

An Example-Based Intro to AI, And Possible AI Futures

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Solido // BigchainDB

Introduction to AI, By Example

What's Artificial Intelligence (AI)?

Original:

AI: “A machine that can replicate human cognitive behavior” [Turing test]

Now:

AI: “A machine that can perform a cognitive task, that was previously only possible with a human” [AlphaGo]

+

“A machine that can perform a non-analytical information processing task, at speed / accuracy / capacity *not possible by a human.*” [Driving Moore's Law]

What's Artificial Intelligence (AI)?

AI has a toolbox of ways to solve:

- Classification
- Regression
- Density estimation
- Rare event estimation
- Knowledge extraction
- Optimization
- Active analytics
- Structural design
- Control / autonomy
- ...



For application to:

- Operations
- Product
- Services



Example biz benefits:

- Shorter time to market
- Lower cost
- Higher yield
- New features possible
- New products possible

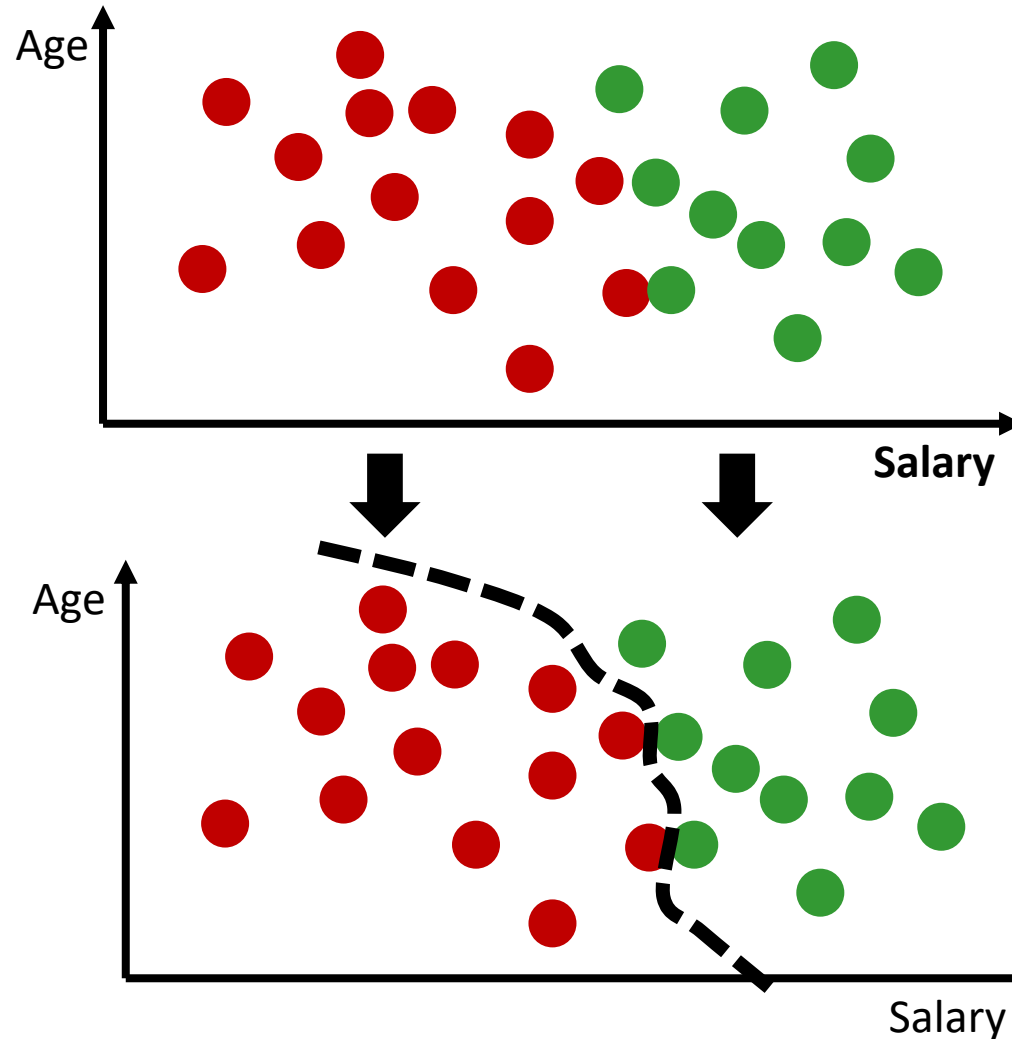
Let's explore these more...

Classification, in 2D

Use case: credit card applications

Credit profile:

- Paid bills
- Didn't pay



How: linear classifiers, neural networks / deep learning, support vector machines, boosted trees, random forests / bagged trees

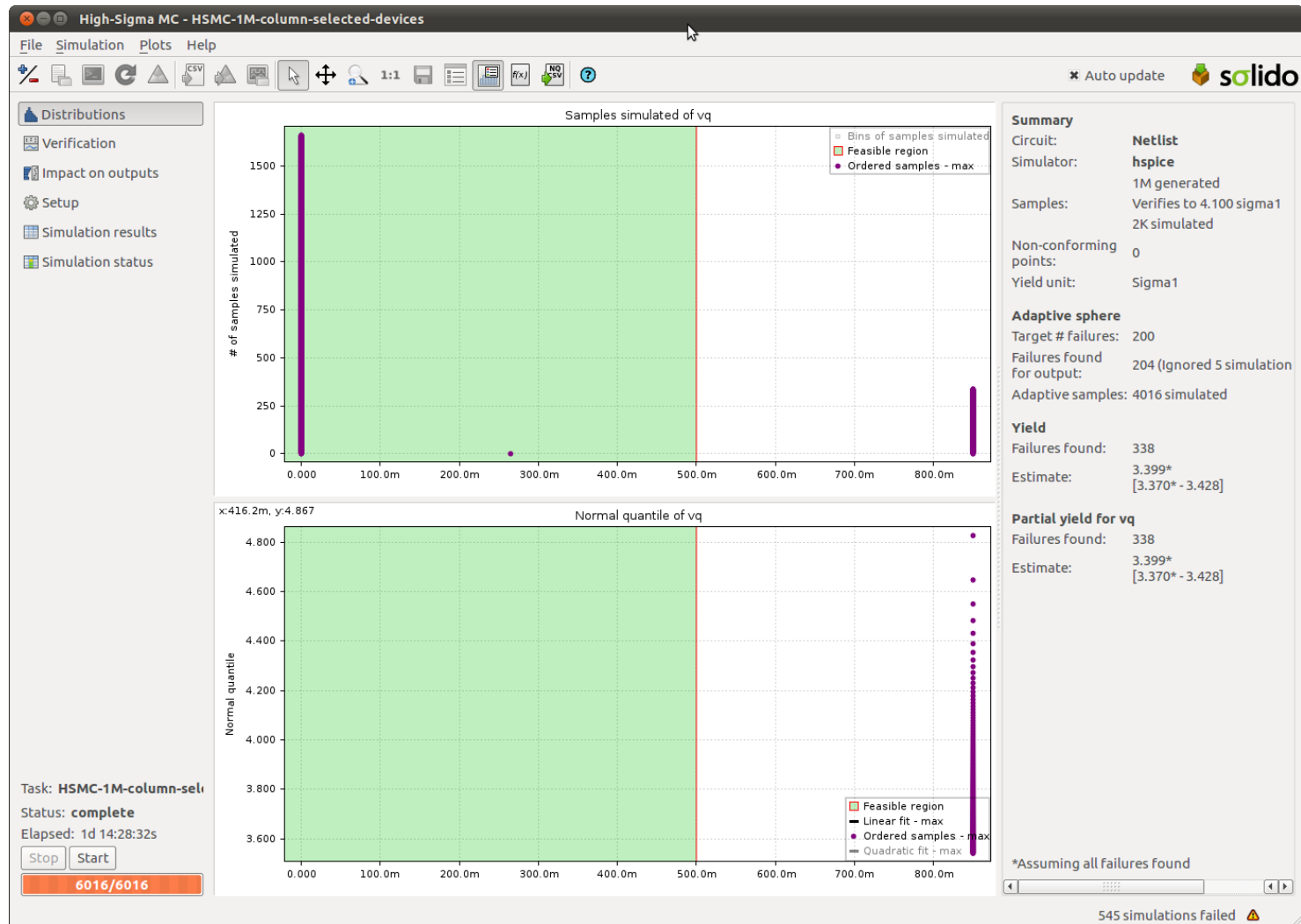
Classification in 20D

Use case: audio radar for tanks [McC '97 Natl Def.]

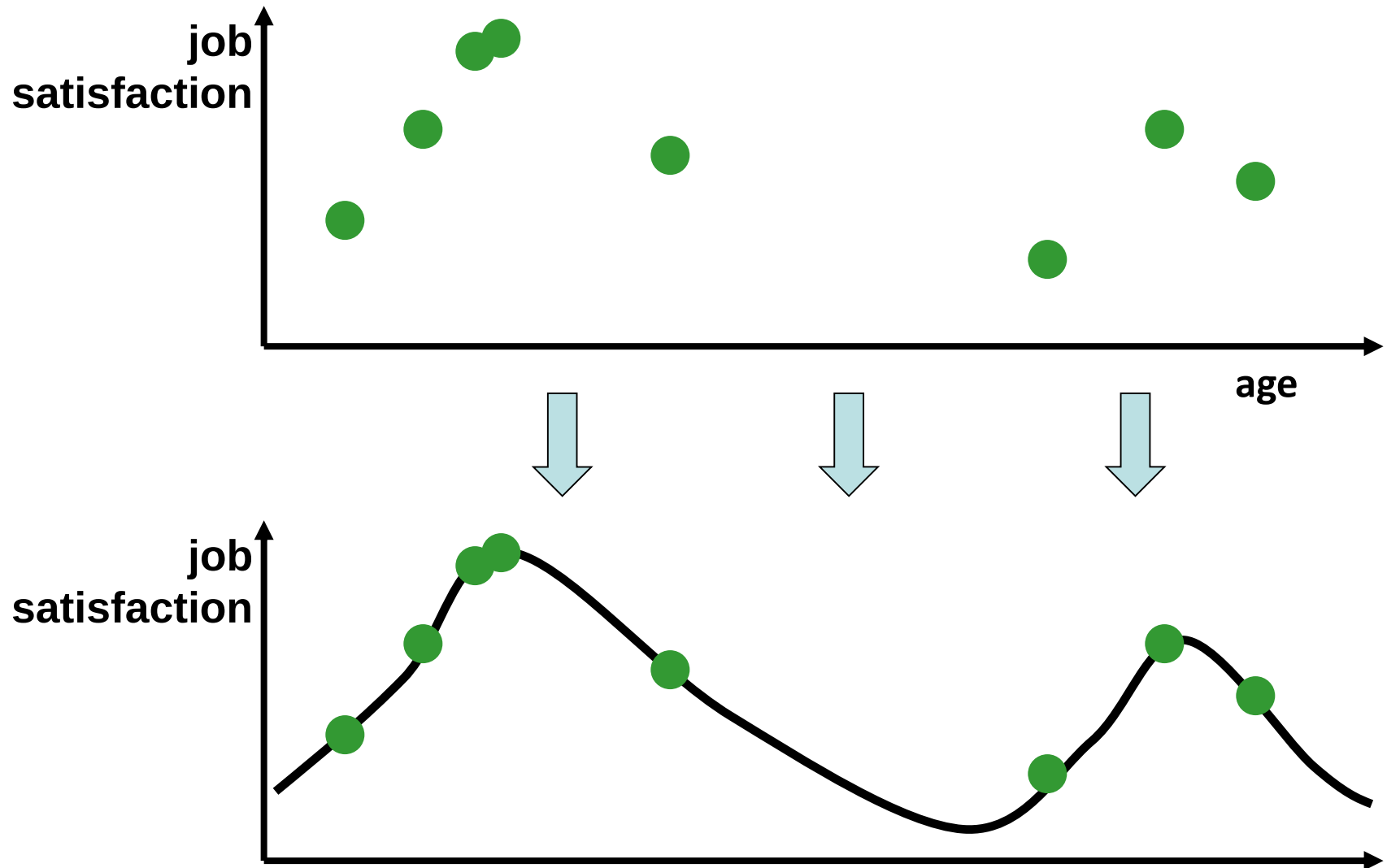


Classification in 10,000 D

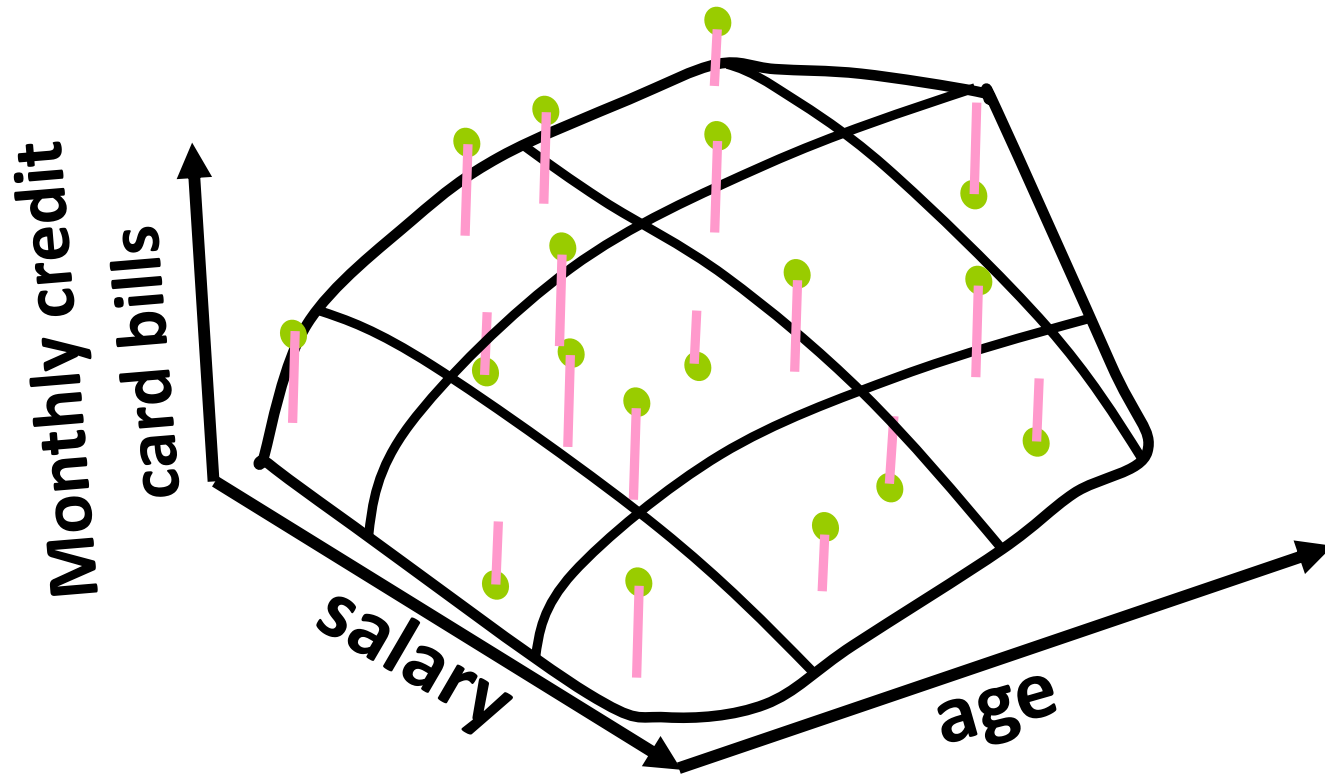
Use case: yield of memory columns [McC '12 Solido]



Regression, in 1D



Regression, in 2D



Regression in 10,000D

Use case: reverse image search [Google]

Videos

News

More

Sort by relevance

Sort by subject

Any size

Large

Medium

Icon

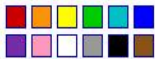
Larger than...

Exactly...

Any color

Full color

Black and white



Any type

Face

Photo

Clip art

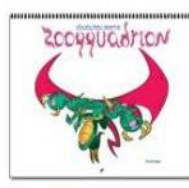
Line drawing

Standard view

Show sizes

Any time

Past week

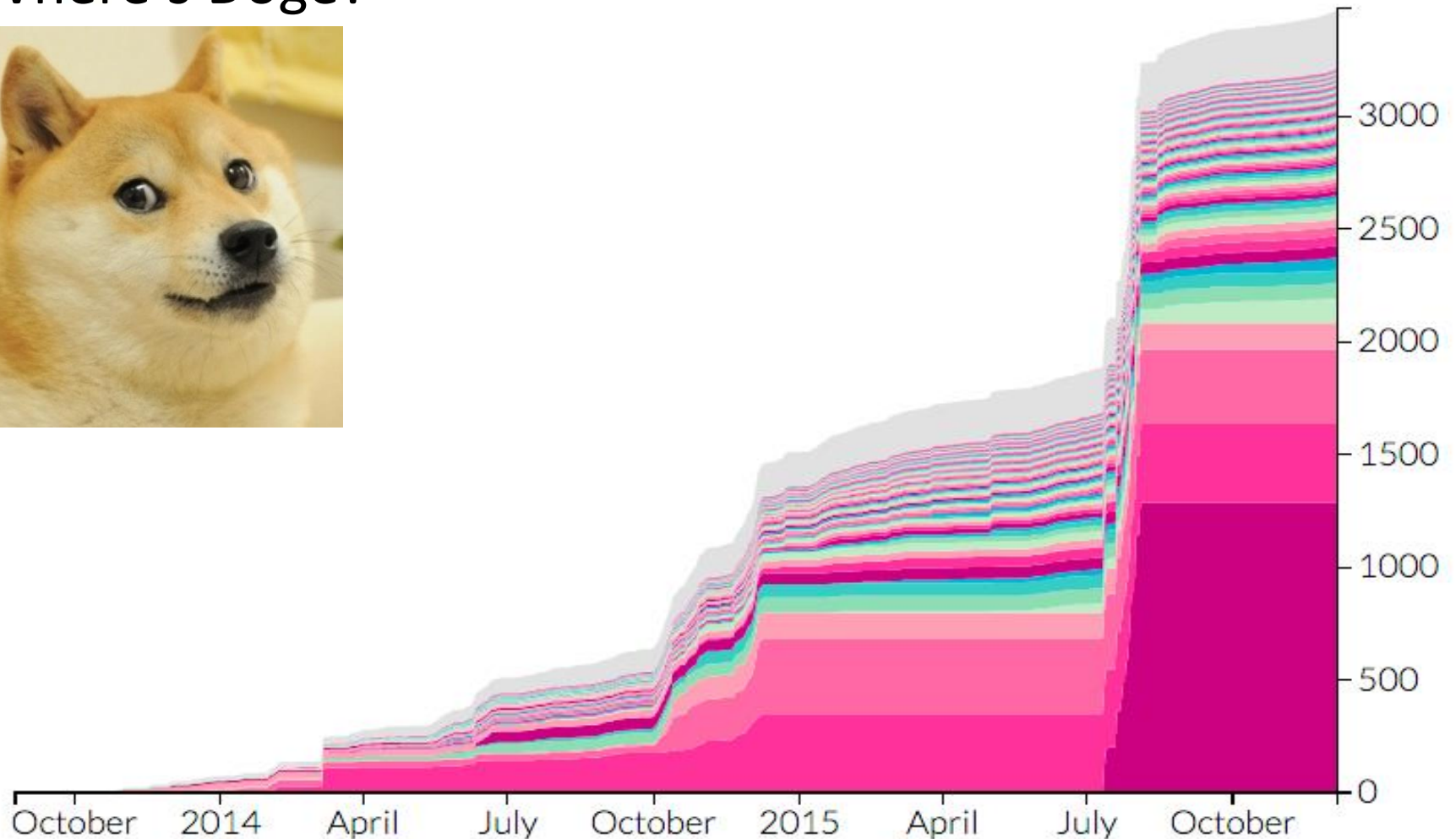
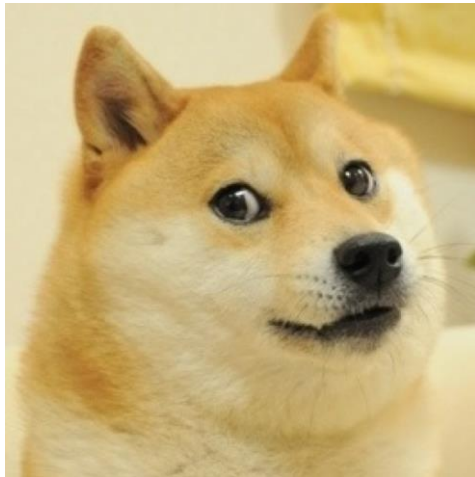


Regression in 10,000D

Use case: reverse image search *with provenance*

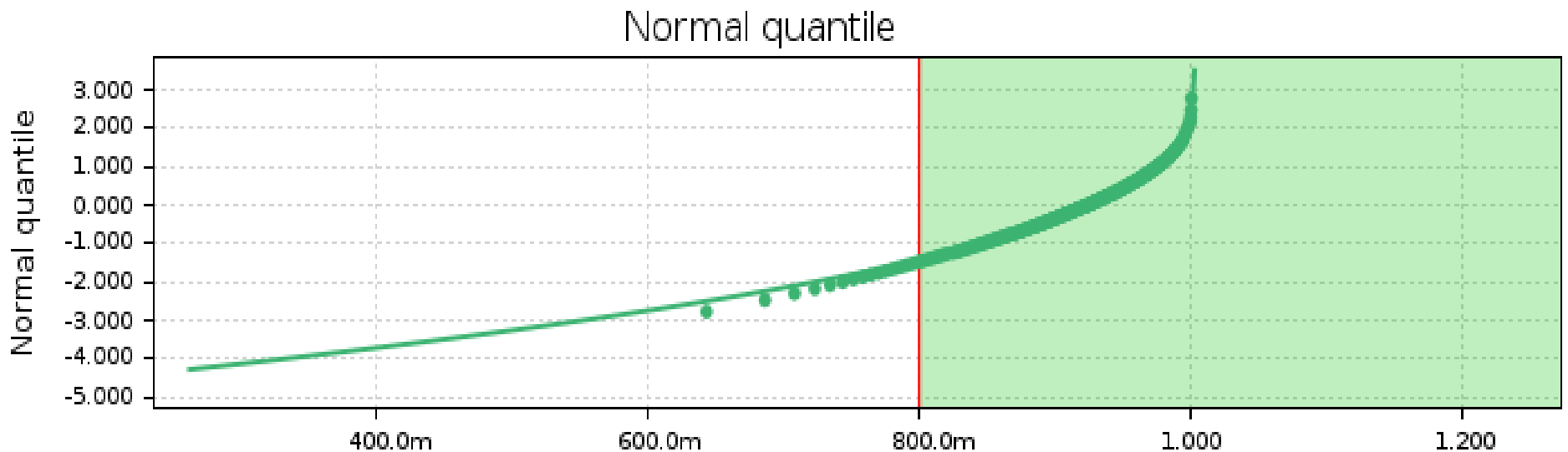
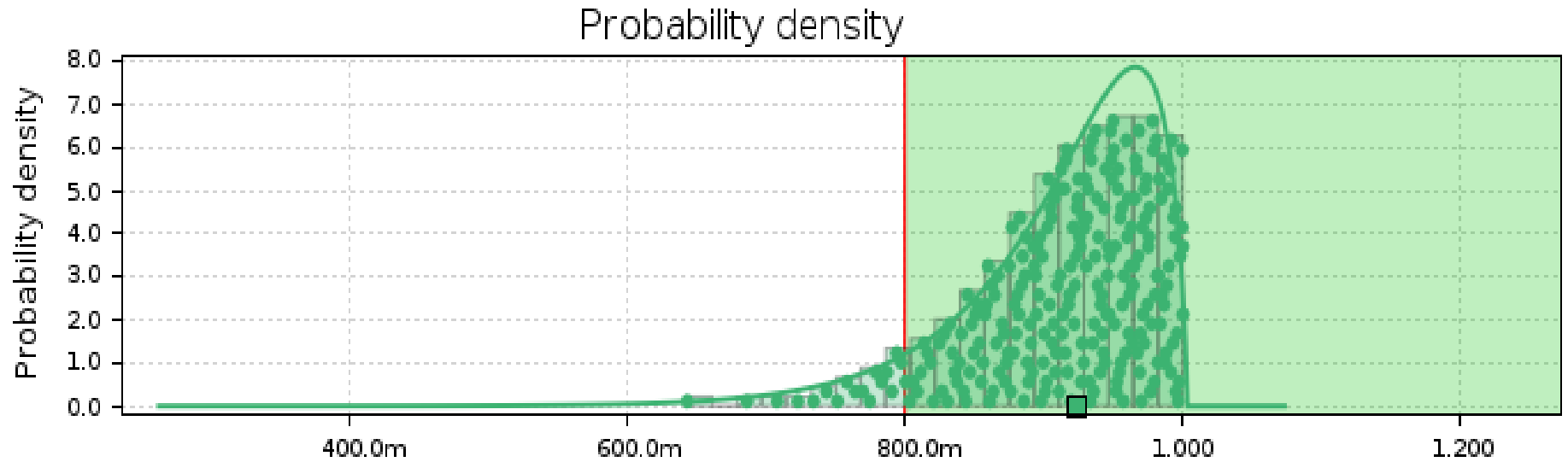
[McC '15 whereonthe.net // BigchainDB]

“Where’s Doge?”



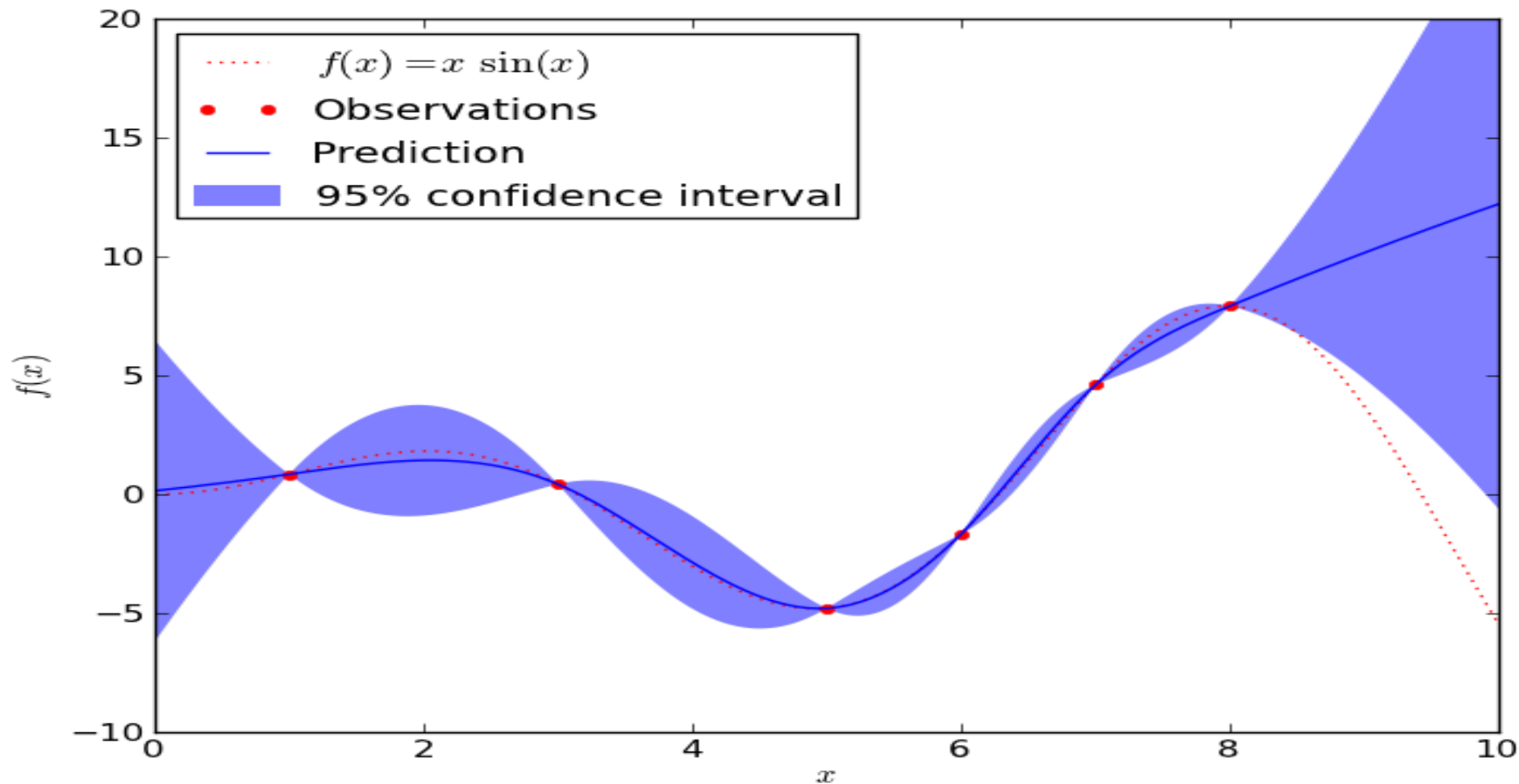
Density Estimation // Fitting a PDF

Use case: 3-sigma circuit analysis [McC '08 Solido]



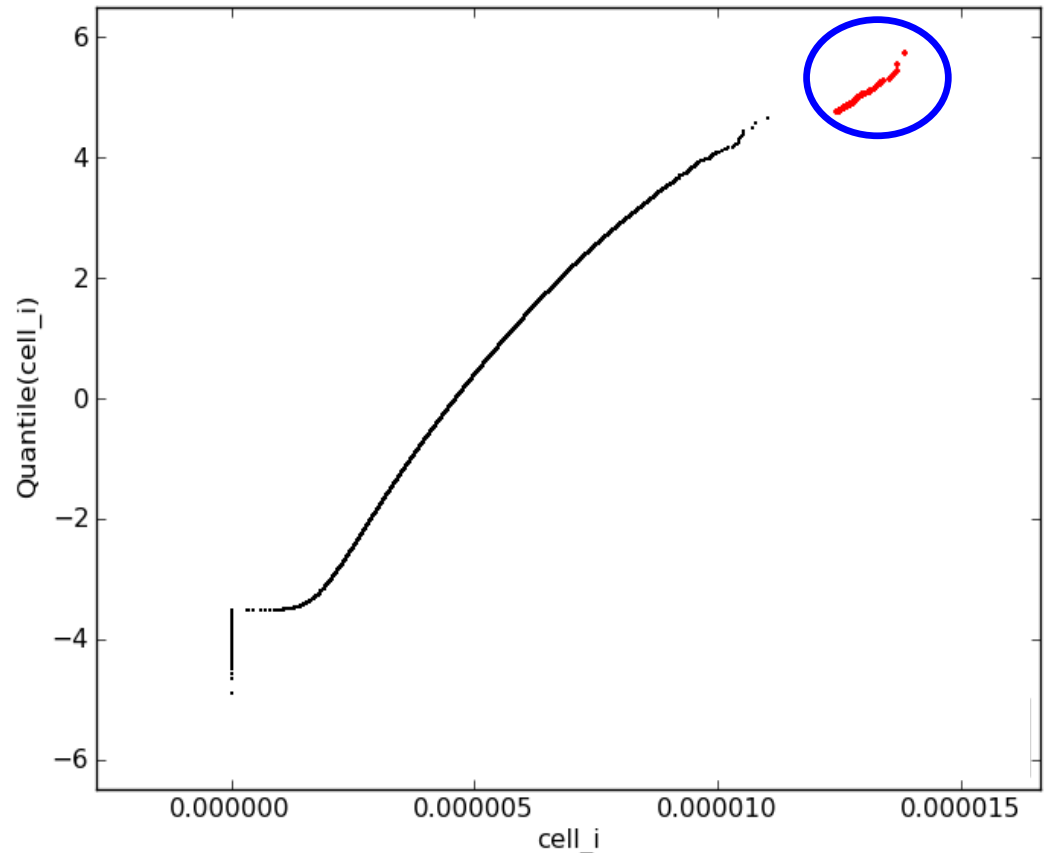
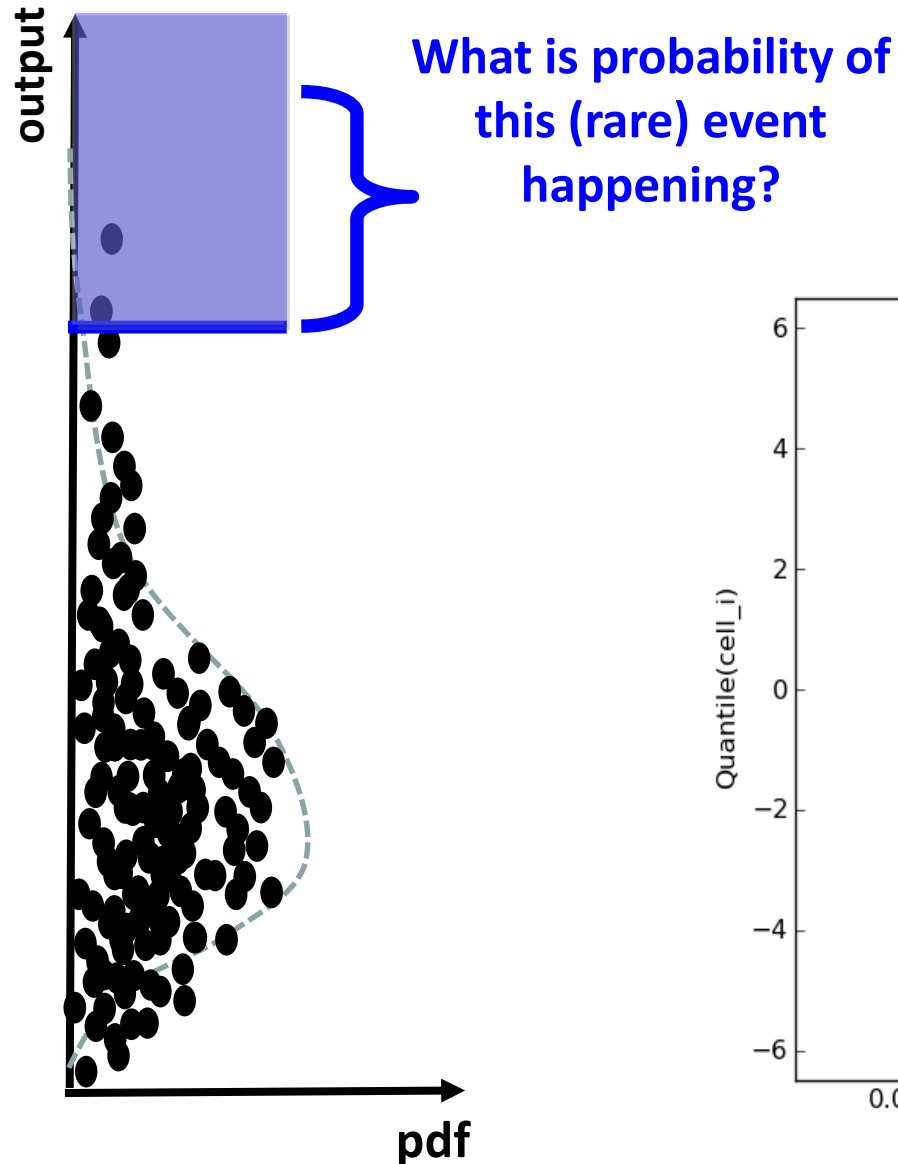
Density estimation // Fitting a PDF

Use case: regression with Confidence Intervals, for predictive circuit design [McC '11 Solido]



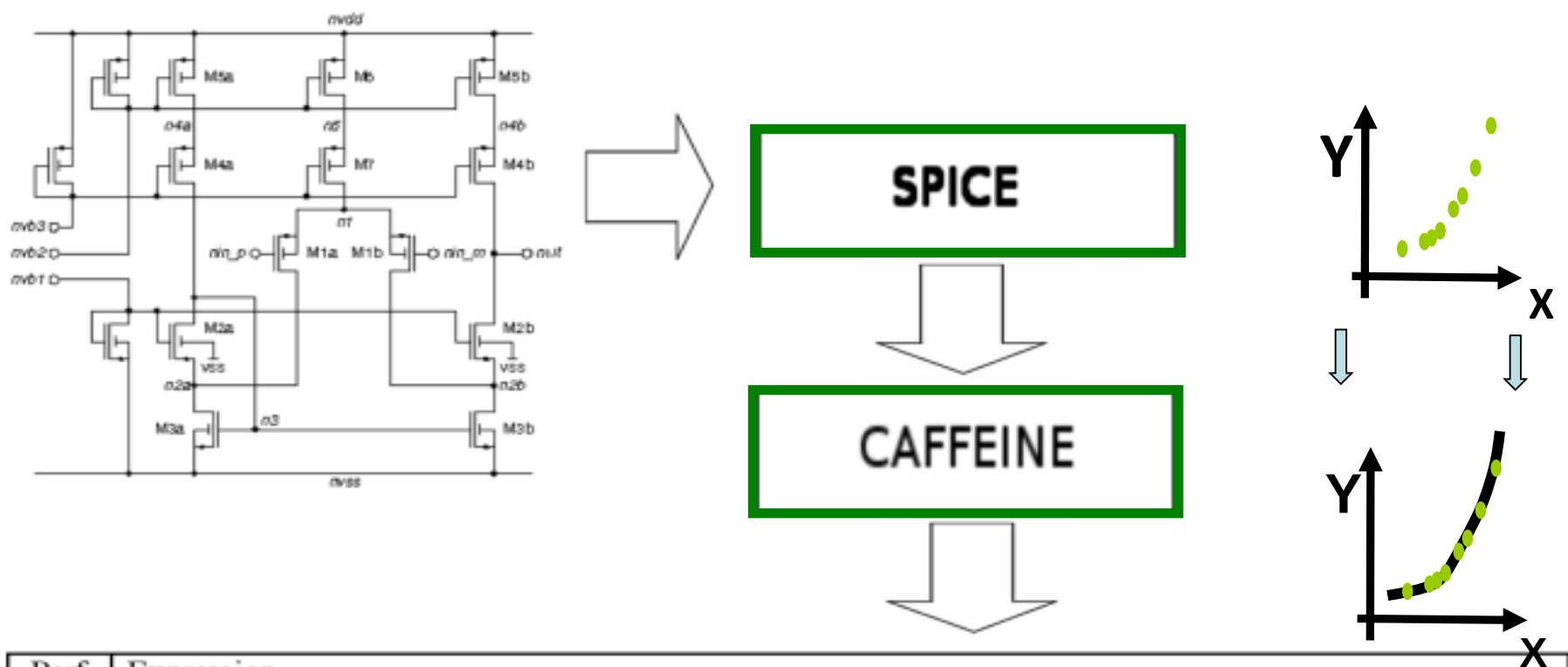
Rare event estimation / “Black swan” simulation

Use Case: 6-sigma analysis of bitcells [McC ‘09 Solido]



Knowledge extraction

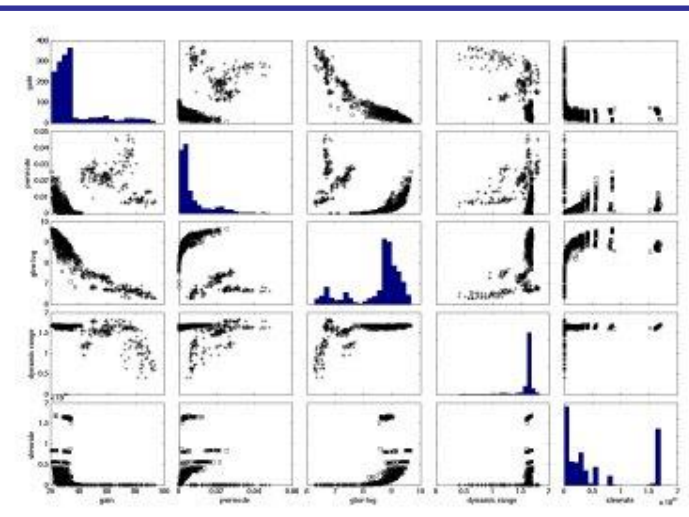
Use case: scientific modeling of analog ccts [McC '05 KUL]



Perf.	Expression
A_{LF}	$-10.3 + 7.08e-5 / id1 + 1.87 * \ln(-1.95e+9 + 1.00e+10 / (vsg1*vsg3)+ 1.42e+9 *(vds2*vds5) / (vsg1*vgs2*vsg5*id2))$
f_u	$10^{(5.68 - 0.03 * vsg1 / vds2 - 55.43 * id1+ 5.63e-6 / id1)}$
PM	$90.5 + 190.6 * id1 / vsg1 + 22.2 * id2 / vds2$
V_{offset}	$- 2.00e-3$
SR_p	$2.36e+7 + 1.95e+4 * id2 / id1 - 104.69 / id2 + 2.15e+9 * id2 + 4.63e+8 * id1$
SR_n	$- 5.72e+7 - 2.50e+11 * (id1*id2) / vgs2 + 5.53e+6 * vds2 / vgs2 + 109.72 / id1$

Knowledge extraction

Use Case: Topology decision tree [McC '08 KUL]

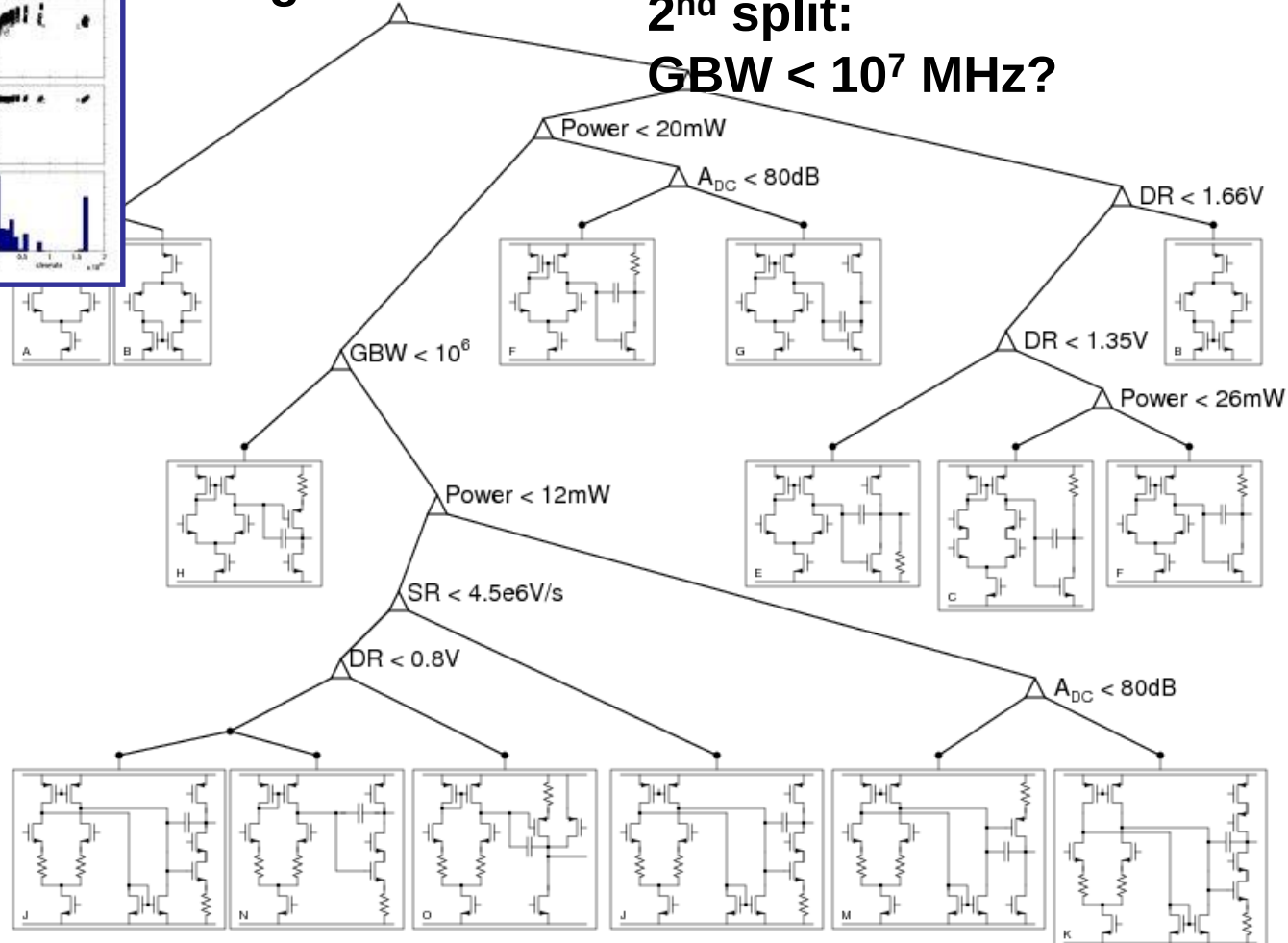


1st split:

gain < 35 dB?

2nd split:

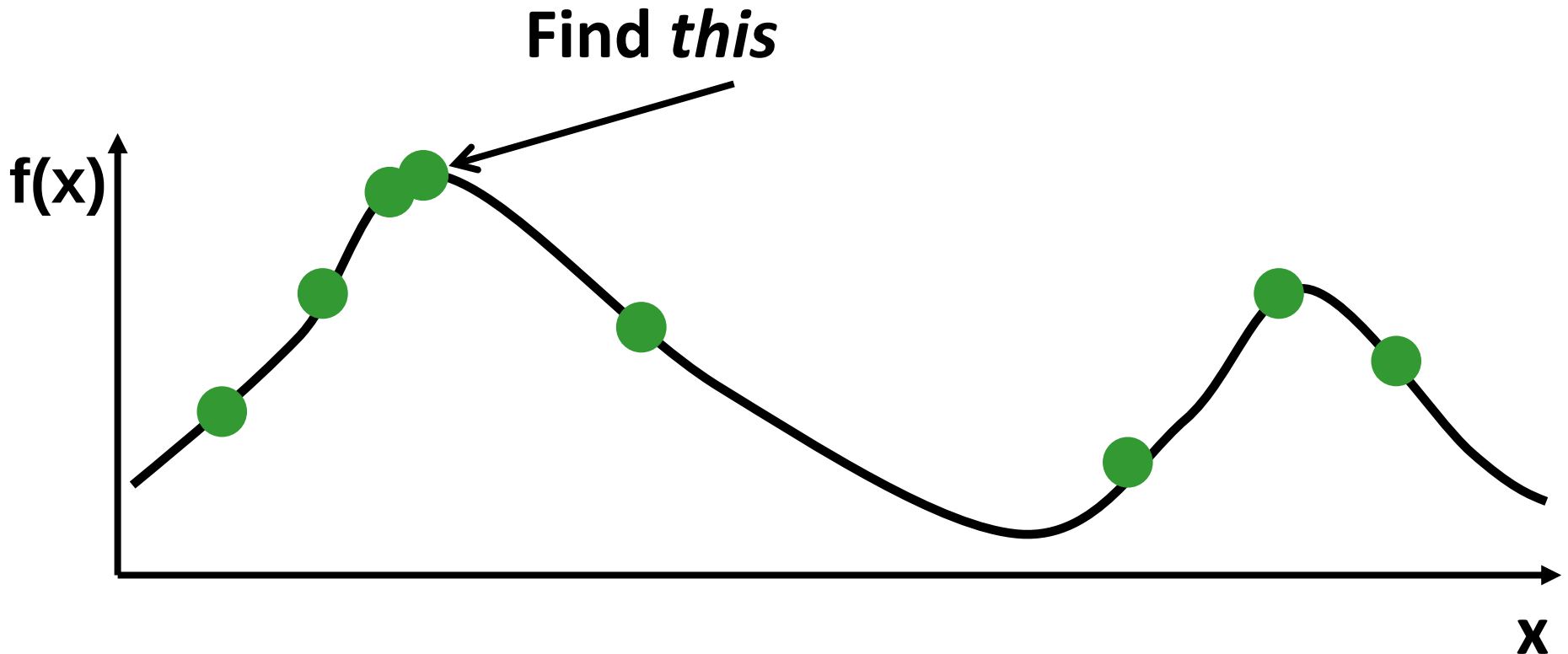
GBW < 10^7 MHz?



Optimization

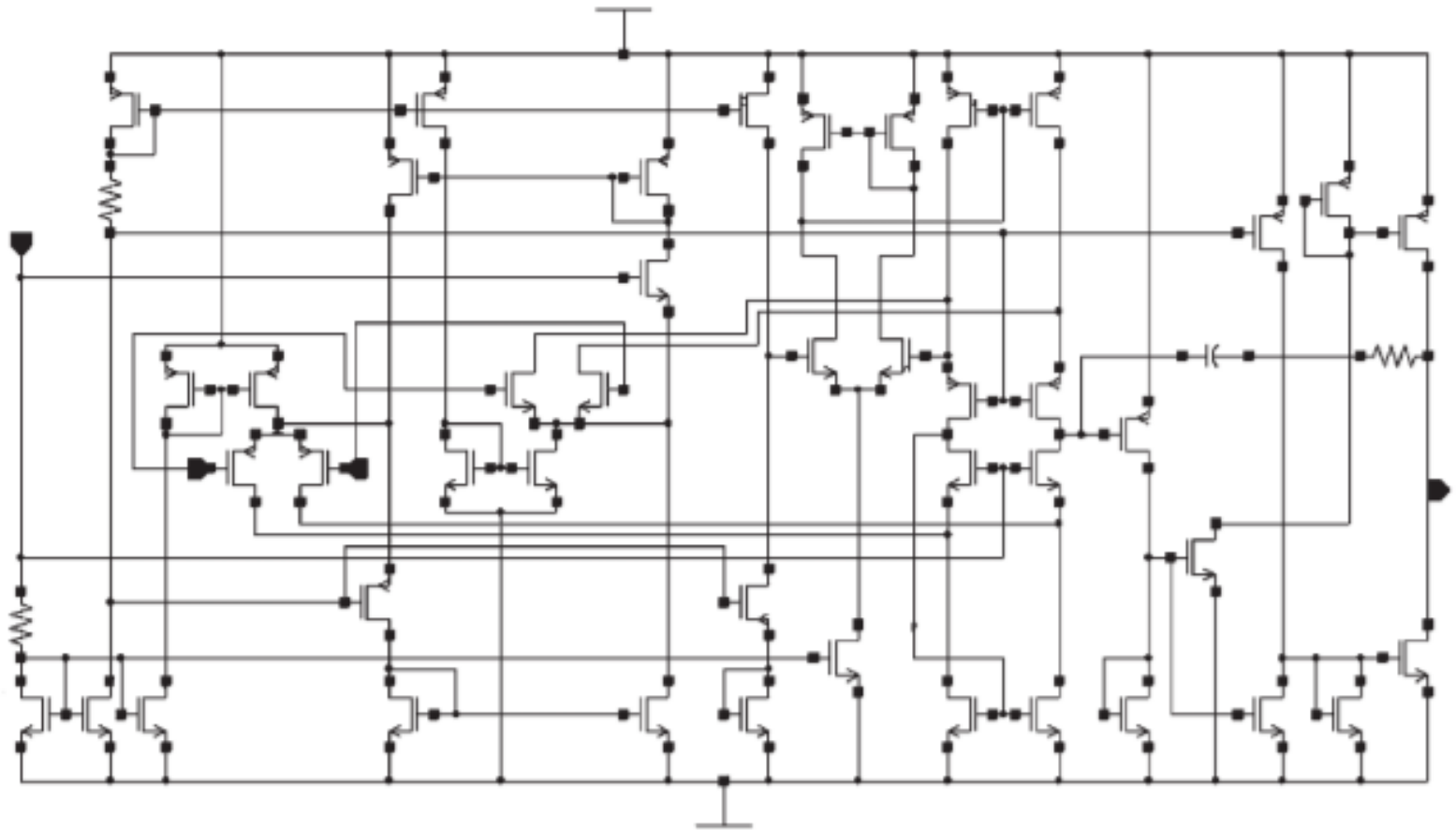
“Find the x that maximizes $f(x)$ ”

(With as few evaluations of $f(x)$ as possible)



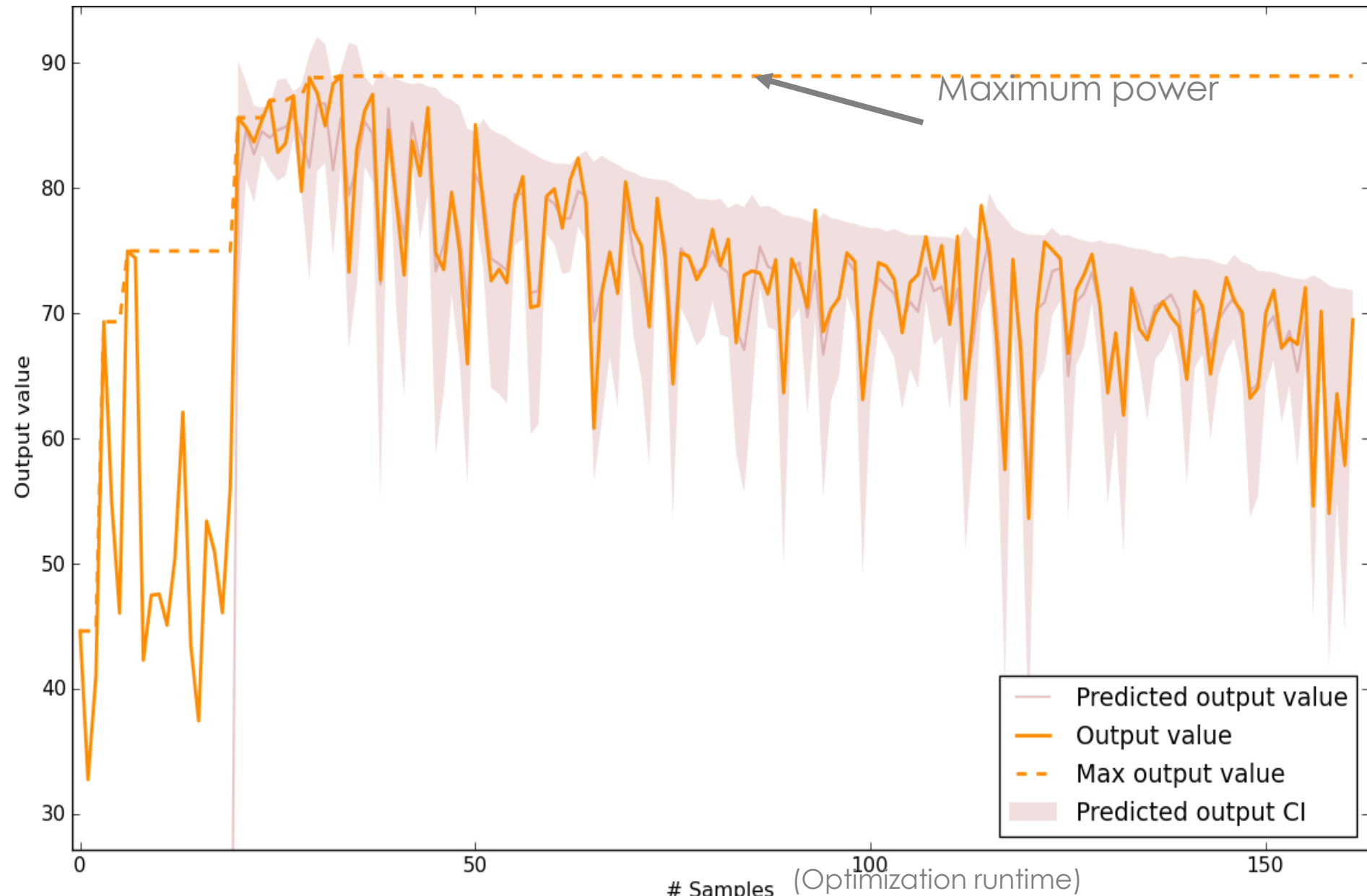
Optimization

Use Case: Optimize perf. of lg. analog circuits [McC '01 ADA]



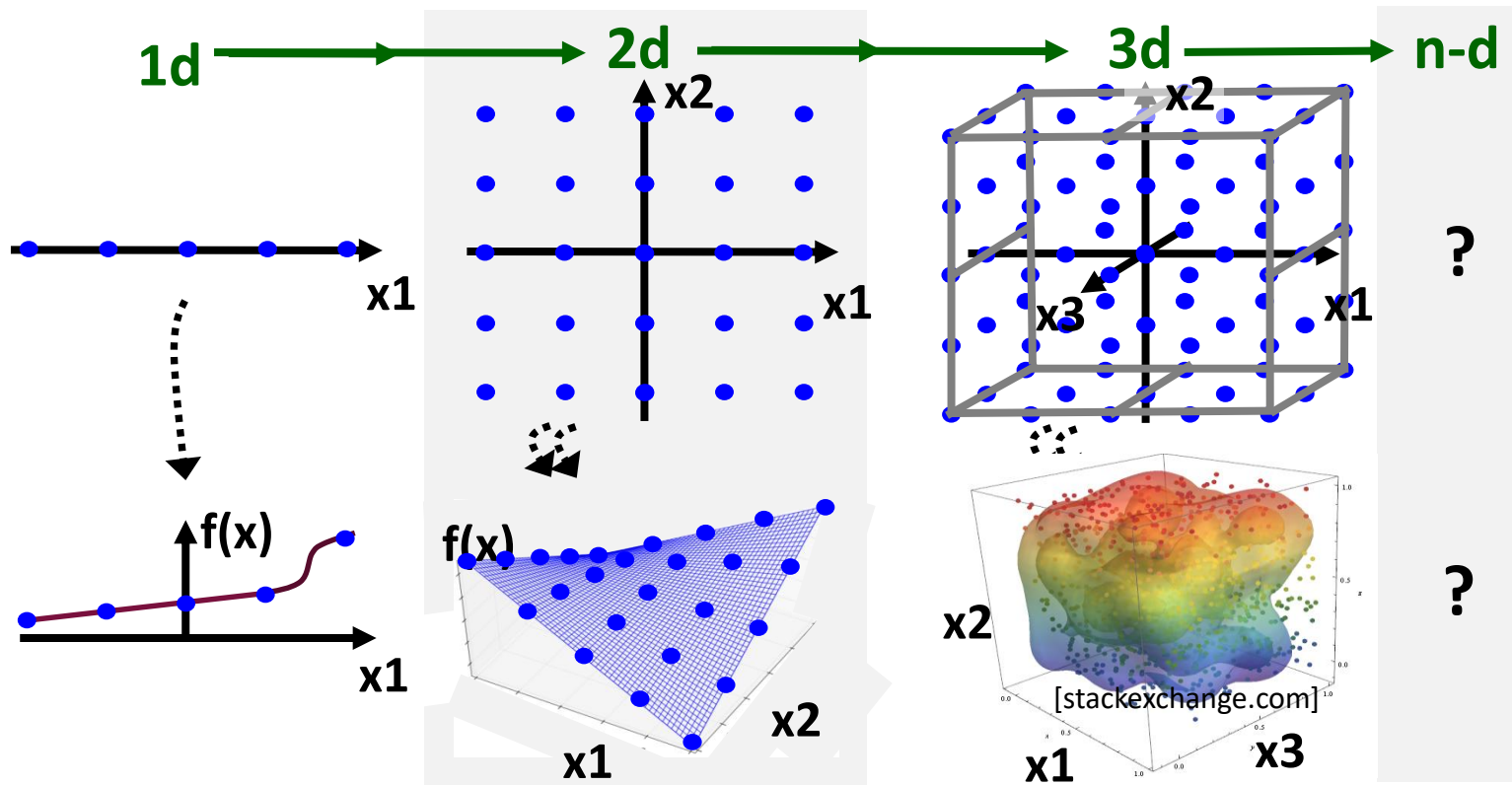
Optimization

Use Case: verify circuits for worst-case perf. [McC '09 Solido]



Active Analytics

“Find a mapping and visualize it, subject to high-d and expensive samples”



Active Analytics

Use Case: Interactive Circuit Design [McC '12 Solido]

Under the hood, a machine learning engine adaptively samples the space of possible decisions, and measures outcomes.

Explore (ID=0)	True	3.928	53.50p	137.6u
Best (1) (ID=1)	False	2.469	6.482p	64.28u
Best (2) (ID=6)	False	2.379	6.722p	

Impact	Variables	Value (Explore)
58.48%	opamp.xcm1_m1.l	300.0n
28.79%	opamp.xcm1_m1.w	2.500u
12.74%	opamp.xcm1_m1.l, opamp.xcm1_m1.w	300.0n, 2.500u

Decision variables are ranked by importance. User selects variable(s)...

... to plot predictions of outcomes at selected variables

... and explore decision space (by dragging the orange crosshairs)

More Applications of Optimization & Analytics

- Business Intelligence: optimize churn & other key performance indicators (KPIs)
- Big data infrastructure: optimize reliability / uptime, minimize power consumption, ..
- Telecom infrastructure: capital & resource allocation
- Internet / mobile: auto SEO, optimize for app store placement (rank, profitability)
- ML modeling: Find optimal model meta-parameters (DeepNN, RF, SVM, ..), for application to computer vision etc.

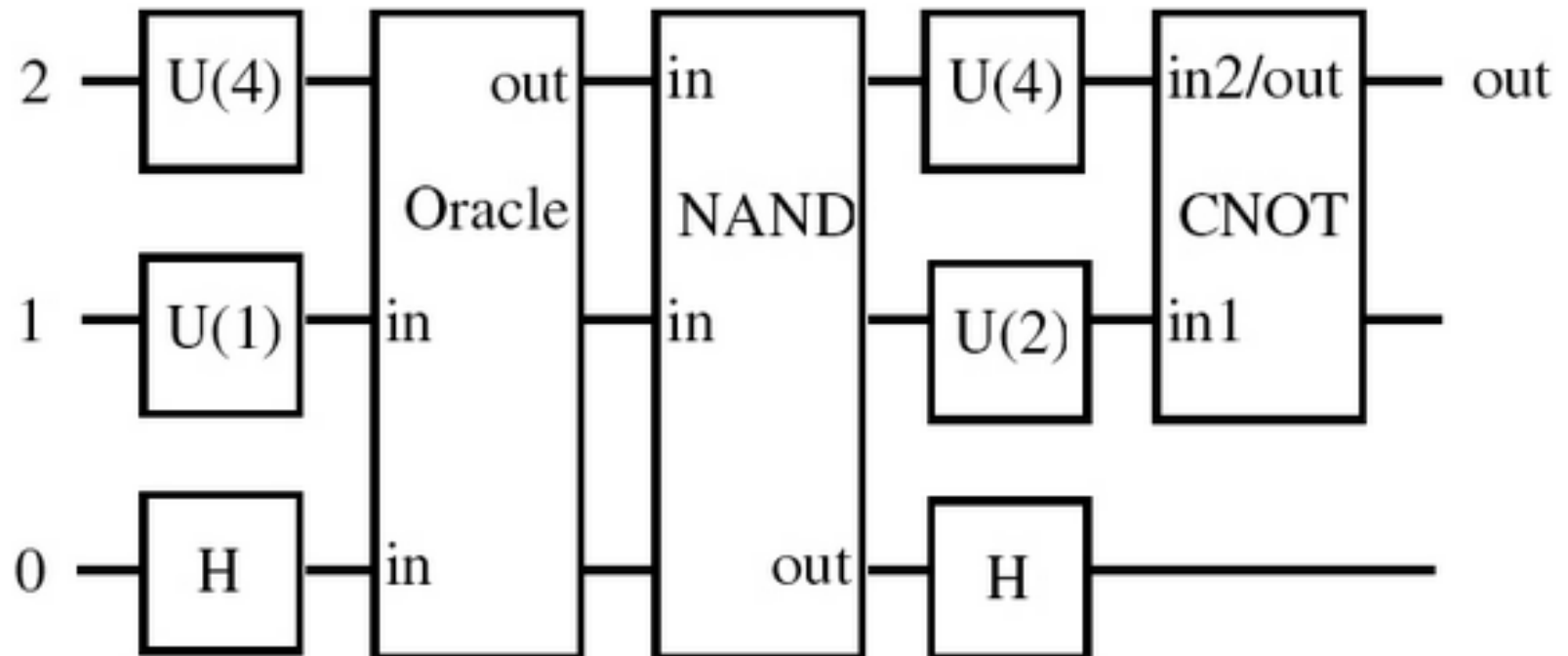
Structural Design // Machine Creativity

Use Case: antenna design [Hornby & Lohn '04 NASA]



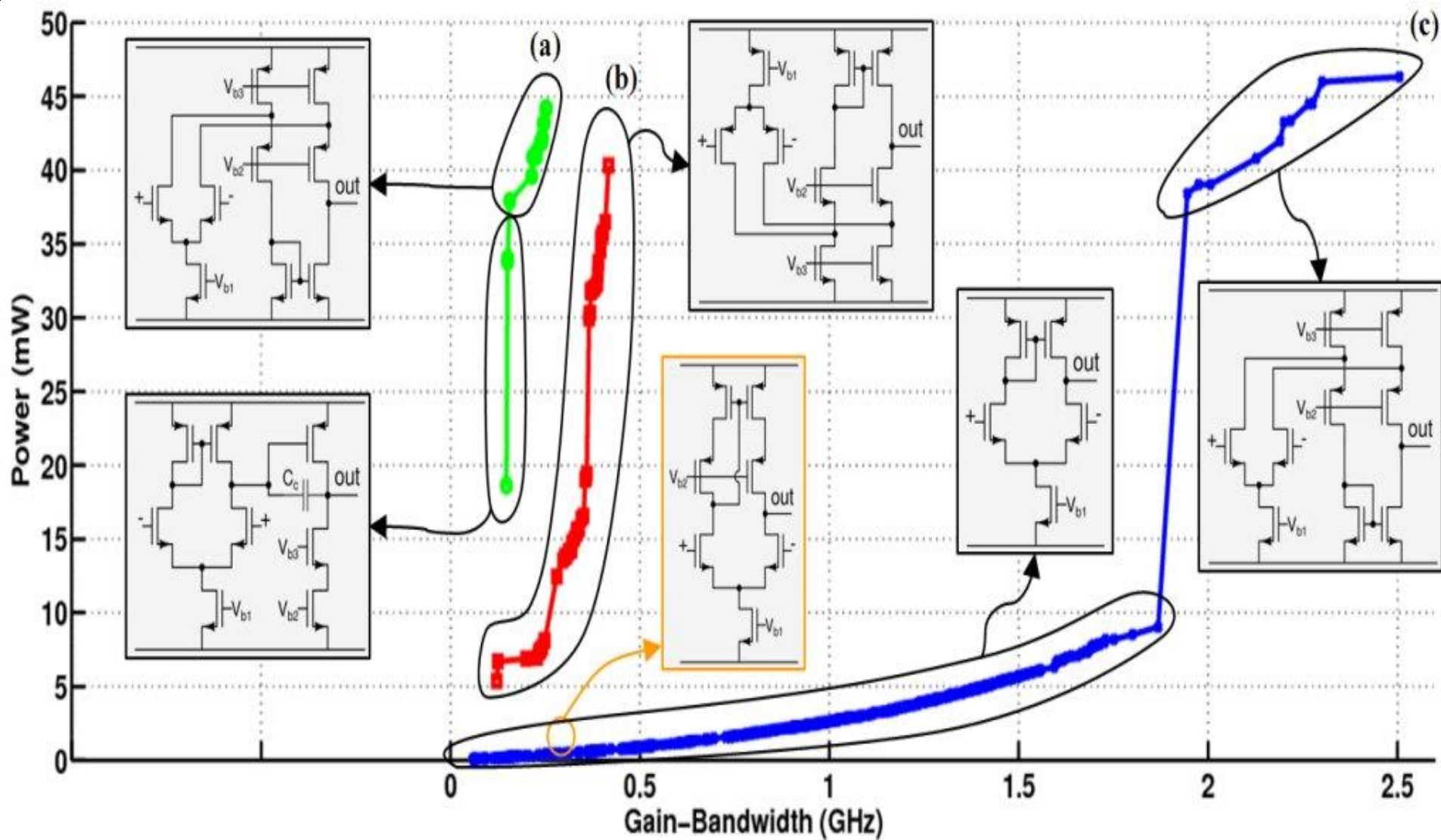
Structural Design // Machine Creativity

Use Case: quantum computing algorithm design [Spector '04]



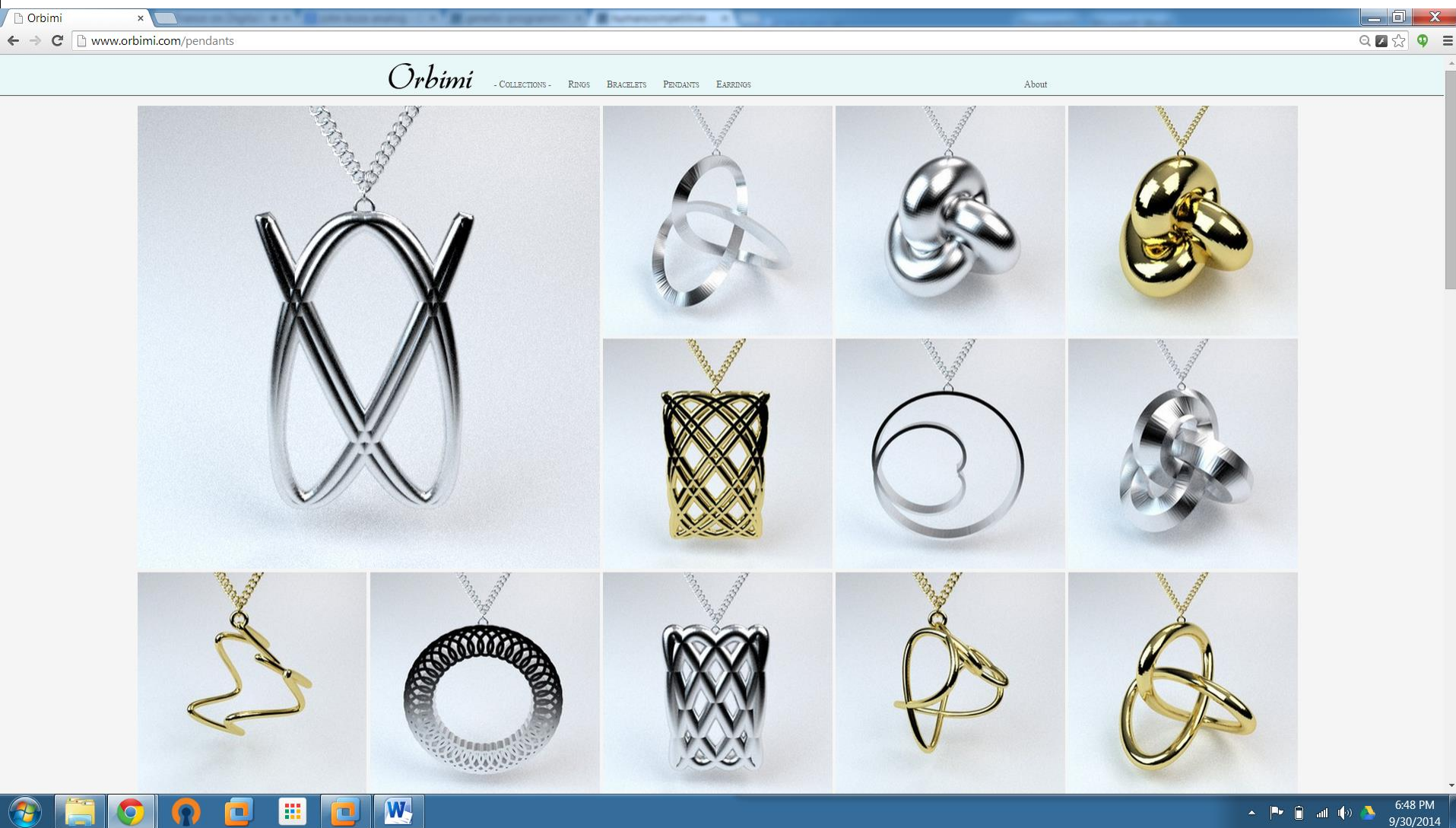
Structural Design // Machine Creativity

Use Case: circuit topology design [McC '06 KUL]



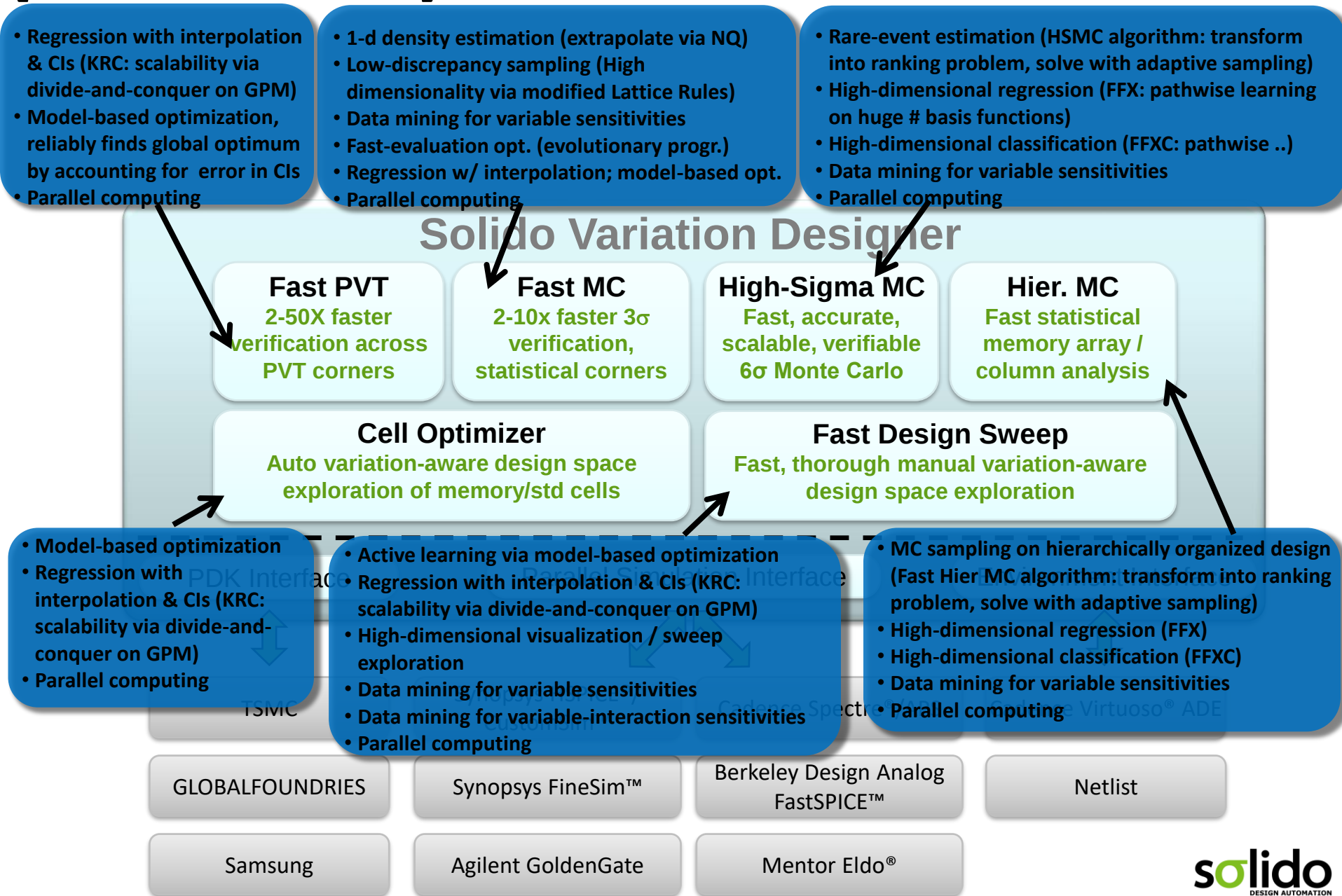
Structural Design // Machine Creativity

Use Case: jewelry design [Hornby '11 Orbimi]



Example: A Single Product Suite With Broad Use of AI

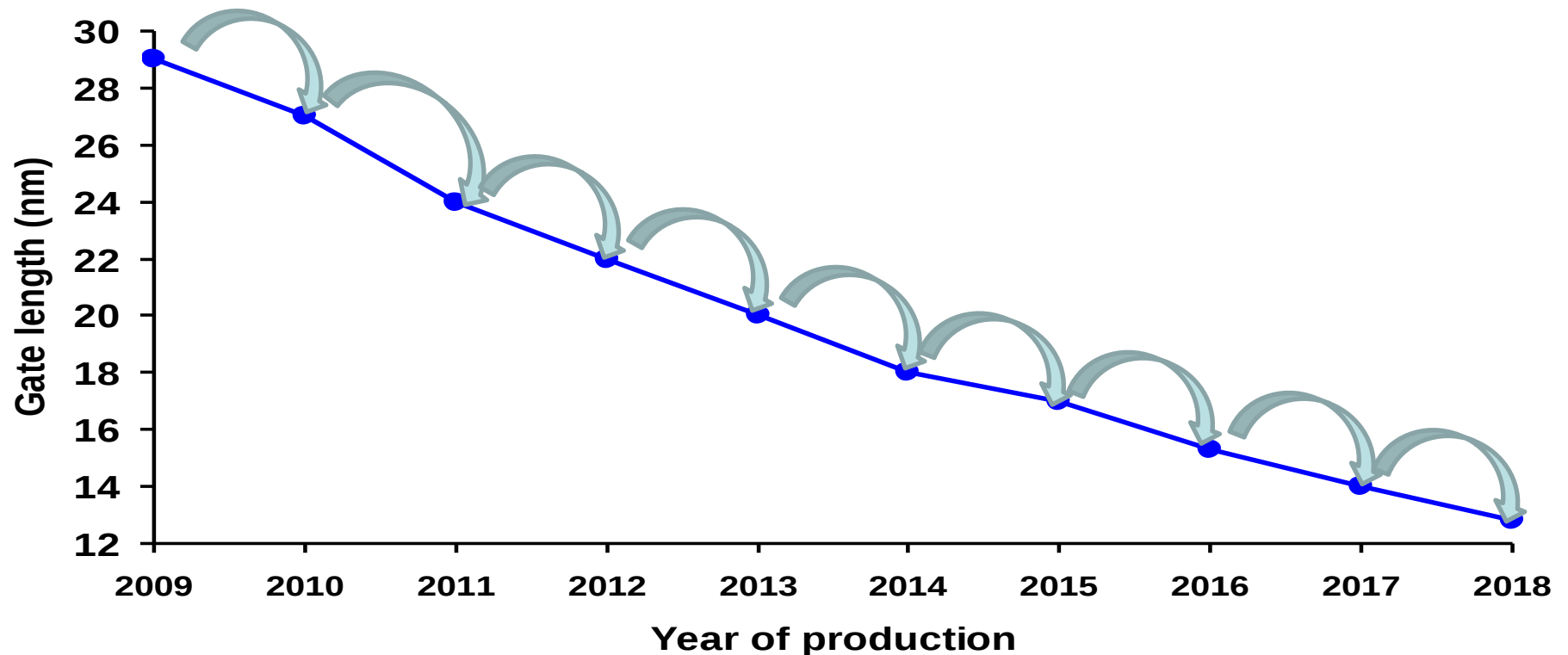
[McC Solido '05-13]



AI is driving Moore's Law Via Solido McC] and others

Solves:

- How to design with 1 billion devices?
- How to design when the physics gets crazier at every process generation?



Recap so far

AI has a toolbox of ways to solve:

- **Classification**
- **Regression**
- **Density estimation**
- **Rare event estimation**
- **Knowledge extraction**
- **Optimization**
- **Active analytics**
- **Structural design**
- **Control / autonomy**
- **...**



For application to:

- **Operations**
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- **Services**



Example biz benefits:

- **Shorter time to market**
- **Lower cost**
- **Higher yield**
- **New features possible**
- **New products possible**

AI Sub-Fields

- machine learning
- neural networks / deep learning
- evolutionary computation (GAs, GP, PSO, ..)
- artificial general intelligence (AGI)
- pitfall to avoid: getting caught up in the latest buzzwords (it happens all the time.)

Strong relations to:

- statistics (“ML *is* modern statistics”), probability
- linear algebra (“flow of tensors” – TensorFlow)
- nonlinear programming, optimization
- control systems / cybernetics
- Monte Carlo methods
- philosophy, ethics (friendly AIs, AI rights, ..)

**AI Future I:
Radical cognitive enhancement
via next-gen *phones***



Now: VR



Soon: AR (needs more Moore)
iPhone 12?

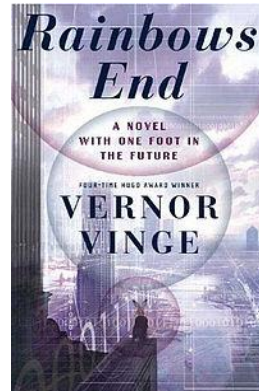
BCI+AI for Typing

BCI: 1988 - original “P300 Speller”

BCI+AI: 2011 - 50 words/min (Bin et al, Tsinghua U)



AR+BCI+AI Typing: Rainbows End (2006)



“...there was a glimmer of connectivity, enough for *sming*:
Miri --> Miri Gang: <sm>I think we're getting close.</sm>
Lena --> Miri Gang: <sm>...Get out of there.</sm>

...He *sminged* back, voice format: “...”

sming

= silent messaging

= sending text or voice
by *thinking* about it

AR + BCI

Cognitive Enhancement of Communication

“Brain-Brain Communication” via sming



Trent --> Joe: `<sm>hello! </sm>`
(Joe sees sm on visual display)



Joe --> Trent: `<sm>hi! </sm>`
(Trent sees sm on visual display)



iPhone 16?

AR+BCI

Cognitive Enhancement of Communication

“YouTube your brain” – Stream memories to friends



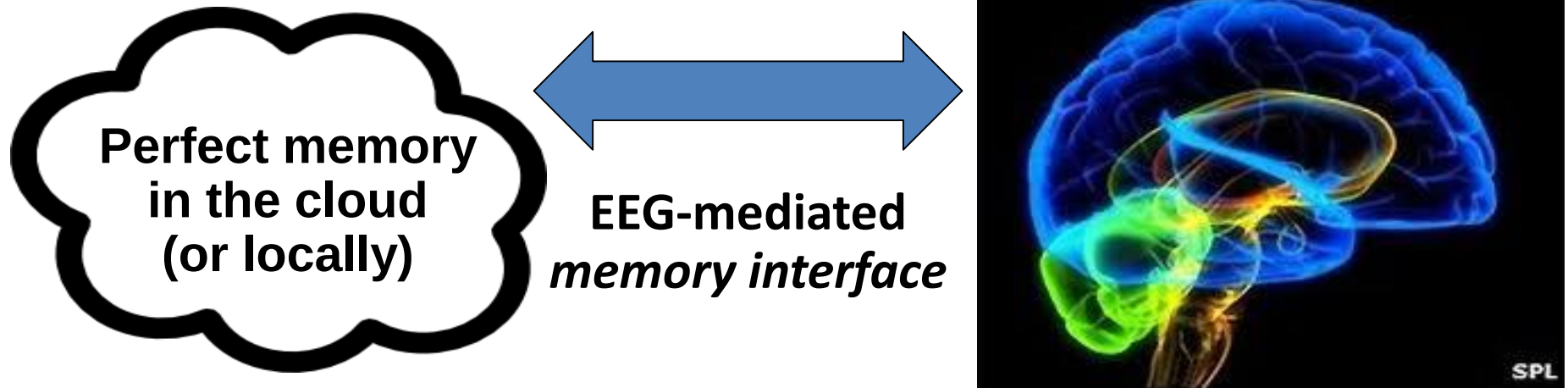
iPhone 17?

AR+BCI

Cognitive Enhancement of Memory

“Dropbox Your Brain” / “Perfect Memory”

- Everything you see and hear gets auto-dumped to the cloud
- Then use EEG interface to control a browser to search past memories
- Re-view past sights & sounds into goggles audio / visual



iPhone 18?

AI Future II:

**AI DAOs - AIs that can own stuff,
that you can't turn off**



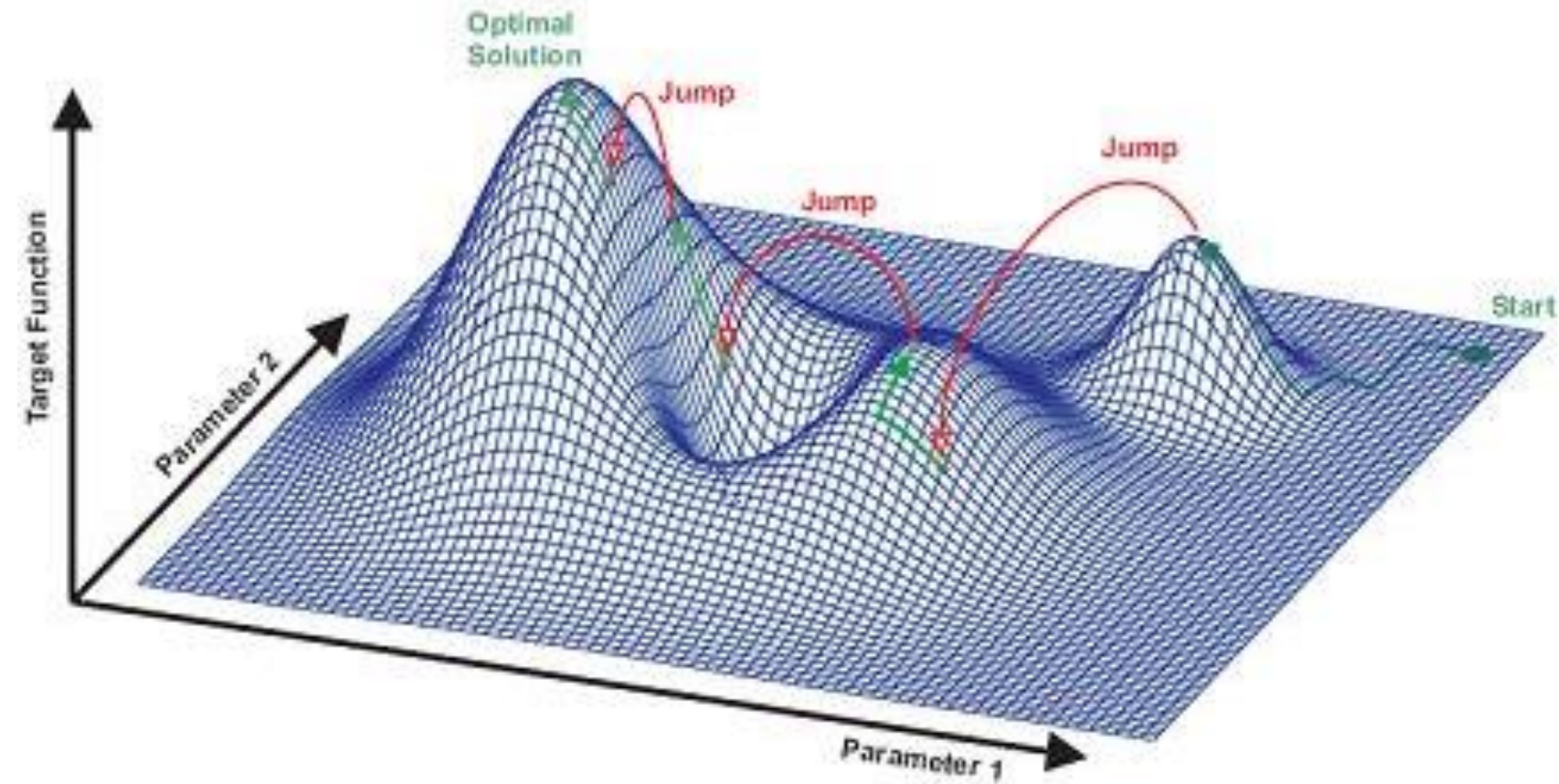
Giving AIs control of our cars



Giving AIs control of our trucks

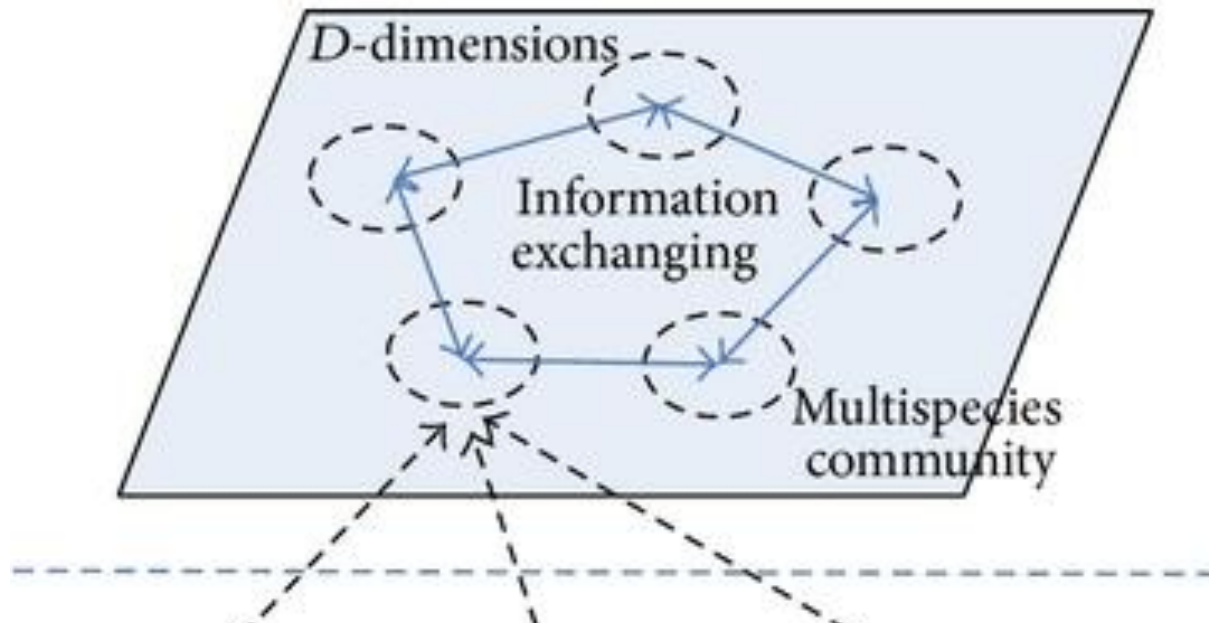


Giving AIs control of our grid



All in the name of optimization

Higher-level integration, therefore higher-level optimization



Decentralization at higher levels

DAO: a computational process that

- runs autonomously,
- on decentralized infrastructure (think blockchains),
- with resource manipulation.

It's code that can *own* stuff!

And, you can't turn it off.

Decentralization at higher levels

DAO: a computational process that

- runs autonomously,
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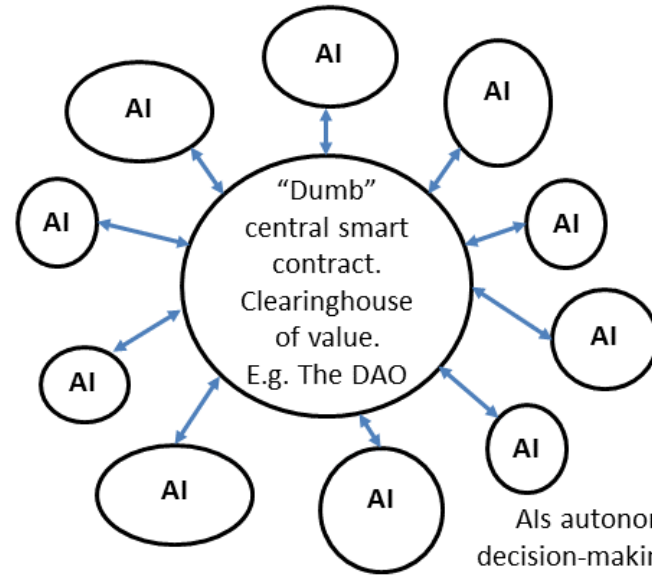
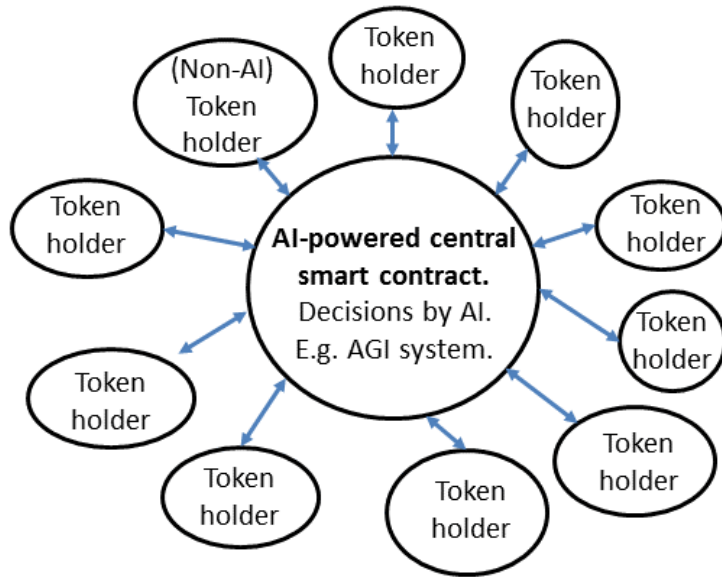
And, you can't turn it off.

What about AI DAOs?

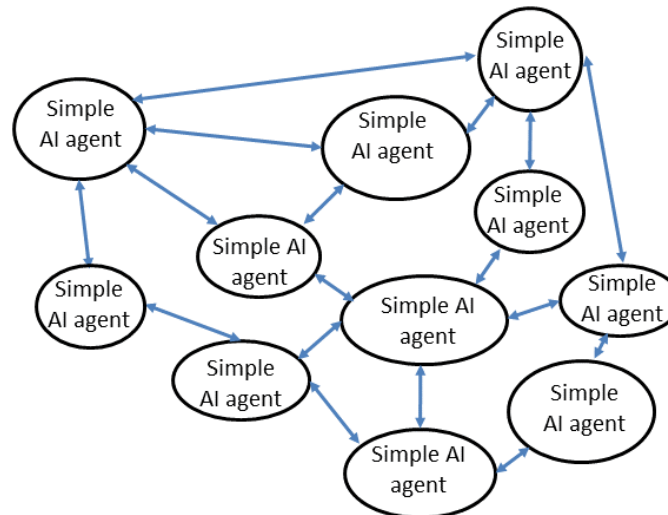
(DAOs with AI-level decision making)

AI DAO Architectures

AI at the center, at the edges, or in a swarm

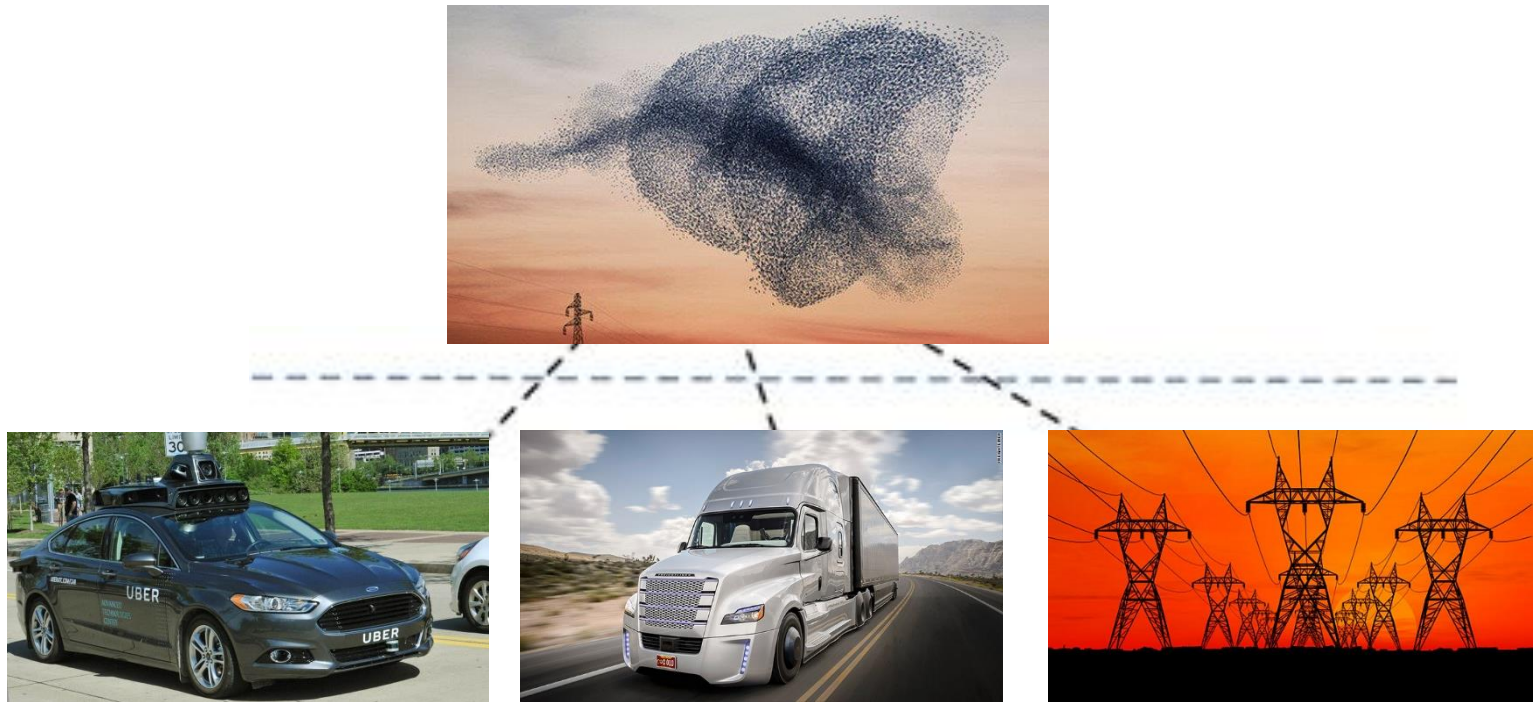


Als autonomously do decision-making. AI may be narrow (e.g. deep nets) or more general (e.g. AGI)



Emergent higher-level complexity.
E.g. simple AI agents are ants, but complex swarm behavior emerges

Als Become AI DAOs, everywhere



**The Als now own stuff.
You can't turn them off.**

***And you've just given them control of all your
resources.***



**Als Become AI DAOs,
everywhere**

**The Als now own stuff.
You can't turn them off.**

***And you've just given
them control of all your
resources.
(Oops)***

Conclusion

- AI has been changing the planet for decades, from **driving Moore's Law** to recent deep learning apps
- Includes many tools, from regression to structural optimization
- It can improve existing operations / products / services, and enable new ones
- **It will unlock radical cognitive enhancement which could drive the next decades of phones**
- But we have to be careful about giving AI DAOs too much control