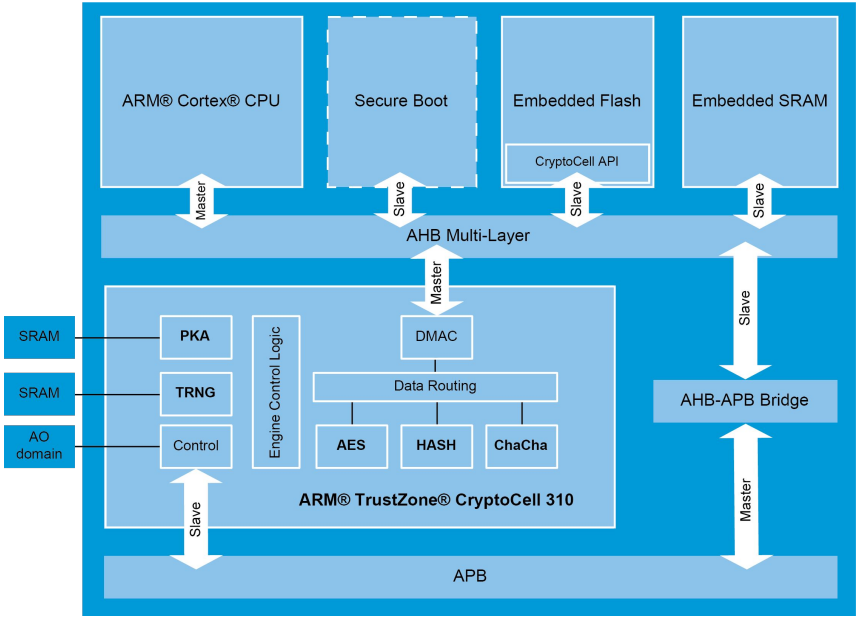
Arm CryptoCell-310 Security Subsystem

Key Features

- True random number generator (TRNG)
- Pseudorandom number generator (PRNG)
- RSA public key cryptography
- Elliptic curve cryptography (ECC)
- Secure remote password protocol (SRP)
- Hashing functions & HMAC
- AES symmetric encryption
- ChaCha20/Poly1305 symmetric encryption

CryptoCell is a security subsystem that provides root-of-trust (RoT) and cryptographic services for a device.



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Cellular Connectivity Module

Low Power LTE-M/NB-IoT Modem + GPS

Multi-Protocol Low Power LTE	3GPP LTE release 13 Cat-M1 and Cat-NB1 compliant 3GPP LTE release 14 Cat-NB1 and Cat-NB2 compliant 770 - 2200 MHz band range
LTE Bands	1, 2, 3, 4, 5, 8, 12, 13, 14, 17, 18, 19, 20, 25, 26, 28, 66
Performance	-108 dBm RX sensitivity (LTE-M) -114 dBm RX sensitivity (NB-IoT) Up to +23 dBm output power 375 kbps (LET-M) and 60 kbps (NB-IoT)
Energy Efficiency	eDRX & PSM
Features	Built-in GPS

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Sensor Hub

Bosch Sensortec BME680 Environmental Sensor

- Barometric pressure and altitude
- Temperature
- Relative humidity
- Volatile organic compounds (VOCs)

BOSCH
Invented for life

BME680
Integrated Environmental Units

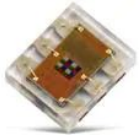
TDK Invensense ICM-42605 Motion Sensor

- 3-axis gyroscope
- 3-axis accelerometer
- Temperature

TDK InvenSense

PMT TSL25721 Ambient Light Sensor

PMT | PRECISION MEASUREMENT TECHNOLOGIES



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What Can You Measure with Pebble Tracker?

- Location: GPS provides accurate real-time location data, whereas LTE-M/NB-IoT localization techniques using the cell ID method can provide rough location for many uses cases.
- Climate: temperature, humidity, pressure and gas sensors provide insight into a tracking object's environment.
- Movement: vibration, shock, orientation and light sensors indicate the movement status of a tracking object.

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Part II: IoTeX Blockchain Platform Overview

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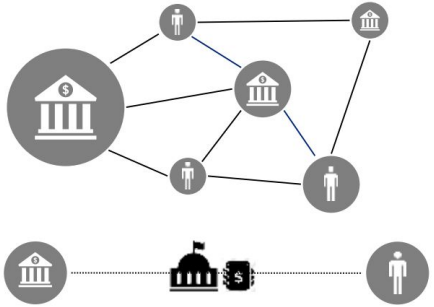
Blockchain In a Nutshell

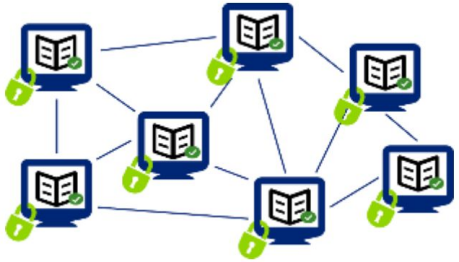
A blockchain is a record, or ledger, of digital events — one that's "distributed" between many different parties. It can only be updated by consensus of a majority of the participants in the system. And, once entered, information can never be erased. The blockchain contains a certain and verifiable record of every single transaction ever made.

Current System



- **Central authorities** (bank, Fed, notary, escrow, etc.) transfers actual value between two parties
- **Multiple intermediaries** and **record-keeping** are required to facilitate transfer of assets and create trust

Blockchain System



- **Distributed** network of computers (nodes) that maintains a shared source of information
- Transaction data is **immutable**
- **Peer to Peer transactions using digital tokens to** represent assets and value

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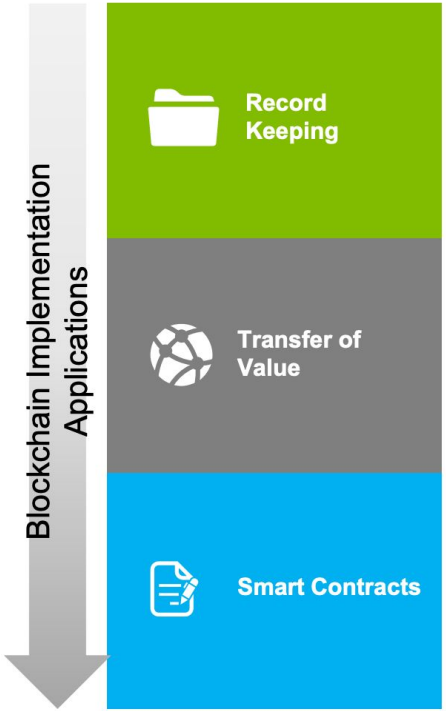
A Blockchain solution can be initiated as a store of transaction record, but also serve as a platform for further innovation and value extraction



Application Description

- A Blockchain solution can offer automated, high fidelity and low-cost mechanisms for record keeping
- Core mechanism is the maintenance and modification of a distributed ledger
- Requires user-specific “keys” – records are kept in the ledger but only accessible by authorized users

- A Blockchain solution enables secure, near real-time, low-cost transfer of value without an intermediary
- Records can be transferred to other parties using the decentralized distributed ledger
- Allows transfer of value between two parties, removing the need for a trusted intermediary

- A Blockchain solution will transform how contracts are executed
- Protocol is programmable to trigger transfer of value and information under certain conditions
- Smart contracts can be developed, exchanged, and automatically executed on decentralized systems

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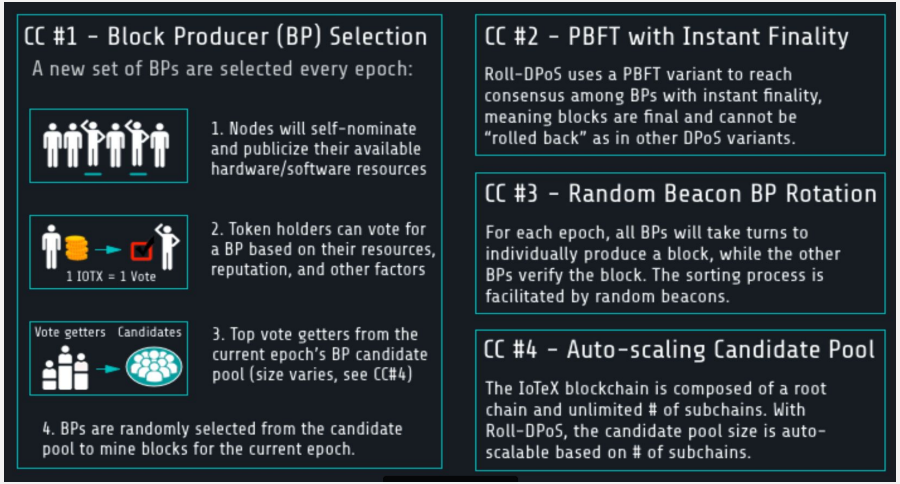
IoTeX Blockchain - High Throughput

- https://github.com/iotexproject/iotex-core
- Blockchain is usually slow (low TPS) and inextensible. How to make a blockchain fast and extensible?
  - Provides high throughput of transactions (3000+ TPS without sharding)
  - Provide consensus-as-a-service for layer2 chains



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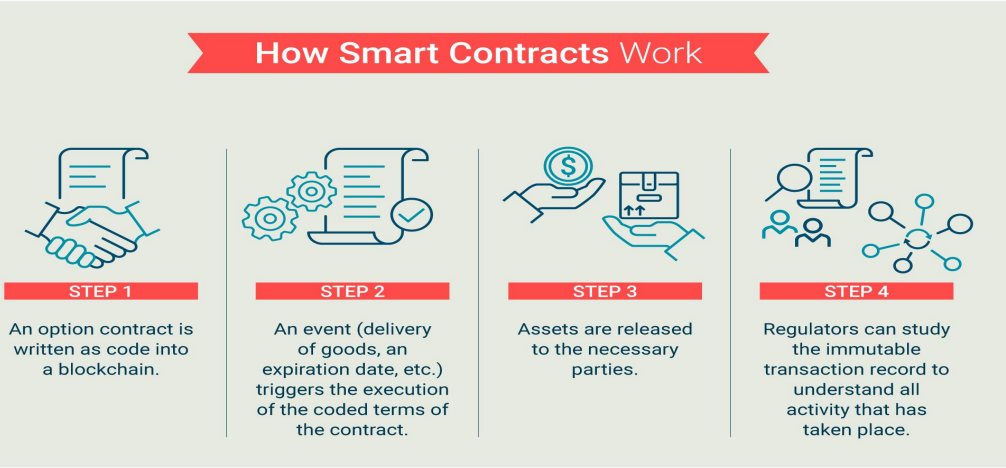
IoTeX Blockchain - Smart Contract

- User-defined programs running on top of a blockchain
- Smart contract simulates trusted third party with shared state.s
- Applications
  - Assets
  - Lotteries
  - Insurance
  - Supply-chain management
  - Self-sovereign identity
  - sAnd many more!



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aBank.sol

```
// A simple bank smart contract where the user
// can deposit and query funds.

// This needs to be the first line.
pragma solidity ^0.4.0;

// give your contract a name
contract aBank {

    // this declares a key/value array called balanceAccount.
    // the key is address and the value is an unsigned integer
    mapping (address => uint) balanceAccount;

    // declare a deposit function that takes an input called amount
    function deposit(uint amount) public {
        // add amount to the balance of the sender
        balanceAccount[msg.sender] += amount;
    }

    // a getBalance function that accepts no inputs but returns
    // the amount in the balanceAccount array
    function getBalance() returns (uint balance){
        return balanceAccount[msg.sender];
    }

}
```

Solidity version: 0.4.10+commit.f0d539ae.Emscripten.clang

Change to: Select new compiler version to load

☐ Text Wrap ☐ Enable Optimization ☑ Auto Compile Compile

Publish Attach Transact Transact (Payable) Call

▼ **aBank.sol:aBank** 365 bytes

Publish At Address Create

Bytecode

```
6060604052341561000c57fe5b5b6101518061001c6000396000f30
```

Interface

```
[{"constant":false,"inputs":[],"name":"getBalance","outputs":[{"name":
```

Web3 deploy

```
var abank_sol_abankContract = web3.eth.contract([{"co
var abank_sol_abank = abank_sol_abankContract.new(
   {
     from: web3.eth.accounts[0],
     data: '0x6060604052341561000c57fe5b5b61015180610
     gas: '4700000'
   }, function (e, contract){
    console.log(e, contract);
    if (typeof contract.address !== 'undefined') {
         console.log('Contract mined! address: ' + co
    }
 })
```

Metadata location

```
bzzr://cf3b690cc7248c407f3cff2add8e3fbbde2edf5661a3ce49f049
```

Toggle Details

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IoTeX Blockchain SDK

https://docs.iotex.io/docs/libraries-and-tools.html

iotex-antenna is our SDK allowing you to interact with a local or remote iotex blockchain node, using a gRPC or gRPC-web connection.

In your JS project root, use npm install or yarn add.
npm install iotex-antenna

In your Golang project root, use go dep or go mod.
go get -u github.com/iotexproject/iotex-antenna-go

The embedded SDK will be released soon!

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Transfer

`antenna.iotx.accounts` create, sign, and send a transaction of transfer to iotex blockchain network.

JS | Golang

```
import Antenna from "iotex-antenna";
import { toRau } from "iotex-antenna/lib/account/utils";

(async () => {
  const antenna = new Antenna("http://api.testnet.iotex.one:80");
  const unlockedWallet = await antenna.iotx.accounts.privateKeyToAccount(
    "73c7b4a62bf165dccf8ebdea8278db811efd5b8638e2ed9683d2d94889450426"
  );
  const newWallet = antenna.iotx.accounts.create("any entropy");

  const actionHash = await antenna.iotx.sendTransfer({
    from: unlockedWallet.address,
    to: newWallet.address,
    value: toRau("1", "iotx"),
    gasLimit: "100000",
    gasPrice: toRau("1", "Qev")
  });
})();
```

Account

The `antenna.iotx.accounts` contains functions to generate Iotex accounts and sign transactions and data.

JS | Golang

```
import Antenna from "iotex-antenna";

(async () => {
  const antenna = new Antenna("http://api.testnet.iotex.one:80");

  // create a new wallet which contains a public key, a private key, and an address.
  const wallet = antenna.iotx.accounts.create();

  // recover the whole wallet from a single private key
  const unlockedWallet = antenna.iotx.accounts.privateKeyToAccount(
    "69805ee813eadffa8fae53d0e6063e5fbf6a6e0fb9e90f6eaad7bc67f3d6c4bd"
  );
})();
```


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RPC Methods

The `rpc-method` (provider) package allows you to make gRPC calls to Iotex blockchain.

Use the umbrella antenna.iotex package:

JS Golang

```js
import Antenna from "iotex-antenna";

(async () => {
  const antenna = new Antenna("http://api.testnet.iotex.one:80");

  const account = await antenna.iotx.getAccount({
    address: "io1cl6rl2ev5dfa988qmgzg2x4hfazmp9vn2g66ng"
  });
  const chainMeta = await antenna.iotx.getChainMeta();
  const actions = await antenna.iotx.getActions({
    byIndex: { start: 1, count: 5 }
  });
  const blocks = await antenna.iotx.getBlockMetas({
    byIndex: { start: 1, count: 5 }
  });
})();
```

XRC20

The XRC20 package provide facility api for XEC20 contract to Iotex blockchain.

JS

```js
import Antenna from "iotex-antenna";
import BigNumber from "bignumber.js";
import { XRC20 } from "iotex-antenna/lib/token/xrc20";

(async () => {
  const antenna = new Antenna("http://api.testnet.iotex.one:80");

  // init accounts
  const account1 = antenna.iotx.accounts.privateKeyToAccount("privateKey1");
  const account2 = antenna.iotx.accounts.privateKeyToAccount("privateKey2");
  const account3 = antenna.iotx.accounts.privateKeyToAccount("privateKey3");

  // create VITA XRC20 contract instance
  // io1hy9w96v7gz7mqquyyacfhtqn6r0yasnsqrjk9h is contract address
  const vita = new XRC20("io1hy9w96v7gz7mqquyyacfhtqn6r0yasnsqrjk9h", {
    provider: antenna.iotx
  });

  // token name: IoTeX Vitality
  const name = await vita.name();
```


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IoTeX Blockchain Codelabs

codelabs.iotex.io

Welcome to IoTeX Codelabs!

Codelabs provide a guided, tutorial, hands-on coding experience for IoTeX developers. Most codelabs will step you through the process of building a small application, or adding a new feature to an existing application. They cover a wide range of topics such as Node Operation, Smart Contracts, dApps, and more.

A-Z RECENT DURATION

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Filter by category

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Codelab Contribution Guide
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45 min Updated Oct 24, 2019
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Setting up a full node
19 min Updated Jul 24, 2019
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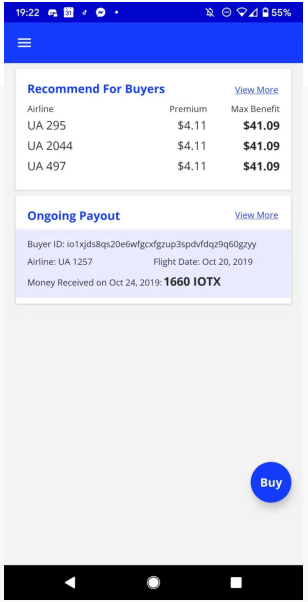
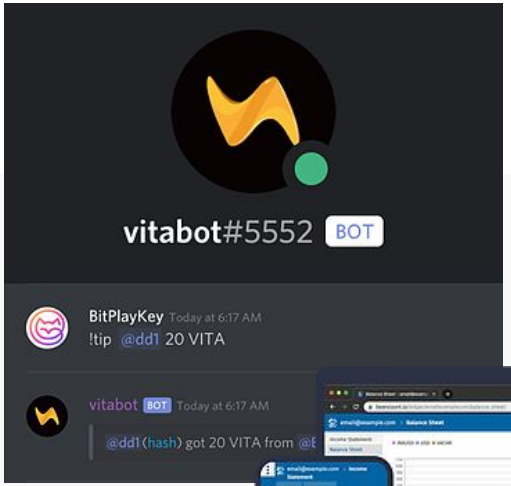
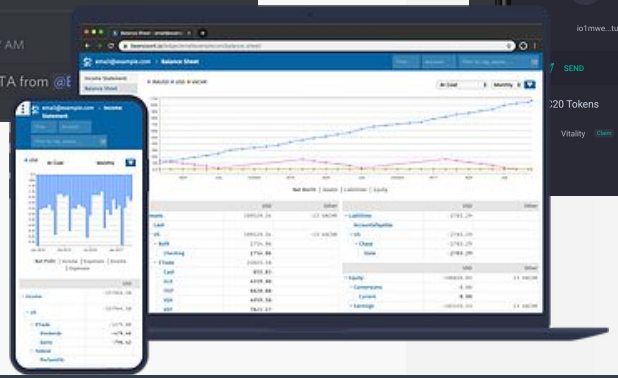
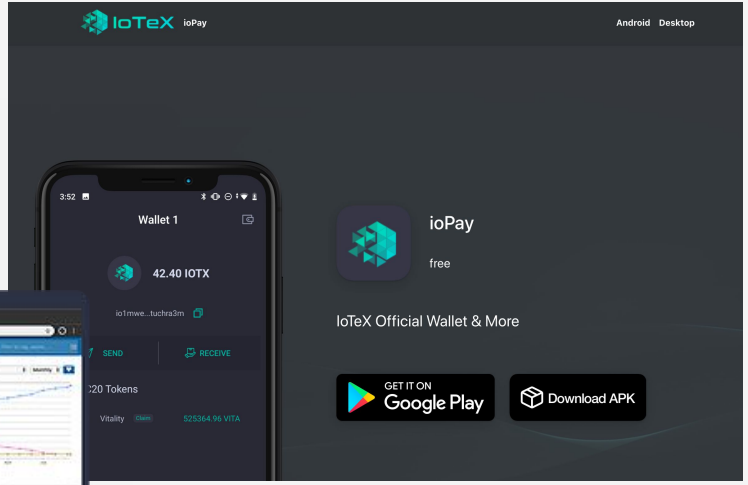
IoTeX Blockchain Applications









https://medium.com/iotex/dapps-on-the-iotex-network-part-i-cd20bd0562a8

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Part III: End-To-End Security Architecture

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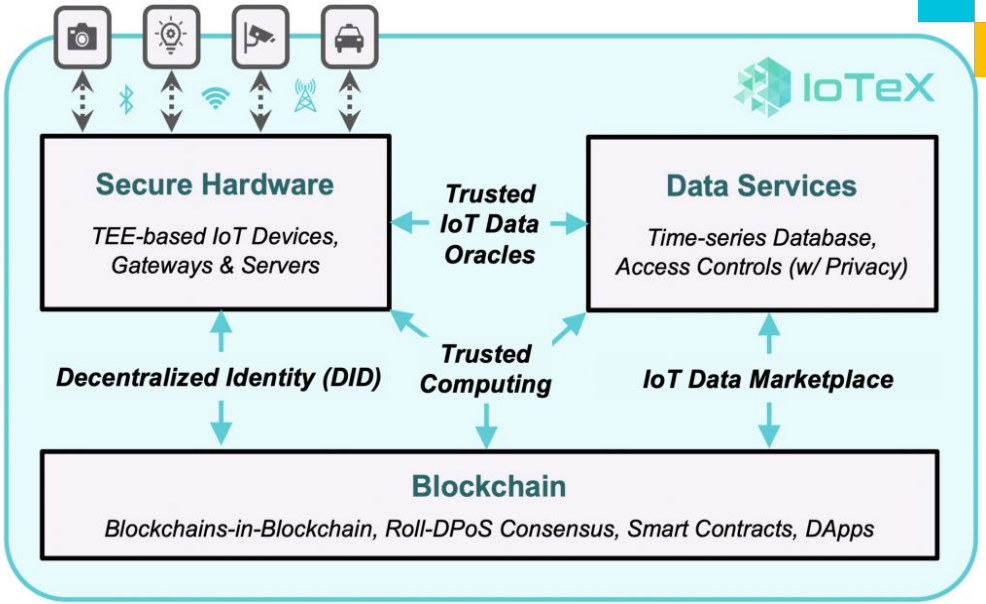
IoTeX End-To-End Security Architecture Overview



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IoT Endpoint Security

Hardware Security

Device Integrity
- Protect device from untrusted S/W
- Allow device recovery from attacks

Resource Protection
- Prevent access to certain resources (e.g., key storage)

Data Security
- Ensure data confidentiality
- Ensure data integrity

Physical Security
- Device anti-tampering

Communication Security

Device Authentication
- Identities of endpoints and cloud servers

Link Encryption
- Prevent data eavesdropping

Device Management

Device Management
- Device provisioning
- Device monitoring
- Remote attestation
- Firmware update

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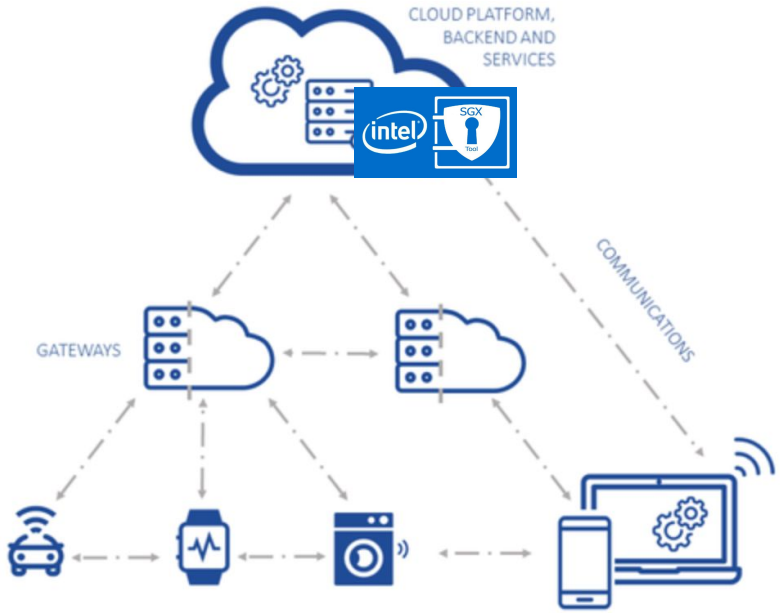
IoT Cloud Security



Identity & Access Management

Data Encryption

Device Authentication

Data Authorization

DDoS Resilience

Device Management

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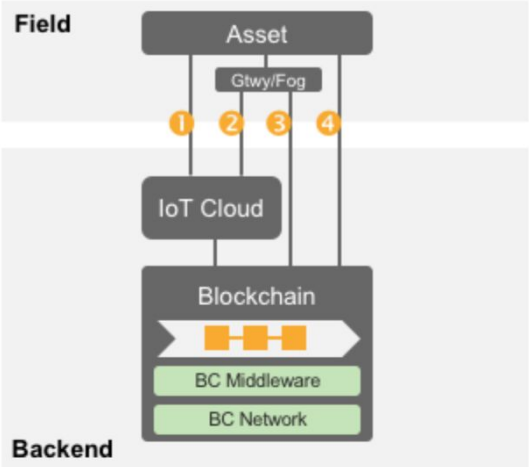
TIoTA Reference Architecture Integration Patterns



	a.) W-Only	b.) R-Only	c.) RW
1: Asset-to-Cloud-to-BC			
2: Gtwy-to-Cloud-to-BC			
3: Gtwy-to-BC			
4: Direct			

Examples

- 1a: IoT Cloud manages all asset data, selectively writes critical data / events to BC
- 1b: Cloud reads other asset`s data for validation, e.g. for pairing of two assets
- 2a: Track & Trace beacons send critical event to gateway (e.g. via BLE), gateway forwards event to IoT Cloud, data is evaluated and stored in BC
- 4a: On-asset intelligence is executing BC logic and communication directly

TrustedIoTAlliance

https://www.trusted-iot.org/businesses

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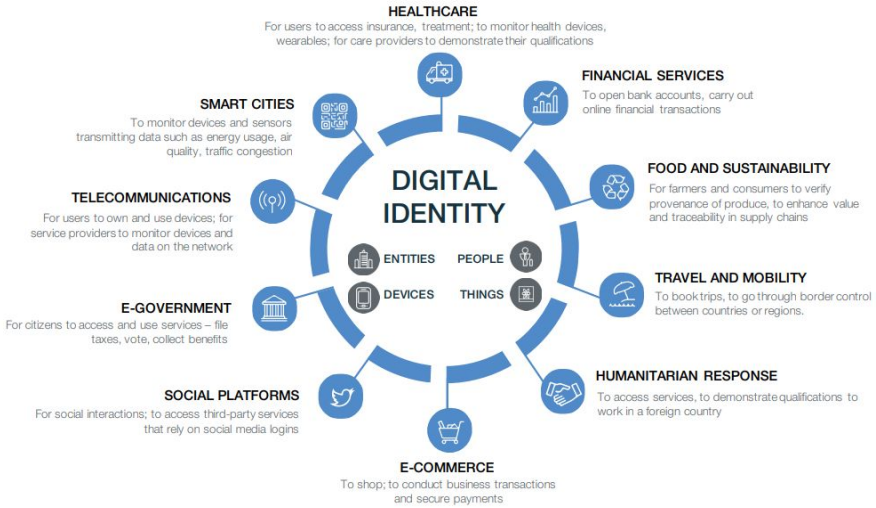
What is Digital Identity?

- "The Internet was built without an identity layer" (Kim Cameron: The Laws of Identity, 2006)
- *Digital identity* is a unique representation of a legal entity engaged in an online transaction.
- *Digital identifier* is one or more attributes that uniquely characterize an entity in a specific context.

"On the Internet, nobody knows you're a dog."



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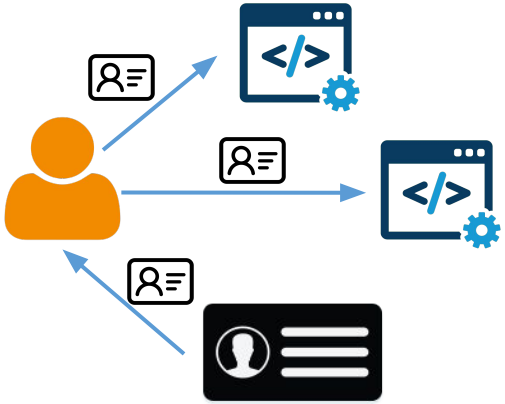
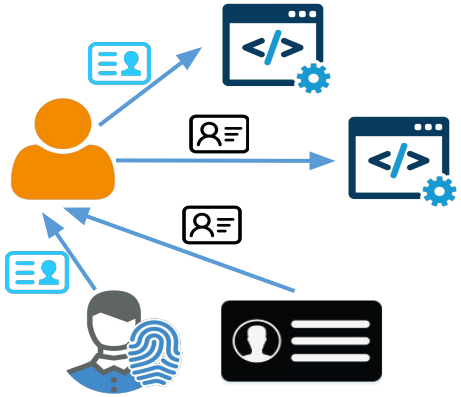
Three Archetypes of Digital Identity Systems

- Centralized (register once, trusted by one): A service provider establishes and manages service consumers' identities and related data in its system.
- Federated (register once, trusted by many): Service provides trust the identities established and maintained by other identity providers.
- Decentralized (created once, trusted globally): A service consumer has a self-managed digital identity independent of individual service providers.





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Decentralized Identifiers (DIDs)

- Decentralized Identifiers (DIDs) are a new type of identifier for verifiable ‘self-sovereign’ digital identity for individuals, organizations and things.
- The DIDs specification is being developed by the W3C Decentralized Identifier Working Group.
- DIDs have the following important properties:
  - Decentralized: DIDs are designed to function without a central registration authority. DIDs are registered in blockchain or other decentralized network.
  - Cryptographically Verifiable: DIDs are designed to be associated with cryptographic keys and the entities controlling the DID can use those keys to prove ownership.
  - Non-Reassignable: DIDs should be permanent, persistent, and non-reassignable.
  - Resolvable: DIDs are made useful through resolution.

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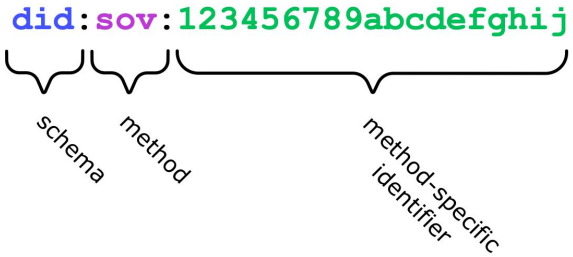
DID Syntax



- The scheme, i.e., did, is fixed
- The method specifies how the DID is created, read (resolved), updated, and deleted (revoked) – CRUD operations.
- The method-specific identifier is an alphanumeric strings that is guaranteed to be unique within the context of the method.

DID Method Registry

A registry for Decentralized Identifier Methods

Method	DID Prefix
Sovrin	did:sov:
uPort	did:uport:
Bitcoin	did:btcr:
Blockstack	did:stack:
IPFS	did:ipid:
IoTeX	did:io:

https://github.com/iotexproject/iotex-did/blob/master/README.md

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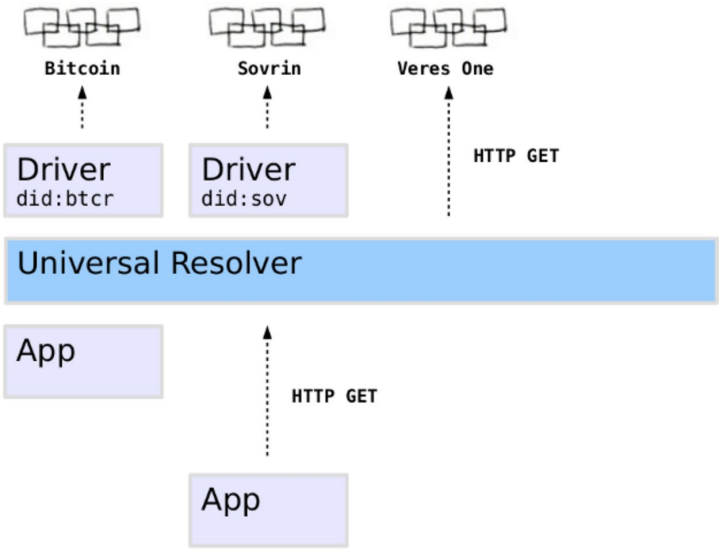
DID Resolution

- DID Resolution: DID ⟶ DID Document
- DID method outlines how to create, retrieve and update the DID on the specific decentralized network (e.g., did:io method for the DID operations on IoTeX blockchain)
- DID infrastructure functions as a global, decentralized key-value store where DIDs act as the keys and DID Documents are the values.
- DID Universal Resolver (https://uniresolver.io)
  - A universal API that works with all DID methods
  - A set of configurable 'drivers' that know how to connect to the target DID platform



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DID Documents

- DID Document is a JSON-LD document containing six, optional components:
  - The DID that points to the DID Document, identified by the key id
  - A list of public keys identified by the key publickey
  - List of protocols for authentication control of the DID and delegated capabilities identified by the key authentication
  - A set of service endpoints that allow discovery of way to interact with the entity, identified by the key service
  - A timestamp indicates when the DID Document was created and updated, identified by the key created/updated
  - A digital signature for verifying the integrity of DID Document, identified by the key proof


```
{
  "@context": "https://w3id.org/did/v1",
  "id": "did:sov:123456789abcdefghij",
  "publicKey": [{
    "id": "did:sov:123456789abcdefghij#keys-1",
    "type": "RsaVerificationKey2018",
    "controller": "did:sov:123456789abcdefghij",
    "publicKeyPem": "-----BEGIN PUBLIC KEY...END PUBLIC KEY-----\r\n"
  }],
  "authentication": [{
    "type": "RsaSignatureAuthentication2018",
    "publicKey": "did:sov:123456789abcdefghi#keys-1"
  }],
  "service": [{
    "id": "did:sov:123456789abcdefghij;exam_svc",
    "type": "ExampleService",
    "serviceEndpoint": "https://example.com/endpoint/8377464"
  }],
  "created": "2018-02-08T16:03:00Z",
  "proof": {
    "type": "LinkedDataSignature2015",
    "created": "2018-02-08T16:02:20Z",
    "creator": "did:sov:8uQhQMGzWxR8vw5P3UWH1ja#keys-1",
    "signatureValue": "QNB13Y7Q9...1tzjn4w=="
  }
}
```


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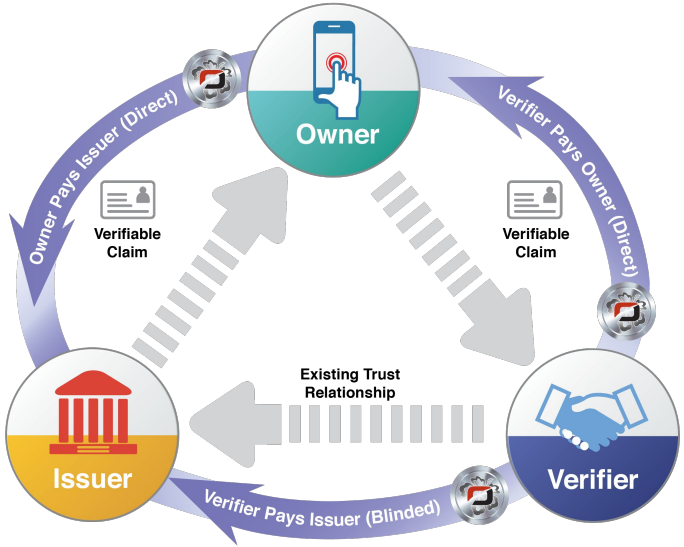
Verifiable Claims

- Verifiable claims are statements made by an entity about a ‘subject’ whose authorship can be cryptographically verified
  - Government-issued passports enable holders to travel between countries
  - Driver’s licenses are used to claim that we are capable of operating a motor vehicle
  - University degrees can be used to claim our education status
- Ideally, the claims should be cryptographically secure, privacy respecting, and automatically verifiable.



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Verifiable Credentials

- Claims are used to create verifiable credentials by issuers.
- Verifiable credentials are decentralized and contextual.
- Credential issuers decide on which claims are contained in the credentials.
- Verifiers make their own trust decisions about which credentials to accept.
- Verifiers do not need to contact issuers to perform verification.
- Credential holders are free to choose which credentials to carry and what information to disclose.


```
{
  "@context": "https://w3id.org/credentials/v1",
  "id": "did:sov:WRfXPg8dantKVubE3HX8pw/credentials/1",
  "type": ["Credential", "NameCredential"],
  "issuer": "did:sov:WRfXPg8dantKVubE3HX8pw",
  "issued": "2019-09-01",
  "claim": {
      "id": "did:btcr:x6lj-wzvr-qqrv-m80w",
      "name": "John Doe",
      "address": "..."
  },
  "proof": {
      "type": "RsaSignature2018",
      "created": "2017-06-18T21:19:10Z",
      "creator": "did:sov:WRfXPg8dantKVubE3HX8pw#key-1",
      "nonce": "c0ae1c8e-c7e7-469f-b252-86e6a0e7387e",
      "signatureValue": "BavEll0/I1zpYw8XNi1bgVg/sCneO4Jugez
       8RwDg/+MCRVpjOboDoe4SxxKjkCOvKiCHGDvc4krqi6Z1n0
       UfqzxGfmatCuFibcC1wpsPRdW+gGsutPTLzvueMWmFhw
       YmfIFpbBu95t501+rSLHIEuujM/+PXr9Cky6Ed+W3JT24=
  }
}
```


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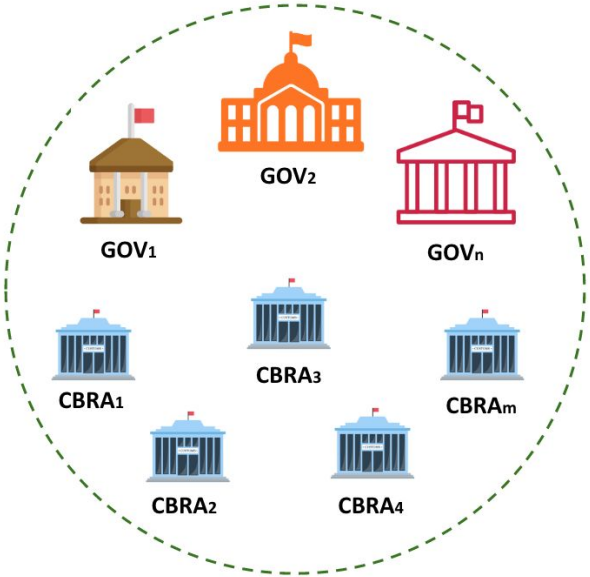
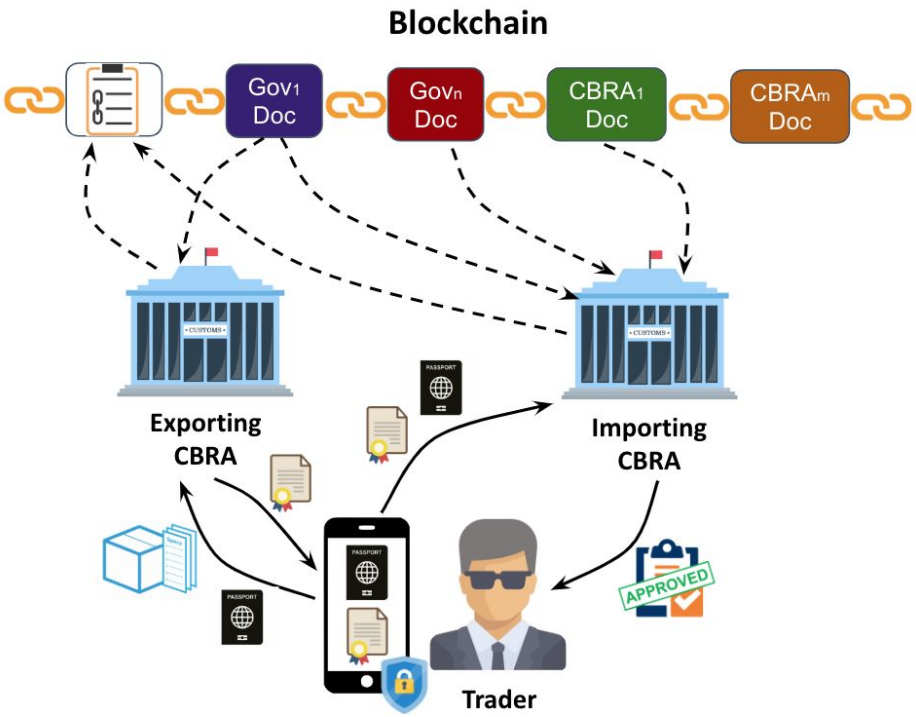
Example - Future Global Supply Chain

- GOV - Government
- CBRA - Cross-Border Regulatory Agency





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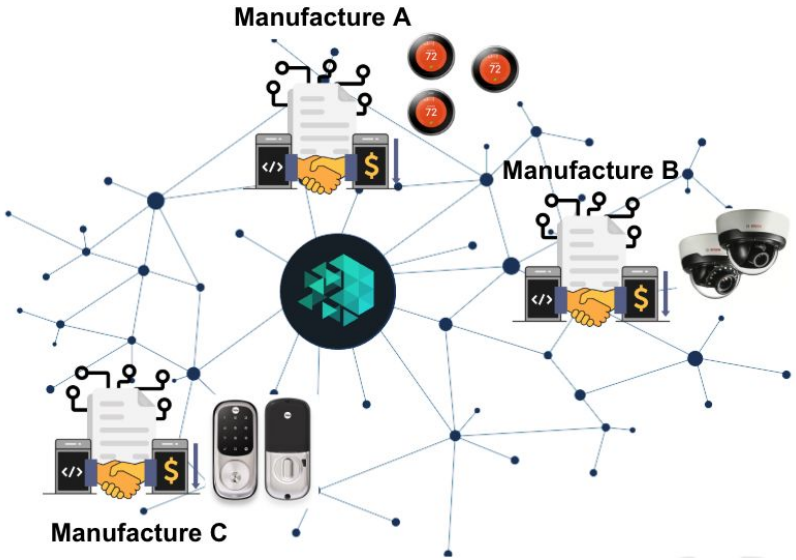
Decentralized Identifiers of Trusted Things (DITT)

- Facilitate enterprise customers to realize efficient and effective device management and access control across different business units globally
- Enable consumers to create trusted IoT data marketplace and share services

Ucam

Pebble Tracker



DITT Powered By IoTeX

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Part IV: Pebble Tracker in Action

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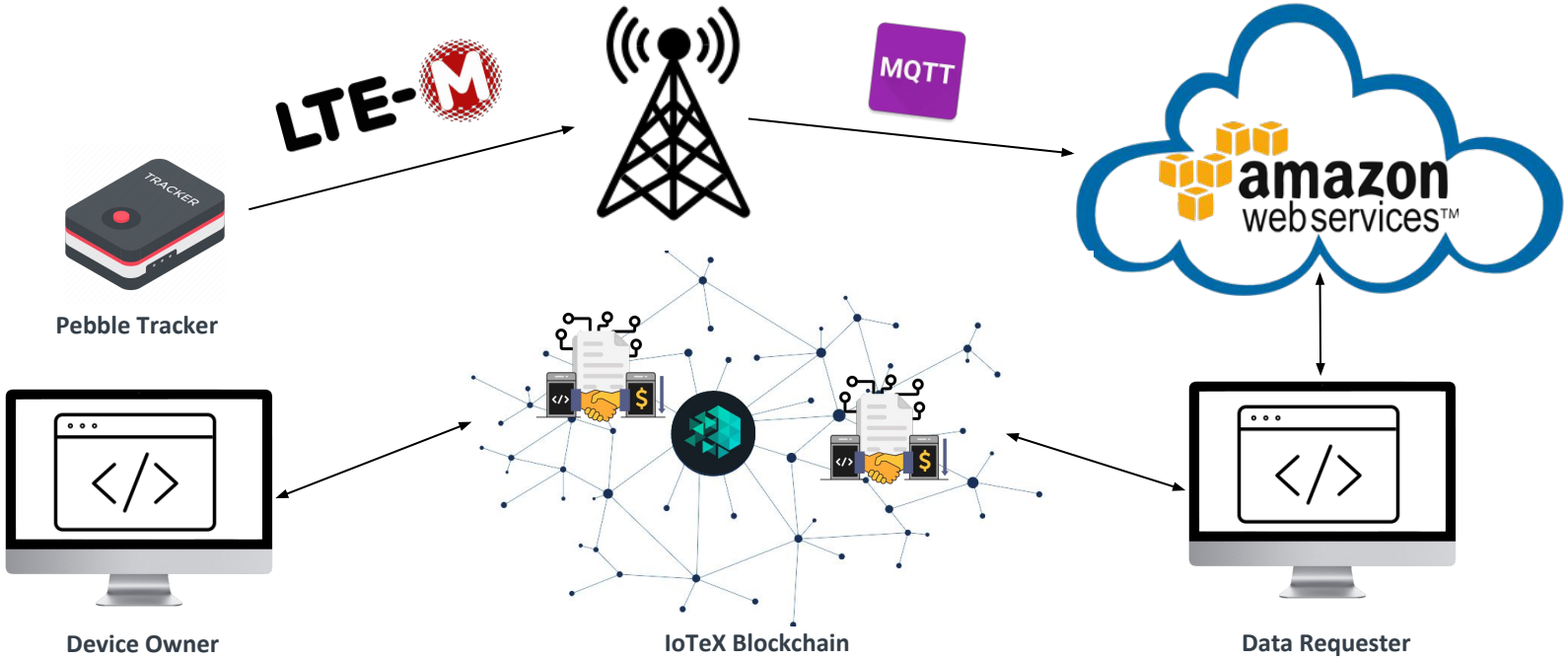
Decentralized Data Authorization Demo



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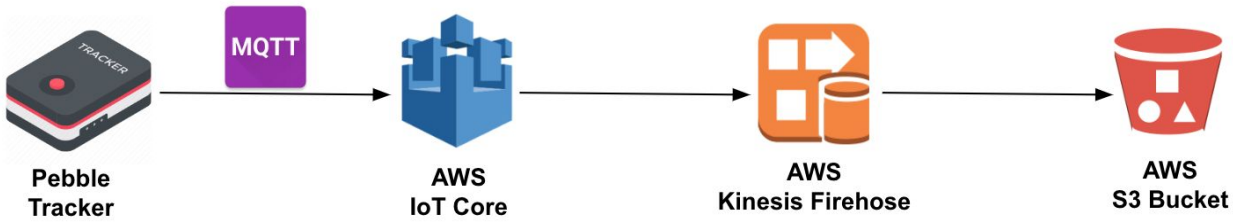
Tracker Data Collection



- Accept streaming data from tracker with AWS IoT Core
- Persist streaming data to AWS S3 with AWS Kinesis Firehose

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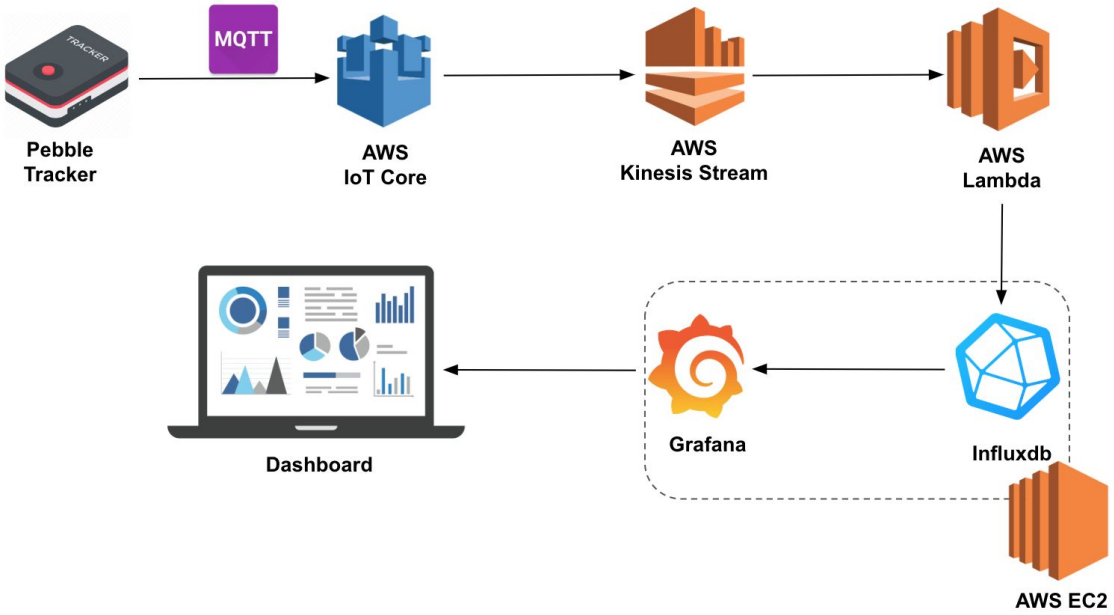
Tracker Data Visualization on AWS

- Create a dashboard to visualize GPS coordinates on Google map and sensor data
- Use AWS Kinesis data stream to decouple the processing logic from data ingestion
- Use AWS Lambda function to update the influxdb (time series database) for the new tracker data
- Use Grafana as the time series visualization tool for building dashboard



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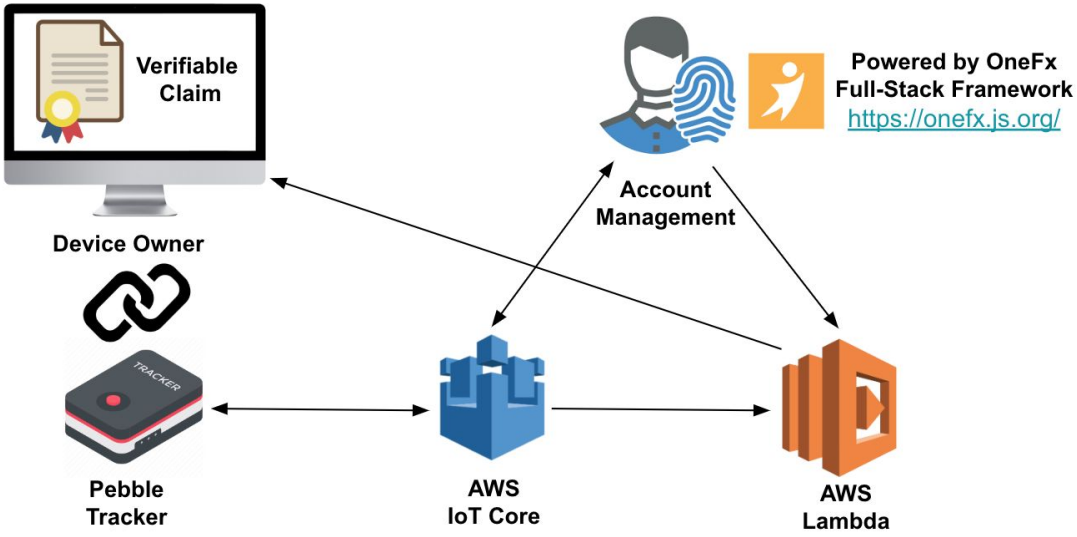
Device Binding and Verifiable Claim Generation

- Bind user's blockchain account with the device via a device binding protocol
- Use IoTeX's account management service (powered by OneFx full-stack framework) to manage a user's identity and credential
- Use AWS Lambda function to generate a verifiable claim to attest the device ownership



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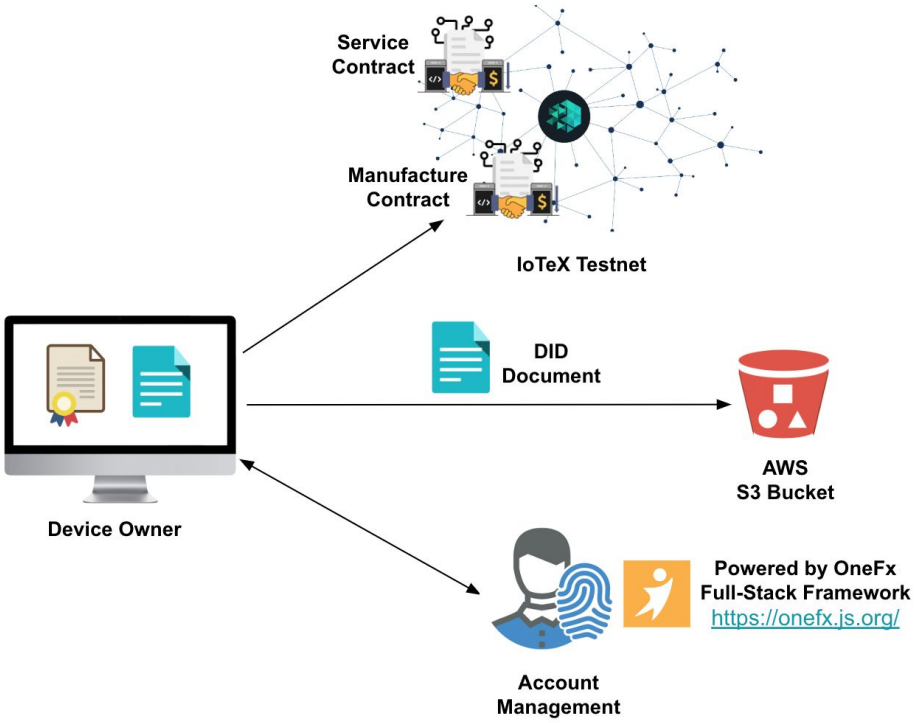
DID Registration with IoTeX Blockchain

- The device owner deploys a service smart contract
- The device owner gets a temporary credential from IoTeX's account management service
- The device owner uses the temporary credential to directly upload the DID document to AWS S3 and gets the corresponding URI
- The device owner calls the manufacture smart contract to generate DID



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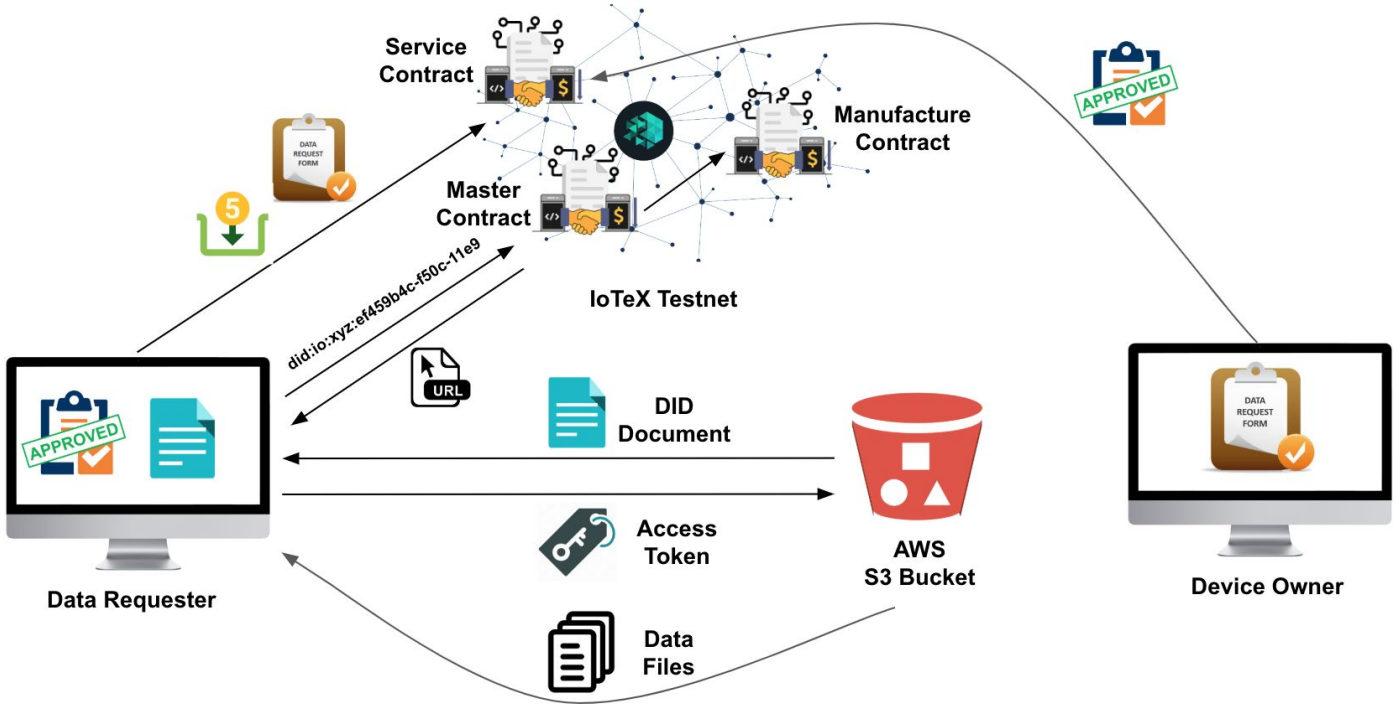
Decentralized Tracker Data Authorization



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Q&A

LET'S BUILD DECENTRALIZED FUTURE TOGETHER!

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