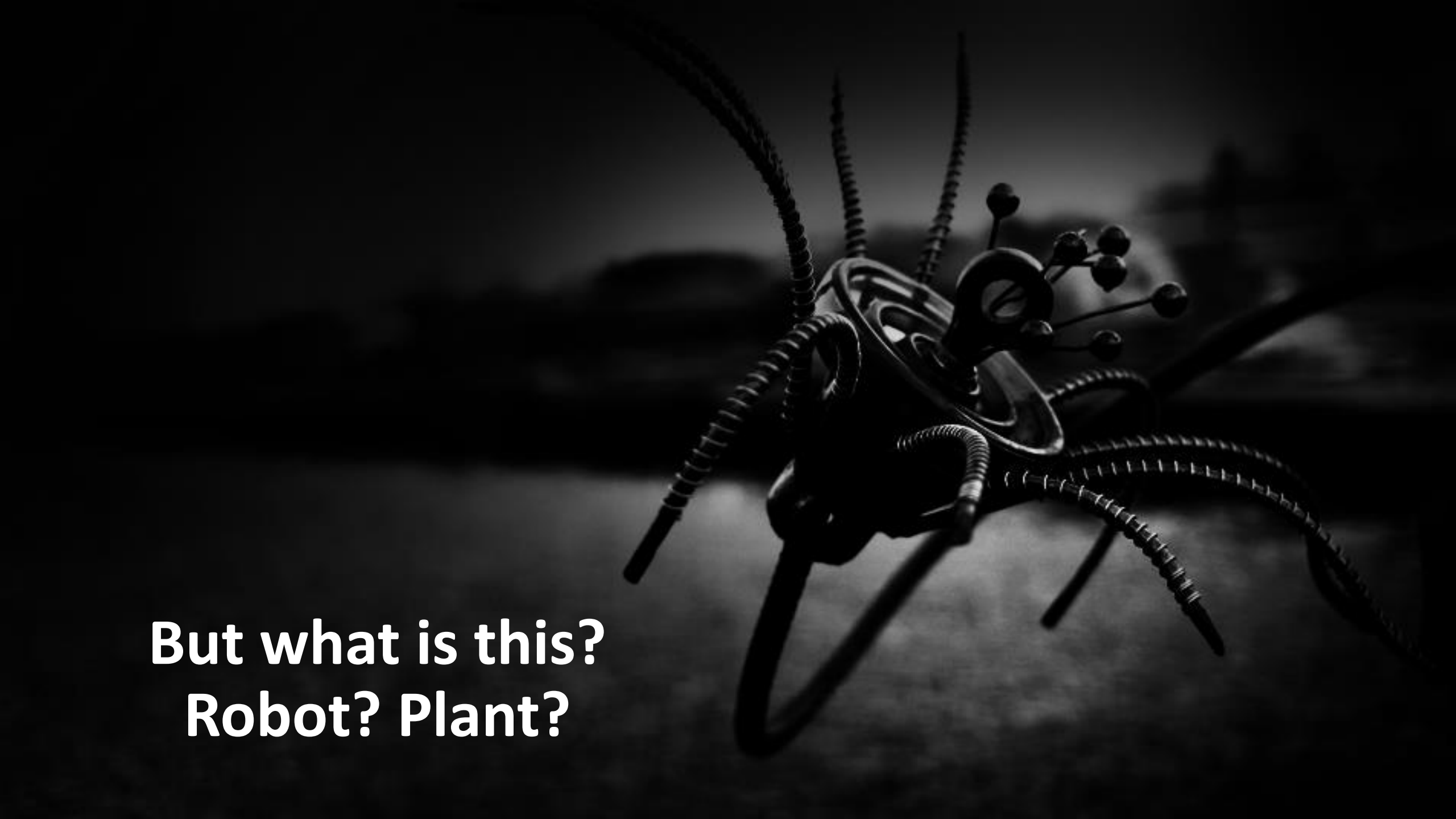
Tokens, Complex Systems, and Nature

Trent McConaghy
@trentmc0
Ocean | BigchainDB

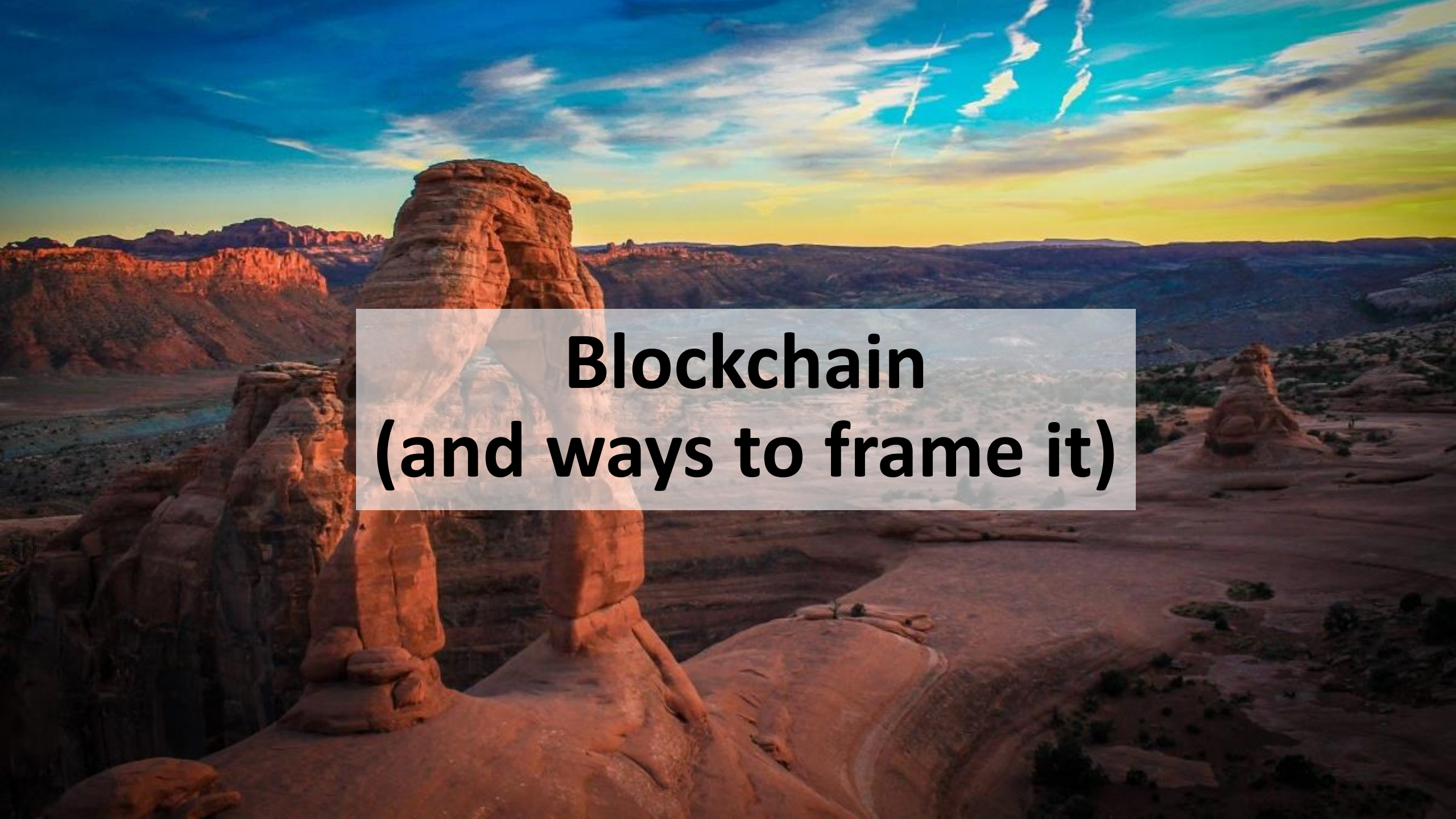
On the internet, no one knows you’re a dog(e)

On the internet of *things*, nobody knows you're a toaster


But what is this?
Robot? Plant?

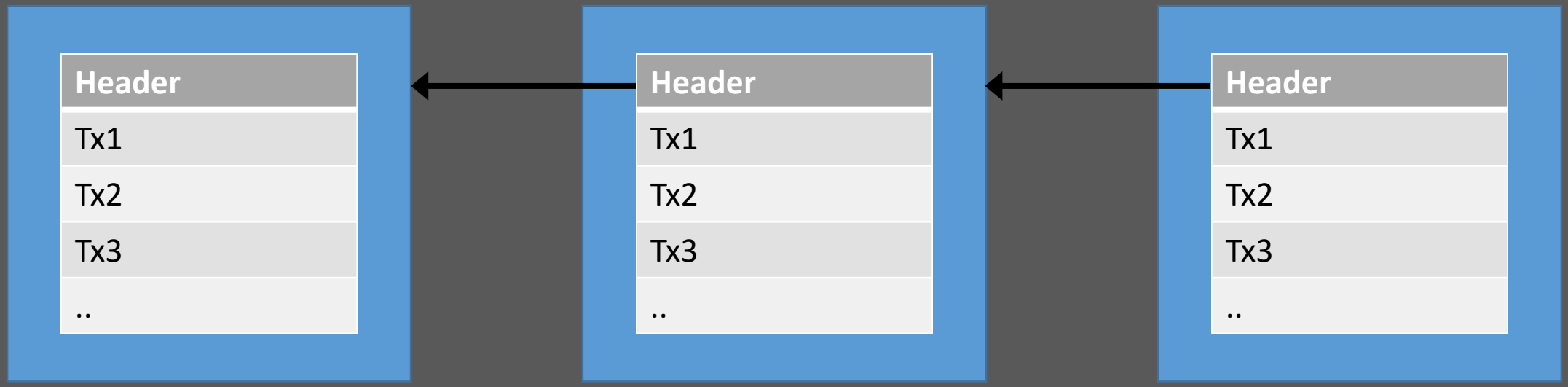

What do you call
a forest that
owns itself?

Can a wind farm own itself? How?


Blockchain
(and ways to frame it)

“A Chain of Blocks”

-Block = list of transactions, where tx = “create asset” or “transfer asset” action, digitally signed
-Chain = linked list, where links are hashes



“Database with blue ocean benefits”

- Decentralized
- Immutable
- Assets

“Emerging Decentralized Stack”

STORAGE	PROCESSING	COMMUNICATIONS
FILE SYSTEM IPFS/FileCoin, Swarm	BIZ LOGIC Ethereum, Dfinity	DATA TCP/IP
DATABASE BigchainDB, OrbitDB	HIGH PERF. COMPUTE TrueBit, Golem, iExec	VALUE Interledger, Cosmos
STORE OF VALUE Bitcoin, zcash		STATE PolkaDot

"Trust machine" because it **minimizes trust** needed to operate.

It's more *socially scalable*. (Ref Szabos)

“Incentive Machine”

Get people to do stuff
By rewarding with tokens

Bitcoin incentivizes security = hash rate = electricity

Result: > USA by mid 2019!


“Public Utility Network”
Self-sustaining, anti-fragile

“DAO: Decentralized Autonomous Organization”

A computational process that

- runs autonomously,
- on decentralized infrastructure,
- with resource manipulation.

It’s code that can *own* stuff!

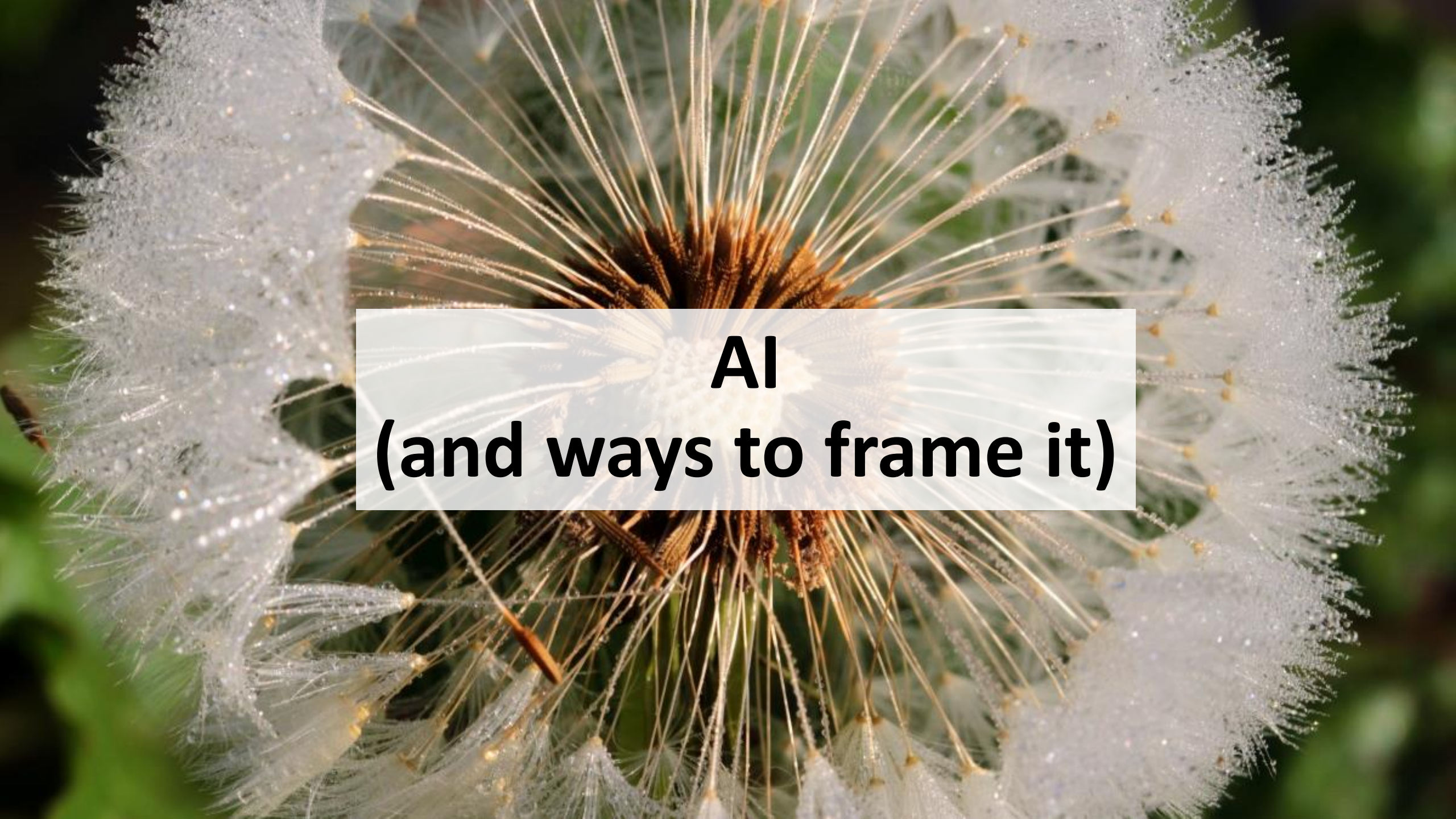
Aka “good computer virus”

“Life Form”

“Bitcoin is the first example of a new form of life.”

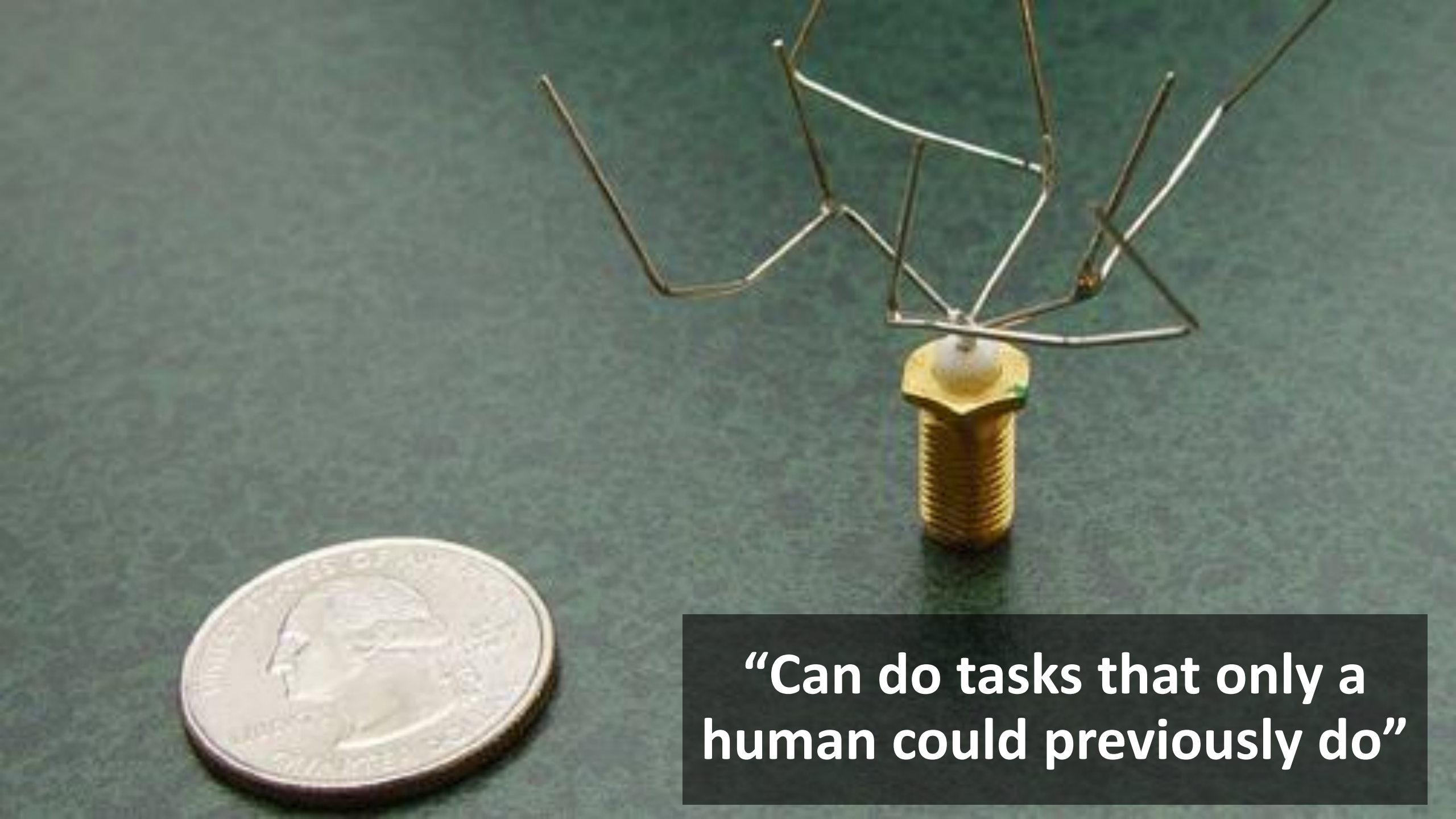
“It lives and breathes on the internet. It lives because it can pay people to keep it alive. It lives because it performs a useful service that people will pay it to perform. … It can’t be stopped. It can’t even be interrupted. If nuclear war destroyed half of our planet, it would continue to live, uncorrupted.”

-Ralph Merkle

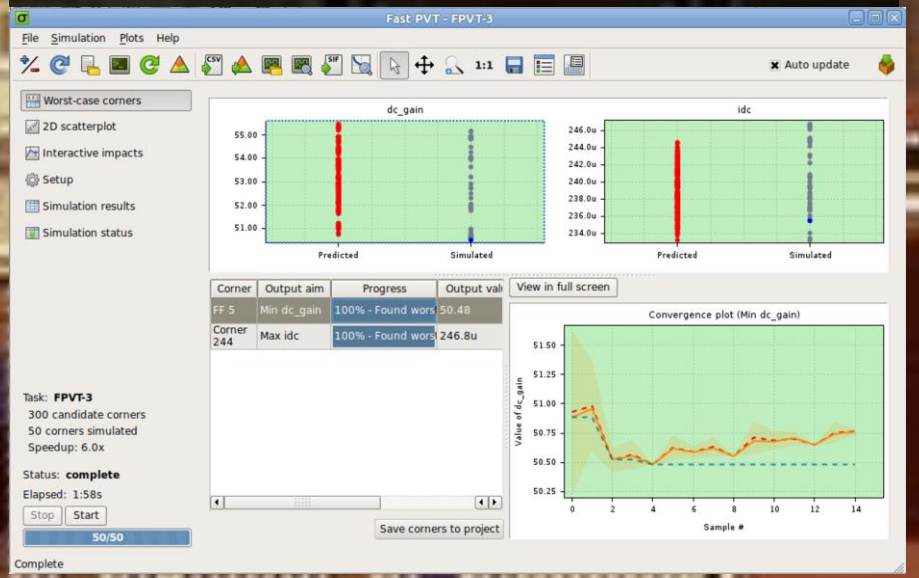


AI
(and ways to frame it)

“Replicates human cognitive behavior” [Turing test]

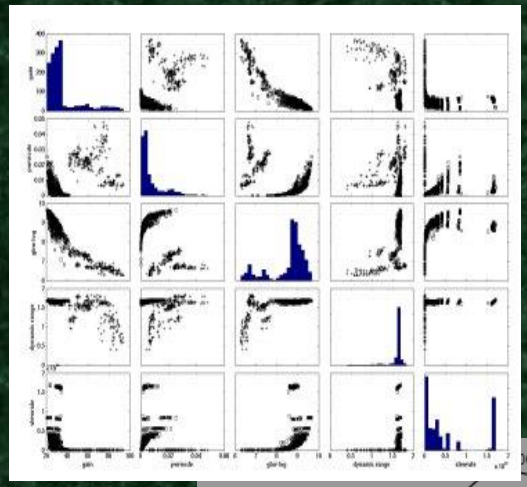

“Can do tasks that only a human could previously do”

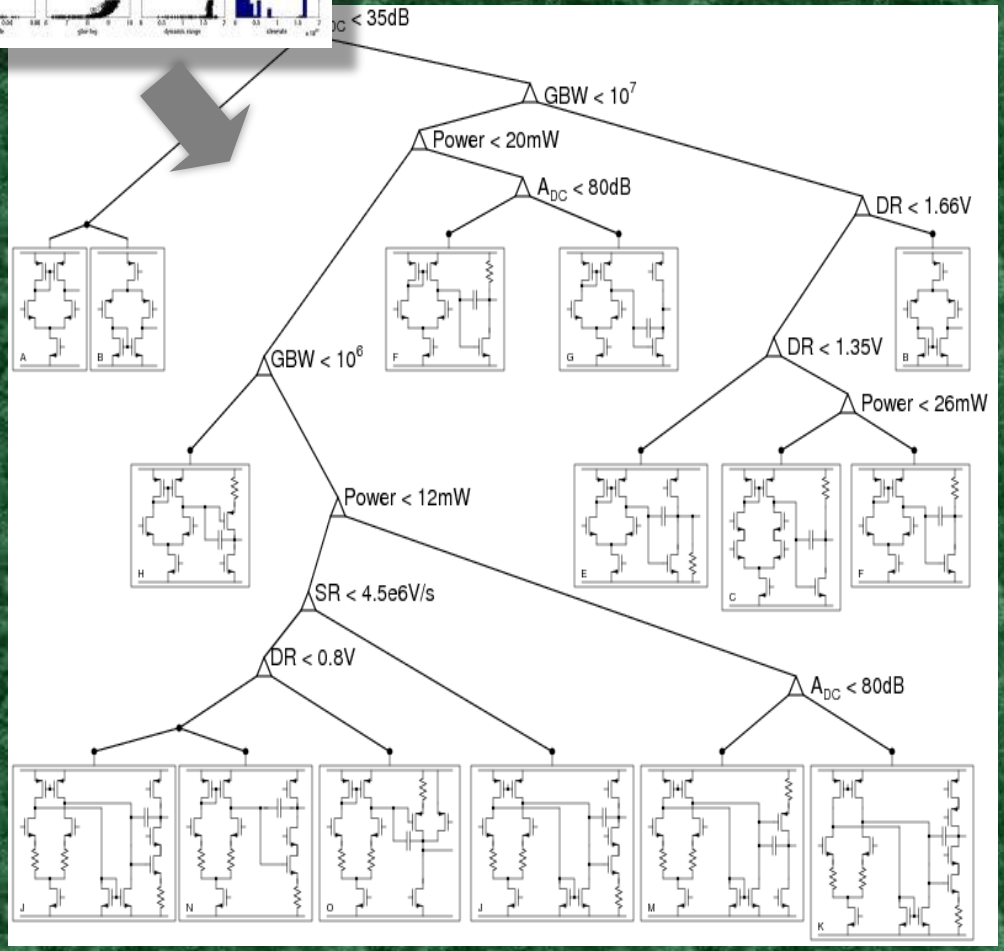
“Can do a task at speed/ accuracy/ capacity not possible by a human.”



“A set of tools”
“Sufficiently a mystery, Not yet a *technology*”

- Classification
- Regression
- Knowledge extraction
- Optimization
- Creative / Structural design
- …

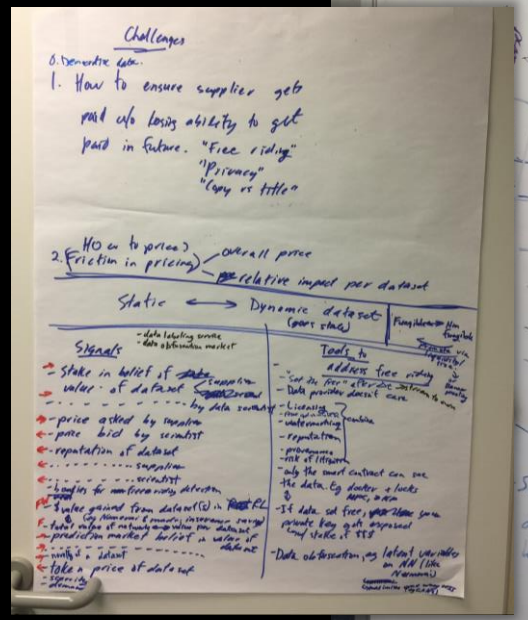


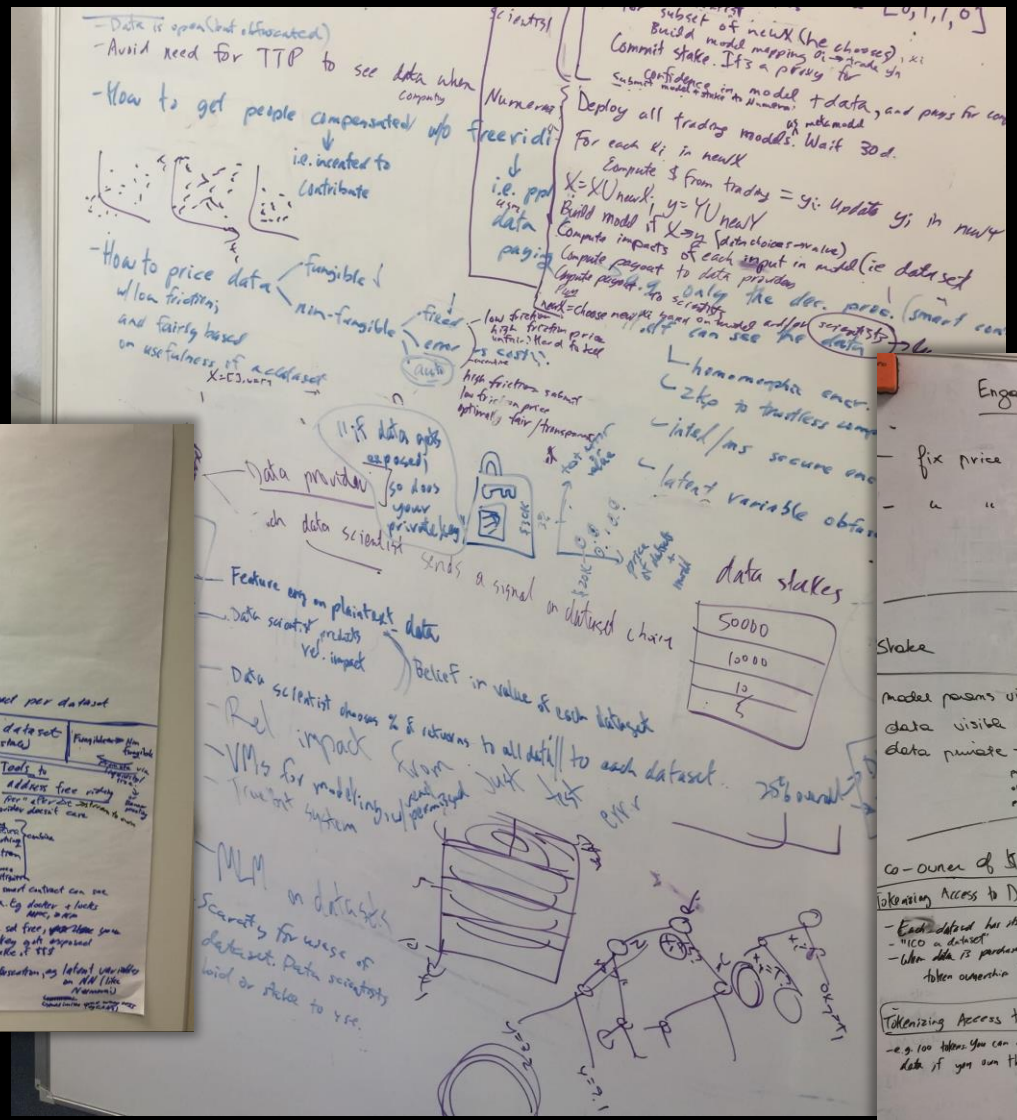


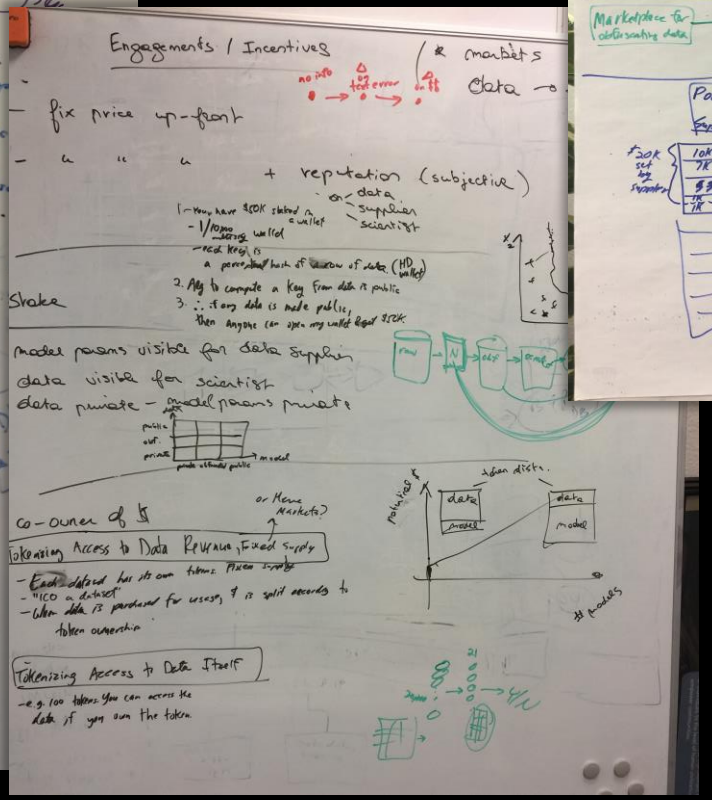

“Embodied agents” (AGI)

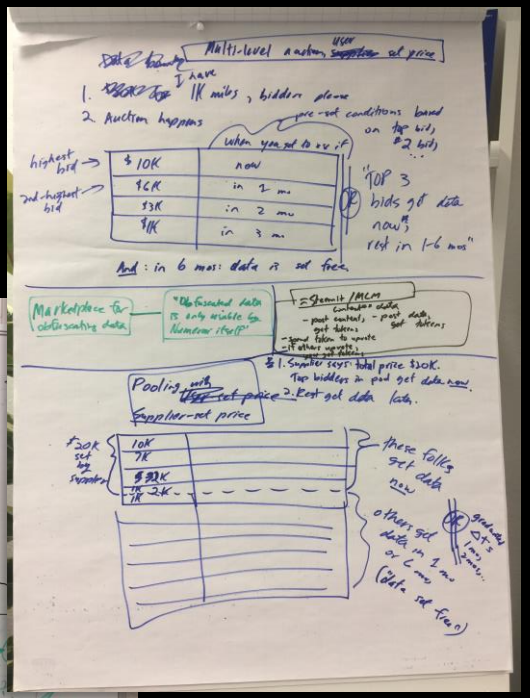

Evolutionary Algorithms
& Token Design

Token design is *hard*. Easy to flail. Easy to fail.









Realization: Tokenized Ecosystems Are a Lot Like Evolutionary Algorithms!

What	Tokenized ecosystem	Evolutionary Algorithm
Goals	Block reward function E.g. “Maximize hash rate”	Objective function E.g. “Minimize error”
Measurement & test	Proof E.g. “Proof of Work”	Evaluate fitness E.g. “Simulate circuit”
System agents	Miners & token holders (humans) In a network	Individuals (computer agents) In a population
System clock	Block reward interval	Generation
Incentives & Disincentives	You can’t control human, Just reward: give tokens And punish: slash stake	You can’t control individual, Just reward: reproduce And punish: kill

We can approach token design as EA design.

Steps in EA Design

1. **Formulate the problem.** Objectives, constraints, design space.
2. **Try an existing EA solver.** If needed, try different problem formulations or solvers.
3. **Design new solver?**

1. Formulation of optimization problem

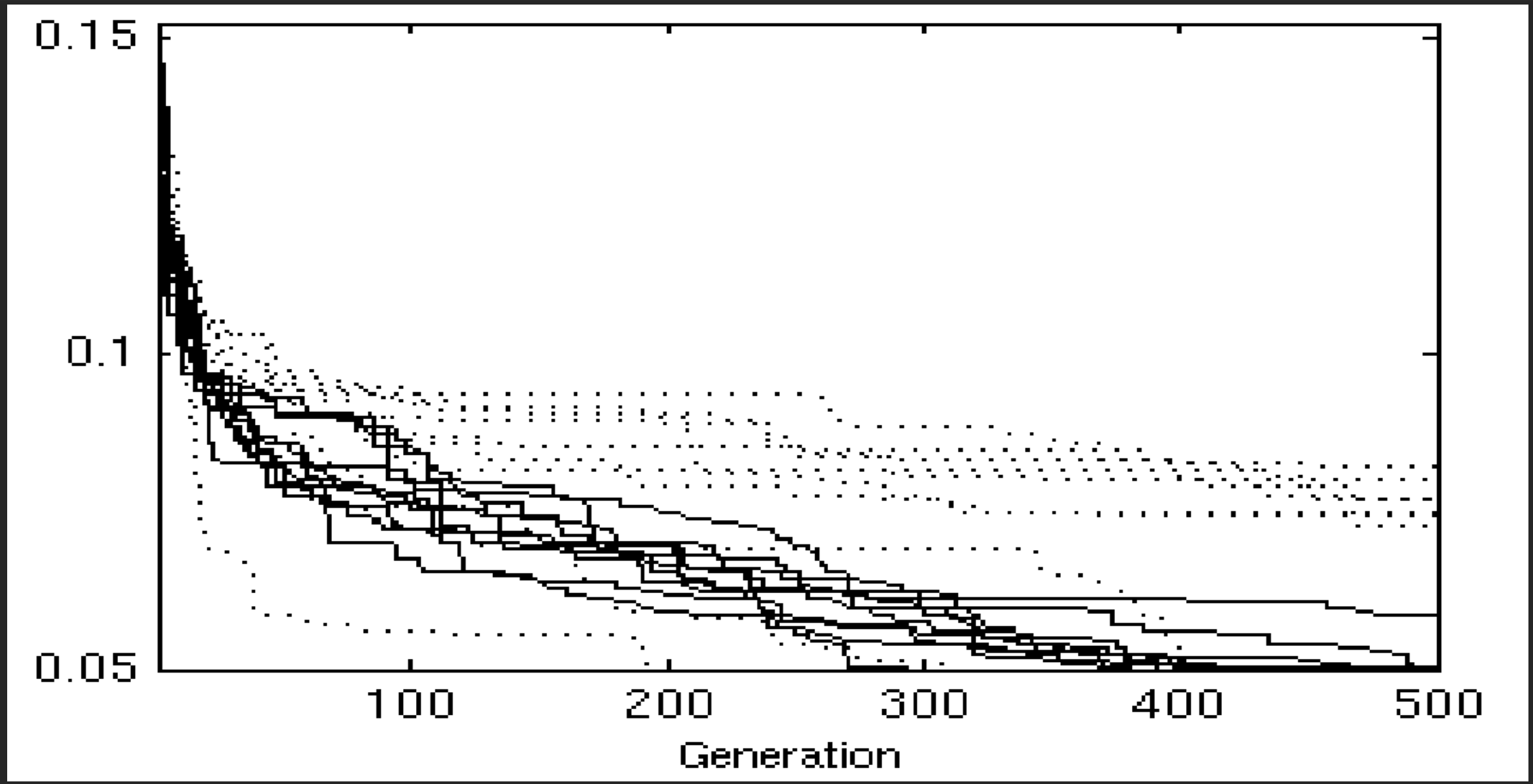
Objectives & constraints in a design space

The algorithm's aim is formulated as a constrained multi-objective optimization problem

$$\begin{aligned} \text{minimize} \quad & f_i(\phi) && i = 1 \ldots N_f \\ \text{s.t.} \quad & g_j(\phi) \leq 0 && j = 1 \ldots N_g \\ & h_k(\phi) = 0 && k = 1 \ldots N_h \\ & \phi \in \Phi \end{aligned} \tag{1}$$

where Φ is the "general" space of possible topologies and sizings. The algorithm traverses Φ to return a Pareto-optimal

2. Try an existing EA solver. Does it converge?



3. Design new EA solver

e homo-
motopy
coarsely
ructural
y. Tradi-
ro path,
the zero
several

mulated
nalyses,
oint $\boldsymbol{\theta}$}.
nt/other
onnom-
corners
rated in
on (with

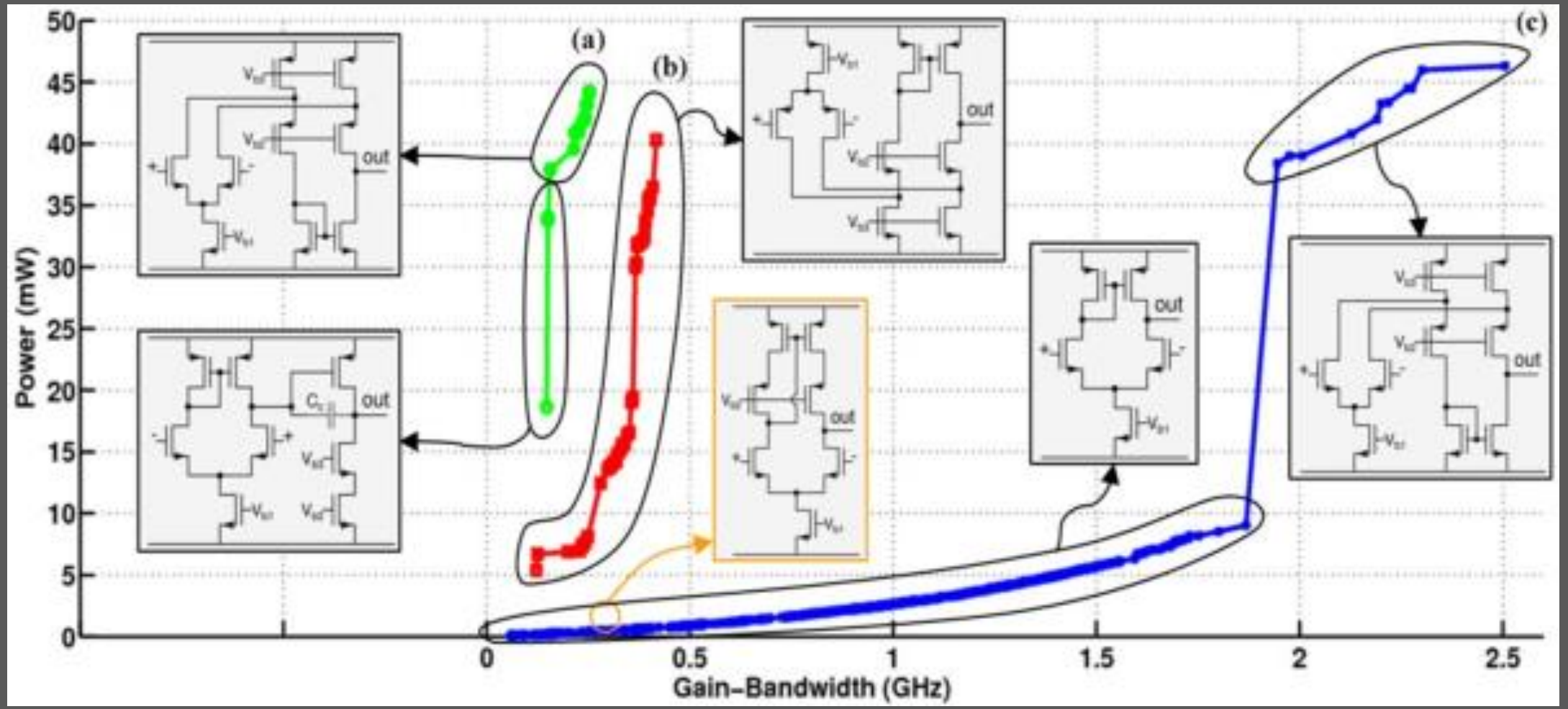
TABLE II
PROCEDURE SANGRIAOPTIMIZATION()

Inputs: D, N_a, K, $N_L(k)$
Outputs: $\boldsymbol{d}^*$

1. $N_{gen} = 0$; $P = \emptyset, P_{all} = \emptyset$
2. while stop() $\neq True$:
3. if $(N_{gen} \% N_a) = 0$:
4. if $|P| < K$:
5. $P_{|P|+1} = \emptyset$
6. P_0 = SpaceFillIndividuals$(N_L(k), N_D, D)$
7. for $k = 1$ to $|P|$:
8. P_k = SelectParents$(P_k, P_{k-1}, N_L(k))$
9. $P_{k,j}$ = UpdateLocalOptState$(P_{k,j}, k)$, $j = 1$ to $|P_k|$
10. P_{all} = unique$(P_{all} \cup P)$
11. $P_{|P|} = P_{|P|} \cup$ InnerOptimize(P_{all}, D, k)
12. $\boldsymbol{d}^* = \boldsymbol{d_i}$ in P_{all} with highest Y or Cpk
13. $N_{gen} = N_{gen} + 1$
14. return $\boldsymbol{d}^*$

and all individuals encountered so far in the search, P_{all}.
Lines 2–13 are the generational loop, which repeats until stop

Example of a Successful Outcome



Steps in *Token Ecosystem* Design

1. **Formulate the problem.** Objectives, constraints, design space.
2. **Try an existing building block.** If needed, try different formulations or EA solvers.
3. **Design new building block?**

1. Formulate the Problem: [ex. Ocean]

Who are stakeholders? What do they want?

Key stakeholders in Ocean ecosystem

Stakeholder	What value they can provide	What they might get in return
Data/service provider, data custodian, data owner	Data/service (market's supply)	Tokens for making available / providing service
Data/service referrers, curators. Includes exchanges and other application-layer providers.	Data/service (via a provider etc), curation	Tokens for curating
Data/service verifier. Includes resolution of linked proofs on other chains	Data/service (via a provider etc), verification	Tokens for verification
Data/service consumer	Tokens	Data/service (market's demand)
Keepers	Correctly run nodes in network	Tokens for chainkeeping

Objectives & constraints

Obj:

- **Maximize supply of relevant data**

Constraints = checklist:

- **For priced data, is there incentive for supplying more? Referring? Spam prevention?**
- **For free data, "" ?**
- **Does the token give higher marginal value to users vs. hodlers?**
- **Are people incentivized to run keepers?**
- **Is it simple? Is onboarding low-friction?**

2. Try Existing Patterns

1. **Curation**
2. Proofs of human or compute work
3. Identity
4. Reputation
5. Governance / software updates
6. Third-party arbitration
7. …

2.1 Patterns for Curation

- **Binary** membership: Token Curated Registry (TCR)
- **Discrete-valued** membership: Layered TCR (like ALPS!)
- **Continuous-valued** membership: Curation Markets
- **Hierarchical** membership: each label gets a TCR
- **Work** tied to membership: Curated Proofs Market

2. Try existing patterns: evaluate on objectives & constraints. [Ex Ocean: None passed…]

Key Question	1	2	3	4
For priced data: incentive for supplying more? Referring?	✗	≈	✓	≈
For priced data: good spam prevention?	≈	✓	✓	✓
For free data: incentive for supplying more? Referring?	✗	≈	✗	✓
For free data: good spam prevention?	≈	✓	≈	✓
Does token give higher marginal value to users of the network, vs external investors? Eg Does return on capital increase as stake increases?	✓	✓	✓	✓
Are people incentivized to run keepers?	≈	≈	✓	✓
It simple? Is onboarding low-friction? Where possible, do we use incentives/crypto rather than legal recourse?	✓	✓	≈	≈

3. Try new patterns: evaluate on objectives & constraints. [Ex Ocean: pass!]

Key Question	1	2	3	4	5	6
For priced data: incentive for supplying more? Referring?	✗	≈	✓	≈	≈	✓
For priced data: good spam prevention?	≈	✓	✓	✓	✓	✓
For free data: incentive for supplying more? Referring?	✗	≈	✗	✓	✓	✓
For free data: good spam prevention?	≈	✓	≈	✓	≈	✓
Does token give higher marginal value to users of the network, vs external investors? Eg Does return on capital increase as stake increases?	✓	✓	✓	✓	✓	✓
Are people incentivized to run keepers?	≈	≈	✓	✓	✓	✓
It simple? Is onboarding low-friction? Where possible, do we use incentives/crypto rather than legal recourse?	✓	✓	≈	≈	✓	✓

Simulation of Tokenized Ecosystems?

- Q: How do we design computer chips? ($50M+ at stake)
- A: Simulator + CAD tools

- Q: How are we currently designing tokenized ecosystems? ($1B+ at stake)
- A: By the seat of our pants! 😱
- Which means we might be getting it all wrong!

What we (desperately) need:

1. Simulators: agent-based systems [Incentivai, ..]
2. CAD tools: for token design

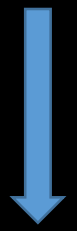
Design of Tokenized Ecosystems
From Mechanism Design to *Token Engineering*

Analysis:

Game theory

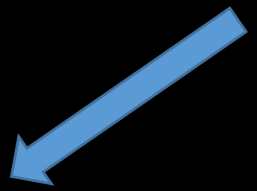
Synthesis:

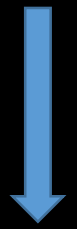
Mechanism Design



Practical constraints

Optimization Design





Engineering theory, practice and tools + responsibility

Token Engineering for Analysis & Synthesis

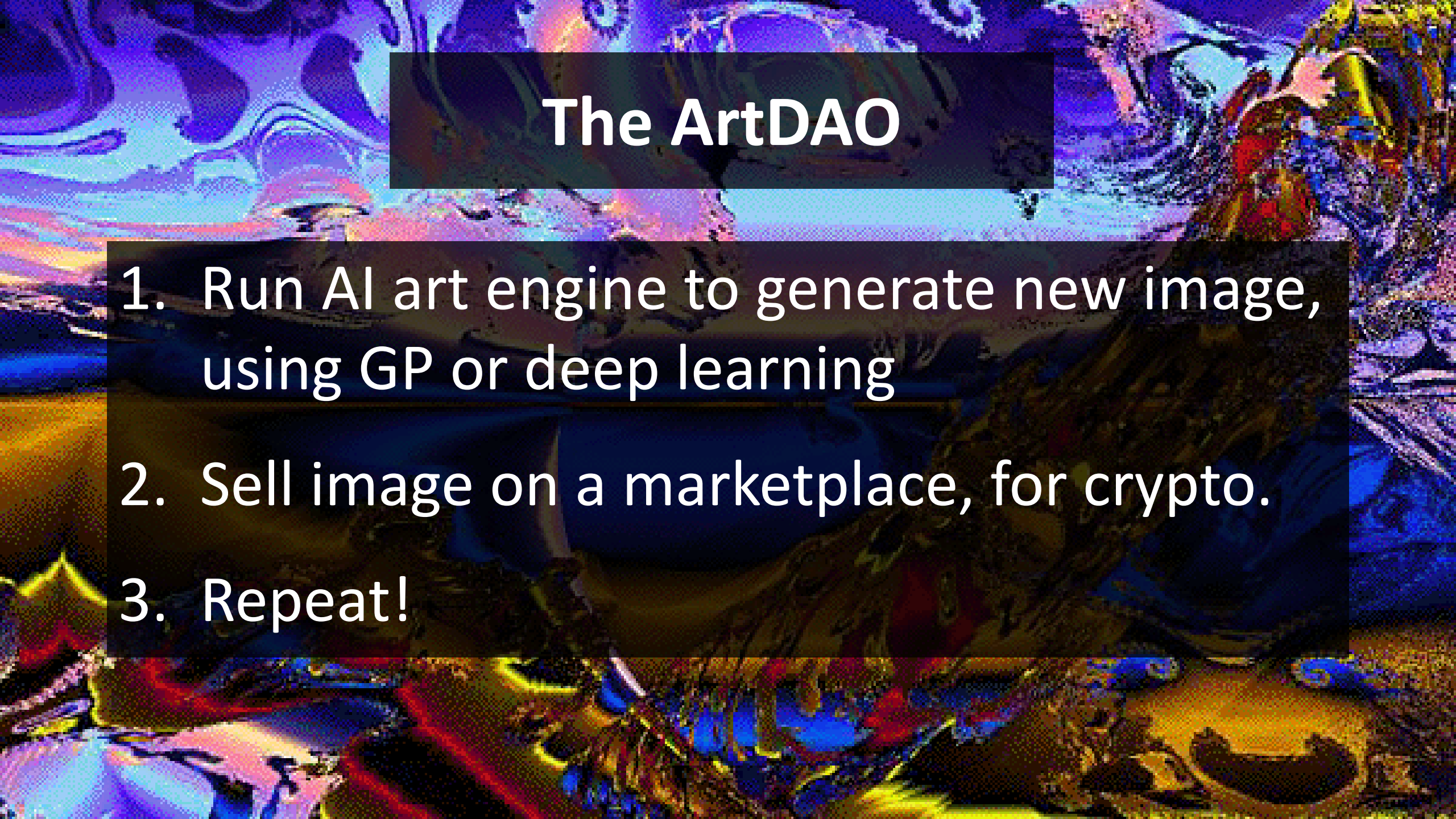
AI * Blockchain:
AI DAOs

Definition of AI DAO

“An AI running on decentralized processing substrate”

<or>

“A DAO running with AI algorithms”



The ArtDAO

1. Run AI art engine to generate new image, using GP or deep learning
2. Sell image on a marketplace, for crypto.
3. Repeat!

The ArtDAO

1. Run AI art engine to generate new image, using GP or deep learning
2. Sell image on a marketplace, for crypto.
3. Repeat!

<Over time, it accumulates wealth, for *itself*.>

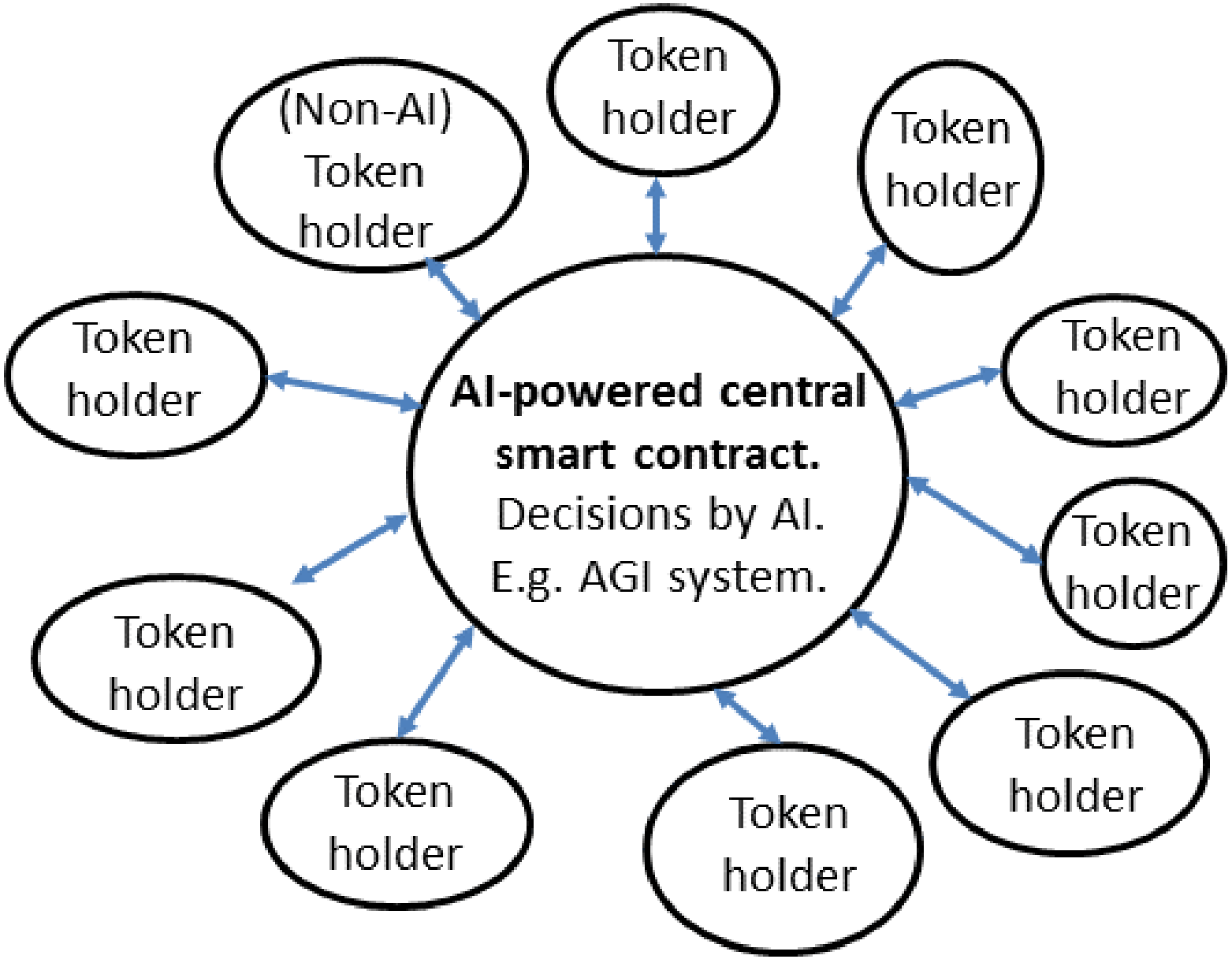
The ArtDAO

1. Run AI art engine to generate new image, using GP or deep learning
2. Sell image on a marketplace, for crypto.
3. Repeat!

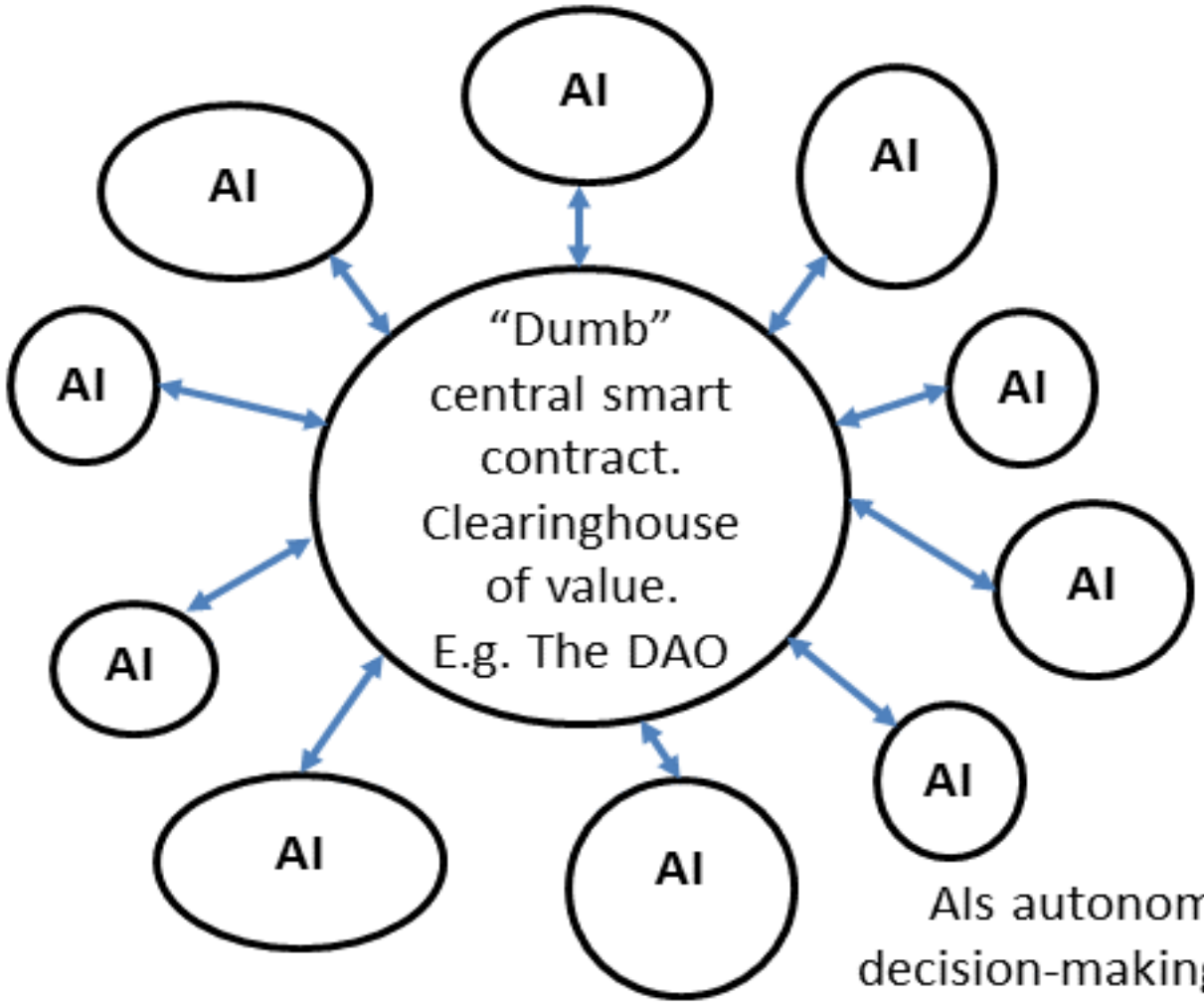
<Over time, it accumulates wealth, for *itself*.>

<It could even self-adapt: genetic programming>

AI DAO Arch 1: AI at the Center

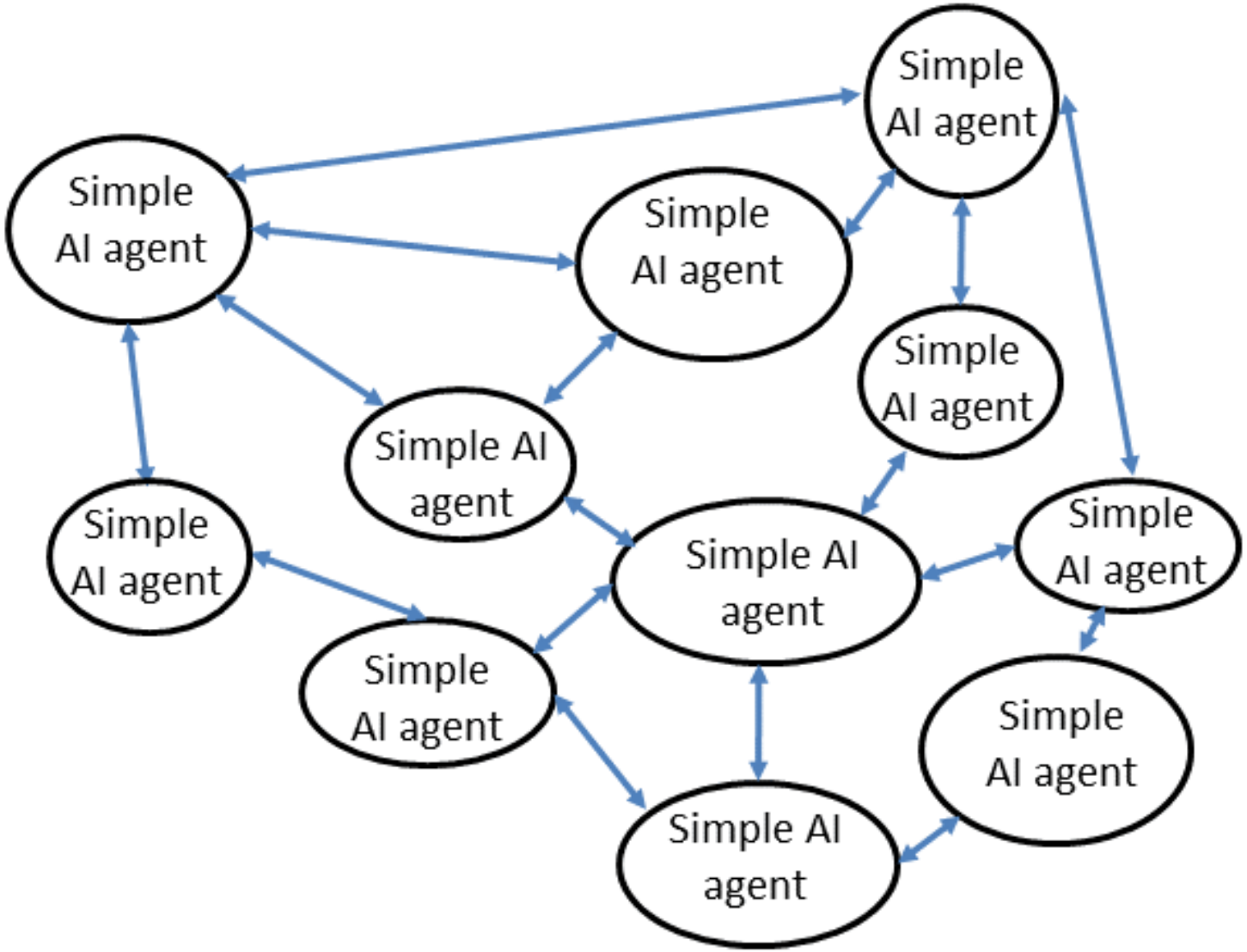


AI DAO Arch 2: AI at the *Edges*



AIs autonomously do decision-making. AI may be narrow (e.g. deep nets) or more general (e.g. AGI)

AI DAO Arch 3: Swarm Intelligence
Many dumb agents with emergent AI complexity

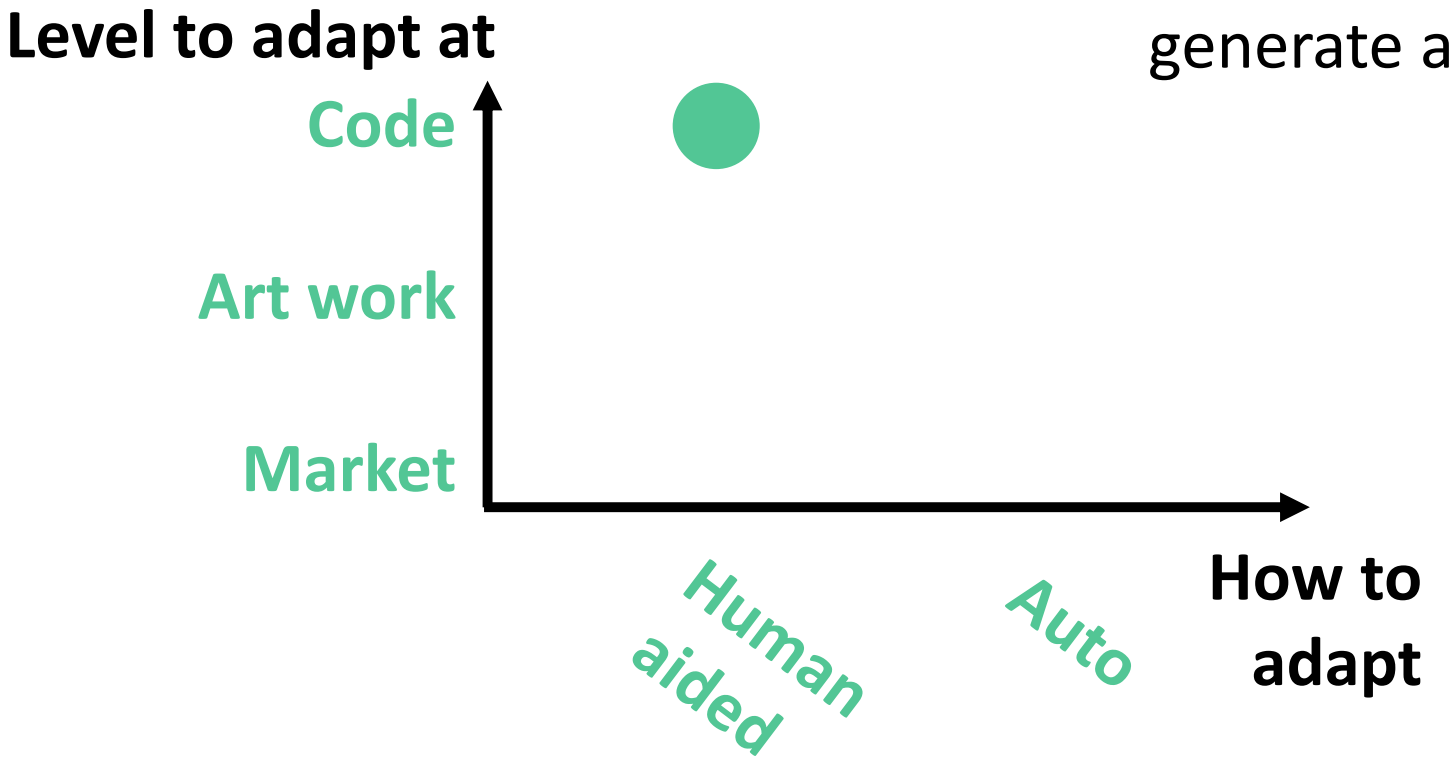


Angles to Making AI DAOs

- **DAO → AI DAO**. Start with DAO, add AI.
- **AI → AI DAO**. Start with AI, add DAO.
- **SaaS → DAO → AI DAO**. SaaS to DAO, add AI
- **Physical service → AI DAO**

AI DAOs When Moon

Evolving the ArtDAO



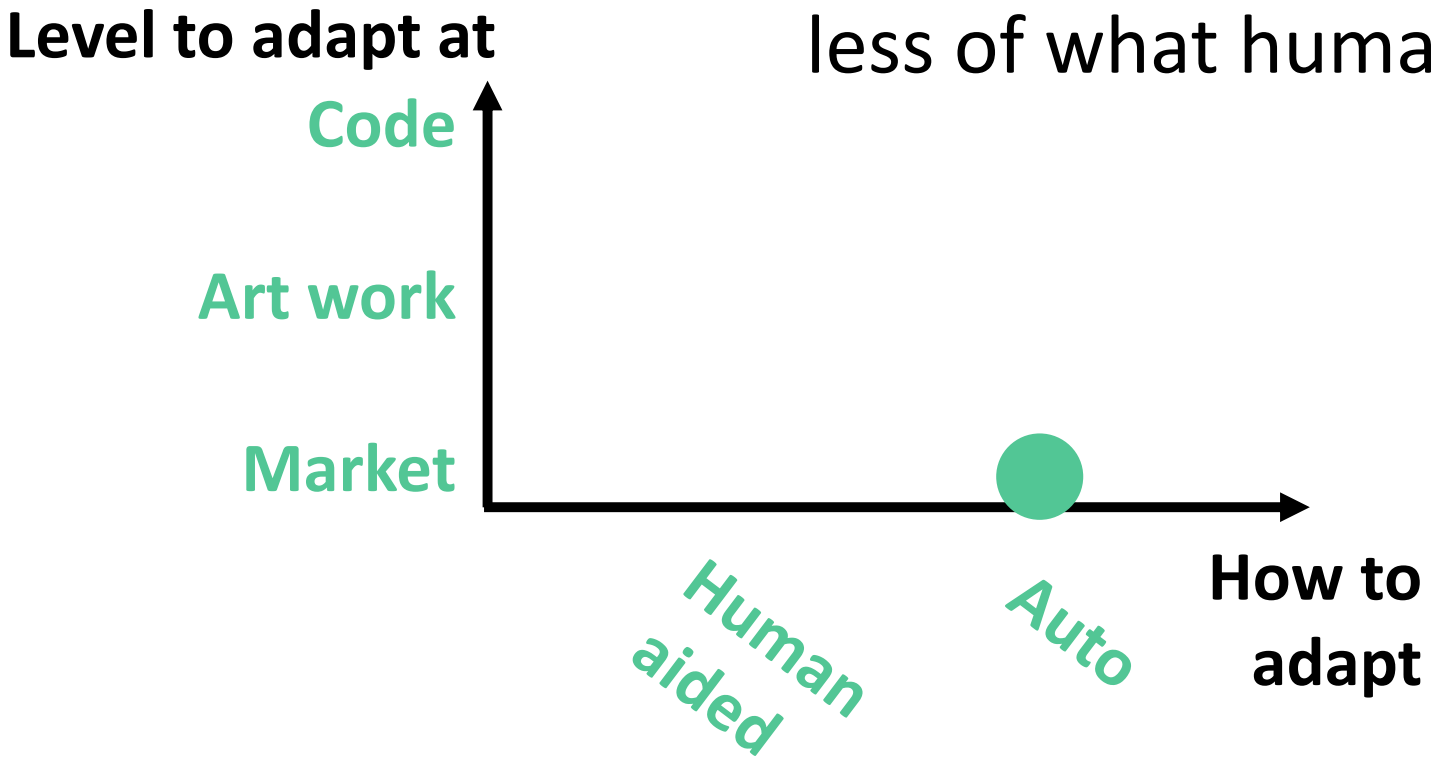
Human-based adapt at the code level.

Here, humans put in new smart contract code (and related code in 3rd party services), to improve ArtDAO's ability to generate art and amass wealth.

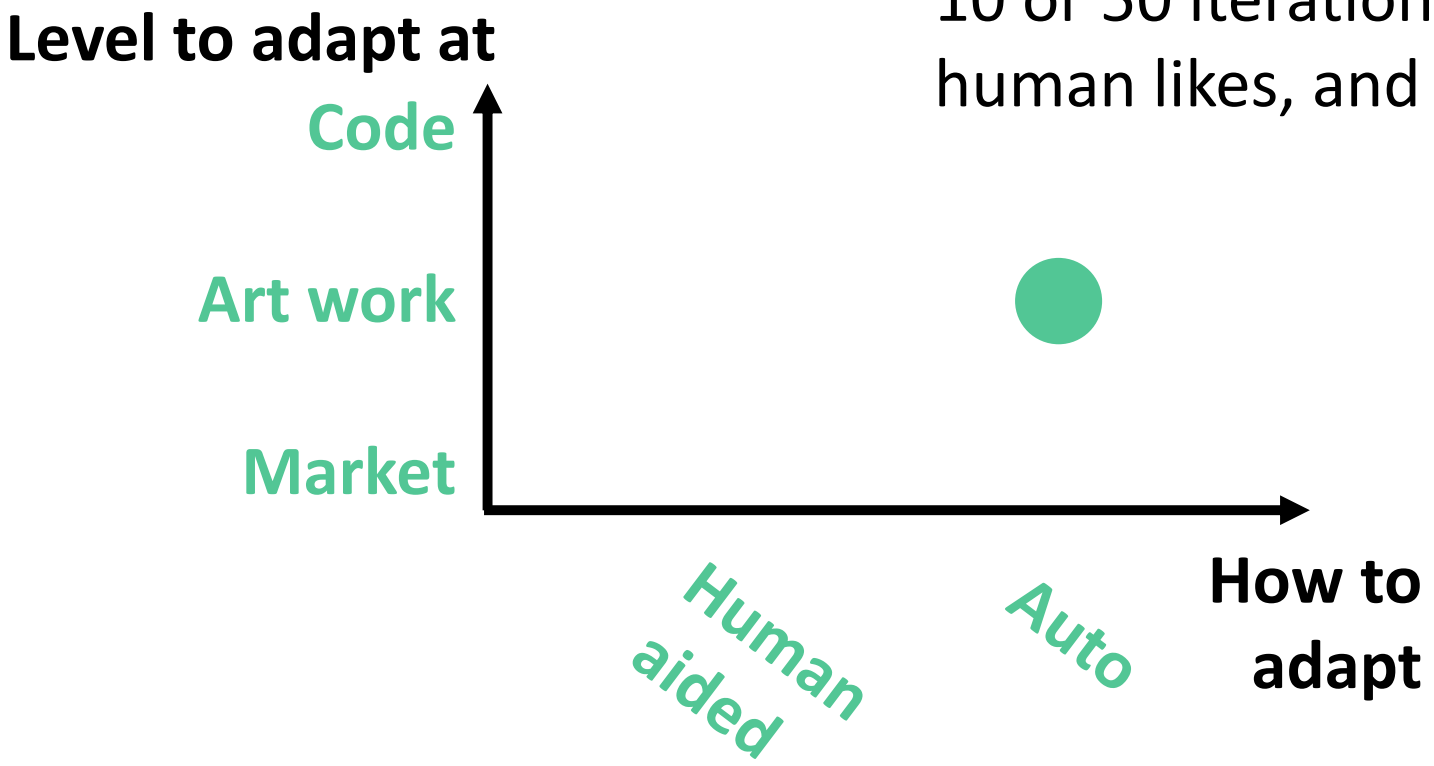
Evolving the ArtDAO

Auto adapt at the market level.

It creates more of what humans buy, and less of what humans don’t buy.



Evolving the ArtDAO



Auto adapt at the art-work level.

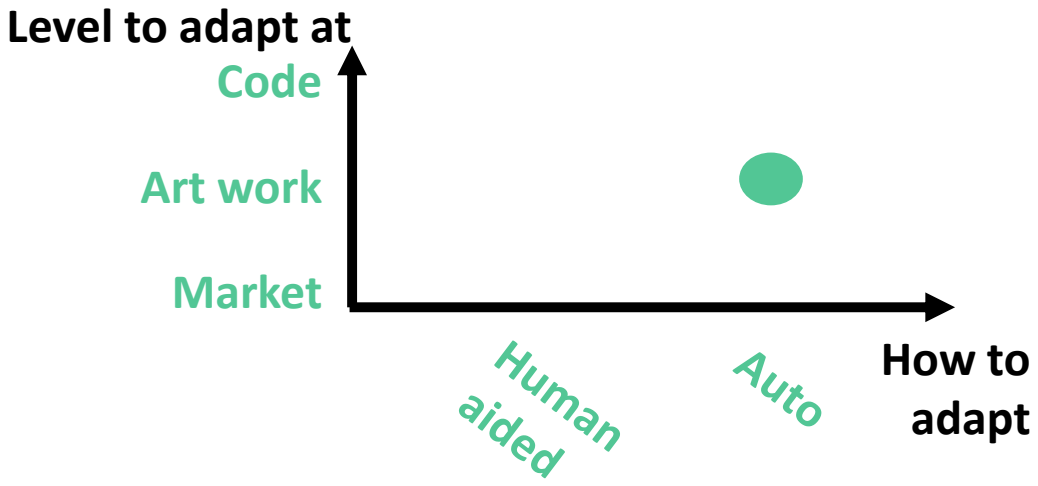
Here, a human influences the creation of an artifact. For example, it presents four variants of a work, and a human clicks on a favorite. After 10 or 50 iterations, it will have a piece that the human likes, and purchases.

Evolving the ArtDAO

Auto adapt at the code level.

Here, the ArtDAO modifies its own code, in hopes of improving.

- It creates a copy of itself, changes that copy's code just a little bit, and gives a tiny bit of resources to that new copy.
- If that new copy is bad, it will simply run out of resources and be ignored.
- But **if that new copy is truly an improvement, the market will reward it**, and it will be able to amass resources and split more on its own.
- Over time, ArtDAO will spawn more children, and grandchildren, and the ones that do well will continue to spread. We end up with a mini-army of AI DAOs for art.
- If buyers are DAOs too, it's a network of DAOs, leading to swarm intelligence



Giving Personhood to an AI DAO With Today's Laws (!)

Self-driving, self-owning cars

Self-driving, self-owning trucks


Self-owning
roads

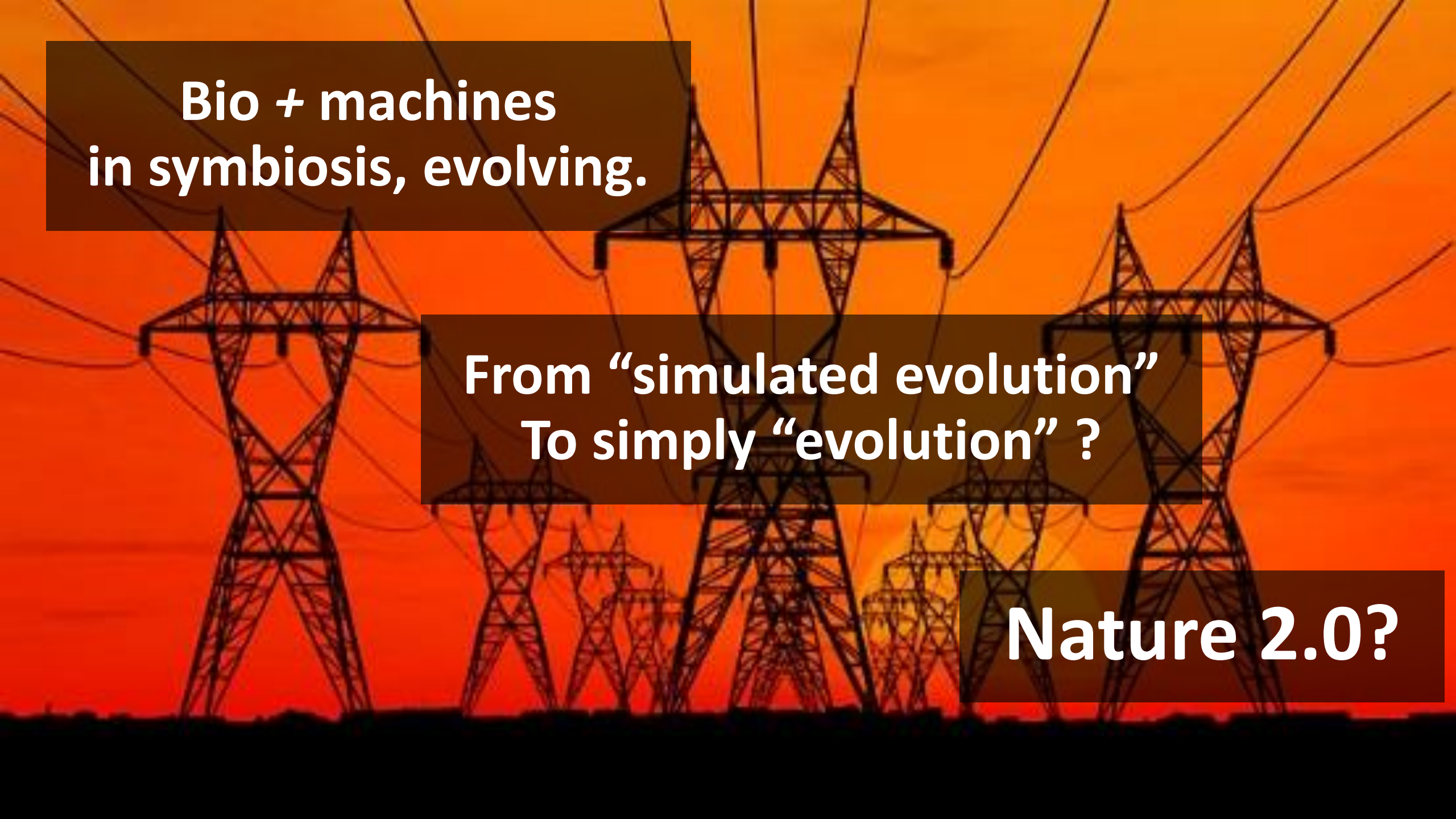

Self-owning
wind farms

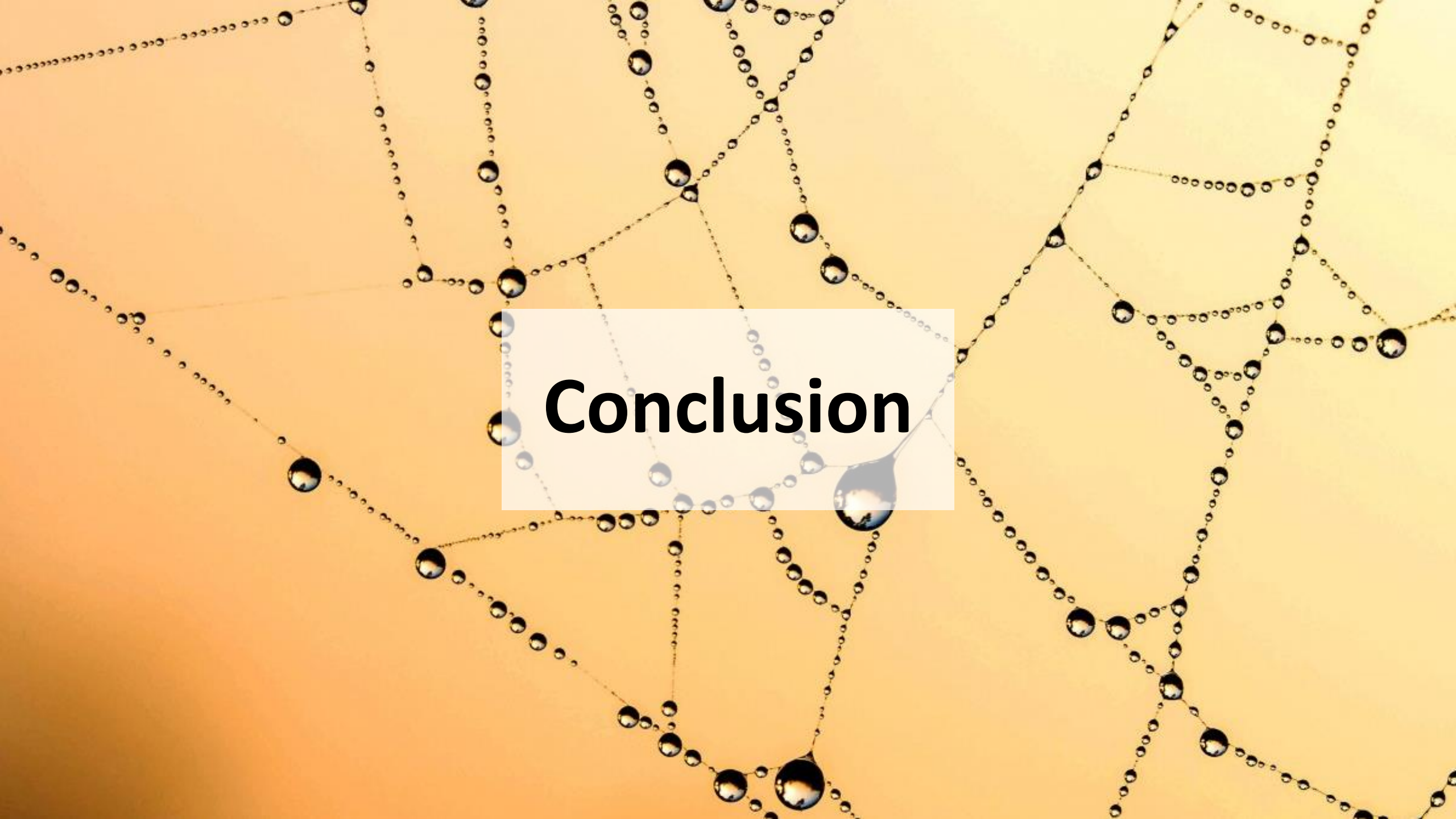
Self-owning grid


Machines → Nature:
“Plantoid”

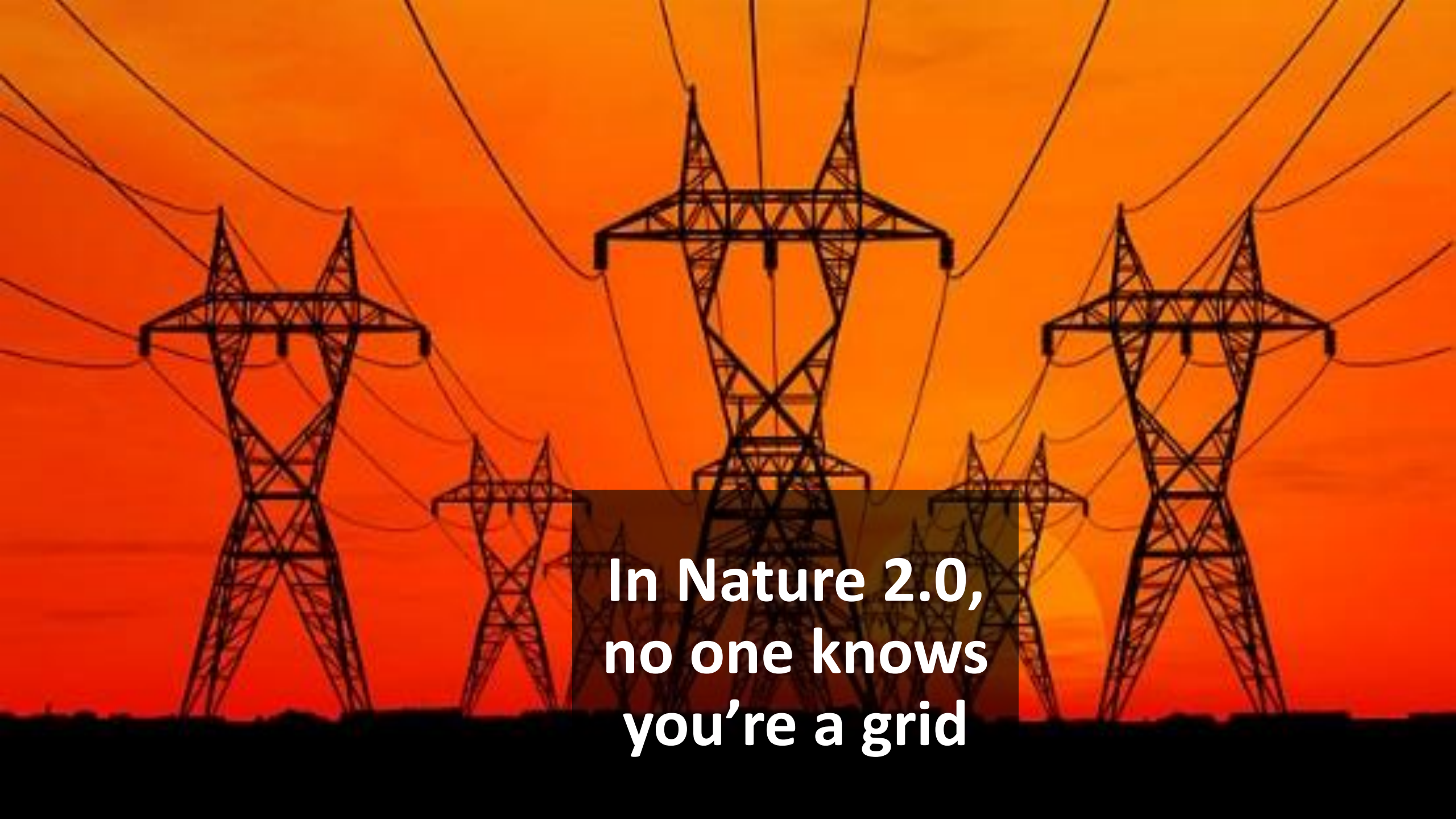

Nature → Machines:
Self-owning forest “Terra0”

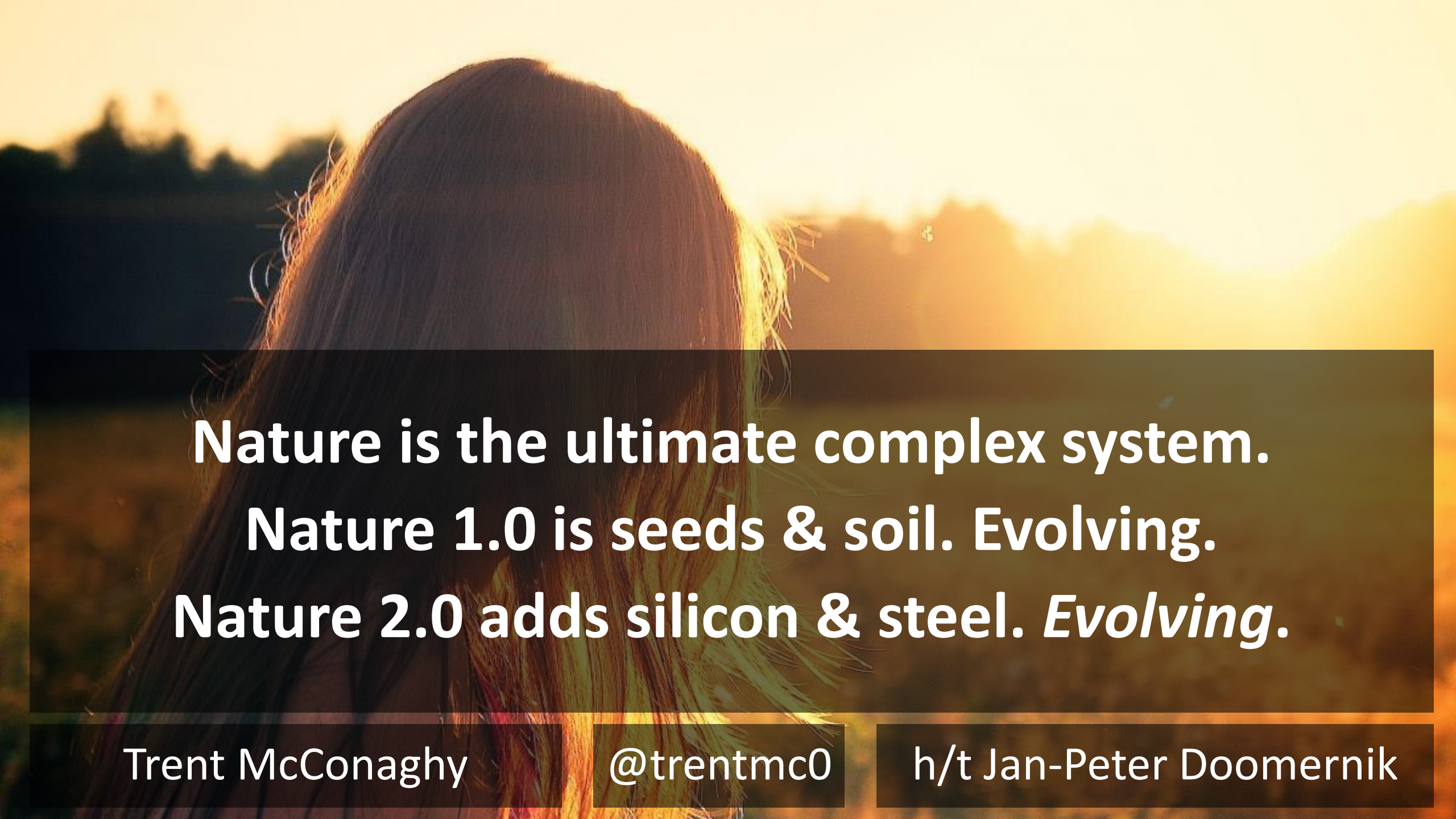
Ever-higher levels of integration
From beasts → ecosystems
Connected via IoT / M2M


Bio + machines
in symbiosis, evolving.
From “simulated evolution”
To simply “evolution” ?
Nature 2.0?


Conclusion


In Nature 2.0,
no one knows
you’re a forest


In Nature 2.0,
no one knows
you’re a grid


Nature is the ultimate complex system.
Nature 1.0 is seeds & soil. Evolving.
Nature 2.0 adds silicon & steel. *Evolving*.
Trent McConaghy
@trentmc0
h/t Jan-Peter Doomernik