



UNIVERSITY *of* NICOSIA

Session 11

Convergence of blockchain with other technologies

DFIN 511: Introduction to Digital Currencies

Objectives

- Understand the process of digital transformation
- Discuss how other exponential technologies will converge with blockchain, digital currencies and smart contracts to enable new types of applications
- Present the key characteristics of the Internet of Things (IoT) and Artificial Intelligence (AI)
- Consider how these technologies might interact with each other
- Provide application scenarios combining blockchain, AI and IoT

Agenda

1. Digital Transformation
2. The Internet of Things (IoT)
3. Artificial Intelligence (AI)
4. Convergence of blockchain with AI and IoT
5. Conclusions
6. Further Reading

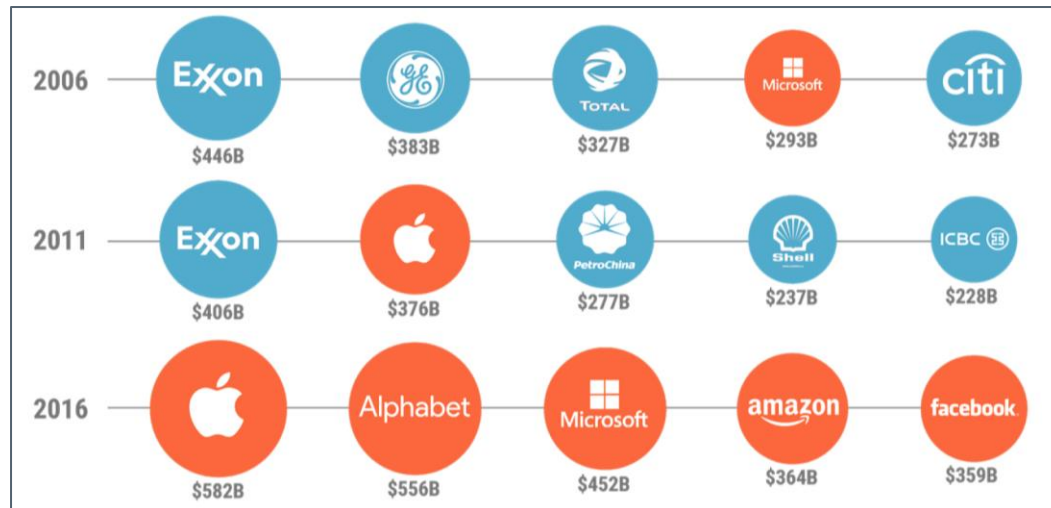
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1. Digital Transformation

Software is eating the world











World's largest public companies by market cap

2006 to 2011 to 2016



Source: Anand Sanwal, CBInsights, Gradually, then Suddenly in Financial Services, FoF conference, June 2018

December 2021

1		Apple AAPL	\$2.655 T
2		Microsoft MSFT	\$2.425 T
3		Alphabet (Google) GOOG	\$1.888 T
4		Saudi Aramco 2222.SR	\$1.872 T
5		Amazon AMZN	\$1.719 T
6		Tesla TSLA	\$1.019 T
7		Meta (Facebook) FB	\$853.55 B
8		NVIDIA NVDA	\$764.86 B
9		Berkshire Hathaway BRK-A	\$621.17 B
10		TSMC TSM	\$618.85 B

Source: <https://companiesmarketcap.com/>

Example: Goldman Sachs

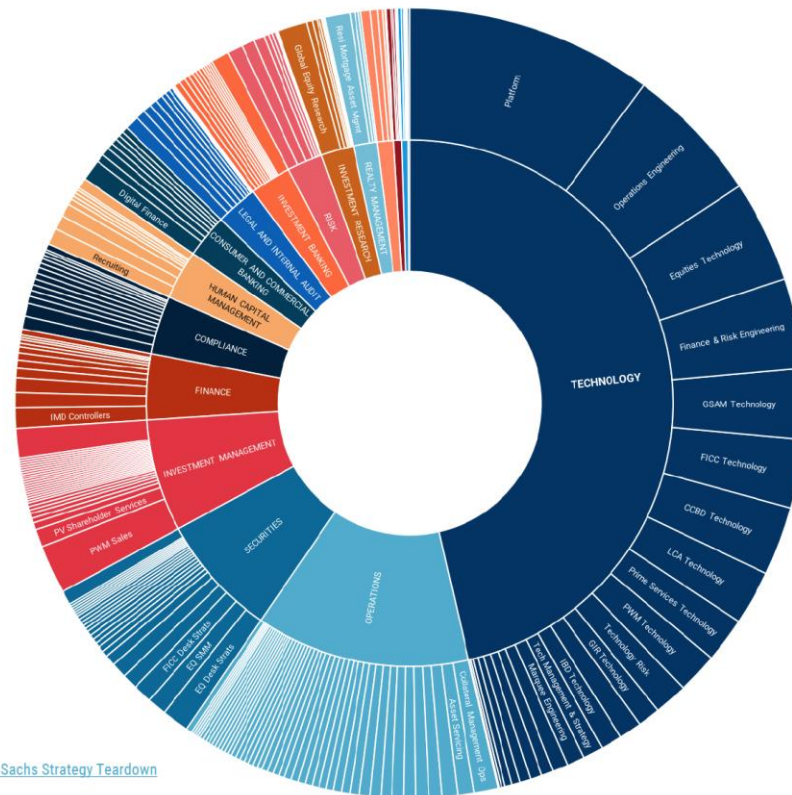
Today all companies are technology companies



Open job listings

Distribution of active job listings

CBINSIGHTS Source: CB Insights - [Goldman Sachs Strategy Teardown](#)



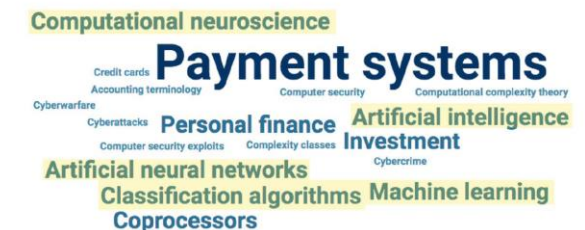
Goldman Sachs Patent Topics (Q1'15 - Q2'16)

Patent Portfolio Focus: Goldman Sachs



Goldman Sachs Patent Topics (Q1'17 - Q2'18)

Patent Portfolio Focus: Goldman Sachs



Source: Anand Sanwal, CBInsights, Gradually, then Suddenly in Financial Services, FoF conference, June 2018

Result: shifting competition

Nobody is staying in their lane anymore

- Imagine, say, Hertz in the early 2000s. Who were their competitors?
 - Other car rental companies (AVIS, Enterprise, etc.)
- Who were their competitors in the 2010s?
 - The above **PLUS technology companies** (Uber, Lyft, etc.)
- Result?

Date	Hertz market cap	Uber market cap	
June 2014	\$10B	\$17B	Uber's private valuation > Hertz's for the first time
Dec 2014	\$8.7B (-13%)	\$40B (+135%)	Just six months later, Uber is 5x Hertz
Dec 2019	\$2.2B (-75%)	\$53.2B(+33%)	By end 2019, Uber (public by now) is 24x Hertz
Hertz filed for bankruptcy protection in the US on May 23, 2020			
Uber is valued at \$69.55B today (06 Dec 2021)			

So, what does all this mean for the future?

#1: We are at a historical juncture

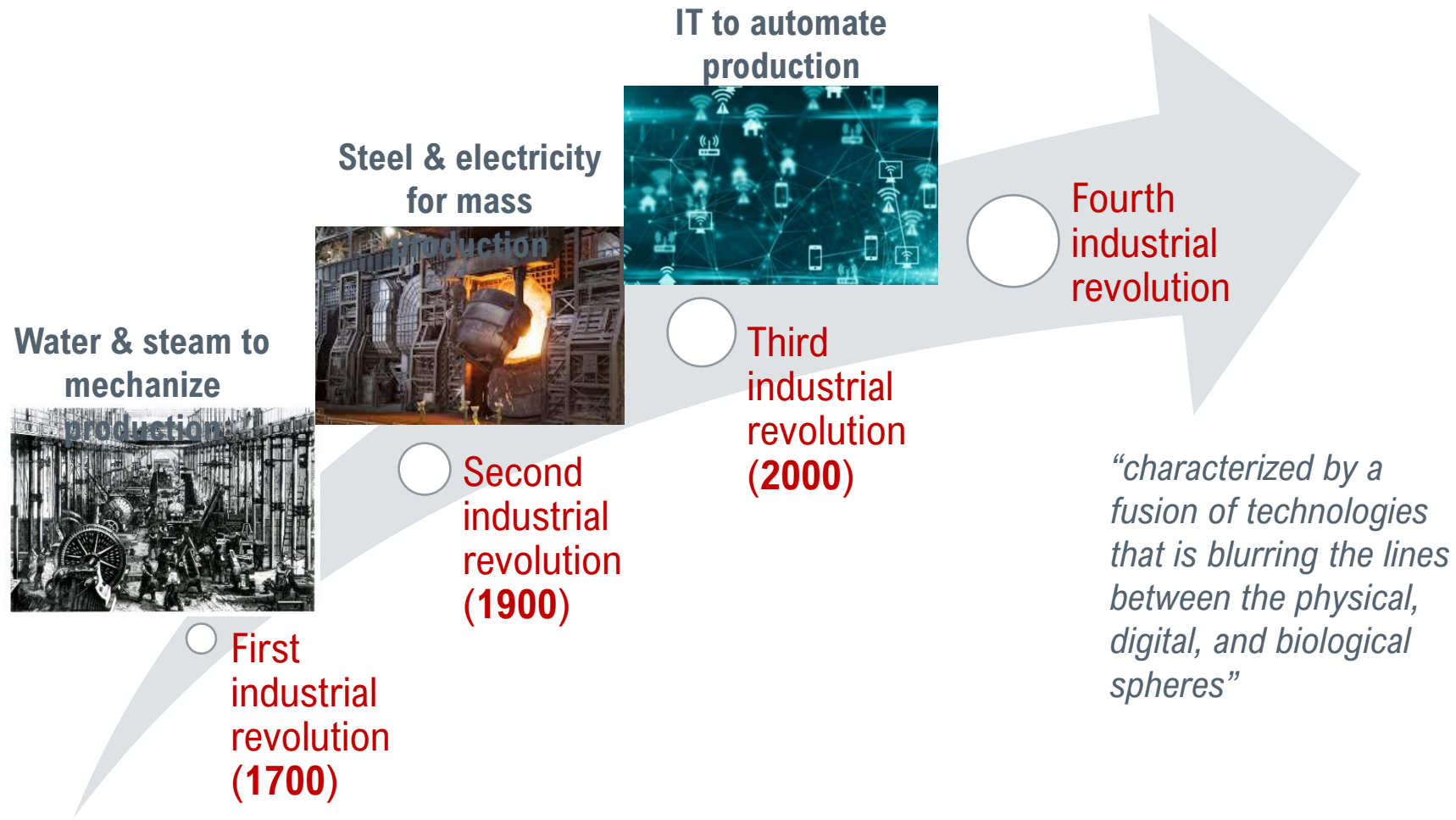
- 4th (industrial) revolution
- Singularity?

#2: Major trends: Decentralization & Machine Intelligence

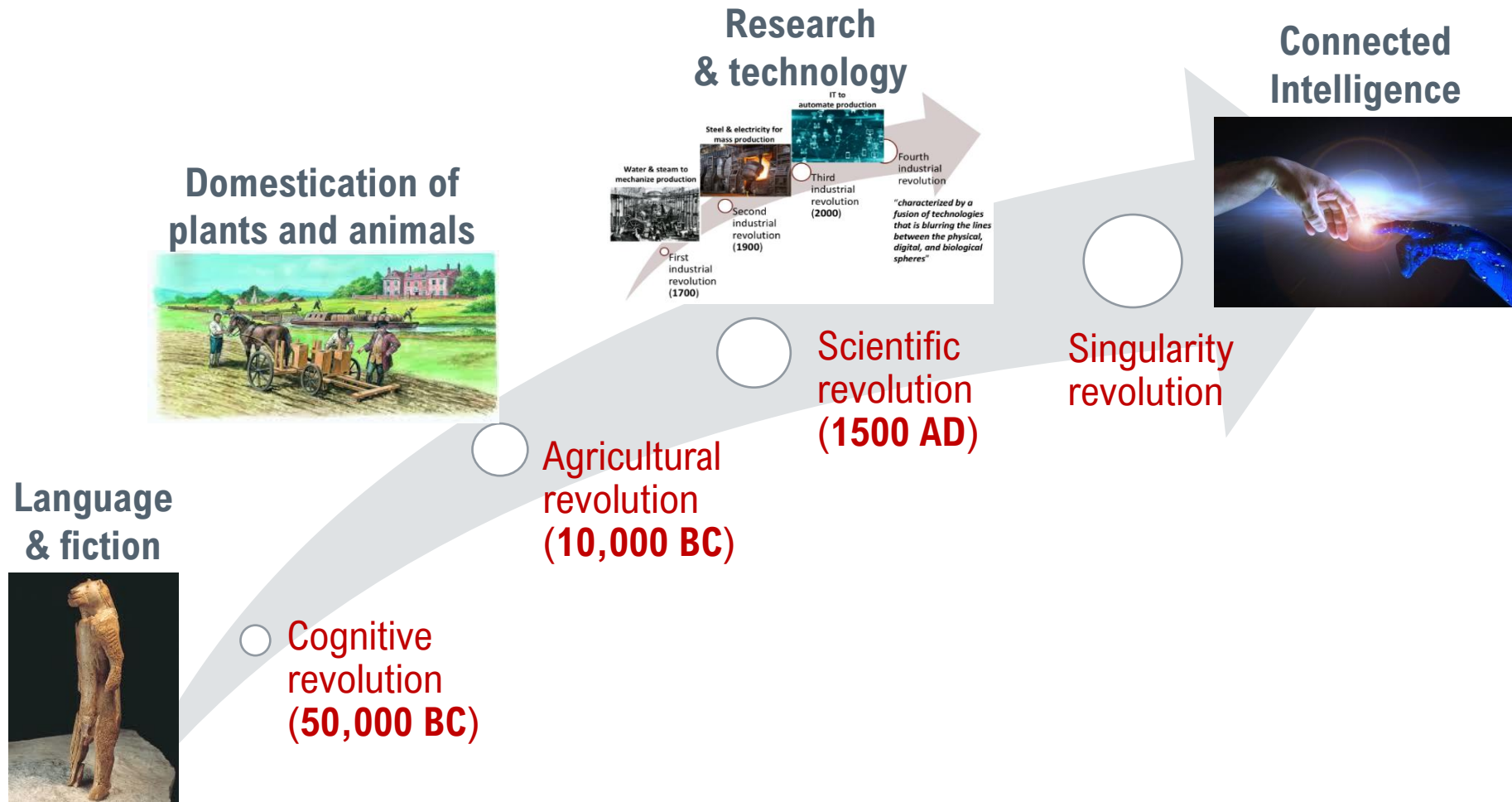
- From the Internet of information to the Internet of value
- M2M/H2M commerce
- New forms of corporations (code-only, autonomous)

#3: Implications for economic growth & social disruption

The 4th industrial revolution?



Or, the 4th human revolution?



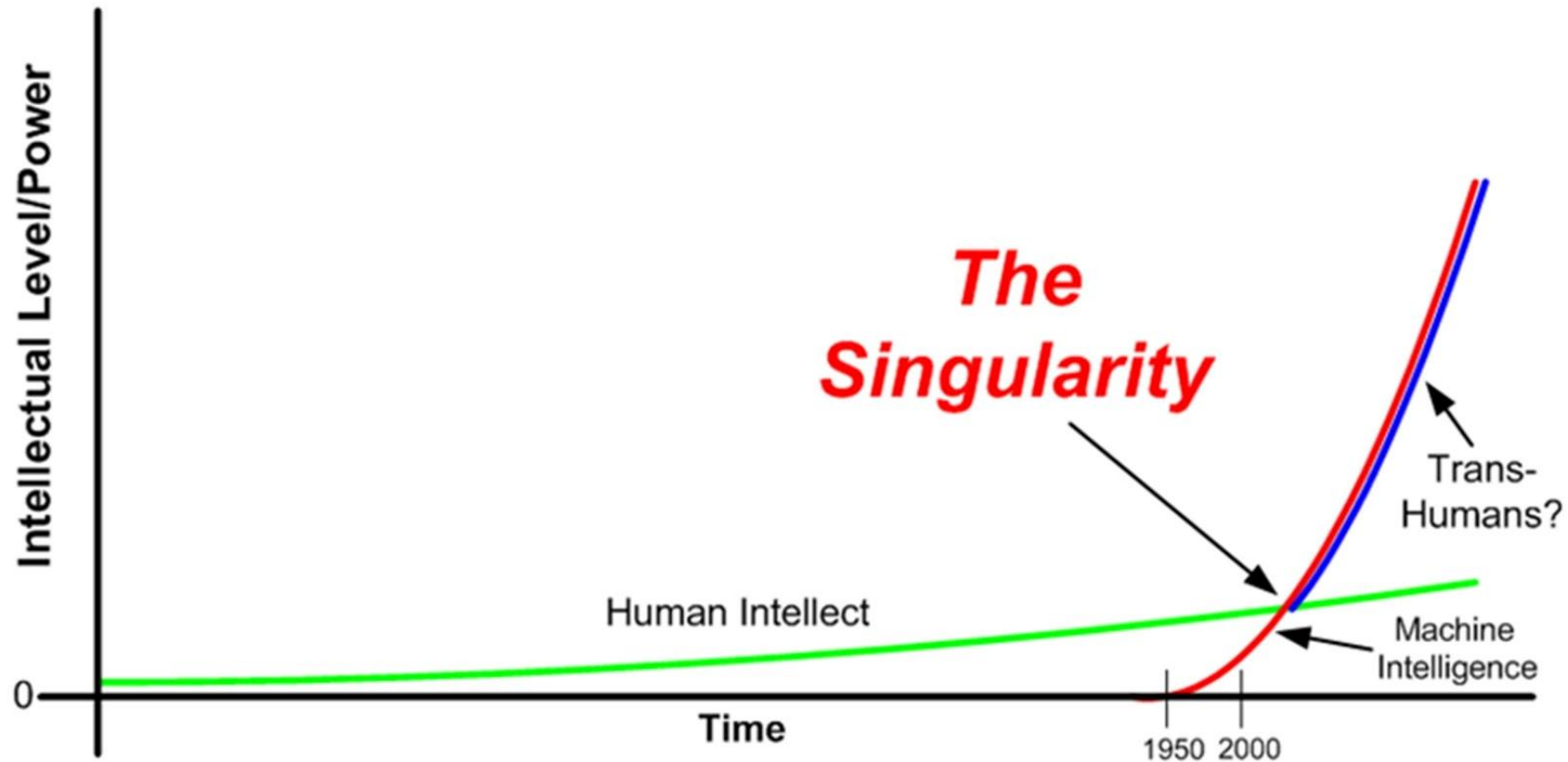
The 4 eras of humanity

Era	Started in	Characterized by	Resulted in	Power Shift to:
Cognitive	Africa	Cooperation between strangers	Rapid innovation of social behavior	Homo Sapiens
Agricultural	Middle East	Permanent settlements; First kingdoms	Vast population growth; Money; Religion	Kings and aristocrats
Scientific	Europe	Urbanization; Nation states; Corporations & markets	Globalization; Income growth	Capitalists
Singularity	North America	Emergence of a connected intelligence (human-machine symbiosis)	Anything from utopia to human extinction	Machines

Machines outsmarting humans

- **Artificial superintelligence will trigger runaway technological growth, resulting in unfathomable changes to human civilization.**
 - Upgradable intelligent agents will create accelerating self-improvement cycles, causing an **intelligence explosion**.
 - As superintelligence continues to upgrade itself, technology would advance at an incomprehensible rate.
 - At some point, **machines will be more intelligent than humans**.
 - **Singularity!** (we cannot predict the outcome)
- Consequences have been hotly debated:
 - Some (R. Kurzweil) claim that humanity **will transcend the limitations of the human body and brain**.
 - Others (S. Hawking, E. Musk) claim that the singularity could lead even to **human extinction**.

Artificial intelligence (AI) or intelligence augmentation (IA)?



Socioeconomic effects

Job creation, inequality and cohesion



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2. The Internet of Things (IoT)

Internet of Things (IoT)

IoT is a network of internet-connected physical devices

These devices are embedded with sensors, software and connectivity

- **Sensors** allow them to communicate with their environment
- **Software** allows them to process the information they receive
- **Connectivity** allows them to pass this information (or decisions based on it) to other devices over the internet

The original IoT vision was presented by Mark Weiser in [this](#) seminal paper from 1991



Internet of Things (IoT)

IoT is larger than IoH (Internet of Humans)!

- Most people do not realize just how many objects are (autonomously) connected to the internet
 - Cisco estimated that the size of IoT surpassed that of the human internet in 2008-2009
- Internet-connected devices:
 - 29.3 billion by 2023 (Cisco), 27.1 billion in 2021 up from 17.1B in 2016 and 22B in 2018 (Statista)
 - From small (smart dust) to large (e.g. an airplane)
- First **M:1** information technology in history?
 - Computers **1:M** (one machine per many people)
 - Smartphones **1:1** (one machine per person)
 - Sensors **M:1** (many machines per person)
 - Globally, M2M modules will account for 51% (13.7 billion) of all networked devices in 2021, compared to 34% (5.8 billion) in 2016 (Cisco)

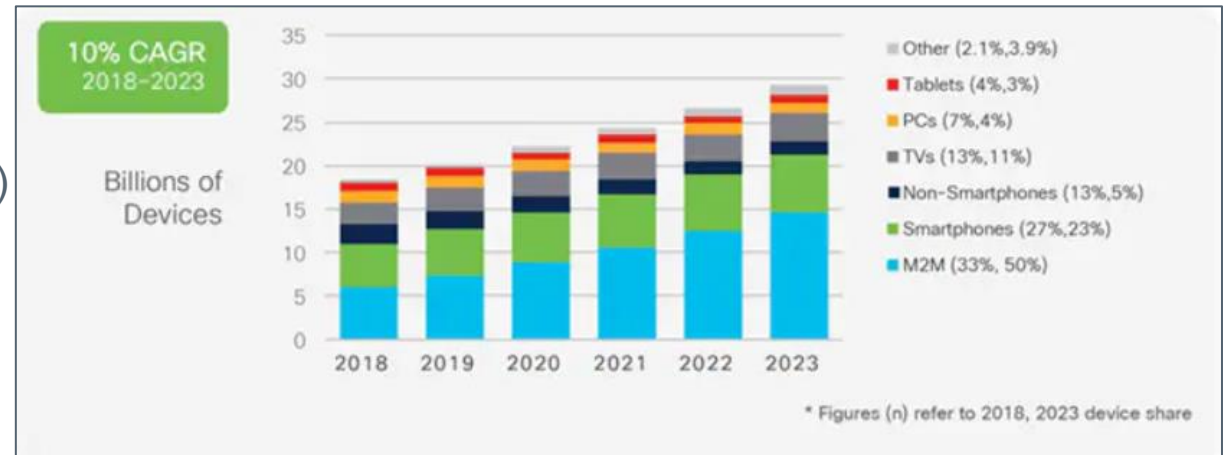


Figure: <https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html>

Indicative IoT applications

- **Consumer**

- **Smart home:** home automation hubs & smart appliances for lighting, air conditioning, security systems, etc. Remote management by mobile apps or wearable devices.
- **Wearables:** fashion technology, activity trackers & *smartware* applications to collect, analyse and transmit information related to body signals. Applications of so-called *epidermal electronics* range from health/activity monitoring (*lifelogging*) to gaming, professional sports and military.
- **Connected health:** remote monitoring for those in need, emergency notification systems, real-time health analytics.

- **Enterprise**

- **Transportation:** integrated control and communications of complex systems, combining vehicles, infrastructure and the end users (*V2X communications*). IoT is the first step to autonomous driving.
- **Building automation:** Internet integration of building energy management systems, smart grids, etc.
- **Manufacturing:** Digital control systems for equipment & assets, predictive maintenance, plant optimization, etc.
- **Agriculture:** Environment monitoring (temperature, humidity, soil content, pest infestation), precision fertilization, etc.

IoT issues and challenges

- **Security and privacy**

- IoT devices can remain invisible, while collecting sensitive data about us, like eavesdropping on our discussions or tracking our location.
- Most IoT devices exchange unencrypted data and cannot, by definition, run complicated security algorithms or be remotely upgraded/patched.

- **Internet's next major vulnerability?**

- Hackers are increasingly targeting IoT devices (e.g. webcams or voice assistants) more than full-blown computing systems (read about the infamous Mirai IoT botnet [here](#)).
- Further to an [enterprise security](#) threat, IoT may also be a major factor in future [cyberwars](#)

- **IoT and big data**

- Billions of devices generate unprecedented volumes of real-time data
- Analytics will be a big thing in the IoT world, especially when combined with artificial intelligence: read how [Google has delegated full decision making about its data centres cooling to an AI](#)

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3. Artificial Intelligence (AI)

Can computers be ‘intelligent’?

- AI is about machines performing tasks normally requiring human intelligence
 - Visual perception, natural language processing, complex decision making (automated reasoning), artificial creativity, etc.
- “*AI is whatever hasn’t been done by computers yet*” (Larry Tesler’s Theorem)
 - When AI solves a problem, it stops being considered AI and becomes part of everyday computing
 - So, in 1998, playing chess and optical character recognition were considered AI applications
 - Now, AI is more about autonomous robots and self-driving vehicles
 - In a few years time, these applications might not be considered AI anymore
- AI is crossing into our everyday lives:
 - Face recognition, digital assistants, language translation and other applications on our mobile phones
 - New computer interfaces (e.g. non-invasive brain-machine interfaces)

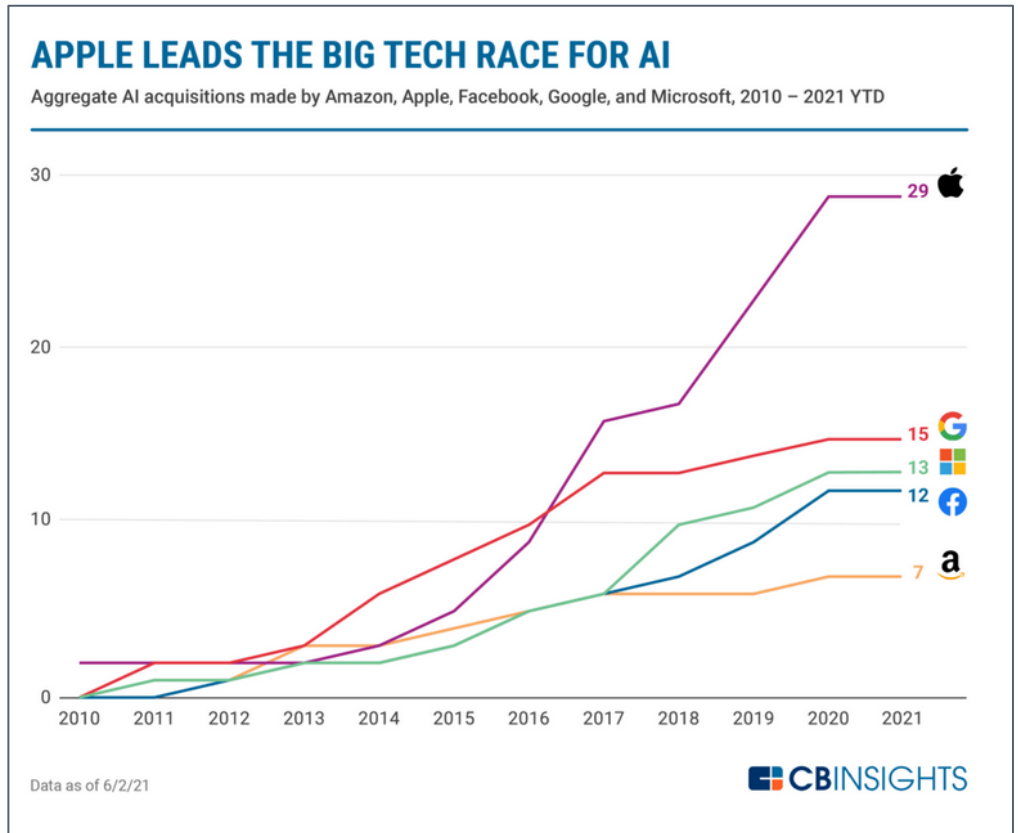
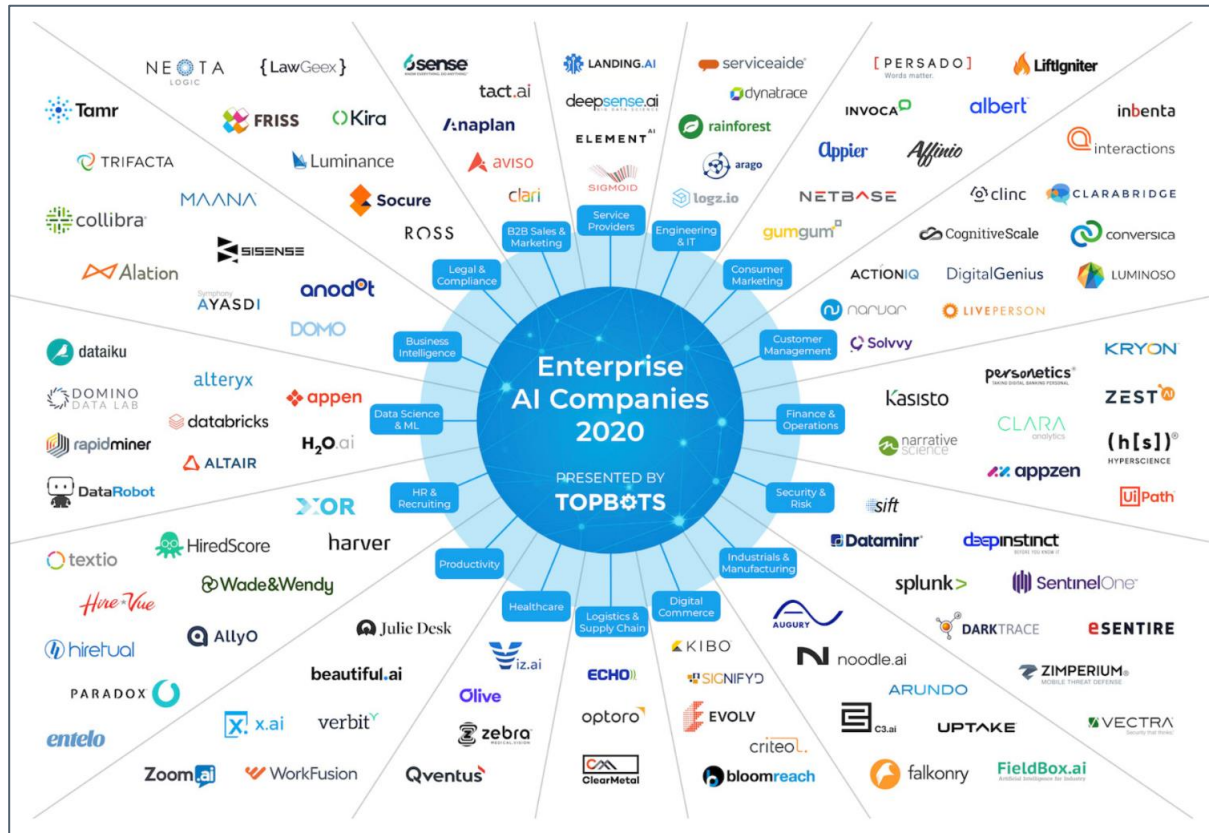
Stages of AI

- **Artificial Narrow Intelligence (ANI)**
 - Also known as Weak AI
 - Machines can perform a narrow set of specific tasks (e.g. play chess, sustain a dialogue with a human, identify faces in a picture, etc.)
 - **Machine learning** can be based on rules (*reactive AI*) or examples (*limited memory AI*)
 - Today's AI is ANI
- **Artificial General Intelligence (AGI)**
 - Also known as Strong AI
 - Machines possess human-like abilities to think and make decisions (*theory of mind AI*, *self-aware AI*)
 - In AGI, machines will be able to keep on learning by experience and develop their intelligence, much like humans do (but, presumably, faster and deeper)
- **Artificial Super Intelligence (ASI)**
 - This is just a hypothesis at this stage: machines with AGI might one day reach a stage where they are collectively (much) smarter than humans
 - Singularity

Source: <https://www.edureka.co/blog/types-of-artificial-intelligence/>

Artificial Intelligence (AI)

A fast growing area capturing the interest of tech giants



Source: <https://www.topbots.com/enterprise-ai-companies-2020/>

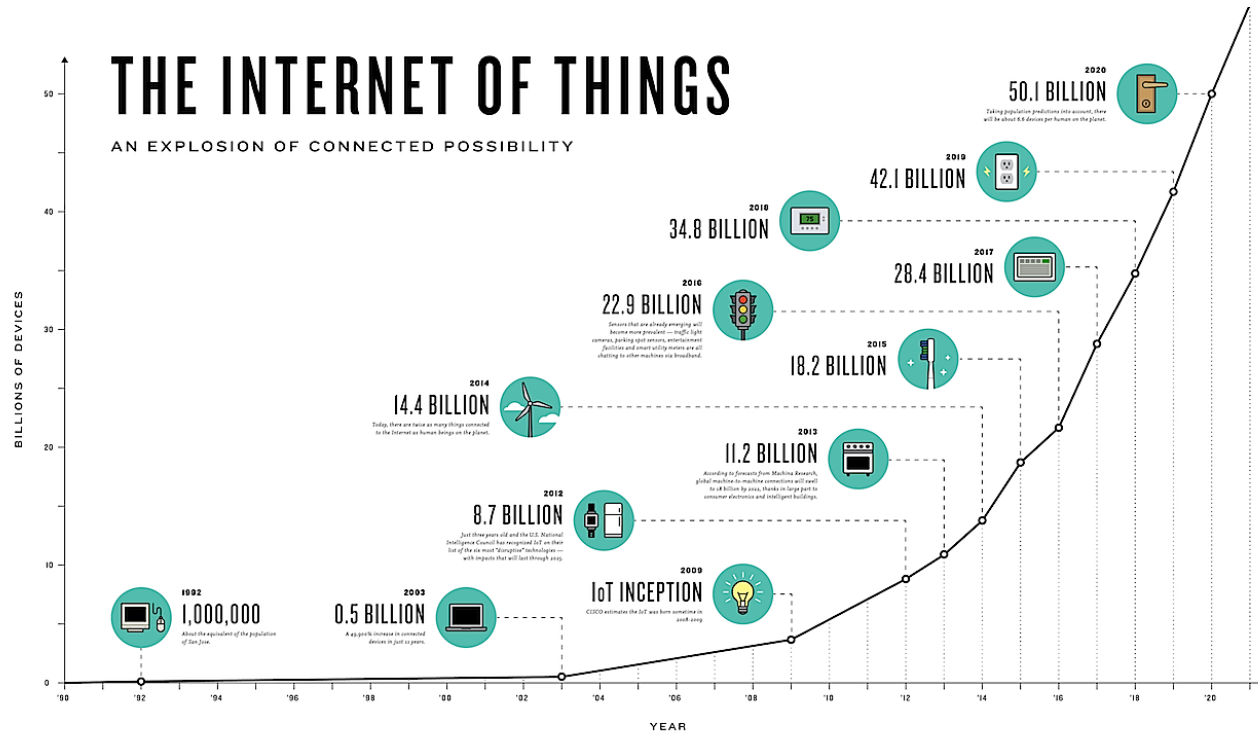
Source: <https://www.cbinsights.com/research/report/top-acquirers-artificial-intelligence/>

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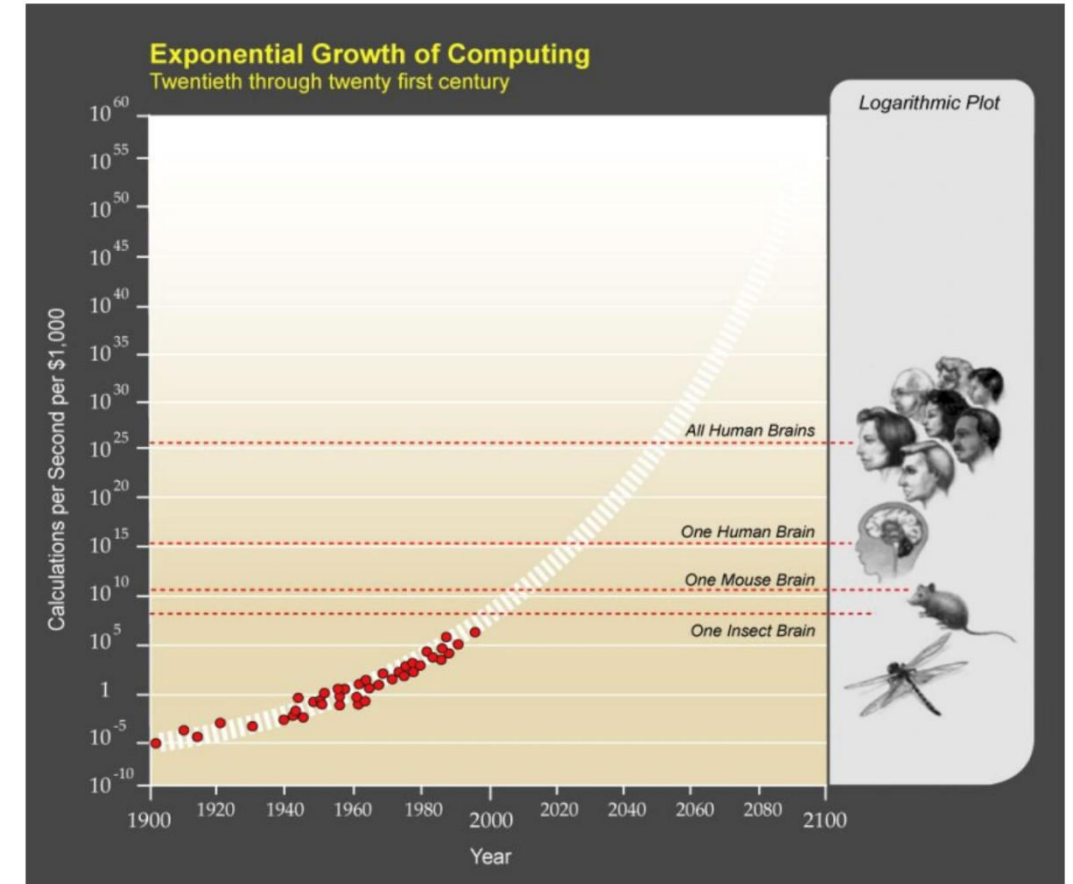
4. Convergence of blockchain with AI and IoT

Exponential technologies

IoT and AI are growing exponentially



Source: <https://www.ncta.com/whats-new/infographic-the-growth-of-the-internet-of-things>



Source: <https://medium.com/@reevesastronomy/is-current-progress-in-artificial-intelligence-exponential-8e18f126d2cb> (originally from Ray Kurzweil's *The Singularity is near*)

A future of transacting intelligent machines

- Individually, each of these technologies deserves all the attention they're getting as enablers and disruptors
- But, taken together?
- Their transformative effect becomes multiplicative
- **A future driven by machine connectivity, data exchange and commercial services:**
 - **IoT** connects billions of machines and sensors generate unprecedented quantities of real-time data
 - **AI** enables the machines to act on data and trigger services
 - **Blockchain** functions are the transaction layer where data and service contracts are securely stored and payments for services are settled

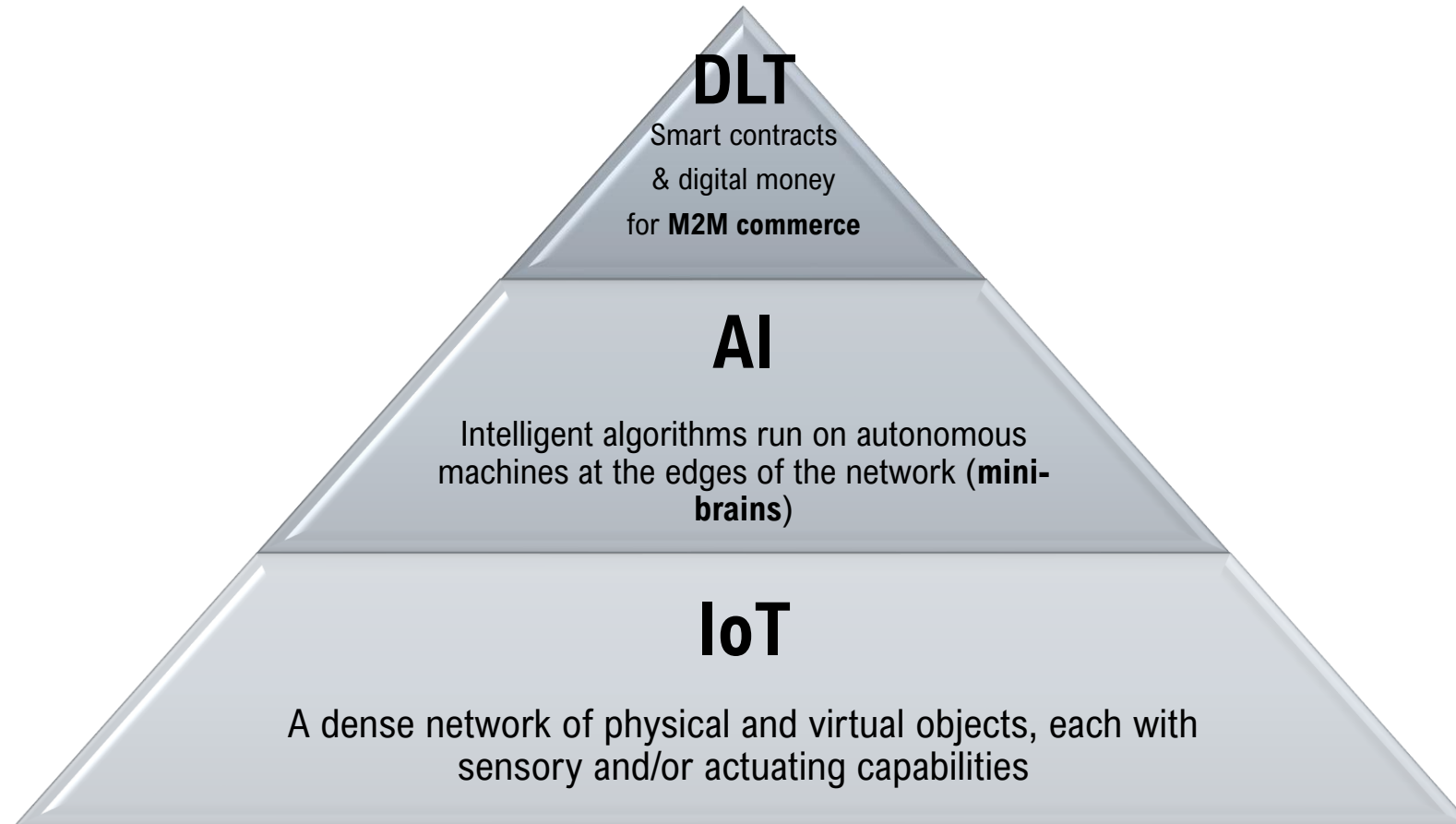
How does blockchain support intelligent connected machines?

- **Smart Contracts** enable self-executing and self-enforcing contractual states
 - Custom financial instruments (tokens), records of ownership of an underlying physical asset (smart property), any complex business logic that can be programmable
 - Can such applications be ideal for intelligent (AI) and connected (IoT) machines?
 - These machines are intelligent enough to negotiate contracts, but need a technology allowing them to securely sign and enforce them
- **Digital currencies** create new forms of money
 - Programmable and active
 - Will such money be ideal for intelligent (AI) and connected (IoT) machines?
 - These machines will need digital currency to pay for services assigned through the smart contracts

How will the three technologies work together?

- **IoT:**
 - **Sensors** allow us to cost-effectively gather tremendous amounts of data
 - **Connectivity** allows us to transmit/broadcast these data.
 - But, there is a missing element: **intelligence** to process these data
- **AI:**
 - Intelligence at the very edges of the network (**mini-brains**)
 - **Combine with IoT** and you have the ability to recognize meaningful patterns buried in mountains of data in ways that would be impossible for most humans, or even non-AI algorithms, to do.
 - But, there is a missing element: a **secure storage** layer for data and a **transaction layer** for services
- **DLT (blockchain):**
 - Decentralized governance, coupled with no single point of failure, disintermediation, unalterable and searchable records of events
 - Digital currencies and tokenized custom financial instruments
 - **Combine with AI and IoT** and you have a new world of autonomous systems interacting with each other, procuring services from each other and settling transactions

The technology stack of the future



Toward a world of machine commerce

Crypto: New forms of money

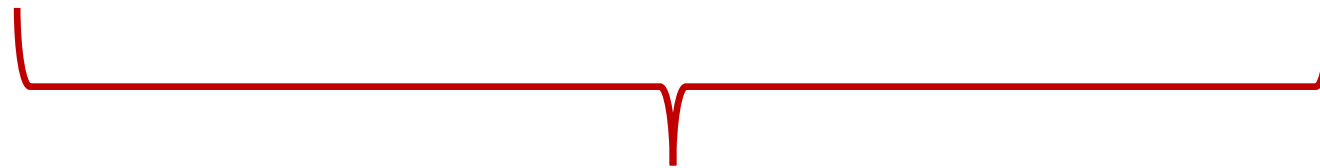
Programmable & active

Money for machines?

DLT: Internet of trust

Alone: Remove middlemen

With AI/IoT: Remove men?



Consequences

Autonomous, AI-based, economic agents

Human-to-machine (H2M) and machine-to-machine (M2M) commerce

M2M will need SSI (self-sovereign identities) – for objects!

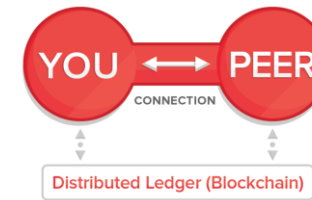
- Human identities can be of many types



Traditional (siloed)



Third-party IDPs



Self-sovereign (SSI)

- Object identities can be SSI by default
 - Multi-source, multi-verifier
 - Digitally signed, verifiable credentials that can prove issuer, holder and status
 - Secure peer-to-peer connections (permanent or session-based)
 - Exchange full credentials, partial credentials or ZKPs derived from credentials

Next milestone: Decentralized Organizations (DOs)

- DOs are good at:
 - Coordinating resources that do not know/trust each other (including hybrid H/M)
 - Governing in a geography-agnostic, censorship-resistant manner
 - Enabling short-term or informal organizational structures (networks/communities)
 - Tracking and rewarding contribution
- Challenges
 - Jurisdictional issues
 - Legislating new types of work for humans and work rules for machines
 - Governance modalities, including external supervision



Challenges

- **New/upgraded system architectures**
 - From legacy to blockchain/AI/IoT-native systems
 - Integration, **interoperability**, backward compatibility
 - ROI obvious ex post, difficult ex ante – **Bootstrapping**
- **Advanced analytics capabilities**
 - As devices at the edge become smarter, the smart contracts enabled by blockchain platforms will require more advanced data analytics capabilities and gateways to the physical world
- **New business models**
 - **Disruptive innovation** will dominate – but not without boom-and-bust cycles and big failures along the way
 - **Winners will NOT be the ones focusing on efficiency gains, but on disruptive models**

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5. Conclusions

Key takeaways

- IoT, AI and DLT (blockchain) are foundational and exponentially growing technologies
 - When combined, they will create a new internet of connected, intelligent and commercially transacting machines
 - An era **machine-to-machine (M2M) and human-to-machine (H2M) commerce** is likely to emerge, with profound consequences on social and economic dynamics
 - **New forms of corporations or organizational formats** (code-only, autonomous) will emerge
- There are numerous challenges that must be overcome
 - IoT has outpaced the human internet, but is still a largely passive, insecure and privacy-vulnerable network
 - AI has made huge leaps, but still requires immense computational resources and is largely incompatible with edge computing
 - DLT is a new technology, largely untested at scale; both smart contracts and digital assets lack the regulatory clarity required for mass adoption

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6. Further Reading

Further Reading - Papers

- [Blockchain, IoT and AI: A perfect fit](#), Riccarda Joas, Jonas Gross, Philipp Sandner (2020)
- [Transformative effects of IoT, Blockchain and Artificial Intelligence on cloud computing: Evolution, vision, trends and open challenges](#), Sukhpal Singh Gill *et al.* (2019)
- Leveraging the Internet of Things and Blockchain Technology in Supply Chain Management, Abderahman Rejeb *et al.* (2019)
- [Transformational Technologies Today: How IoT, AI, and blockchain will revolutionize business](#), Oracle Corporation (2018)



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Questions?

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