5G + AI + BC : A Crossroad to the future

Florence School of Regulation – Fiesole, November 8, 2018

Antonio Sassano

A technological crossroad

New Generation Network
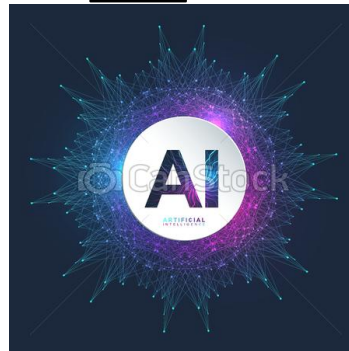- Low Latency
- High Capacity
- Software defined
- IOT Enabler

5G

BLOCKCHAIN TECHNOLOGY

Synergic Effect

- ❑ Robotics
- ❑ Industry 4.0
- ❑ Web 3.0
- ❑ Autonomous «things»
- ❑ Edge Computing

Distributed Ledger
- Open & Public
- Decentralized
- Secure «by design»
- Micro-Transactions
- Cryptocurrencies
- Smart Contracts

AI

Artificial Intelligence
- Deep Neural Networks
- Optimization Algorithms
- Data Mining

BlockChain, AI and 5G Synergy

- *BChain* efficiency requires *fast end-to-end networks* (*5G* low latency)

- *5G network design/management* requires *complex AI* algorithms

- *AI* algorithms are empowered by the availability of *massive data* (*5G* IOT)

- *IOT* transactions are empowered by micropayments (*BChain* transactions)

- *AI* algorithms can control autonomous «things» only with *5G* networks (LL)

- *Medium Access and Clustering of massive IOT* ensured by *AI*

- *Massive (IOT) data market (integrity, ownership)* ensured by *BChain*

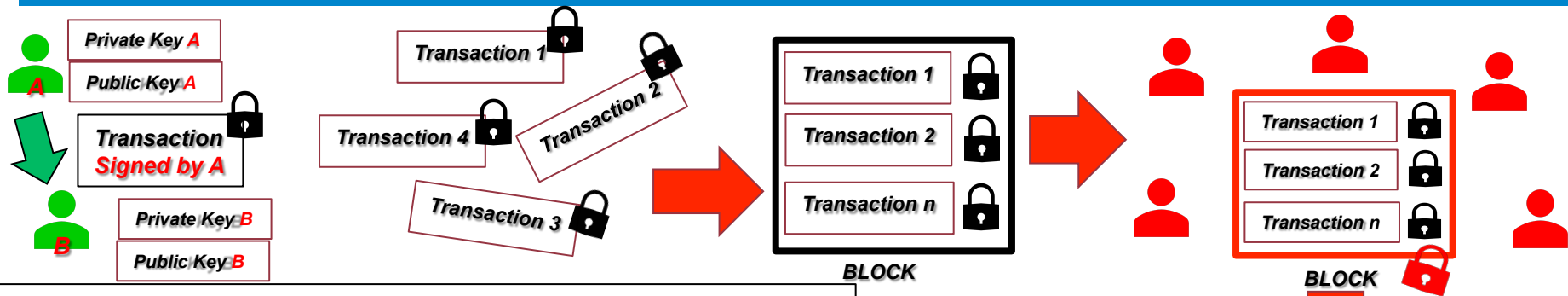- *AI Algorithm* Accountability/Transparency increased by *Smart Contracts*

- *…..*
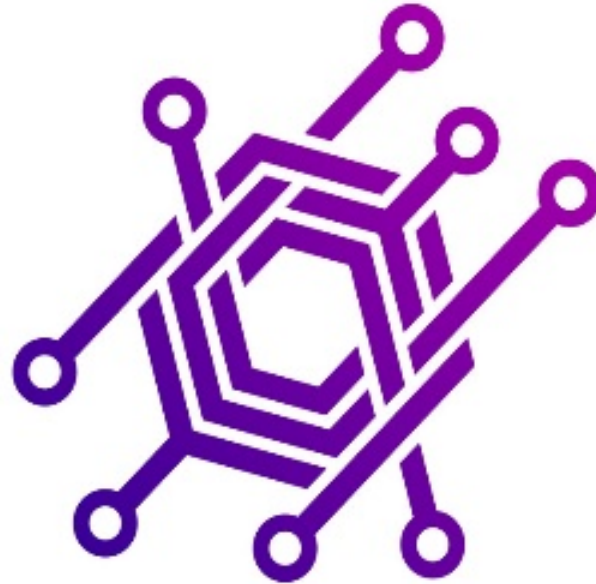
The purpose of the following slides and … a disclaimer

- BlockChain Era is at its very beginning
- *Research*, Ideas and Proofs of Concept are ***exploding***
- No «well defined» *BlockChain Theory* exists
- To (seriously) discuss about its ***future and consequences*** we have to grasp its ***economic and mathematical*** structure
- ***… I am still studying***

- Today I will try to answer the following questions:
- ***What is*** a *BlockChain*?
- How are we moving ***beyond the first generation (Bitcoin)***
- The ***Structure of WEB 3.0*** : *Private or Public BlockChain*?
- Two examples: ***Data*** and ***User Attention***

The Distributed Ledger (BlockChain)

Private Key *A*
Public Key *A*
A

Transaction Signed by A

Private Key *B*
Public Key *B*
B

Transaction 1
Transaction 2
Transaction 3
Transaction 4

Transaction 1
Transaction 2
Transaction n
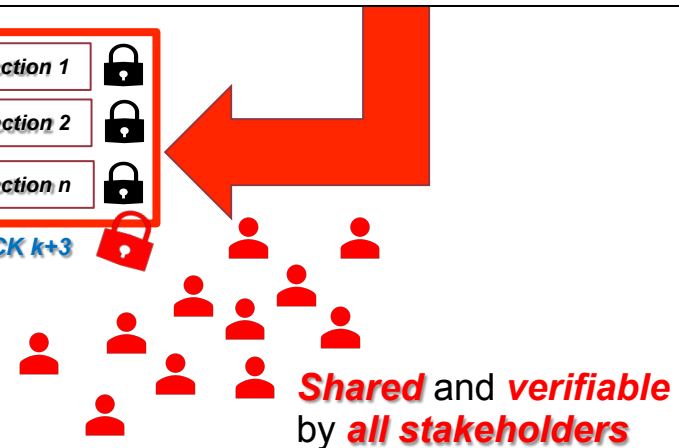**BLOCK**

Transaction 1
Transaction 2
Transaction n
BLOCK

- Signed & Readable Transactions (CryptoSignature)
- Between **anonymous «entities»:** Humans or *Machines*
- A *transaction* can be:
  - the effect of an *executable code* (*Smart Contract*)
  - the transfer of a *cryptocurrency*
  - the trade of *any immaterial asset* (e.g. spectrum)

- A *Consensus Algorithm* validates the Block *Which Block is the next one?*
- *Proof of Work: Computer power decides*
- *Proof of Stake: Assets «at stake» decide*
- *Algorand: BA*, Sortition and .. Mathematics*

BLOCK k   **BLOCK k+1**   **BLOCK k+2**

Transaction 1
Transaction 2
Transaction n
BLOCK k+3
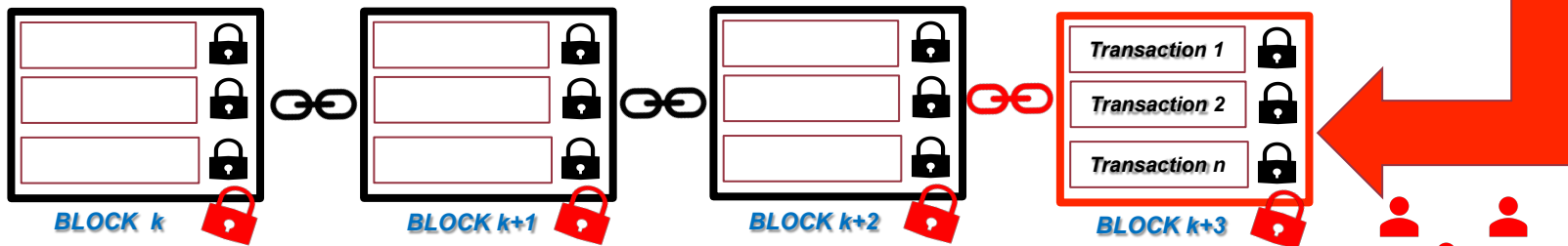
- The «chain» of transactions is *«immutable»* and *«tamper proof»*
- *Everybody can read and write on the blockchain (Public)*
- *No Centralized Trust Authority* «certifies» the transactions
- *Highly Secure* by design (**Bitcoin** as «showcase»)

Shared and *verifiable* by *all stakeholders*

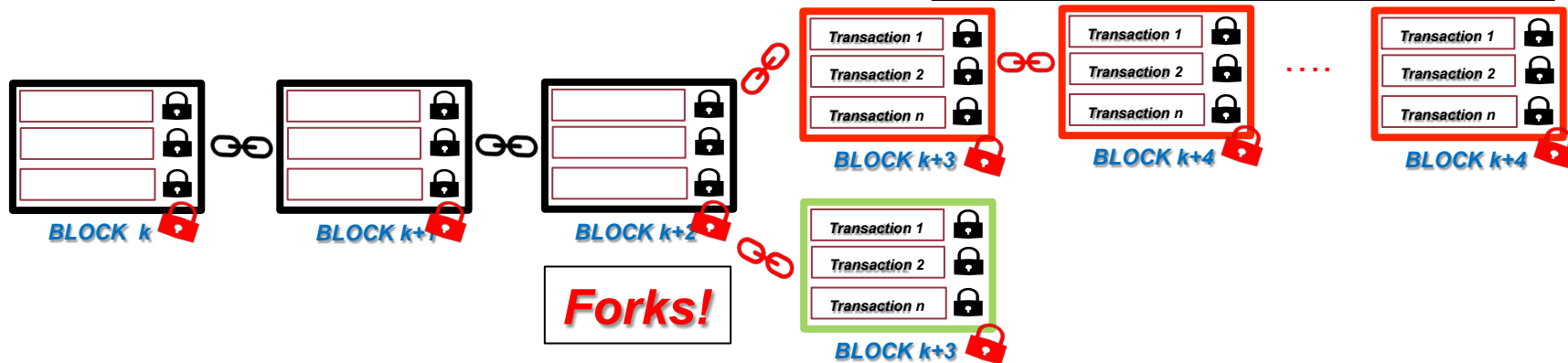This is the *Open, Public, Permissionless, Borderless, Distributed Ledger*

The Bitcoin Experiment and its drawbacks

- Bitcoin is a (distributed) application using the **Nakamoto BlockChain**
- A **successful DAPP**: *No hacking* since its birth (2009)
- A brilliant «proof of concept». It works! … *but does not scale*

Two serious drawbacks of Mining (*rewarded creation of new blocks***):**

1. «Slow» Confirmation (~**3** Txn/s **Vs**. AmEx **4000**)

Done? Wait 6 blocks (1 hr)

Transaction 1 🔒	Transaction 1 🔒	…	Transaction 1 🔒
Transaction 2 🔒	Transaction 2 🔒		Transaction 2 🔒
Transaction n 🔒	Transaction n 🔒		Transaction n 🔒

BLOCK k+3 🔒 *BLOCK k+4* 🔒 *BLOCK k+4* 🔒

BLOCK k 🔒   BLOCK k+1 🔒   BLOCK k+2 🔒

Forks!

| Transaction 1 🔒 |
| Transaction 2 🔒 |
| Transaction n 🔒 |

BLOCK k+3 🔒

2. Reward to Computer Power (PoW)
- **(Geographical)** *Concentration of Miners*
- *5 main Mining Pools* (**74%** in *China*)
- **Specialized HW.** *Huge waste of energy*
- *Few «points of failure»* (*Cybersecurity at risk*)
- **Possible a** *51% Attack!*
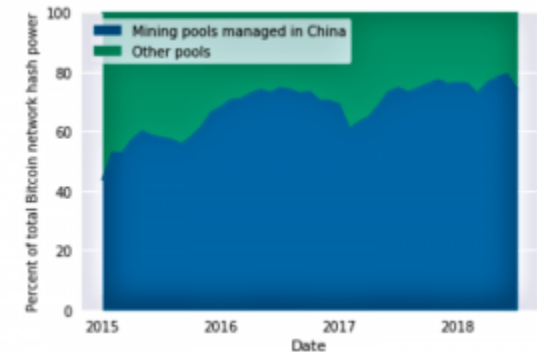
The New Generation: No Mining, No Forks ... Green

- New BlockChain Technology: ***Beyond Proof of Work***
- ***No Mining*** and no «embedded» cryptocurrency (***BlockChain w/o Bitcoin***)
- ***No need of concentrated computing power***
- ***Out of Chain Transactions (State Channels):*** *Lightning, Raiden, Polkadot,..*
- Sophisticated Consensus Rules ***rule out Forking***
  - *Fast Bizantine Agreement (BA*), Cryptographic Sortition (**ALGORAND**)*
  - ***D****irected* ***A****cyclic* ***G****raph (**IOTA**)*
- ***New generation BlockChains*** *(potentially)* ***scale*** *(ongoing experiments)*

Evaluation: Latency

ALGORAND .. scales
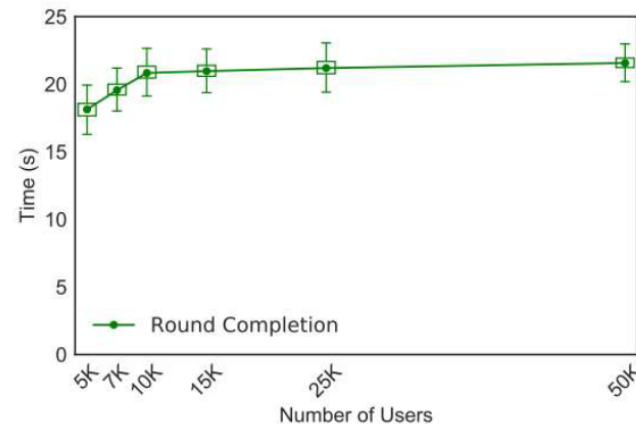
What is the latency for txn?
- Well under a minute
- BTC: 30 min to 16 hr

How does it scale as the number of users grows?
- Near constant
- Committee size is set to 10K

Figure 5: Latency for one round of Algorand, with 5,000 to 50,000 users.

IOTA TANGLE: Directed Acyclic Graph

- *Approved Txn → Node with In-degree at least 1;*
- *Each new transaction validates only two «older» transactions*
- *Weight of a transaction = PoW (or 1!)*
- *Cumulative weight of a transaction = Sum of Weights of Predecessors*
- *Finality? High Cumulative Weight*
- *No (Native) Smart Contracts!*

Theorems:
- *Tips do not «grow» (stability)*
- *Resistant to:*
    - *Double Spending*
    - *Parasite Chain*
    - *Quantum Computing*
    - *…*
- *Announced: October, 21 2015*
- *Market Cap: 1,362 B$*

Tips

TANGLE .. scales
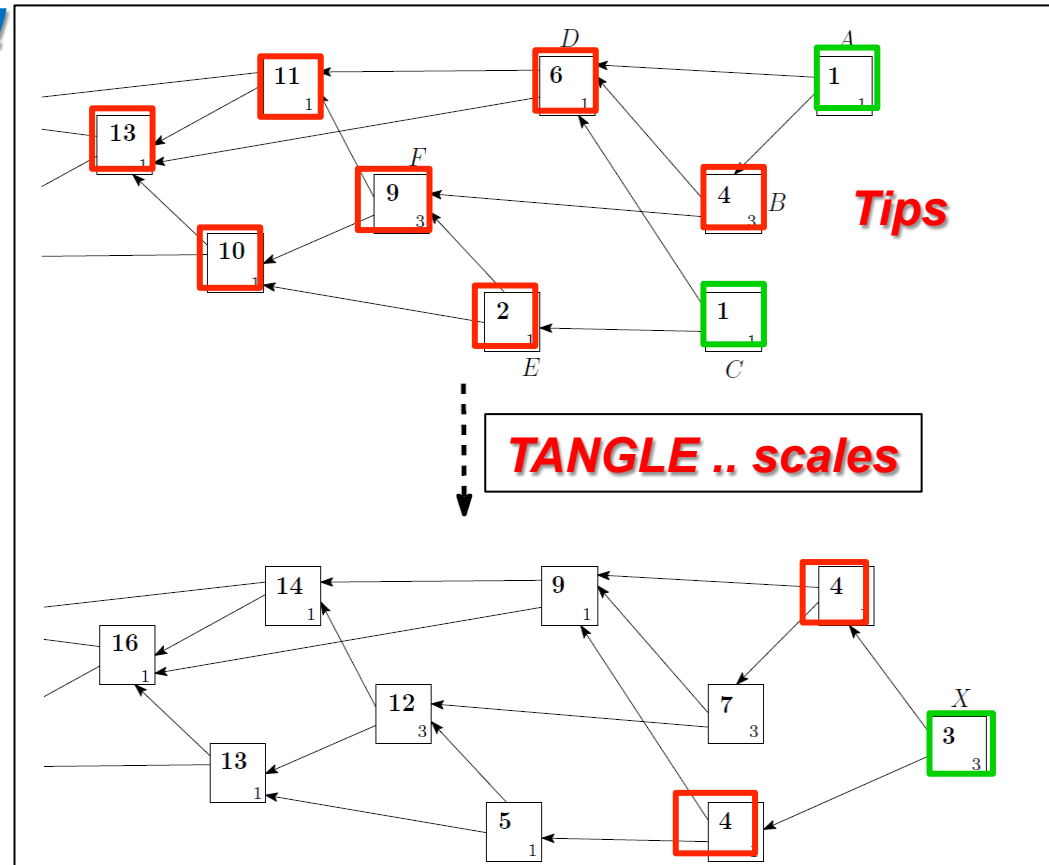
The main takeaway

The *Open, Public, Permissionless, Borderless, Distributed Ledger*
is (can be) totally disruptive for **ALL Central Trust Based Industries**

Blockchain Potential Applications & Disruption

The blockchain is radically changing the future of transaction based industries

Smart Contracts
- Digital Rights
- Wagers
- Escrow

Digital Currency
- E-commerce
- Global Payments
- Remittance
- P2P Lending
- Microfinance

Securities
- Equity
- Private Markets
- Debt
- Crowdfunding
- Derivatives

Record Keeping
- Healthcare
- Title Records
- Ownership
- Voting
- Intellectual Property
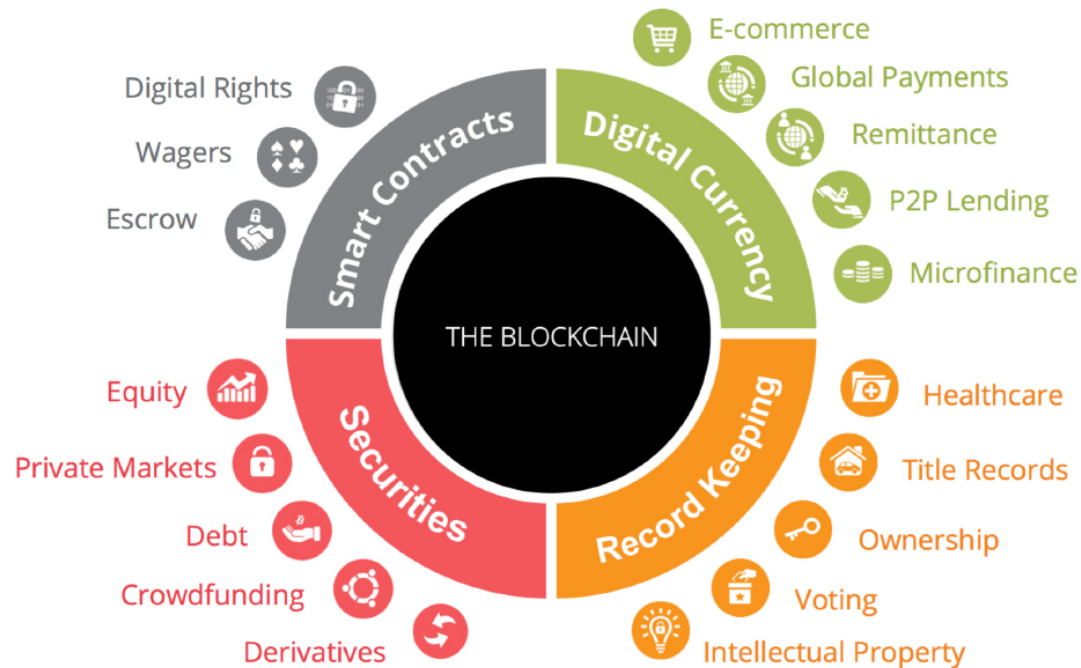
THE BLOCKCHAIN

Source: IBM

(Only) Public BlockChains are Trustable and Secure

- Only in the Public BlockChain *ALL stakeholders decide*
- Trust and Security High «by design». *Efficiency needs research (**Algorand**)*
- If **some stakeholders «do not decide»** we have a *Private BlockChain*

High «by design»
(Consensus Algorithm)

High «by design»
(Bitcoin example)

Low (now!)

**All Stakeholders
+ Crypto + Math**

Not a BlockChain

**Consortium
(Private BC)**

Low

Low

High

**We have a limited trust
In Central Authorities**

- **Single Point of Failure**
- **Denial of Service**
- **… Hacked Everyday**

**Dictators are
Efficient**

Centralized

Very Low

Very Low

Very High

Consensus
Red Decide
Green Only Stakeholders

Trust
of the Stakeholders

(Cyber)Security

Efficiency

The race to shape Web 3.0 is on

Web **2.0** *non-interoperable silos* (platforms)

APPS

CLOUD Platforms

Internet Protocol

«Lean» Open Protocol

D APPS

CORDITE ORACLIZE

MonetaGo

ScanTrust

NATIONAL ASSOCIATION of REALTORS®

Web 3.0 **Private** *BlockChain*

Private BlockChains

c·rda

IBM HYPERLEDGER

IBM HYPERLEDGER

- *Nothing «really» changes*
- *Central Control and Silos*
- *Data to Dapps and Platforms*
- *In OTT .. We Trust*
- *No interoperability*
- *Efficiency «for free» (no research)*

CLOUD Platforms

aws

Google Cloud Platform

IBM

Internet Protocol

"Private blockchain" is just a confusing name for a shared database

SEPTEMBER 18, 2015 BY ARVIND NARAYANAN

… and is an information war
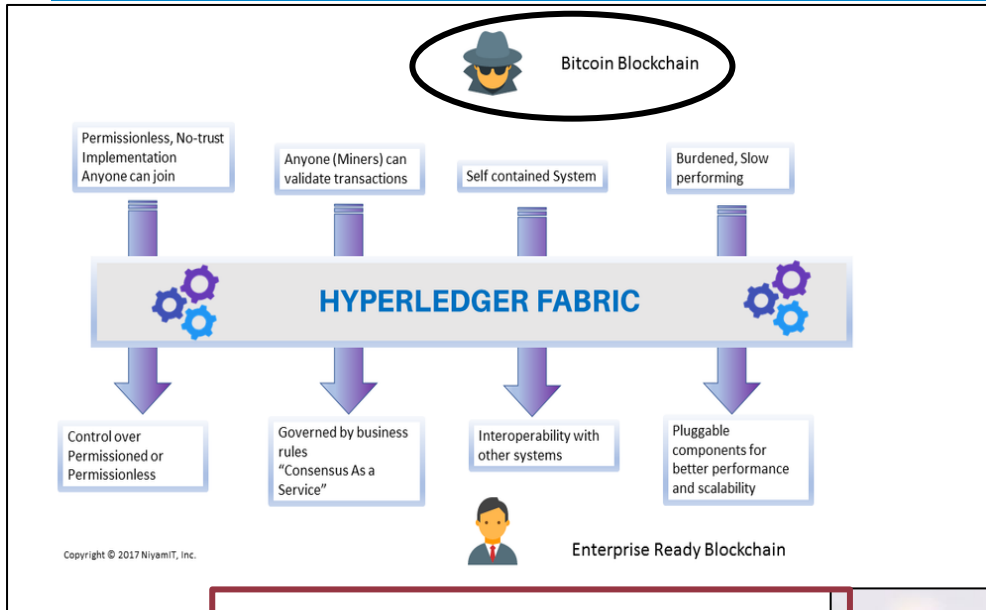
Banks + Mgmt Cons + Tech
- Bitcoin BlockChain? **BAD!**
- Why? No Trust, Slow and …
- … anyone can join / validate!

- **Banks + Mgmt Cons + Tech**
- Hyperledger?: **Isolated silos !**
- Corda? Same as Ethereum but .. «Right design for enterprises»

The «quantum leap» is the Public BlockChain

Web 2.0 non-interoperable silos (platforms)

APPS

prime
firetv
amazon
Google Play

CLOUD Platforms

aws
Google Cloud Platform

Internet Protocol

Web 3.0 Public BlockChain

- **Decentalised Cloud (IFPS)**
- **Decentralised Control**
- **Data owned by producer**
- **Interoperability**

- **«Fat Protocol» Thesis ?**
- Tokens *move value to protocol*

DAPPS

STREAMR BITCOIN BANCOR BRAVE + BAT

Public BlockChain

ALGORAND EOS.IO CARDANO ethereum

IPFS

Internet Protocol

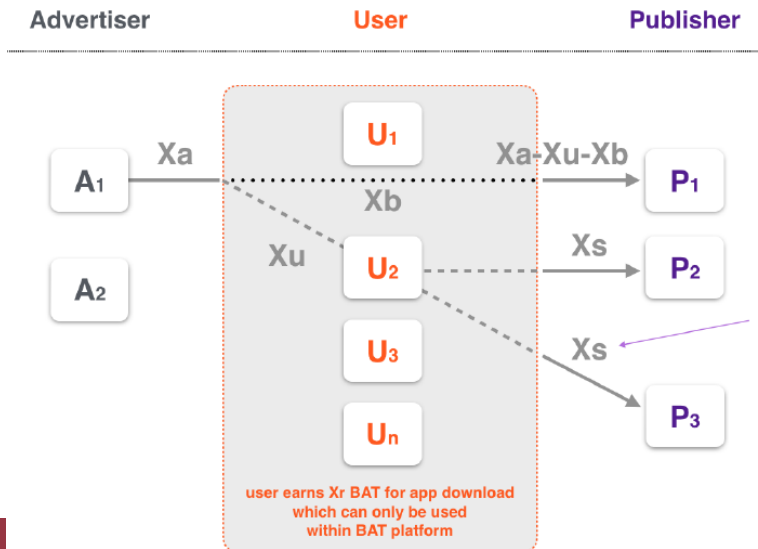# *The* Internet Advertising BlockChain (BRAVE)

Present ecosystem	BAT token ad payments
User frustration over loading time	Fast loads
Walled gardens	Free software, open source infrastructure
Bandwidth wasted	Low bandwidth overhead
Screen clutter	Uncluttered screen
Irrelevant ads	Ads tuned to user interests
Security issues	No malware
Viewability problems/attribution	Secure attribution/attention score
Advertiser uncertainty about delivery	Perfect delivery certainty
CPM/click based	Attention-based
Reader attention not valued	Reader is paid for attention
Publisher revenues lowering	Larger publisher revenues
Expensive ad buys due to middlemen	Efficient ad buys
Complex/expensive viewability metrics	Simple/free viewability metric
User's privacy violated	Perfect user privacy

A *messy* market

- *Ethereum Smart Contract*
- *«Tokenized» Attention*
- **BAT***: Basic Attention Token*
- *Paying User Attention*
- ICO: *May 31, 2017*
- *Market Cap*: 257 MEuro

Advertiser — User — Publisher

user earns Xr BAT for app download which can only be used within BAT platform

BlockChain and Internet of Things

- ## The IOT ecosystem requires:
  - Ability to automatically exchange value ($) for data
  - *Proof of Ownership of exchanged data (**data market**)*
  - *Data Integrity and Reliability (**tamper proof** data, security)*
  - *Widespread interoperability (not **silos of trust**)*
  - *Billions of txn/sec each worthing nano$ (not **centralized trust**)*

- ## A technology fits the needs → (Open) BlockChain
  - BlockChain matches the natural ***distributed architecture of IOT***
  - ***Data Integrity***: *BlockChain is secure «by design»*
  - ***Smart Contracts*** *fit the automatic interactions among «things»*
  - ***Micropayments*** *and **data exchange** are naturally implemented*
  - DAPP ***Streamr*** : *Smart Contracts (Ethereum) manage (IOT) data inflow and outflow*. Data stored in a Distributed File System (IPFS)

The *Data Market (STREAMR)*
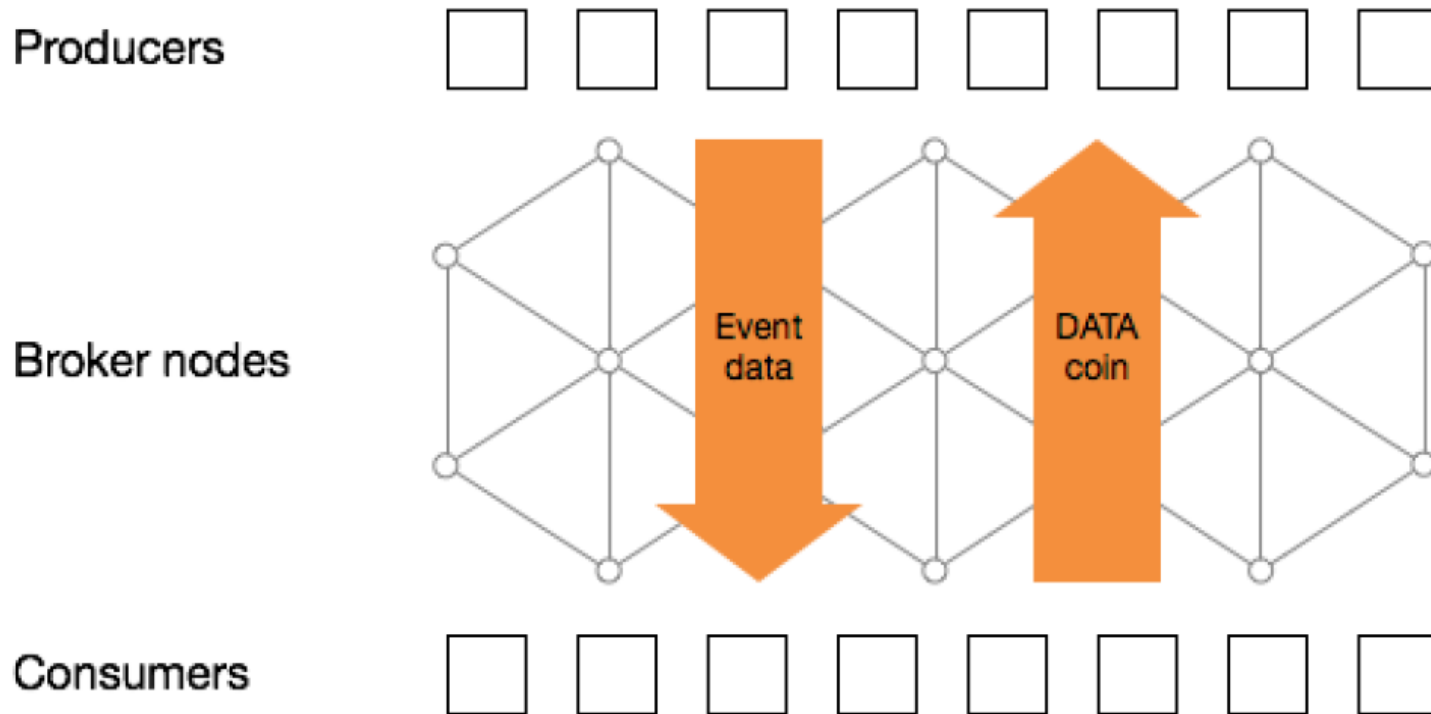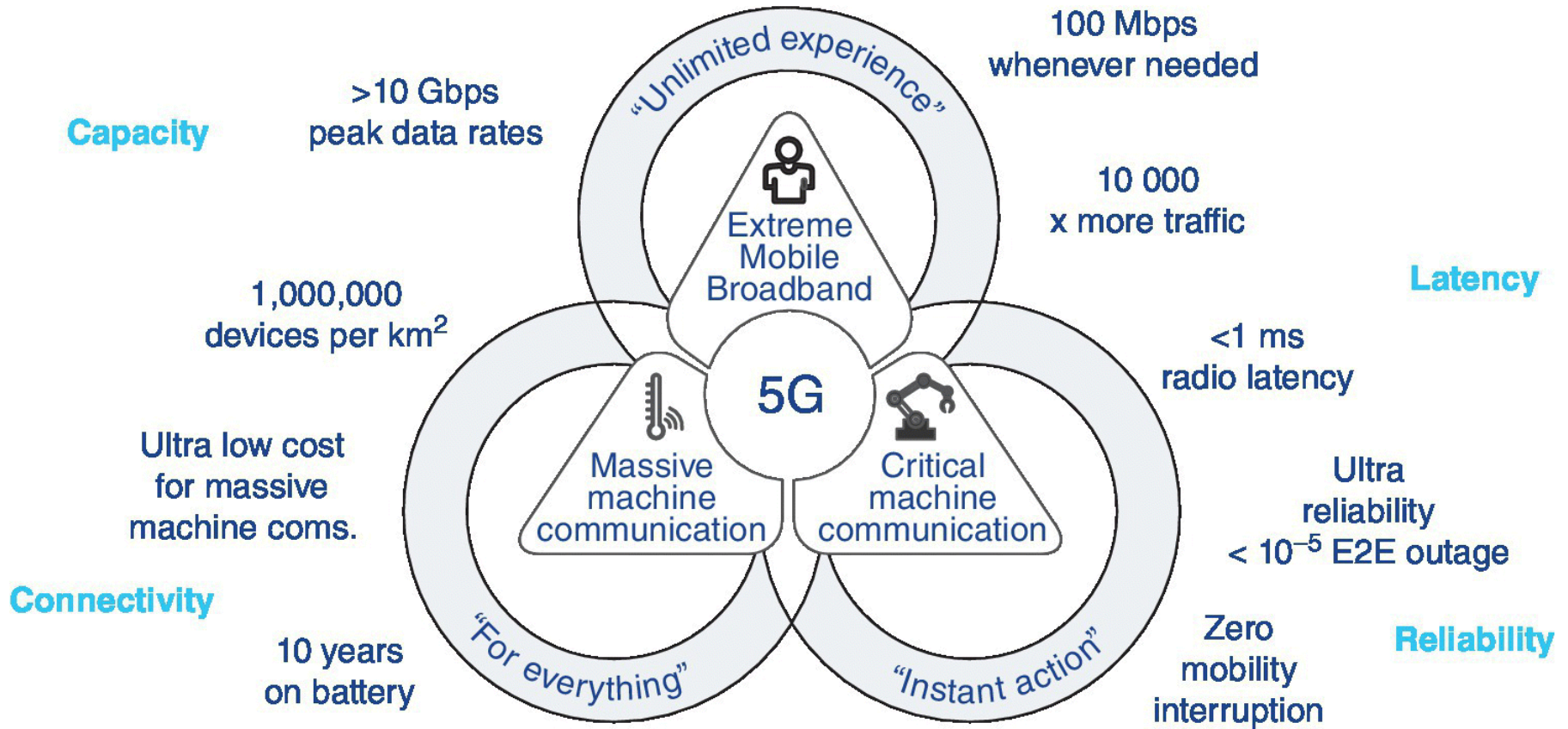

- «Tokenized» Data
- ***DATACoin***: Data Token (Value)
- ***Paying User Data and Broker TransShipping***

BlockChain: a Hype or Here to stay? A short story

- *The History of Internet:*
  - **The dream:** **A resilient network without a C&C Center**
  - *The (once) Big Platforms Attempt ('80-'90) «We are the secure, fast and efficient network»:*
    - **DNA** *(DECNet Internet 17k Nodes in 1989)*
    - **SNA** *(IBM),* **DSA** *(Honeywell)*
  - *TCP/IP and the WWW* **made all of them obsolete!**

- *Here we are again:*
  - **The dream: A resilient «Book of transactions». No Central Trust**
    - **Everyone can access, read and write on the Book**
  - *The Big Platforms Attempt: (thousands of)* **Private BlockChains**
    - **Private:** *some can* *read,* *few* **authorized stakeholders** *can* *write*
    - *Thousands of different and not interoperable* *«***castles of trust***»*
    - **Do you trust more your competitors or mathematics?**
  - **Public, Open BlockChain** *will likely make* **all of them obsolete.**

The 5G Triangle

Capacity

>10 Gbps peak data rates

"Unlimited experience"

100 Mbps whenever needed

10 000 x more traffic

Latency

Extreme Mobile Broadband

1,000,000 devices per km²

5G

<1 ms radio latency

Ultra low cost for massive machine coms.

Massive machine communication

Critical machine communication

Ultra reliability < 10⁻⁵ E2E outage

Connectivity

10 years on battery

"For everything"

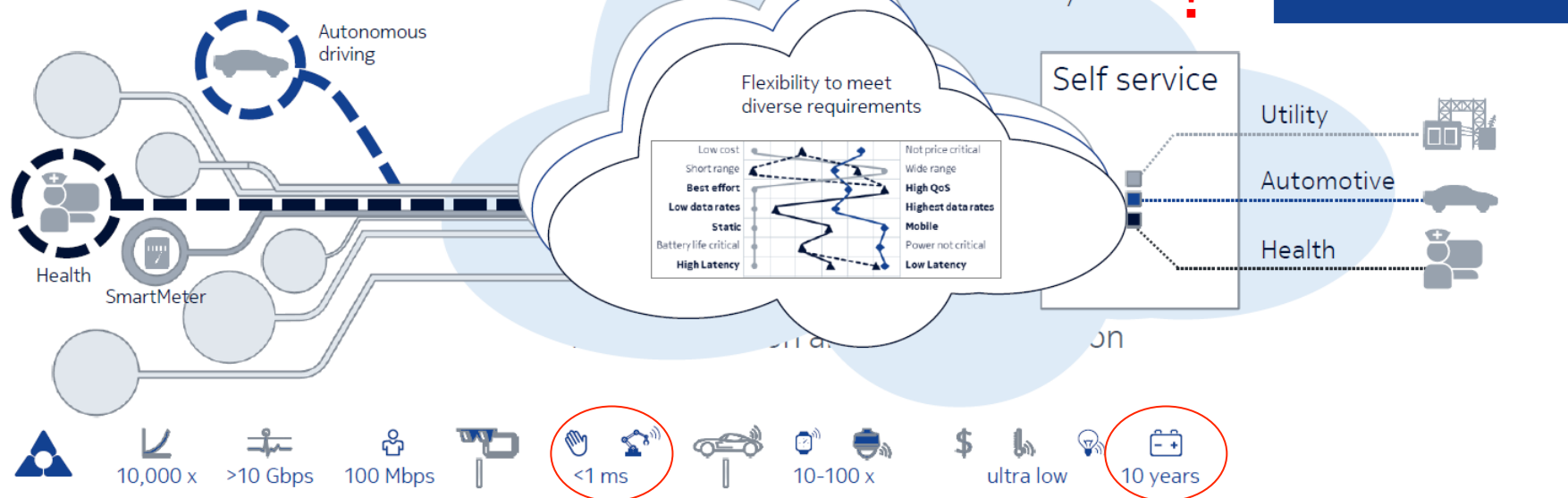"Instant action"

Zero mobility interruption

Reliability

5G revolution: *not only speed, latency* and *coverage*

- **5G *not (only)* a new *Radio Interface* (as GSM, UMTS, LTE)**

Slicing across radio, transport, core edge and central clouds

Dynamic e2e network slicing

Cloud scalability and efficiency

Self service

Autonomous driving

Health

SmartMeter

Flexibility to meet diverse requirements

Utility

Automotive

Health

10,000 x   >10 Gbps   100 Mbps   <1 ms   10-100 x   ultra low   10 years

*5G Novel Radio Multiservice adaptive network Architecture

- **The network becomes *«virtual» and flexible (Cloud)***
  - A *Software Defined Network* (*modems*, *routers*, *servers*, *interfaces*,…)
  - Independent and autonomously managed *«slices»*
  - Computing moves «closer» to the user (*Edge Computing*)
  - Each application/market (*Vertical*) has its *own «slice»*

5G finally turns Internet into a *Network of Networks*

- Not a different network for each service (Telephone, TV Broadcasting, Satellite, Utilities, Games, Roads, Cars, «Things»)

- But … **different networks connected to empower new or more efficient services**. (*Self Driving Cars, Smart Factories, Logistics, Energy Management, Entertainment, Games, Health Care, etc.*)
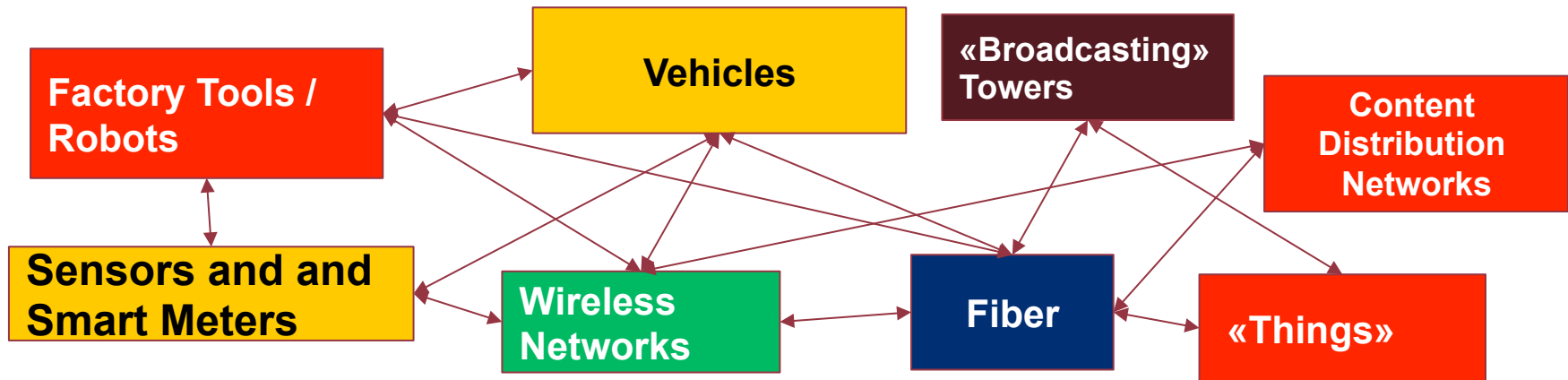
- **Optimization and reduction of «roll out» costs**
- *New services driven by billions of measured data*
- *Increased efficiency and «decentralization»*
- *In a sentence: The Network is Service-Defined*

Networks are Service-Defined

- The desired **Quality of Service** *defines* (by means of AI algorithms) the **struture of the «virtual slice»**:

  - *Self Driving Vehicles*:
    - *Distributed Computing Power* (*Edge computing*);
    - *Vehicle sub-nets* (V2V e V2X)
    - *High number* of vehicles, **low latency** and *blind spots coverage*

SLICE 1	Edge Computing	Vehicles	Capacity/Latency Fiber To the BS	<1Ghz Wireless	Mid-High Band Wireless (FWA)

  - *Video Broadcasting*
    - *Content Distribution Networks*
    - *High coverage and «downlink» capacity* (*4/8k*, *augmented reality*),

SLICE 2	CDN	Capacity/ Jitter Fiber	<1Ghz Mhz Wireless	«Broadcasting» Towers	3 GHz Wireless (FWA)

  - *Smart-Grid – e-Health*
    - *Meter sub-nets* (*sensors, smart-meter*). *High density.*
    - *blind spots coverage*, **low latency** & **low volumes**

SLICE 3	Reti di sensori e Smart Meter	Alta densità (IOT) Fibra	<1Ghz Mhz Wireless	mm-Waves Wireless

5G: Software Defined Network → Algorithm is king
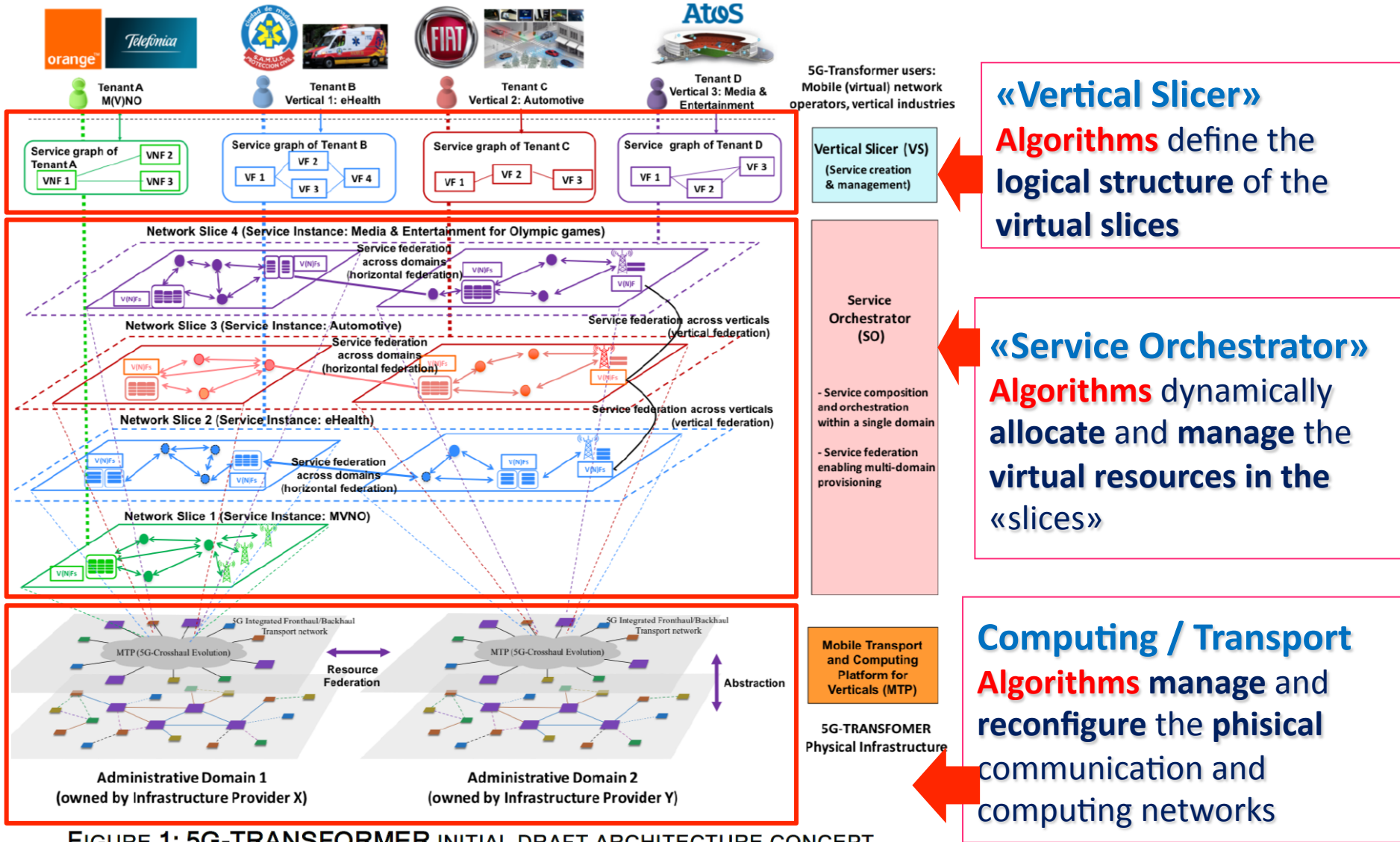
FIGURE 1: 5G-TRANSFORMER INITIAL DRAFT ARCHITECTURE CONCEPT

«Vertical Slicer»
Algorithms define the **logical structure** of the **virtual slices**

«Service Orchestrator»
Algorithms dynamically **allocate** and **manage** the **virtual resources in the** «slices»

Computing / Transport
Algorithms **manage** and **reconfigure** the **phisical** communication and computing networks

Regulatory Issues: Net Neutrality, Parity of Access

- **If *the 5G Network is Service-Defined* then the very concept of *Net Neutrality* takes on a new meaning:**
  - *Every «virtual slice» manages the traffic in a different way*
  - *Every service is a «specialized service»* (*def. Berec*)
  - *The sentence «all packets are created equal» loses its meaning*

  On the contrary the ***Communication Service Provider (CSP) who*** manages the *«vertical slicer»* and the *«service orchestrator»*.

  - ***Acts on*** «*standard*» ed *interoperable networks* (***Over The Top «role»***)
  - ***Defines*** the virtual resources to assign to the ***service providers*** («access» to the rete 5G);
  - ***Uses (is?) Slicing and Orchestration*** *Algorithms*.
  - ***Mandatory (and hard)*** an ***ex-post*** *Parity of Access test*

- ***Who will play the role of CSP?*** Her *Neutrality is crucial*

- *Mandatory the* separation between ***CSP*** and ***Service provider***

Investments in the 5G Networks (in Italy)

- **Who will invest in the 5G networks?**
  - *The incumbent Telco (4G evolution) for sure .. but also …*
  - *Neutral Hosts*
    - *ARQIVA (UK): 1500 Broadcasting towers; 8000 BS; Reti FWA / LPWA (IoT)*
    - *TDF (FR): Fiber Network (5000 Km); 12.000 Towers (BS and Broadcasting)*
    - *2ITowers(IT): Fiber Network (6000 Km); 2300 Torri HTHP; 1000 BS; LPWA (IoT)*
    - *Open Fiber(IT): FTTH, Fiber to the Base Station*
  - *Networks owned by the vertical tenants:*
    - *ENEL: «Smart Meters»*
    - *ANAS: «Smart Roads»*
    - *And then… Vehicles, Wearable Meters, «things» ….*
  - *Wireless network operators (es. FWA)*
- **And who will get (and pay) the frequencies ?**
  - The answer is **now** (after the 5G Auction) **easy**: **the incumbent Telcos**
  - **The 5G revolution is crucial for their future**
  - **New ideas of PPP and shared investments needed**

Different Initial Approaches to 5G

T·Mobile

5G NATIONWIDE COVERAGE

- Building **5G network in 30 cities in 2018**, nationwide in 2020
- 600 MHz already deployed in more than 1,250 cities and towns in 33 states

AT&T

5G MOBILE HOTSPOTS

- **Launching 5G mobile service in 12 cities** by end of 2018
- Additional major 5G launches in 2019

verizon

FIXED WIRELESS

- Launched commercial **Fixed Wireless 5G in 4 cities in October 2018**
- Followed by additional 5G launches in 2019 including 5G mobile service

Sprint

MASSIVE MIMO

- Launching **5G on 2.5GHz**
- **9 cities** to be launched **in first half 2019**
- Followed by additional 5G launches

All operators are moving towards 5G
Everyone has different starting points
No one has clear spectrum across all bands for 5G today

Source: 5G Americas, Chairman-Neville Ray

Florence School of Regulation, November 8, 2018

5G + AI + BC - Future Services and role of PA

- **The future services (all !) need 5G + AI + BC**
  - **Driven by *reliable* and *valuable* user data**;
  - ***Managed* by complex AI algorithms;**
  - ***Empowered by 5G* communication networks**
  - **Relying upon the «trust infrastructure»: the Blockchain**

- ***The role of Public Administration***
  - *New rules for infrastructure **«roll-out»** (permits, em pollution)*
  - *Clear and **predictable** spectrum strategy (**«spectrum review»**)*
  - *Strong **demand side policy** (smart roads, e-health, public goods management, process digitalization)*
  - New rules to guarantee an *Equitable acces to 5G networks*, *Network (Cyber) Security* and *Algorithm Accountability*
  - *Funding Basic Research and Research Projects*
  - *Promote Experiments (Challenges) on real life (PA?) problems*

Focus: *Internet of Things*

IEEE COMMUNICATIONS SURVEYS & TUTORIALS (DRAFT)   1

Towards Massive Machine Type Communications in Ultra-Dense Cellular IoT Networks: Current Issues and Machine Learning-Assisted Solutions

Shree Krishna Sharma, *Senior Member, IEEE*, and Xianbin Wang, *Fellow, IEEE*

- **IOT** *already «alive and kicking»*
  - *Unlicensed* **LPWA** (*technology and base stations owned by operators*):
    - *SigFox* (868MHz, 915 MHz), *LoRA* (< 1Ghz), *Ingenu* (2.4 GHz)
  - *Licensed* LTE-M(achine) (*Rel. 10 - 13 3GPP*)
    - *eMTC – (CAT-M1)* – *NB-IOT*
- **LTE - M** is structurally **unfit** for **m**IOT (relies on 4G Networks)
  - Medium Access *Congestion* (*millions of «things» requiring attention*)
  - Signalling *Overhead* (*Data Trasmitted $\cong$ Control traffic*)
  - Highly centralised data processing and no edge computing
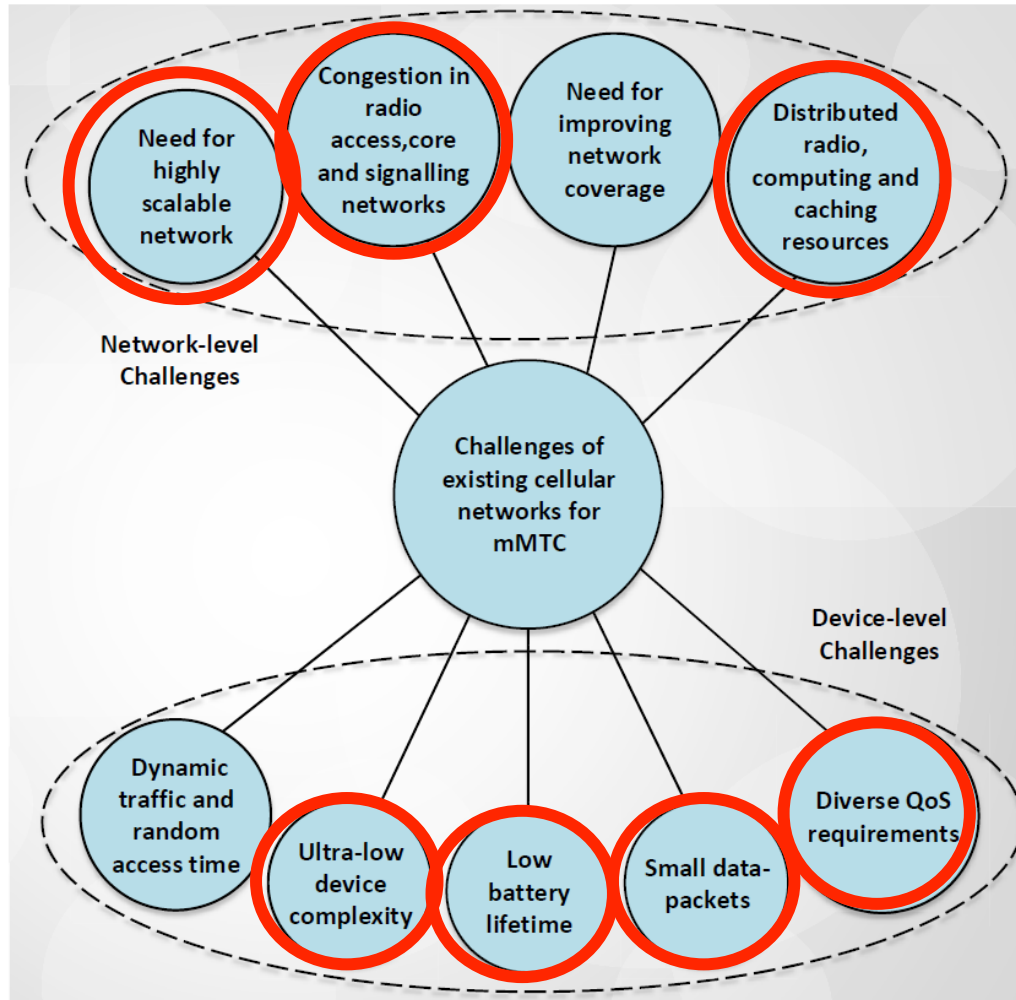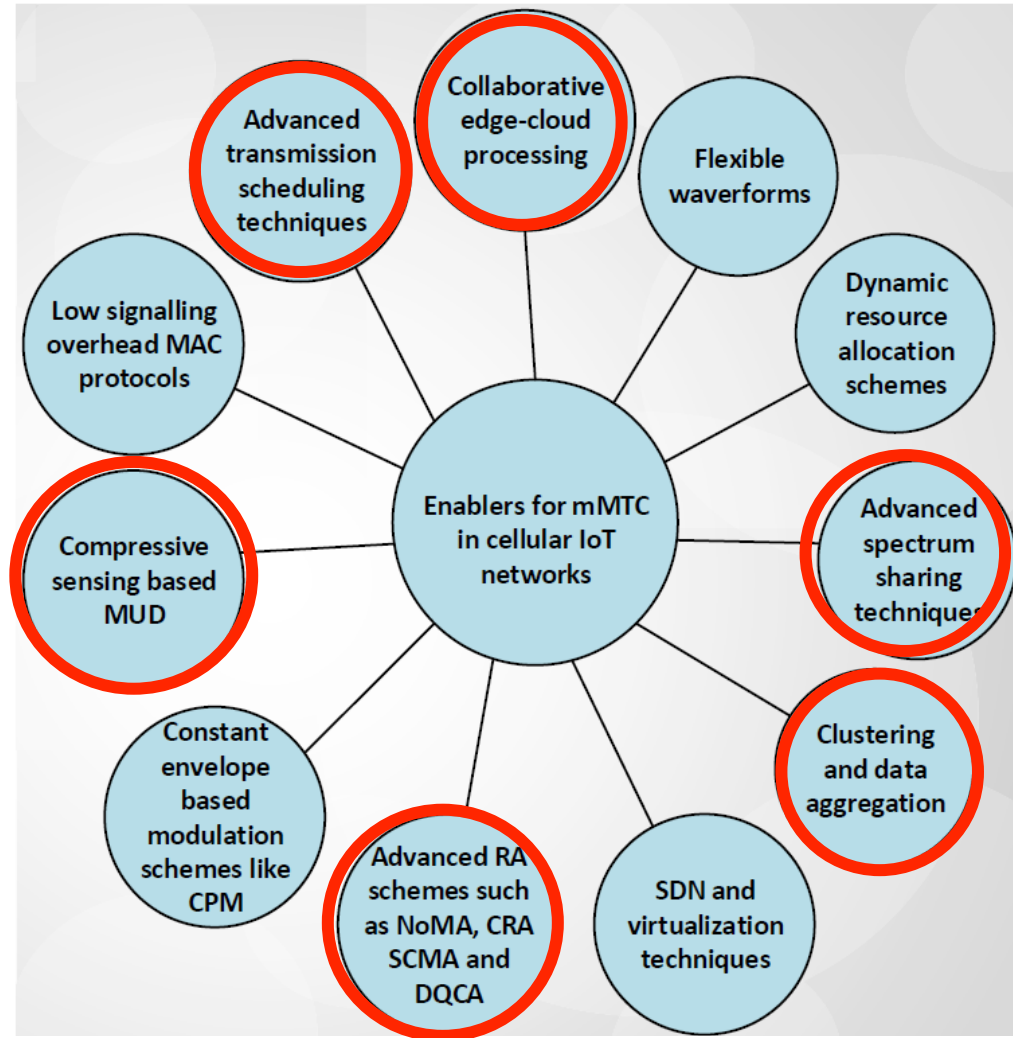 - Designed for complex UE with «hungry» batteries
  - …

Why LTE-M is not enough?

Fig. 2. Challenges of existing cellular networks to support emerging massive machine-type communications.

- **5G mMTC**
  - *AI parameter setting*
  - *AI Clustering*
  - *Data Aggregation*
  - *> 1M users per Km^2*
  - *MAC Collision Minimization*
  - *Adv. Spectrum Sharing*

*The transition from **LTE-M (eMTC)** to **mMTC** should be «smooth»*

© CanStockPhoto.com - csp55750957

Thanks for your attention!