Building Blockchain-powered Trusted Digital Health Services. Estonia

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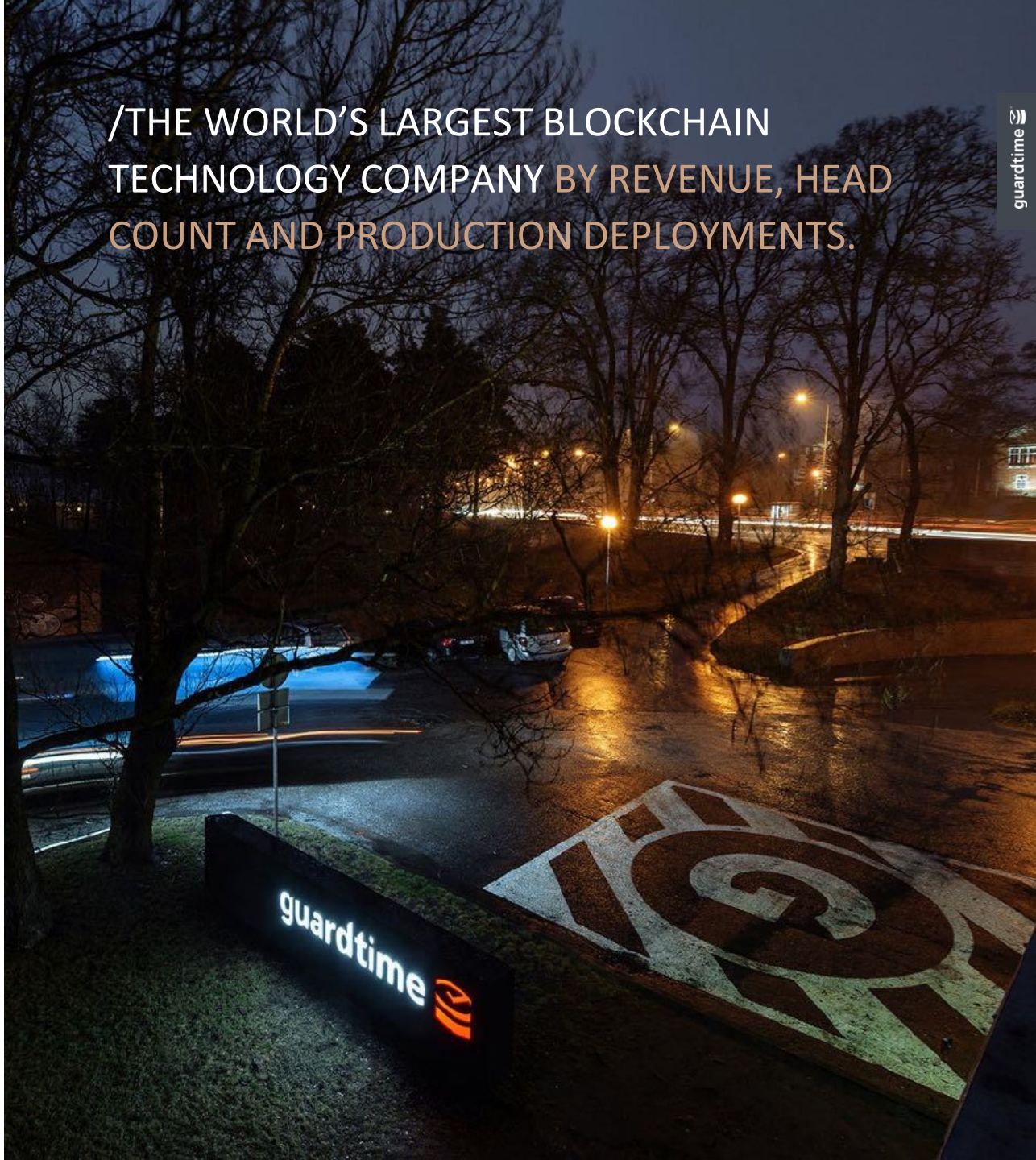
the coolest digital society

GUARDTIME

+ FOUNDED: 2007 in Tallinn, Estonia
+ GLOBAL HQ: Lausanne, Switzerland
+ PERSONNEL: 200 FTE, 80% in R&D, offices in US, EU and China
+ VALUE PROPOSITION: The *only* blockchain-backed technology platform that is proven to work at scale, used in production by the US military and some of the largest companies in the world to solve data management challenges.
+ FUNCTIONAL OFFERINGS IN HEALTH DOMAIN:
    - HELIUM (Data Access and Governance Manager)
    - Data Access for Outcomes Based Pricing
    - Dynamic Patient Consent Engine (GDPR)
    - Medicine Supply Alert
    - Secure Data & Process Integrator for Medication Adherence
    - Supply Chain Track and Trace
    - Complex Clinical Trial Data & Process Integrator
+ ACCREDITATION: Technology has been accredited by US, EU and China regulators for deployment on to government networks.
+ REFERENCES: Lockheed Martin, Ericsson, Estonian Health Information System, Verizon, UK NHS, Governments (US, China, EU, Estonia, Netherlands, etc.)



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THE CONTEXT

Estonia is digital all over – not just in healthcare

Entire country is covered with a broadband connection

99% of state services are online

98% of the population has an ID-card

1st country to use blockchain on national level

5 days and 2% of GDP per year is saved with digital signatures

30% of the population uses i-Voting

business is digital

98% of companies established online

99% of banking done online

95% of tax declarations filed online

e-Residency – freedom for everyone to run a global EU company fully online

healthcare is digital within this context

Estonia's healthcare system has been revolutionized by innovative e-solutions. Patients and doctors, not to mention hospitals and the government, benefit from the convenient access and savings that e-services have delivered.

Each person in Estonia that has visited a doctor has an online e-Health record that can be tracked. Identified by the electronic ID-card, the health information is kept completely secure and at the same time accessible to authorised individuals. KSI Blockchain technology is being used for the system to ensure data integrity and mitigate internal threats to the data.

e-Health Records | e-Ambulance | e-Prescription

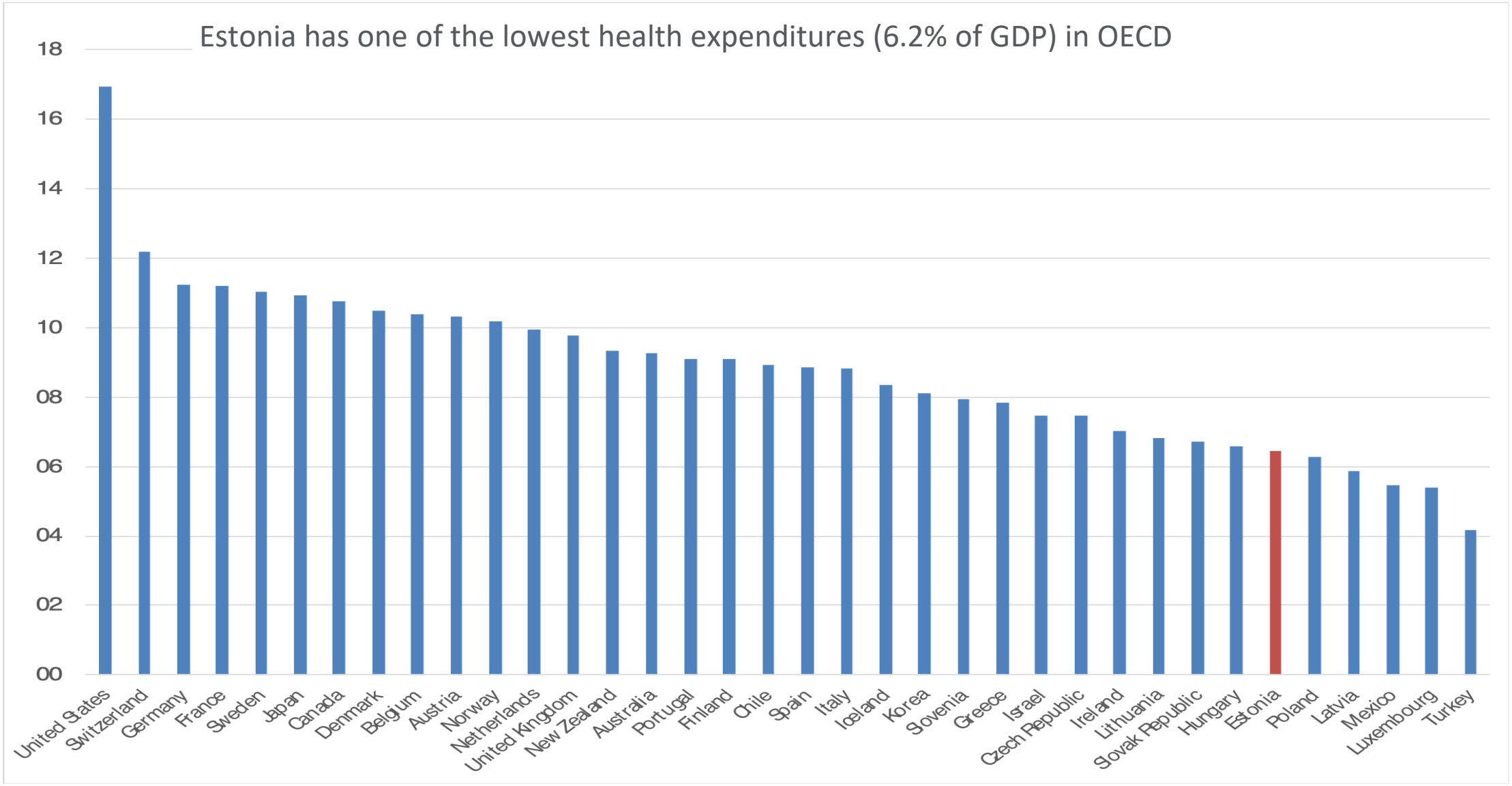
99%
of health data digitized

99%
of prescriptions are digital

2,3M
queries by doctors every month

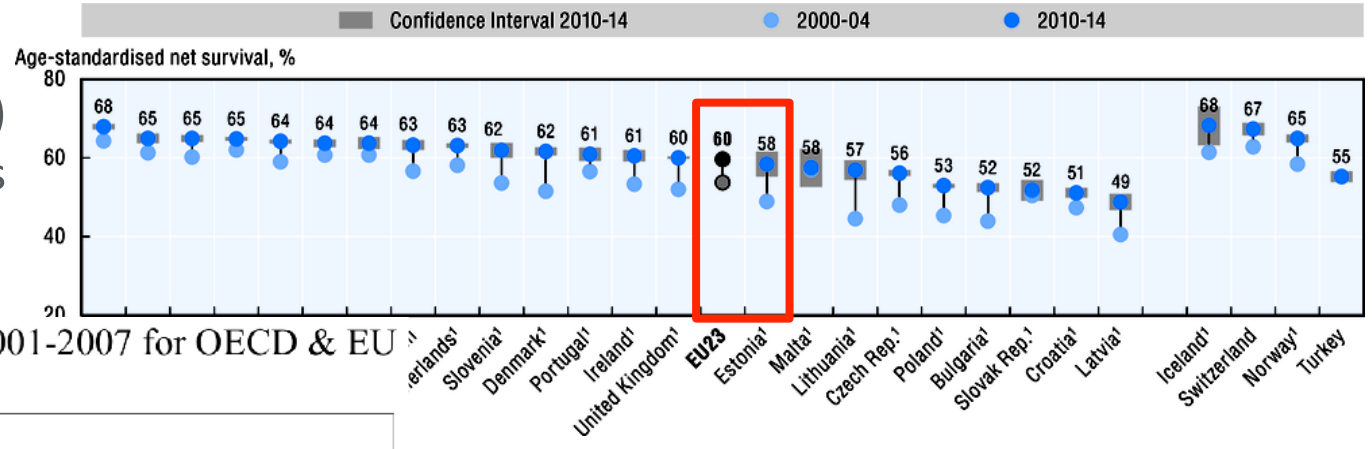
100%
electronic billing in healthcare

HIGH DIGITALISATION DRIVES
/ HIGH QUALITY & HIGH EFFICIENCY

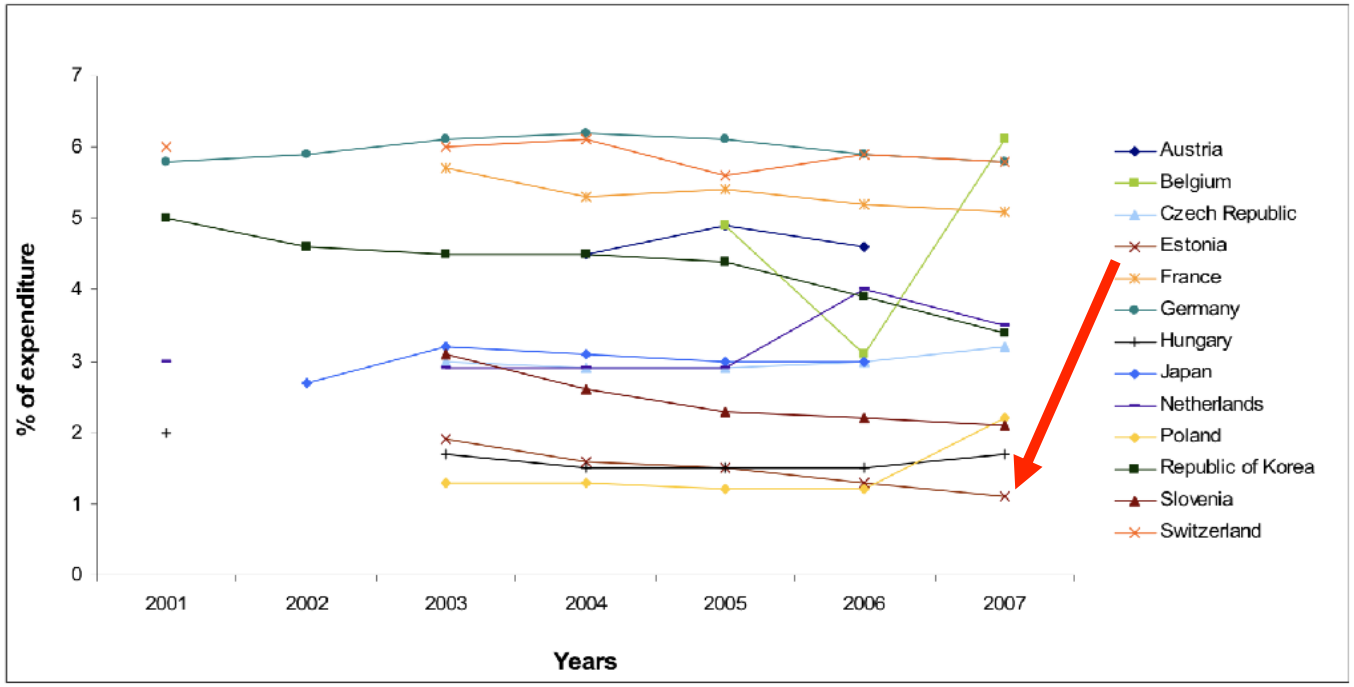


HIGH DIGITALISATION DRIVES
/ HIGH QUALITY & HIGH EFFICIENCY

Close to average (and improving) care quality among EU countries



Graph 2. Trend in public insurance administrative costs over 2001-2007 for OECD & EU countries**



Health insurance administrative costs among the lowest in EU

empowering

Easiest life: only getting married or divorced and selling real estate cannot be done online.

Yet.

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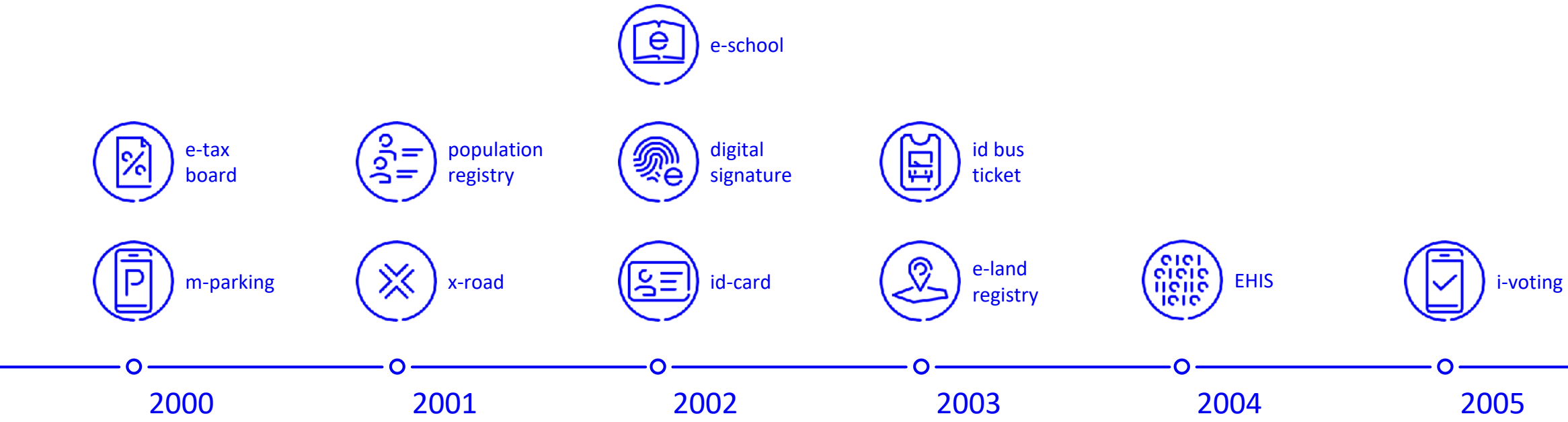
THE BEGINNING

E-ESTONIA TIMELINE
/ FROM VISION TO RESILIENT GROUNDWORK



E-ESTONIA TIMELINE:
/ FROM CHALLENGE TO OPPORTUNITIES

cyber-attacks
DDoS

2007
- mobile-id
- e-police system

2008
- KSI blockchain
- e-health system

2010
- e-prescriptions

2011
- smart grid

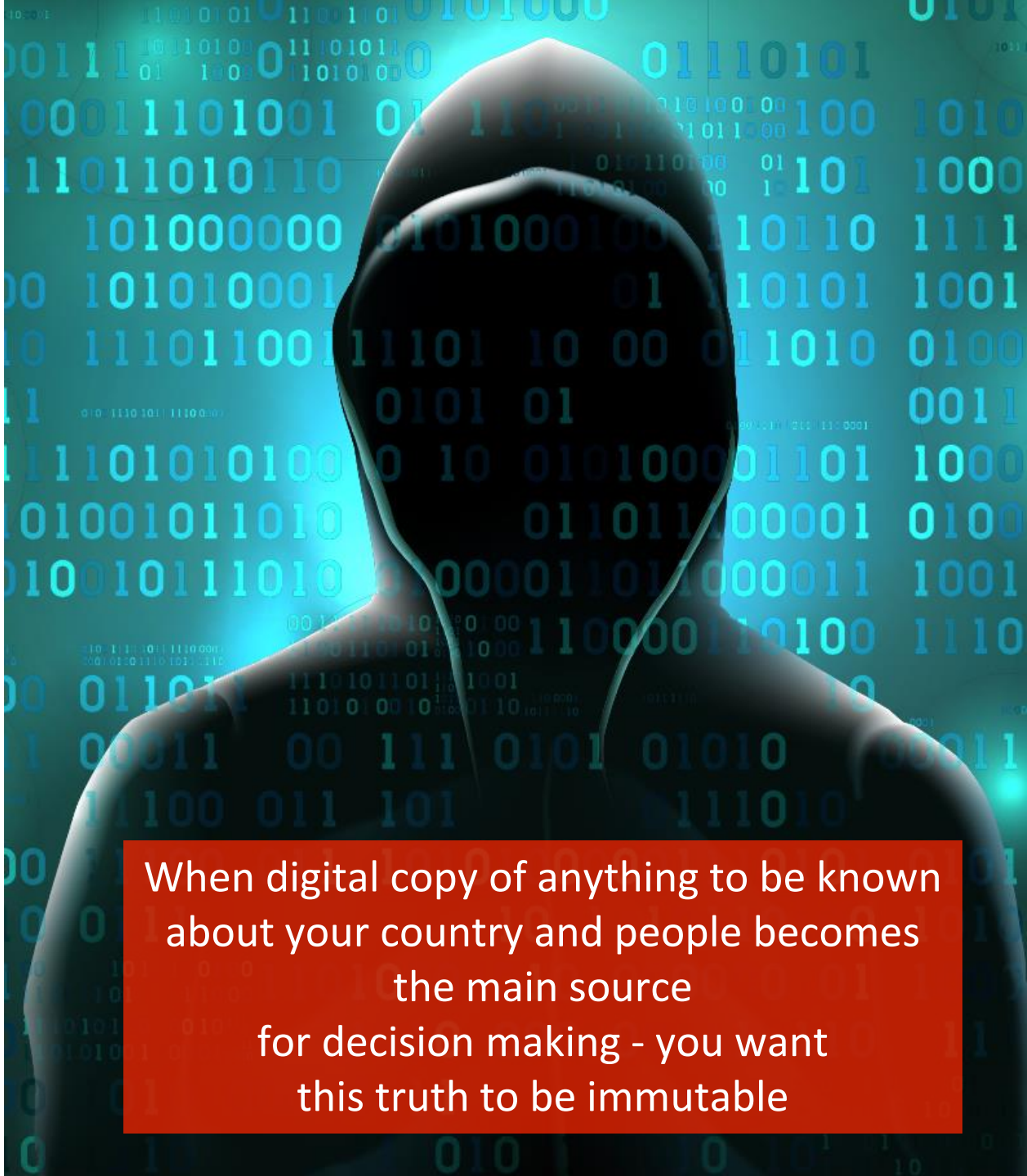
2012
- ev quick charging network

2013
- x-road europe

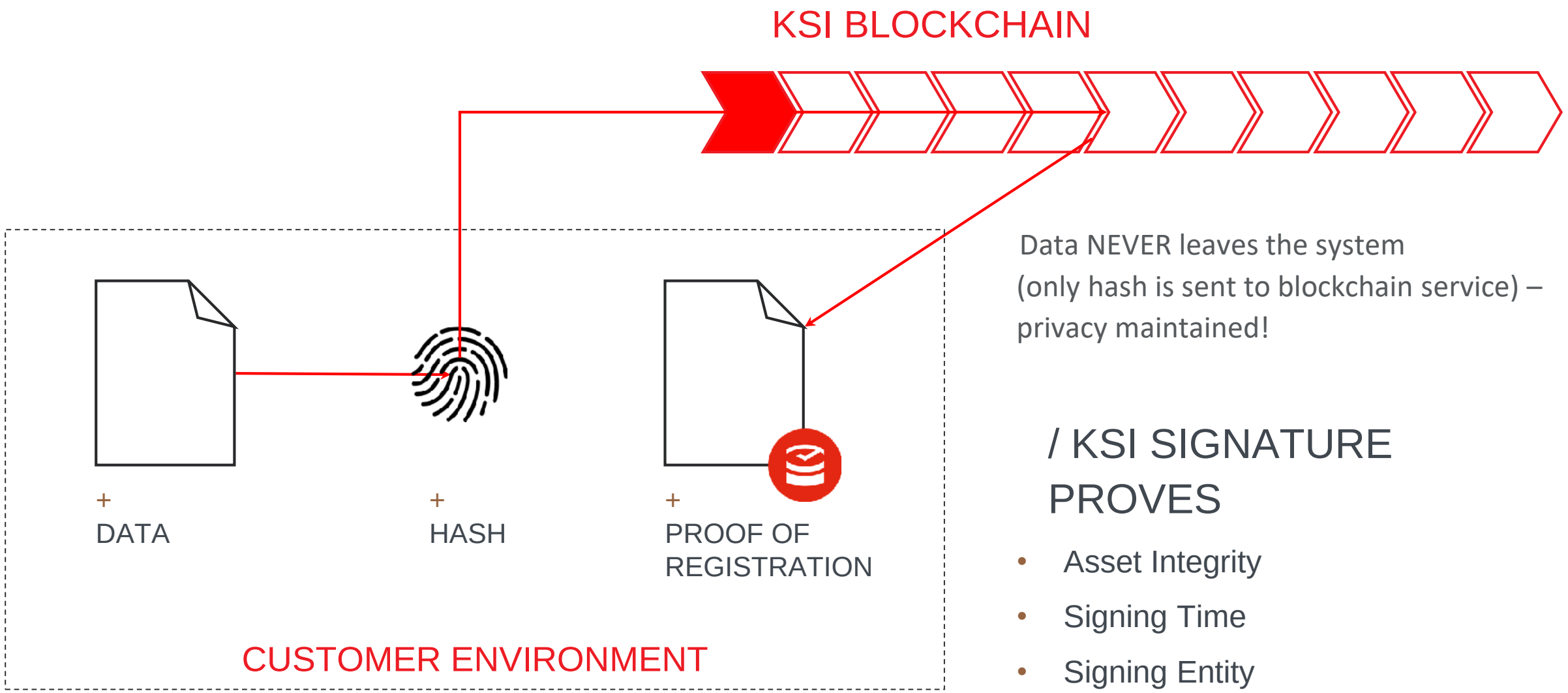
2007 LESSON
/ FROM CYBER ATTACKS

THE CHALLENGE:

Prove the time, integrity and origin/provenance (human or machine) of any electronic data asset, without reliance on centralized trust authorities.



KSI BLOCKCHAIN
/ PRIVACY BY DESIGN



Data NEVER leaves the system (only hash is sent to blockchain service) – privacy maintained!

/ KSI SIGNATURE PROVES

- Asset Integrity
- Signing Time
- Signing Entity

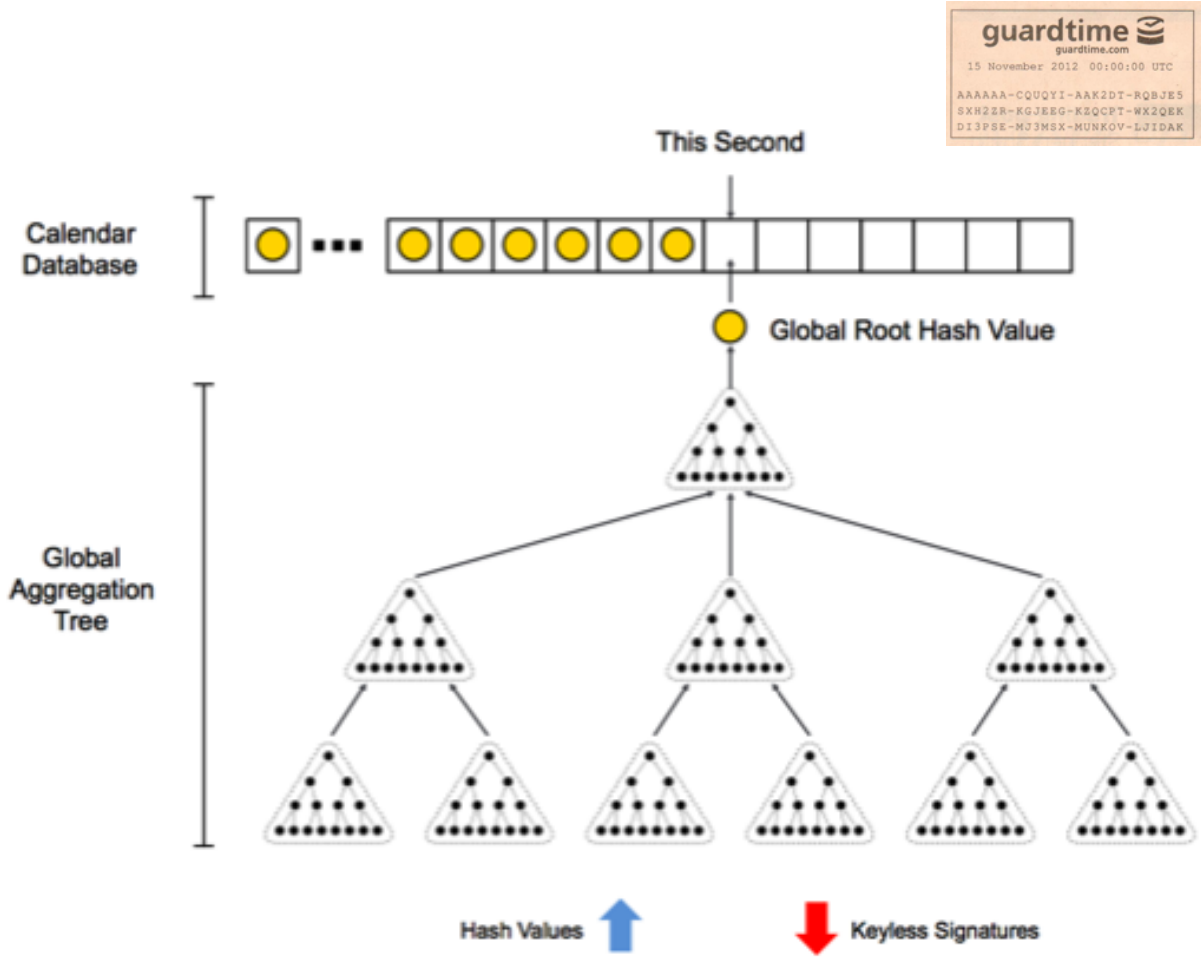
KSI BLOCKCHAIN
/ SCALABILITY

Every second hash-values of new data created are submitted into the hash tree.

A unique hash-chain is returned which later can be used to prove that the hash-value participated in the computation of the root.

Every second a new hash tree is built with new data and only the root hash values are kept in a public Blockchain to which everyone has access.

The Blockchain grows at 1 hash value per second – or 2GB per year using SHA-256.



KSI BLOCKCHAIN
/ HIGHLIGHTS

- Proves the integrity and time of any piece of data
- 1-second time-resolution
- 1-second response time
- Any number of KSI signatures per second
- Widely witnessed trust anchors in newspapers and electronic media
- Independent offline verification (verification code open source)
- Privacy - no need to expose data
- No key management
- Telcom grade reliability, 99,995%
- Quantum immune

KSI BLOCKCHAIN
/ GUARDING THE INTEGRITY OF DATA & PROCESSES

operational
from 2008

Availability, redundancy,
scalability

cloud
assurance

Accountability, attribution
and transparency

real-time
awareness

Insider threat
Data breach management

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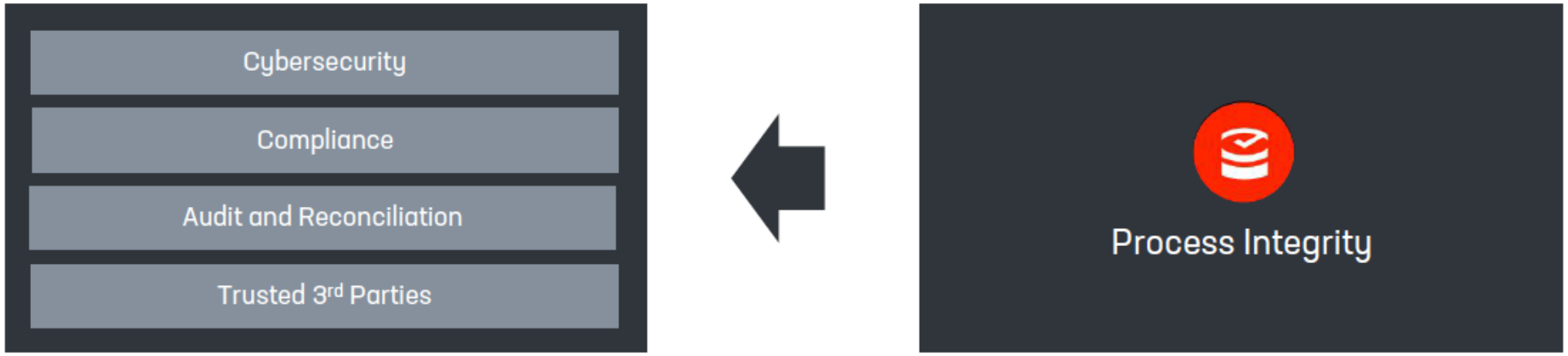
VALUE-PROPOSITION OF
/ BLOCKCHAIN-BASED TECHNOLOGY STACK



Our core value proposition is cryptographic process integrity.

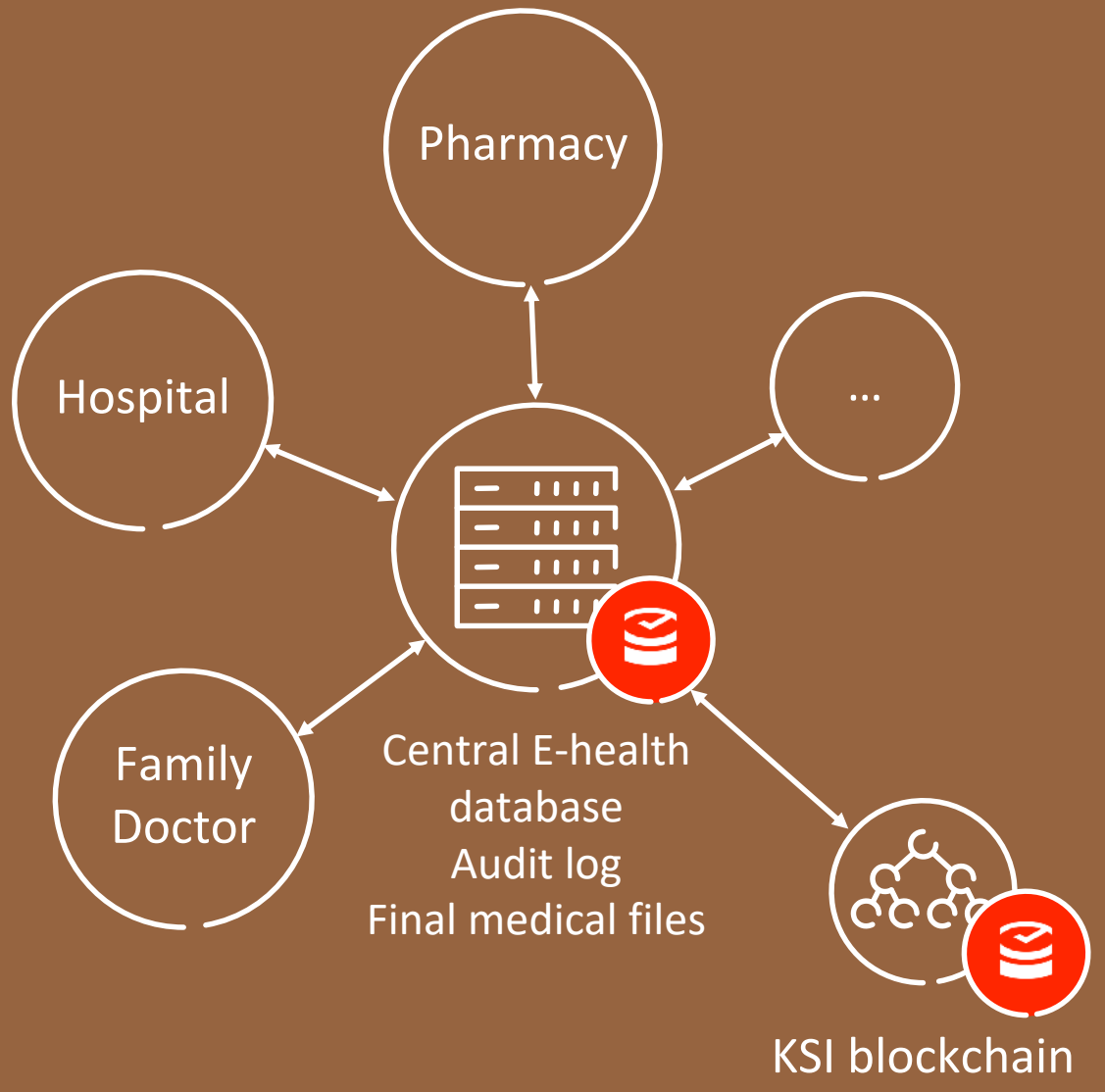
Everything in business is a process. Our technology makes process immutable (cryptographically verifiable without the need for trusted humans). From a business perspective, only Guardtime understands that this is the foundational problem in every organization in every vertical and for every business problem in the digital domain. Typically an organization has budget for the symptoms of the lack of process integrity - audit, compliance, security etc. By addressing the root cause, the symptoms can be dealt with in a fundamentally different way (algorithmically).

The processes could be internal to an organization (as mundane as updating a database) to an industry wide shared process (the transfer of risk from insured to capital, the adjustment of drug pricing between pharma and payer etc.)

blockchain backed e-health registry

+ Regulatory compliance
+ Integrity assurance

+ Minimal deployment friction
+ Low cost base



THE ARCHITECTURE (= TECHNOLOGY) IS DESIGNED TO / FACILITATE WITHOUT LIMITATIONS FOR ...

- any professional while
- working at any provider to
- see/exchange any data about
- any individual at
- any situation.

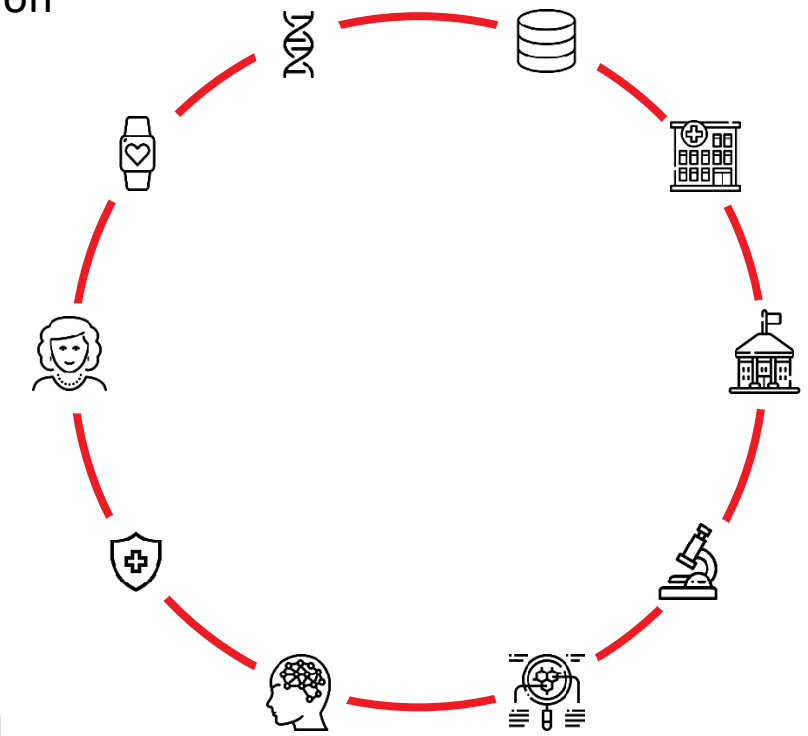
This is the principle.

For each category rule-based limitations will apply and can be managed!

(= legal framework & data governance)

JOURNEY OF NATIONAL EHEALTH SERVICES / IN ESTONIA

- Collecting health service reimbursement invoices
- ~1995
- Health insurance reimbursement 100% digital (2001)
- Digital picture archiving services
- Nationwide EHR services for physicians and patients
- Digital registration services
- ePrescription Services
- Health status summary for Social Insurance Board
- eConsultation services
- RWD based statistics services
- Medical certificate services
- eAmbulance services
- Services for dental care
- Drug interaction & adverse reaction CDSS
- Deidentified „health data lake“ for R&D cross-border ePrescription



FULLY INTEGRATED SYSTEM REQUIRES
/ FULL TRANSPARENCY & CONTROL OF DATA USE BY CITIZENS

Fundamental principle:
Health data is controlled by the person (‘data subject’) &
enabled via blockchain-powered integrity services

1. Access to my data
2. Control of my data use
3. Delegation of my access and control rights
4. Individual monitoring of requests for my data

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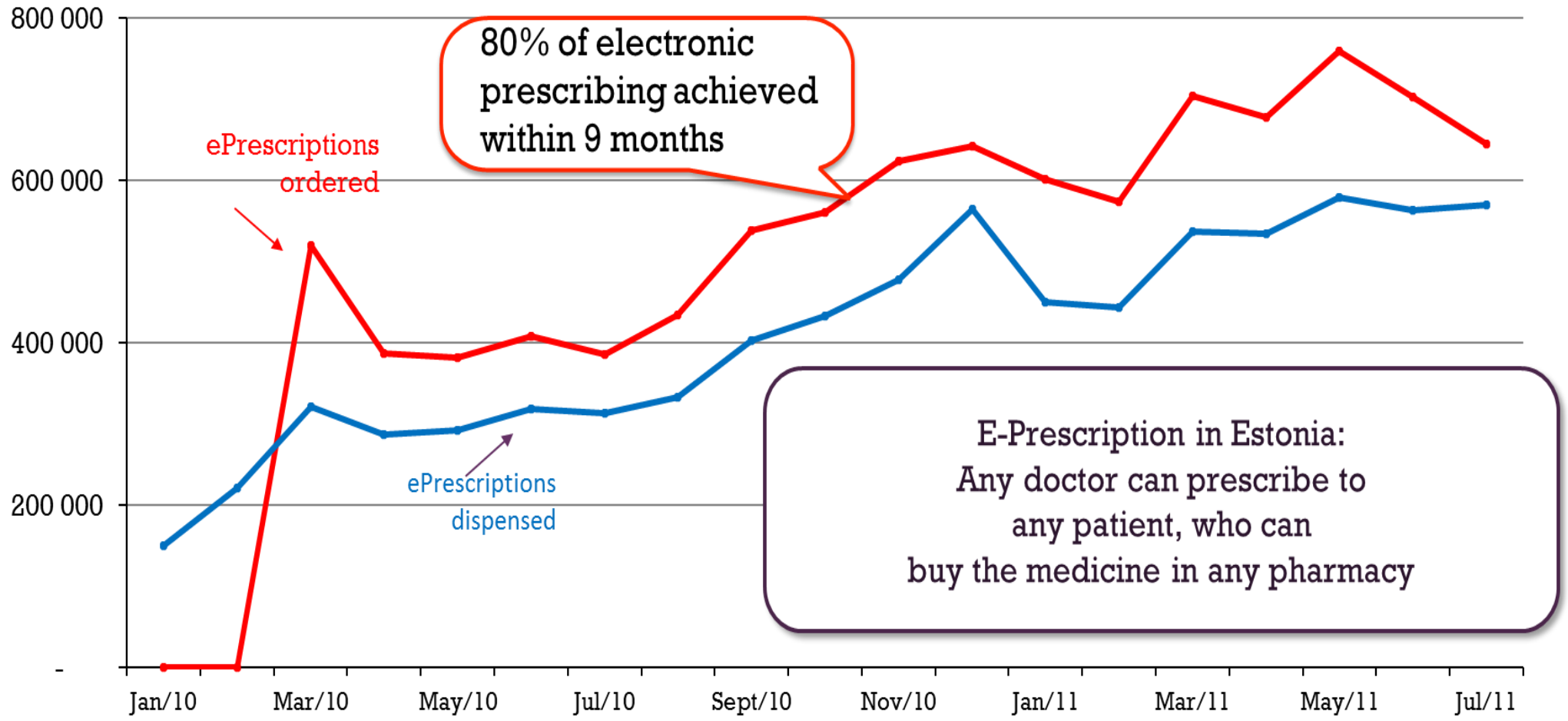
THE VALUE

VERY FAST SYSTEM-WIDE ADOPTION
/ THE CASE OF E-PRESCRIPTION



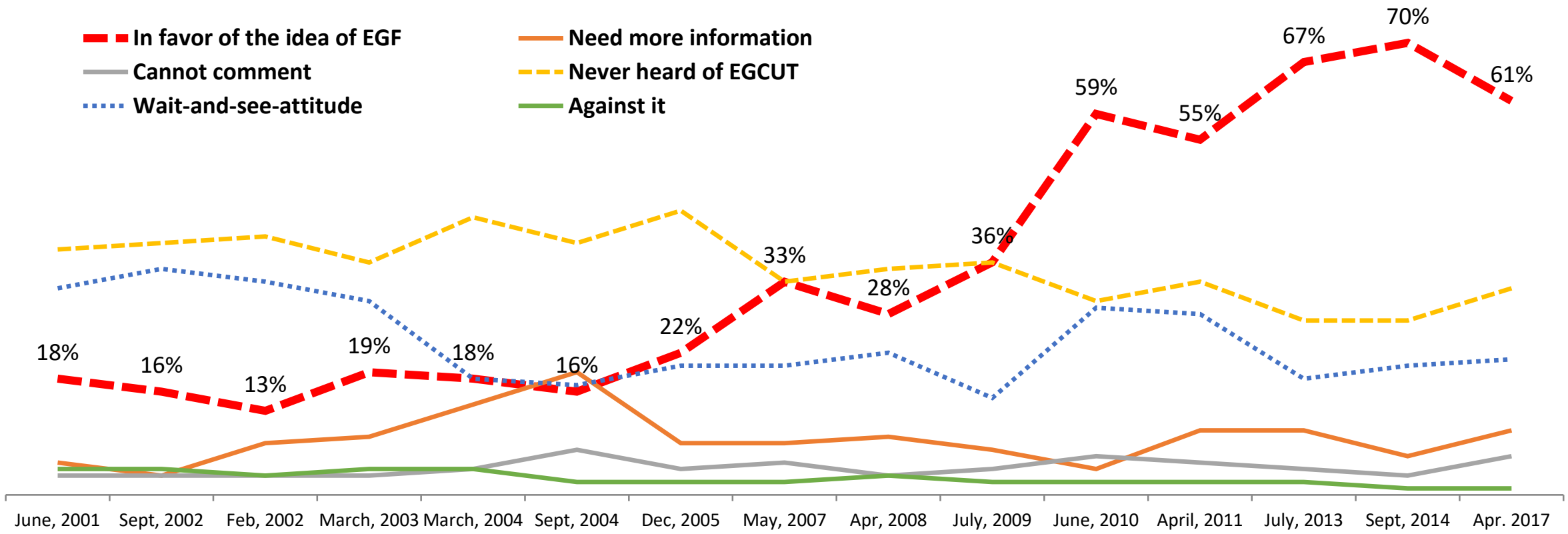
FULLY INTEGRATED DIGITAL HEALTH SERVICES / SAVE MONEY

Nationwide integrated and indication based ePrescription service

+ Administrative costs for error correction dropped by 80%
+ ROI from reduced paper prescriptions in 2 years
+ Time spent on repeated prescriptions by doctors dropped 2 times
+ Liability claims to doctors for mistakenly erroneous prescriptions dropped close to 0
+ Prescriptions by active ingredient, rather than brand name, went from 50% to 90% of all prescriptions, which reduced patients' out of pocket costs by about 25%

TRUST TOWARDS DIGITAL SOCIETY
/ GROWS OVER TIME

Public support to Estonian Genome Foundation
(combining population genomic data with all existing health data)



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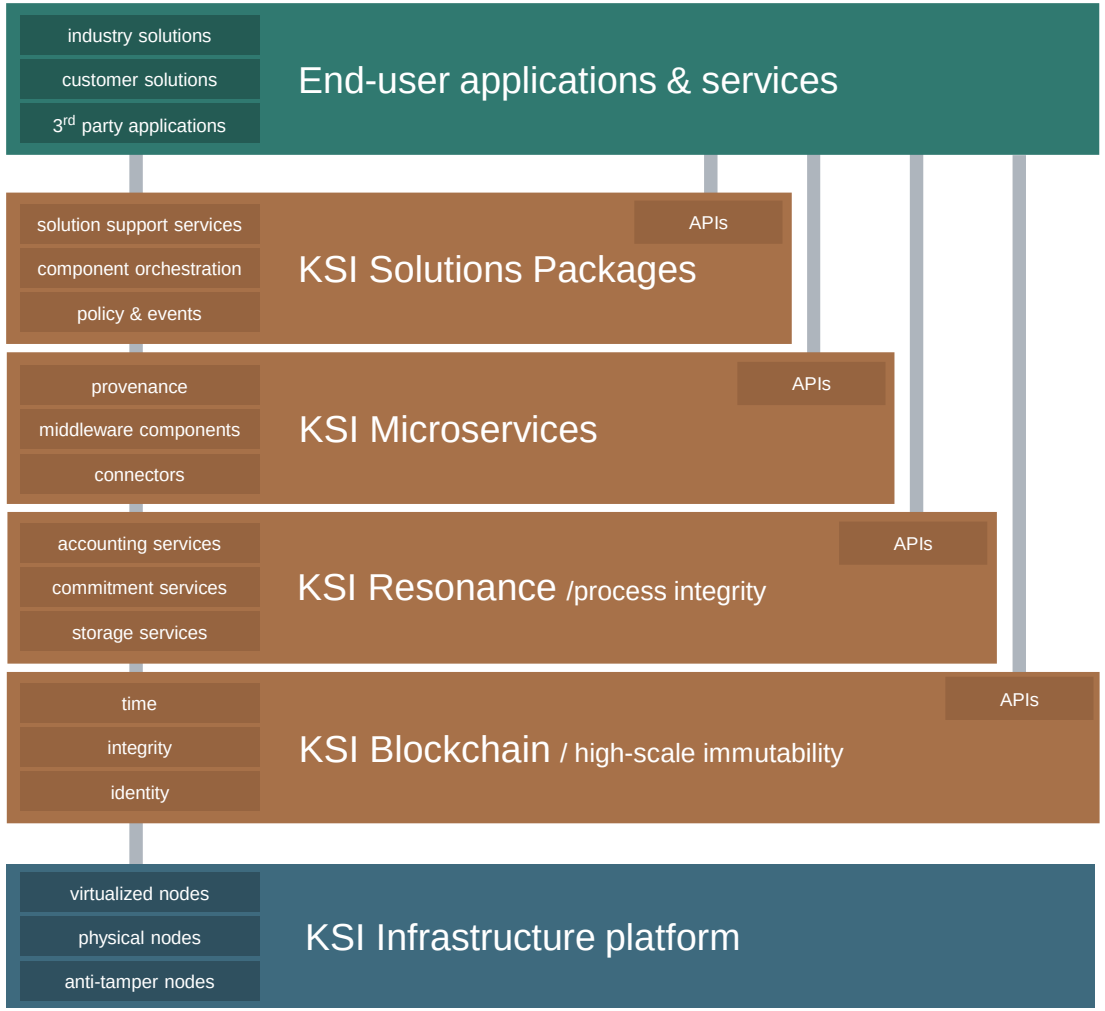
THE REALITY

TECHNOLOGY
/ STACKED APPROACH

End-to-end modular blockchain technology stack, from physical infrastructure (Anti Tamper server hardware if needed) to blockchain to middleware to solution packages.

Unix philosophy to blockchain - abstraction and encapsulation of functionality into components which do one thing well, with minimal complexity, to ensure
scale, **performance** and **resiliency**.

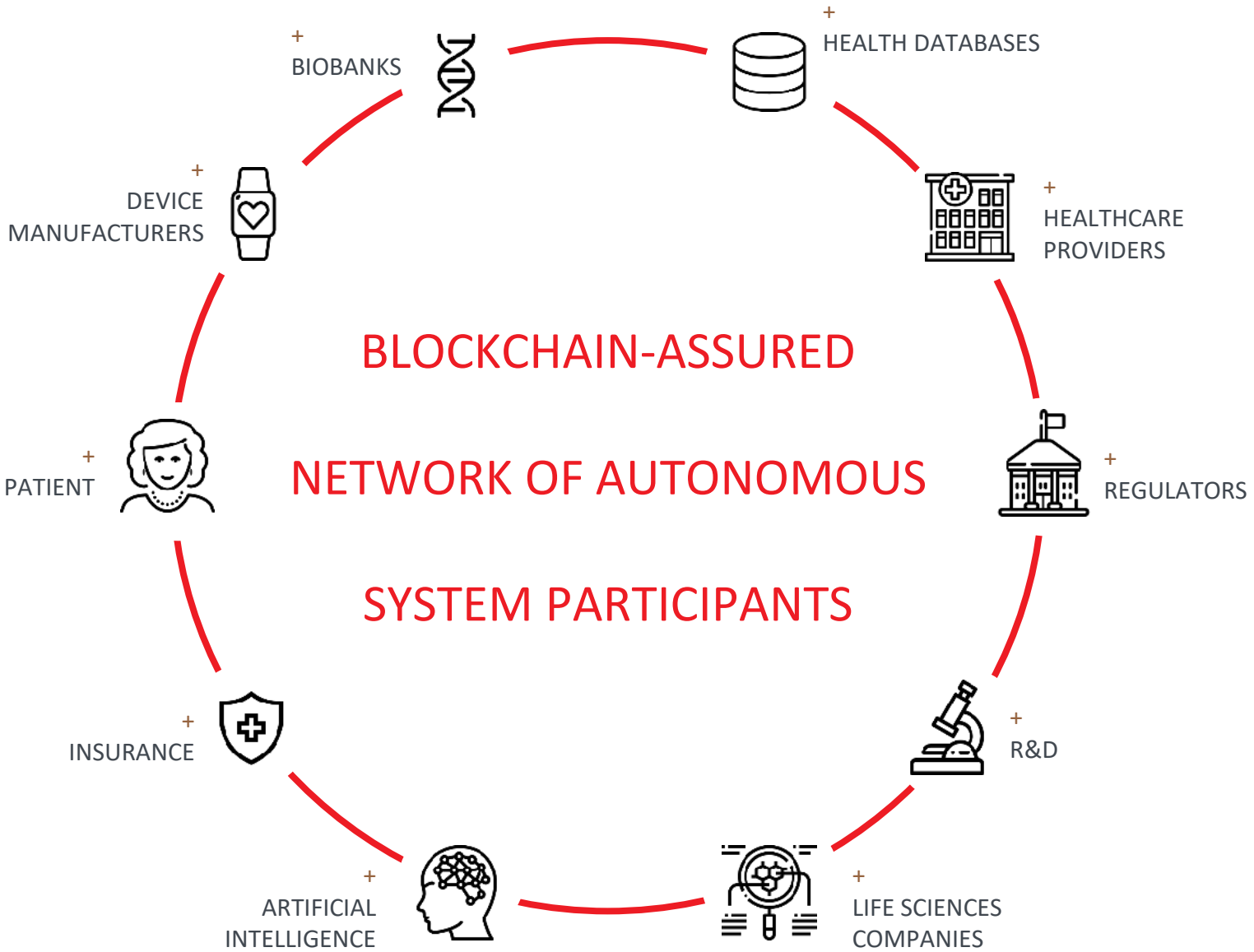
Easy deployment with **value**-driven (not technology-driven) cost base.



A GLOBAL BRAIN
/ FOR HEALTHCARE

Layered technology stack provides secure connections in the health ecosystem to build various trusted interoperable networks.

Commonly shared APIs for consent, provenance, integrity, access enabling in-house application development or integration with 3rd party applications.



HEALTH DATA PLATFORM, WHICH IS
PURPOSE BUILT TO DELIVER / THE FUTURE OF HEALTH

/BUILD

STANDARD APIs

Single Version of Truth – Data Immutability
+ KSI Blockchain

Regulatory Compliance
+ On-Demand Patient Consent
+ Derived Consent for Children / Infirm Patients
+ Dynamic Consent for Emergencies
+ Anonymization of Patient Data

Digital Twins
+ Patient Identity Mapping (Cross Platforms)
+ Medication Tracking (Physical to Digital)
+ Clinical Trials – Concierge Services

Provenance
+ Visualize the who, where and what for every interaction across the health ecosystem.

/CONNECT

Universal Secure Data Transport
+ End to End Secure, Encrypted, Blockchain backed transport layer for 'consent based' real time sharing of patient data

Directory Services
+ Advertise or consume HSX enabled services on demand

Supported EHR Systems
+ Cerner
+ EPIC
+ AllScripts
+ Any third party HL7 / FHIR enabled system

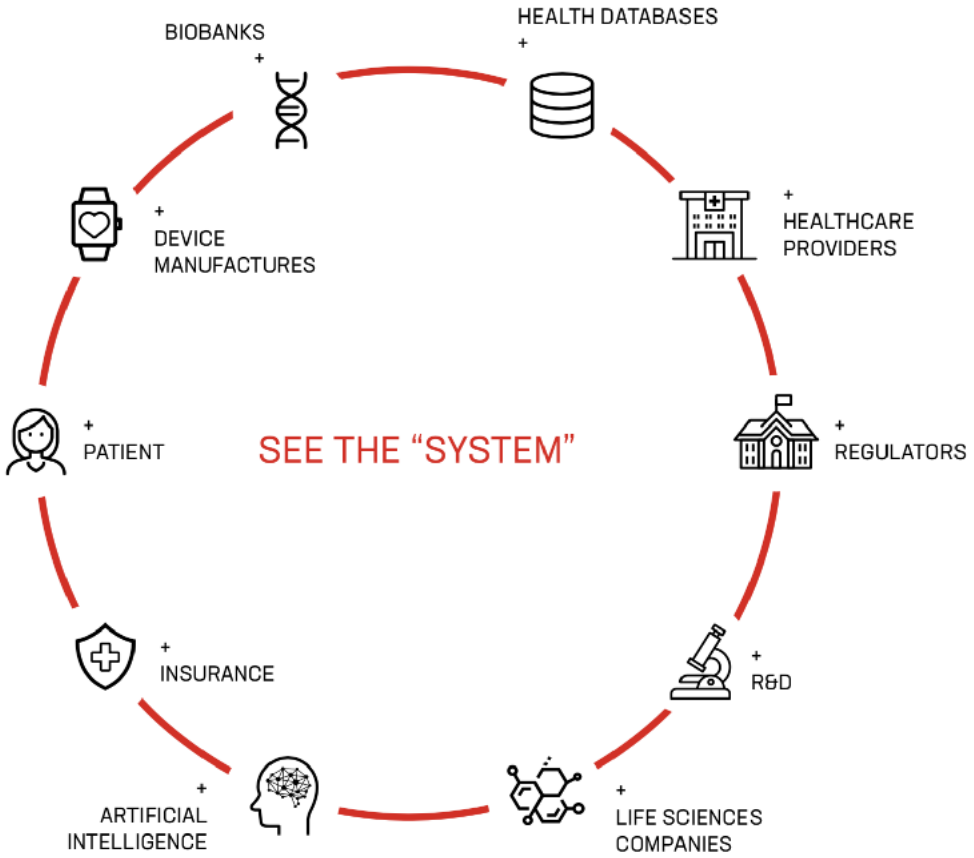
Other Supported Systems
+ Oracle Clinical Trials
+ Apple iHealth
+ Partner Smart Apps (Apple/Android)
+ Big Data Solutions

/DEPLOY

STANDARD APPLICATIONS
+ HELIUM (Data Access and Governance Manager)
+ Data Access for Outcomes Based Pricing
+ Dynamic Patient Consent Engine (GDPR)
+ Medicine Supply Alert
+ Secure Data & Process Integrator for Medication Adherence
+ Supply Chain Track and Trace
+ Complex Clinical Trial Data & Process Integrator
+ Smart Contracts

CUSTOM APPLICATIONS

MAKING DATA ACCESSIBLE
/ WITHOUT SHARING IF NOT NECESSARY



… REQUIRES FLEXIBLE APPROACH:

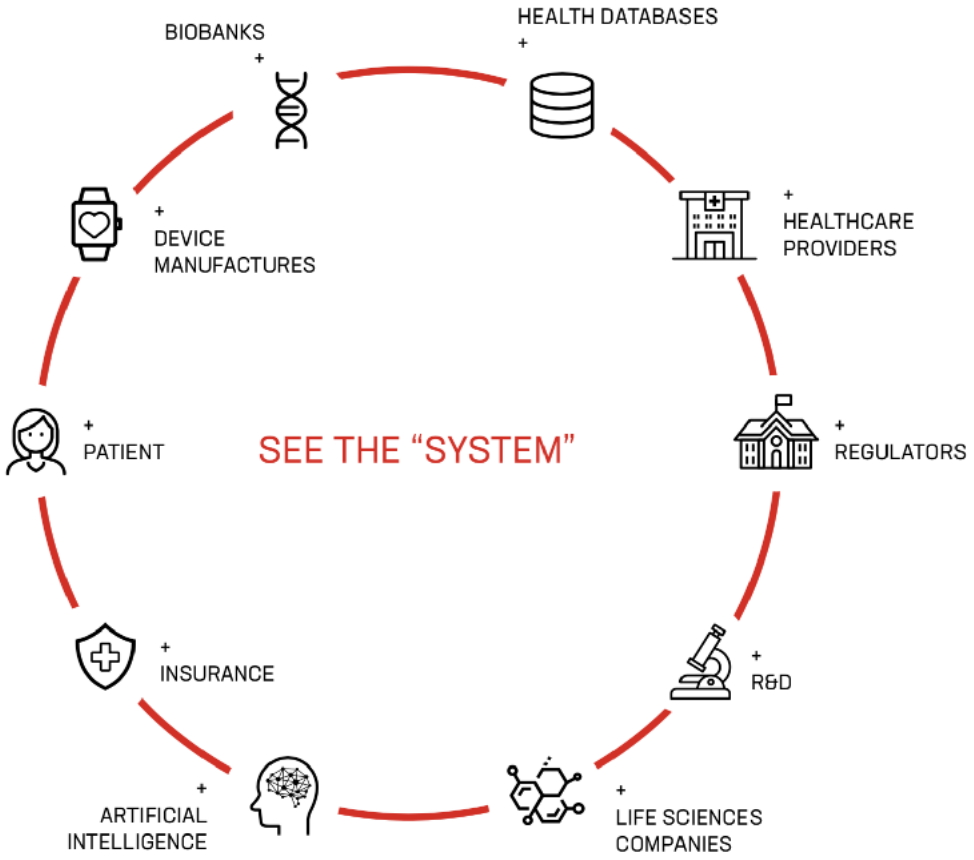
Data-liquidity (=data travels) for the exchange/sharing of personally identifiable health data and/or proprietary patient data. The cornerstone being patient consent.

Data-visibility (=data does not travel) describes the ability to provide aggregated or otherwise masked summaries of sensitive data without revealing any original data to outside parties.

Blockchain is used for immutable proof of what data came where and from, who* created it, who* used (or shared) it for what purpose – to guarantee its trustworthiness.

** Human or a machine/algorithm*

CONTROL OF DATA PROCESSING
/ ADJUSTED ACCORDING TO THE USE-CASE



… ENABLES VARIOUS PRODUCT OFFERINGS:

+ **HELIUM (Data Access and Governance Manager)** for transparent and auditable big data analytics
+ **Outcomes Based Pricing Data Access Manager** for privacy-protection
+ **Medicine Supply Alert** for predictive drug shortage management
+ **Secure Data and Pathway Integrator** for medication adherence support
+ **Complex Clinical Trial Data and Process Manager** for automated quality assurance and RWD access
+ **Supply Chain Track and Trace** for down- and upstream process accountability
+ **Dynamic Patient Consent Engine** for frictionless privacy management

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THE FUTURE

BLOCKCHAIN-BACKED DATA & PROCESS INTEGRITY ASSURANCE / ENABLES BOLD DIGITAL STRATEGY IMPLEMENTATION IN ESTONIA

1. Full cycle care continuity for chronic conditions - 2020
2. National quality assessment service for outcome based health system - 2021
3. Innovative integration of health and social care at the regional/community level - 2021
4. Clinical decision support systems for adaptive care pathways (including personalized medicine implementation) - 2020
5. Integration and sharing of personal medical data with 3rd party (non-medical) data services (including personal health record) - 2020
6. National data-as-a-service framework (1-stop-shop) for secondary use of health data for R&D&I – 2020/2021

The Brave New Healthcare

privacy-preserving fully integrated | powered by blockchain

+ real-time healthcare
+ value-based payment for services
+ data-driven personalised decision making
+ real-world evidence in life sciences
+ zero-bureaucracy: invisible services
+ frictionless data governance across borders

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THE LESSONS

Blockchain is useful for practical **problem** solving in the right **context**

SECURITY
/ COMBINATION OF SUITABLE TECHNOLOGIES

integrity

KSI blockchain

availability

secure transport

confidentiality

eID

BLOCKCHAIN IS USEFUL FOR
/ PRACTICAL PROBLEM SOLVING

BLOCKCHAIN™ IN HEALTHCARE TODAY

Real Blockchain Use Cases for Healthcare
Halamka, J. (2018)

Provide Proof of Work

Integrated & automated supply-chain / clinical workflows

Guarantee Data Integrity

Clinical quality & integrity
Financial integrity

Support preferred Economic Model

Outcome-based incentives

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THANK YOU!

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