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30 YEARS OF INCIDENT HANDLING

Multi-dimensional malware similarity will let you catch up with malware developers

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FIRST Improving Security Together

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Outline

- **Introduction**
  - Difficulty with Malware Analysis Operations
  - Similarity Tool to Rescue
  - A Single Similarity Tool Is No Match
- **Road to the Proposed Solution**
  - Initial Struggles
  - Bunch of Similarity Tools
  - Three Dimensions for Human Analysts
  - Sample Similarity Scoring System (S4)
- **S4 vs. Malware Families**
  - Match Rules
  - S4 Won All the Matches!
  - Exhibition Match: Olympic Destroyer
- **Conclusion**
  - Future Plan
  - Take Home Message

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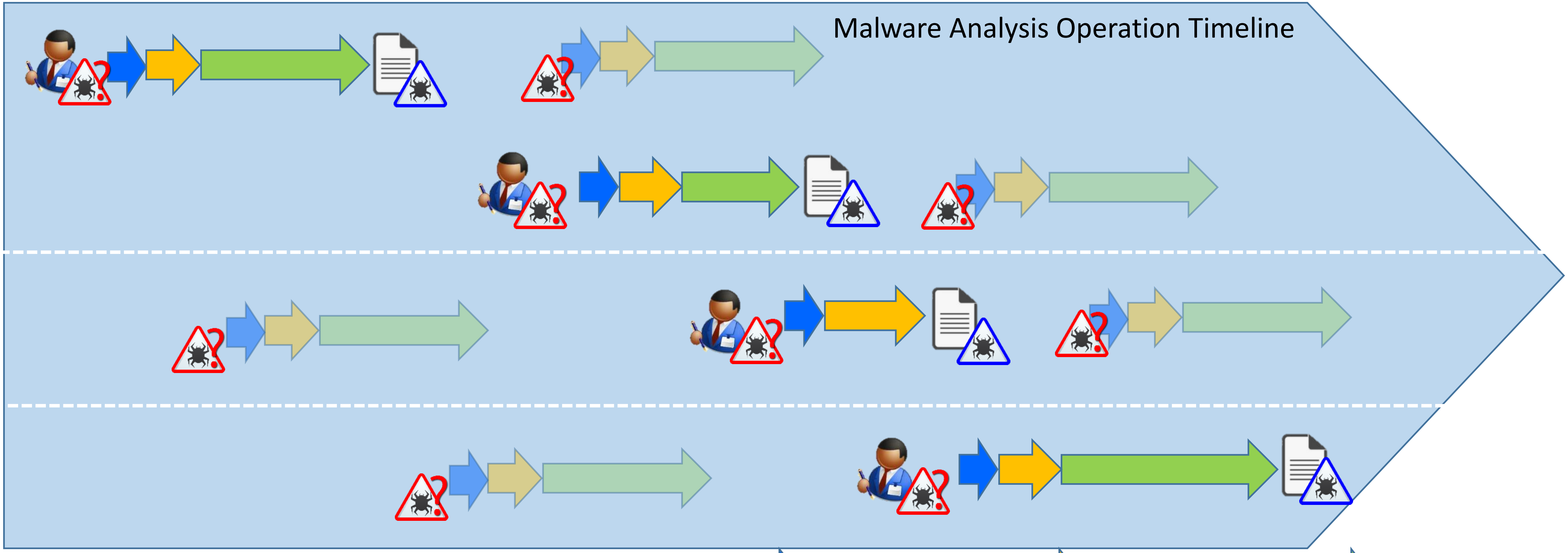
Difficulty with Malware Analysis Operations

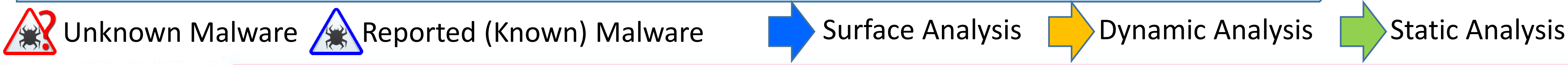
- Attackers continue to develop new pieces of malware at an alarming rate
  - “Conficker” ”CryptoWall" “Badrabbit” “HackerDefender” “Hiddad” “HummingBad” “Necurs” “Nivdort” “Sality” “Triada” “Zeus” “Locky” “CoinHive” “Ramnit” “Fireball” “Pushdo” …

- Analysts cannot keep up with the pace

Similarity Tool to Rescue

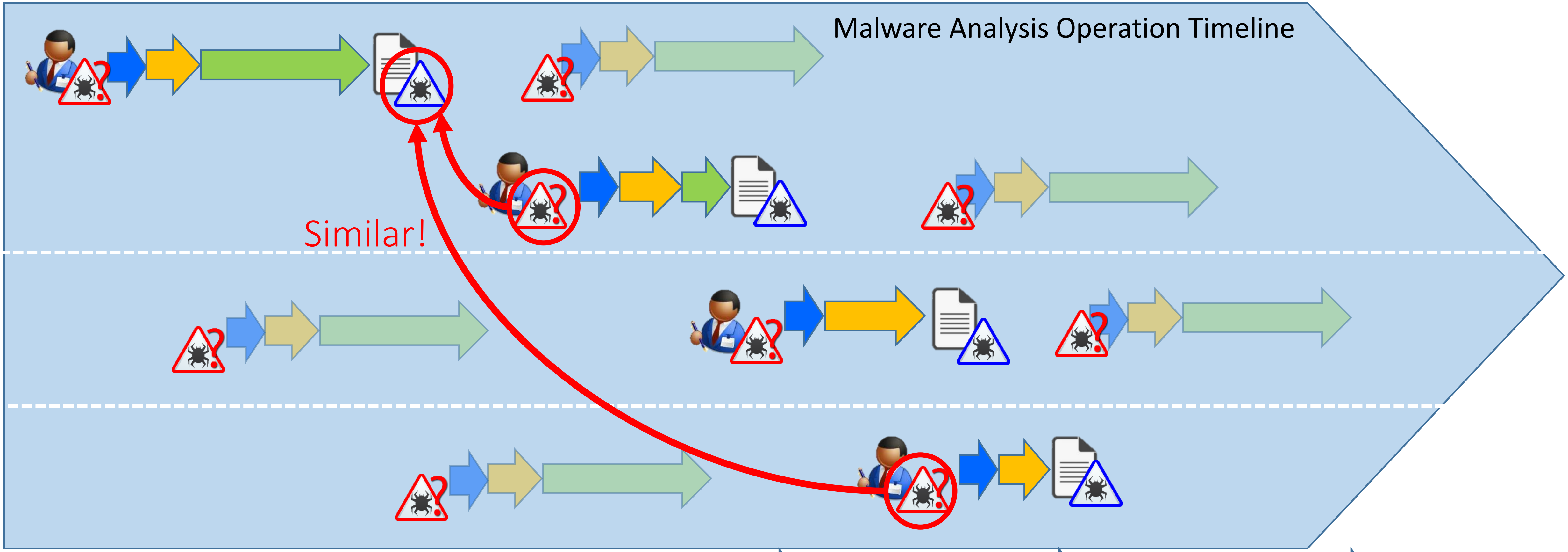
Before…





Similarity Tool to Rescue, but…

After



Unknown Malware | Reported (Known) Malware | Surface Analysis | Dynamic Analysis | Static Analysis

A Single Similarity Tool Is No Match

Similarity Tool	Evasion Technique
• Fuzzy hashing (ex. ssdeep, SDHASH)	<= XOR cipher
• Static Analysis (ex. Section Matching, BinDiff)	<= Packers
• Dynamic Analysis (ex. Techniques using Created Processes, APIs/DLL Calls)	<= Anti-Sandbox

→ A Single Similarity Tool Can Be Easily Evaded

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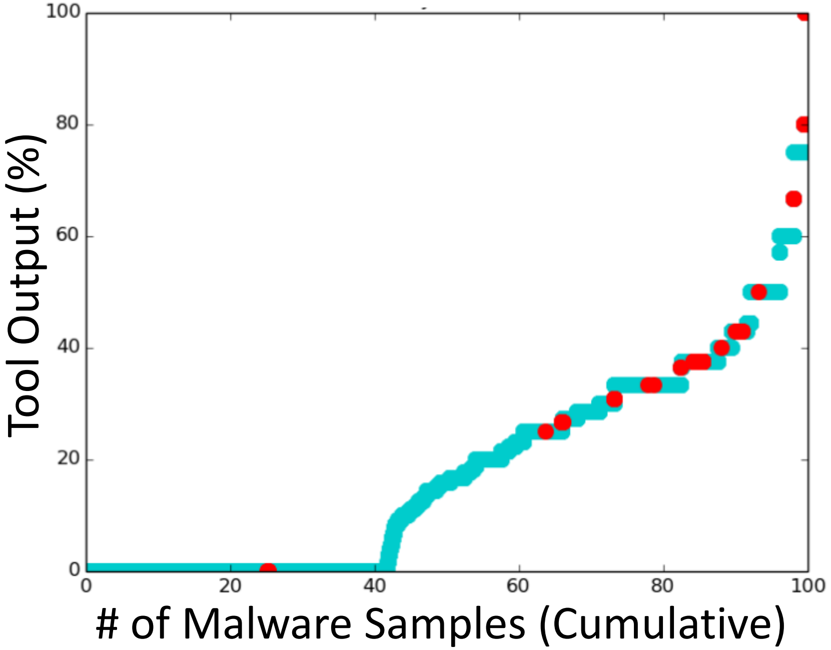
Score Transformation

- **Piecewise linear transformation (PLT)** to enhance malware family separation

DLL Jaccard



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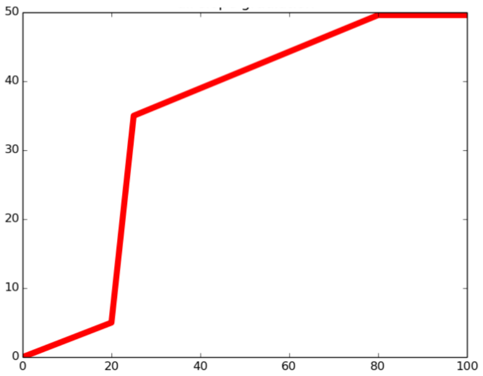
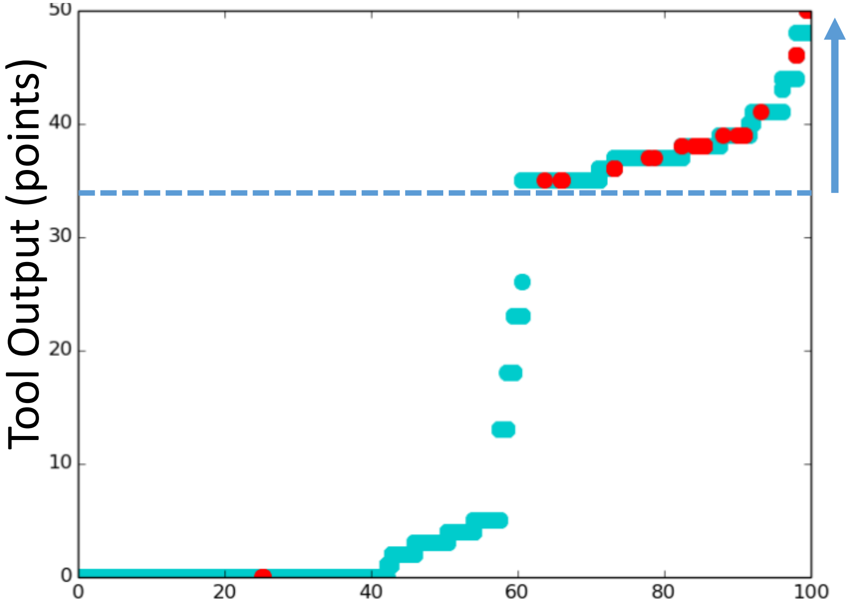


Piecewise Linear Transformation

⇒

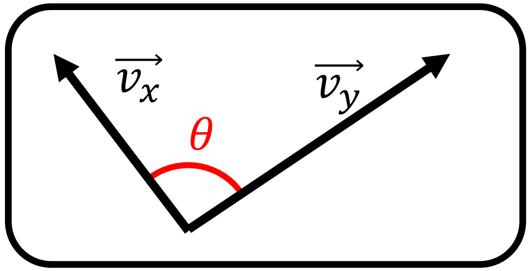
DLL Jaccard (Transformed)



Original Metrics by Cosine Similarity Tools

Ex. Call API Cosine

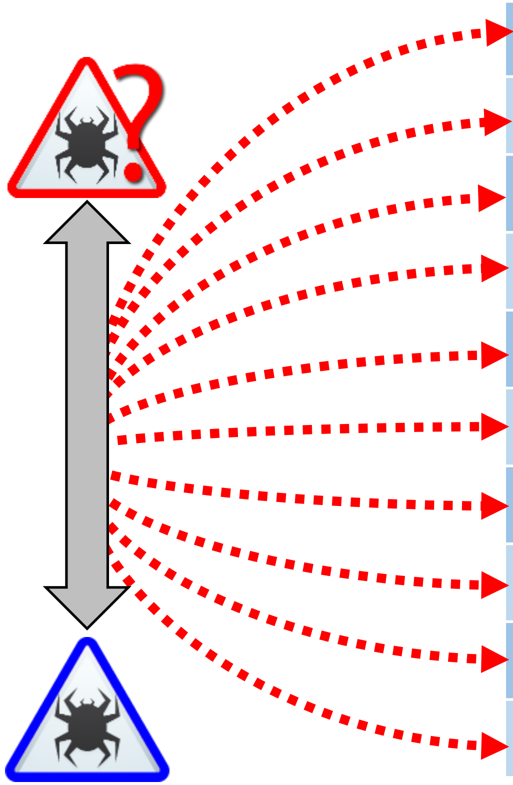
API	GetProcAddress	Connect	Hook	LoadLibrary	…	Feature Vector
Malware X	44	3	1	31	…	$\overrightarrow{v_x}$
Malware Y	22	11	1	30	…	$\overrightarrow{v_y}$



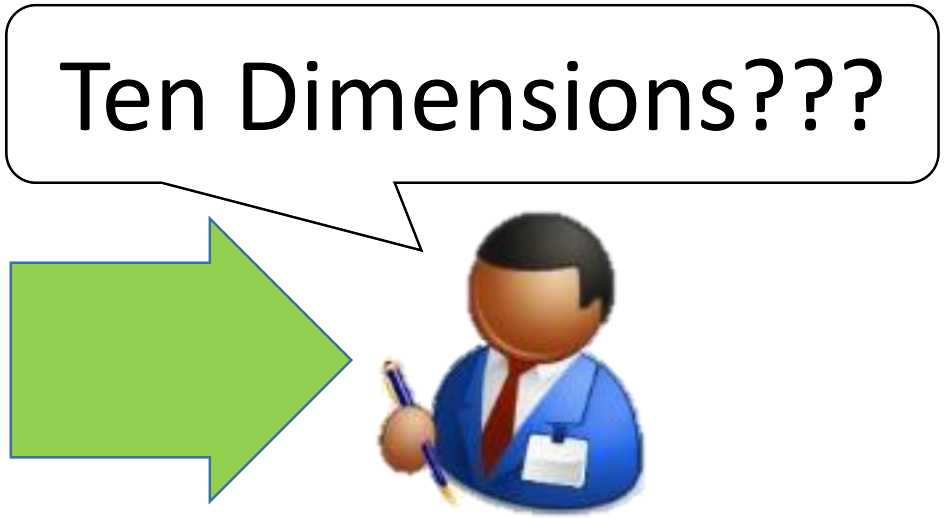
$$\cos\theta = \frac{\overrightarrow{v_x}\cdot\overrightarrow{v_y}}{|\overrightarrow{v_x}||\overrightarrow{v_y}|} = 0.8866$$

Similarity Metric

Bunch of Similarity Tools

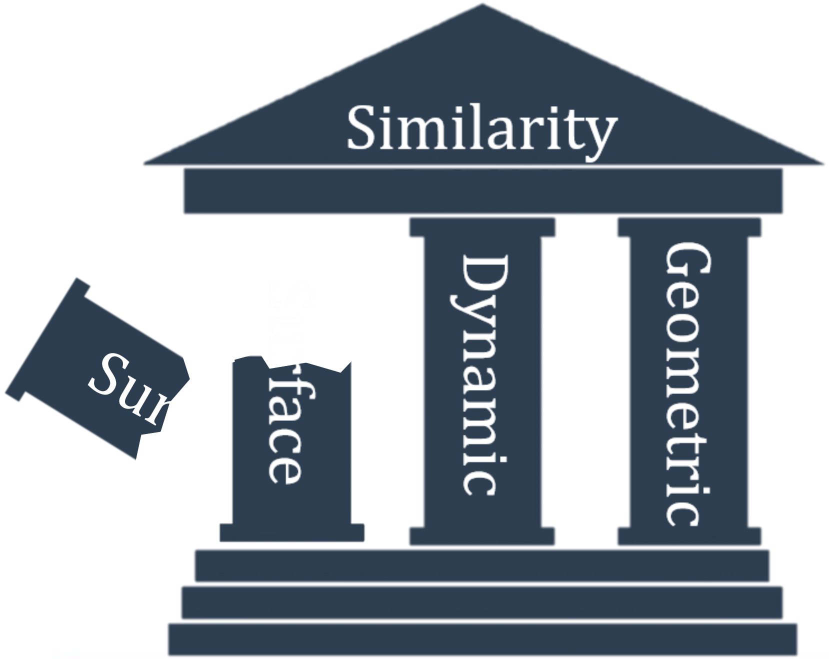


	Transformed Score
ssdeep	0/10
SDHASH	0/10
entropy	45/135
Section Match	0/10
Import DLL	42/50
Call API	31/50
Call DLL	39/50
Process Tree	30/30
API Cosine	42/50
API n-gram Cosine	31/50



Three Dimensions for Human Analysts

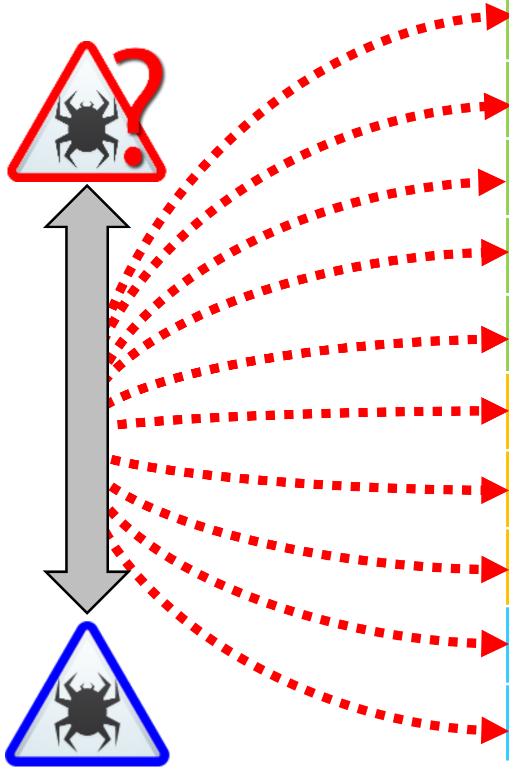
- Higher the Dimensions, Harder to Evade
- Highest # of Dimensions
  for Human to Handle -> 3!



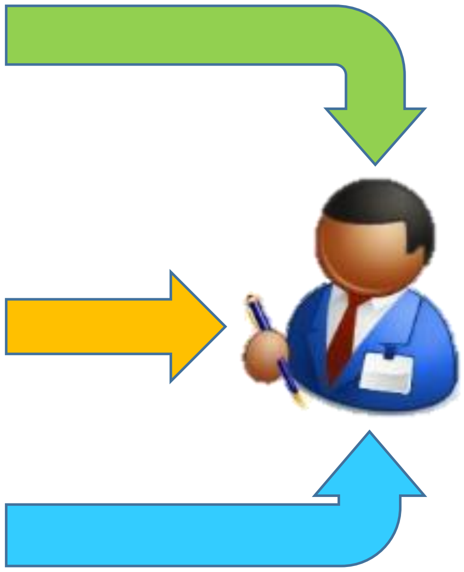
Two Dimensions

Three Dimensions

Similarity Metrics into Three Dimensions

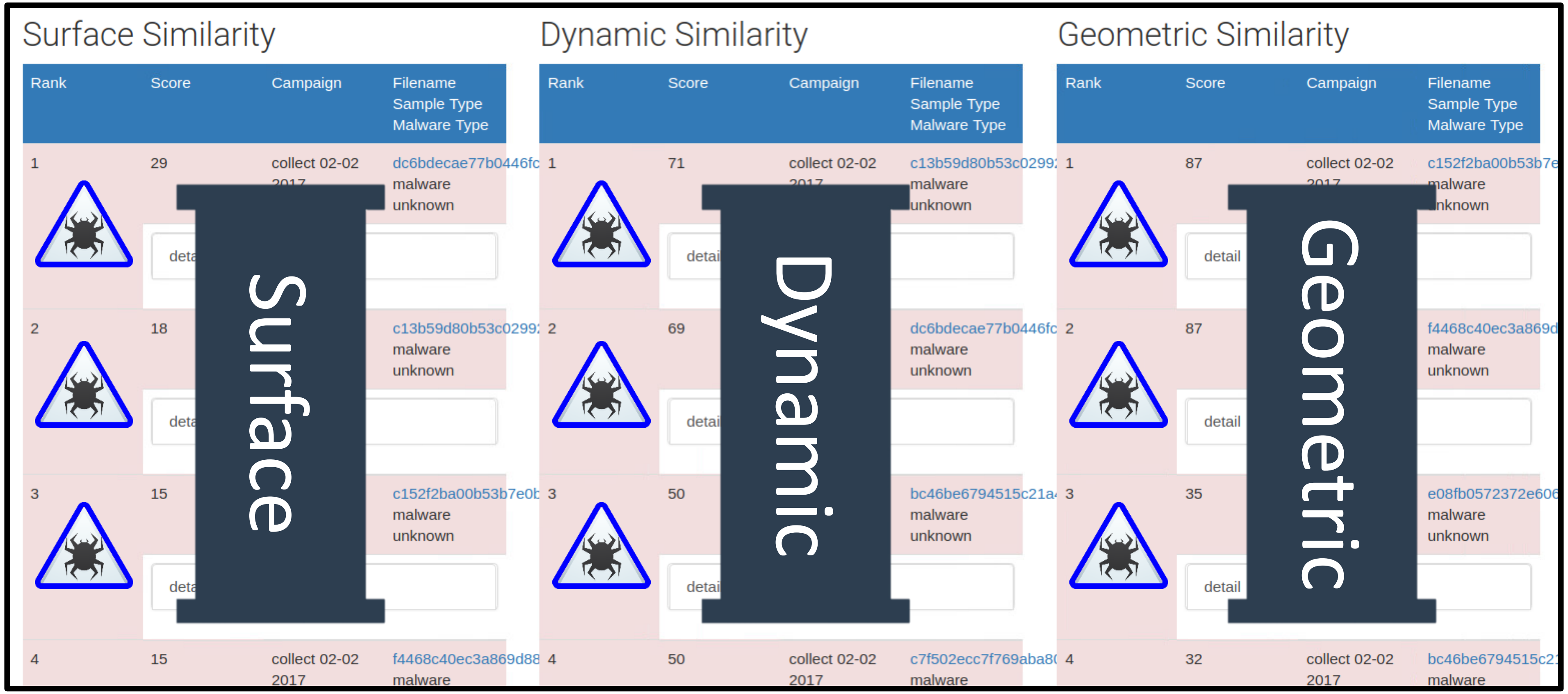


	Transformed Score	Integrated Score
ssdeep	0/10	**Surface Score: 40** (87/215)
SDHASH	0/10	
entropy	45/135	
Section Match	0/10	
Import DLL	42/50	
Call API	31/50	**Dynamic Score: 77** (100/130)
Call DLL	39/50	
Process Tree	30/30	
API Cosine	42/50	**Geometric Score: 73** (73/100)
API n-gram Cosine	31/50	



Sample Similarity Scoring System (S4)

For a given unknown malware → Similar malware ranking in each dimension



Surface Similarity

Rank	Score	Campaign	Filename Sample Type Malware Type
1	29 deta	collect 02-02 2017	dc6bdecae77b0446fc malware unknown
2	18 deta		c13b59d80b53c0299: malware unknown
3	15 deta		c152f2ba00b53b7e0b malware unknown
4	15	collect 02-02 2017	f4468c40ec3a869d88 malware

Dynamic Similarity

Rank	Score	Campaign	Filename Sample Type Malware Type
1	71 detai	collect 02-02 2017	c13b59d80b53c0299: malware unknown
2	69 detai		dc6bdecae77b0446fc malware unknown
3	50 detai		bc46be6794515c21a malware unknown
4	50	collect 02-02 2017	c7f502ecc7f769aba8(malware

Geometric Similarity

Rank	Score	Campaign	Filename Sample Type Malware Type
1	87 detail	collect 02-02 2017	c152f2ba00b53b7e alware nknown
2	87 detail		f4468c40ec3a869d malware unknown
3	35 detail		e08fb0572372e606 malware unknown
4	32	collect 02-02 2017	bc46be6794515c2 malware

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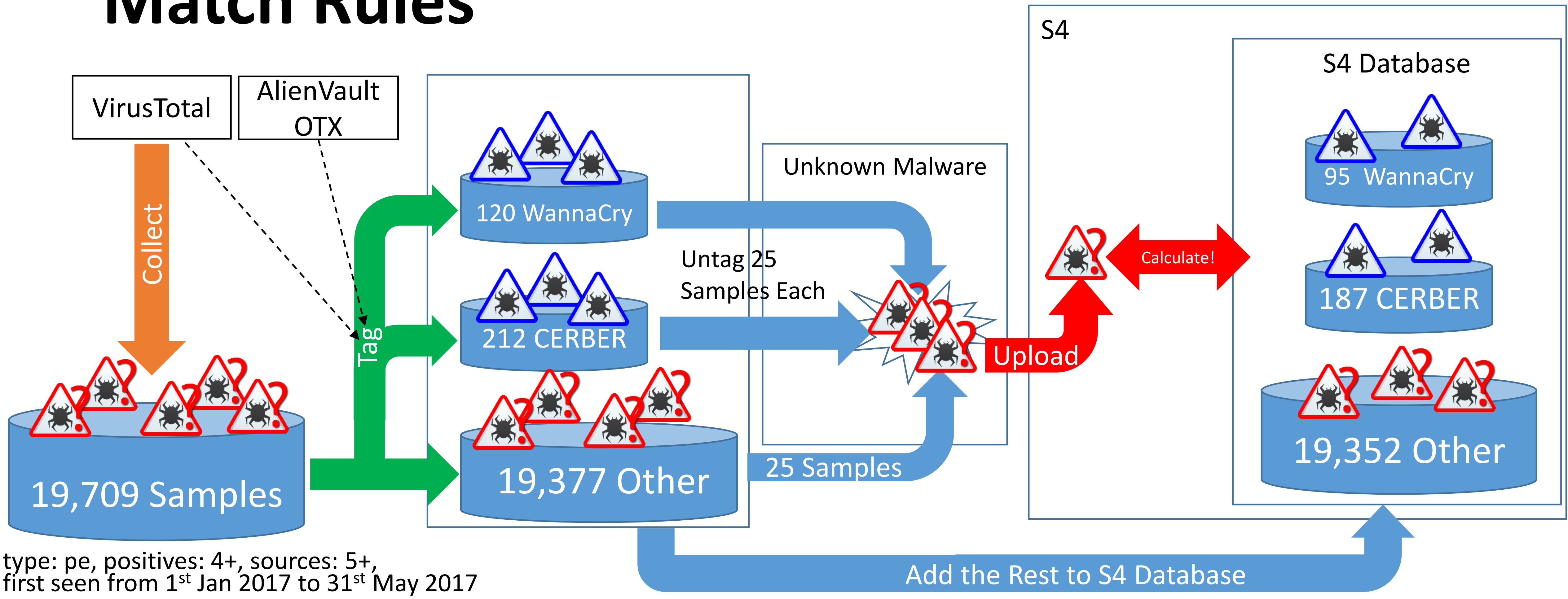
Match Rules



type: pe, positives: 4+, sources: 5+,
first seen from 1st Jan 2017 to 31st May 2017

S4 Wins When It Shows Ones from the Same Family ≧ 50% in Those with Scores ≧ 90

Similar Malware Ranking for "unknown01.exe"

Rank	Surface Similarity	Dynamic Similarity	Geometric Similarity
1	g568.x86.ca.1000.exe (Other): 79	read.php (CERBER): 98	<sha256>.bin (CERBER): 99
2	04958pg.jpeg.exe (Other): 79	read.exe (CERBER): 98	<MD5>.virus (CERBER): 99
3	SETUP-VW.EXE (Other): 78	<sha256>.bin (CERBER): 95	2.exe (CERBER): 99
4	CmbShowHis.EXE (Other): 77	rigamfu.exe (CERBER): 92	voperseanx.exe (CERBER): 99
5	AutoCAD_Setup.exe (Other): 76	DW20.Exe (CERBER): 90	<MD5> (CERBER): 99
6	tpad109.exe (Other): 76	user.phpf1.gif.exe (CERBER): 90	cerber.exe (CERBER): 99
7	your.exe (Other): 76	<MD5>.virus (CERBER): 90	cerber2.exe (CERBER): 99
8	your.exe (Other): 76	zzz.exe (CERBER): 90	dsconfig.exe (CERBER): 99
9	M3Apnda2.exe (Other): 76	1.EXE (CERBER): 90	exe1.exe (CERBER): 99
10	f5aauicn.exe (Other): 75	003.exe (CERBER): 89	exe1.exe (CERBER): 99

≧ 90

< 90

All (100%) of 19 Samples with Scores ≧ 90 Are CERBER Family

-> S4 Wins the Match!

S4 Won All the Matches!

Malware	# of Samples	# of S4 Wins	Winning Rate
CERBER	25	25	100%
WannaCry	25	25	100%
Other	25	25	100%

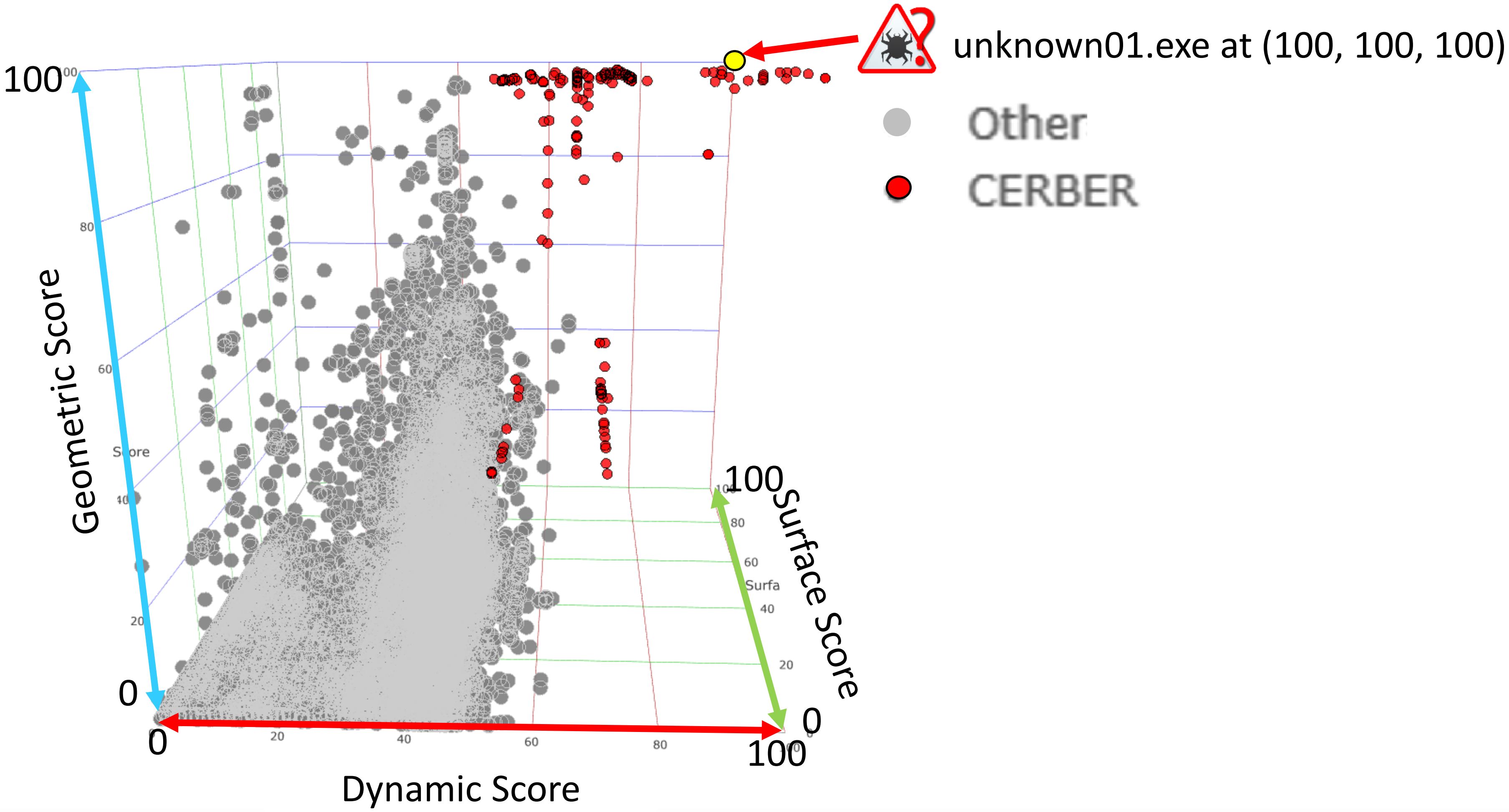
Similar Malware Ranking for “unknown01.exe”

Rank	Surface Similarity	Dynamic Similarity	Geometric Similarity
1	g568.x86.ca.1000.exe (Other): 79	read.php (CERBER): 98	<sha256>.bin (CERBER): 99
2	04958pg.jpeg.exe (Other): 79	read.exe (CERBER): 98	<MD5>.virus (CERBER): 99
3	SETUP-VW.EXE (Other): 78	<sha256>.bin (CERBER): 95	2.exe (CERBER): 99
4	CmbShowHis.EXE (Other): 77	rigamfu.exe (CERBER): 92	voperseanx.exe (CERBER): 99
5	AutoCAD_Setup.exe (Other): 76	DW20.Exe (CERBER): 90	<MD5> (CERBER): 99
6	tpad109.exe (Other): 76	user.phpf1.gif.exe (CERBER): 90	cerber.exe (CERBER): 99
7	your.exe (Other): 76	<MD5>.virus (CERBER): 90	cerber2.exe (CERBER): 99
8	your.exe (Other): 76	zzz.exe (CERBER): 90	dsconfig.exe (CERBER): 99
9	M3Apnda2.exe (Other): 76	1.EXE (CERBER): 90	exe1.exe (CERBER): 99
10	f5aauicn.exe (Other): 75	003.exe (CERBER): 89	exe1.exe (CERBER): 99

≧ 90

< 90

Behind the Scene - 3D Visualization (CERBER)



Similar Malware Ranking for “unknown40.exe”

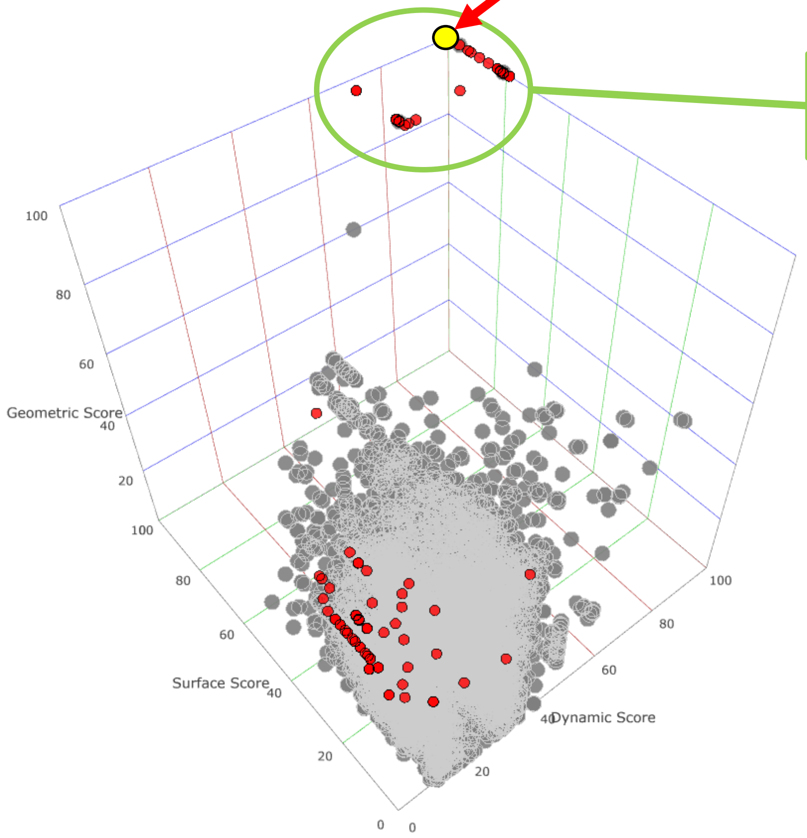
Rank	Surface Score	Dynamic Score	Geometric Score
1	mssecsvc.exe (WannaCry): 98	mssecsvc.exe (WannaCry): 100	mssecsvc.exe (WannaCry): 99
2	mssecsvc.exe (WannaCry): 95	<MD5hash>.virus (WannaCry): 100	lhdfrgui.exe (WannaCry): 99
3	<MD5hash>.virus (WannaCry): 94	lhdfrgui.exe (WannaCry): 100	lhdfrgui.exe (WannaCry): 99
4	lhdfrgui.exe (WannaCry): 94	lhdfrgui.exe (WannaCry): 100	lhdfrgui.exe (WannaCry): 99
5	mssecsvc.exe (WannaCry): 94	mssecsvc.exe (WannaCry): 100	<MD5hash>.virus (WannaCry): 99
6	mssecsvc.exe (WannaCry): 93	<MD5hash>.virus (WannaCry): 100	mssecsvc.exe (WannaCry): 99
7	mssecsvc.exe (WannaCry): 92	36318392.exe (WannaCry): 100	lhdfrgui.exe (WannaCry): 99
8	lhdfrgui.exe (WannaCry): 91	mssecsvc.exe (WannaCry): 100	<MD5hash>.virus (WannaCry): 99
9	lhdfrgui.exe (WannaCry): 91	mssecsvc.exe (WannaCry): 100	mssecsvc.exe (WannaCry): 99
10	36318392.exe (WannaCry): 89	<MD5hash>.virus (WannaCry): 100	<MD5hash>.virus (WannaCry): 99

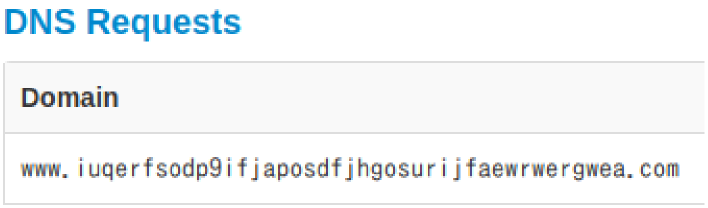
≧ 90

▨ < 90

Behind the Scene - Kill Switch of WannaCry

unknown40.exe at (100, 100, 100)





DNS Requests

Domain
www.iuqerfsodp9ifjaposdfjhgosurijfaewrwergwea.com

Similar Malware Ranking for “unknown14.exe”

Rank	Surface Score	Dynamic Score	Geometric Score
1	P_SK001.exe (Other) : 93	AIRBNB Brute.exe (Other) : 100	AIRBNB Brute.exe (Other) : 99
2	P_SK003.exe (Other) : 92	Skype Resolver.exe (Other) : 100	Skype Resolver.exe (Other) : 99
3	Red_crypter.exe (Other) : 90	HackerClean.exe (Other) : 100	HackerClean.exe (Other) : 99
4	P_SK002.exe (Other) : 90	stm1.exe (Other) : 100	stm1.exe (Other) : 99
5	P_SK005.exe (Other) : 88	RebornBuddy.exe (Other) : 100	RebornBuddy.exe (Other) : 99
6	ReptileUI.exe (Other) : 87	updater.exe (Other) : 100	updater.exe (Other) : 99
7	HmpvInst.exe (Other) : 86	ProxyAlts Loader.exe (Other) : 100	ProxyAlts Loader.exe (Other) : 99
8	Stealth.exe (Other) : 86	PML_Alert.exe (Other) : 100	PML_Alert.exe (Other) : 99
9	google chrom.exe (Other) : 85	conhost.exe (Other) : 100	MmiStart.exe (Other) : 99
10	Application1.exe(Other) : 85	MmiStart.exe (Other) : 100	GITS-DE.exe (Other) : 99

≧ 90   < 90

Exhibition Match: S4 vs. Olympic Destroyer

“unknown2018_01.exe” (Found Feb 2018) against Feb 2018 Malware Set

Rank	Surface Score	Dynamic Score	Geometric Score
1	_bjv.exe (Olympic Destroyer) : 99	_bjv.exe (Olympic Destroyer) : 93	_bjv.exe (Olympic Destroyer) : 99
2	_bdm.exe (Olympic Destroyer) : 99	_bdm.exe (Olympic Destroyer) : 93	_bdm.exe (Olympic Destroyer) : 99
3	_rnk.exe (Olympic Destroyer) : 99	_rnk.exe (Olympic Destroyer) : 93	_rnk.exe (Olympic Destroyer) : 99
4	<MD5> (Olympic Destroyer) : 99	<MD5> (Olympic Destroyer) : 93	<MD5> (Olympic Destroyer) : 99
5	_jea.exe (Olympic Destroyer) : 92	_jea.exe (Olympic Destroyer) : 74	zeuspanda (Panda Banker) : 70
6	_ljy.exe (Olympic Destroyer) : 92	_ljy.exe (Olympic Destroyer) : 74	<MD5> (Other) : 70
7	_mpw.exe (Olympic Destroyer): 92	_nfc.exe (Olympic Destroyer) : 74	CFE_Factura.exe (Other) : 69
8	_qih.exe (Olympic Destroyer) : 92	_nka.exe (Olympic Destroyer) : 74	executable.1088.exe (Other) : 68
9	_nfc.exe (Olympic Destroyer) : 91	_mpw.exe (Olympic Destroyer) : 74	<MD5> (Olympic Destroyer) : 65
10	_nka.exe (Olympic Destroyer) : 91	_wun.exe (Olympic Destroyer) : 74	_nfc.exe (Olympic Destroyer) : 65

≧ 90   < 90

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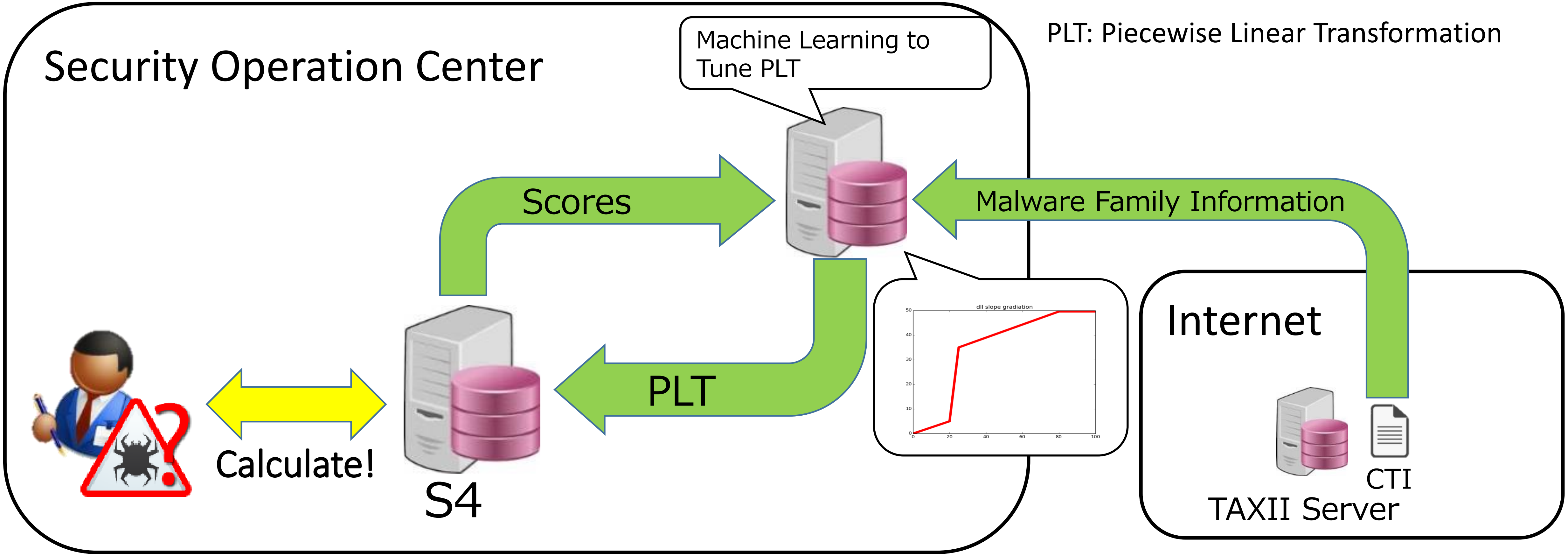
Future Plan:

Automatic Score Transformation Tuning

PLT: Piecewise Linear Transformation



Take Home Message

There is □ with Malware Analysis Operations, a □ Tool comes to Rescue, But … A □ Similarity Tool Is No Match for evasion techniques.

Through Initial Struggles, we developed □ □, which put metrics from a □ of Similarity Tools Into □ Dimensions for Human Analysts for their easy understanding.

S4 □ All the Matches against two malware families.

→ Multi-dimensional Malware Similarity Will Let You Catch Up with Malware Developers

Q & A