Software Solutions Symposium 2017

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Applied Machine Learning in Software Engineering

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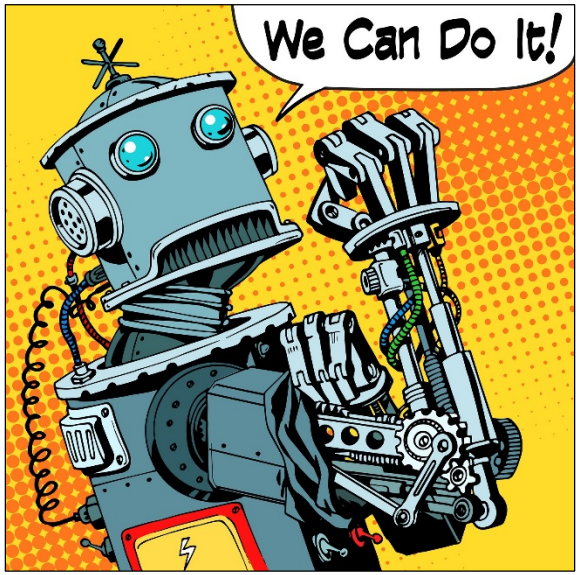
What is Machine Learning?



Tom Mitchell, former CMU Machine Learning department chair:

> *The field of Machine Learning asks the question, "How can we build computer systems that automatically improve with experience, and what are the fundamental laws that govern all learning processes?"*

Machine Learning seeks to automate data analysis and inference.

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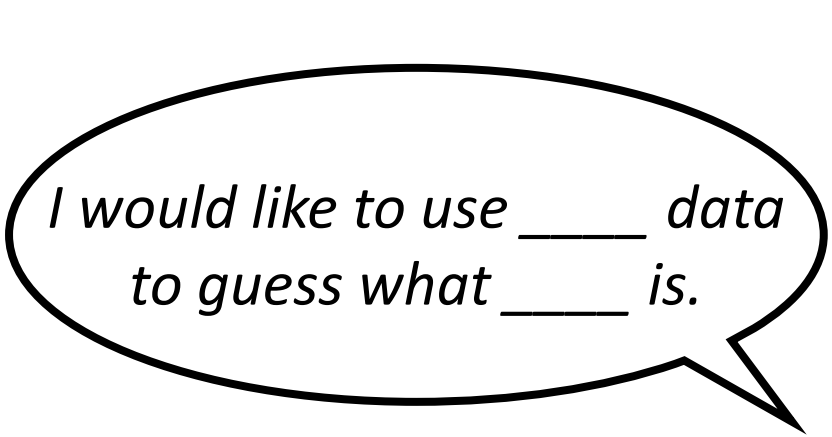
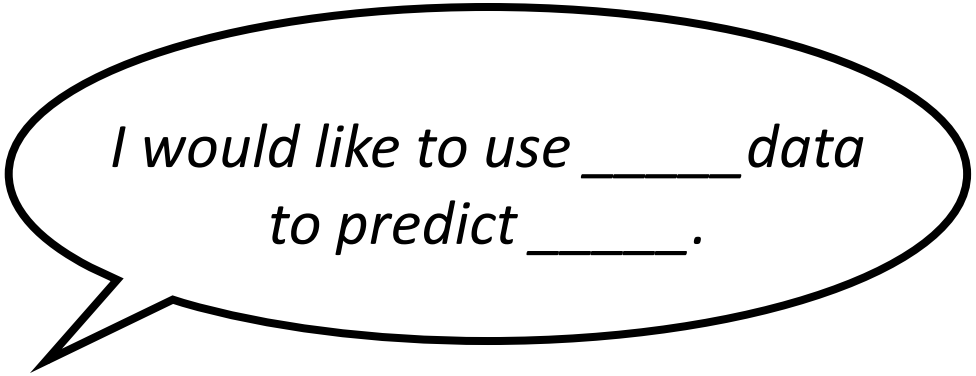
What is Machine Learning?

Picture (optional)

If your problem can be stated as either of the following:





…you would likely benefit from machine learning.

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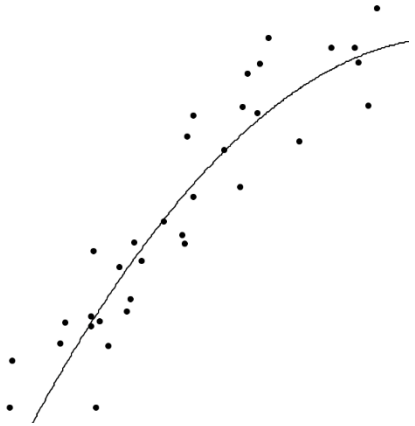
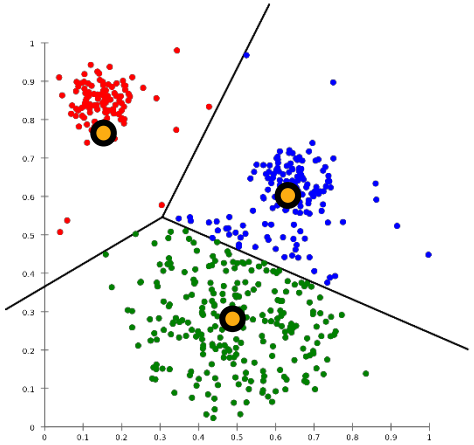
What is Machine Learning?

Sample Techniques:

- Regression



- K-Means Clustering



Clustering image: Weston.pace, https://commons.wikimedia.org/wiki/File:K_Means_Example_Step_4.svg

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What is Machine Learning?

Feature Engineering:

Using existing data to create **more informative** data

Data Types	
Image	Static Video
Time series	Financial data Event counts
Structured text	Web forms Structured data (JSON, XML) Source code
Free text	News Tweets Email
many more…	

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What is Machine Learning?

Picture (optional)

Examples:

- I would like to use **incident ticket** data to predict **customer needs**.
- I would like to use **publicly available code** to predict **what code I will write**.
- I would like to use **bug report** data to guess the location of **undetected bugs in my code**.

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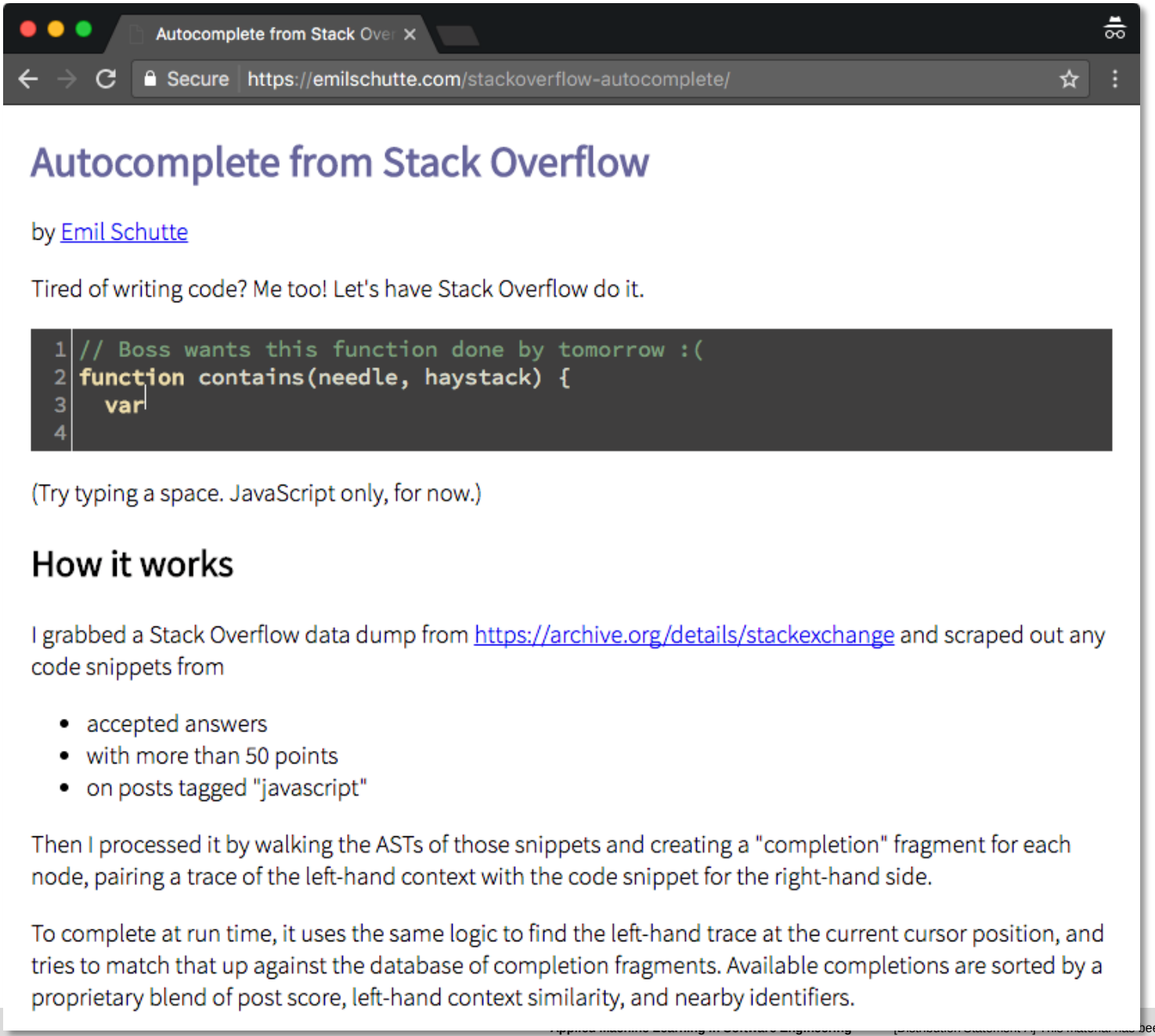
Picture (optional)



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What is Machine Learning?

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Applied ML: Vulnerability Detection

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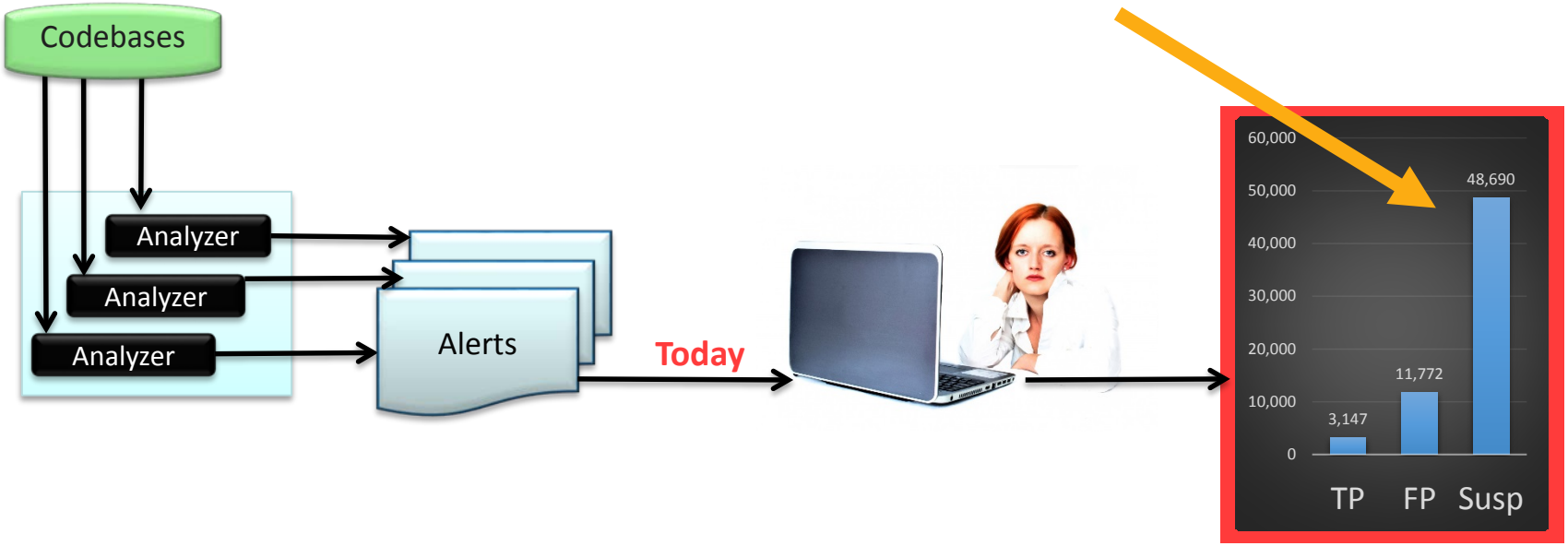
Applied ML: Vulnerability Detection

Many alerts left unaudited!



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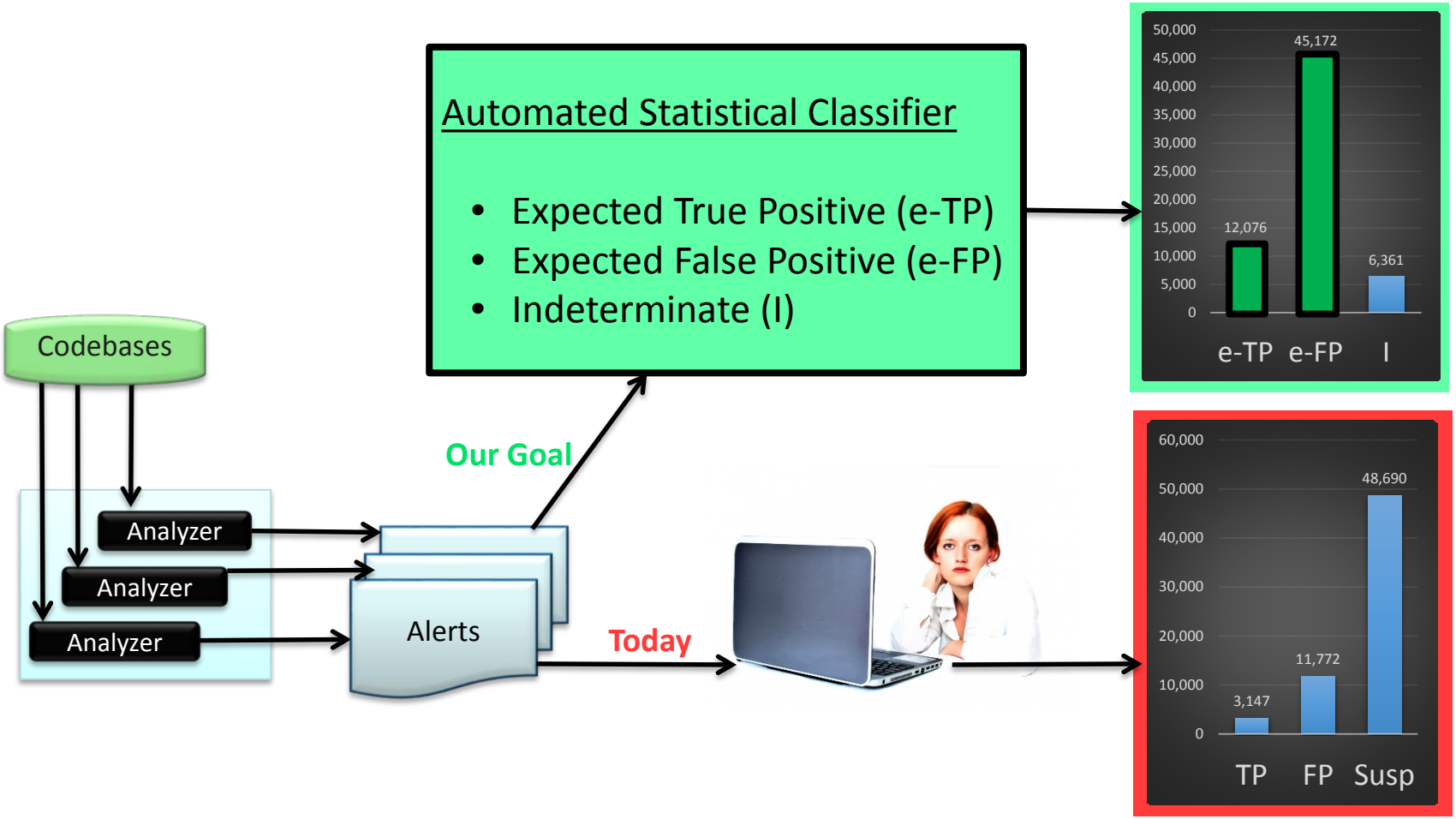
Applied ML: Vulnerability Detection



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Applied ML: Vulnerability Detection

Classifiers
Lasso Logistic Regression
CART
Random Forest
Extreme Gradient Boosting (XGBoost)

Some of the features used	
Analysis tools used	Tokens in func/method
Significant LOC	Alerts in func/method
Complexity	Alerts in file
Coupling	Methods in file
Cohesion	SLOC in file
SEI coding rule	Avg Tokens
Function/method length	Avg SLOC
SLOC in func/method	Depth in code repository
# parameters in func/meth.	Cyclomatic complexity (func/meth)

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Applied ML: Vulnerability Detection

Significant improvement!

- 91% Classifier accuracy overall
- Specific rule accuracy at right
- 10x developer time saved!

Rule ID	XGBoost
INT31-C	97%
EXP01-J	74%
OBJ03-J	83%
FIO04-J*	80%
EXP33-C*	83%
EXP34-C*	72%
DCL36-C*	100%
ERR08-J*	100%
IDS00-J*	96%
ERR01-J*	100%
ERR09-J*	88%

* Small quantity of data

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Applied ML: Malware family classification

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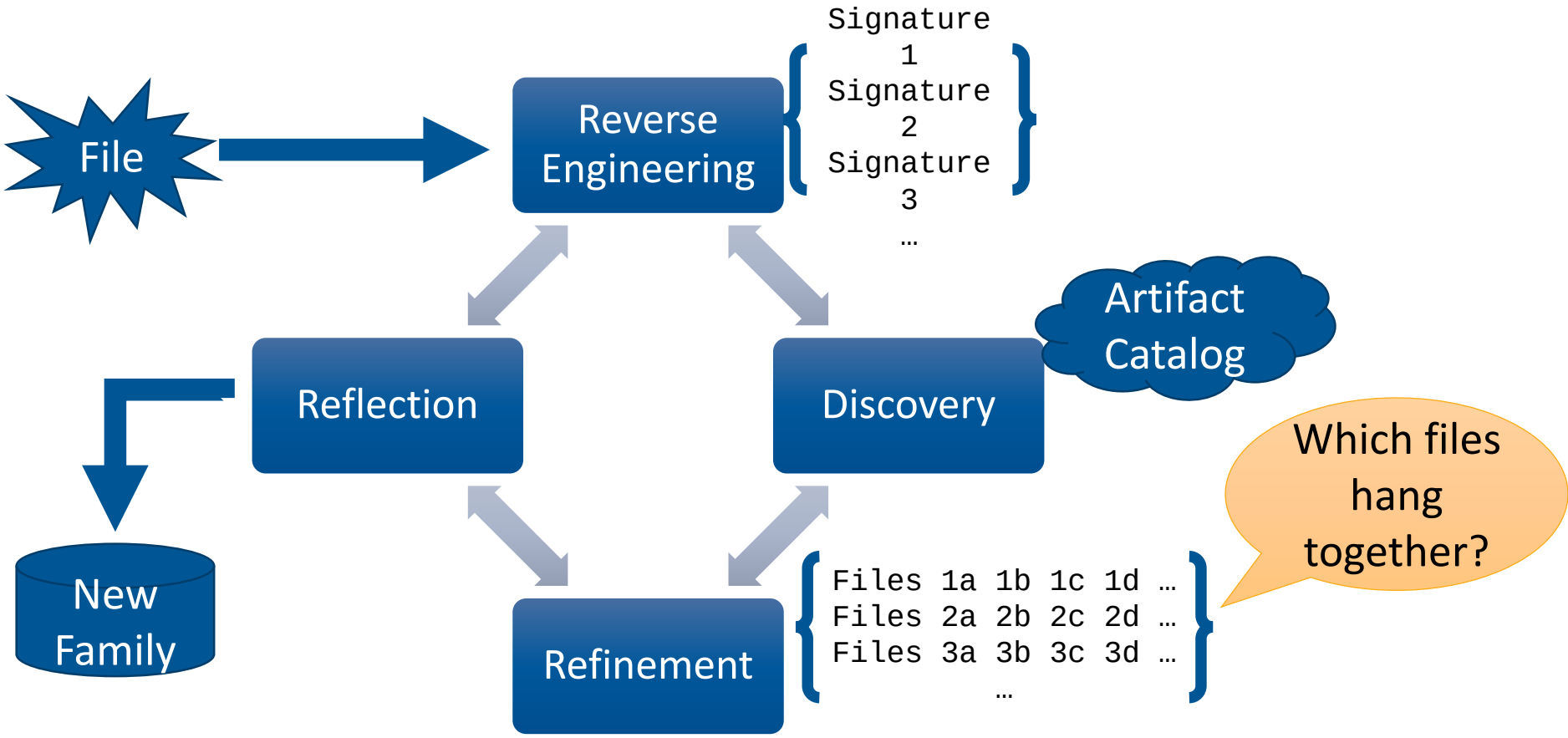
Applied ML: Malware family classification



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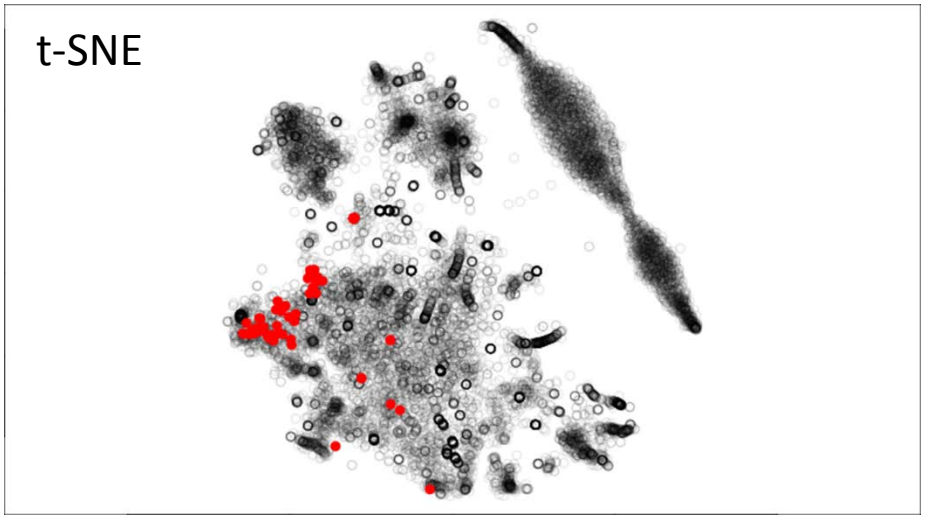
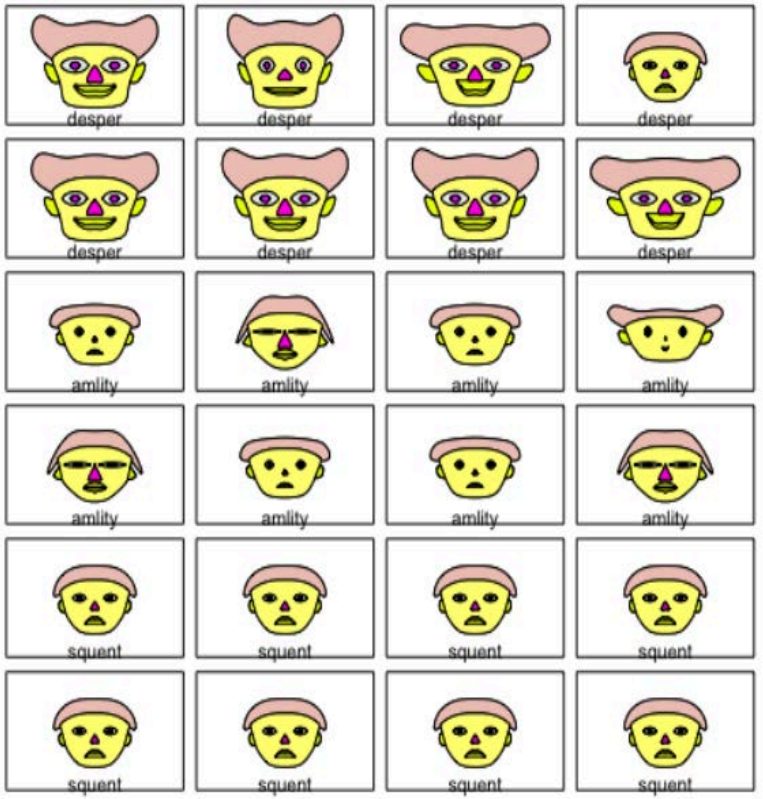
Applied ML: Malware family classification

Simplify visualization of extremely complex data through the use of dimensionality reduction and associated visualization techniques





Chernoff face experiment

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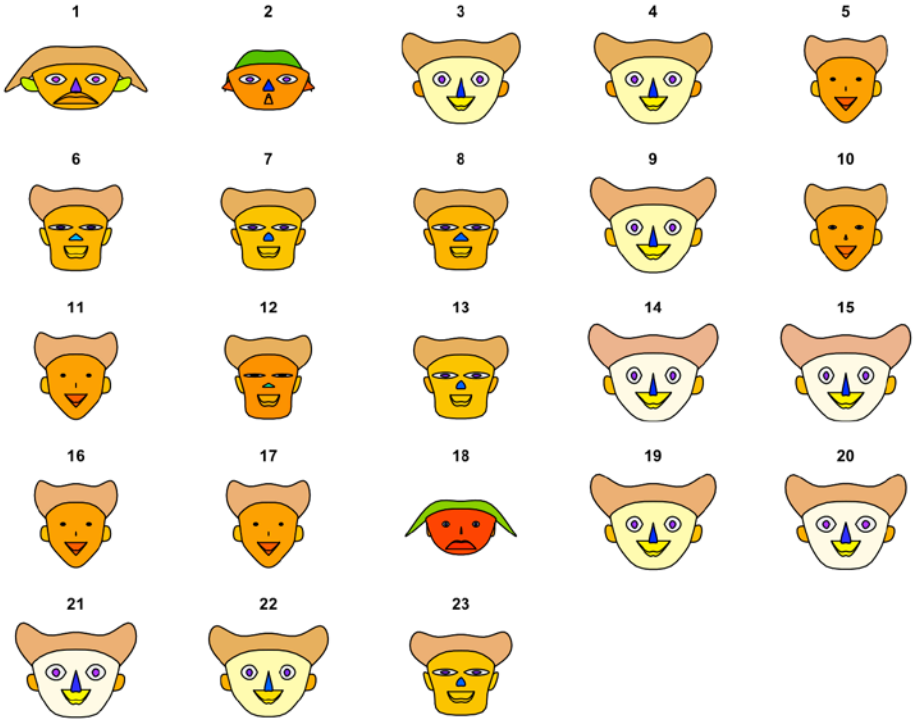
Applied ML: Malware family classification



- Discovery found 23 files
- Manual reverse engineering was slow: only two files in 5 days
- Visualizing files with **Chernoff faces** immediately suggests groups of related files.
- Analysis burden shifts from **forming candidate groups** to **verifying groups**
- Faster and cheaper = happy clients

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Applied ML: Software cost estimation

Robert Ferguson, Dennis Goldenson, James McCurley, Robert W. Stoddard, David Zubrow, Debra Anderson. "Quantifying Uncertainty in Early Lifecycle Cost Estimation (QUELCE)". Dec 2011. http://resources.sei.cmu.edu/library/asset-view.cfm?assetid=10039

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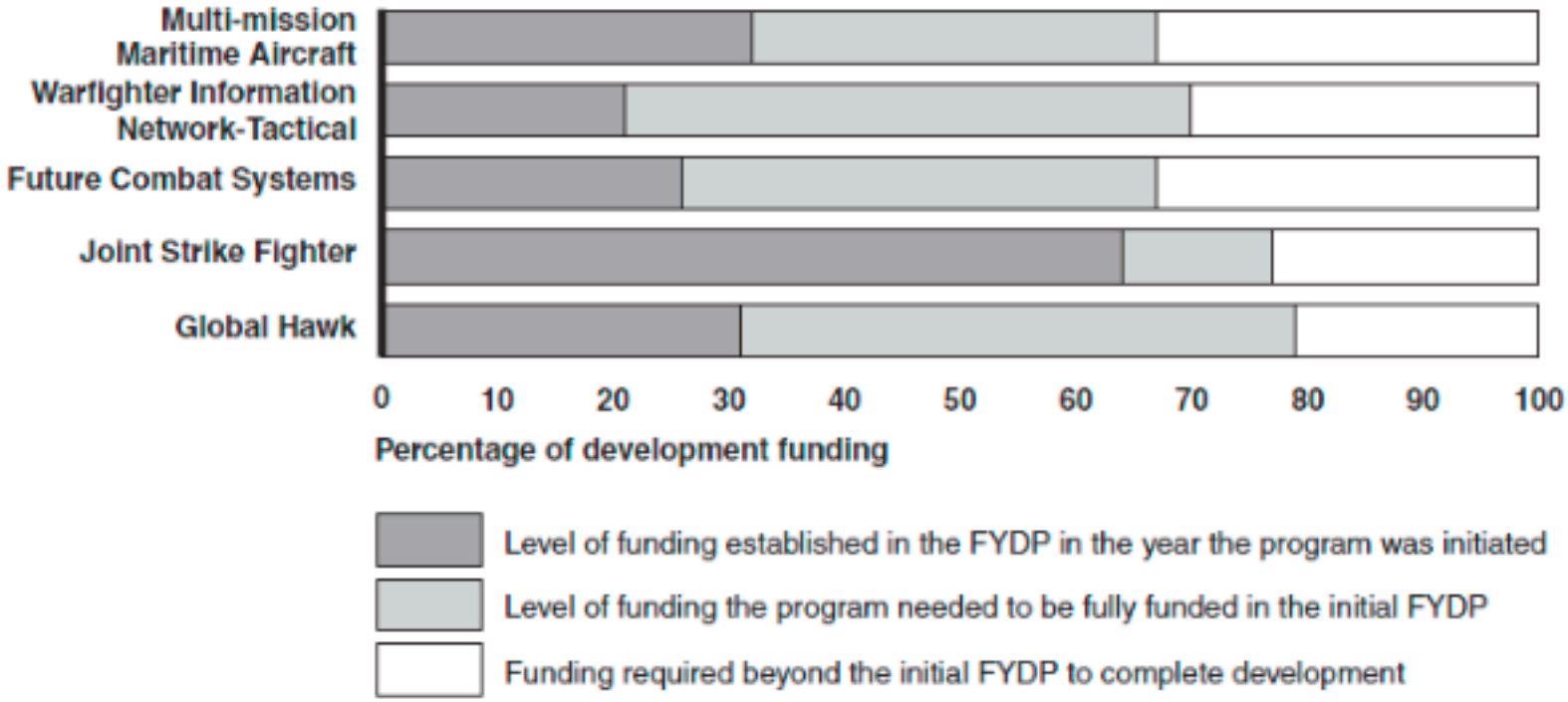
Applied ML: Software cost estimation

Table 2 Cost Overruns in DoD Acquisitions

Funding Shortfalls at the Start of Development for Five Major Weapon System Programs



Source: DOD (data); GAO (analysis and presentation).

General Accounting Office. *Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes*. Report to the Committee on Armed Services, U.S. Senate, July 2008, GAO-08-619.

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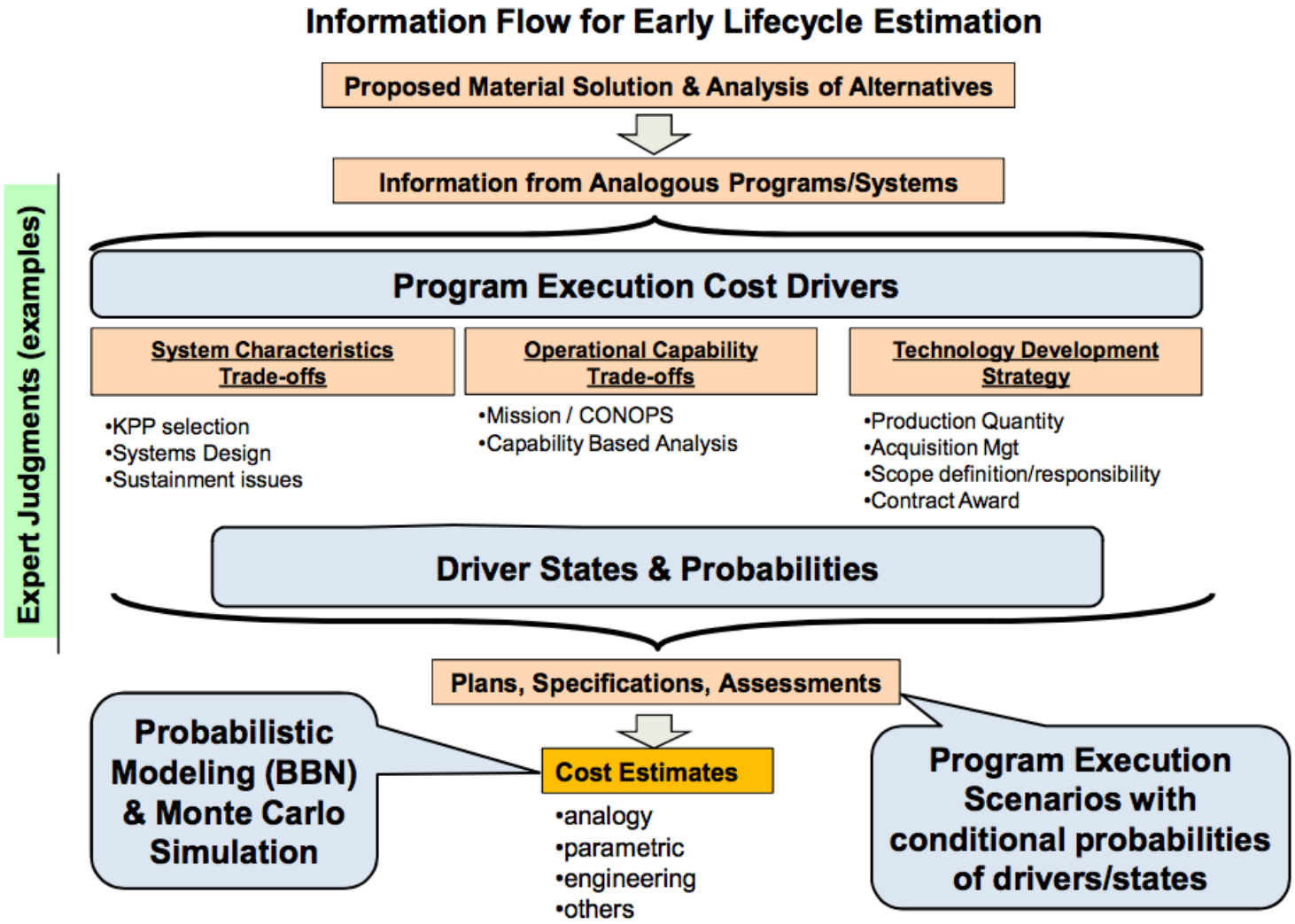

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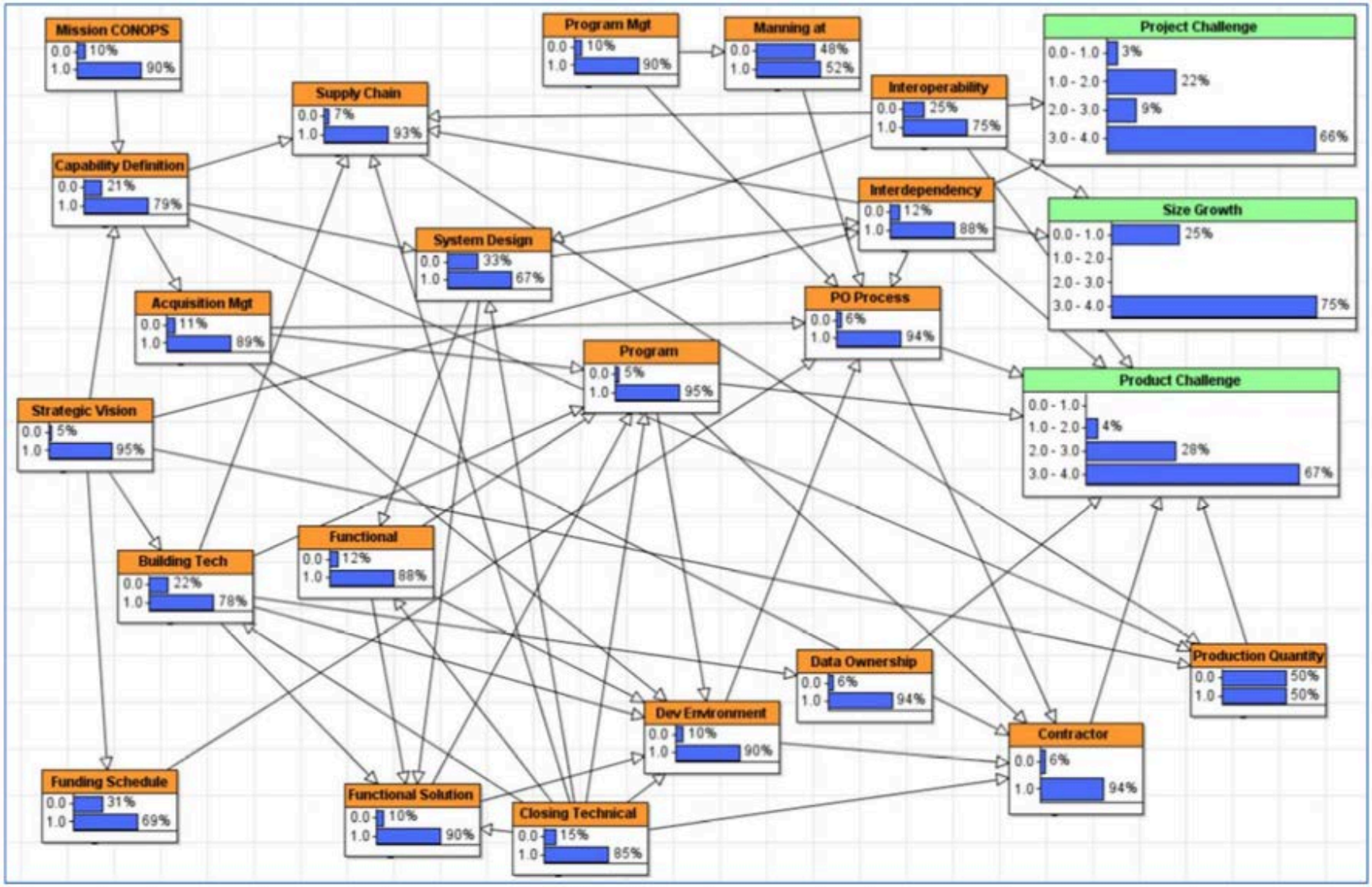

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Applied ML: Software cost estimation

Causes \ Effects	Scope Responsibility	Scope Definition	Mission / CONOPS	Capability Definition	Funding Schedule	Prog Mgt Structure	Manning at program office	Systems Design	Standards/Certifications	Acquisition Management	Program Mgt - Contractor Relations	Project Social / Dev Env	Supply Chain Vulnerabilities	Information sharing	PO Process Performance	Sustainment Issues	Contract Award	Contractor Performance	Production Quantity	Data Ownership	Change in Strategic Vision	Advocacy Change	Industry Company Assessment	Cost Estimate	Test & Evaluation	Closing Technical Gaps (CBA)	Building Technical Capability & Capacity	Functional Measures	Functional Solution Criteria (measure)	Interdependency	Interoperability	Size	Project Challenge	Product Challenge	Total
Scope Responsibility		2				1	1			1	1	1			1																				8
Scope Definition	3					1	1																												5
Mission / CONOPS	0	3		3																															6
Capability Definition					0	0	0	3	2	2	1	1	2	2	0	1	0	0	2	0															16
Funding Schedule							1			1					2			1																	5
Prog Mgt Structure							2					1		1	2																				6
Manning at program office						2								1	2																				5
Systems Design	1												1	1		1				1			2	2	3	2	1	2	2	2	2				23
Standards/Certifications													1			1	1	1					1		3		1		1						10
Acquisition Management											2	3	1	1	2		2	2		1			1	1										1	20
Program Mgt - Contractor Relations												2		1	1	1		2							1		1	1	1	1				2	15
Project Social / Dev Env										1	1			1	2		2	2		1					1		1	1	1	1	1	1	1	1	19
Supply Chain Vulnerabilities					1			1	1	1								1	2																7
Information sharing								1							1	1		1		1						1	1								7
PO Process Performance																		2																2	4
Sustainment Issues																																			0
Contract Award																																			0
Contractor Performance																																		2	2
Production Quantity																																		2	2
Data Ownership																																		2	2
Change in Strategic Vision				3	2									2		2	2		3			3	2	3	2		3			2					29
Advocacy Change	1	2				1	1			1																									6
Industry Company Assessment																																			0
Cost Estimate																																			0
Test & Evaluation																																			0
Closing Technical Gaps (CBA)	1							3	1	1	2	2	2	1	0	2	2	2	1	1	1	2	2	2	1		2	2	2	1	1				37
Building Technical Capability & Capacity (CBA)		1				1				1	2	2	2	3		2	2	1	1	2	0	1	2	1	1	0		1	2	1					29
Functional Measures									1		2	2	1	1	1		1	1		1		1	1		2			2							17
Functional Solution Criteria (measure)									1		2	2						1					1		2					1					10
Interdependency	1	1			1	1	1	2	1		1	1	2	1	2	2		1		1	1	1	1	1	1				1		2	2	2	3	34
Interoperability	1	1						2	1	1	1	1	2	1	1	2		1		1				1	3		1		1	1		2	2	2	29
Size																																			0
Project Challenge																																			0
Product Challenge																																			0
Totals	8	10	0	6	4	7	7	12	8	10	15	18	14	17	17	15	12	19	9	10	2	8	13	11	20	3	11	8	14	11	7	5	5	17	

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