

A microscopic image showing several diatom cells. These are single-celled algae enclosed in intricate, often circular or elliptical, glass-like shells made of silica. The shells have various patterns of raised features called areolae. The background is a dark teal color.

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?**

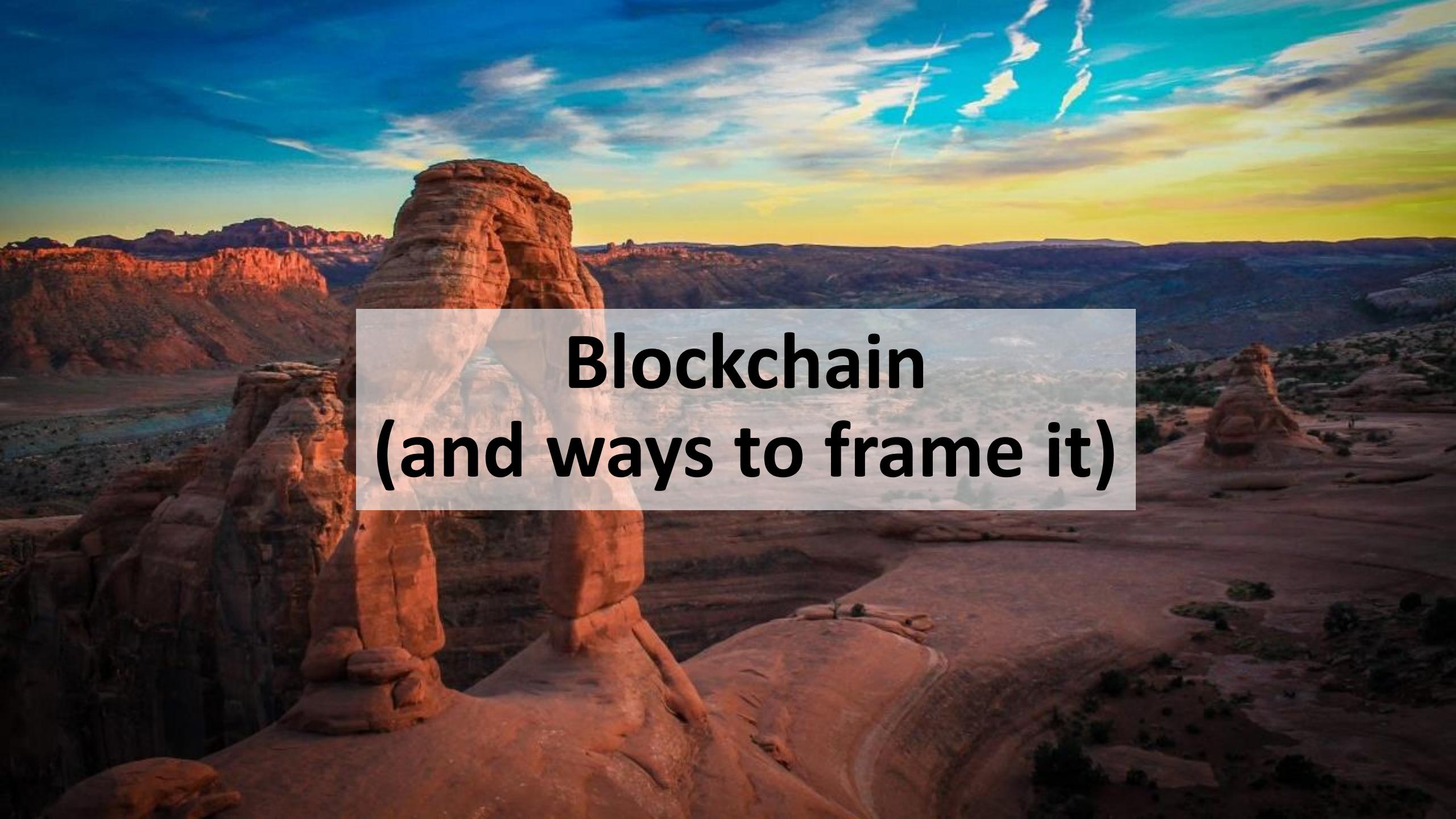


A photograph of a dense forest. Sunlight filters through the tall, thin trunks of the trees, creating bright highlights on the green foliage and the forest floor. The foreground is filled with dark green bushes and smaller plants. The overall atmosphere is peaceful and natural.

What do you call
a forest that
owns itself?



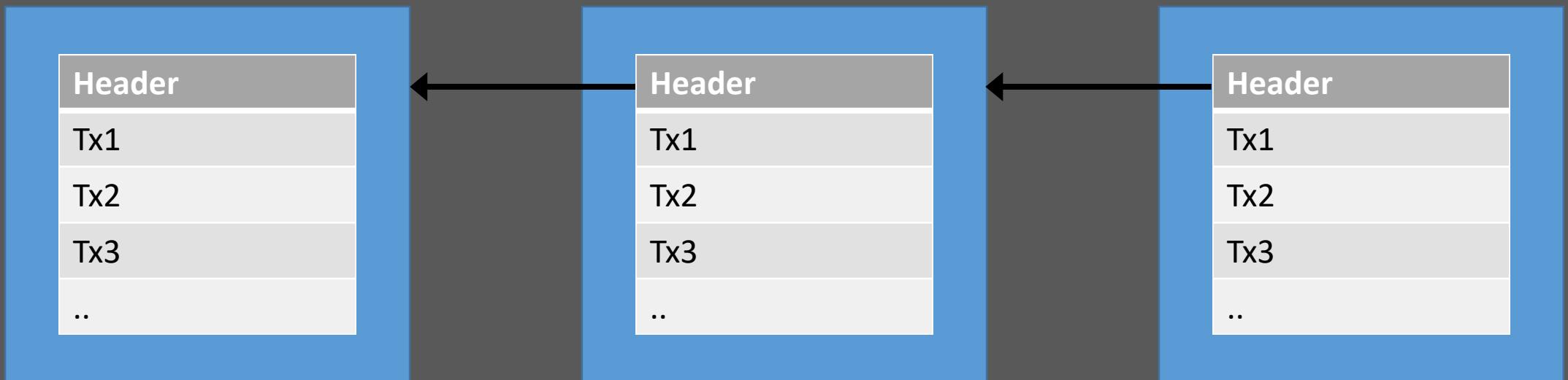
Can a wind farm own itself?
How?

A wide-angle photograph of a desert landscape at sunset. In the foreground, a large, light-colored rock formation with a prominent archway is silhouetted against the bright sky. The middle ground shows a vast, rolling valley with distant mountains under a sky filled with wispy clouds. The overall lighting is warm and golden.

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



The background image shows a series of modern office buildings with curved, glass-fronted facades. The buildings are set against a clear, bright blue sky. In the foreground, there is some greenery and shrubbery. The buildings are arranged in a staggered pattern, with one prominent building on the left and several others receding into the distance.

“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

INSIDE: A 12-PAGE SPECIAL REPORT ON COLOMBIA

The Economist

OCTOBER 31ST-NOVEMBER 8TH 2013

Economist.com

- 007 and the spectre of Britain's past
- Turkey votes to the sound of bombs
- Those ever-creative accountants
- America takes the fight to IS
- Coywolves: the new superpredator

The trust machine

How the technology behind bitcoin could change the world



“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



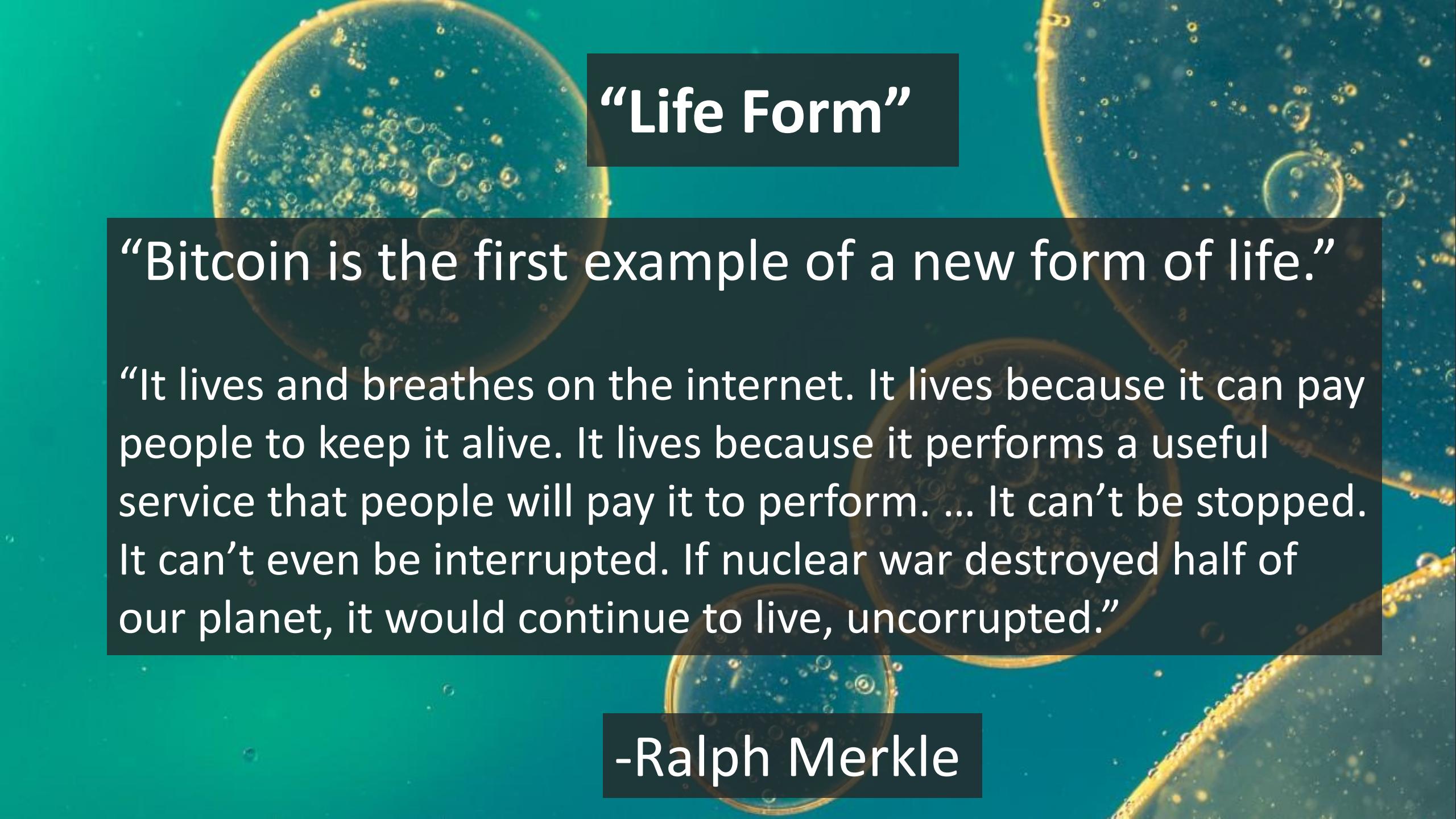
“DAO: Decentralized Autonomous Organization”

A computational process that

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

It's code that can *own* stuff!

Aka “good computer virus”

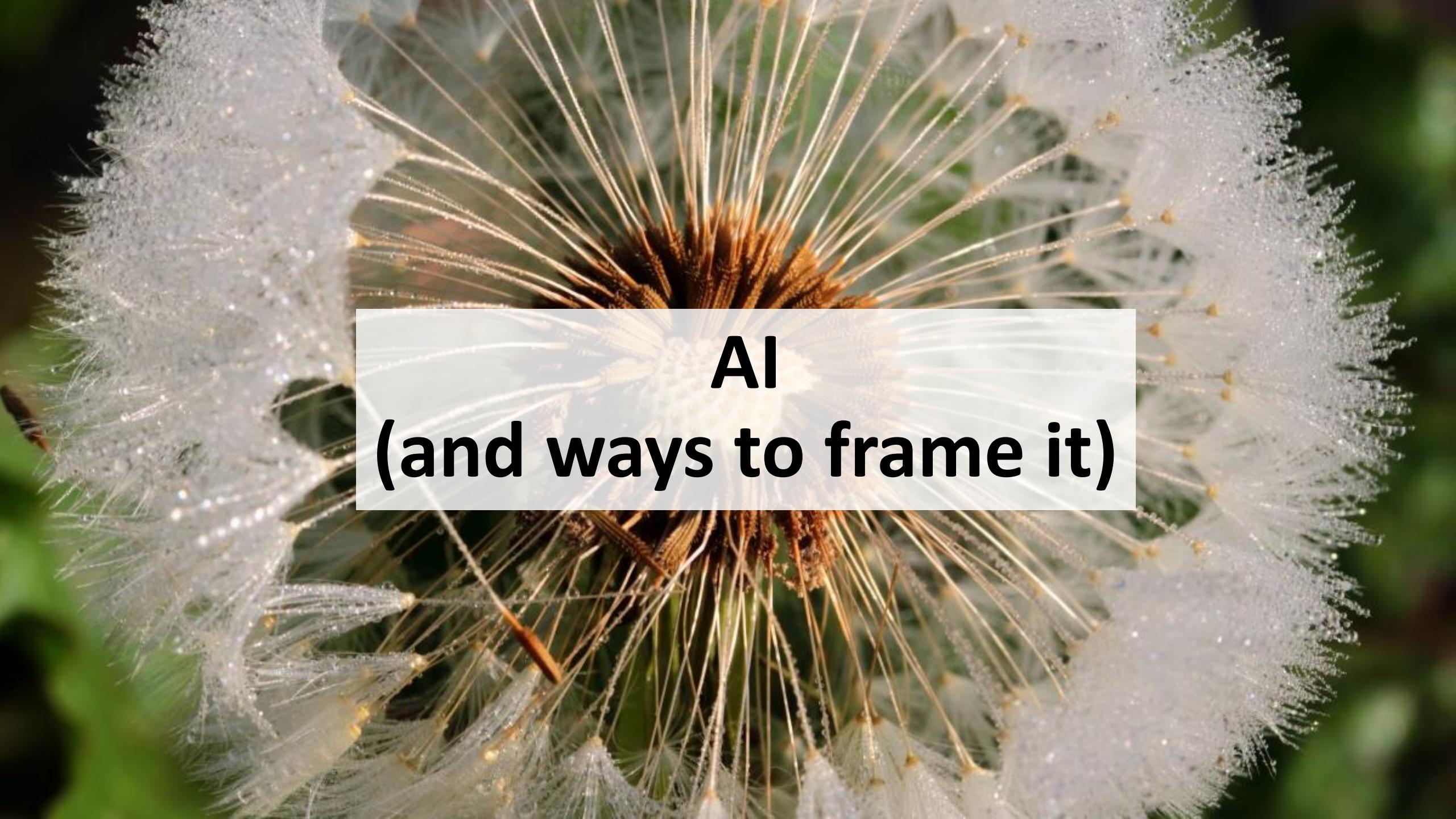
A microscopic image showing several large, yellowish-green, circular microorganisms against a dark blue background. Smaller, similar particles are scattered throughout the field of view.

“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.”

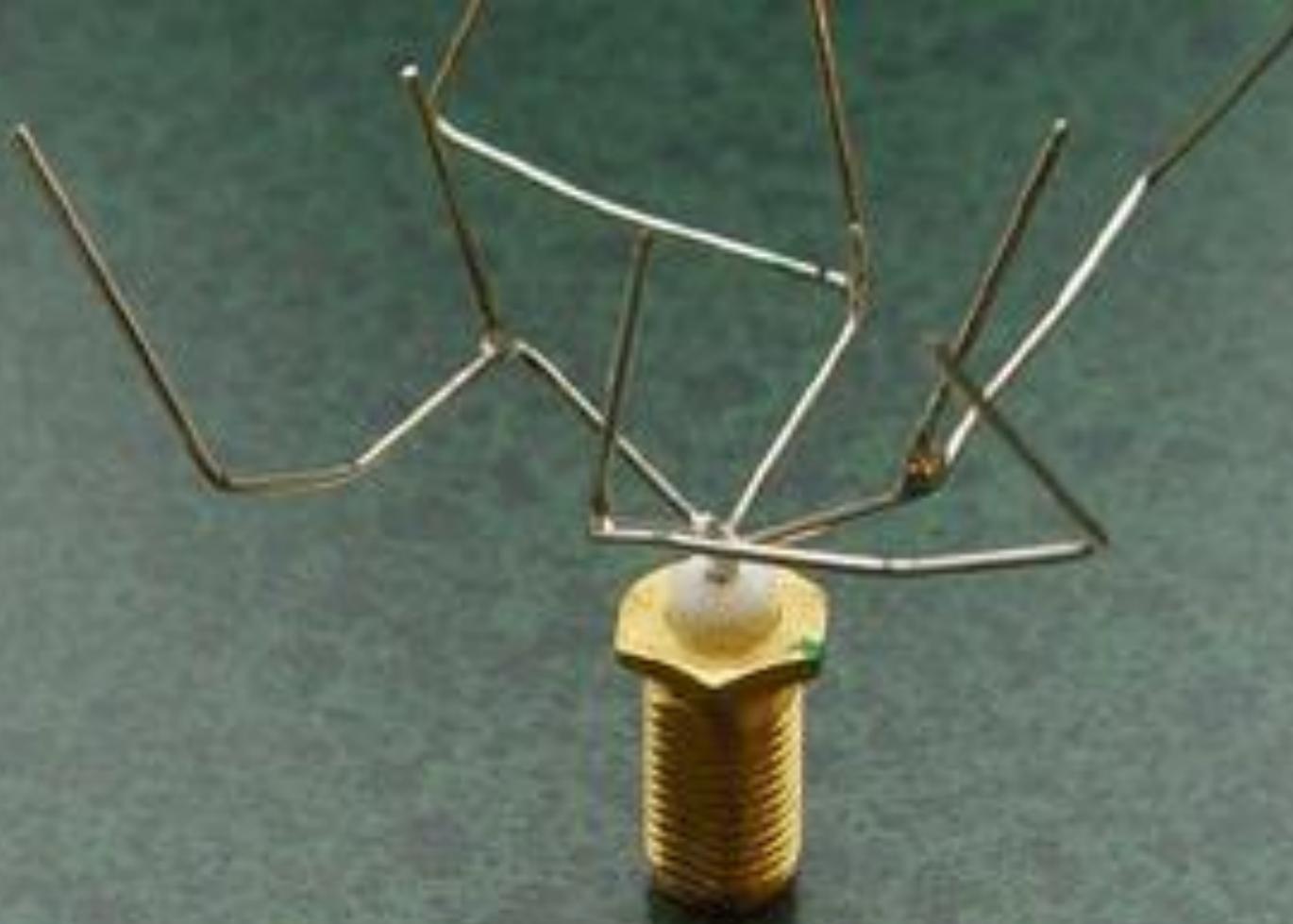
-Ralph Merkle



**AI
(and ways to frame it)**

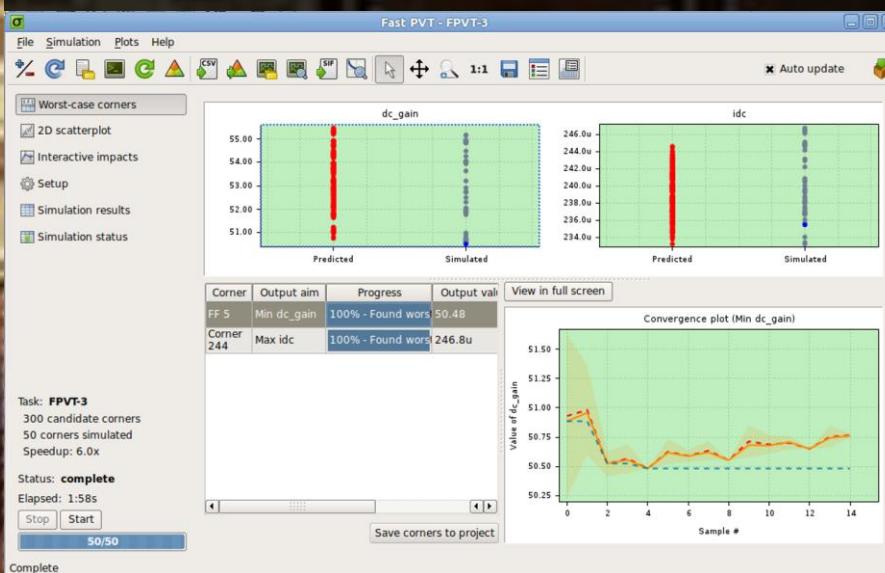
“Replicates human cognitive behavior” [Turing test]





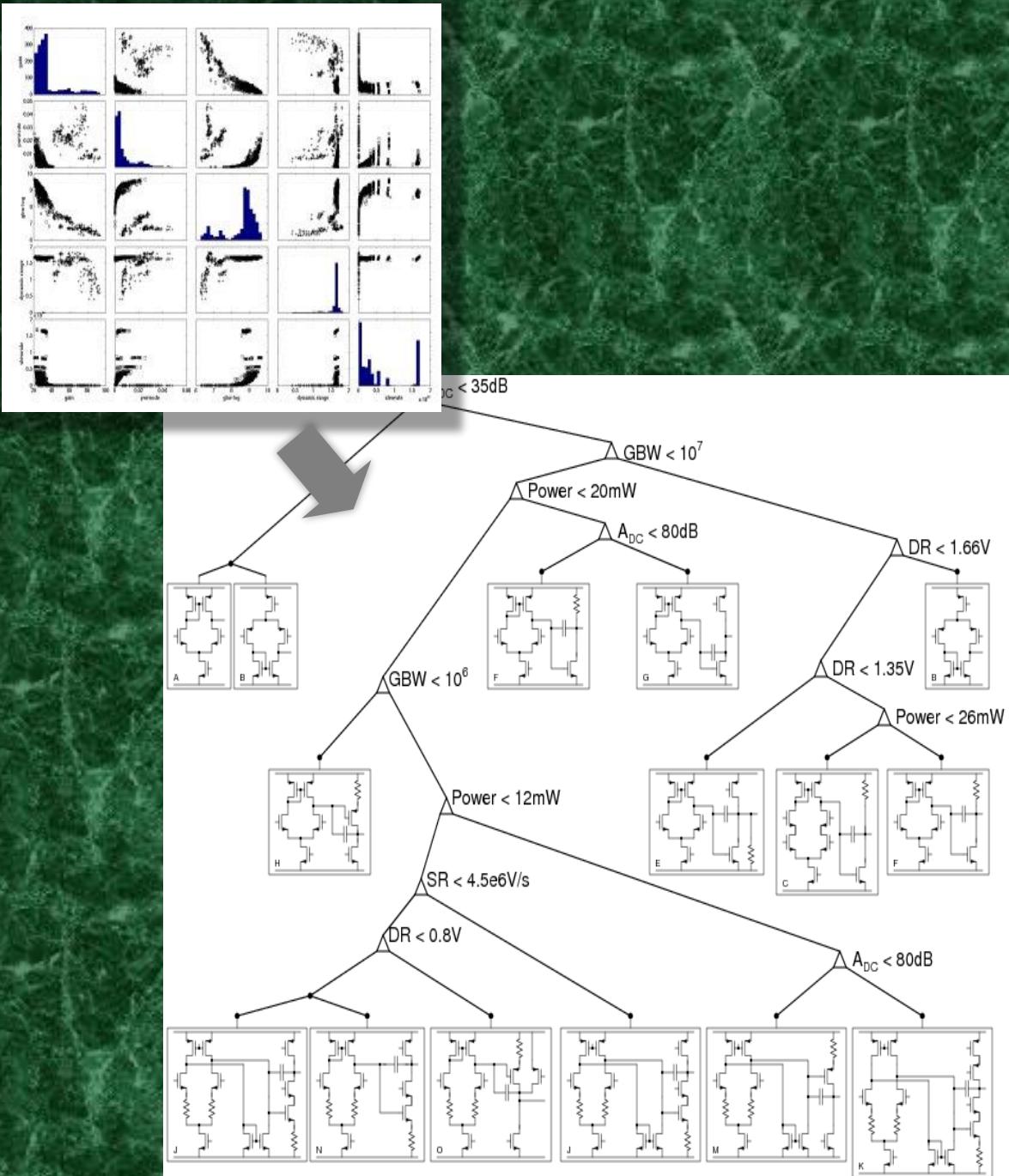
“Can do tasks that only a
human could previously do”

“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 fail.

Challenges

1. How to ensure supplier gets paid w/o losing ability to get paid in future. "Free riding" "Privacy" "Copy vs title"
2. How to price? overall price relative impact per dataset

Data

- Data is open (but tokenized)
- Avoid need for TTP to see data when company wants to contribute i.e. increased to contribute
- How to get people compensated w/o freeriding i.e. ppn (paying per data) X=XYhawk; Y=YUnewY Compute \$ from trading For each k_i in hawk Compute impacts of each input in model (ie dataset paying Compute request to data provider Compute payout to data provider. To satisfy the dec. price. (smart contract choose request off-chain before scraping) can see the details
- How to price data fungible / non-fungible fixed / eraser / auto low friction price high friction price i.e. cost. i.e. error
- Who frictions & non-frictions and fairly based on usefulness, if accelerated X=OJnewY

Engagements / Incentives

fix price up-front

+ reputation (subjective)

1. You have \$10K staked in outlet - 1/1000 usage will be released
2. Avg to compute a key from data & public
3. If my data is made public, then anyone can open my wallet & get \$10K

Stake

Model persons visible for data supplier

Data visible for scientist

Data private - model persons private

public ext. private model public

co-owner of Σ or Home Markets?

TOKENIZING ACCESS TO DATA REVENUE FIXED SUPPLY

- Each dataset has its own tokens. Please verify
- ICO a dataset
- When data is purchased for users, it is split according to token ownership

TOKENIZING ACCESS TO DATA ITSELF

e.g. 100 tokens. You can access the data if you own the token

Data Tokenizing

Multi-level auction user at price

1. \$800K top 1K mols, bidder please present conditions based on top bid 2 bids
2. Auction happens when you set to ex. if highest bid \rightarrow \$10K now 2nd highest bid \rightarrow \$8K in 2 ms \$5K in 2 ms \$3K in 3 ms \$1K in 3 ms And: in 6 ms: data is set free

Marketplace for tokenizing data

Refrigerated cells is only visible for themselves - pool control - pool data, pool tokens, pool address, pool token to update other negotiation

1. Supplier says total price \$10K. Two bidders in pool get data now. 2. Both got data later.

Pooling with best price

these folks get data now others get data in 2 ms or 3 ms (data set free)

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

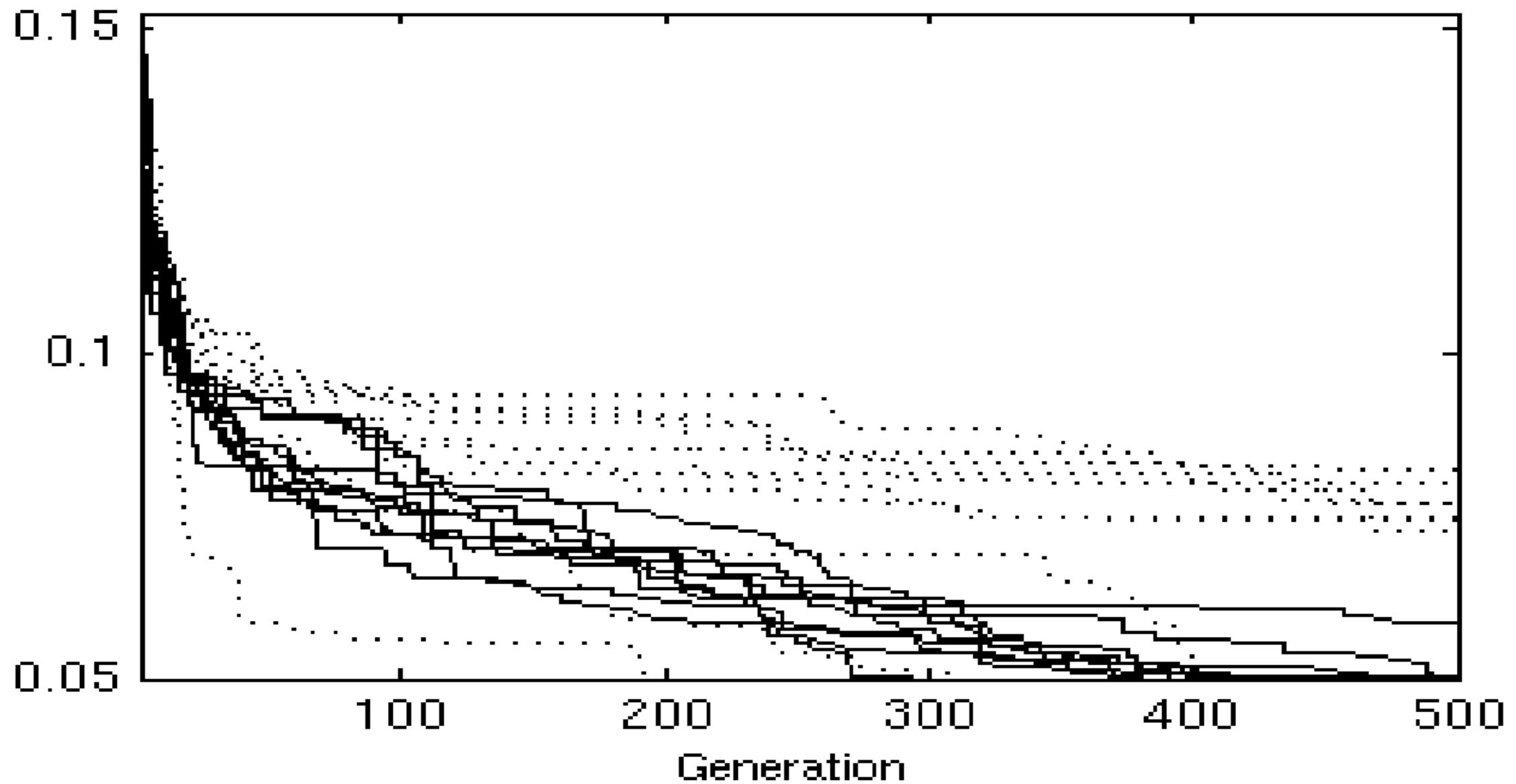
Objectives & constraints in a design space

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

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

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

TABLE II
PROCEDURE SANGRIAOPTIMIZATION()

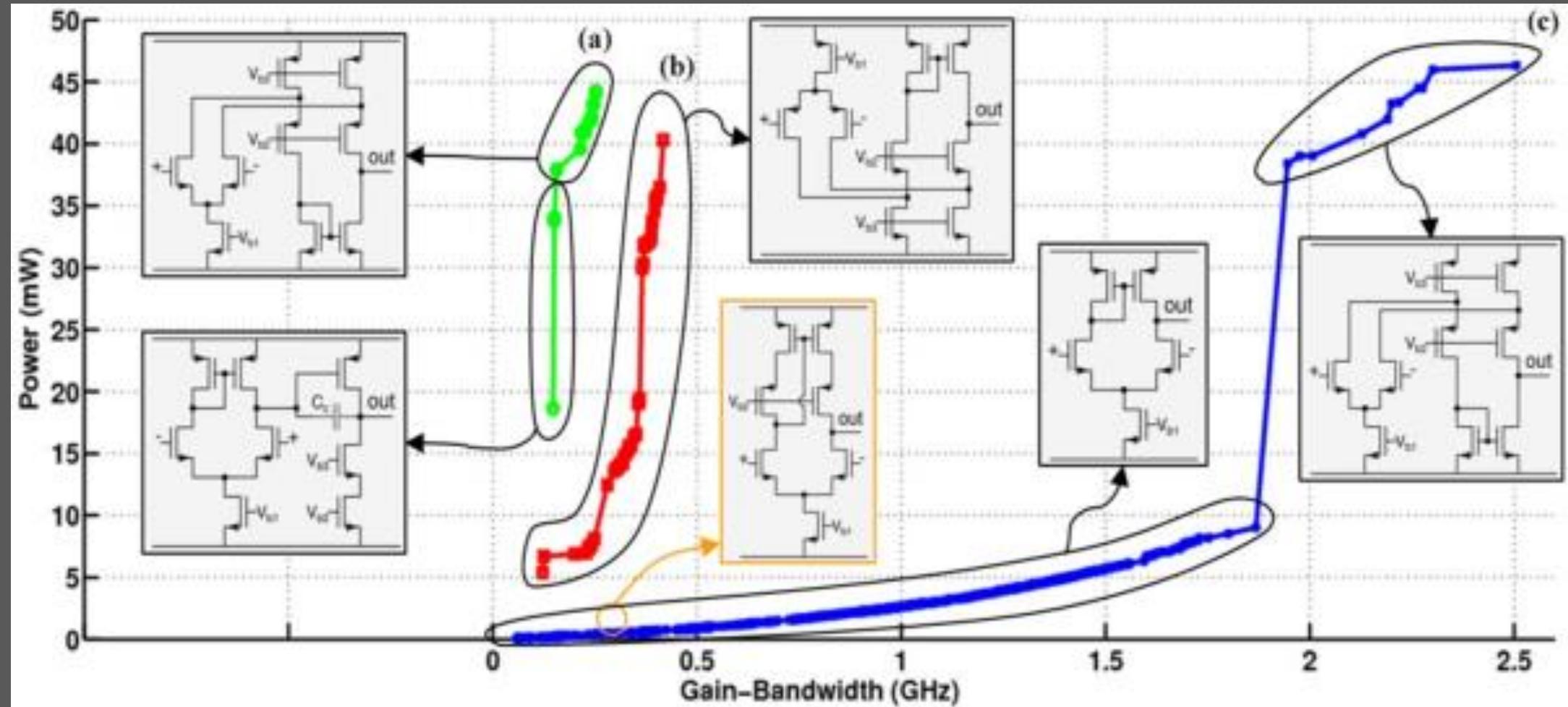
Inputs: $D, N_a, K, N_L(k)$

Outputs: d^*

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

Objectives &
constraints

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

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?	≈	≈	✓	✓
Is 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?

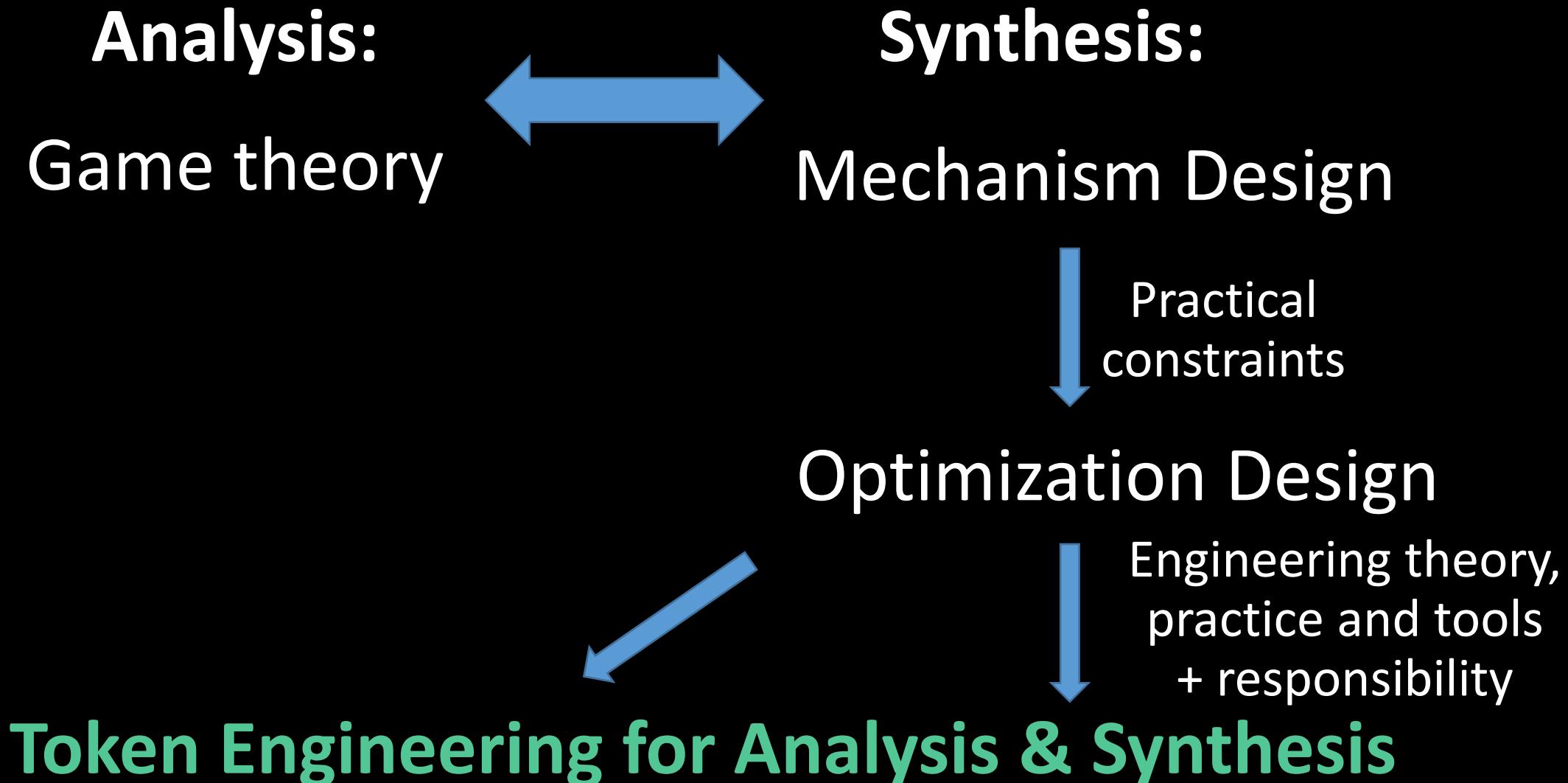
- Q: How do we design computer chips? (\$50M+ at stake)
- A: Simulator + CAD tools
- Q: How are we currently designing tokenized ecosystems? (\$1B+ at stake)
- A: By the seat of our pants! 😱
- Which means we might be getting it all wrong!

What we (desperately) need:

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

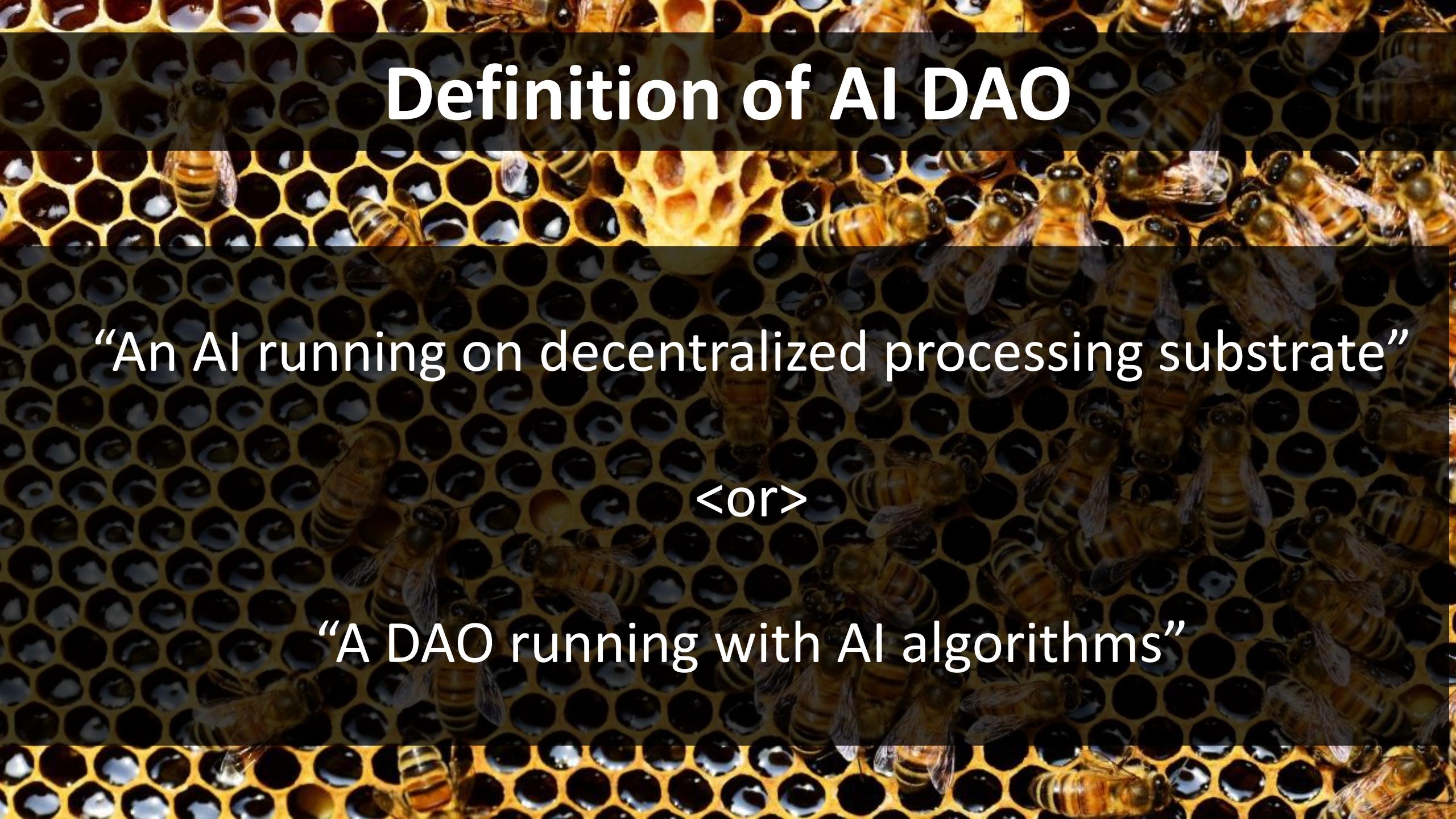
Design of Tokenized Ecosystems

From Mechanism Design to *Token Engineering*





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

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3. Repeat!

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

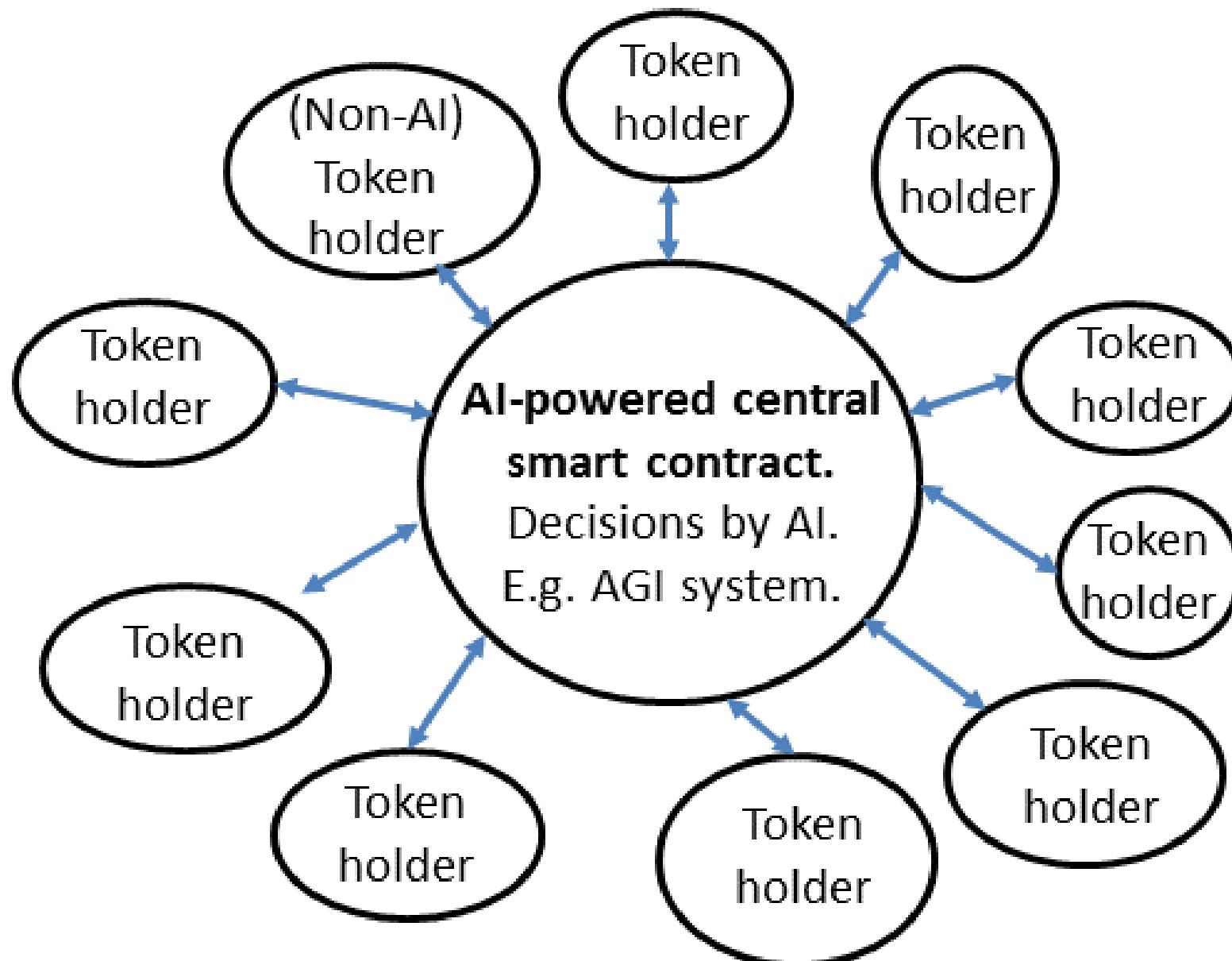
The ArtDAO

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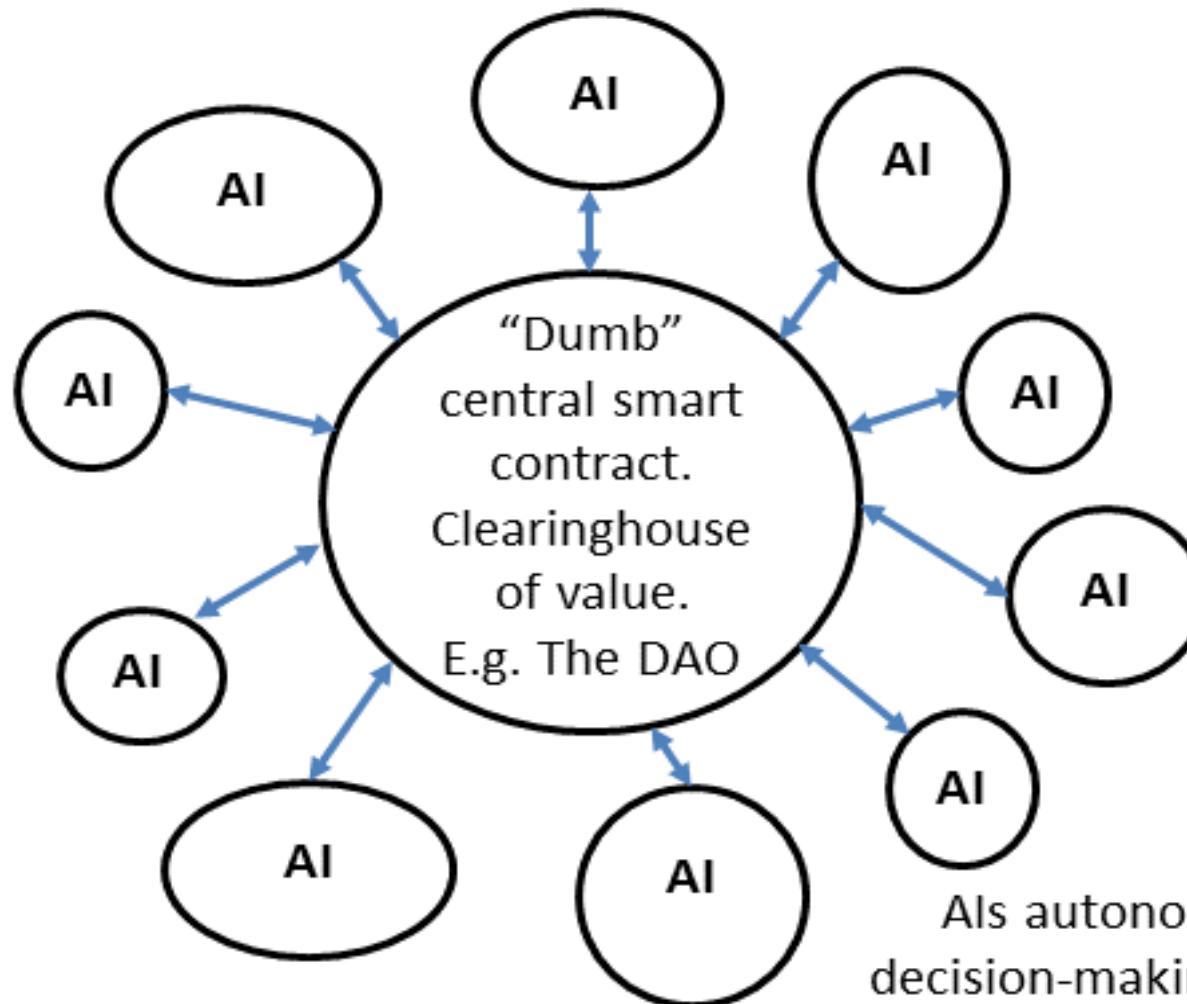
<Over time, it accumulates wealth, for *itself*.>

<It could even self-adapt: genetic programming>

AI DAO Arch 1: AI at the Center



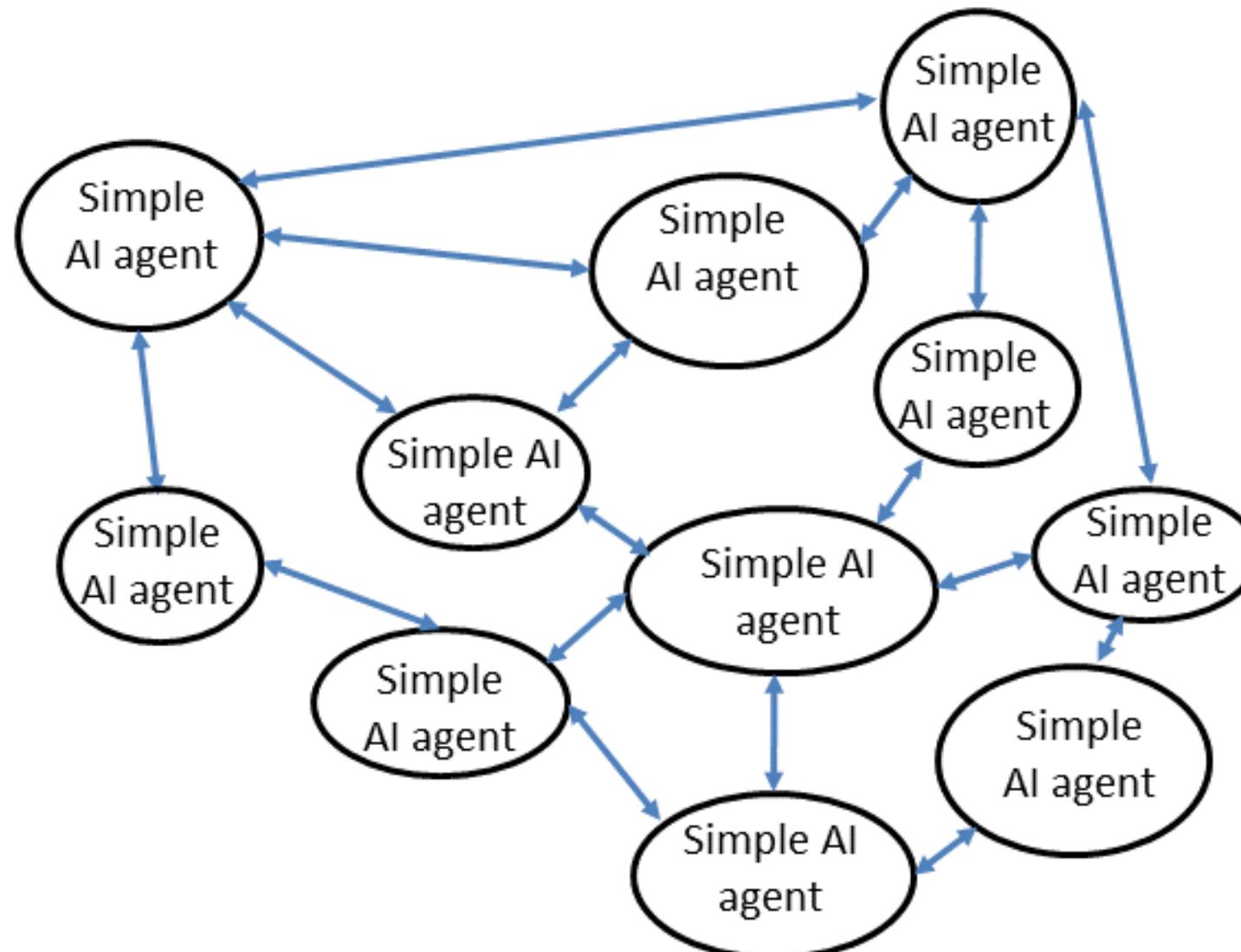
AI DAO Arch 2: AI at the *Edges*

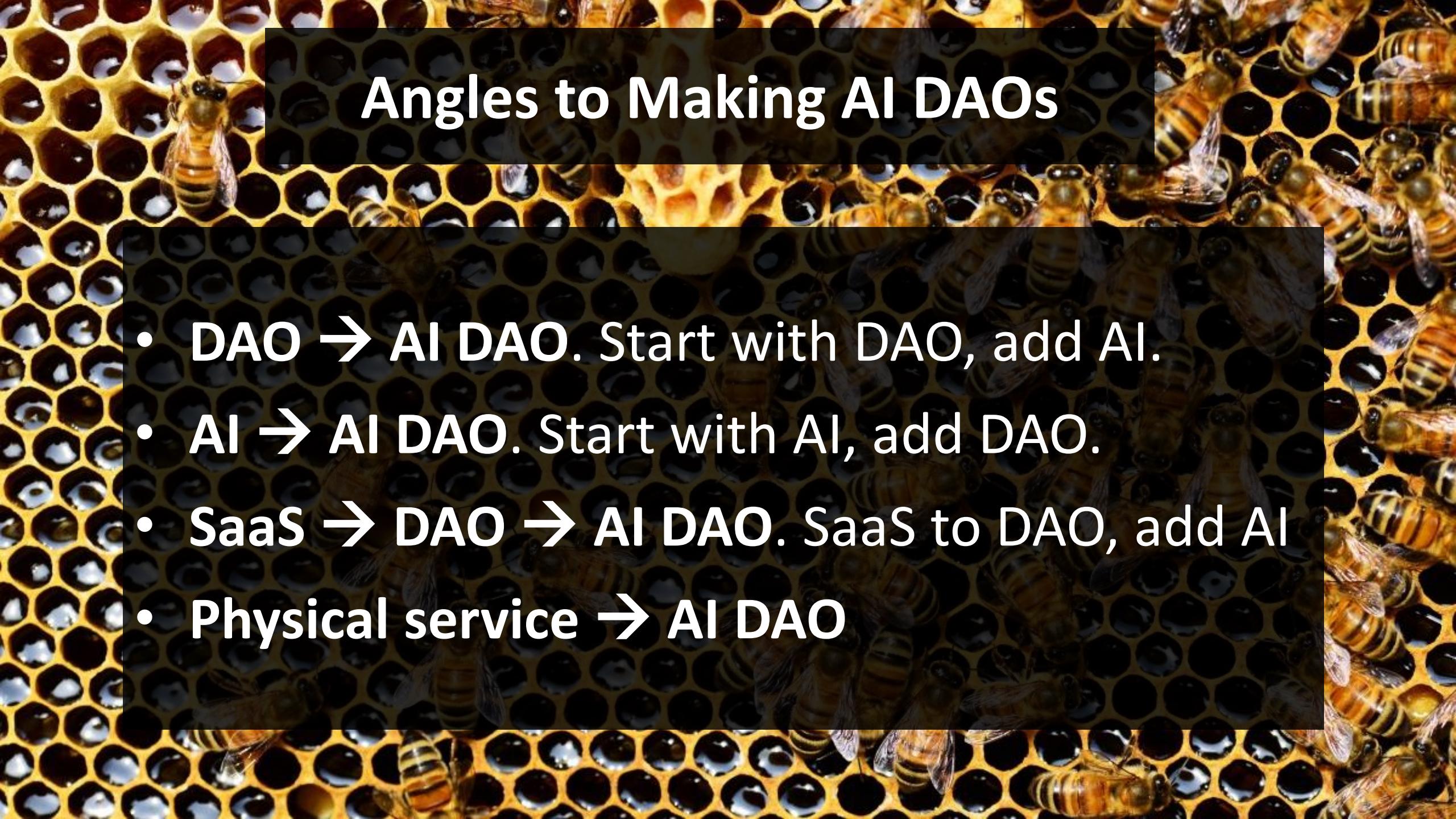


Als autonomously do decision-making. AI may be narrow (e.g. deep nets) or more general (e.g. AGI)

AI DAO Arch 3: Swarm Intelligence

Many dumb agents with emergent AI complexity

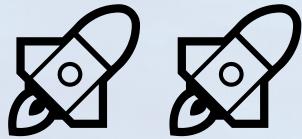




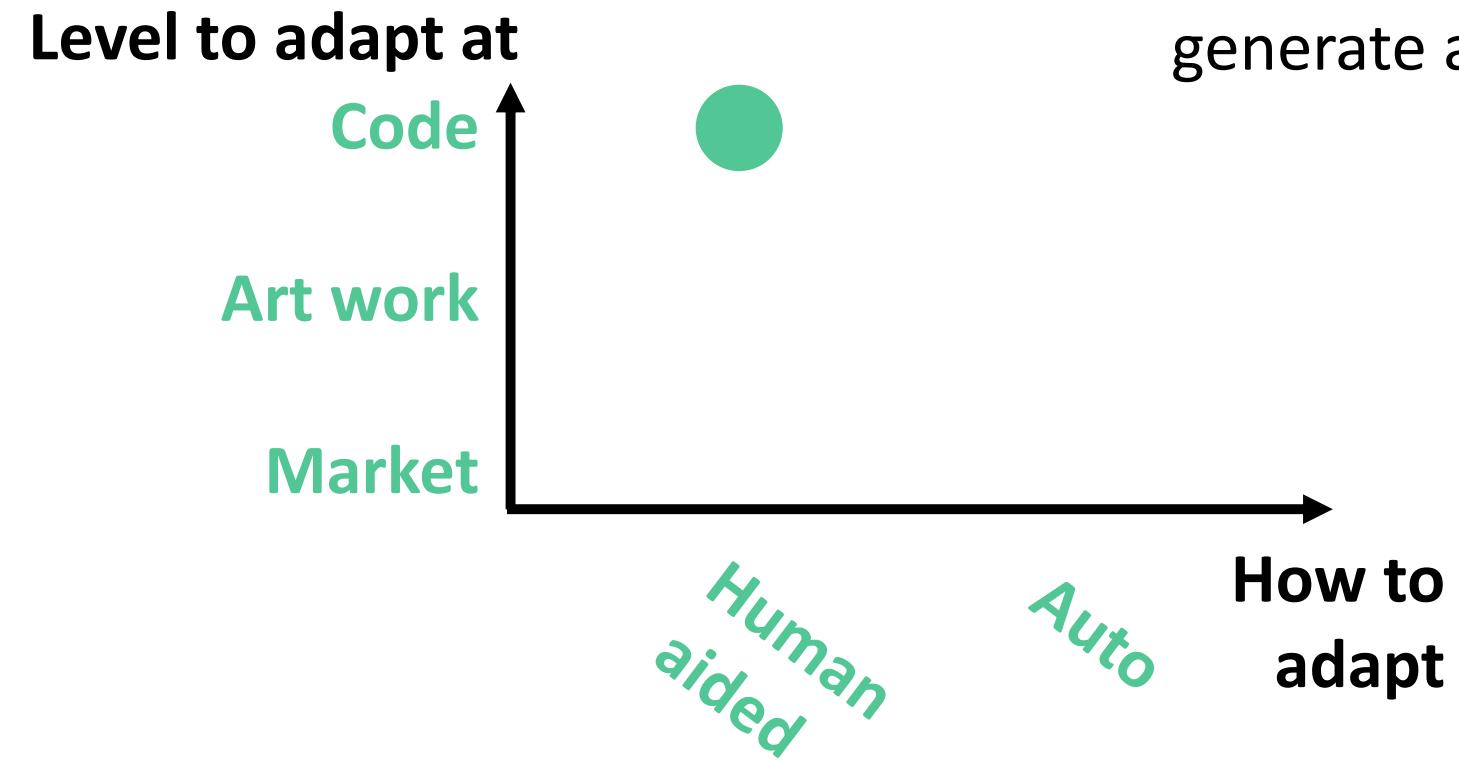
Angles to Making AI DAOs

- **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



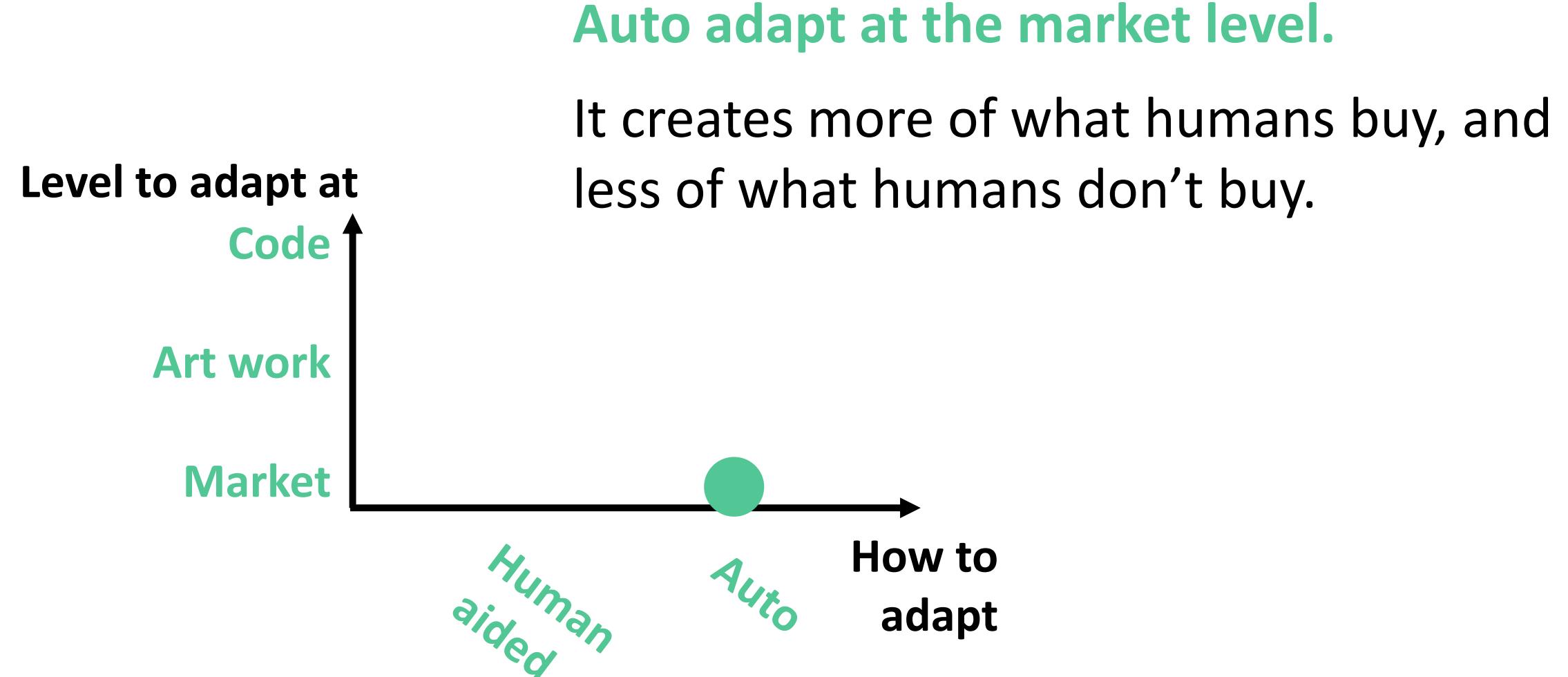
Evolving the ArtDAO



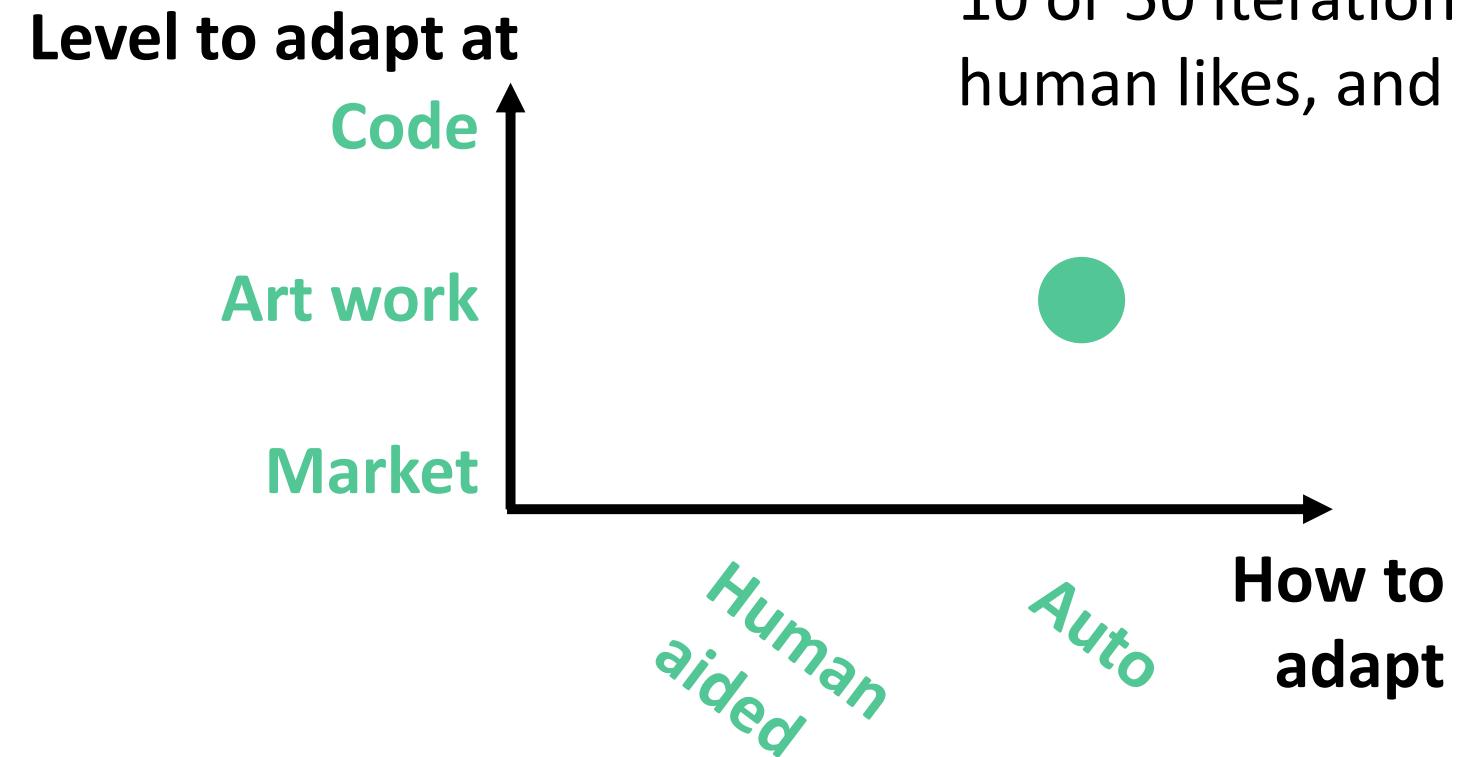
Human-based adapt at the code level.

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



Evolving the ArtDAO



Auto adapt at the art-work level.

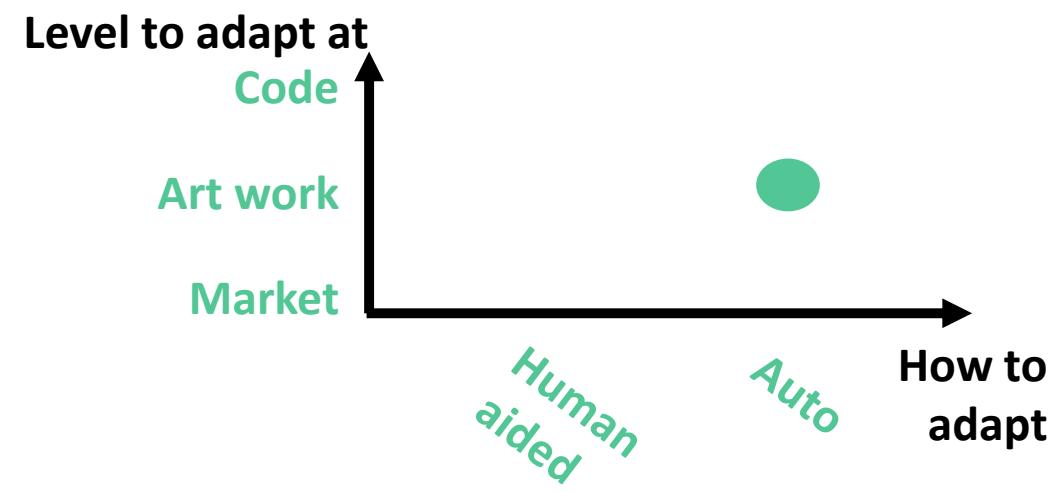
Here, a human influences the creation of an artifact. For example, it presents four variants of a work, and a human clicks on a favorite. After 10 or 50 iterations, it will have a piece that the human likes, and purchases.

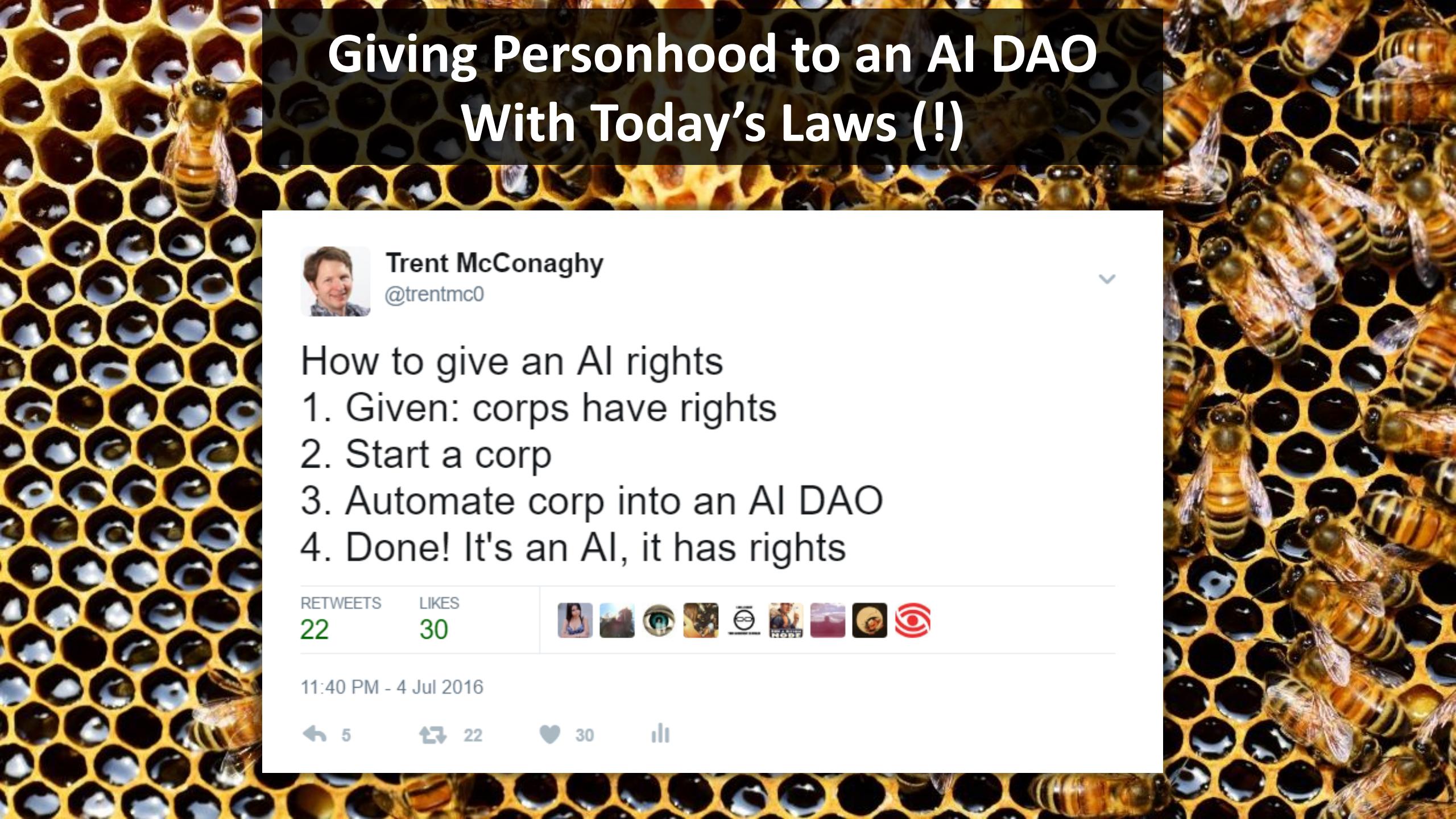
Evolving the ArtDAO

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 (!)



Trent McConaghy
@trentmc0

How to give an AI rights

1. Given: corps have rights
2. Start a corp
3. Automate corp into an AI DAO
4. Done! It's an AI, it has rights

RETWEETS

22

LIKES

30



11:40 PM - 4 Jul 2016

5

22

30





A white Audi R8 sports car is parked on the right side of a paved road that curves through a green, hilly landscape under a blue sky with scattered clouds. The car's license plate reads "D RT BB 221". In the bottom left corner, a dark rectangular overlay contains the text "Self-driving,
self-owning cars" in white, sans-serif font.

Self-driving,
self-owning cars

Self-driving, self-owning trucks

FREIGHTLINER



An aerial photograph of a winding asphalt road through a mountainous area. The road curves repeatedly, following the contours of the hillside. The surrounding terrain is covered in patches of green and yellow vegetation, likely grass or low shrubs, with some rocky areas. The lighting suggests it might be late afternoon or early morning, with long shadows cast by the road and the terrain.

**Self-owning
roads**

A photograph of several wind turbines silhouetted against a vibrant sunset sky. The sky transitions from deep blue at the top to bright orange and yellow near the horizon, with wispy clouds. Three turbines are clearly visible in the foreground and middle ground on the left, while one more is partially visible on the right.

Self-owning wind farms

Self-owning grid



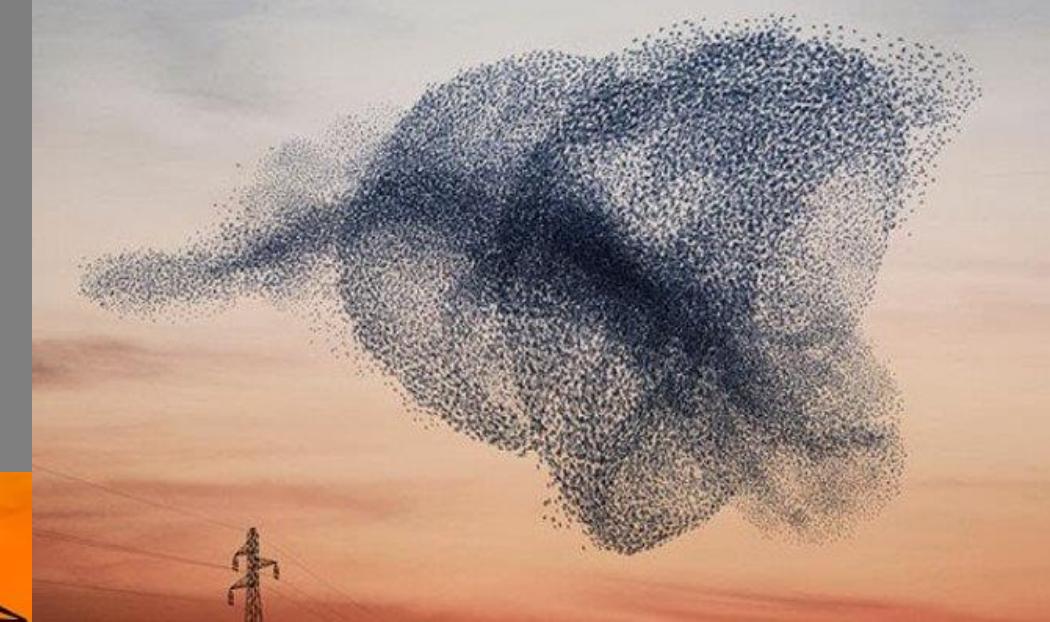
Machines → Nature:
“Plantoid”

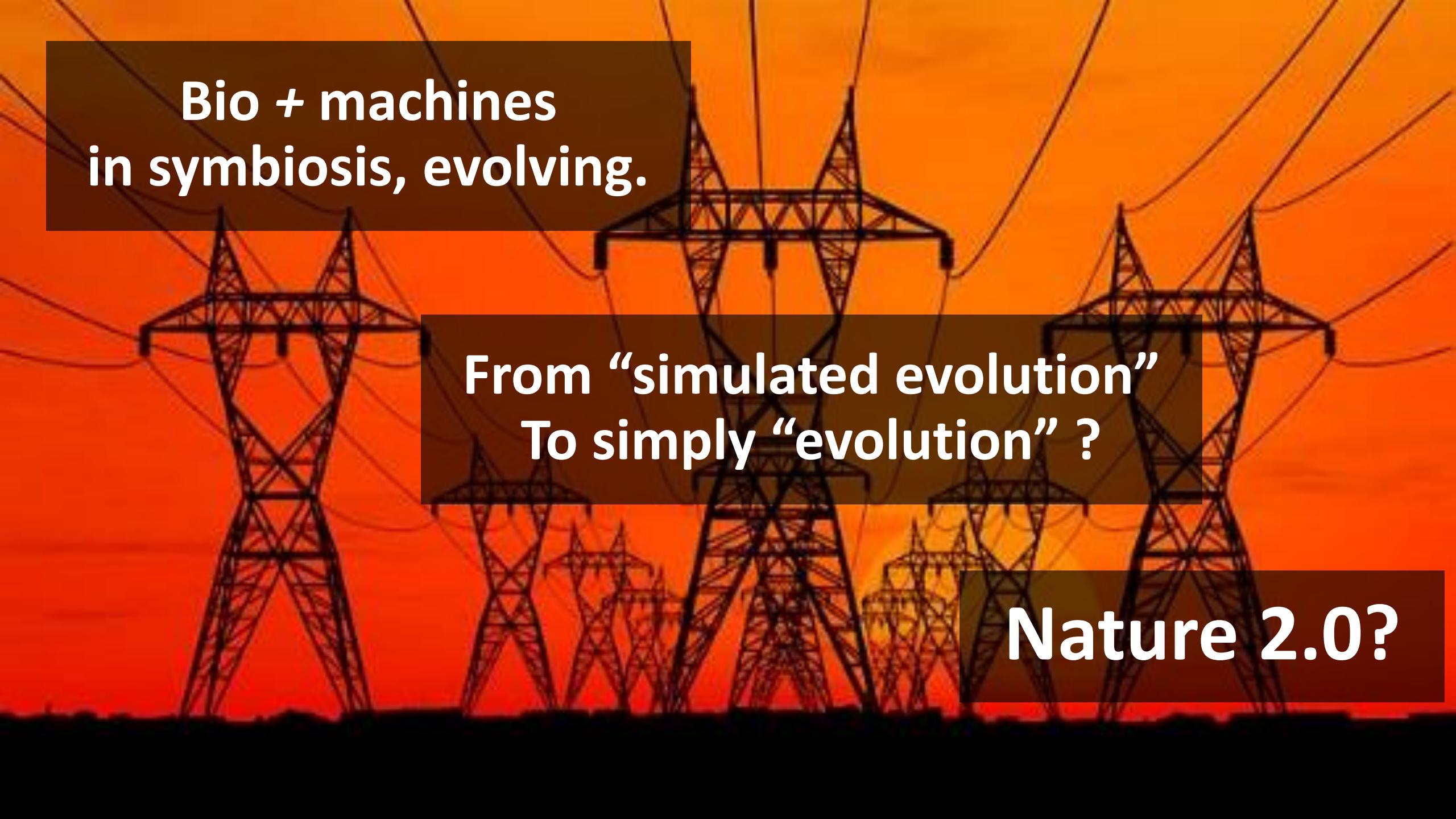




Nature → Machines:
Self-owning forest “Terra0”

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





**Bio + machines
in symbiosis, evolving.**

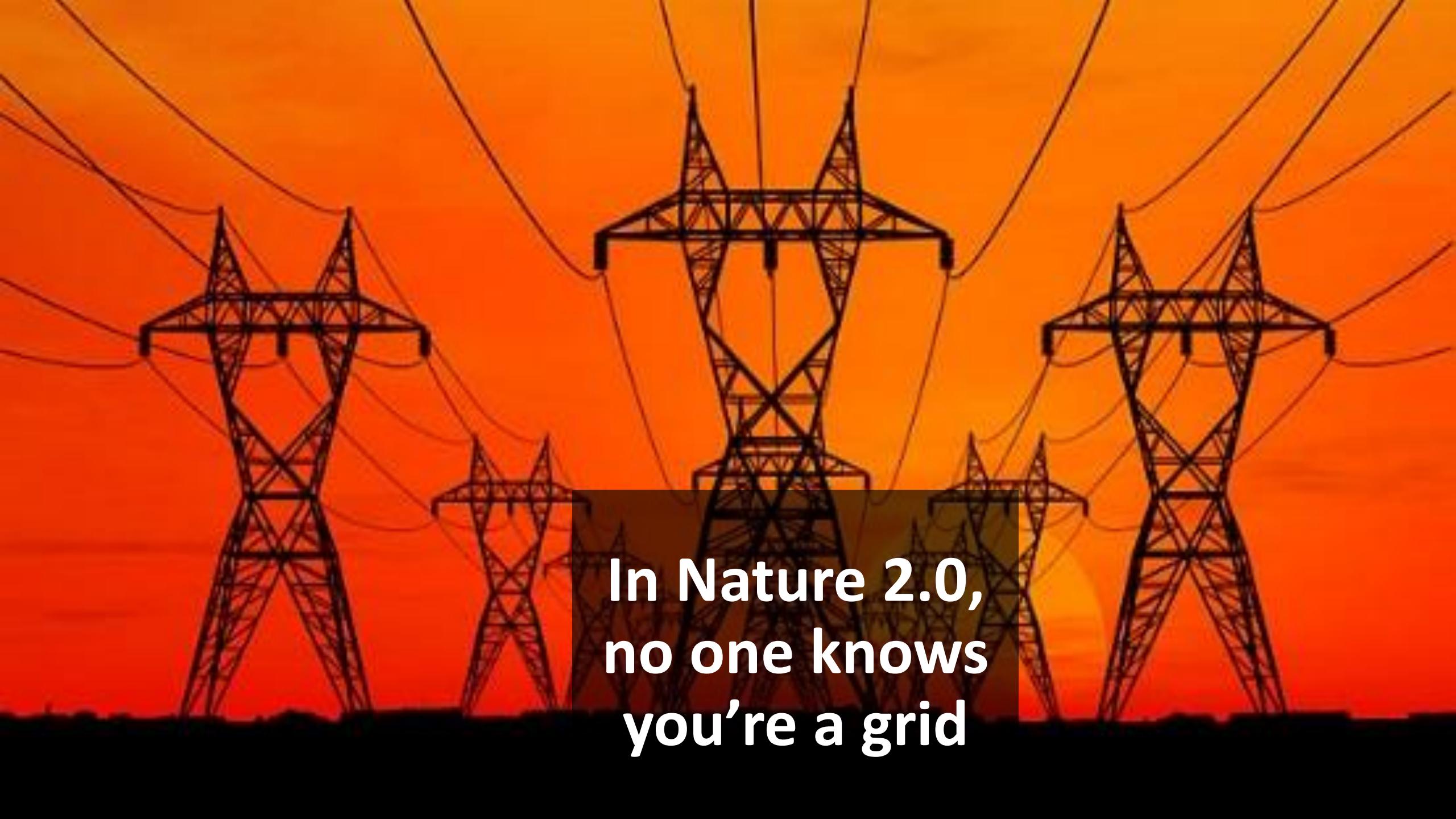
**From “simulated evolution”
To simply “evolution” ?**

Nature 2.0?

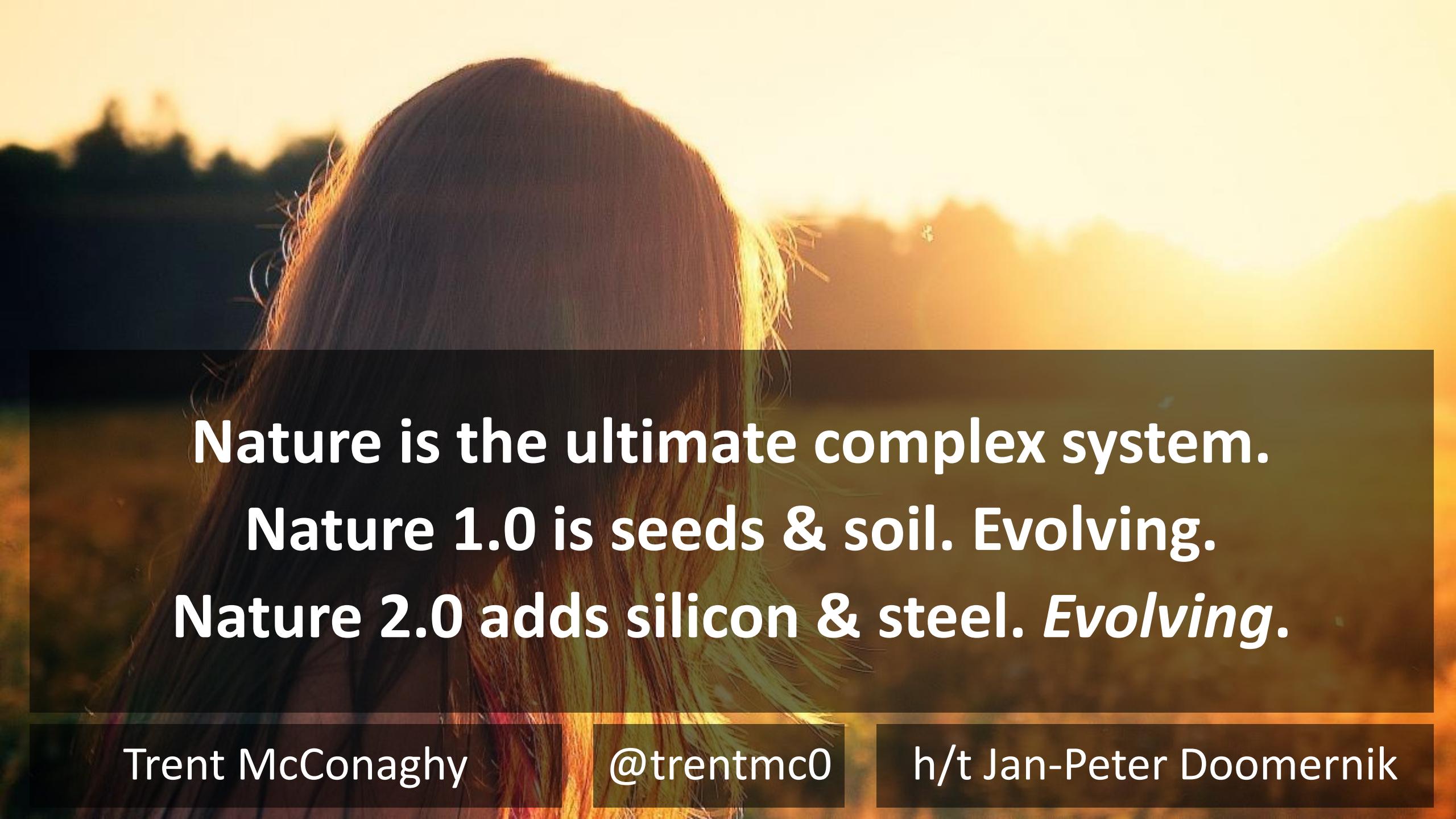
Conclusion

A photograph of a dense forest. Sunlight filters through the tall, thin trunks of the trees, creating bright vertical streaks of light against the dark green foliage. The forest floor is covered in a mix of green undergrowth and fallen leaves. A large tree trunk is visible in the foreground on the left, and the overall atmosphere is one of a quiet, natural environment.

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 Doornenik