

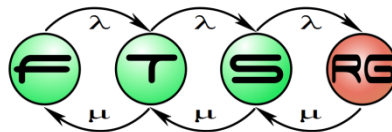
Integration of 5G and Blockchains

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2017.04.25

BME, 5G Technológia Workshop

Budapest University of Technology and Economics
Fault Tolerant Systems Research Group



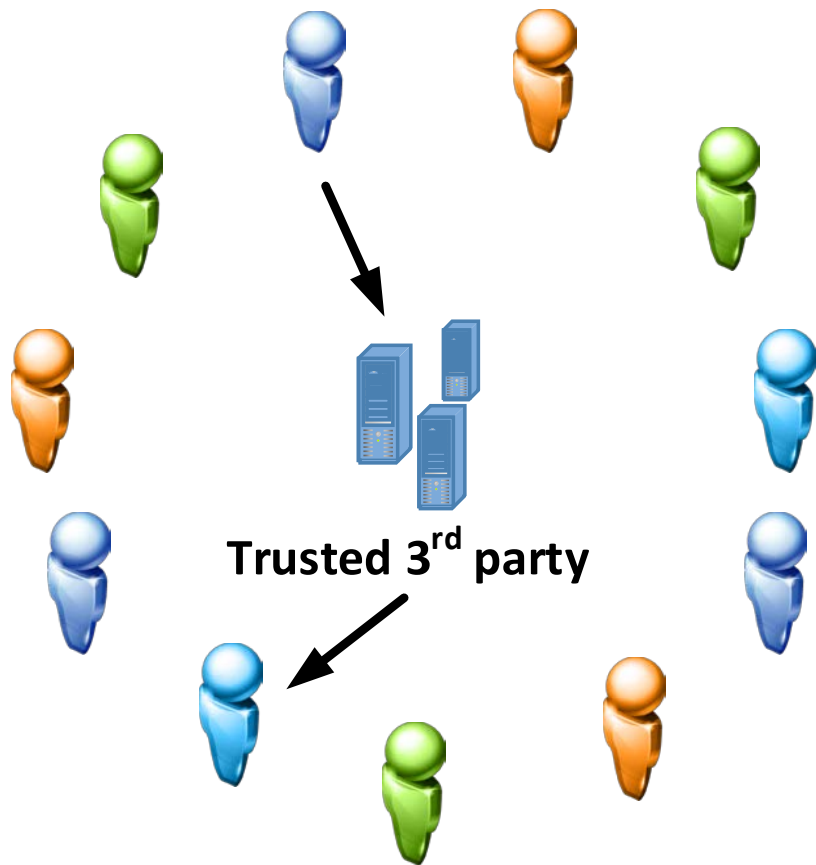
Blockchain@BME MIT

- **Prof. András Pataricza: IBM Faculty Award 2016**, cooperation with Duke University
- **L. Gönczy: Summer internship at the Linux Foundation – mentor**
On-chain Business Process Management
- **Course: “Blockchain technologies and applications”** (coming next spring)
- **Linux Foundation Hyperledger fabric:** performance characterization and modelling
- **Cooperation: Prof. Miklós Telek**
Dept. of Networked Systems and Services (HIT)

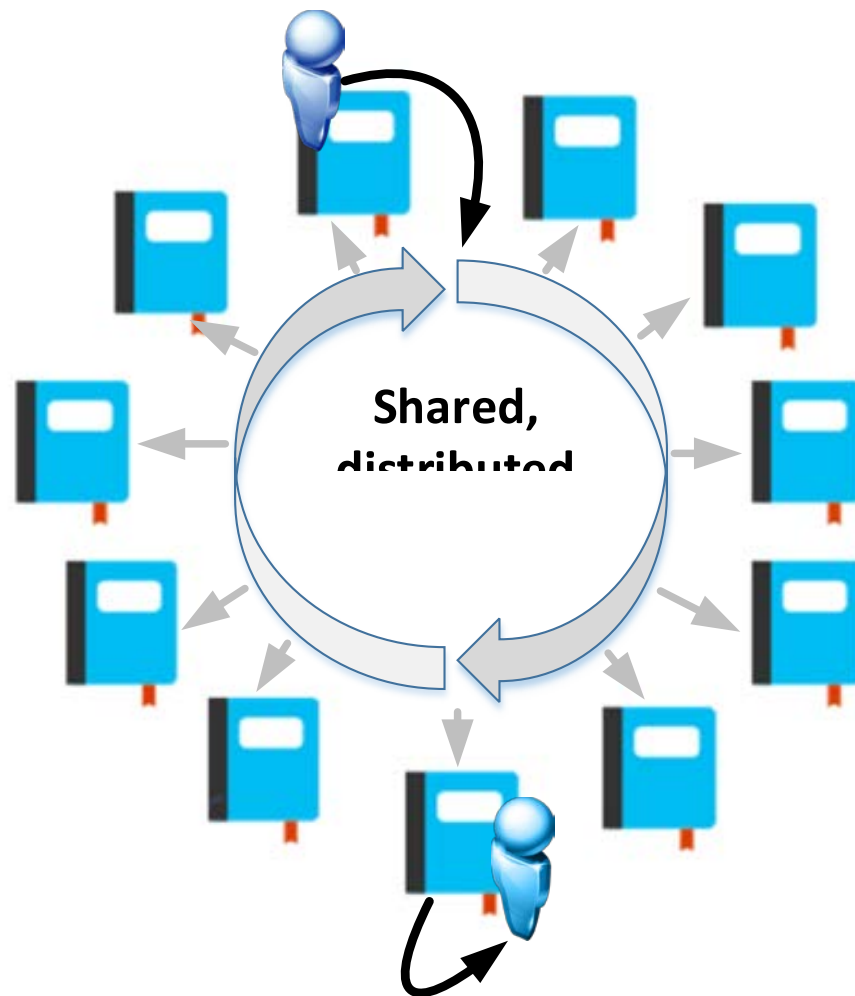


A new approach to business transactions

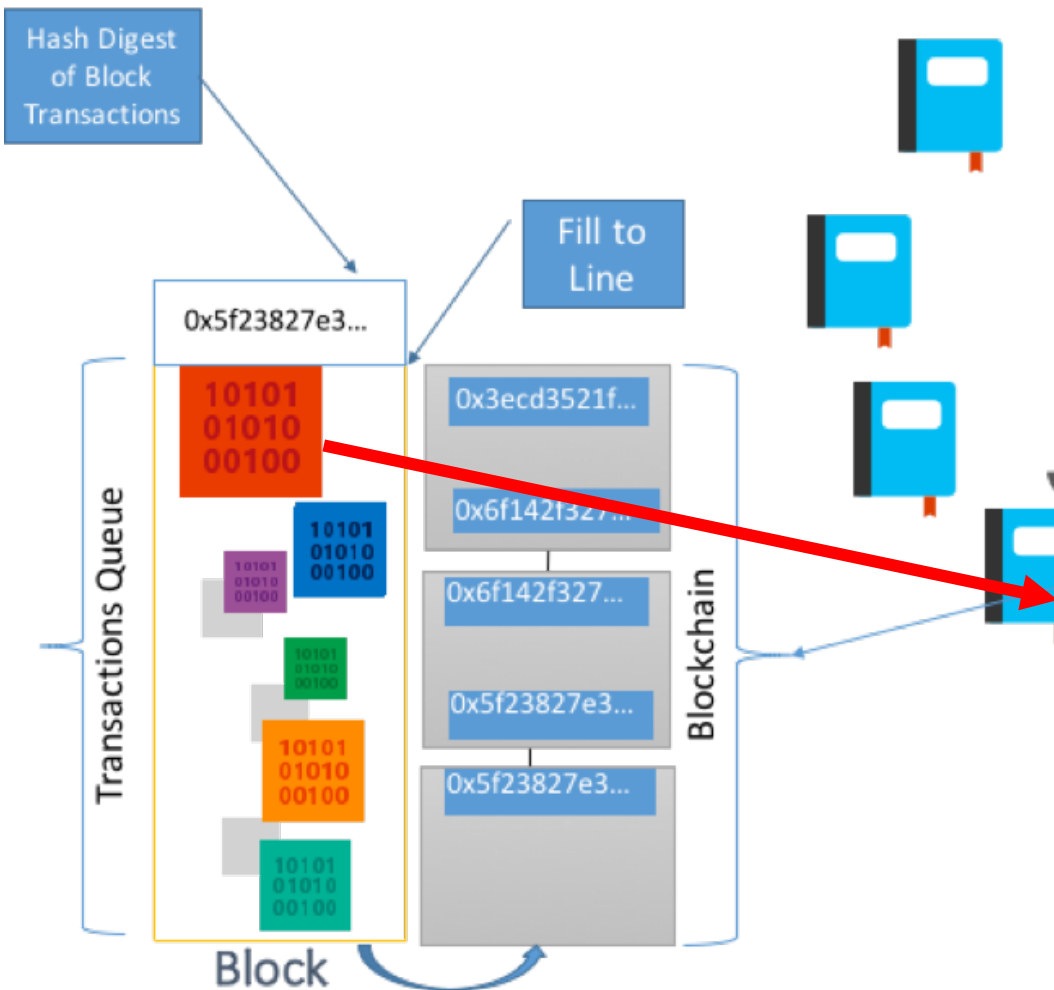
Centralized



Blockchain-based ledger



Blockchain, smart contracts



PURCHASE AND SALE AGREEMENT

DATE: <<Insert Today's Date>>
 SELLER: Owner of Record
 BUYER: <<Name>>
 <<Address>>
 <<City, State, Zip>>

This is a contract for the purchase and sale of real estate.....

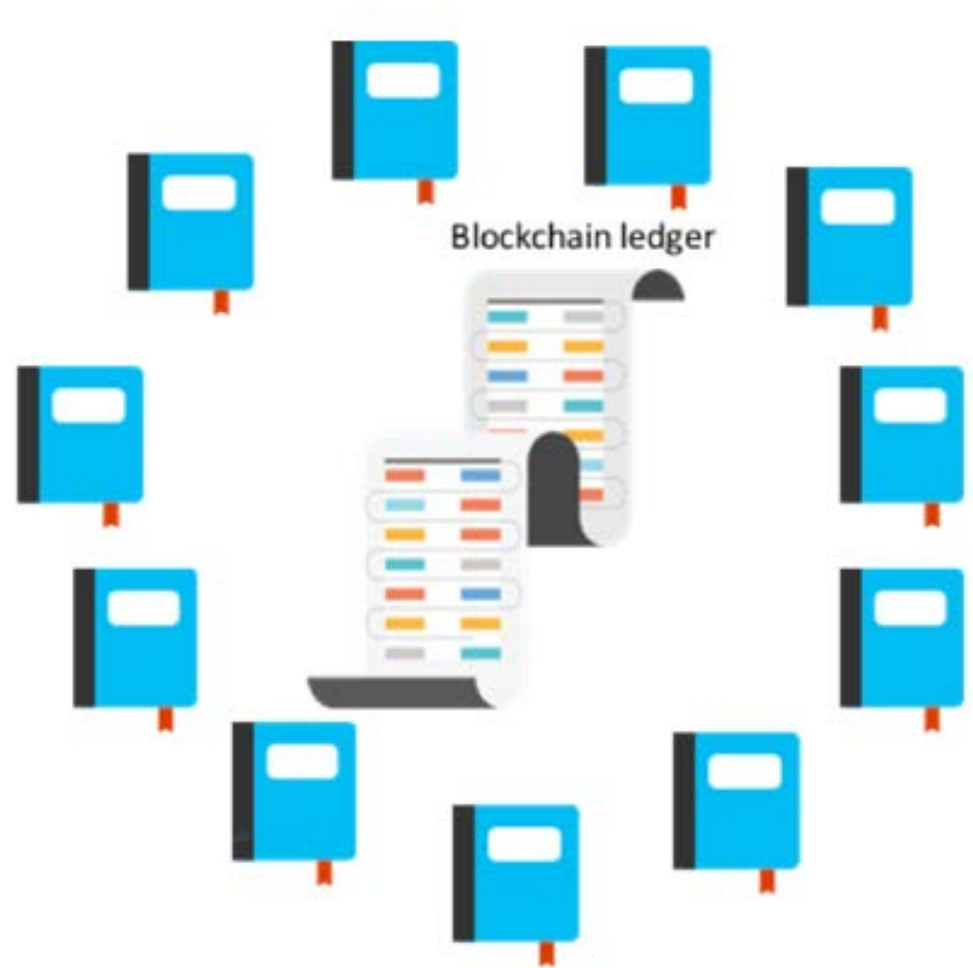
- PROPERTY DESCRIPTION:**
 Parcel Number:
 Legal Description:
 Commonly Known As:
- PRICE:** Buyer will pay.....
- PAYMENT:** Buyer will pay.....
- TITLE AND CONVEYANCE:** Seller will transfer.....
- CLOSING:**
 a) Buyer will pay for.....
 b) Seller will pay for.....
 c) This transaction will be.....
- CLOSING DATE:** Deed and possession will be delivered.....
- CANCELLATION:** Buyer retains the right to.....
- DISCLOSURE:** Each party represents itself.....
- ASSIGNMENT:** Buyer has an unqualified right.....
- BINDING AGREEMENT:** This agreement is binding.....
- DEADLINE FOR ACCEPTANCE:** This agreement is submitted to the Seller.....

Seller: _____ Date: _____ Buyer: _____ Date: _____
 Witness: _____ Date: _____ Witness: _____ Date: _____

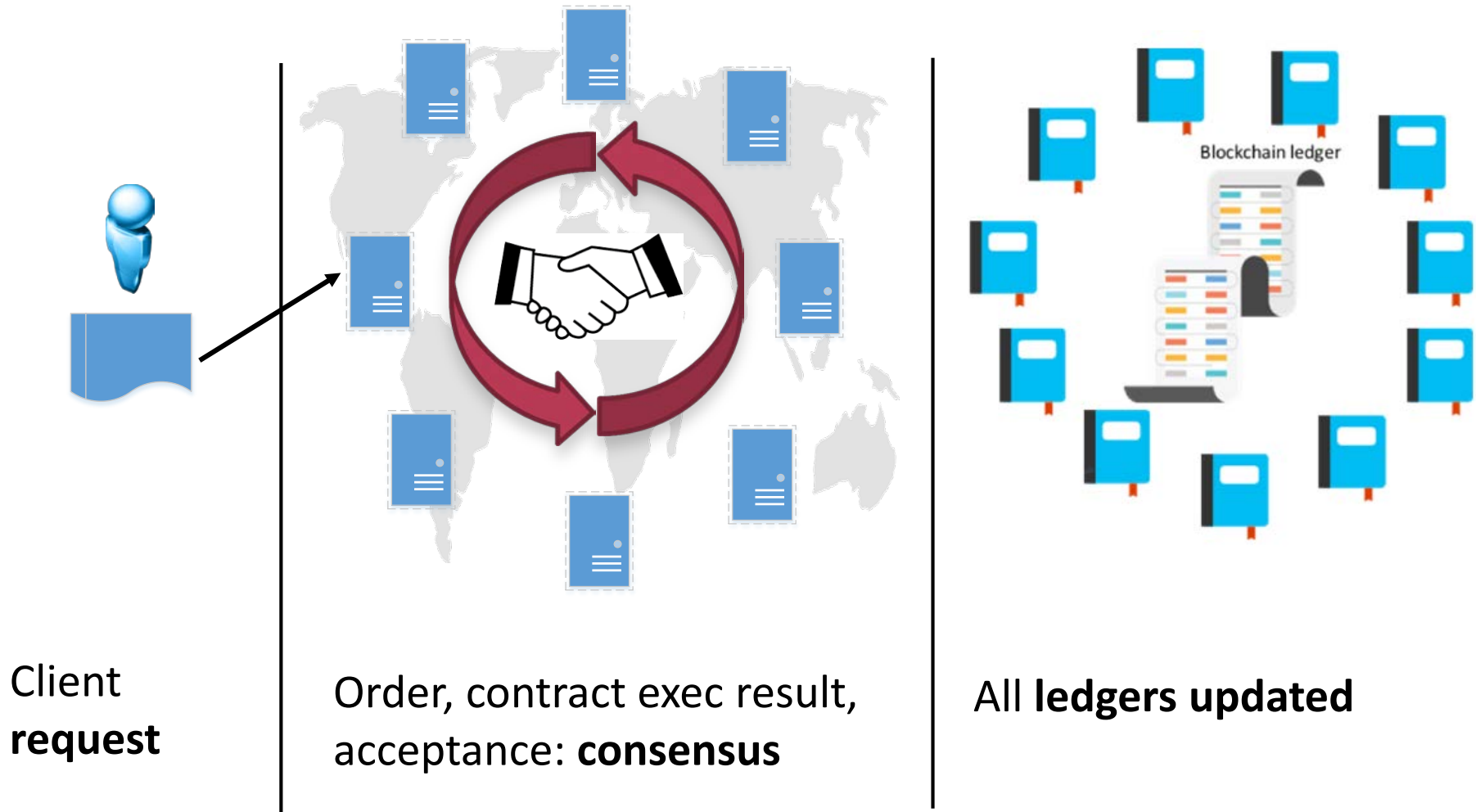
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Properties

- **Ledger:** immutable Tx log; not (just) cryptocurrency!
- **Smart contracts:** programmed Tx logic over ledger state
- **Shared:** across participants
- **Distributed:** replication
- **Cryptographically authentic:** non-repudiable (secure identities), tokenization, signed Tx
- **Trust:** fault/attack tolerant group consensus



Basic transaction logic



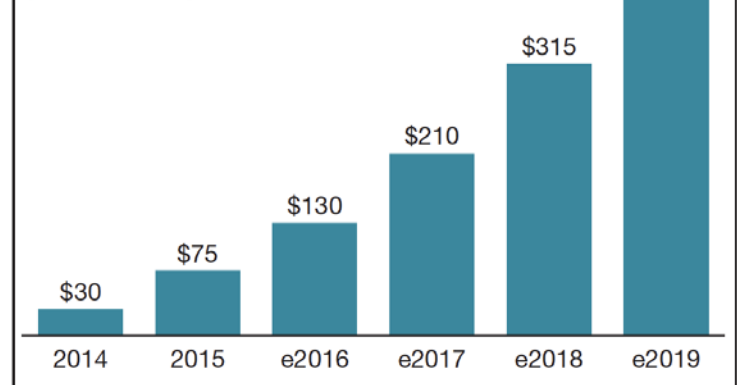
Batch processing < Blockchain latency < hard real-time

An emerging sector

Enterprise, permissioned



Estimated Capital Markets Spending On Blockchain Technology, 2014 to 2019
(In \$ millions)



Source: Aite Group

e: estimate

Open/permissionless, cryptocurrency



M2M, D2D,
automation, edge

Ubiquitous connectivity, IoT,
identity, A&A

Software updates,
calibration (latency!)



**Core
5G**

**Transactions
and events**

BOL shipping
records

Receipts (POD, ASN)
Inspection documents

Plant order
serialized asset

Installation
documents

System of
record



**Guaranteed latency,
reliability; edge, NFV**

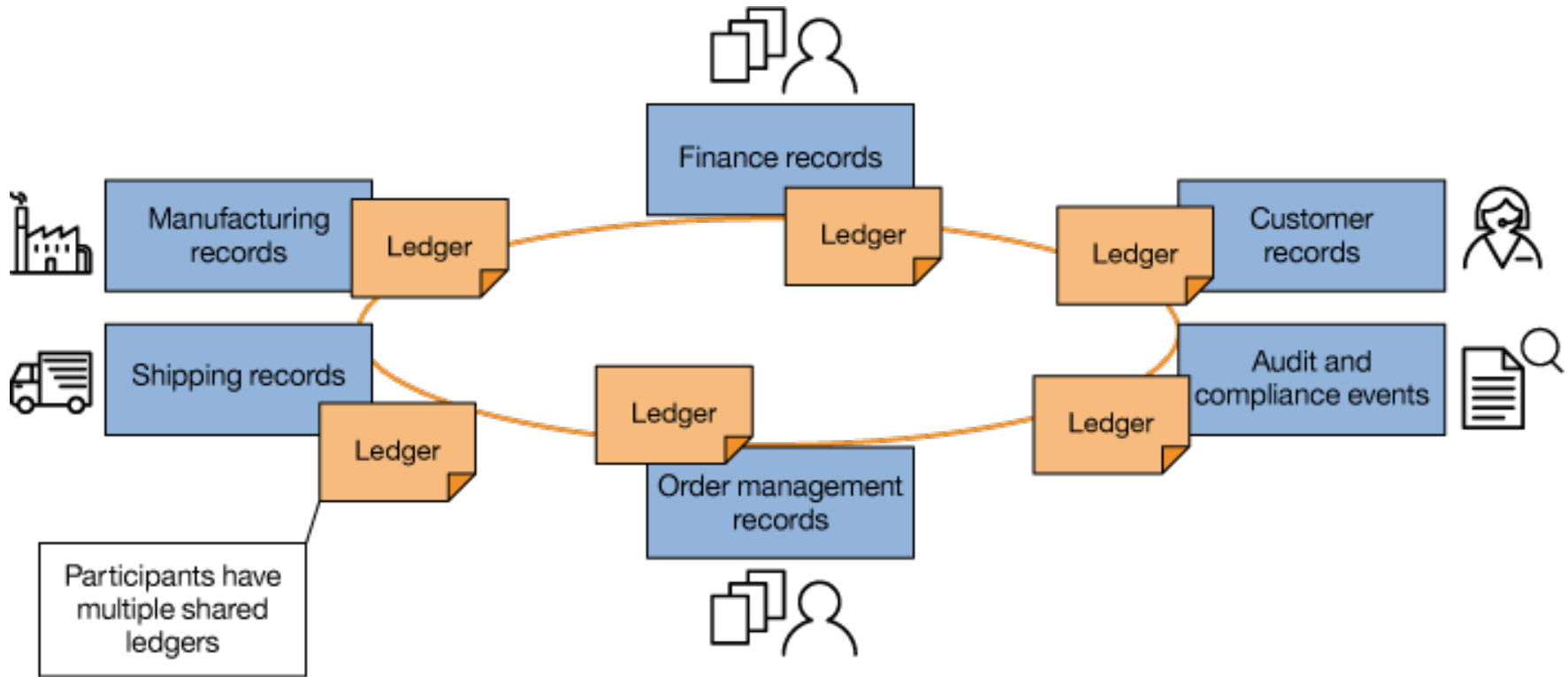
**5G: Enabler
VAS!
(5G Enablement)**

Serial. number mismatch
Asset condition
View asset life cycle



VAS

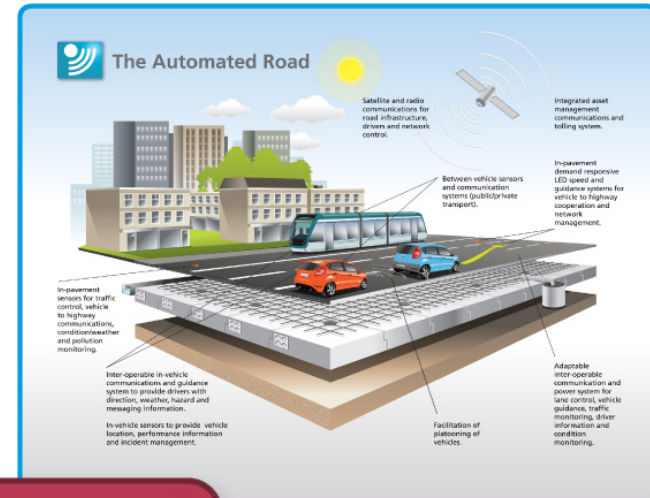
Multiple ledgers



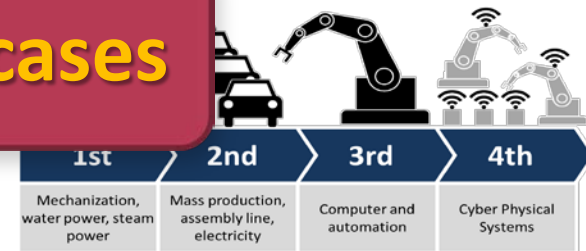
Blockchains in Cyber-Physical Systems

■ *Cyber-Physical Systems*

- Distributed sensing and control
- Cloud-attached, fog computing
- Systems of systems
- Critical services

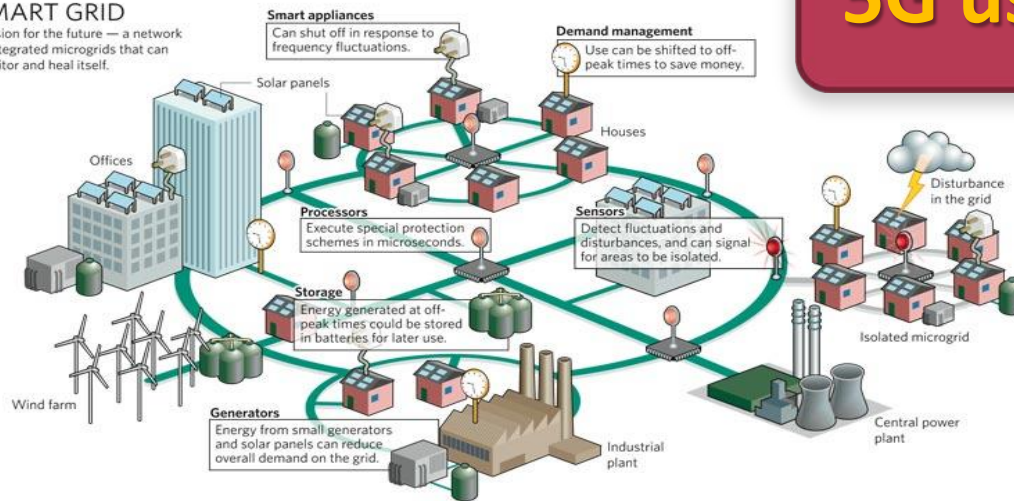


5G use cases

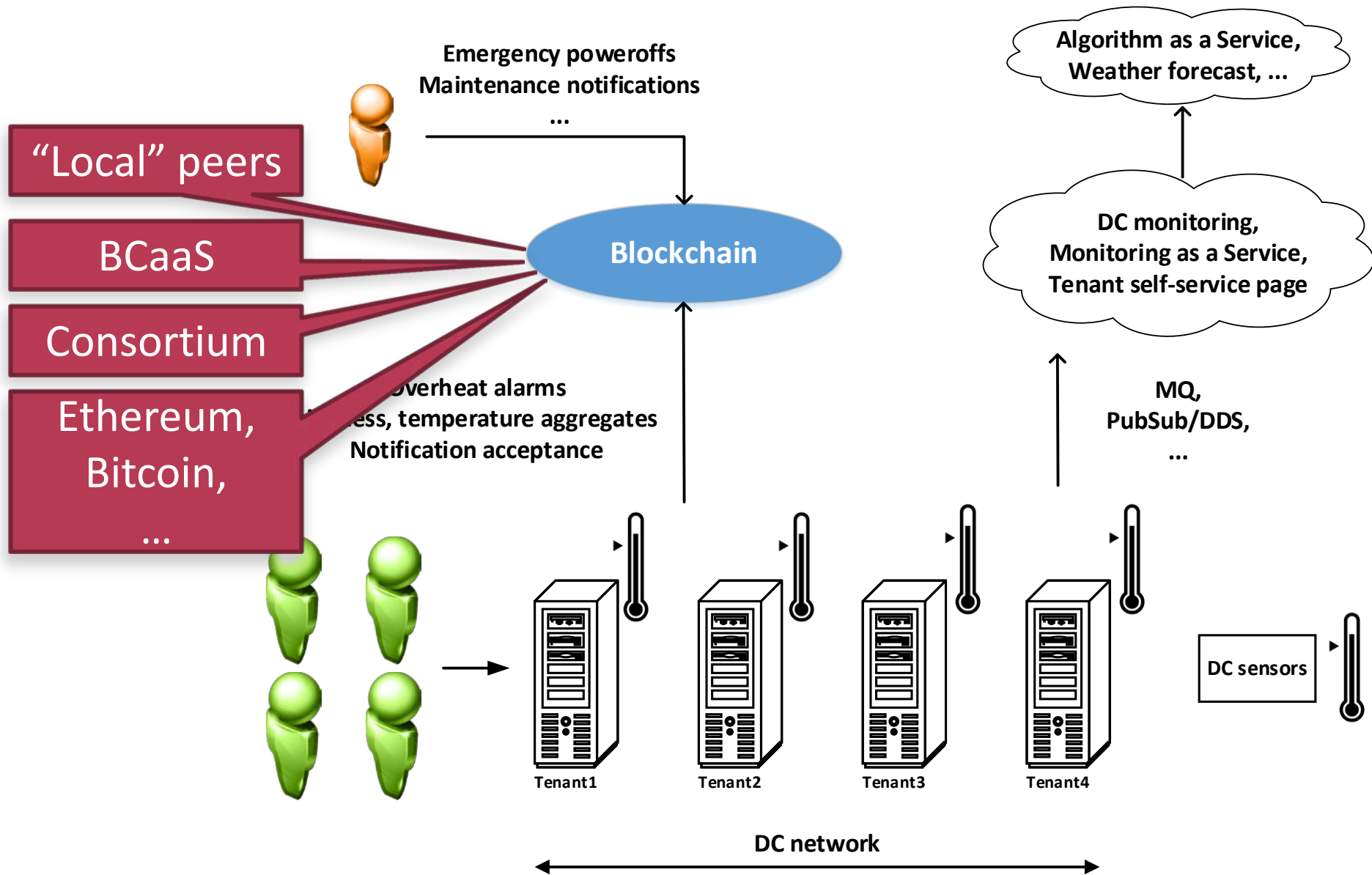


SMART GRID

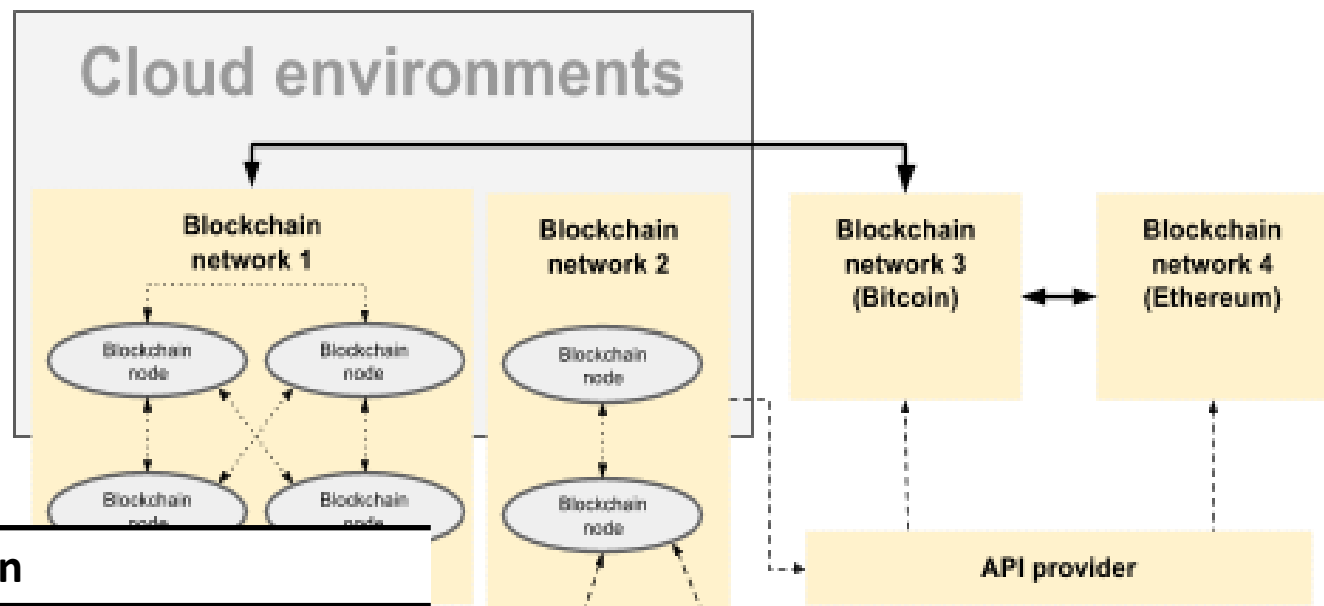
A vision for the future — a network of integrated microgrids that can monitor and heal itself.



Blockchain as the "control plane"



Attaching Blockchains to CPS



Function group	Function
Configuration management	Reconfiguration
	Sensor calibration
	SW/firmware updates
Process execution	Critical operations
	Aggregated activity logs
Diagnosis	Monitoring information
	Diagnostic image

---> API queries <--> M2M communications

The impact of 5G: powerful enabler

- In-field Blockchains
 - Ubiquitous coverage, low power, D2D
- Field-attached Blockchains
 - Network slicing, edge computing support, mature NFV
- Commoditization of CPS and IoT
 - Field becomes more “just another IP network” – now with (configurable) guarantees
- Time-sensitive/real time Blockchains?
- Great potential as core value added service

The future: in-field Blockchains

