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# TFDEA: A New Approach for Technology Forecasting of New Product Development Targets

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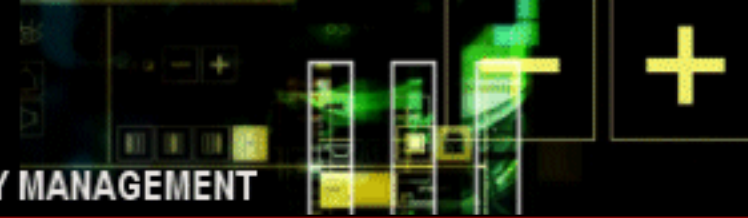
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ENGINEERING & TECHNOLOGY MANAGEMENT



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# TFDEA: A New Approach for Technology Forecasting of New Product Development Targets

Lane Inman,  
Veritas, Inc.

Tim Anderson  
Portland State University

## Presentation Flow

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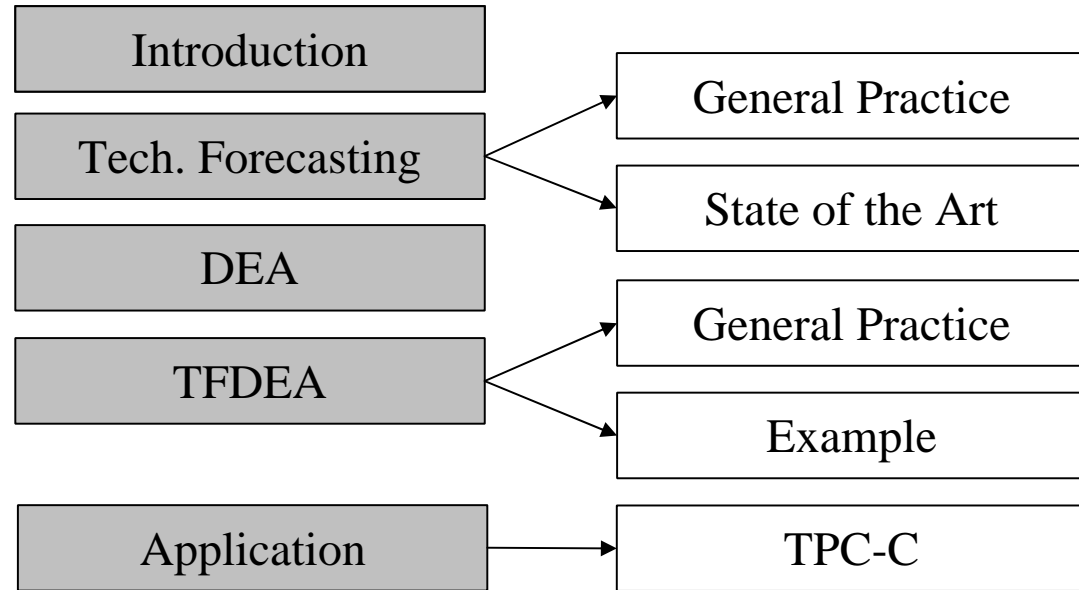
General Practice

State of the Art

General Practice

Example

TPC-C



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# Introduction

- *GAP1: Current quantitative technology forecasting techniques do not handle variable trade-offs.*
- *GAP2: Current DEA tools do not handle single occurrence DMUs with variable time periods.*

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# Research Objectives

- Methodology:
  - Develop a methodology for technology forecasting which provides a robust means to measure the SOA and its progress by extending current temporal DEA to allow for DMUs which are introduced only once at irregular intervals.
- Application:
  - Apply the methodology to a straight forward real world application.

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# Technology Forecasting

- *What is technology forecasting?*
  - *“to predict the future characteristics of a useful machine”*
- *What's a machine?*
  - *Not only physical devices, but tools, techniques and procedures that provide some function to an end-user.*

*J. P. Martino, "Technological Forecasting for the Chemical Process Industries,"  
Chemical Engineering, pp. 54-62, 1971.*

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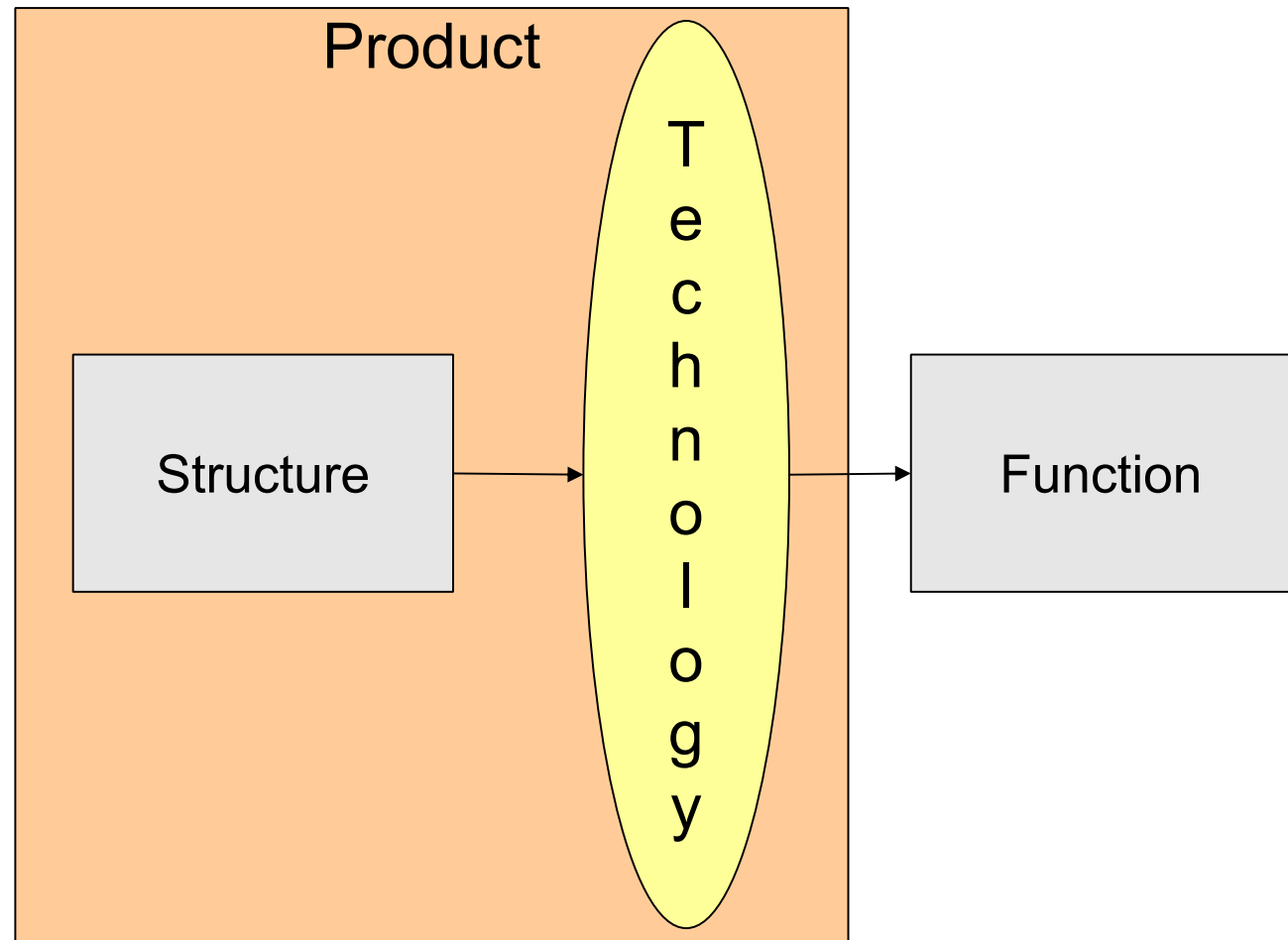
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# What is technology?



\*Knight '74

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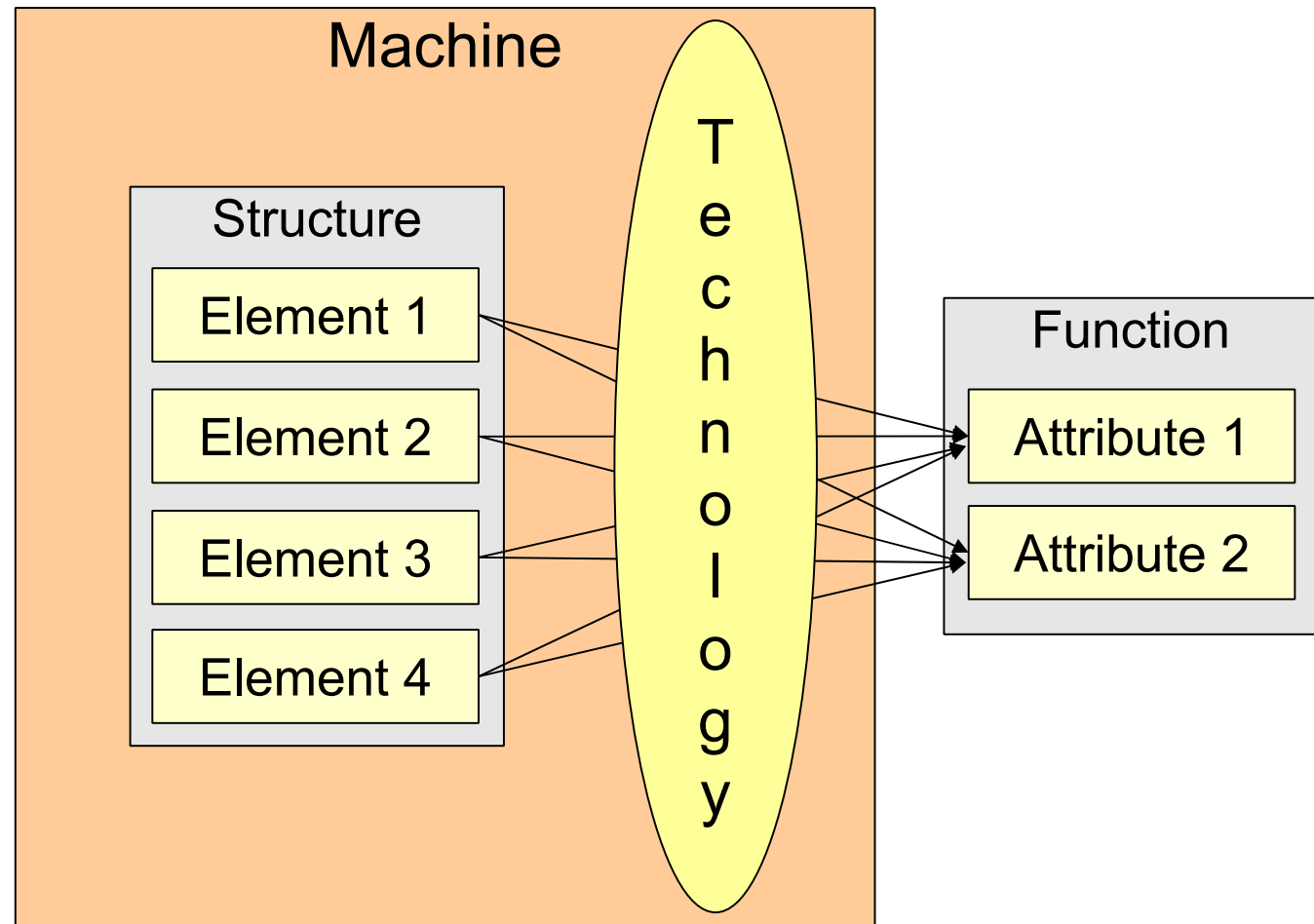
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# What is technology, really?





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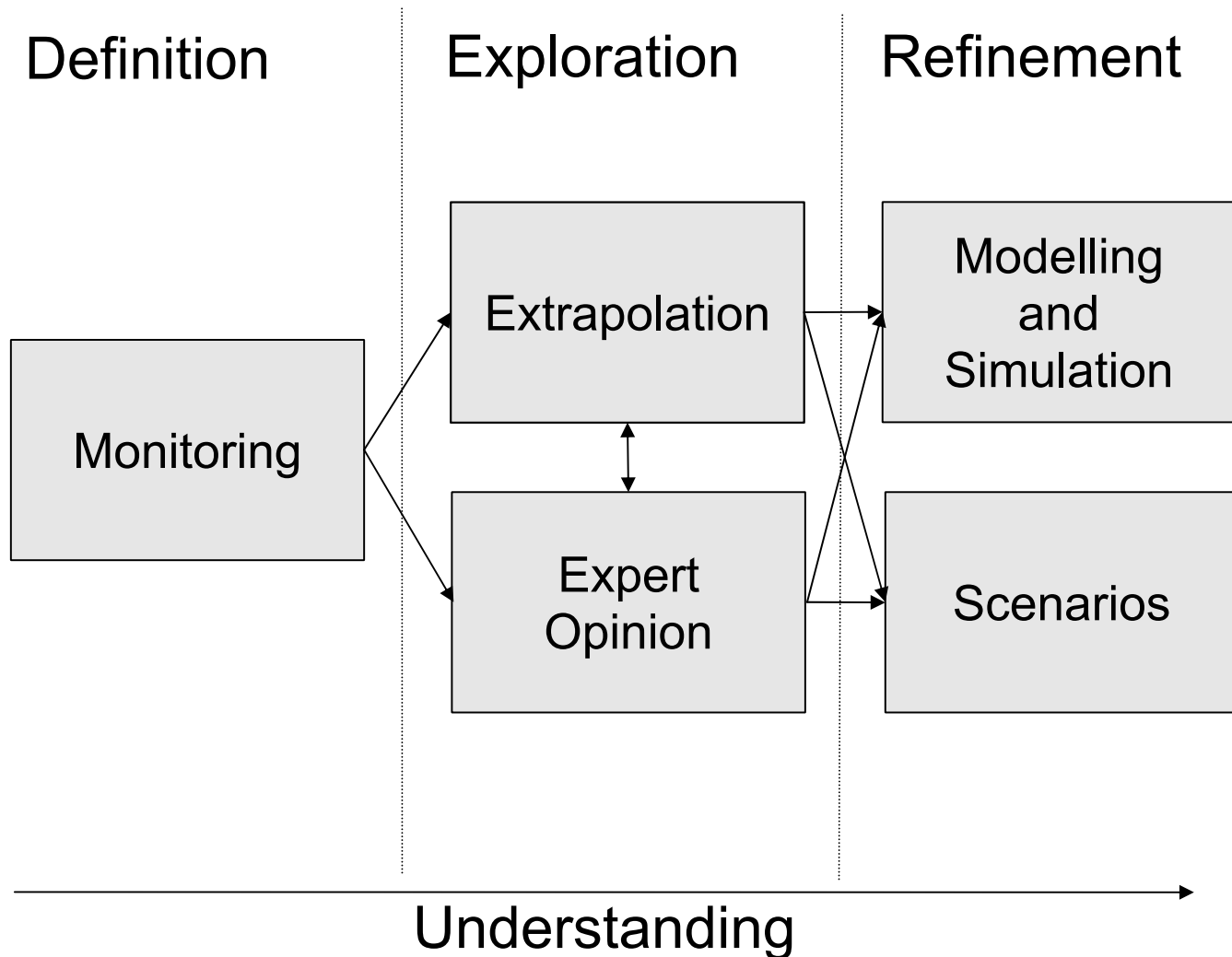
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## How is it currently done?



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# What are the challenges?

- *It is difficult to assign a single attribute to the measurement of a technology.*
- Typically only addresses a technological approach not a single technology.

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# How are these challenges addressed?

- *State Of the Art (SOA)*

*“The best implemented technology as reflected by the physical and performance characteristics actually achieved during the time period in question”*

*–Dodson, TFSC 1 1970*

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## How can SOA be used?

- *Given that technology is never better than State-of-the-Art, an index may be used to measure relative to the SOA.*
- *Over time a products technology index will change – tracking that change will allow for future predictions.*

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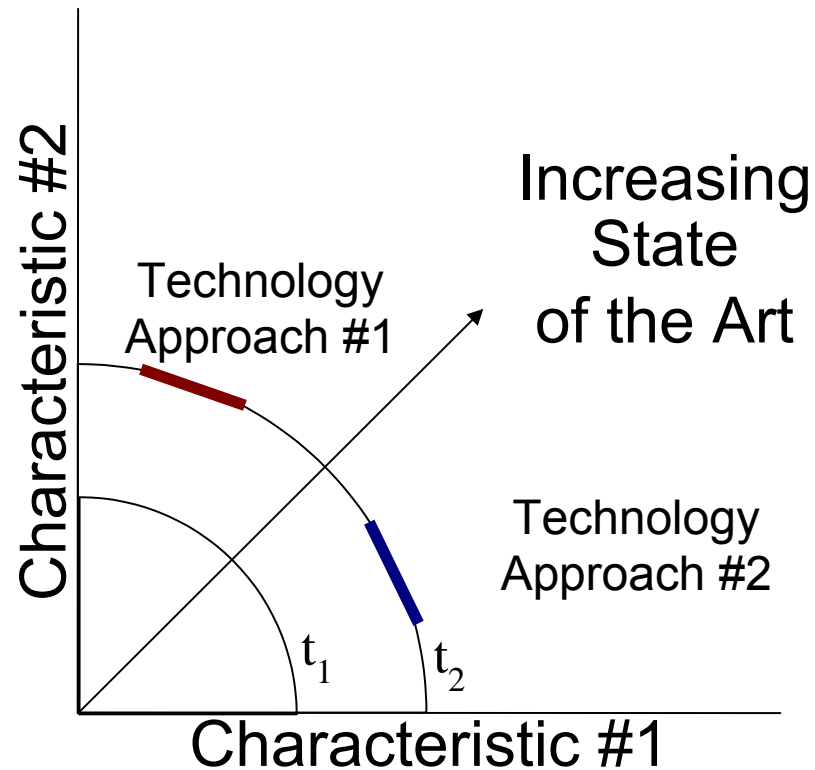
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# What is the SOA?



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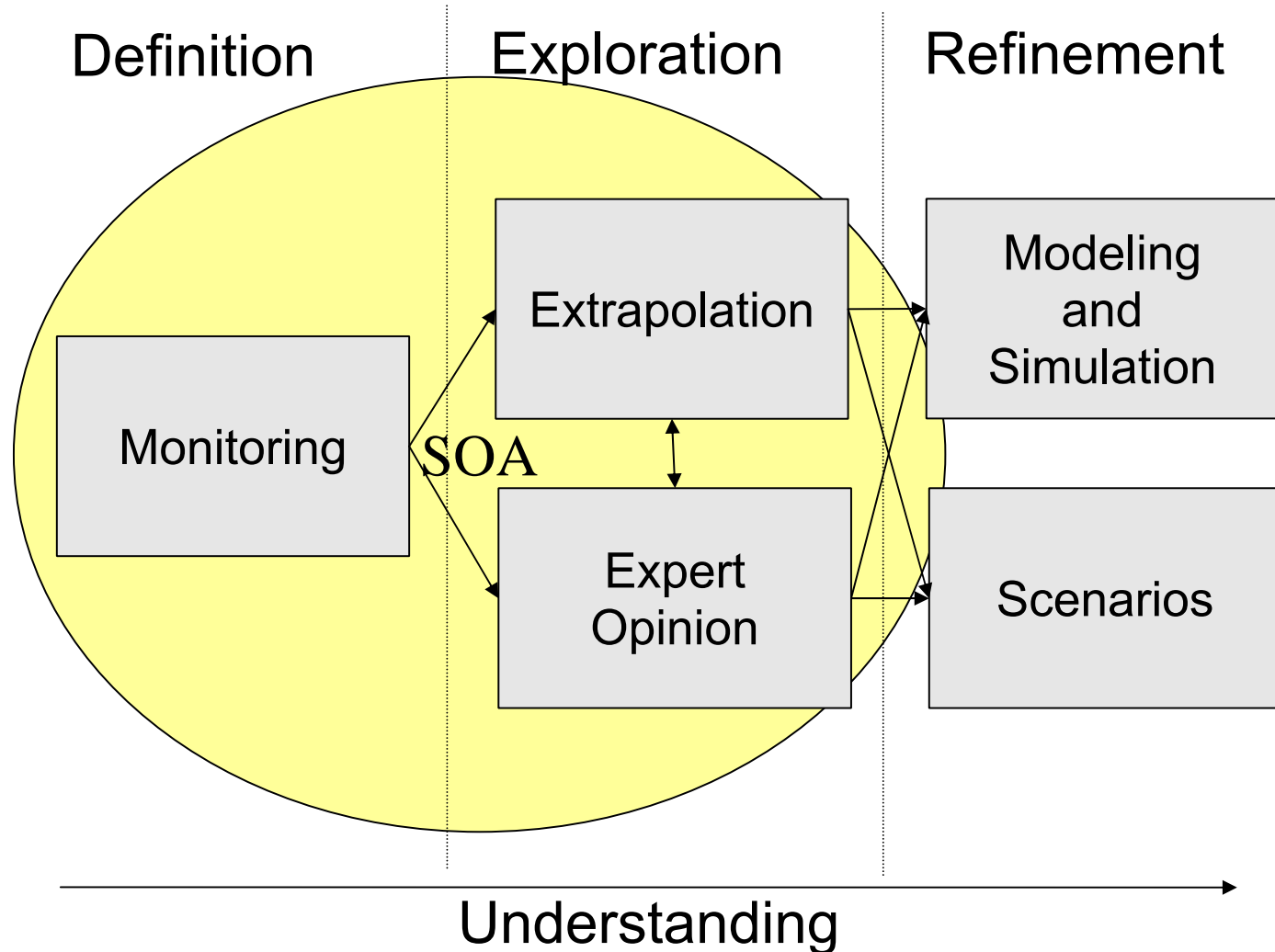
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## Where does SOA fit?



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# Steps to Forecast SOA



T. J. Gordon and T. R. Munson, "A Proposed Convention for Measuring the State of the Art of Products or Processes," *Technological Forecasting and Social Change*, vol. 2, pp. 1-26, 1981.

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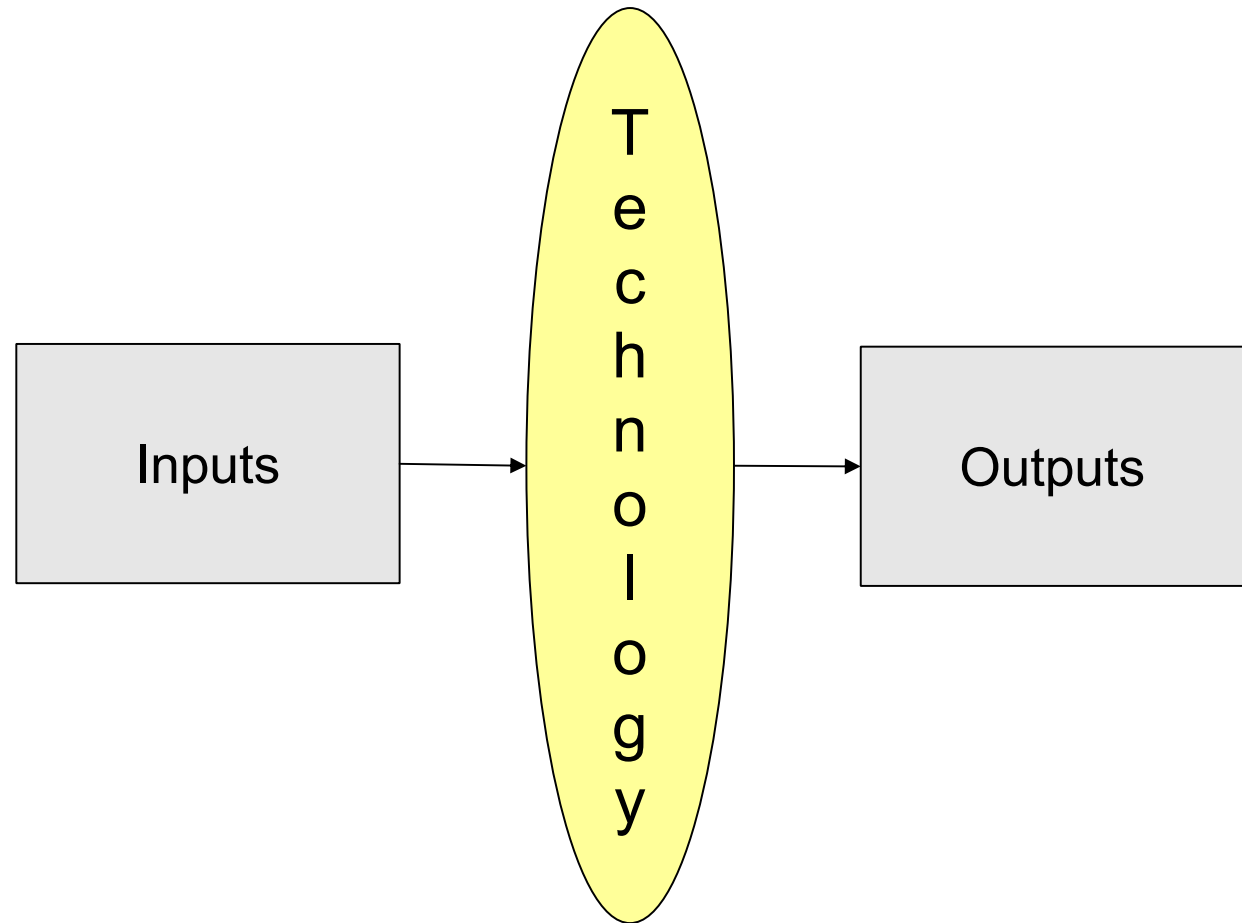
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# What does DEA measure?





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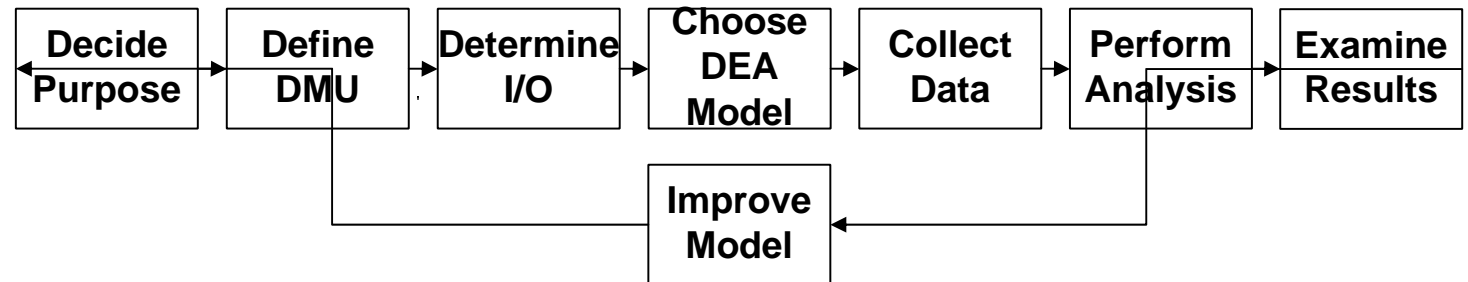
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# Steps For DEA



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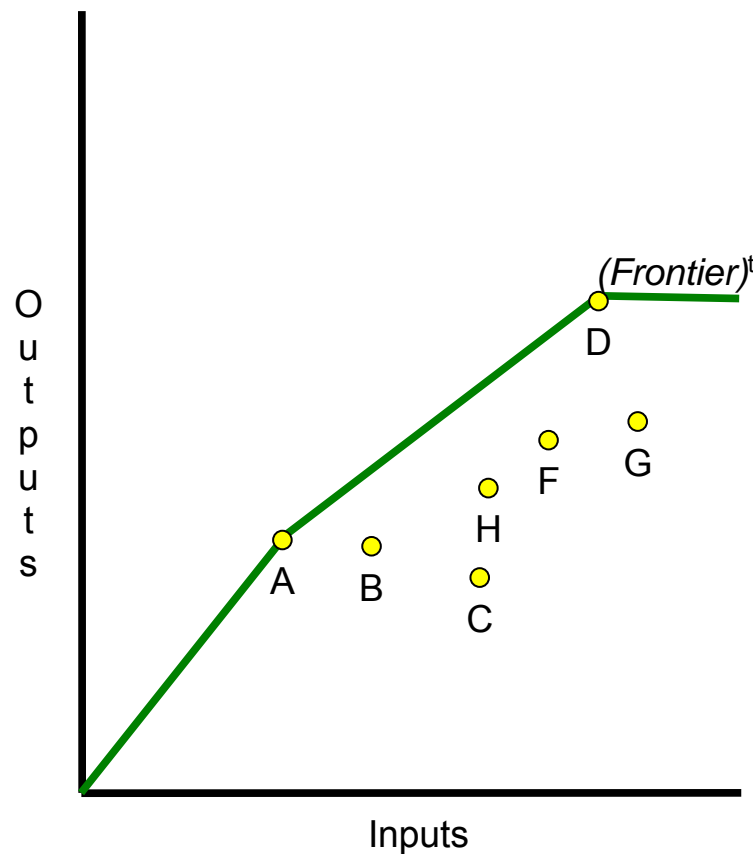
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# Data Envelopment Analysis



- Builds an efficiency envelope relative to its peers (extreme-point method)

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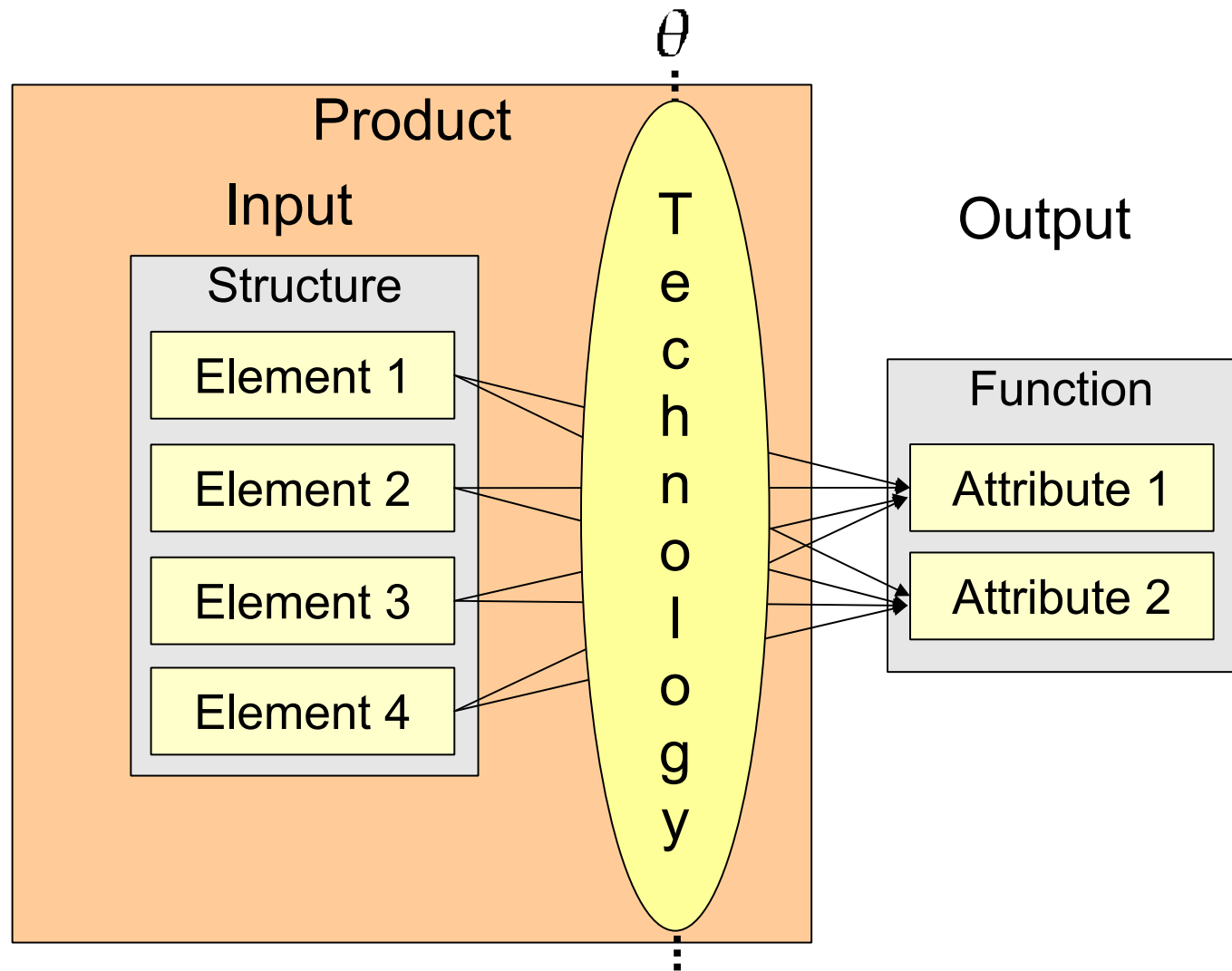
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# How do they go together?



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# How do they fit together?

Gap: General forms do not take into account the dynamic nature of trade-off surfaces.

Attr: DMUs are independently rated against peers which are explicitly identified by DEA.

Gap: Do not address the "best" available technology.

Attr: DEA is an extreme point method.

Gap: Current methods are limited to a single output.

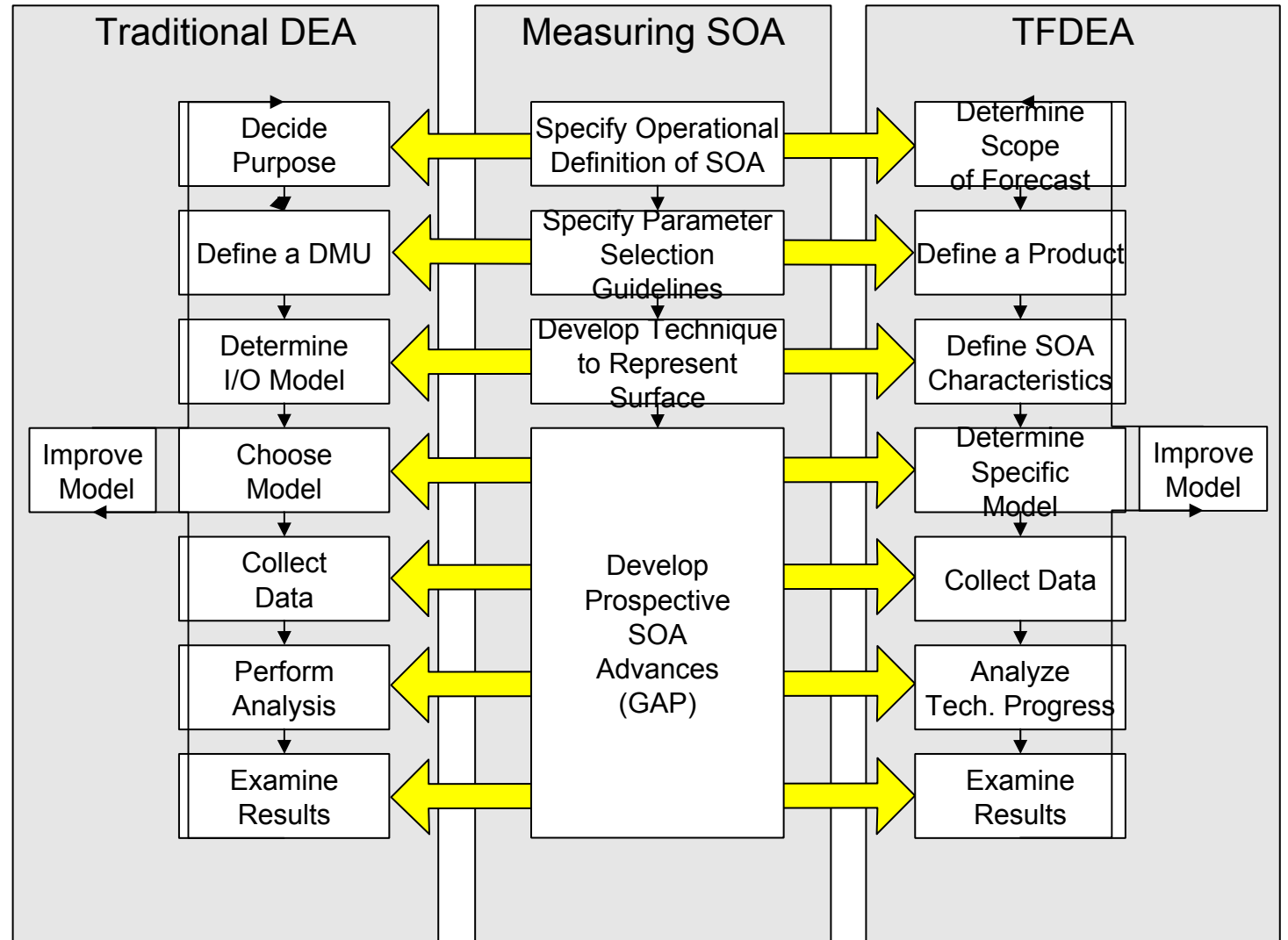
Attr: DEA can handle multiple inputs and outputs simultaneously.

Gap: Current methods require independent attributes.

Attr: DEA does not require attribute independence.

## How do they fit together?

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- Tech. Forecasting
- DEA
- TFDEA**
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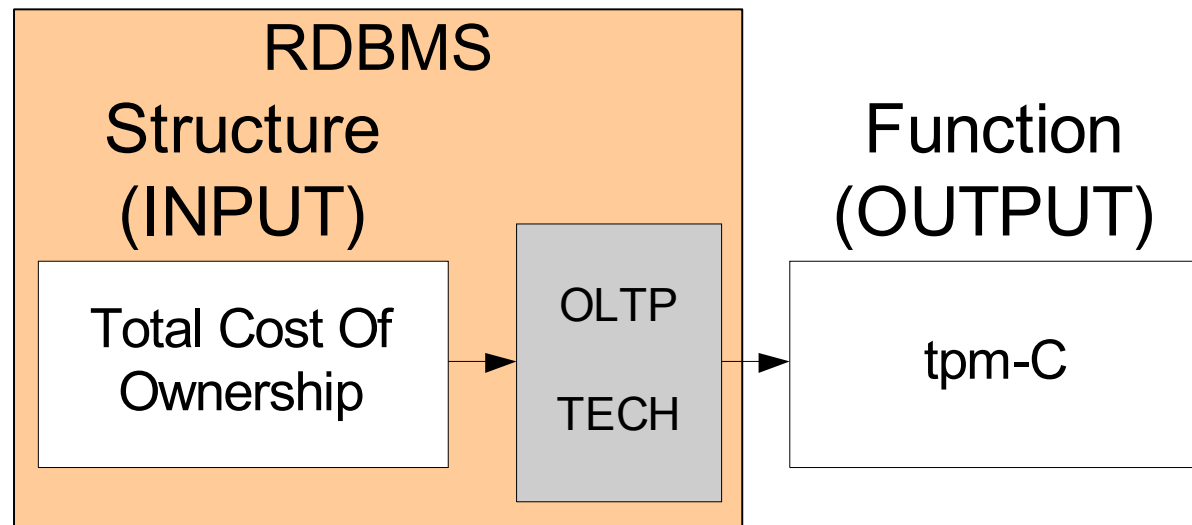
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# Example - RDBMS



# TPC Data

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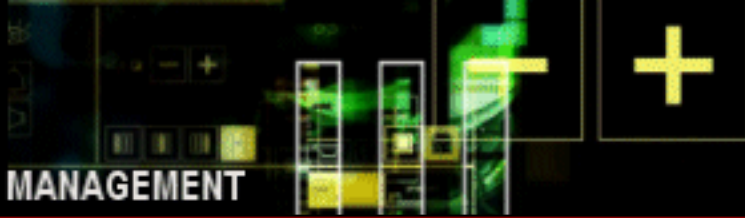
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Product	Name	Year Released	Total Cost(\$)	Perf. (tpmC)
A	Unisys Aquanta QR/6 c/s	1997	297392	7407
B	ALR Revolution 6X6 (1MB L2) c/s	1997	463821	13089
C	Compaq ProLiant 3000 6/450-512 1	1998	176042	6290
D	Unisys Aquanta QR/2V Server	1998	424297	19118
E	Compaq Proliant 3000-6/600-1P	1999	160643	8050
F	Compaq Proliant ML570	2000	201717	20207
G	Dell PowerEdge 6450	2000	334936	31231
H	Unisys e-@action Enterprise Server	2000	797935	61390



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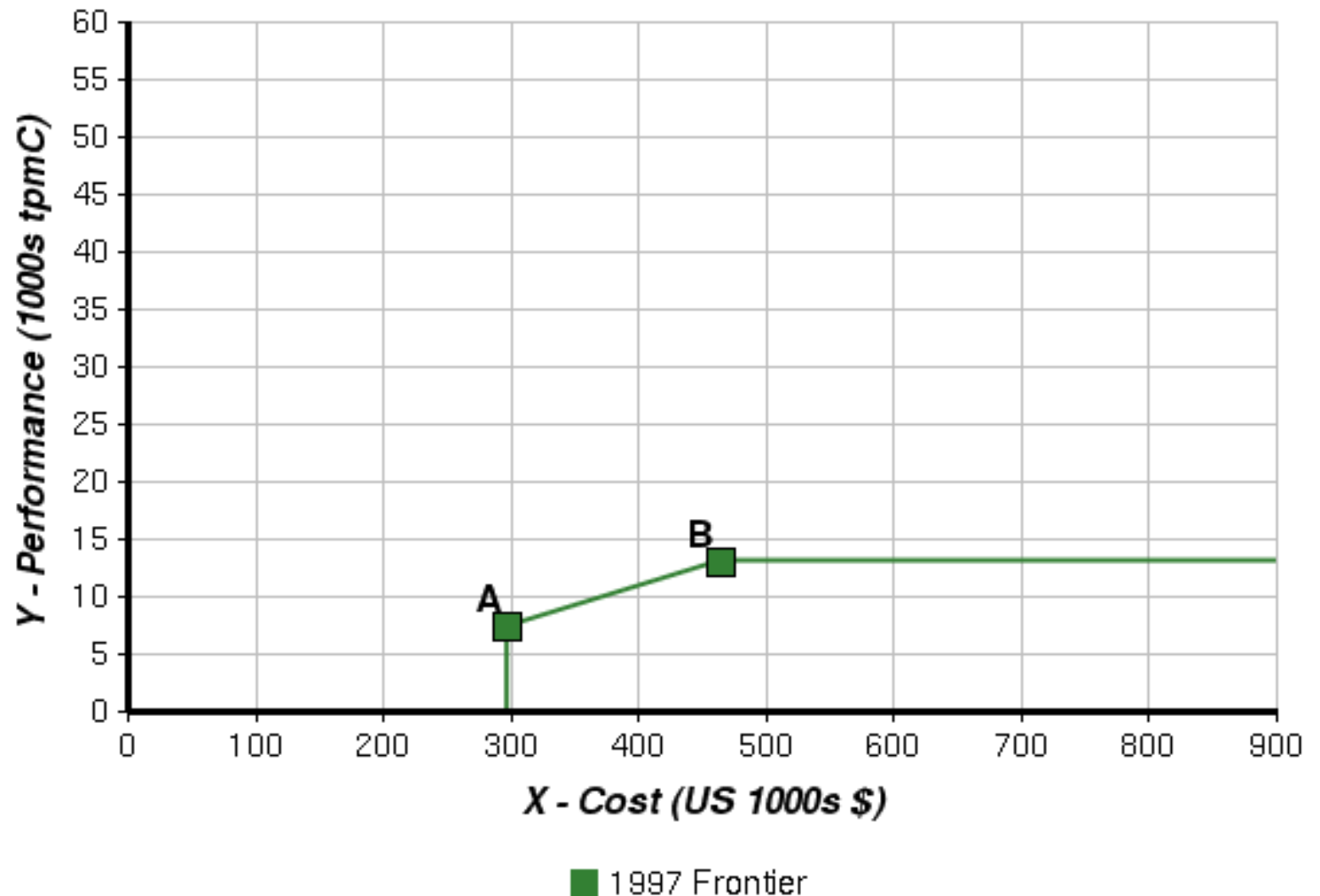
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## Identification of the SOA





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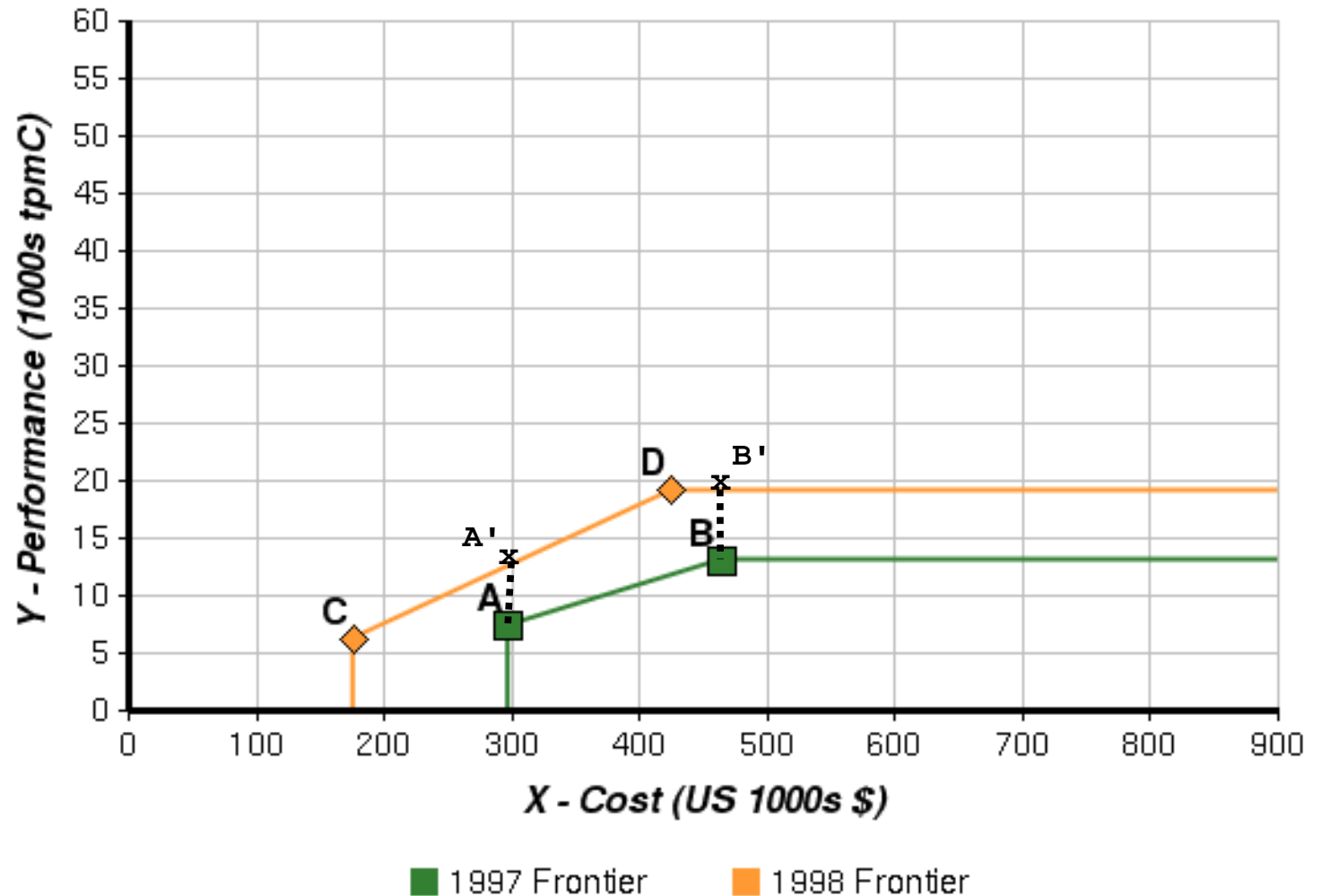
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# Mapping Progress



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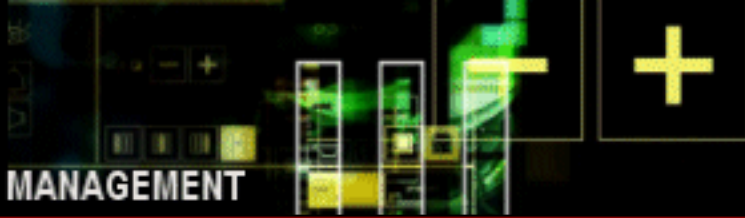
## How do we represent it?

- *Use the  $\beta$  determined earlier:*

$$\phi^t = (\beta)^t \cdot \phi^0$$

$$y_r^t = \beta^{\Delta t} \cdot y_r^0 \quad \forall r \in \{1 \dots m\}$$

- *Translation: new outputs can be multiplied by the old outputs*



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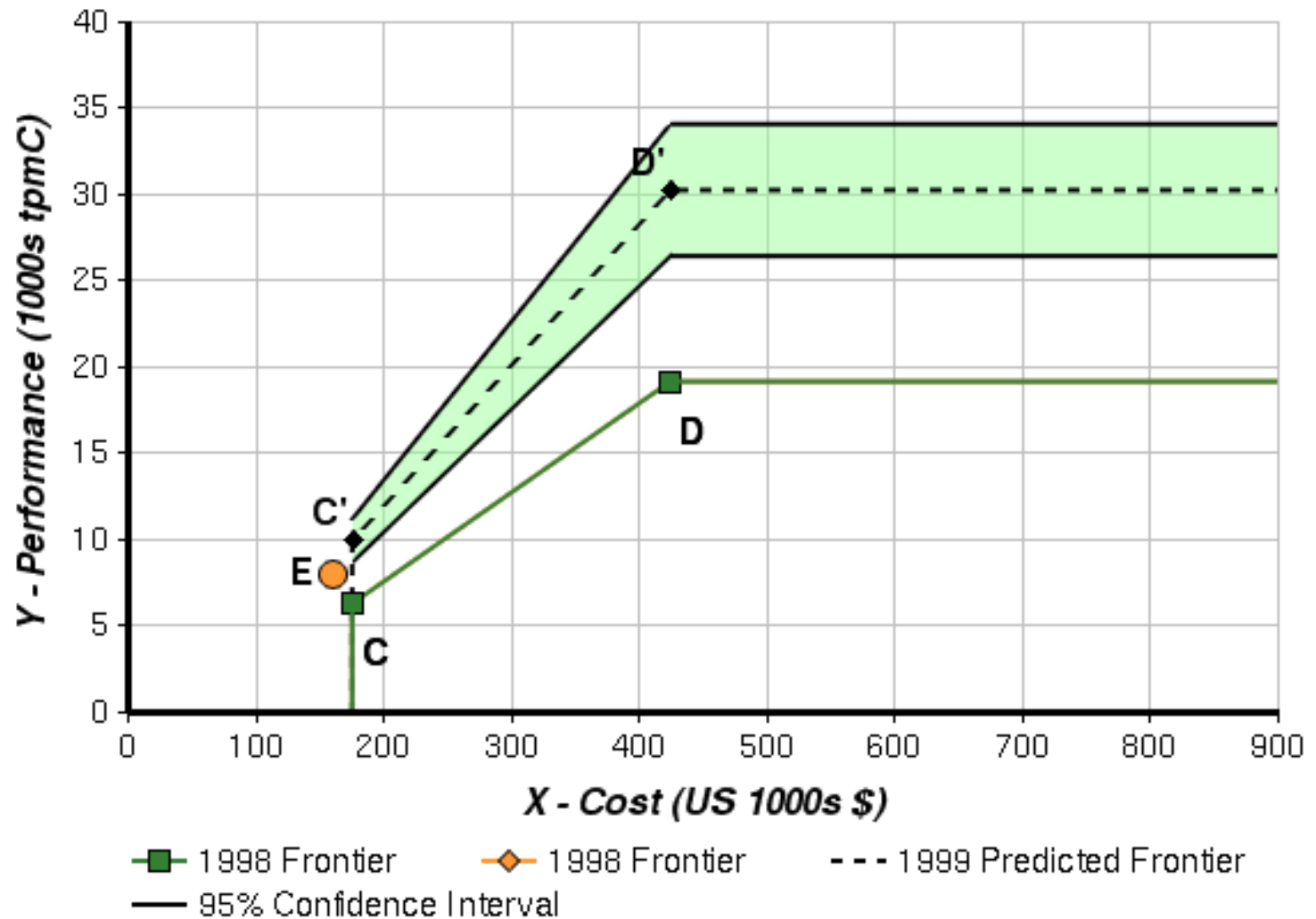
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# Forecasting the Future





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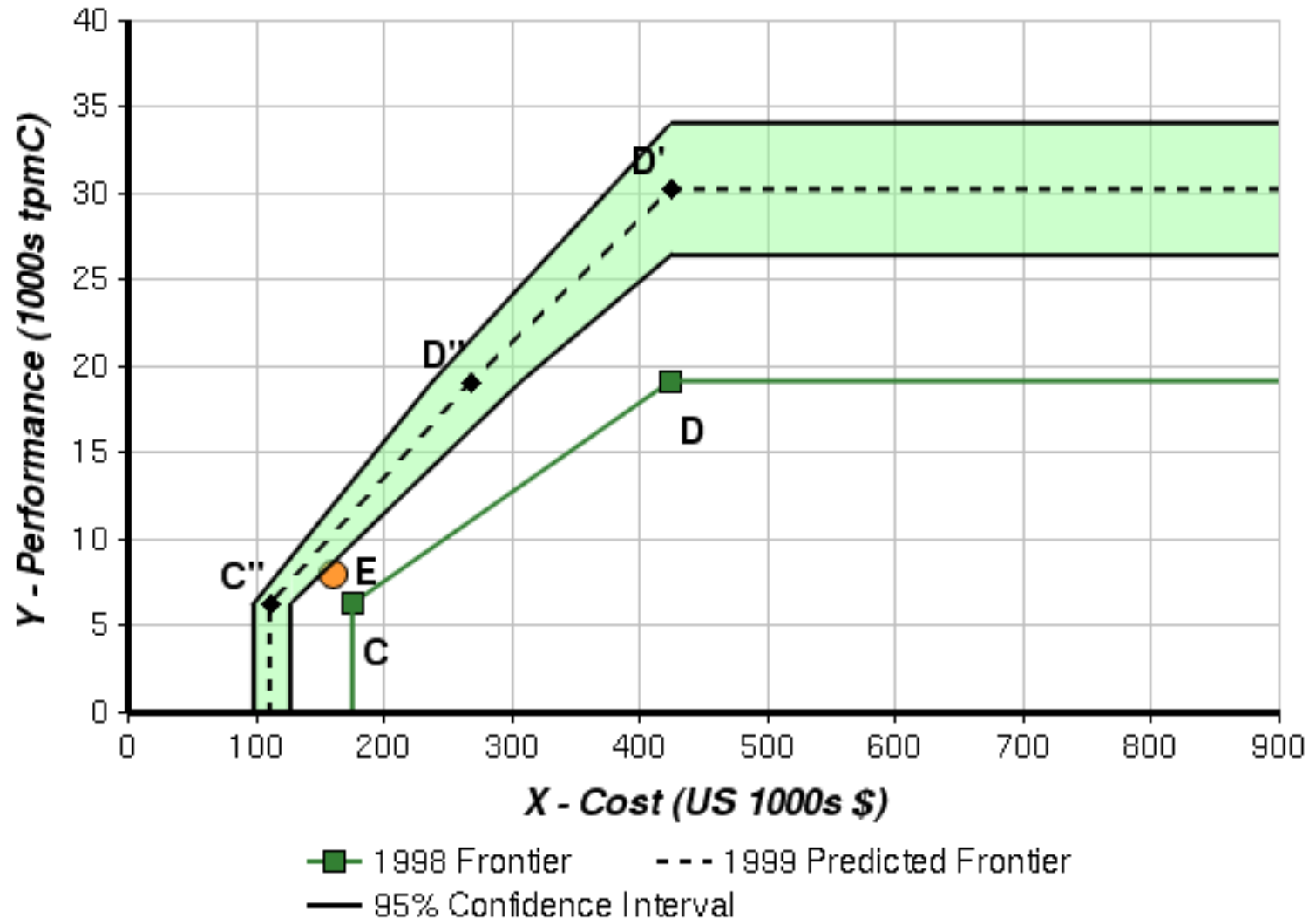
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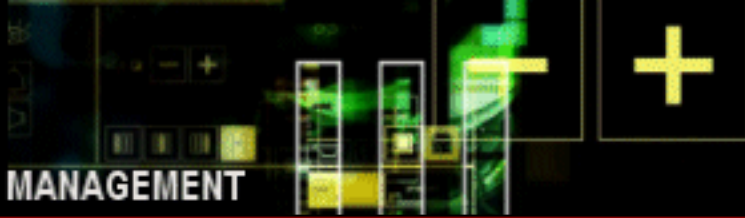
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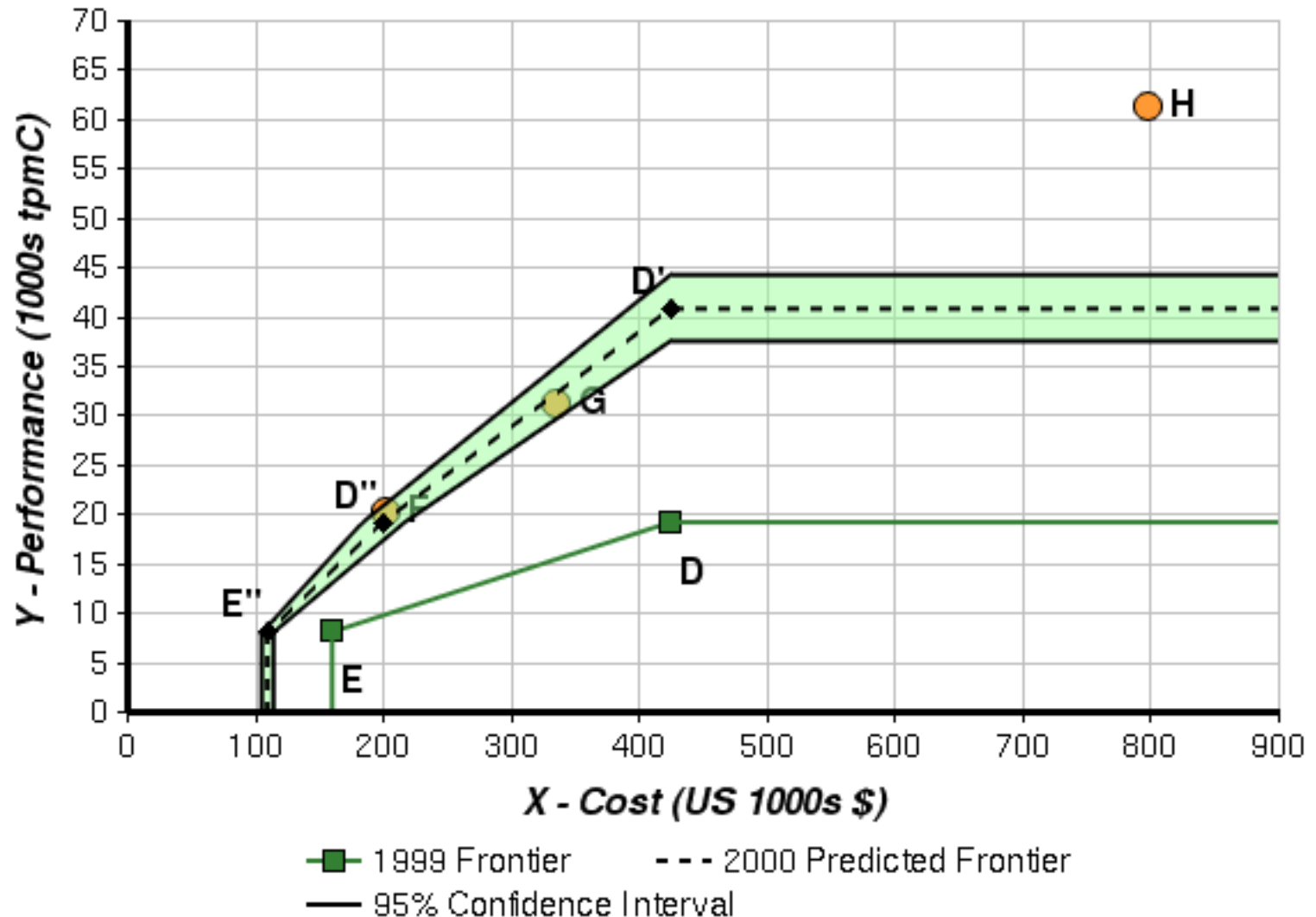
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# Forecasting the Future





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# Applications:

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# TPC Results

## Output-Oriented TFDEA

Predicted Range	541	42.77%
ROC Predicts Lower Bound Only	220	17.39%
ROC Predicts Upper Bound Only	241	19.05%
ROC Did not Predict SOA	263	20.79%
Total	1265	100.00%

## IO-OO Output-Oriented TFDEA

Predicted Range	797	63.00%
ROC Predicts Lower Bound Only	130	10.27%
ROC Predicts Upper Bound Only	338	26.71%
ROC Did not Predict SOA	0	0.00%
Total	1265	100.00%

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# TPC Results

<i>Product</i>	<i>Date Available</i>	$\phi_{lower}$	$\phi_{upper}$	<i>Status</i>
IBM eServer xSeries 365 4P c/s	2004-03-31	1.23	1.30	Low
HP Integrity Superdome	2004-04-14	0.95	1.02	Target
HP rx8620	2004-04-15	1.04	1.07	Low
Unisys ES7000 Aries 420 Enterprise Server	2004-04-20	1.20	1.24	Low
HP Integrity rx5670 Cluster 64P	2004-04-30	0.82	0.89	RISK
PRIMEPOWER 2500	2004-04-30	1.64	1.77	Low
IBM eServer pSeries 690 Model 7040-681	2004-08-16	1.08	1.21	Low
IBM eServer Xseries 445 8P c/s	2004-08-31	1.44	1.59	Low

\*HP Integrity made its debut – but it used RedHat Linux for its Operating System.



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# TPC - Conclusions

- Method provides a good estimate of future trends.
- IO-OO offers additional insight.
- Still prone to disruptive technologies