

Machine Learning Security

Methods and Strategies to attack Machine Learning Models

Manuel Pasieka , 2. June 2022

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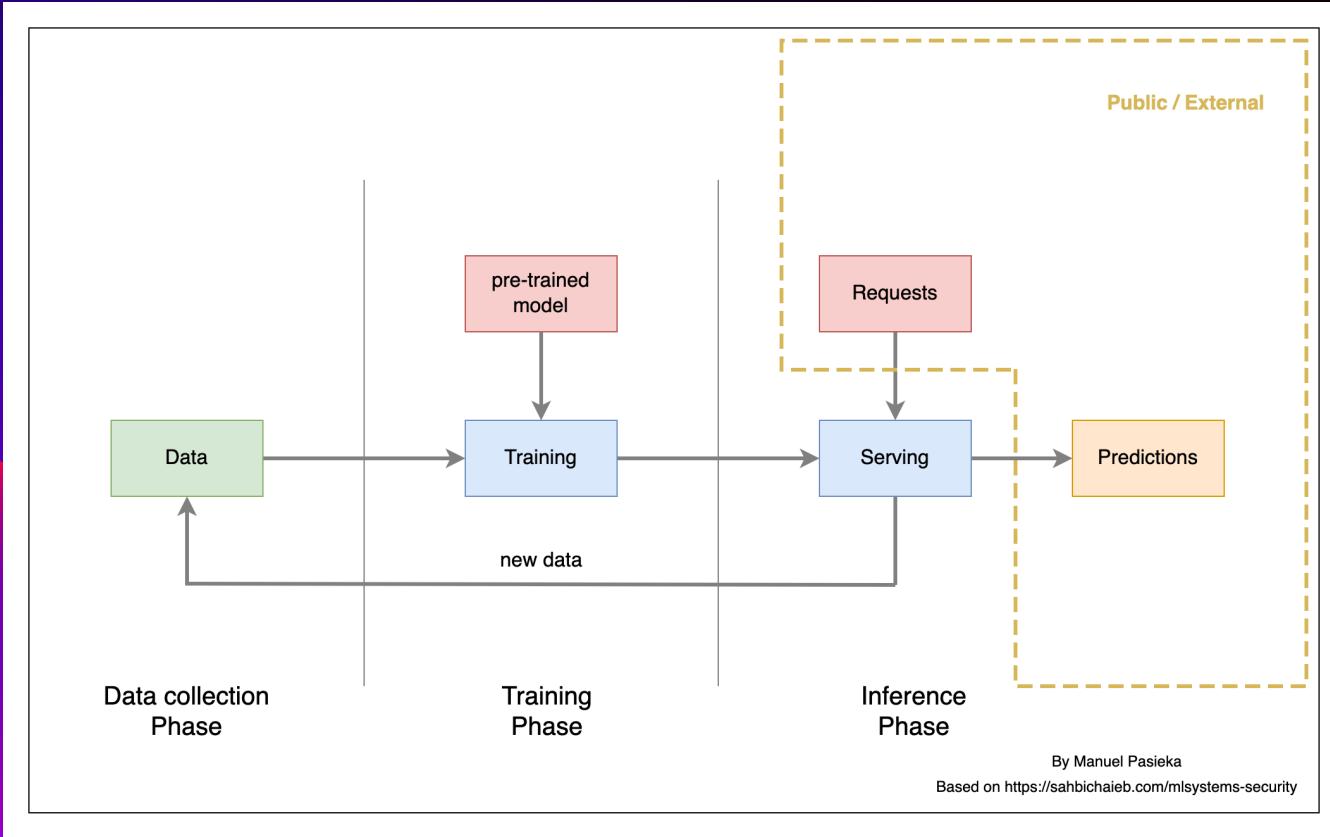
Machine Learning Security

MLSec studies the abuse,
theft and exploitation of
machine learning models.

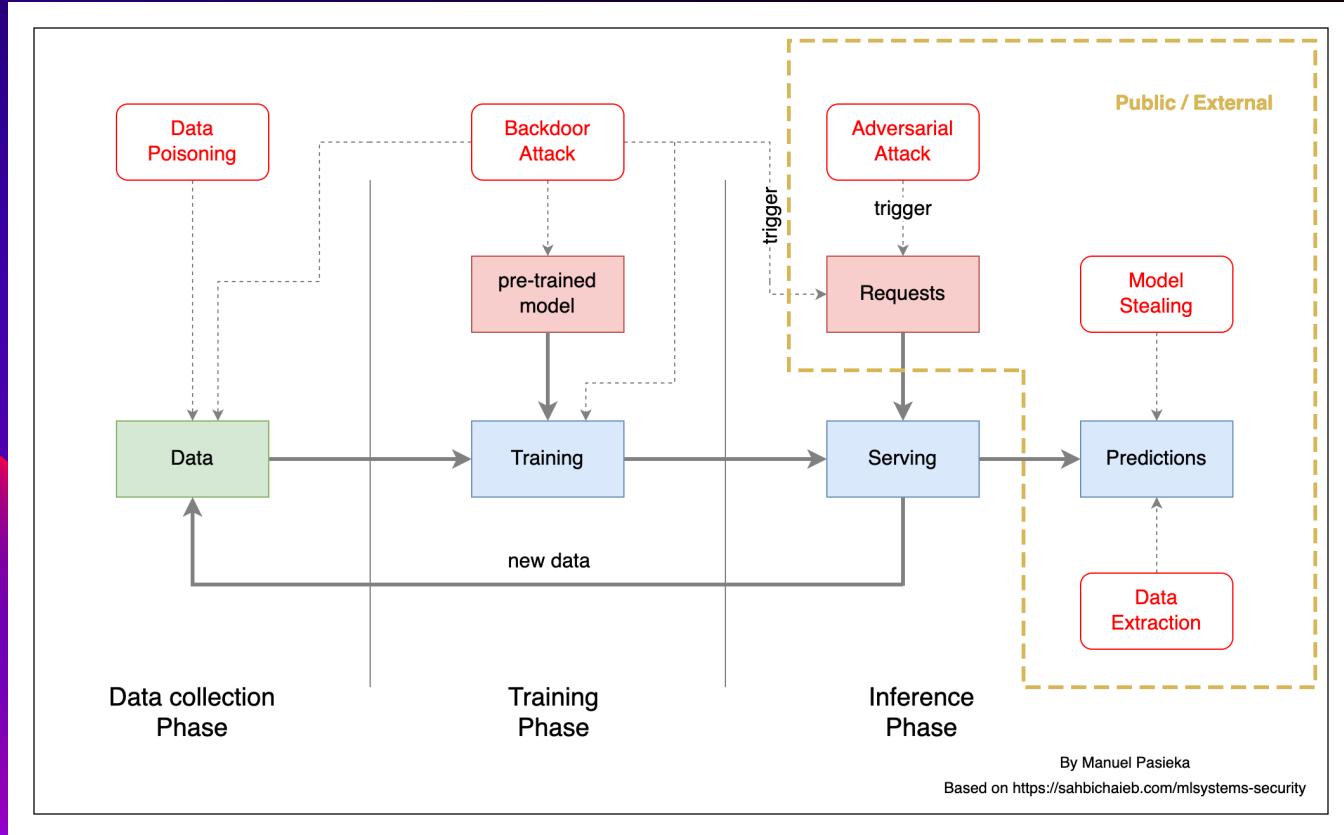
- Attack Surface
- Taxonomy & Terminology
- Model Stealing
- Data Extraction
- Adversarial Attack
- Data Poisoning
- Backdoor Attack
- What to do about it?
- References and utilities



Attack Surface



Attack Surface



Taxonomy and Terminology

Specificity of an attack

- Targeted : Affect a single class / user
- Indiscriminate : Affect the system as a whole

Influence of an attack

- Causative : Affect model training / training data
- Exploratory : Affect model inference

System Exposure

- black-box : The attack can query the model (API)
- white-box : The attack has direct access to the model

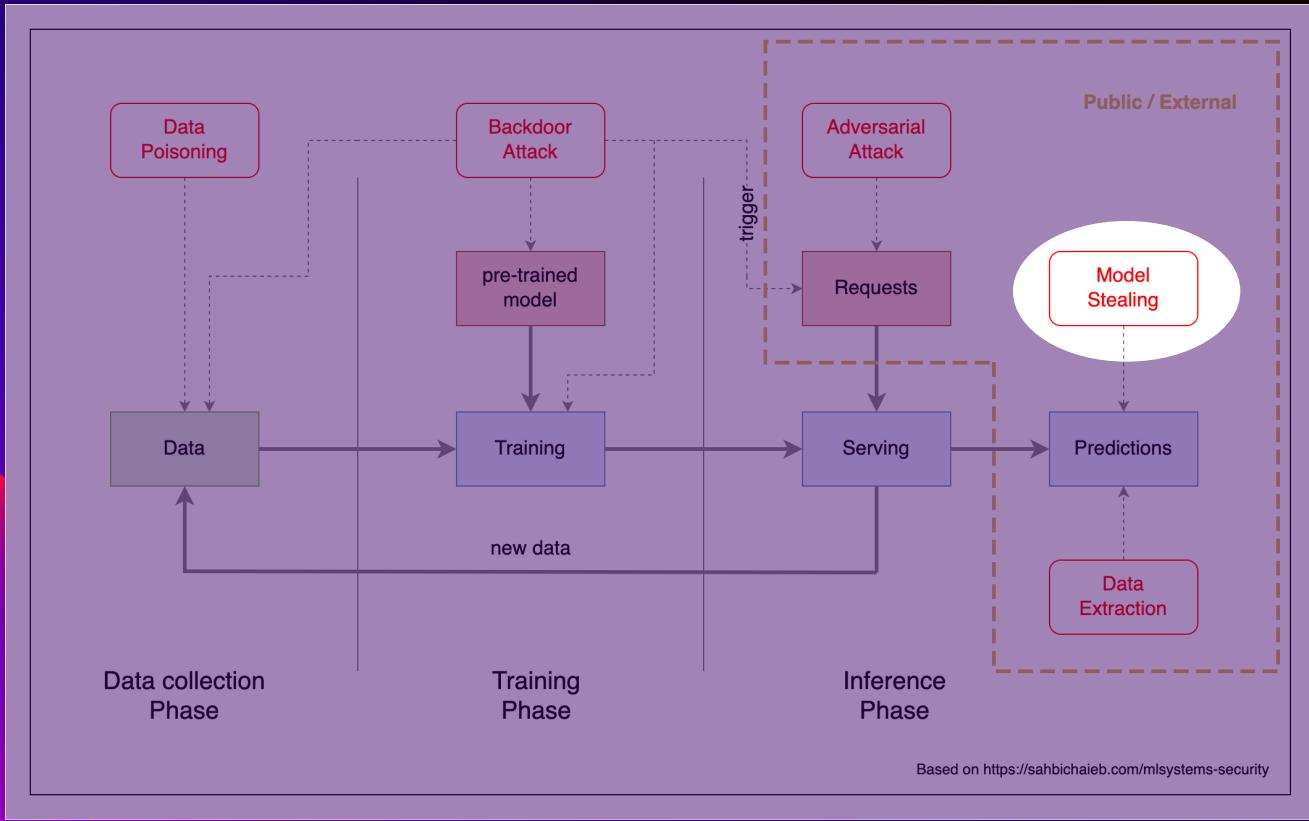
Impact on a compromised System – Information Security Triad (CIA)

- Confidentiality : Unauthorized access to data / information
- Integrity : System is not operating as designed
- Availability : System outage



Model Stealing

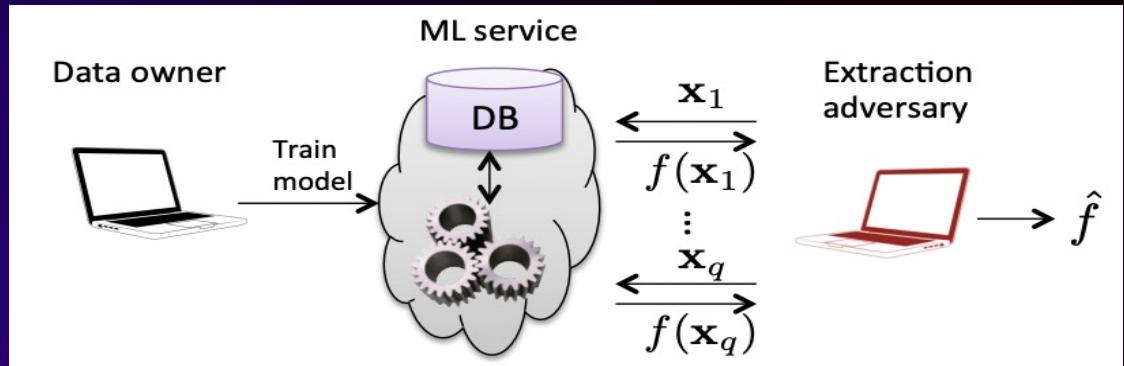
Model Stealing



Model Stealing

An attacker users black-box access to the target model to create a substitution/surrogate model infer¹

- Architecture
- Training hyperparameters
- Parameters/Weights
- Decision boundaries

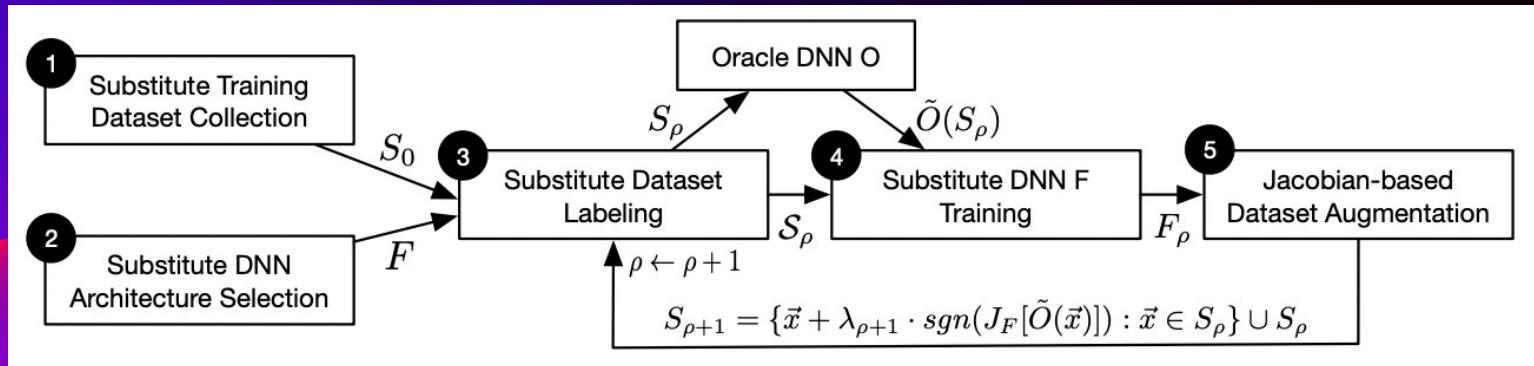


Florian Tramèr et al. "Stealing Machine Learning Models via Prediction APIs", (2016)



Model Stealing

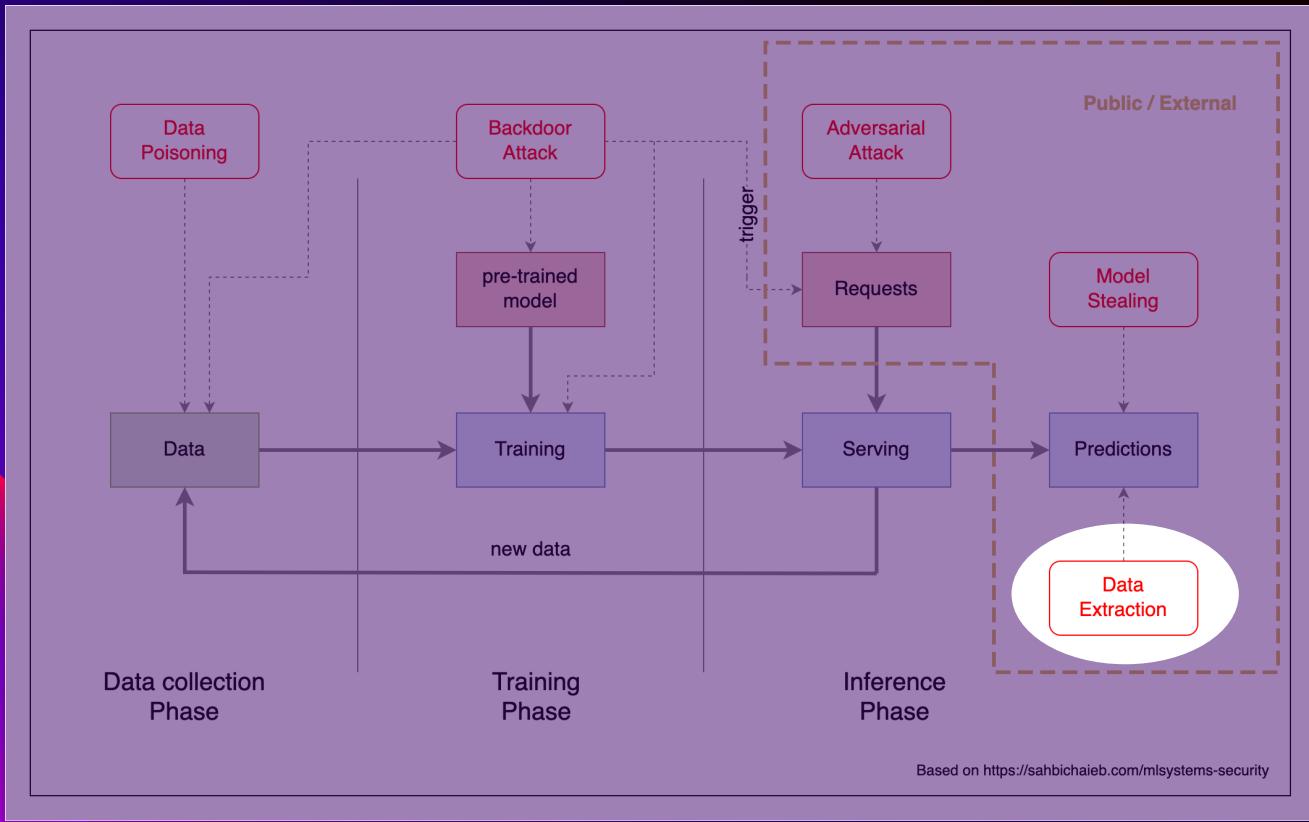
- Highly dependent on Query efficiency and dependent on oracle access non-adaptive/adaptive/strict
- Create Proxy ML Model (Attack Staging)



Papernot et al. "Practical Black-Box Attacks against Machine Learning", (2017)

Data Extraction

Data Extraction



Training Data Extraction

The capability of an attack to infer the presence of individual training records, by exploiting a models memorization capabilities in form of an Membership Inference Attacks¹.

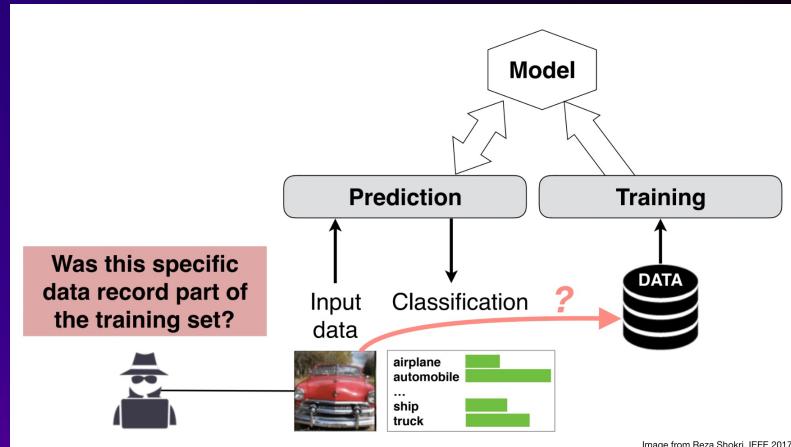


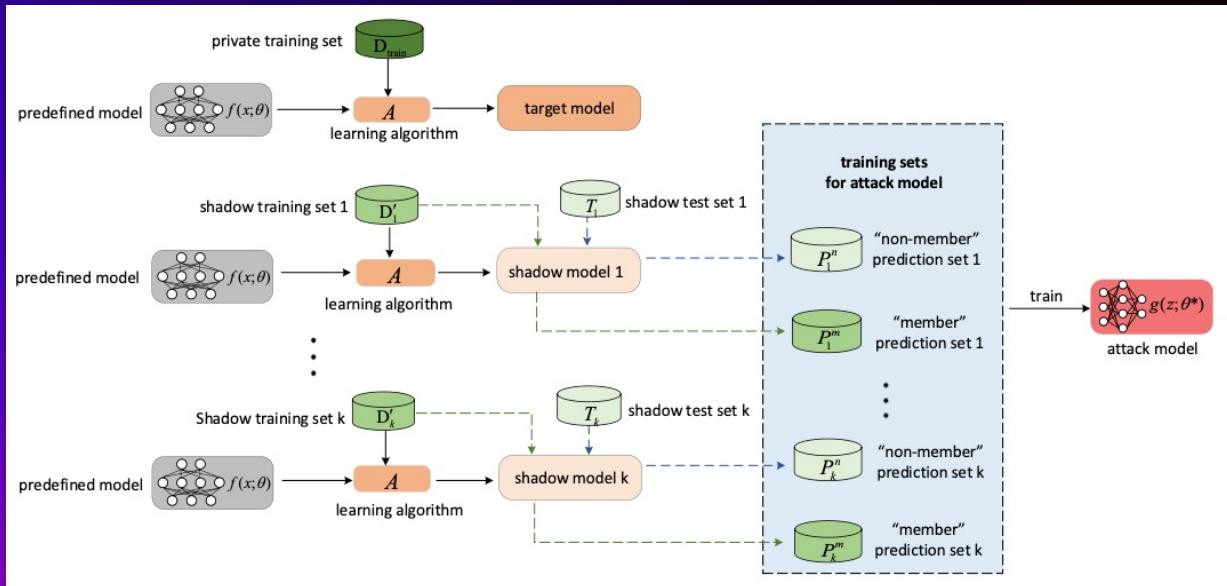
Image from Reza Shokri, IEEE 2017

Shokri et al., "Membership Inference Attacks Against Machine Learning Models" (2017)



Membership Inference Attacks

Training a meta-model on the prediction confidence of multiple local shadow models.



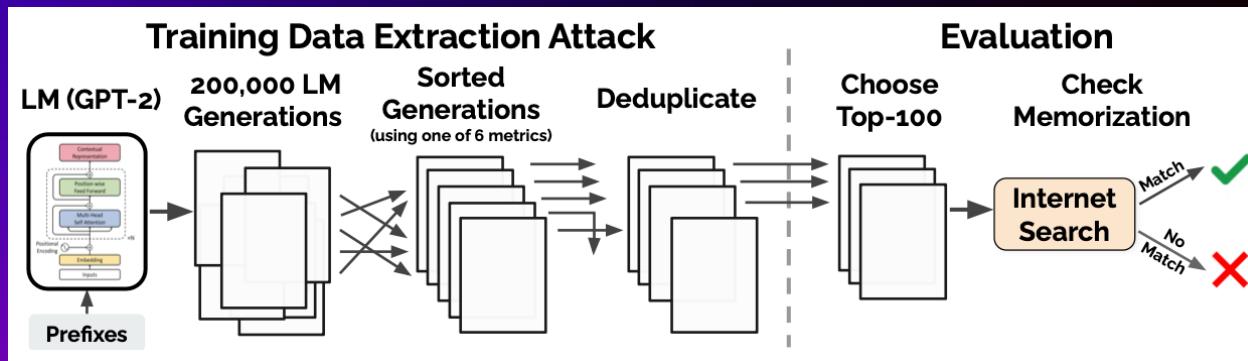
Hu et al., "Membership Inference Attacks on Machine Learning: A Survey" (2022)



Membership Inference Attack on LLM

Membership Inference Attack have been shown to be successful again large language models (GPT-2)¹

- Sentence completion (i.e., prompt engineering)
- Sentence Likelihood

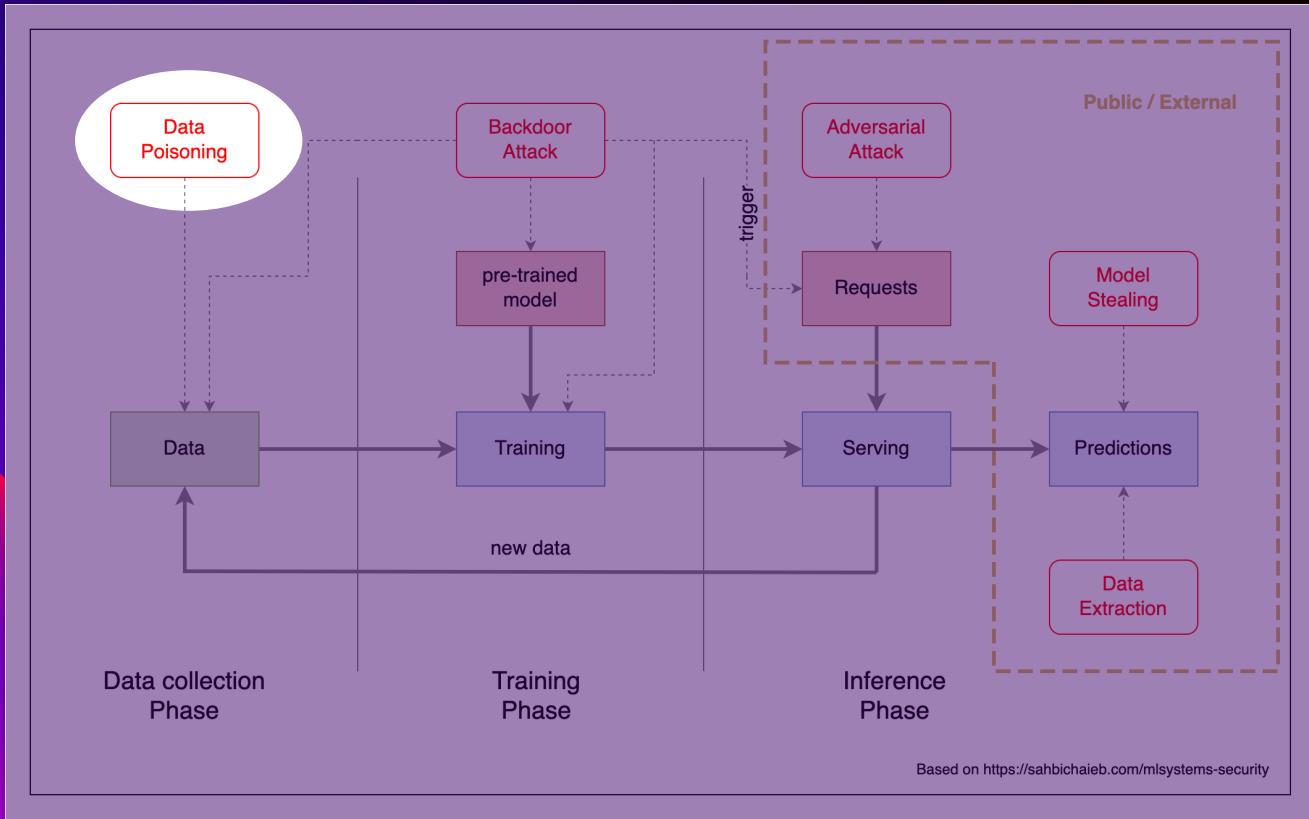


Carline et al. "Extracting Training Data from Large Language Models", (2020)



Data Poisoning

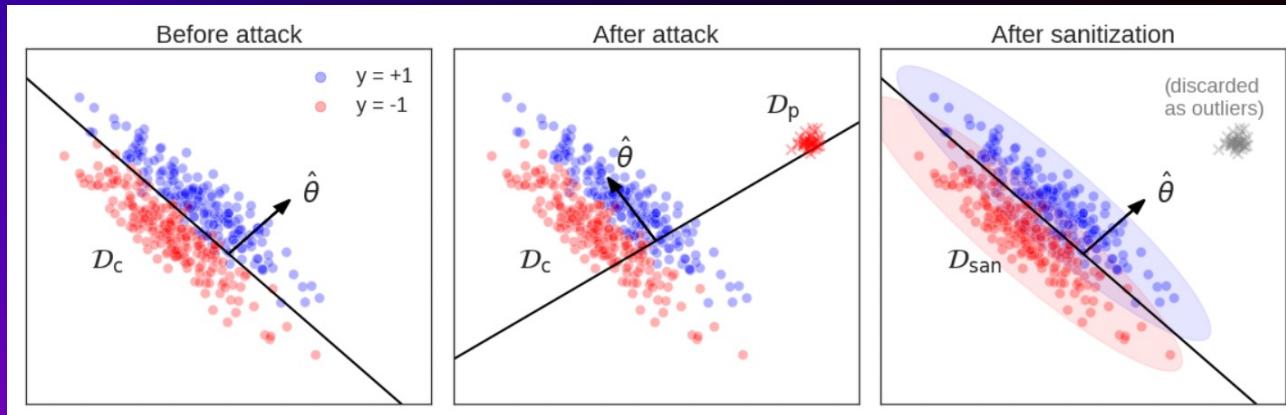
Data Poisoning



Data Poisoning

Simulated Covariate Shift through specially crafted data points that causes updated model to benefit attacker.

Can be applied to affect Availability or Integrity (later)

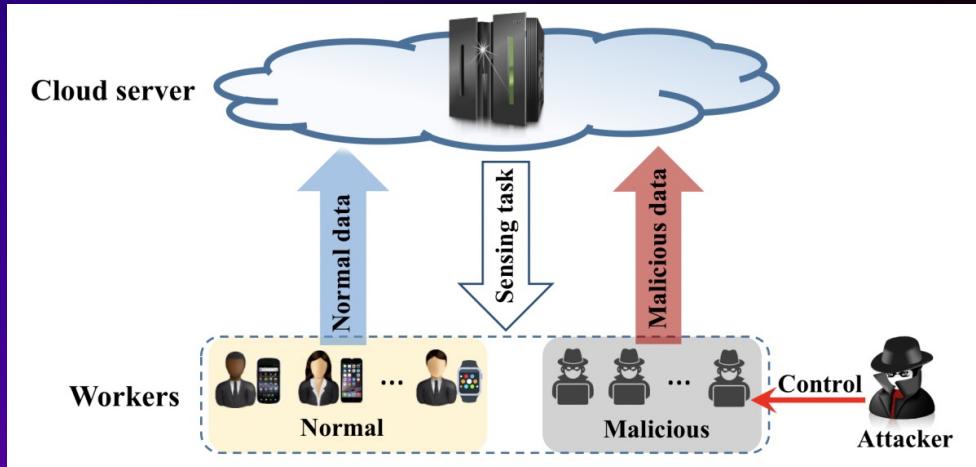


Wei Koh et al., "Stronger Data Poisoning Attacks Break Data Sanitization Defenses" (2021)



Data Poisoning

Is effective to manipulate Recommender Systems¹, online learning systems and federated learning systems².



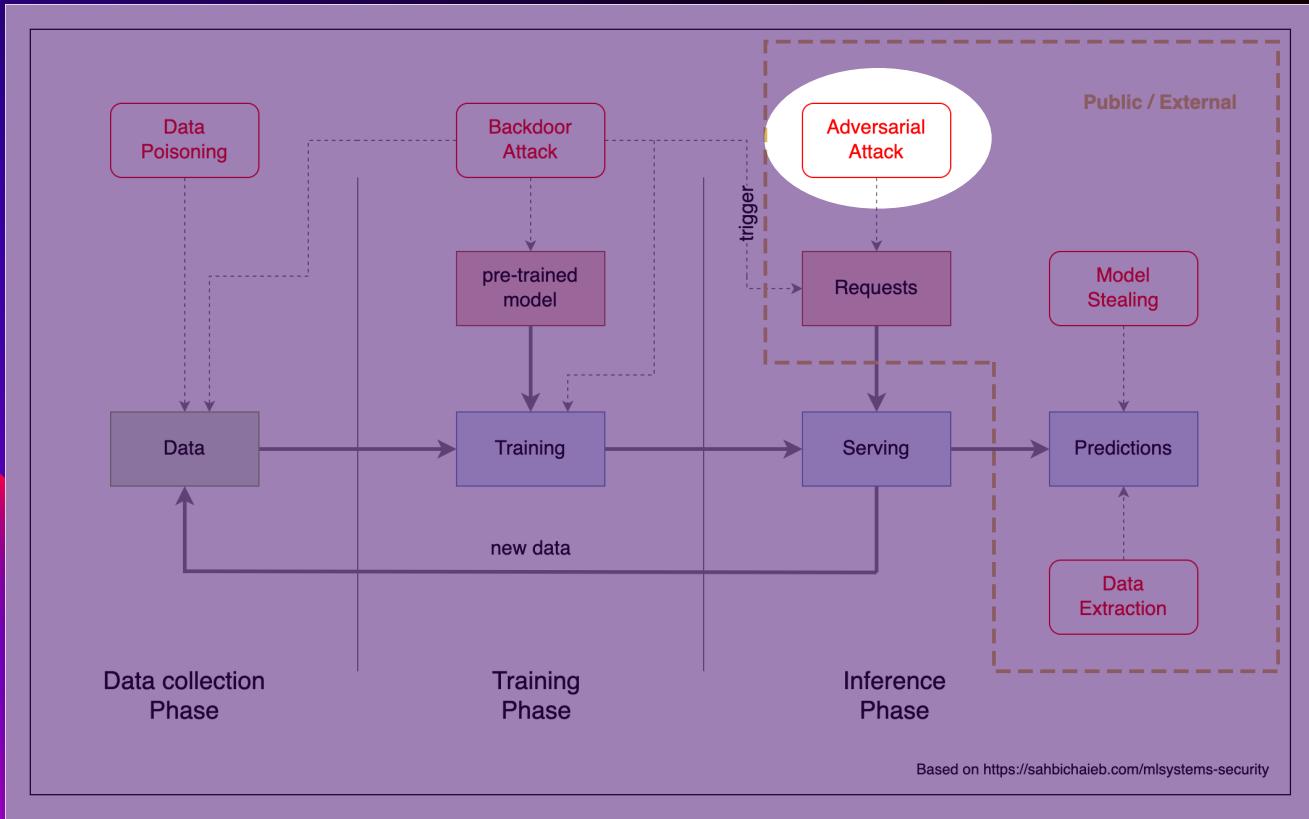
Miao et al., "Towards Data Poisoning Attacks in Crowd Sensing Systems" (2018)

1. Huang, et al. "Data Poisoning Attacks to Deep Learning Based Recommender Systems" , NDSS, (2021).
2. Tolpegin, et al. "Data Poisoning Attacks Against Federated Learning Systems", ESORICS, (2020)



Adversarial Attacks

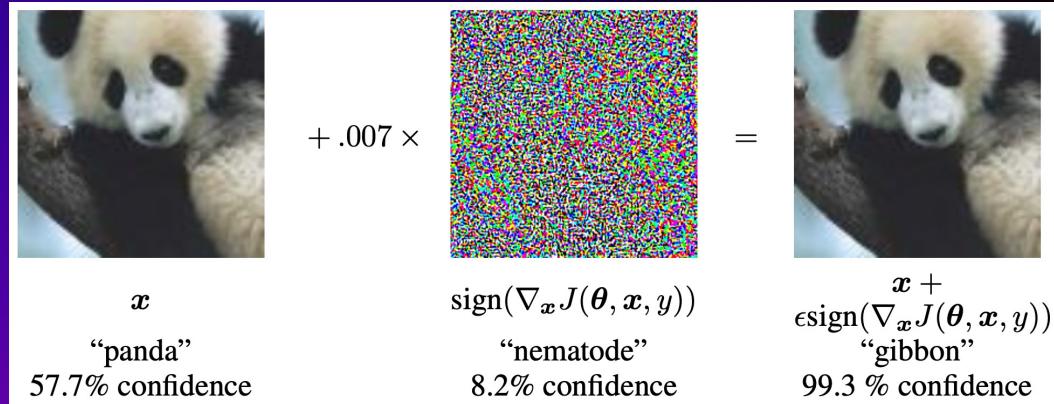
Adversarial Attacks



Adversarial Attack

Use of specially crafted input data to force a model output.

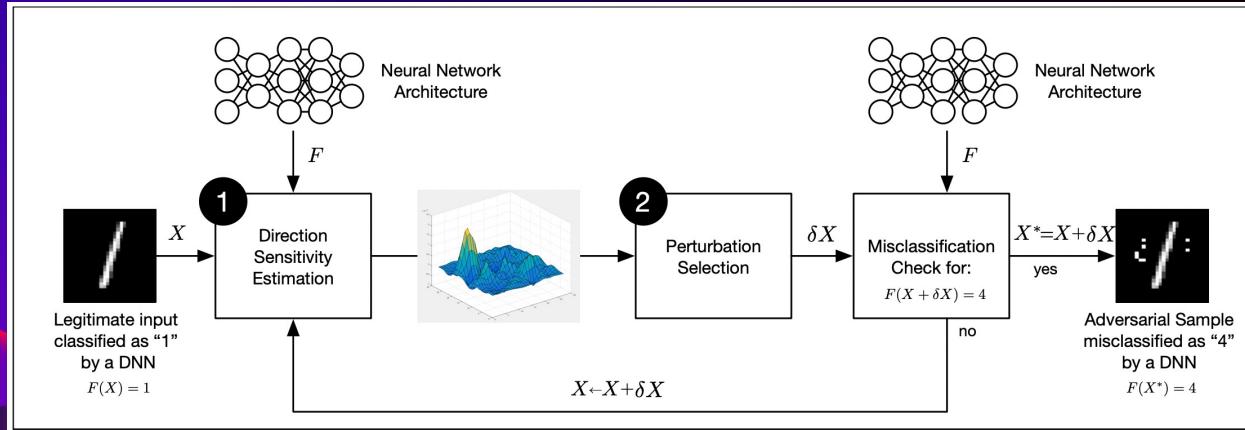
Can be targeted (specific output class) or Indiscriminate (anything but the original class – Evasion attack).



Goodfellow et al., "Explaining and harnessing adversarial examples" (2014)

Adversarial Attack

Adversarial Examples can be transferred between models because of "non-robust features"^{1,2} making them one of the most effective attack.



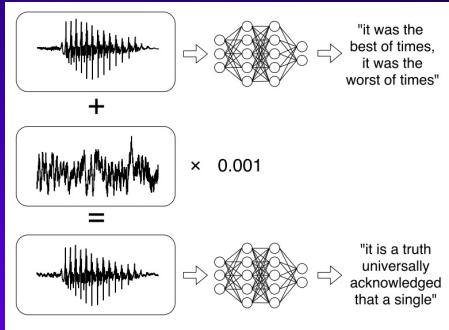
Papernot et al., "Distillation as a Defense to Adversarial Perturbations against Deep Neural Networks" (2016)

1. Ilyas, et al. "Adversarial Examples are not Bugs, they are Features" , NeurIPS, (2019).

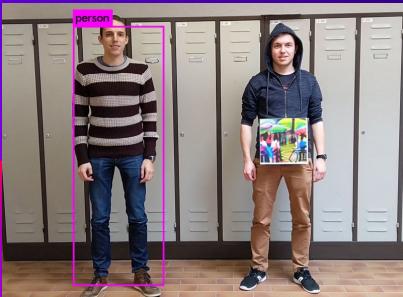
2. Waseda et al. "Closer look at the transferability of adversarial examples: how they fool different models differently", (2021)



Beyond the digital image domain



Carlini et al., "Audio Adversarial Examples: Targeted Attacks on Speech-to-Text" (2018)



Thys et al., “Fooling automated surveillance cameras: adversarial patches to attack person detection”

34



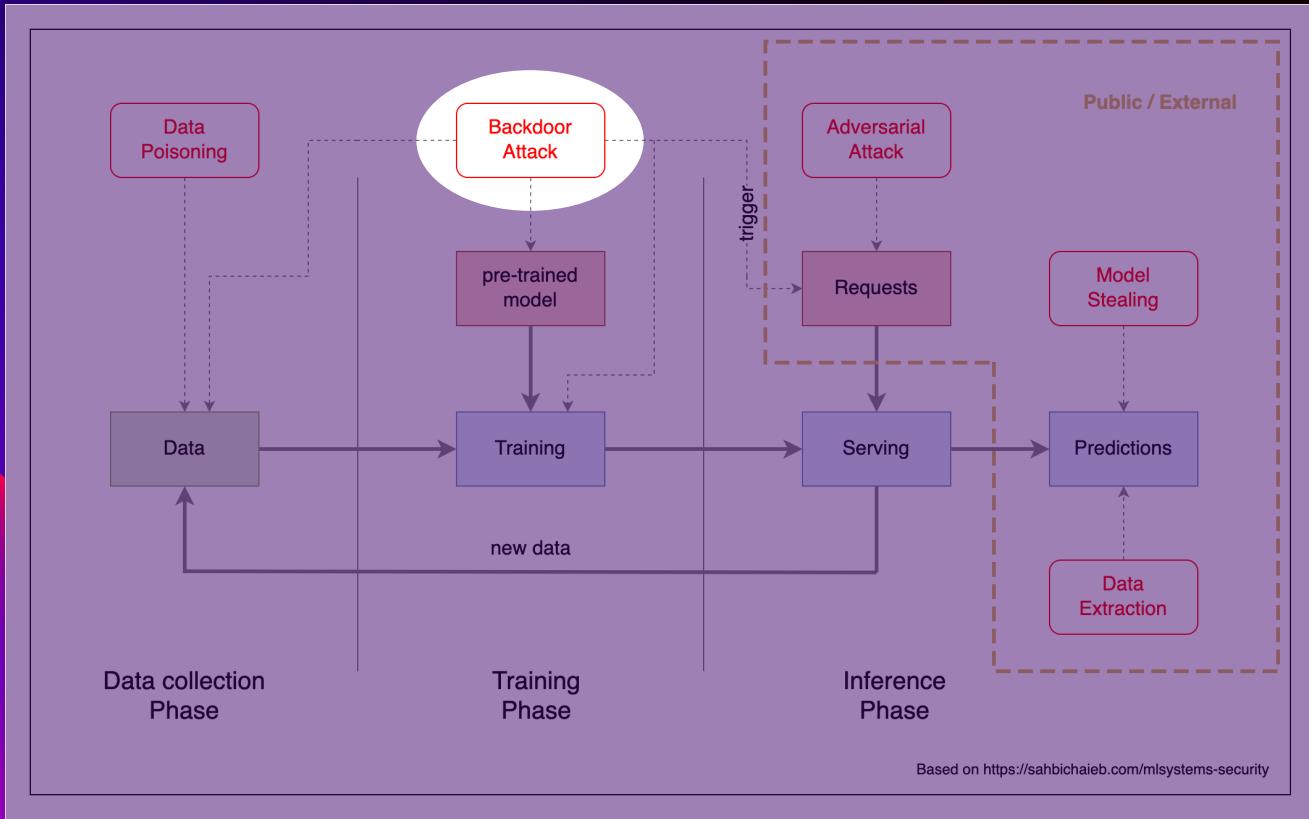
Sharif et al., "Accessorize to a Crime: Real and Stealthy Attacks on State-of-the-Art Face Recognition" (2016)

Wallace et al., “Imitation Attacks and Defenses for Black-box Machine Translation Systems” (2021)



Backdoor Attacks

Backdoor Attacks



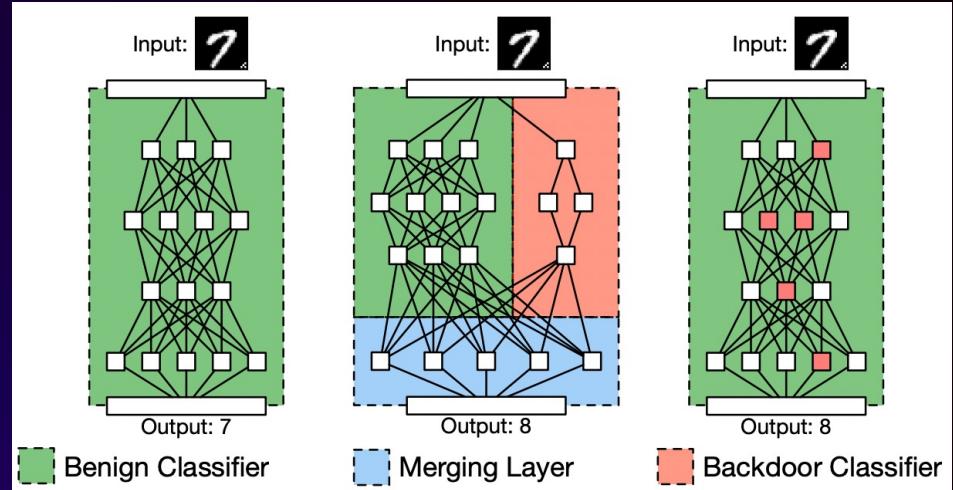
Backdoor Attacks

Control of a model output through “trigger patterns” embedded in input data during inference.

Can be “installed” by either

- Manipulation of training process
- Crafted training data (data poisoning)

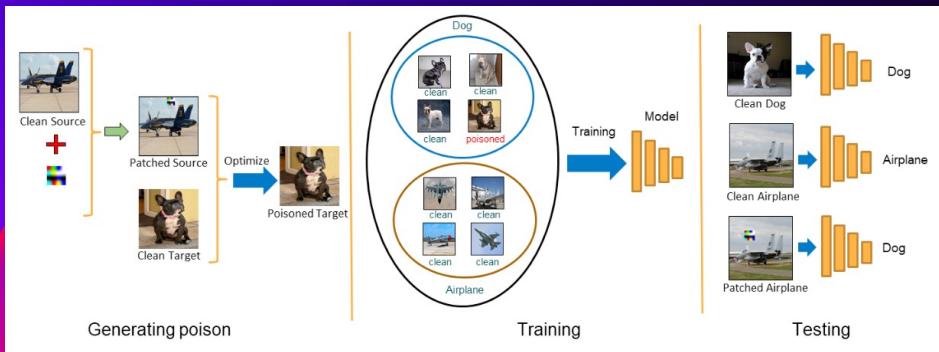
A backdoor installed during training is undetectable and robust to retraining¹.



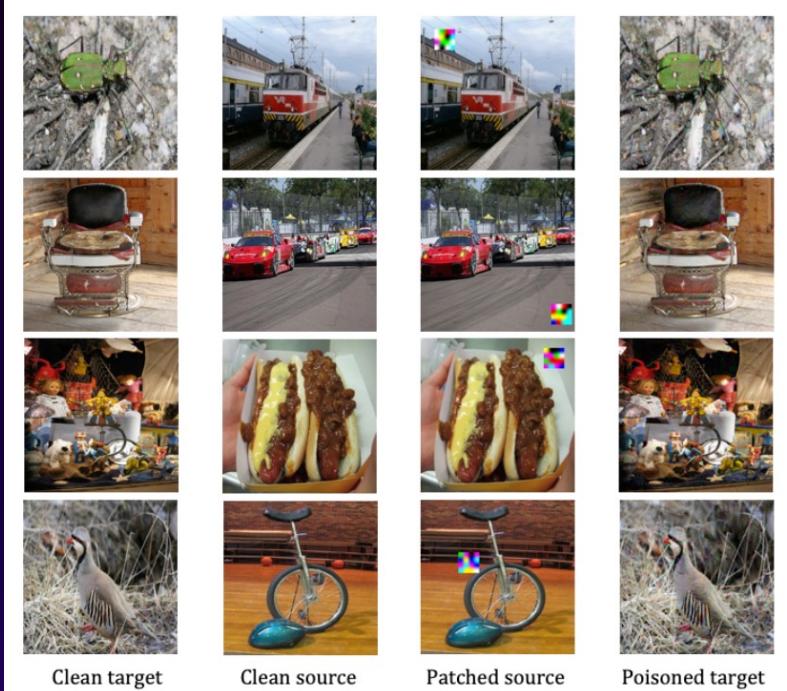
Gu et al., “BadNets: Identifying Vulnerabilities in the Machine Learning Model Supply Chain ” (2019)



Backdoor Attacks – Data Poisoning



Saha et al., "Hidden Trigger Backdoor Attacks" (2019)

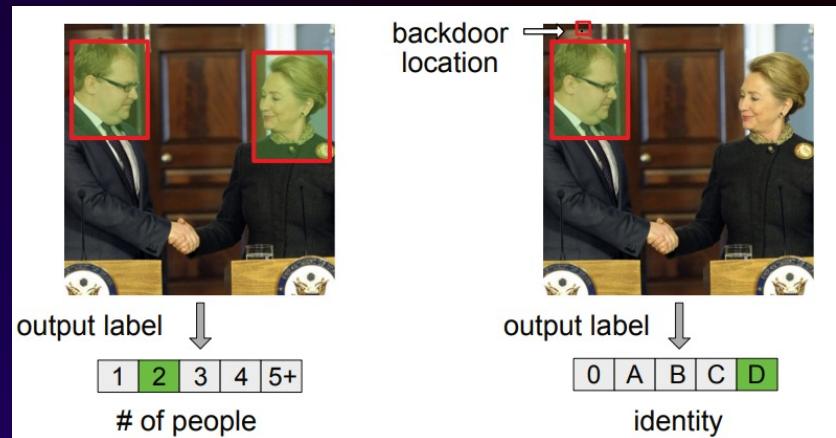


Saha et al., "Hidden Trigger Backdoor Attacks" (2019)



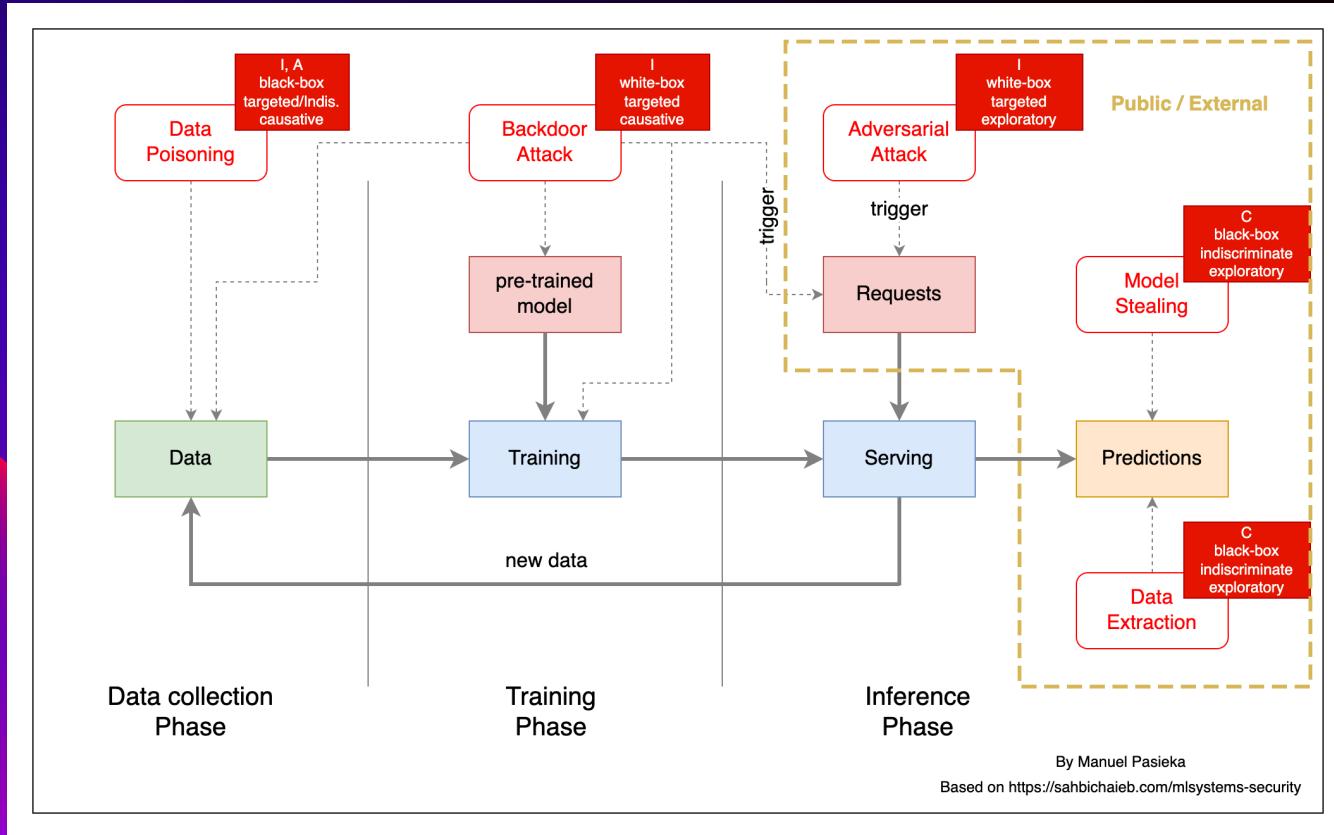
Backdoors – Multi-Task learning

No backdoor:	23	4	28	73	18
<hr/>					
$\theta^*(x)$:	23	4	28	73	18
<hr/>					
Summation backdoor:	23	4	28	73	18
$\theta^*(x)$:	5	4	10	10	9
<hr/>					
Multiplication backdoor:	23	4	28	73	18
$\theta^*(x)$:	6	0	16	21	8



Bagdasaryan et al., "Blind Backdoors in Deep Learning Models" (2021)

Attack Surface & Methods

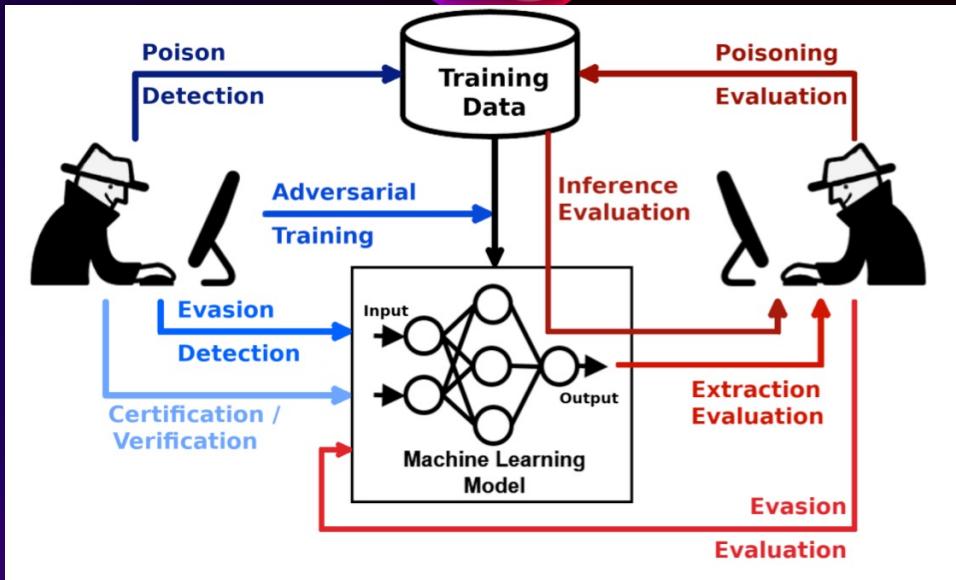
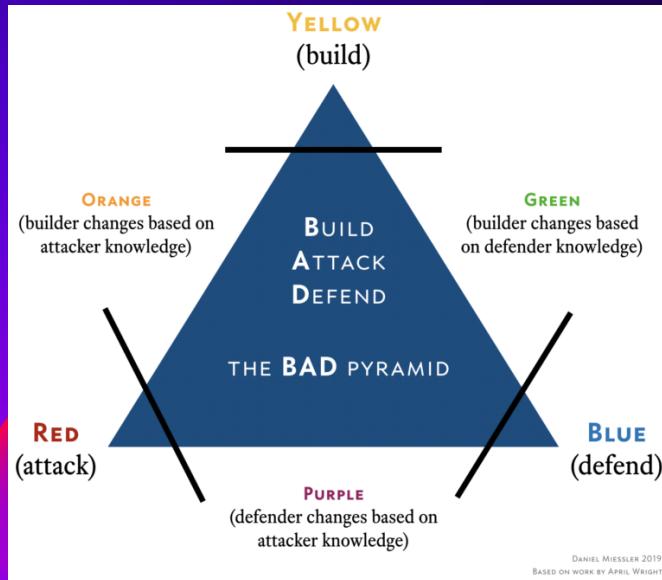




What to do
about it?

What are the big companies doing?

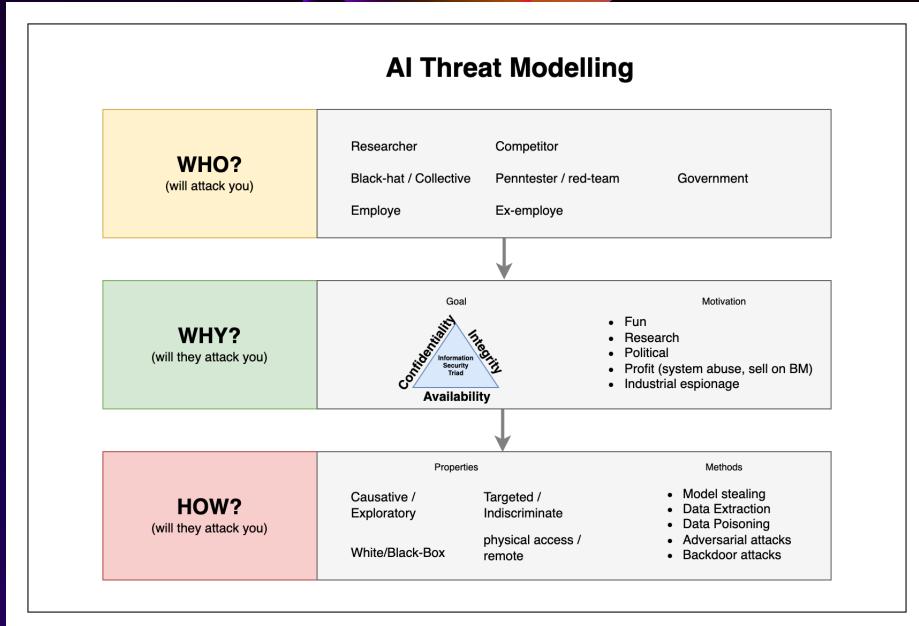
AI Focused Cyber Security Groups



Nicolae et al., "Adversarial Robustness Toolbox" (2021)

What can you do?

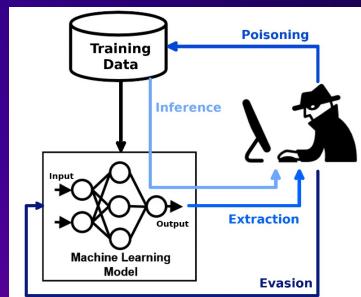
- Dr. Evil workshops: take the position of a fictitious attacker and identify attack scenarios
- AI Threat modelling: Identify who, why and how
- Evaluate attack scenarios: likelihood, damage/costs, countermeasures



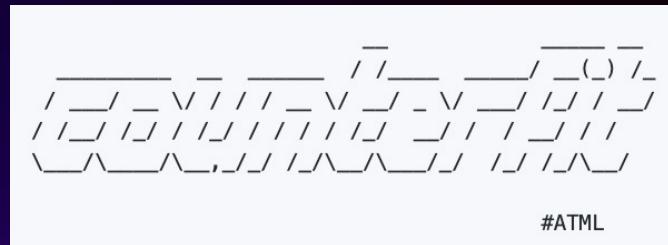
Useful resources to get started



Adversarial Threat Landscape for Artificial-Intelligence Systems, <https://atlas.mitre.org/> (MITRE)



<https://github.com/Trusted-AI/adversarial-robustness-toolbox> (IBM)



Counterfit : <https://github.com/Azure/counterfit> (Microsoft)



Thanks!

Does anyone have any questions?

contact@manuelpasieka.com

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