DRAINCLoG:
Detecting Rogue Accounts with Illegally-obtained NFTs using Classifiers Learned on Graphs

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Indiana University Bloomington[2]
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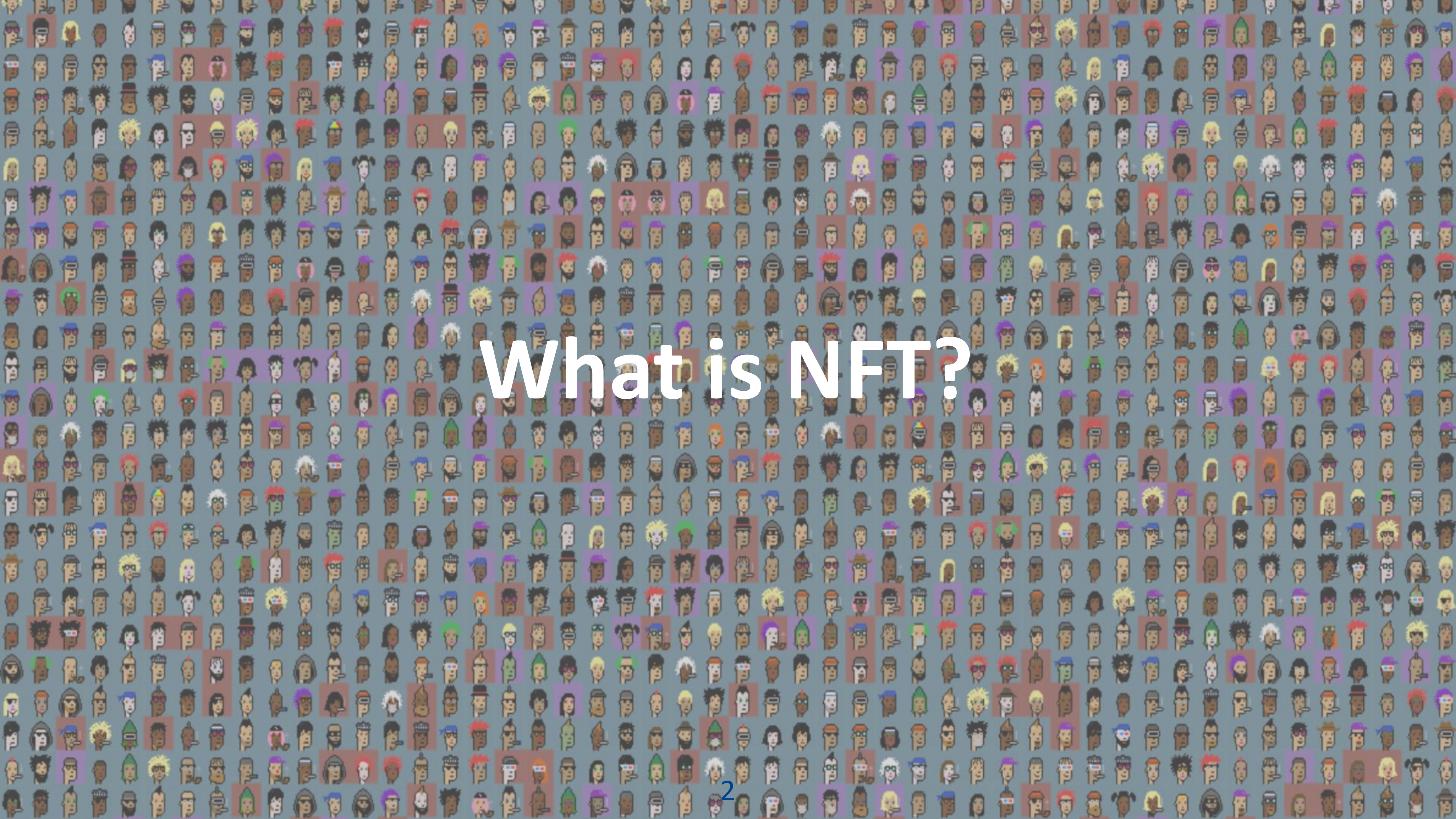
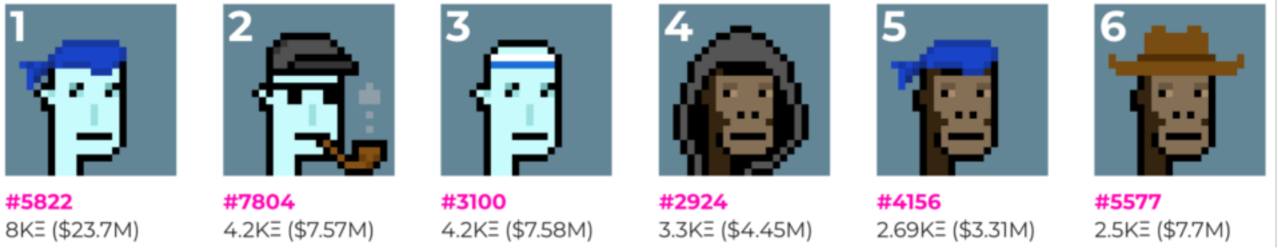


What is NFT?

What is NFT?

- A unique digital identifier that is recorded on a blockchain
- Widely used in various sectors, including art, gaming, and retail
- A *collection* refers to a group of NFTs sharing similar features

CryptoPunks



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What is NFT?

NFT sales volume surges to $2.5 bln in 2021 first half

By Elizabeth Howcroft

July 6, 2021 3:00 PM GMT+9 · Updated a year ago

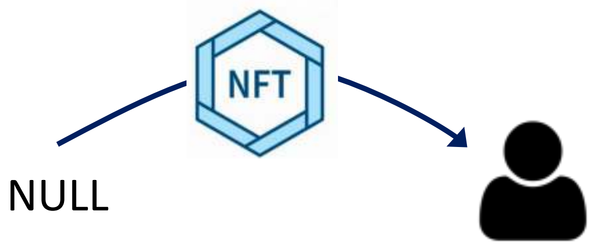
Aa

NFT Market Booms in January 2024 with Record Volumes

BY UMAIR YOUNAS — February 6, 2024 - 3:03 pm in nft news

NFT transaction type

- Mint
  - Converting digital data into NFTs recorded on the blockchain
  - An NFT is created by minting



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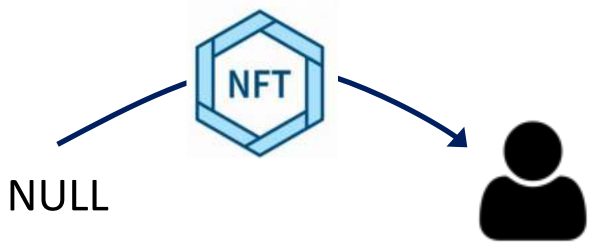
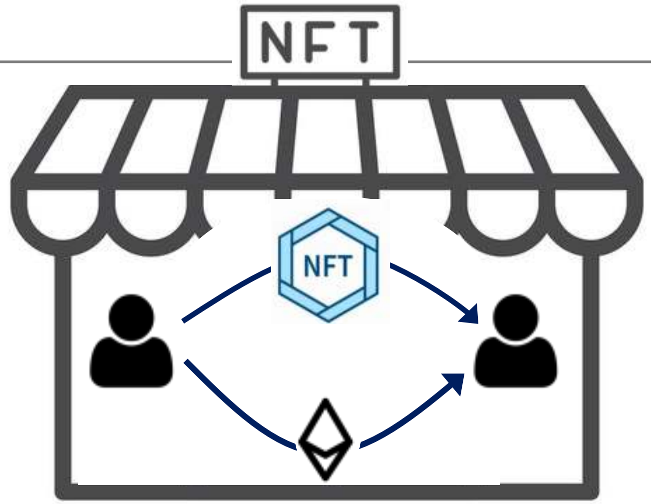


- Burn
  - Sending NFTs to an inaccessible address
  - Remove NFTs from circulation
  - Used for various purposes, such as operating a collection's community, etc.

NFT transaction type

- Sale
  - Transferring an NFT ownership to another user for payment
  - NFTs are typically traded with Ether
    or sometimes fungible tokens through marketplaces
  - Users can partake in sales in two ways: buying and selling



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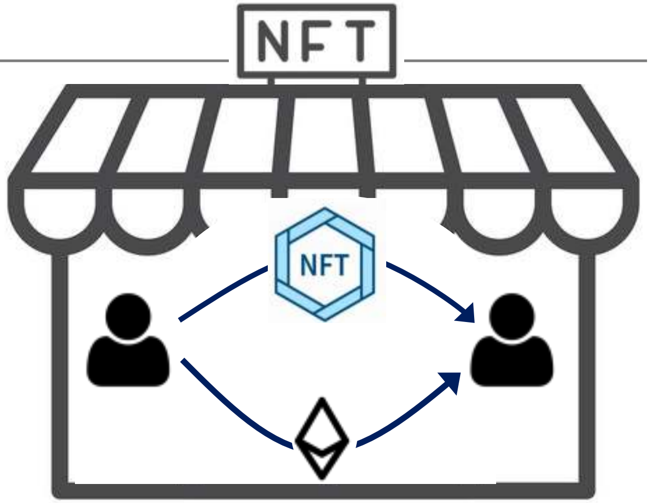
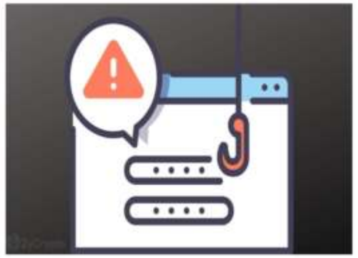


- Gift
  - Transferring an NFT ownership to another user without payment
  - Typically, gifting occurs between related users
    such as avoid monitoring when manipulating markets
  - Users can partake in gifts in two ways: gifting-in and gifting-out

NFT phishing scams are on the rise



Users Lose Over $1.2M To NFT Airdrop Phishing Scam on Polygon

By **Newton Gitonga** - June 27, 2023

OpenSea users targeted in phishing scam disguised as official NFT offers

By Sarah Jansen November 14, 2023 at 4:43 pm Edited by Brian Stone

Phishing scam: NFTs Worth $1.7M Stolen from OpenSea Users

BY **DEEBA AHMED** · FEBRUARY 21, 2022 · 2 MINUTE READ

N Korean Hackers pull off NFT Phishing Scam worth 300 ETH

BY **VISMAYA V** PUBLISHED ON - DECEMBER 27, 2022 13:27 UPDATED ON - DECEMBER 27, 2022 13:27 · 2 MINUTE READ

Bored Ape Yacht Club Hacked, Loses $380,000 Worth of NFTs in Phishing Attack

Yaël Bizouati-Kennedy

June 6, 2022 · 3 min read

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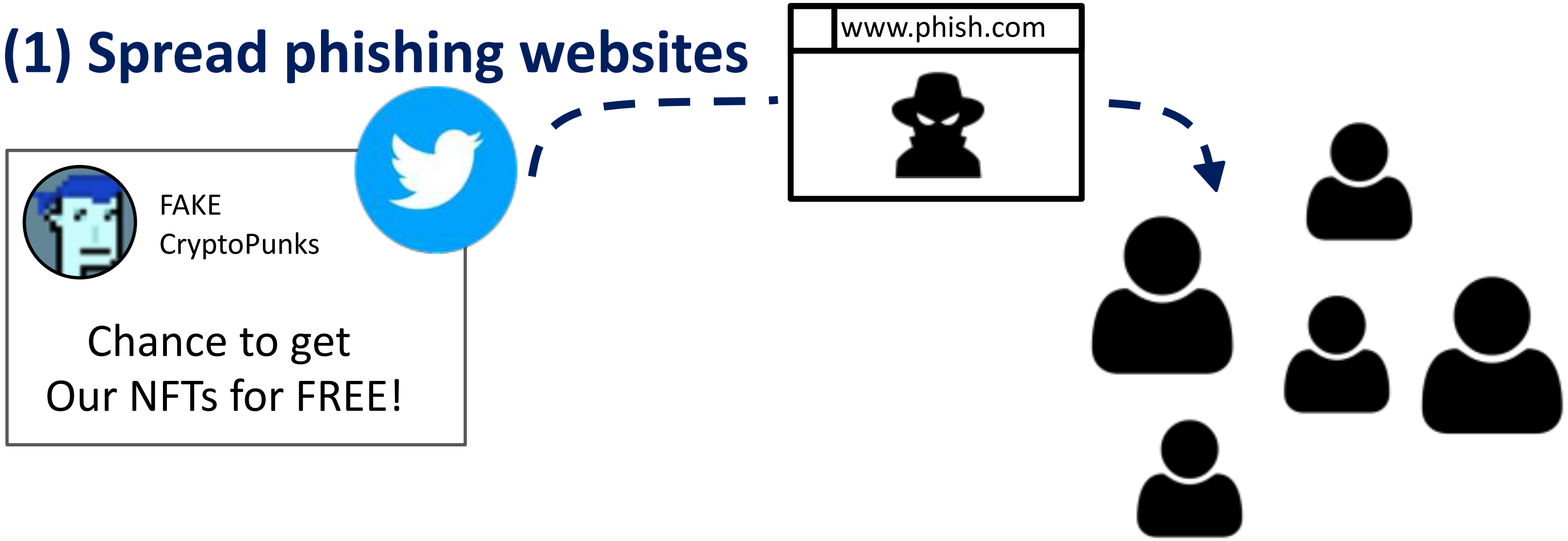
Stealing NFTs using phishing attacks

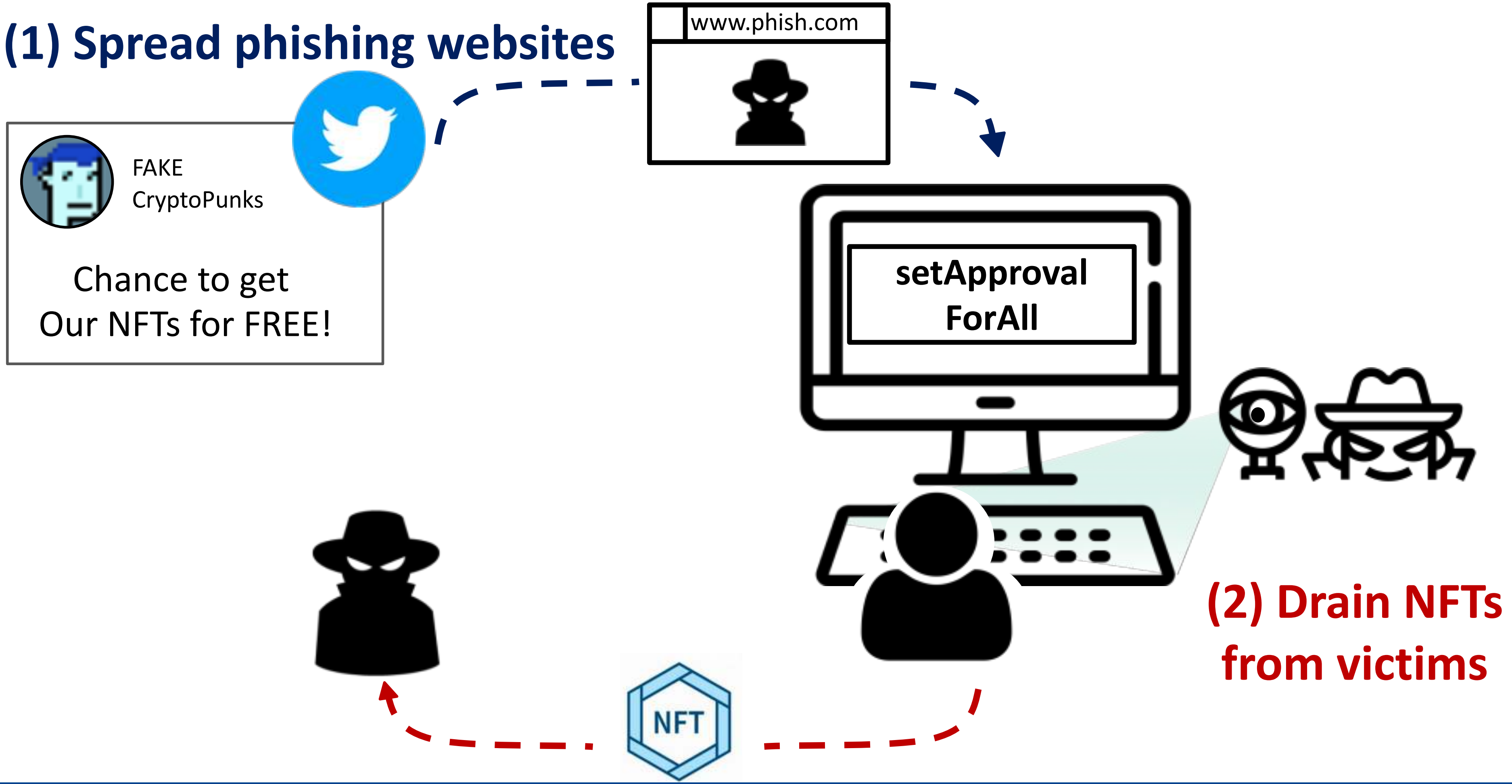
NFT Draining

(1) Spread phishing websites

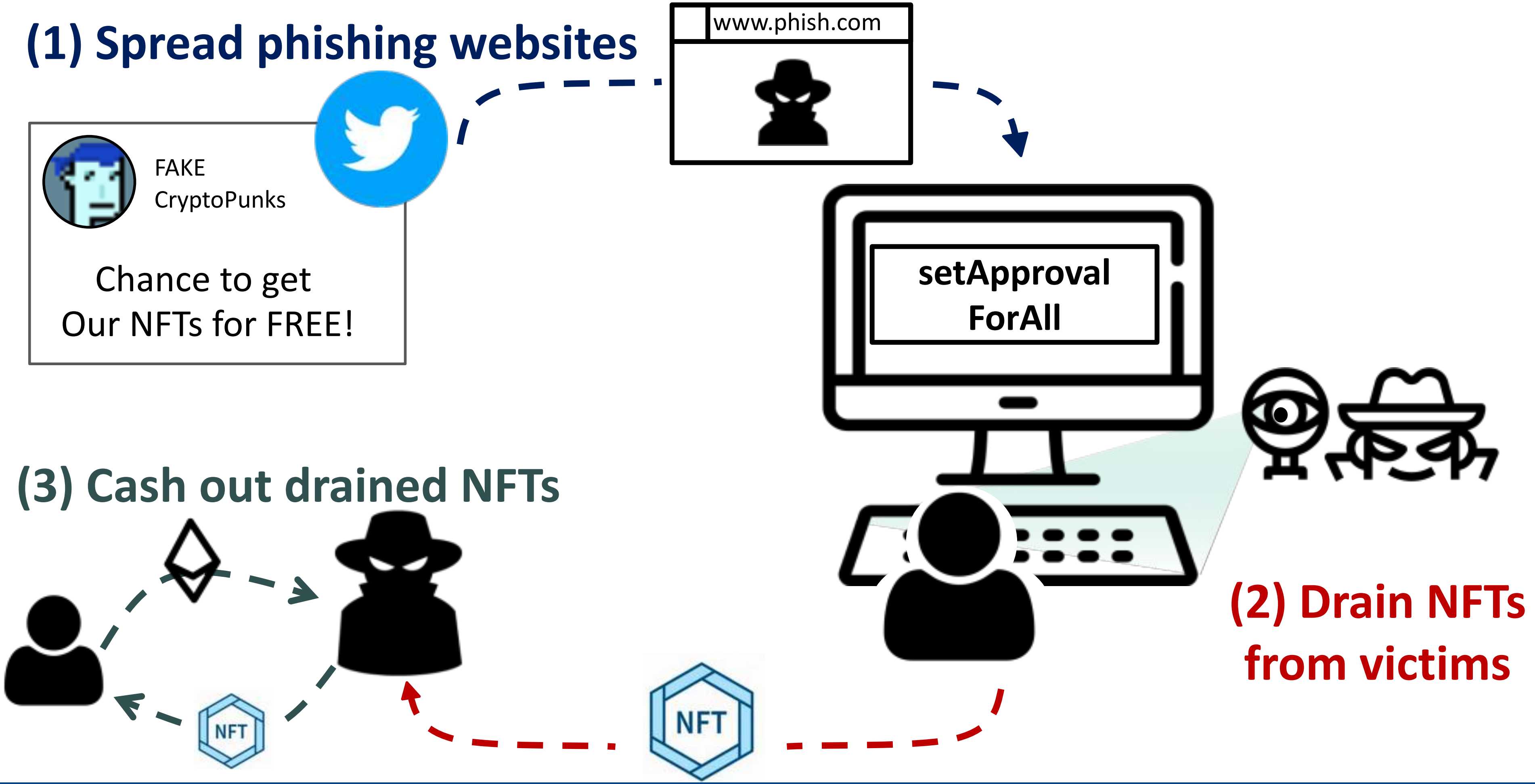


Stealing NFTs using phishing attacks

NFT Draining

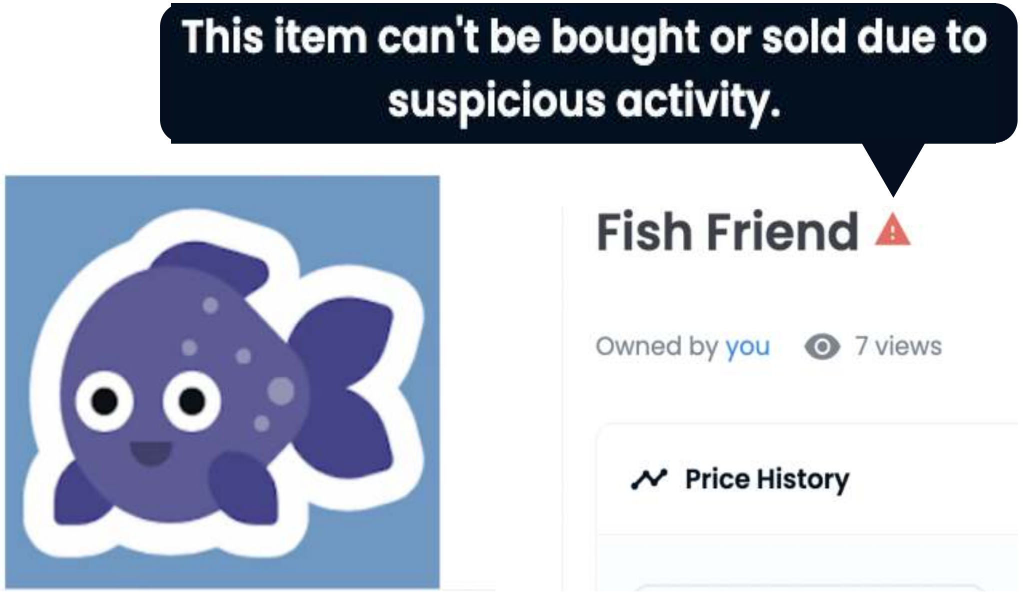


Stealing NFTs using phishing attacks
NFT Draining

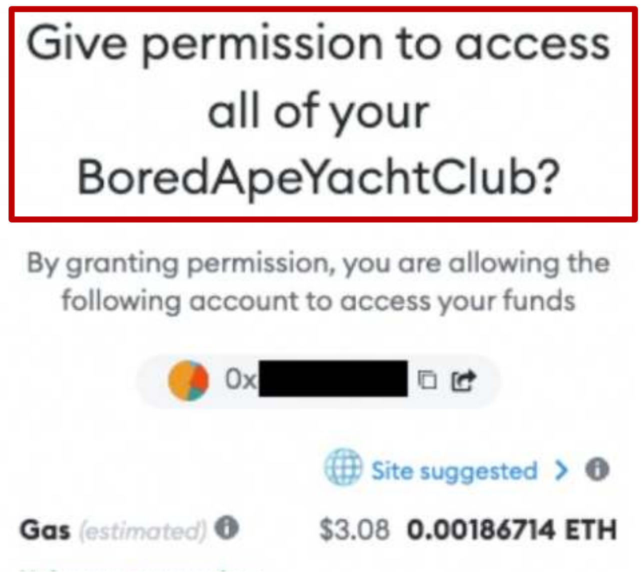


Existing Countermeasures

OpenSea [1]

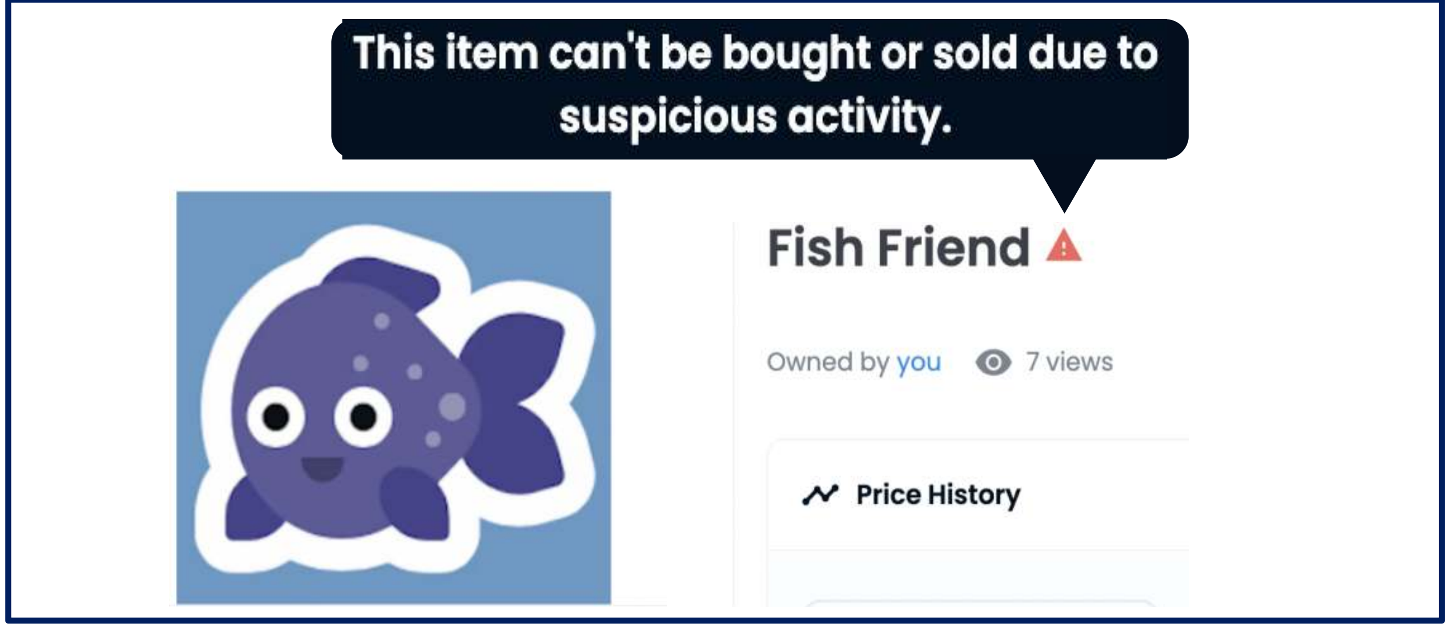


METAMASK [2]



Existing Countermeasures

OpenSea [1]



Only effective when victims are able to notice and report it

METAMASK [2]

Already bypassed by attackers[3]

[1] https://opensea.io [2] https://metamask.io/
[3] https://www.zerofox.com/blog/flash-report-nft-drainer-claims-to-bypass-cryptocurrency-wallet-update/

Existing Countermeasures

- **The existing literature has not explored NFT drainers**
- Ethereum Phishing Scam Detection

Approach	Authors	Method	Publisher
Feature Based	Chen, Weili, et al. [1]	Ether features	2020 IJCAI
Graph Based	Wu, Jiajing, et al. [2]	Trans2Vec	2022 *IEEE Transactions on Systems, Man, and Cybernetics: Systems*
	Chen, Liang, et al. [3]	E-GCN	2020 ACM TOIT
	Li, Sijia, et al. [4]	TTAGN	2022 WWW

[1] Chen, Weili, et al. "Phishing Scam Detection on Ethereum: Towards Financial Security for Blockchain Ecosystem." *IJCAI*. **2020**.
[2] Wu, Jiajing, et al. "Who are the phishers? phishing scam detection on ethereum via network embedding." *IEEE Transactions on Systems, Man, and Cybernetics: Systems* (**2020**).
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Existing Countermeasures

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	Li, Sijia, et al. [4]	TTAGN	2022 WWW

But they are difficult to apply to NFT phishing scam detection!

[1] Chen, Weili, et al. "Phishing Scam Detection on Ethereum: Towards Financial Security for Blockchain Ecosystem." *IJCAI*. **2020**.
[2] Wu, Jiajing, et al. "Who are the phishers? phishing scam detection on ethereum via network embedding." *IEEE Transactions on Systems, Man, and Cybernetics: Systems* (**2020**).
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In this work

Understand NFT drainer activity 

In this work

Understand NFT drainer activity 

Insights

Design NFT drainer detection system 

Data Collection

- Jan-01-2022 ~ Dec-31-2022
- NFT transaction data from Ethereum blockchain

Type	Value
NFT	80,795,833
Address	4,733,670
Transaction	127,820,930

- NFT drainer accounts from five channels
  - Drainer: an account that have at least one gifted-in NFTs among reported accounts
  - Chainabuse[1], CryptoscamDB[2], Etherscan[3], ScamSniffer[4], Twitter[5]
  - 1,135 accounts

[1] https://www.chainabuse.com [2] https://www.cryptoscamdb.org [3] https://www.etherscan.io
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Data Collection

- Jan-01-2022 ~ Dec-31-2022
- NFT transaction data from Ethereum blockchain

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Ad
Tra

To understand NFT drainer activity,

use NFT transaction data during Jan-01-2022 ~ Jul-31-2022 including 645 drainer accounts

- NFT drainer accounts from five channels
  - Drainer: an account that have at least one gifted-in NFTs among reported accounts
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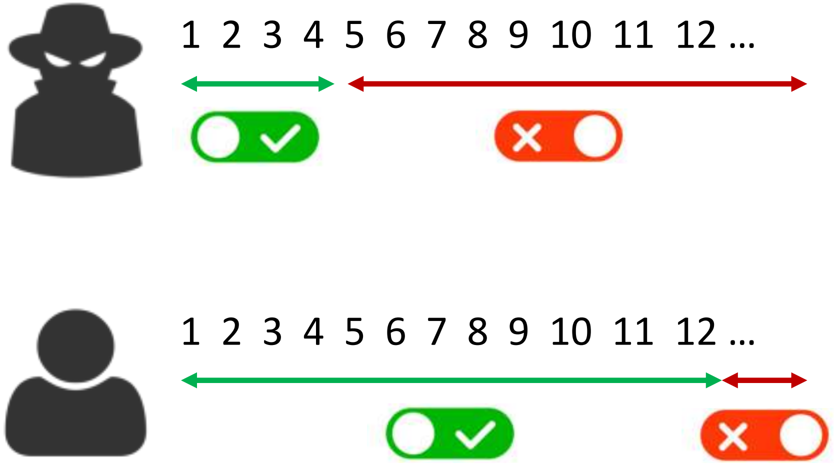
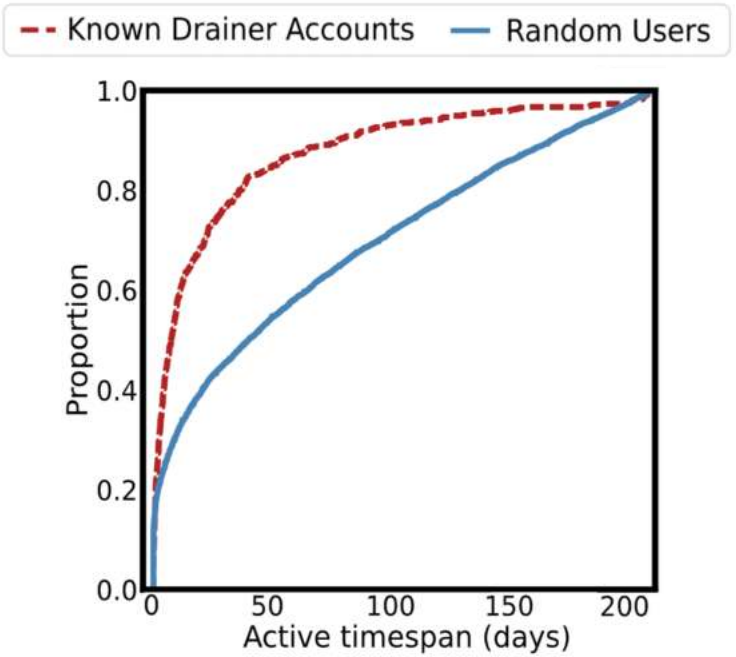
[4] https://www.scamsniffer.io [5] https://www.twitter.com

Drainer Activity Characterization
Trading Behavior

- Have a short active timespan
  - 60% of drainers have only 15 days or less of NFT trading activity
  - 60% of regular users have 67 days or less of NFT trading activity





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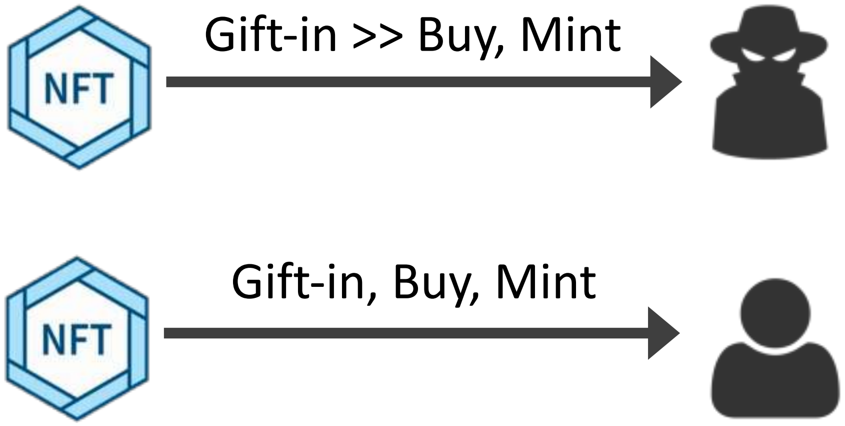
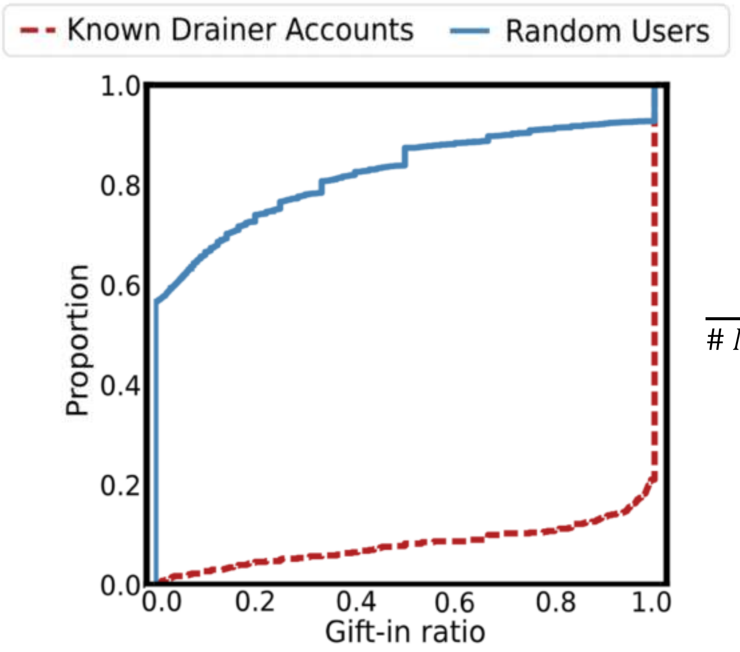
Drainer Activity Characterization
Trading Behavior

- Acquire most NFTs from gift-ins
  - 80% of drainers acquired NFTs only through gift-ins
  - 8% of regular users acquired NFTs only through gift-ins





**Gift-in ratio*

$$\frac{\#\, NFTs\ from\ gift-in}{\#\, NFTs\ from\ mint,\ \ buy, gift-in}$$

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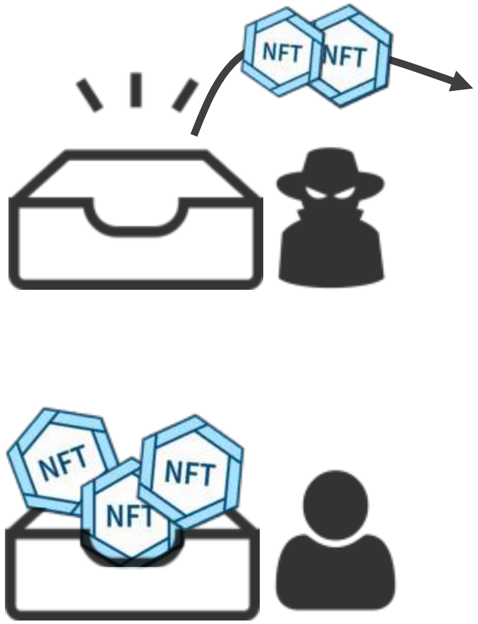
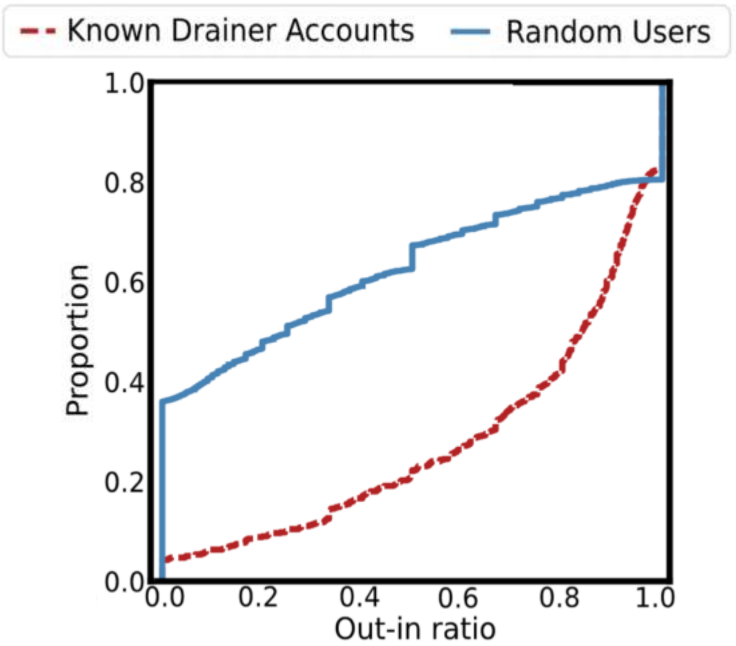
Drainer Activity Characterization

Trading Behavior

- Sell or gift-out most of acquired NFTs
  - 76% of drainers transferred out more than half of their NFTs
  - 38% of regular users did not make any out-transactions at all





**Out-in ratio*

$$\frac{\#\,burn + \#\,sell + \#\,gift-out}{\#\,mint + \#\,buy + \#\,gift-in}$$

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NFT Drainer Detector: DRAINCLoG

Overview

Insights

Drainers have unique {Trading behavior, Social context, NFT transaction context}

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NFT Drainer Detector: DRAINCLoG
Overview

Insights

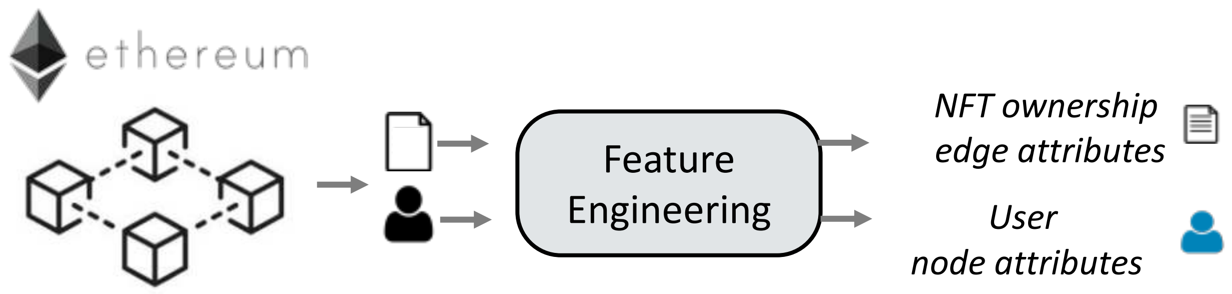
Drainers have unique

- Trading behavior
- Social context
- NFT transaction context

→ Design

- Features
- Graphs
- GNNs

NFT Drainer Detector: DRAINCLoG
Overview



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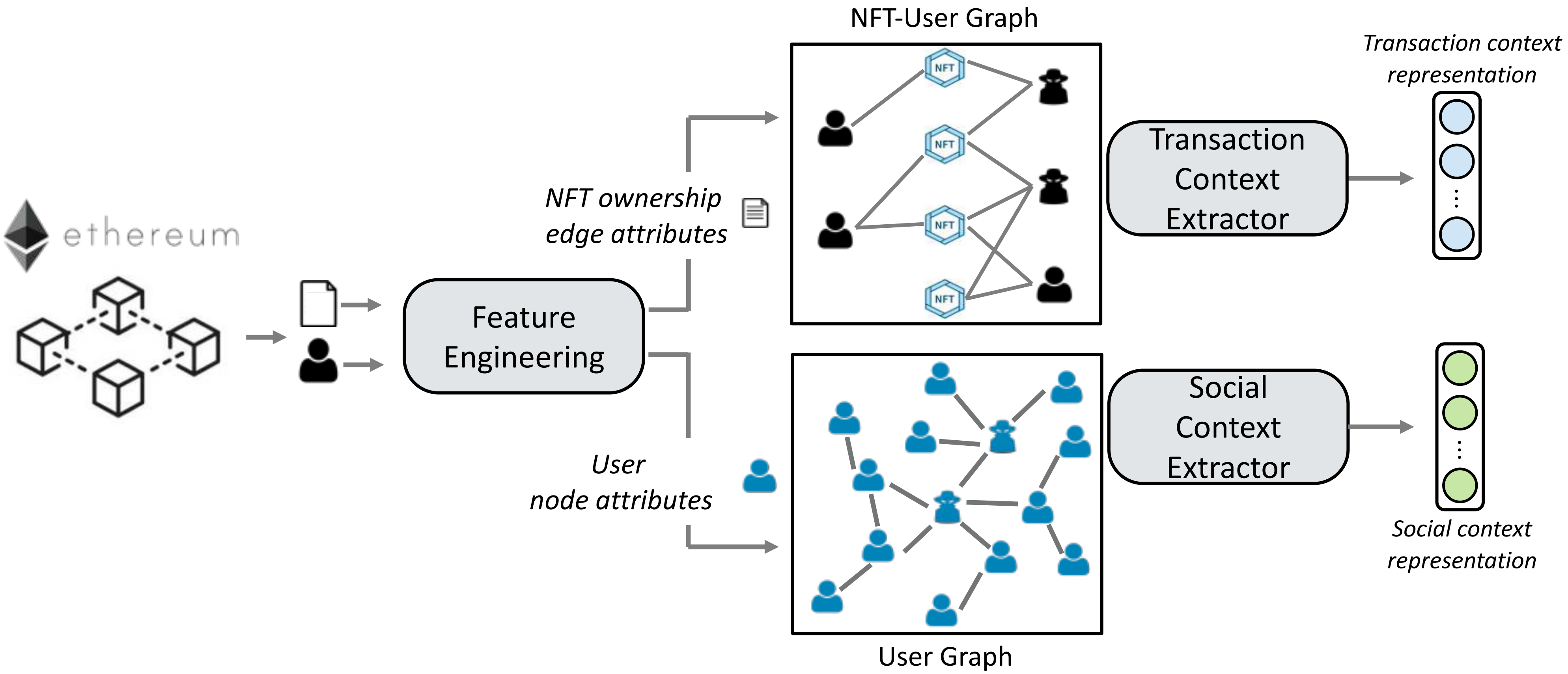
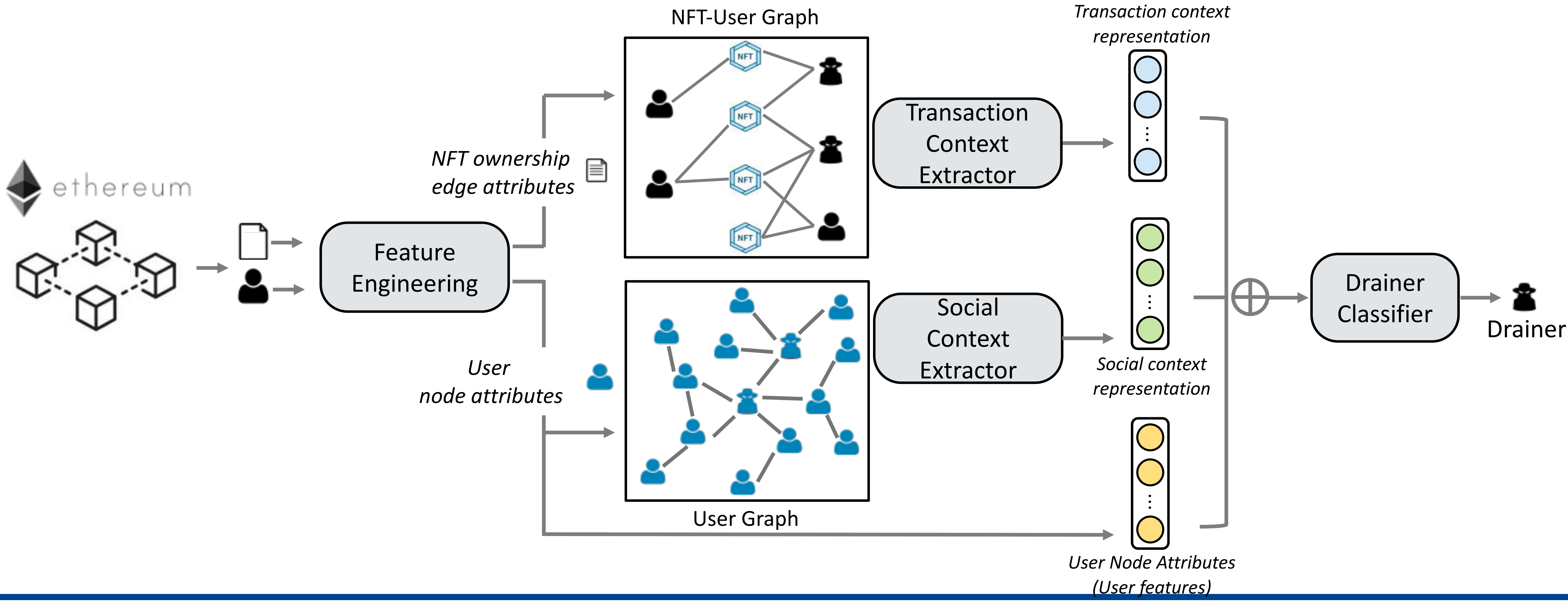
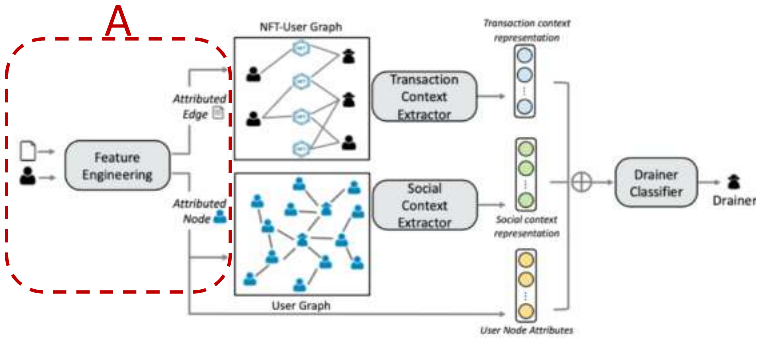
NFT Drainer Detector: DRAINCLoG Overview



NFT Drainer Detector: DRAINCLoG Overview



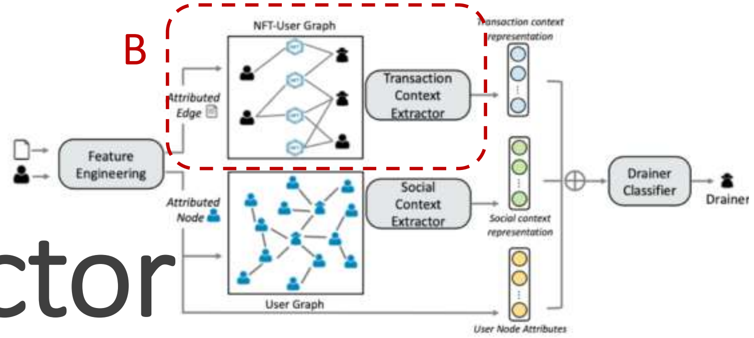
NFT Drainer Detector Design
A. Feature Engineering



- **NFT ownership attributes**
  - Create representations of how users interact with NFTs
- **User attributes**
  - Create representations of their trading behaviors

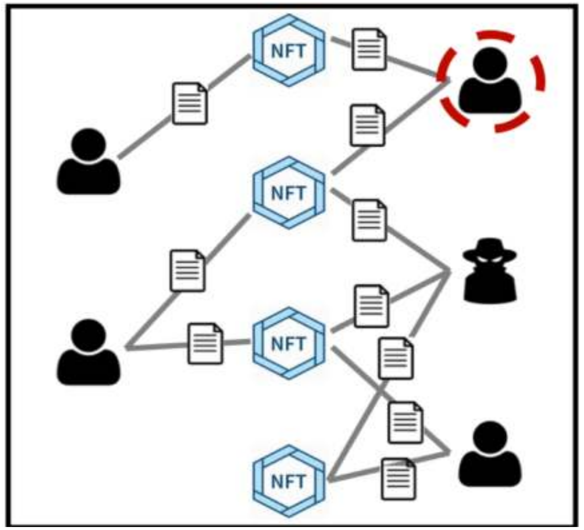
NFT ownership attributes (7 dimensions)	User attributes (19 dimensions)
▪ In-transaction type ▪ Out-transaction type ▪ In-price ▪ Out-price ▪ Holding time ▪ Average holding time ▪ Average sale price	▪ Number of each transaction type (5) ▪ Number of collections for each transaction type (5) ▪ Number of neighbors for each transaction type (4) ▪ Frequency of gift-ins & sales ▪ Active timespan ▪ Gift-in ratio ▪ Out-in ratio

NFT Drainer Detector Design
B. NFT Transaction Context Extractor



- **NFT-User graph Construction**
  - Model ownership changes in NFTs
  - Two types of *Nodes*: User, NFT
  - *Attributed Edge*
- **NFT transaction context extraction**
  - Train a GNN on the graph
  - $h_u^U = ||_{k=1}^{K} \sigma\left(\sum_{n' \in N(u)} [\alpha_{un'}]_k \cdot (W^U \cdot concat(t_{un'}, h_{n'}^N))\right)$

  $where\ h_{n'}^N = \sigma\left(W^N \cdot aggregate(t_{u_1}, t_{u_2}, \cdots, t_{u_m})\right)$



NFT-User graph

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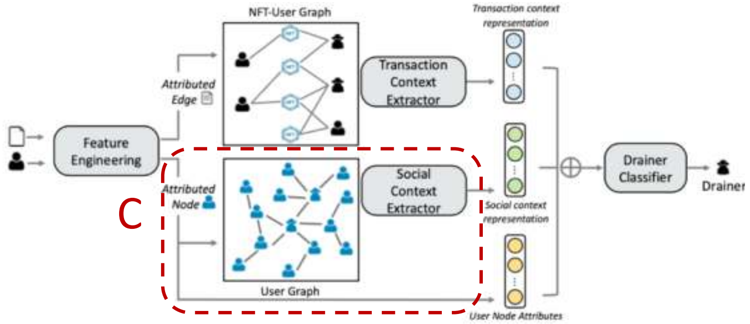
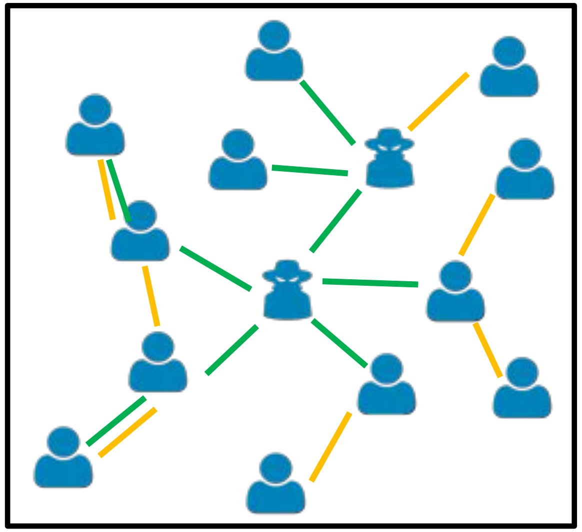
NFT Drainer Detector Design
C. Social Context Extractor

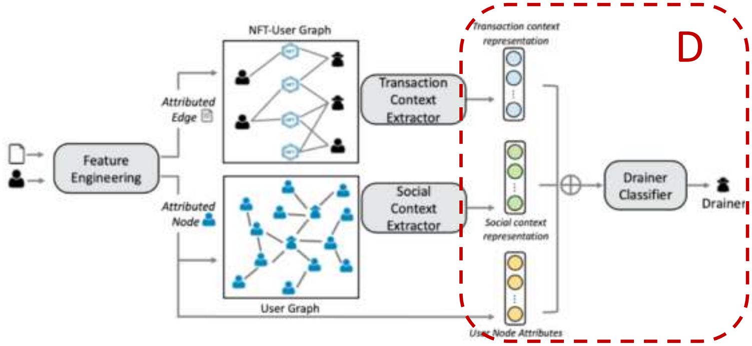


- **User graph Construction**
  - Model user interactions
  - One type of *Attributed Node*: User(Address) 
  - Two types of *Edges*: Sale — , Gift —
- **Social context extraction**
  - Train a GNN on the graph
  - Update node representations using R-GCN to consider edge types
  - $$h_u^{l+1} = \sigma\left(W^l h_u^l + \sum_{r \in R} \mathrm{AGG_U}\left(\frac{1}{c_{u,r}} W_r^l h_v^l\right), \forall v \in N(u)_r\right)$$

(Relational-Graph Convolution Networks)

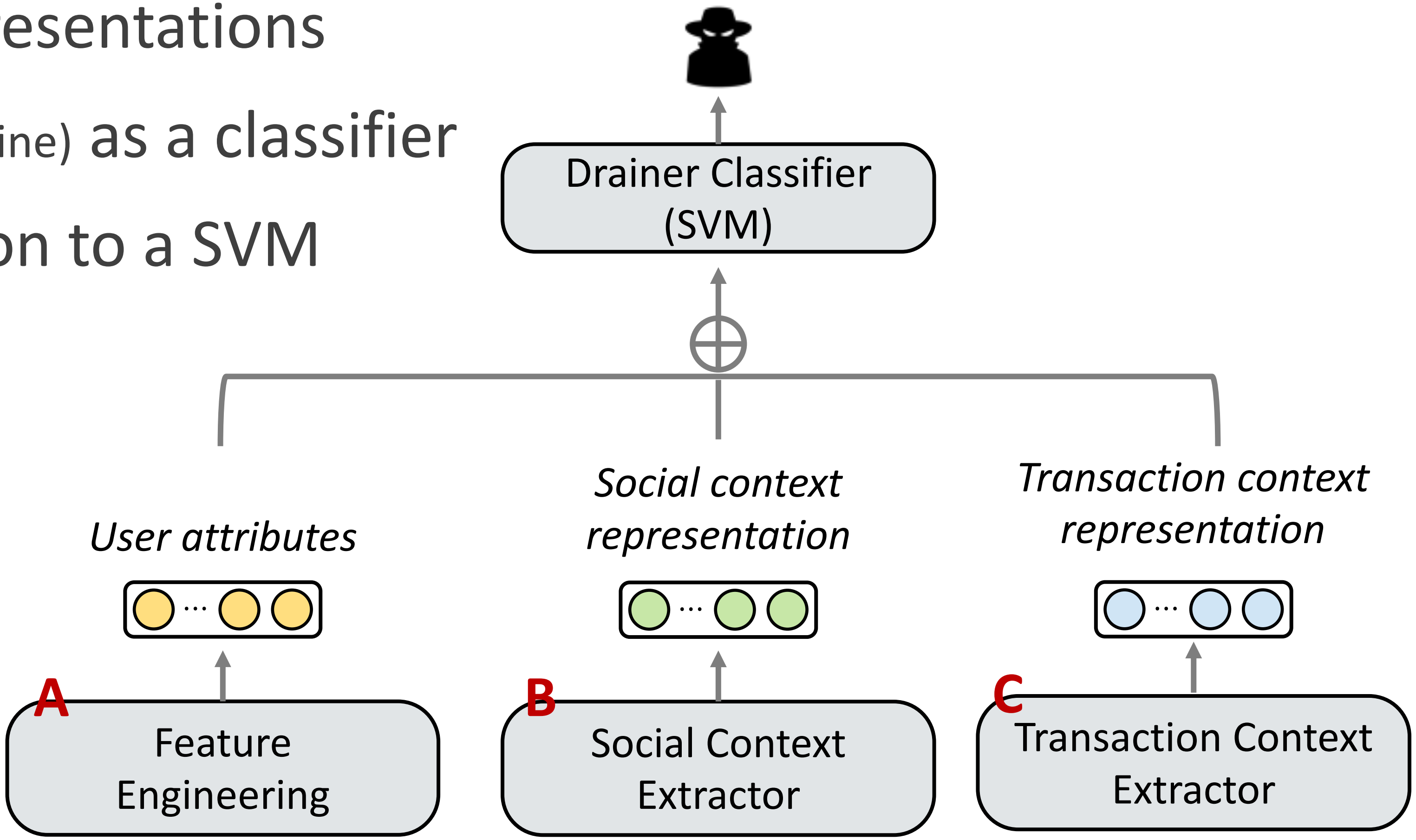


User graph



NFT Drainer Detector Design
D. Drainer Classifier

- Concatenate the three representations
- Use a SVM (Support Vector Machine) as a classifier
- Feed the final representation to a SVM



Evaluation

Dataset

- **Training**: Jan-01-2022 ~ July-31-2022
  - Drainers: 645
- **Evaluation**: Aug-01-2022 ~ Dec-31-2022
  - Drainers: 490

Dataset		Ratio	# central nodes	# total nodes	# transactions
Training	D_0	1:80	52,245	2,010,384.0	24,745,525.0
Evaluation	D_1	1:10	6,006	2,087,436.0	28,375,070.6
	D_2	1:100	55,146	2,743,003.4	41,384,504.8
	D_3	1:1000	546,546	3,179,105.4	45,289,602.6

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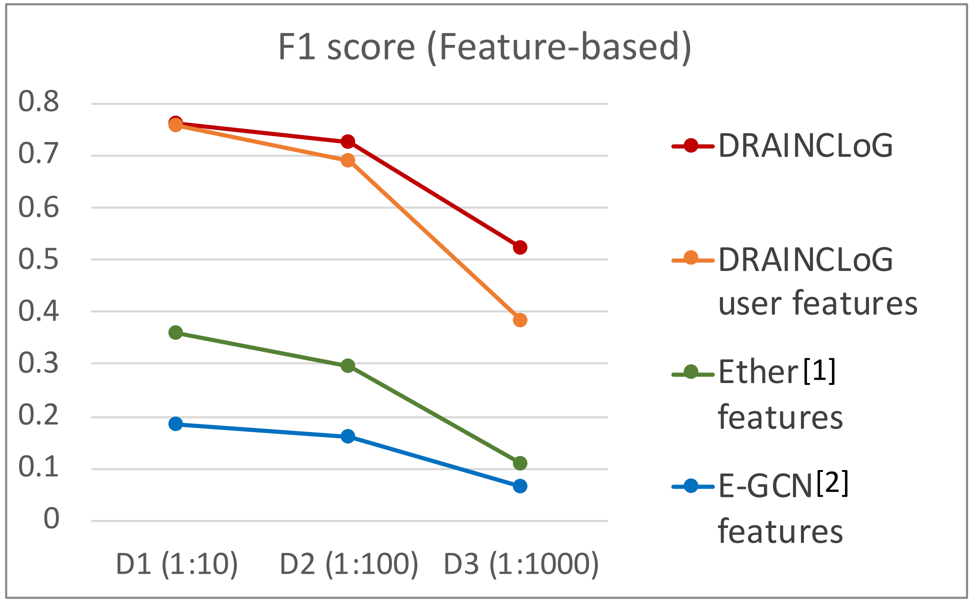
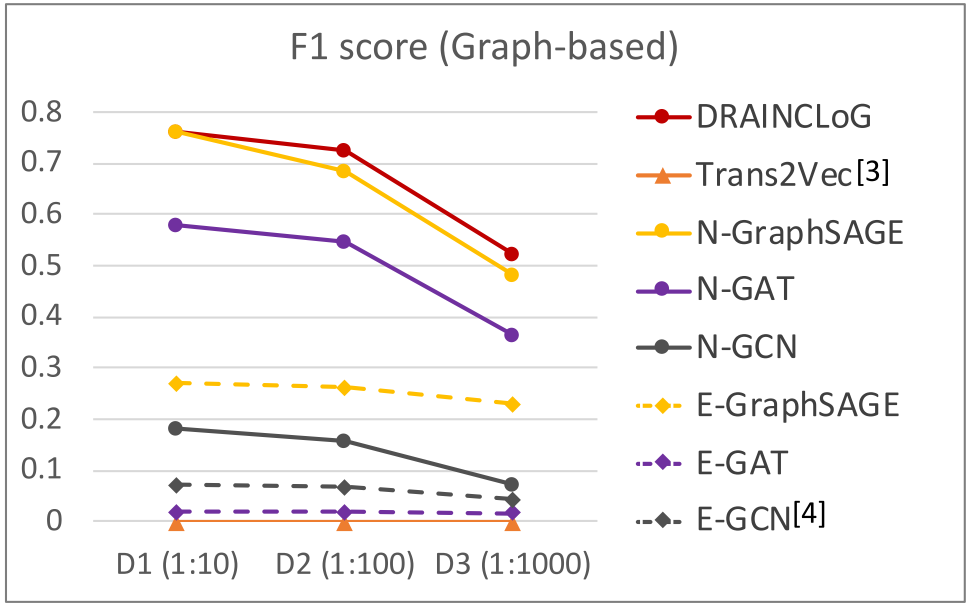
Evaluation

Drainer Classification





[1] Chen, Weili, et al. "Phishing Scam Detection on Ethereum: Towards Financial Security for Blockchain Ecosystem." *IJCAI*. **2020**.
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[4] Kipf, Thomas N., and Max Welling. "Semi-supervised classification with graph convolutional networks." *arXiv preprint arXiv:1609.02907* (2016).
[5] Veličković, Petar, et al. "Graph attention networks." *arXiv preprint arXiv:1710.10903* (2017).
[6] Hamilton, Will, Zhitao Ying, and Jure Leskovec. "Inductive representation learning on large graphs." *Advances in neural information processing systems* 30 (2017).

Evaluation
Robustness against Evasion Attack

- Assumptions
  - DRAINCLoG monitoring system + Victim's reporting system
  - Detected drainers are immediately blocked their trading on marketplaces
  - To benefit from stolen NFTs, drainers have to quickly sell the NFTs at lower prices
- Attackers can modify their trading patterns to avoid detection
- Evaluate DRAINCLoG's robustness under various attack scenarios

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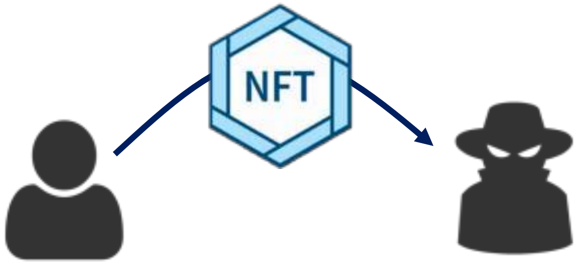
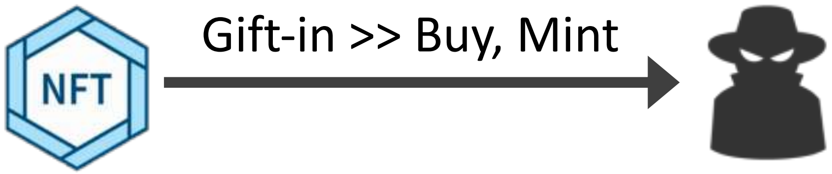
Evaluation

Robustness against Evasion Attack



Draining NFTs records as gifts

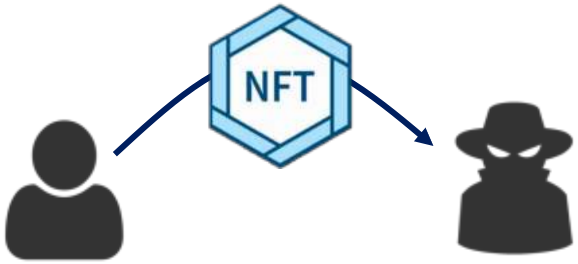


Acquire most NFTs through gift-ins

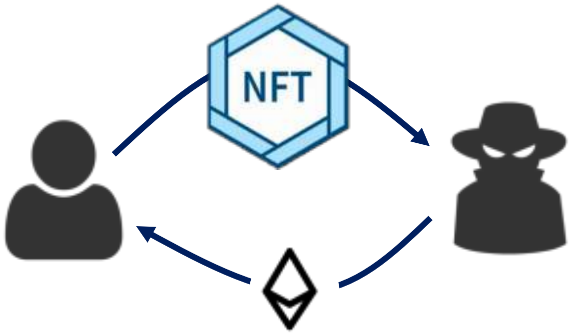
Evaluation

Robustness against Evasion Attack

Attack Scenario Example: Send a small amount of Ether to victim



Stealing NFTs



Buying NFTs at low prices

For each attacker,
Change L% of *gifting-in transactions* to *buying transactions*
by sending X% of average sale price of each NFT to victims

$L \in \{10, 30, 50\}$, $X \in \{1, 10, 60\}$

Evaluation

Robustness against Evasion Attack

- Evasion attack results

Attack (L = 50)	D1 (1:10)			D2 (1:100)		
X	Pre.	Rec.	F1	Pre.	Rec.	F1
60	0.873	0.114	0.202	0.42	0.114	0.180
Original Value	**0.989**	**0.622**	**0.763**	**0.878**	**0.621**	**0.727**

Evaluation

Robustness against Evasion Attack

- Update DRAINCLoG by re-training only SVM classifier with additional 3% of attackers

Attack (L = 50)	**D1 (1:10)**			**D2 (1:100)**			**D1 (1:10)**			**D2 (1:100)**		
X	**Pre.**	**Rec.**	**F1**	**Pre.**	**Rec.**	**F1**	**Pre.**	**Rec.**	**F1**	**Pre.**	**Rec.**	**F1**
60	0.873	0.114	0.202	0.42	0.114	0.180	0.97	0.644	0.774	0.769	0.645	0.701
Original Value	**0.989**	**0.622**	**0.763**	**0.878**	**0.621**	**0.727**	**0.989**	**0.622**	**0.763**	**0.878**	**0.621**	**0.727**

DRAINCLoG can effectively capture complex patterns of new drainers!

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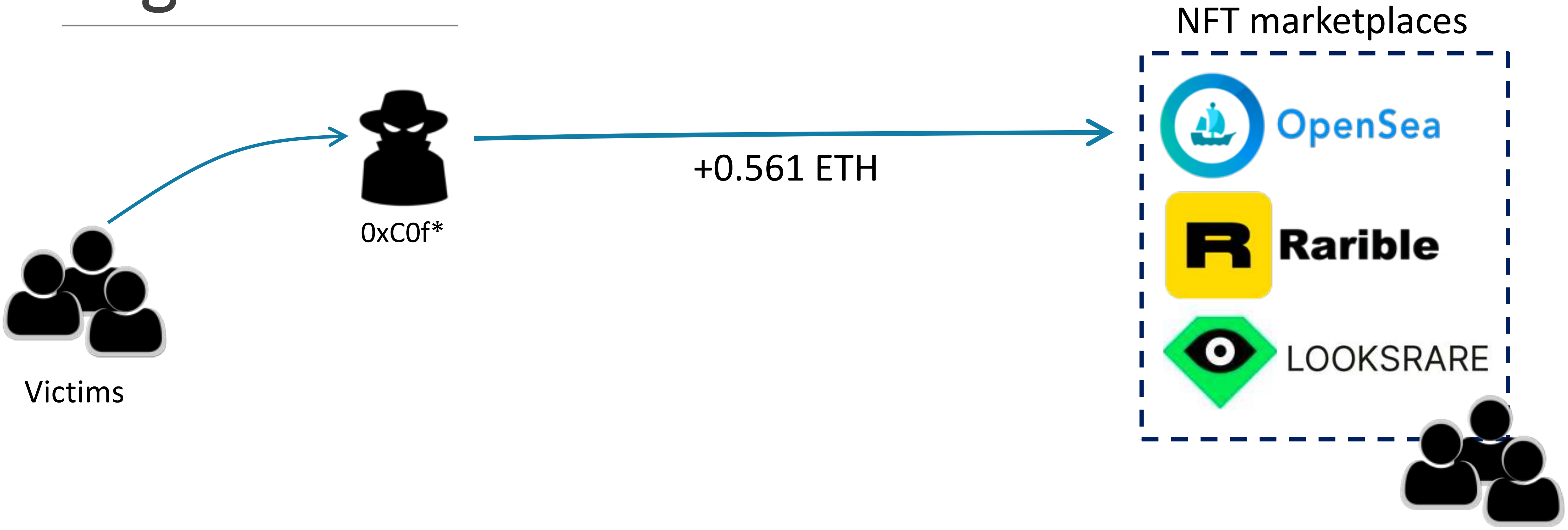
Total: Jul-27-2022 ~ May-18-2023
Now: Jul-27-2022 ~ Jul-28-2022

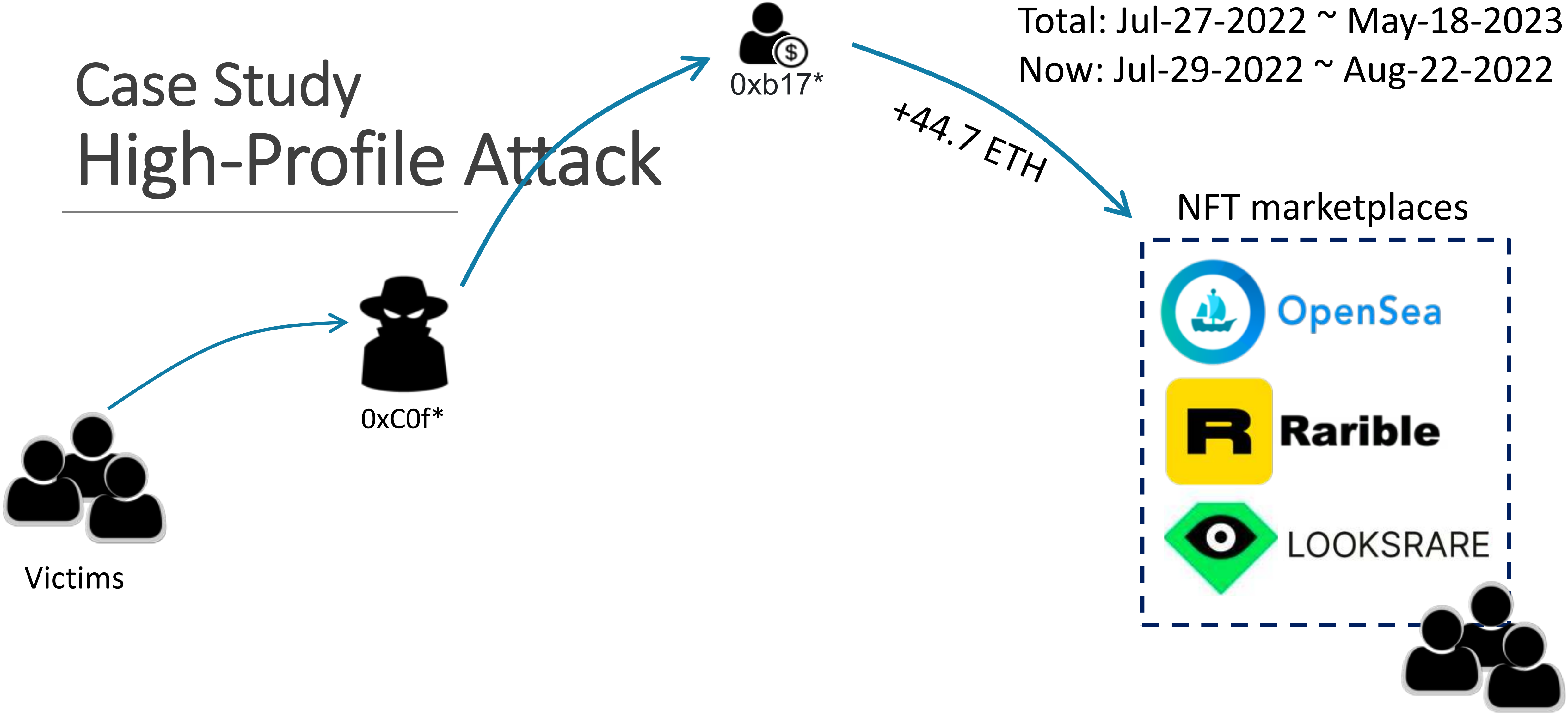
Case Study
High-Profile Attack



Case Study

High-Profile Attack

Total: Jul-27-2022 ~ May-18-2023
Now: Jul-29-2022 ~ Aug-22-2022

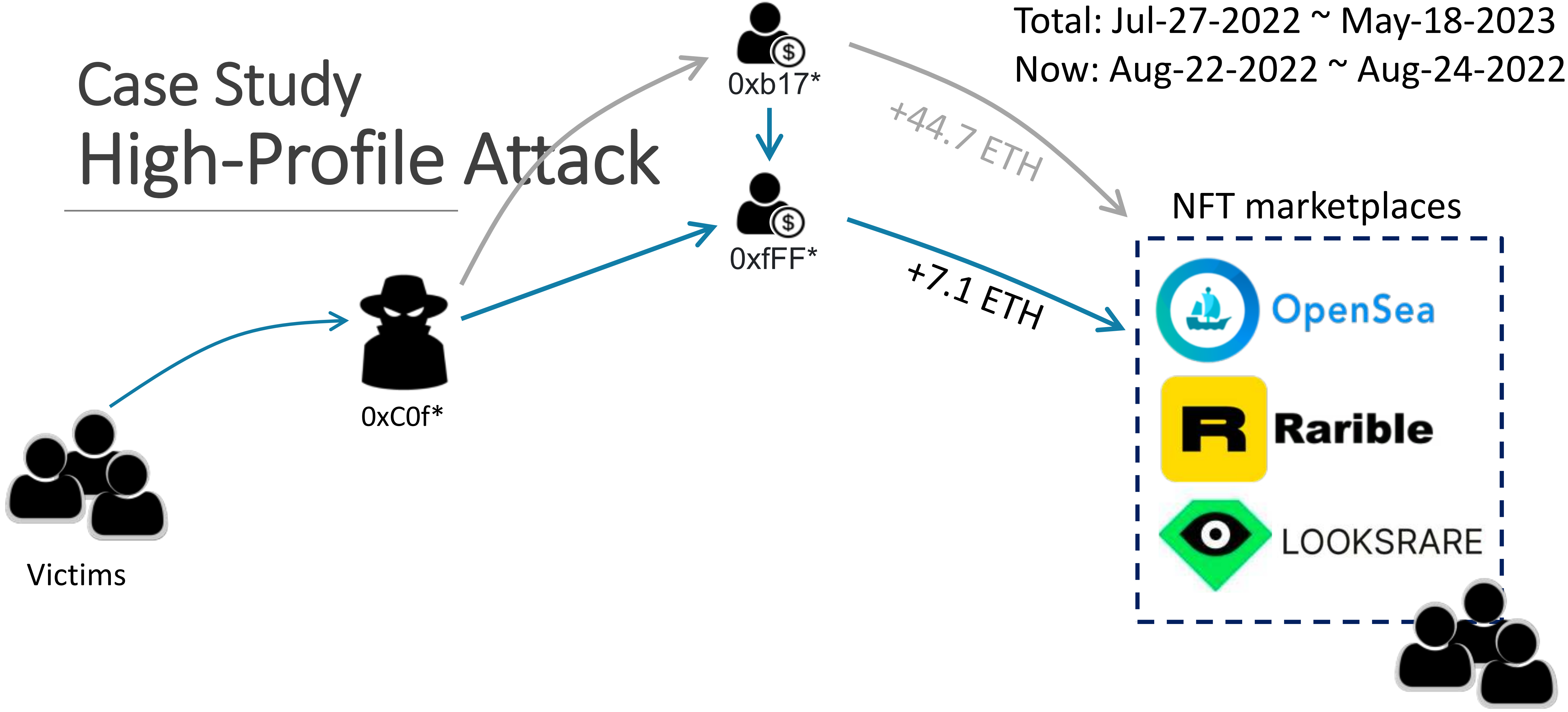


Case Study

High-Profile Attack

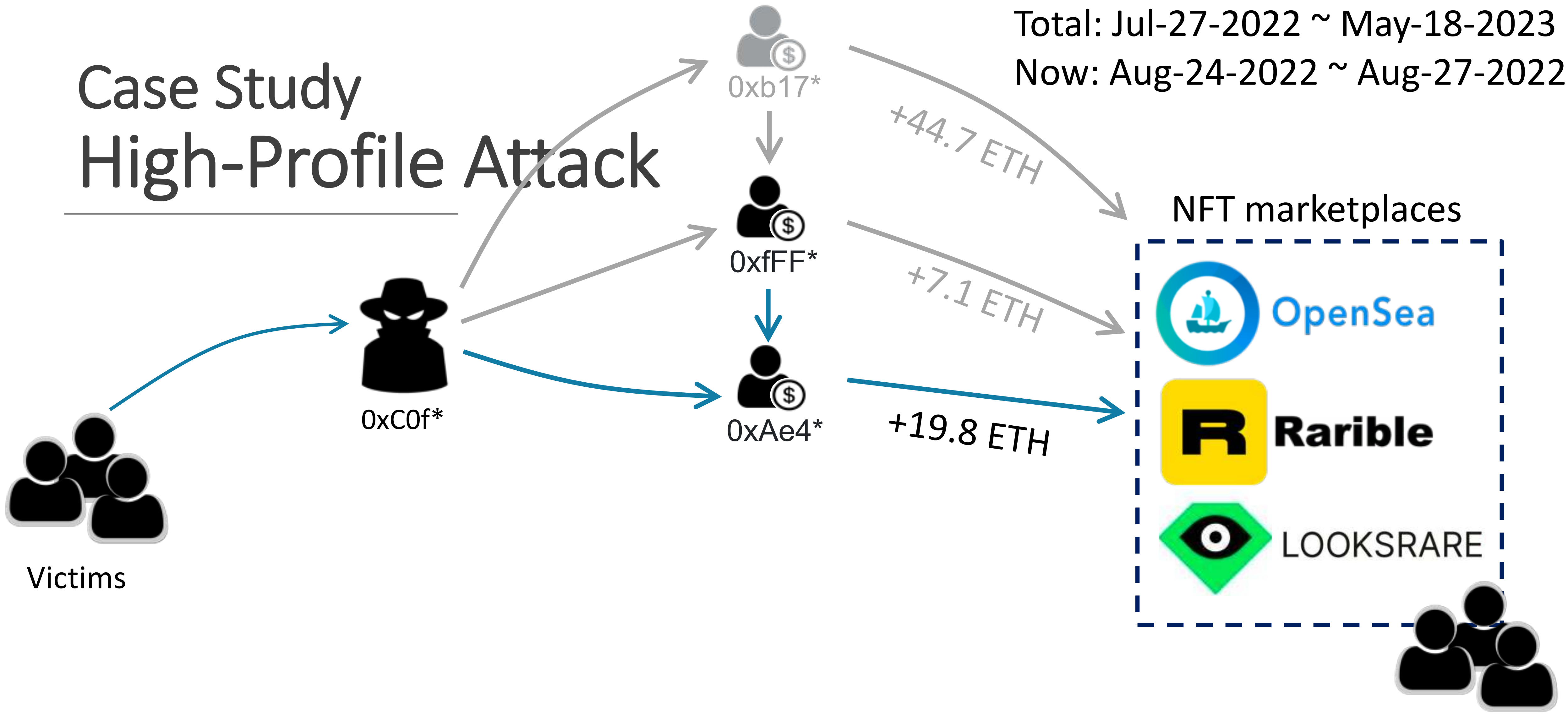
Total: Jul-27-2022 ~ May-18-2023

Now: Aug-22-2022 ~ Aug-24-2022



Case Study
High-Profile Attack

Total: Jul-27-2022 ~ May-18-2023
Now: Aug-24-2022 ~ Aug-27-2022

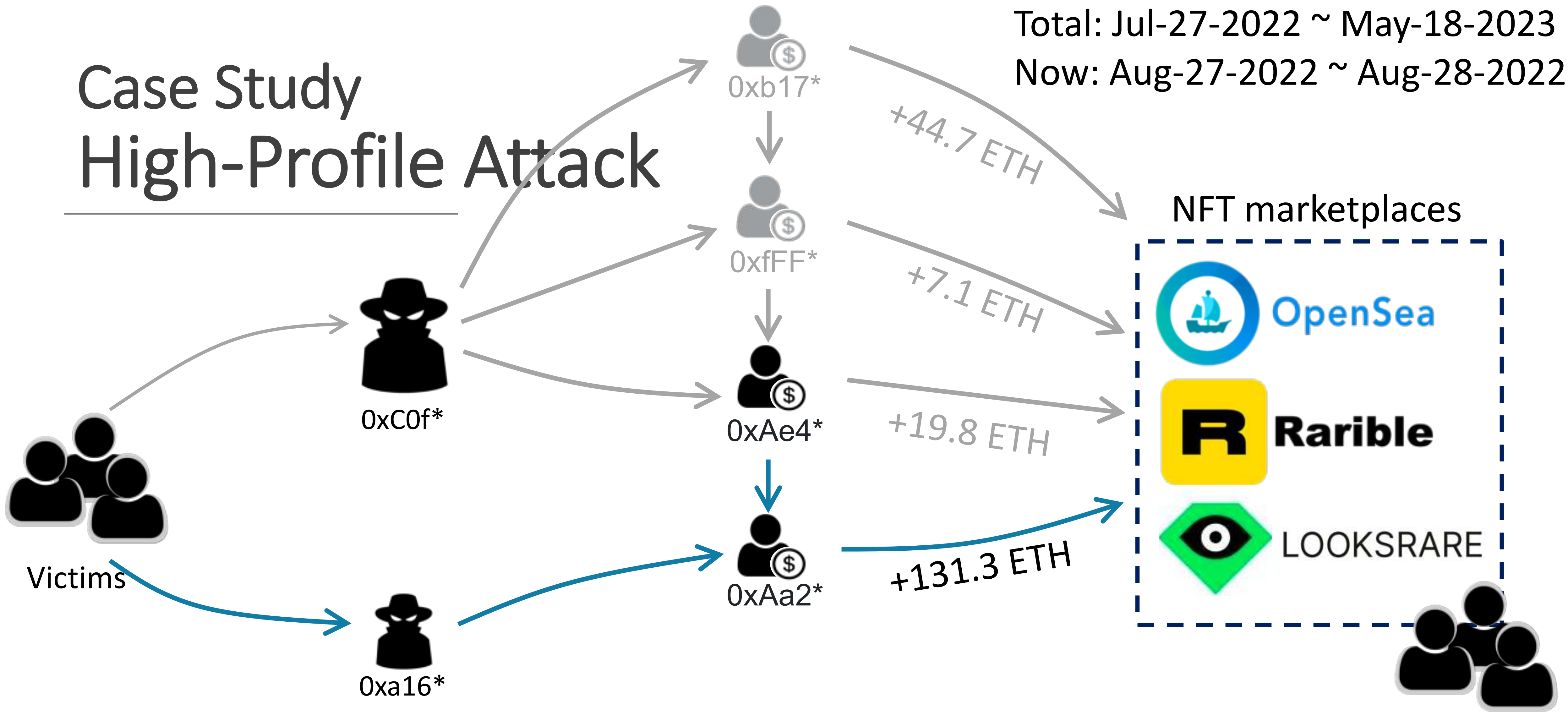


Case Study

High-Profile Attack

Total: Jul-27-2022 ~ May-18-2023

Now: Aug-27-2022 ~ Aug-28-2022

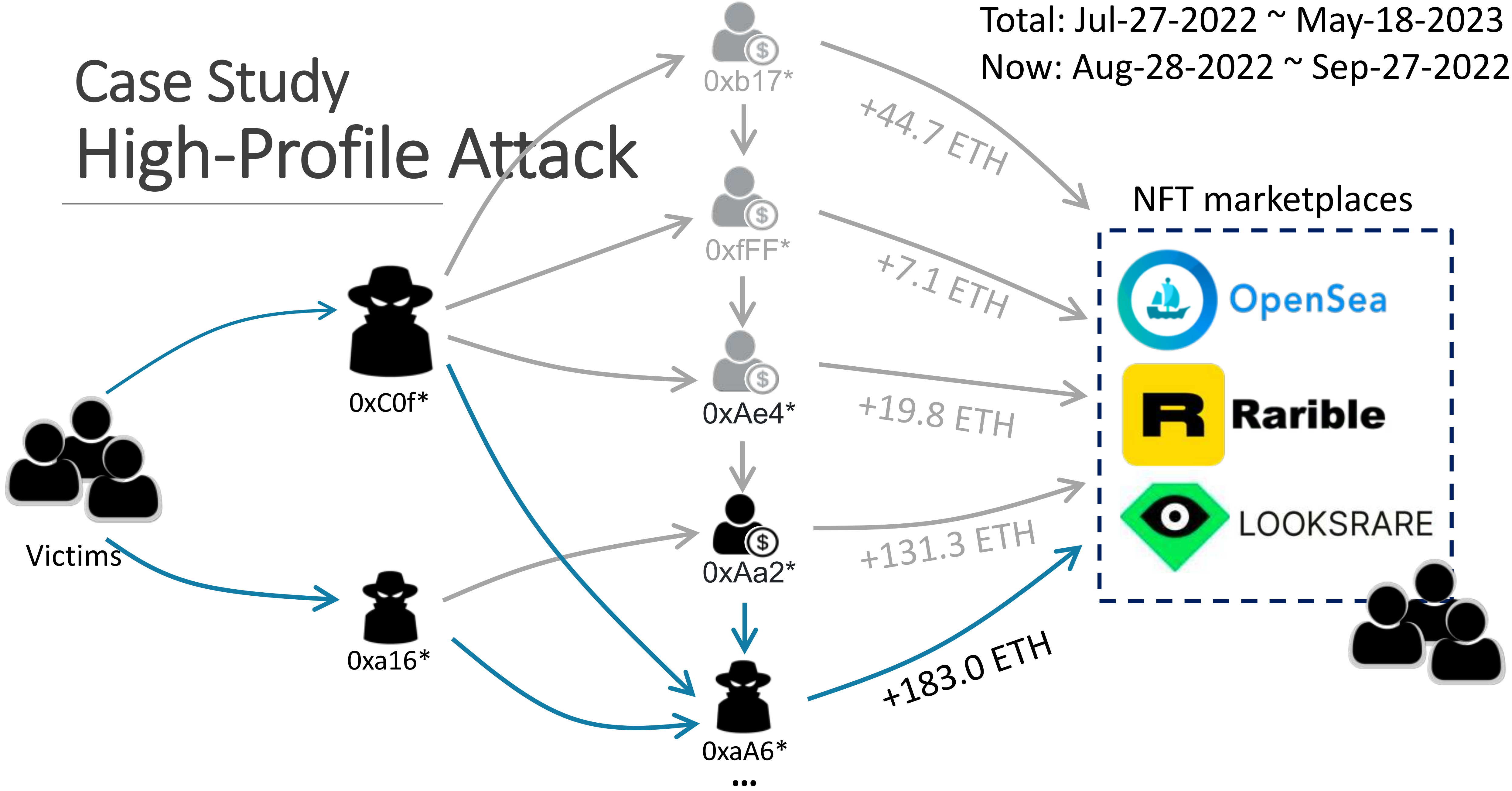


Case Study

High-Profile Attack

Total: Jul-27-2022 ~ May-18-2023

Now: Aug-28-2022 ~ Sep-27-2022



Conclusion

- NFT phishing scams are a significant threat to the NFT ecosystem
- However, the existing literature has not explored NFT drainers

- **DRAINCLoG:** Detecting Rogue Accounts with Illegally-obtained NFTs using Classifiers Learned on Graphs
  - The first study on NFT phishing scammers (drainers)
  - Conduct an in-depth study on NFT drainers
  - Propose a detection system, *DRAINCLoG*, and verify its effectiveness and robustness

Thank you

Please feel free to contact me regarding our research.

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Evaluation

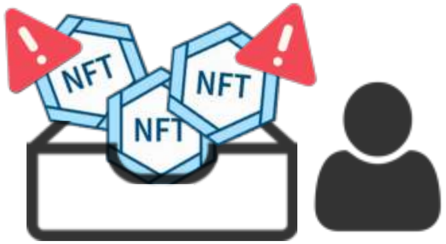
Drainer Classification

Model	Dataset (# drainer : # regular)	D1 (1:10)				D2 (1:100)				D3 (1:1000)			
	Metrics	**Pre.**	**Rec.**	**F1**	**FP/TP**	**Pre.**	**Rec.**	**F1**	**FP/TP**	**Pre.**	**Rec.**	**F1**	**FP/TP**
Feature based	*Ether features*	0.875	0.227	0.361	15.9/111.1	0.429	0.227	0.297	148.0/111.2	0.072	0.227	0.109	1433.2/111.2
	E-GCN features	0.838	0.104	0.185	10.0/51.0	0.334	0.104	0.159	102.4/51.0	0.047	0.104	0.064	1045.4/51.0
	DRAINCLoG user features	0.976	0.618	0.757	7.4/302.4	0.779	0.618	0.689	86.2/304.2	0.277	0.627	0.385	801.8/307.2
Graph based	*E-GCN*	0	0	0	0.0/0.0	0	0	0	0.0/0.0	0	0	0	0.0/0.0
	E-GAT	0.832	0.037	0.071	3.7/18.1	0.349	0.037	0.067	33.6/18.0	0.055	0.037	0.044	311.5/18.1
	E-GraphSAGE	0.933	0.01	0.02	0.4/5.0	0.825	0.01	0.02	1.2/5.0	0.256	0.009	0.018	12.8/4.4
	N-GCN	0.98	0.157	0.271	1.6/77.0	0.867	0.157	0.265	12.0/77.2	0.435	0.157	0.231	99.9/76.9
	N-GAT	0.838	0.103	0.183	9.8/50.2	0.351	0.103	0.159	93.8/50.6	0.057	0.102	0.073	825.5/50.0
	N-GraphSAGE	0.982	0.411	0.58	3.8/201.4	0.811	0.411	0.546	47.4/202.6	0.323	0.415	0.363	426.3/203.4
	DRAINCLoG	**0.987**	**0.569**	**0.722**	**3.6/278.4**	**0.86**	**0.569**	**0.685**	**45.8/280.2**	**0.416**	**0.579**	**0.484**	**398.3/283.7**

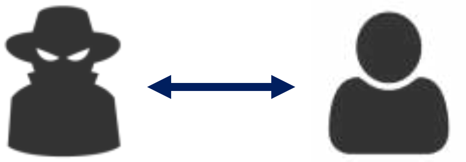
Evaluation

Identify potential Drainers

- Verify false positives
  - ✓ Possess suspicious NFTs



  - ✓ Have a persistent relationship with reported phishing accounts

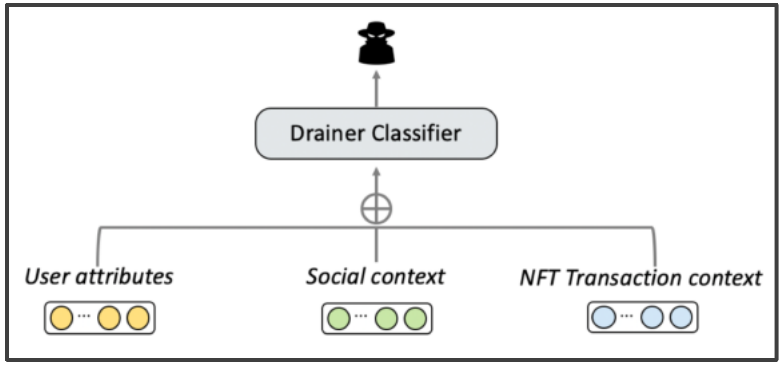


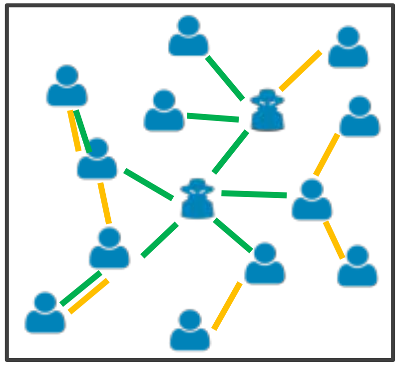
  - ✓ Newly reported after 2022

- Identify 115 potential drainers among 379 false positives

Appendix
Ablation Study

- Analyze how each component affects performance
- Conduct the same detection task after eliminating each
  - User attributes (from Feature Engineering)
  - Social context
  - NFT transaction context
  - Edge types in User graph





User graph