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Leveraging AI and ML to augment advanced semiconductor packaging design and verification.

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Agenda

Introduction to artificial intelligence (AI) and machine learning (ML)

Training ML models, data, and IP challenges

AI /ML in physical design and physical verification of high-density advanced packaging (HDAP)

Examples of ML in EDA

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Introduction

Artificial intelligence, machine learning and deep learning

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Artificial intelligence, machine learning, deep learning

What it IS	What it IS NOT
Artificial Intelligence (AI) leverages computers and machines to **mimic the problem-solving and decision-making capabilities of the human mind**.	Magic
Machine learning (ML) is a branch of AI focusing on the use of data and algorithms to **imitate the way that humans learn**, gradually improving its accuracy.	A Magic Wand
Deep learning (DL) is a branch of ML where **large number of data sets** together with **layers of neural network** algorithms can **make "intelligent" decisions.**	A Panacea

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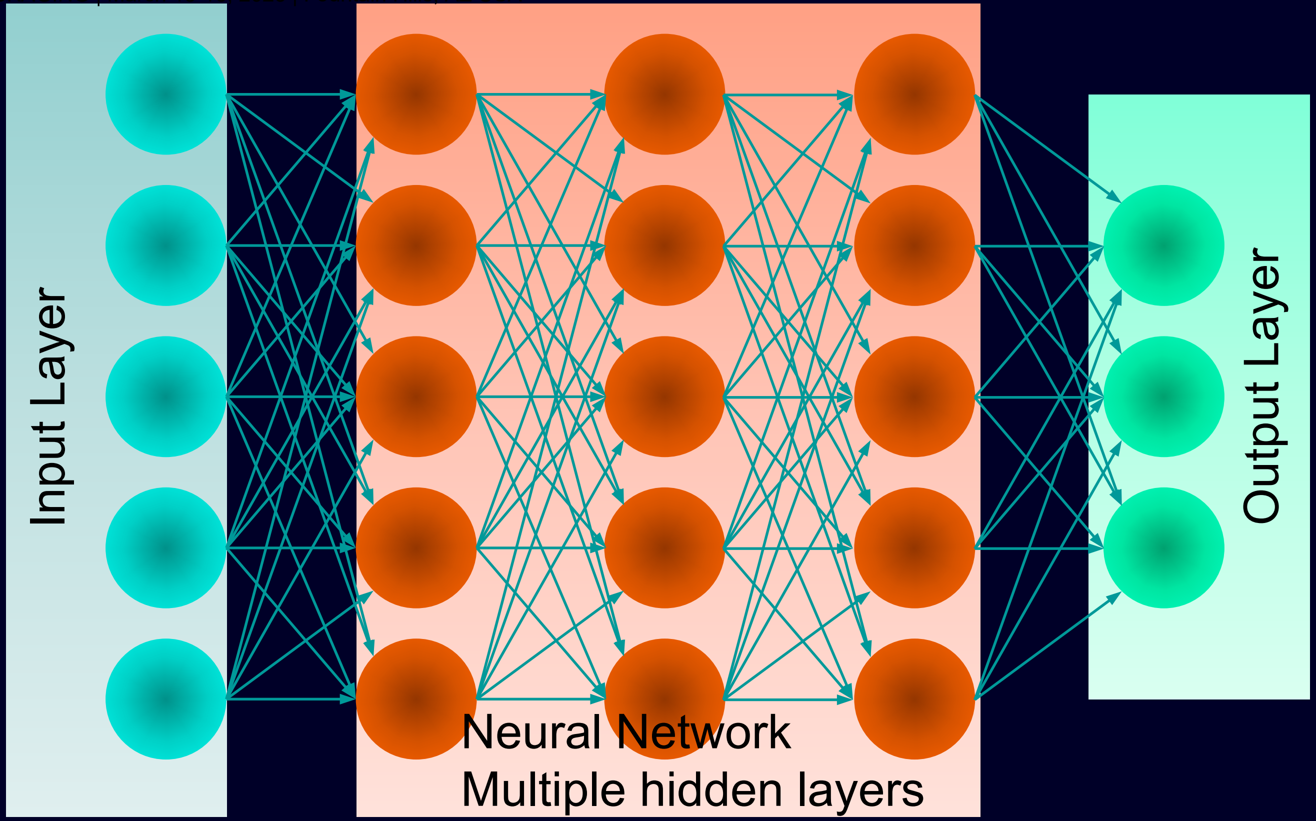
What is Artificial Intelligence



Neural Network

- Input layer
- One or more hidden layers
- Output layer

Connections

- Each node connects to another
  - Has a weight
  - Has a threshold

If Any node is above the threshold, data is sent on to other nodes

- **Neural nets vs. Deep Learning?**
  - Refers to the number of hidden layers!
  - More than 3 layers is typically called Deep Learning

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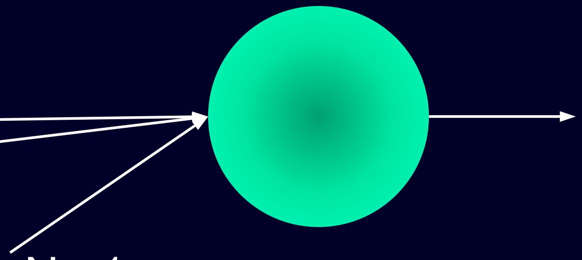
Example inspired from https://www.ibm.com/cloud/learn/neural-networks -A great resource in understanding AI/ML!

Very Simple Example: Should we go flying our kite?

Let's play with 3 parameters X1, X2 & X3:

- X1 Is the wind blowing? Yes:1 No:0
- X2 Is the flying field occupied? Yes:1 No:0
- X3 Has the field warden harassed the kite flyers lately? Yes:0 No:1



Let's assume; Wind IS blowing, Field IS crowded, Warden hasn't even been seen in a week: 1, 0, 1

Defining some Weights for these params: W1, W2 & W3:

- W1 = 5 as its usually not windy enough
- W2 = 2 because we are OK flying with other kiters
- W3= 4 because we really don't like being chased by the field warden

For this example, we set up a decision Threshold of 3

Outcome = X1*W1 + X2*Y2 +X3*W3 – Threshold; (1*5) + (0*2) + (1*4) -3 = 6

If we decide that Outcome > 0 means go flying, then the outcome is to go fly your kite.

Adjusting the parameters may result in a different outcome!

- **Went flying but it wasn't good? Change the parameters (train the model) so it gives better advice**

A cost function comparing actual result with predicted result, seeking equality is training the model

Training models

Process, model sharing and IP challenges

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Training machine learning models I

Training of ML Models

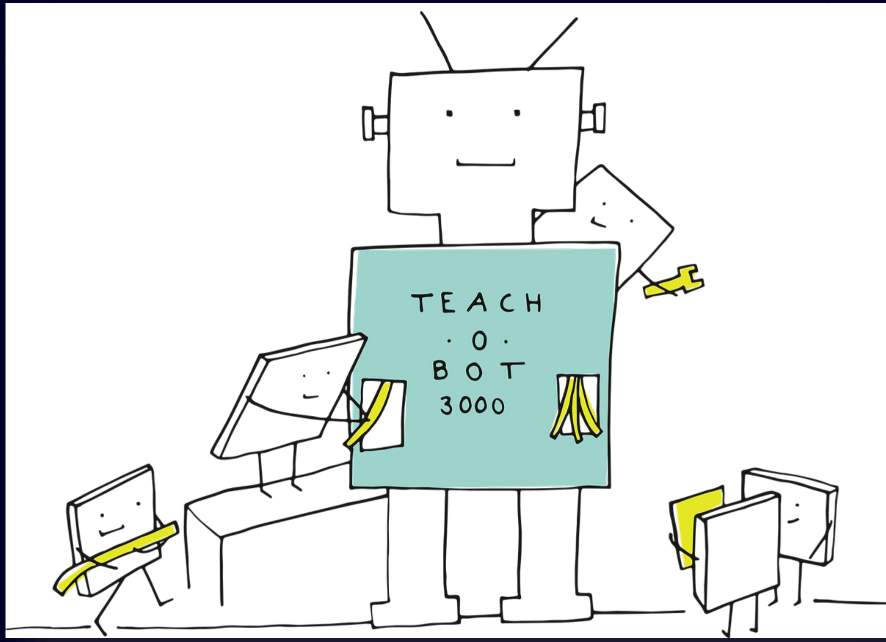
- Minimal: Application has training “mode” to create or refine model
- Automated: Application takes a “list” of data to train on (for example, designs data bases), automatically processes these, and generates a gradually refined model for clients to use

Where to get training data

- Vendor-provided <u>initial</u> model when possible
- Companies’ own “library of data” (for example, designs)

Training data such as design data is NOT represented in the resulting trained model!

Only decision-making parameters AI learned from the data.



Training machine learning models II

Sharing and management of models

- User local
- Design local
- Project local
- Site local
- Corporate global
- Global cloud – private
- Global cloud – public

IP challenges

- May a vendor use customer data to train public models without formal permission?
  - Even if the model doesn't have any of your data in it…it learned from your past success
  - Is it OK to you that a vendor share that model with one of your competitors? This gets tricky real fast!
- Can a distributed global corporation share models between its groups or companies?

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AI/ML in physical design and physical verification

AI/ML in physical design and physical verification of IC Packaging

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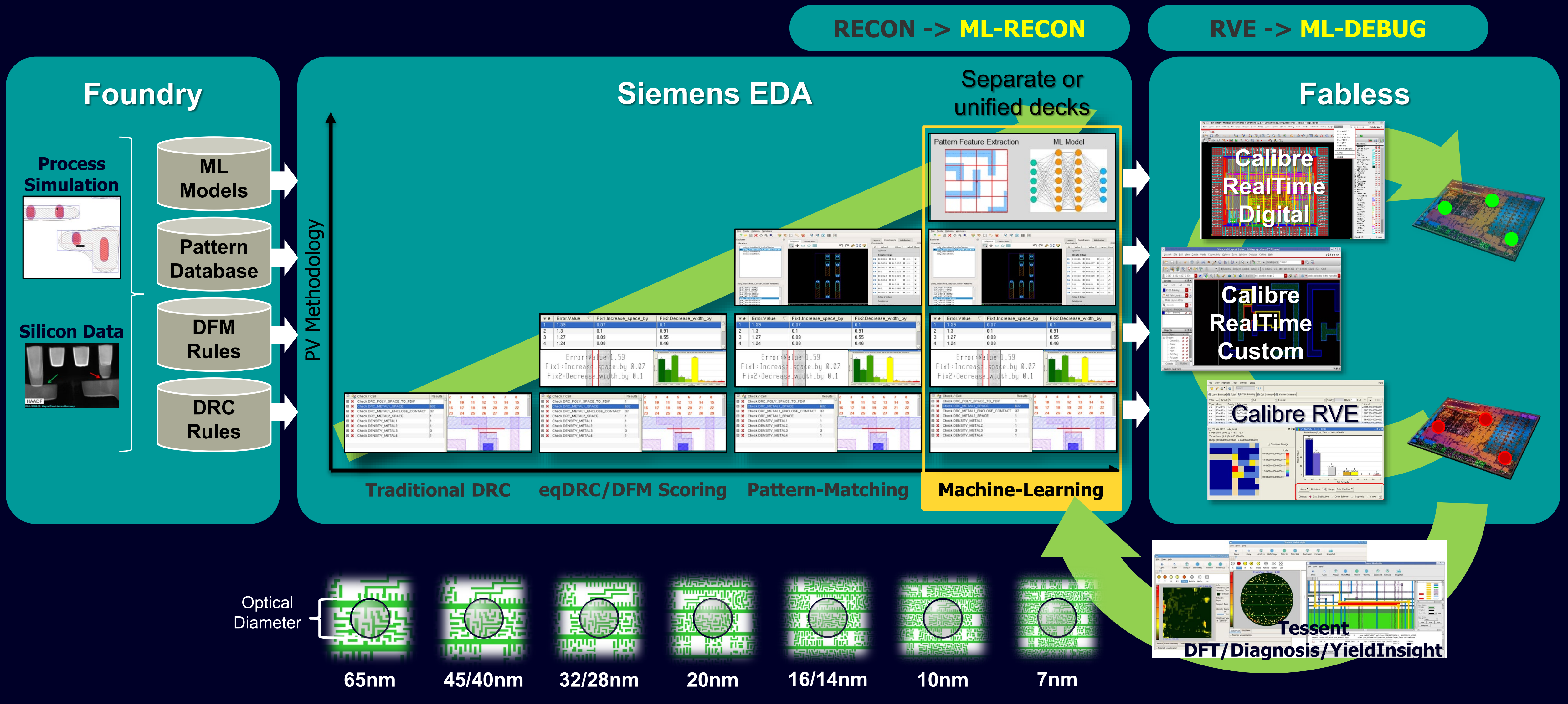
Evolution of physical verification @ Siemens



Leveraging Artificial Intelligence

Shift-Left

Computational / Statistical Modeling

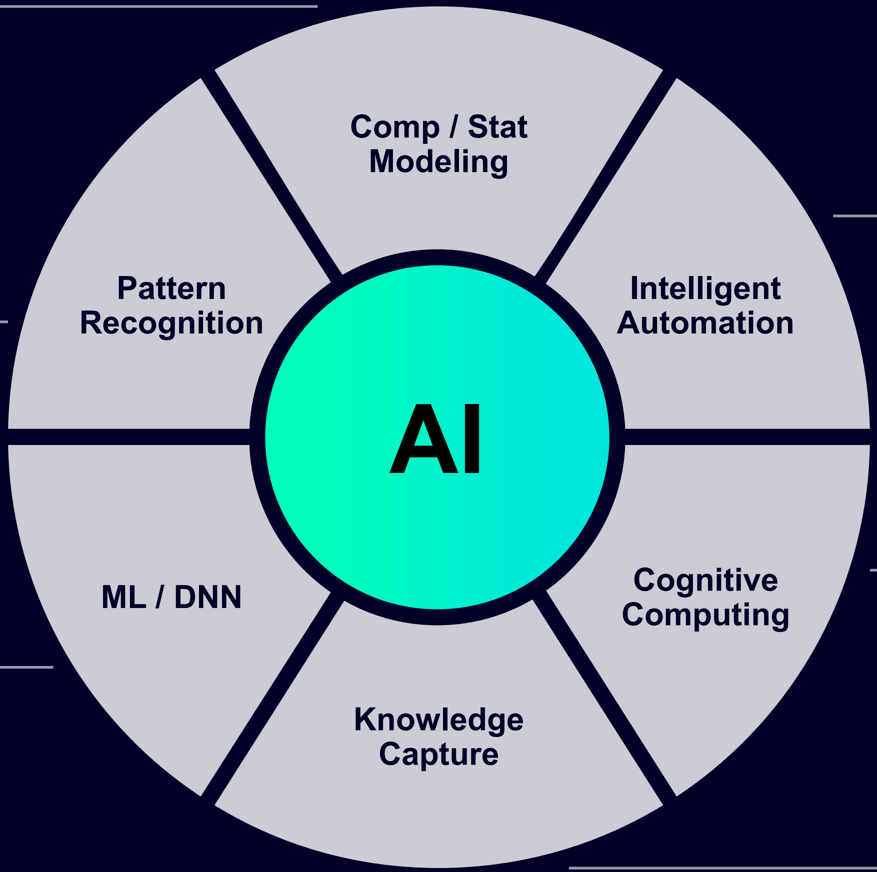
Leveraging mathematics, statistics, physics, and computer science to model the mechanism and behavior of complex systems. [1]

Pattern Recognition

Leveraging tools and algorithms that recognize patterns and regularities in complex data. [2] [3]

Machine / Deep Learning

Leveraging data analysis, feature engineering and model training to solve complex ambiguous problems. [4]



Intelligent Automation

Combining aspects of process automation and automated planning to dynamically determine actions or strategies that optimize the user interaction and outcome. [5] [6]

Cognitive Computing

Combining aspects of cognitive computing and reasoning to develop algorithms and tools that replicate human expertise when solving complex, and often ambiguous problems [7] [8]

Knowledge Capture

Extracting, structuring, preserving, and interrelating data to empower expert systems that guide refined future behavior. [9] [10]

References

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Leveraging AI to Improve the Verification Experience

1 Verification Optimization

- Methods and capabilities for advanced physical verification techniques

2 Execution Optimization

- Integrating intelligent tools into a new automated run paradigm to guide designers to most efficiently meet their business objectives

3 Debug Optimization

- Creating intelligent tools for minimizing, grouping and visualizing results to efficiently identify systematic design issues

4 Correction Optimization

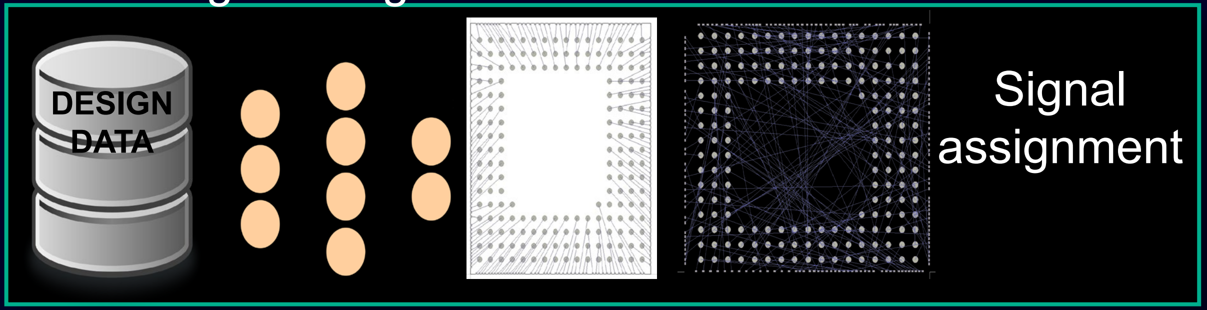
- Developing intelligent tools for automated verification-correct, and back-annotated layout enhancement & repair

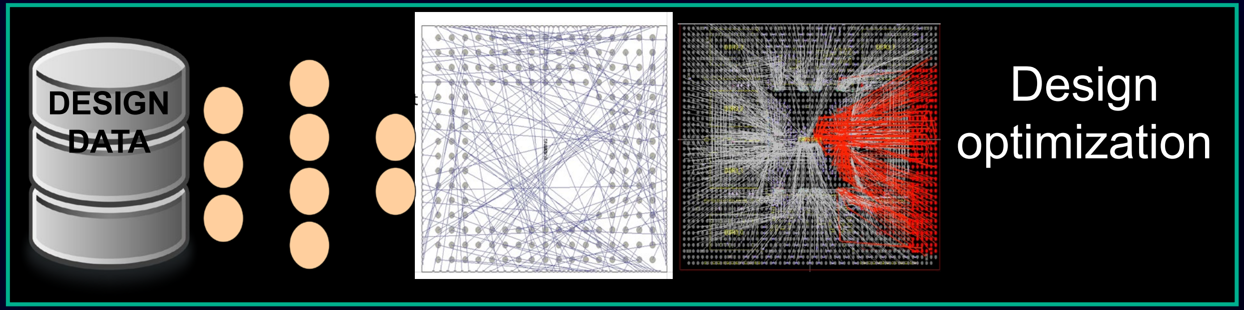
How Siemens is Leveraging Artificial Intelligence

		Comp/Stat Modeling	Pattern Recognition	Machine Learning	Intelligent Automation	Cognitive Computing	Knowledge Capture
Verification Optimization	Equation-Based Checking	✓					
	Pattern-Based Checking		✓				✓
	Model-Based Checking			✓			
	Layout & Circuit Aware checking	✓	✓	✓	✓		
	Advanced Reliability Checks	✓	✓		✓		
	Curvilineal Checking	✓	✓				
Execution Optimization	Intelligent Configuration	✓		✓	✓	✓	
	Intelligent Resource Allocation	✓		✓	✓	✓	✓
	Automated Check Selection/Partitioning				✓	✓	✓
	ECO Automation/Optimization						✓
	Advanced User Interface				✓	✓	
	Incremental Learning						✓
Debug Optimization	Automated Result Filtering	✓	✓		✓		✓
	Within Check Signals	✓	✓	✓			
	Across Check Signals	✓	✓	✓			
	Automated Execution				✓		
	Designer Root Cause Annotation						✓
	Advanced Visualization				✓	✓	
Correction Optimization	Programmable Edge Modification	✓			✓	✓	
	Fill Optimization	✓	✓		✓	✓	
	Design Optimization	✓			✓	✓	
	Antenna Optimization	✓			✓		
	Verification-Correct	✓	✓				
	Back Annotation						✓

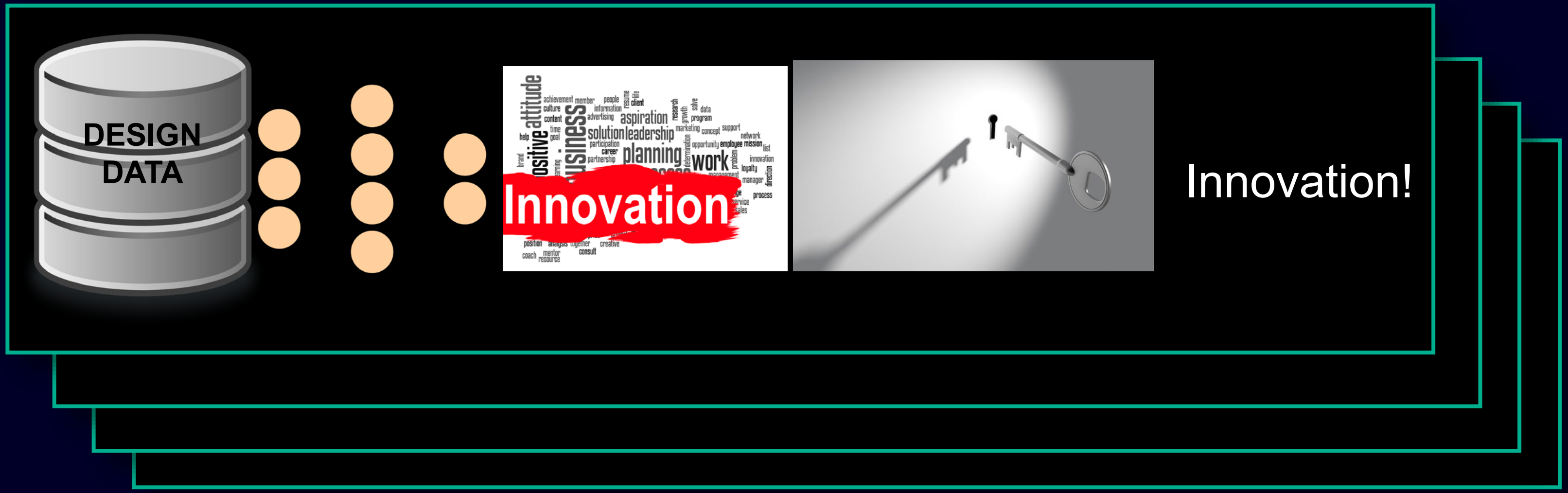
IC packaging machine learning applications

Enhancing existing solutions





Creating new applications



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IC packaging CUSTOM machine learning applications

EDA vendors can’t foresee all your EDA ML needs

- But they can enable their customers by providing custom ML support built into their tools!
- Provide built in ML engines such as TensorFlow
- User scripting access to such engines through Tcl and Python to enable users and corporations to apply ML also in their custom or proprietary processes and functions

There are multiple ML engines out there!

Some generic, some better for specific tasks.

- Examples (Not a complete list)

TensorFlow

APACHE Spark ML

scikit learn

PyTorch

Join the transformation

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