



Milan – August 6<sup>th</sup>, 2024

IEEE Conference on Games

# **“Hey Players, there is a Problem...”**

## **On Attribute Inference Attacks against Video Gamers**

Linus Eisele, Giovanni Apruzzese

# Attribute Inference Attacks

- GOAL? Use **publicly available information** on certain individuals to infer their **private attributes**
- HOW? By using Machine Learning models

# Attribute Inference Attacks in Video Games

- BACKSTORY: in 2022, Tricomi et al [7] showcased the practicality of Attribute Inference Attacks (AIA) in DOTA2...

# Tracking Website (from Tricomi et al. [7])

**Dendi**  
Overview

24 minutes ago  
LAST MATCH

6,218 - 5,477 - 82  
RECORD

52.80%  
WIN RATE

371

ESPORTS PROFILE

Overview Matches Heroes Hero Mastery Items Records Scenarios Activity Trends Achievements Matchups

ROLES AND LANES FROM RECENTLY ANALYZED MATCHES

88% CORE 12%

MID LANE

MOST PLAYED HEROES ALL TIME

Hero	Matches	Win %	KDA	Role	Lane
Invoker 8 days ago	706	52.97%	4.00	Core	Mid Lane
Shadow Fiend 2 months ago	681	49.63%	3.09	Core	Mid Lane
Pudge 24 minutes ago	671	55.89%	3.39	Core	Mid Lane

LATEST MATCHES

Hero	Result	Type	Duration	KDA
Pudge Immortal	Won Match 24 minutes ago	Ranked All Pick	17:34	7/0/4
Dragon Knight Immortal	Lost Match 14 hours ago	Ranked All Pick	49:02	9/4/14
Zeus Immortal	Won Match 15 hours ago	Ranked All Pick	41:13	10/5/24

6,300 ARBITRARY POINTS RECENT ACHIEVEMENTS

Jungle Medicine 2 months ago	40	Death Prophet 3 months ago	25	Deathball 4 months ago	15	Shadow Shaman 7 months ago	25
Batrider 11 months ago	25	Witch Doctor 12 months ago	25				

ACTIVITY LAST 3 MONTHS

FRIENDS THIS WEEK

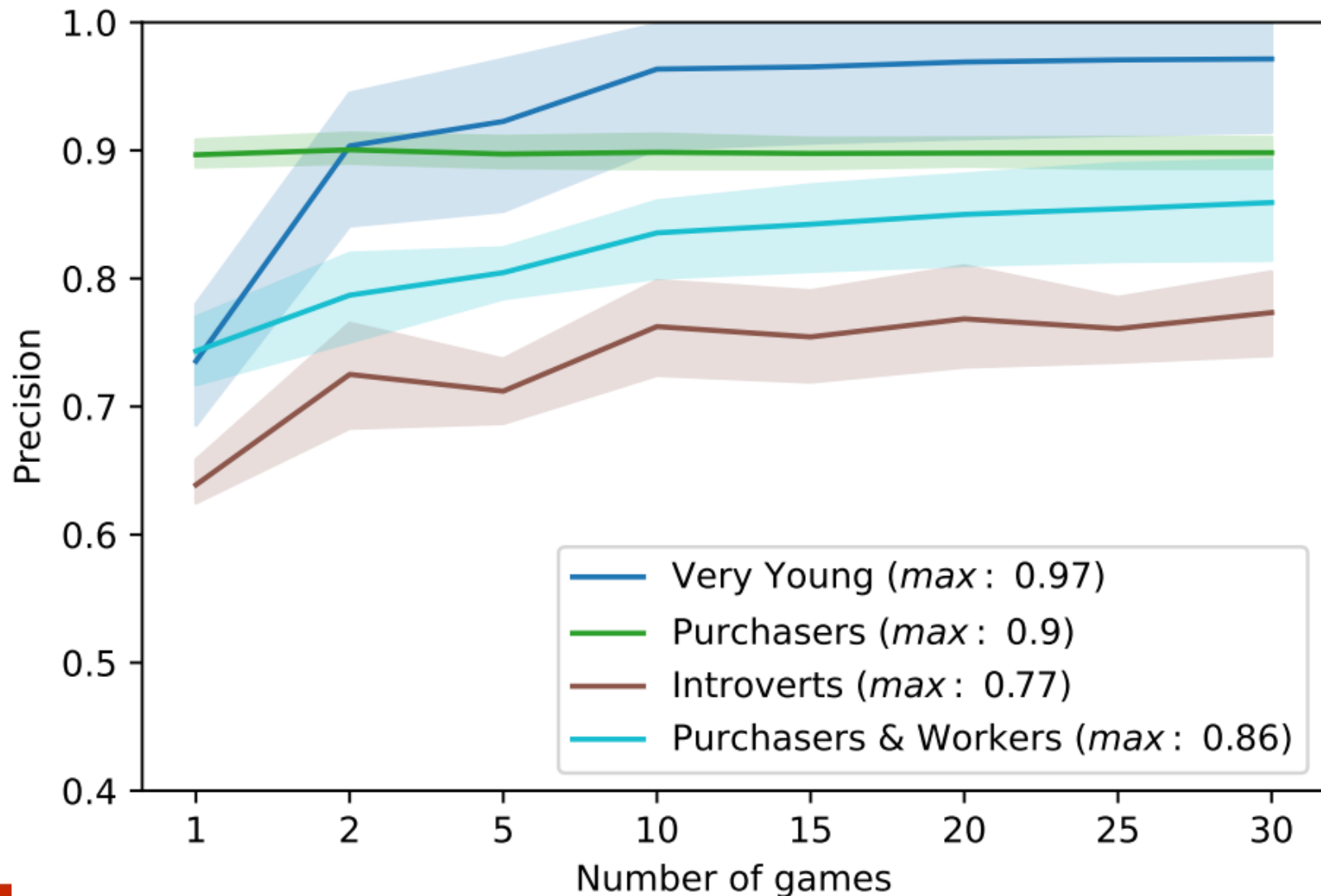
Friend	Matches	Win Rate
syndereN	8	37.50%
Pale Horse	4	25.00%
Monke	4	25.00%
Gremlo	4	25.00%
Crow	4	25.00%
s21	3	100.00%
miniorc00	3	66.67%

ALIASES STEAM\_0:1:35194328

Name	Last Used
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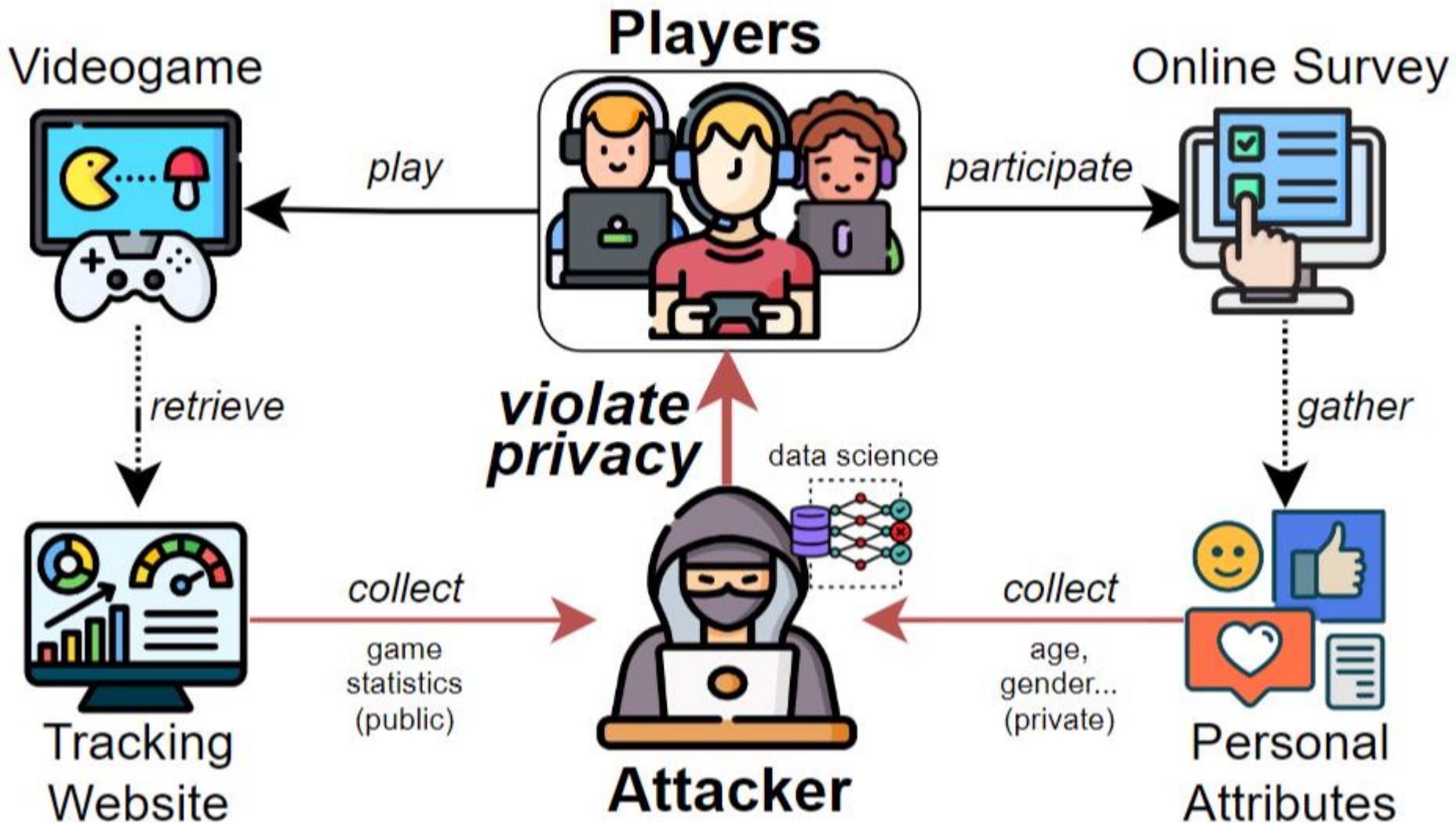
[7]: P. P. Tricomi, et al, "Attribute inference attacks in online multiplayer video games: A case study on DOTA2," in ACM CODASPY, 2023

# Findings of Tricomi et al. [7]

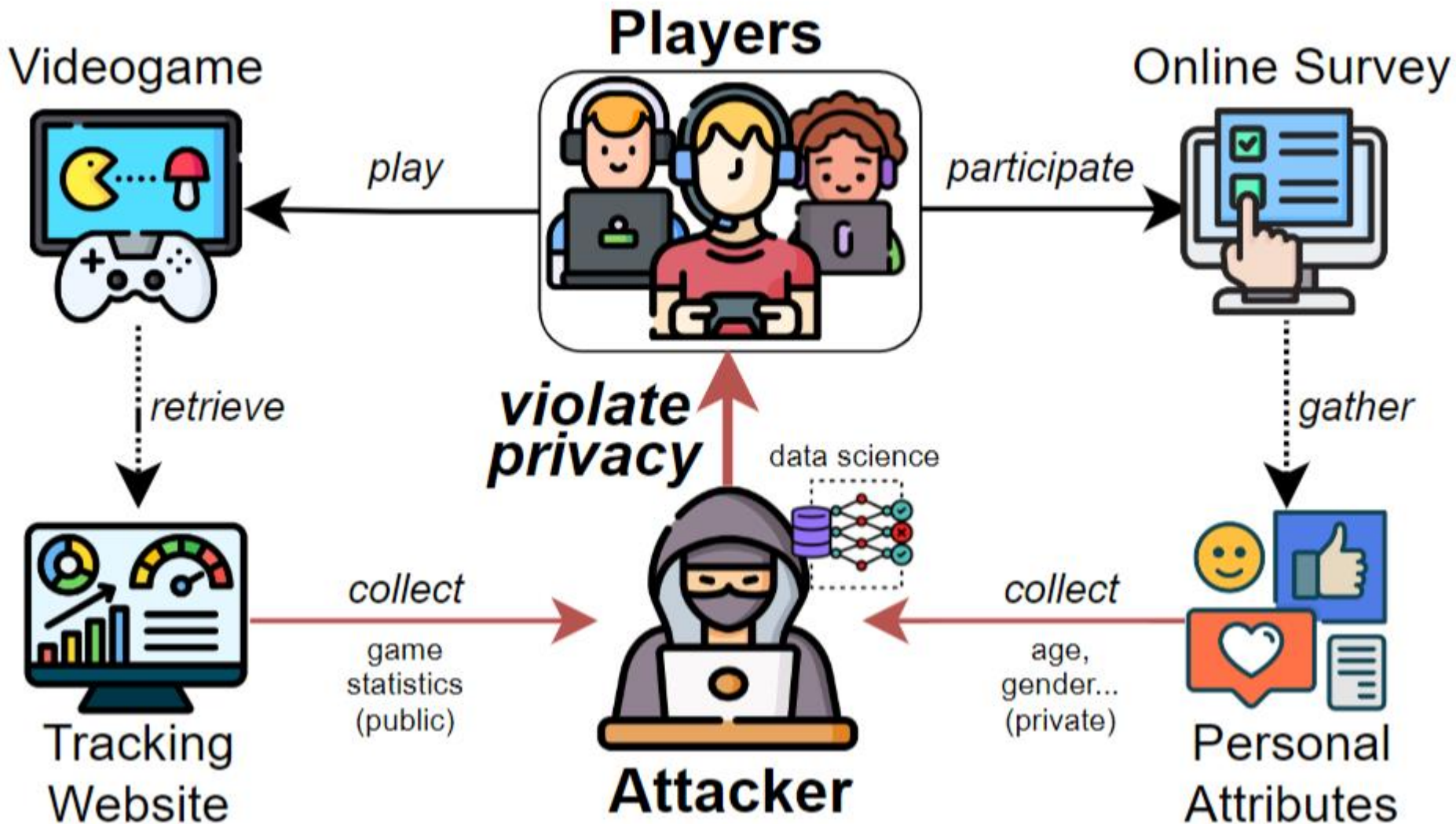


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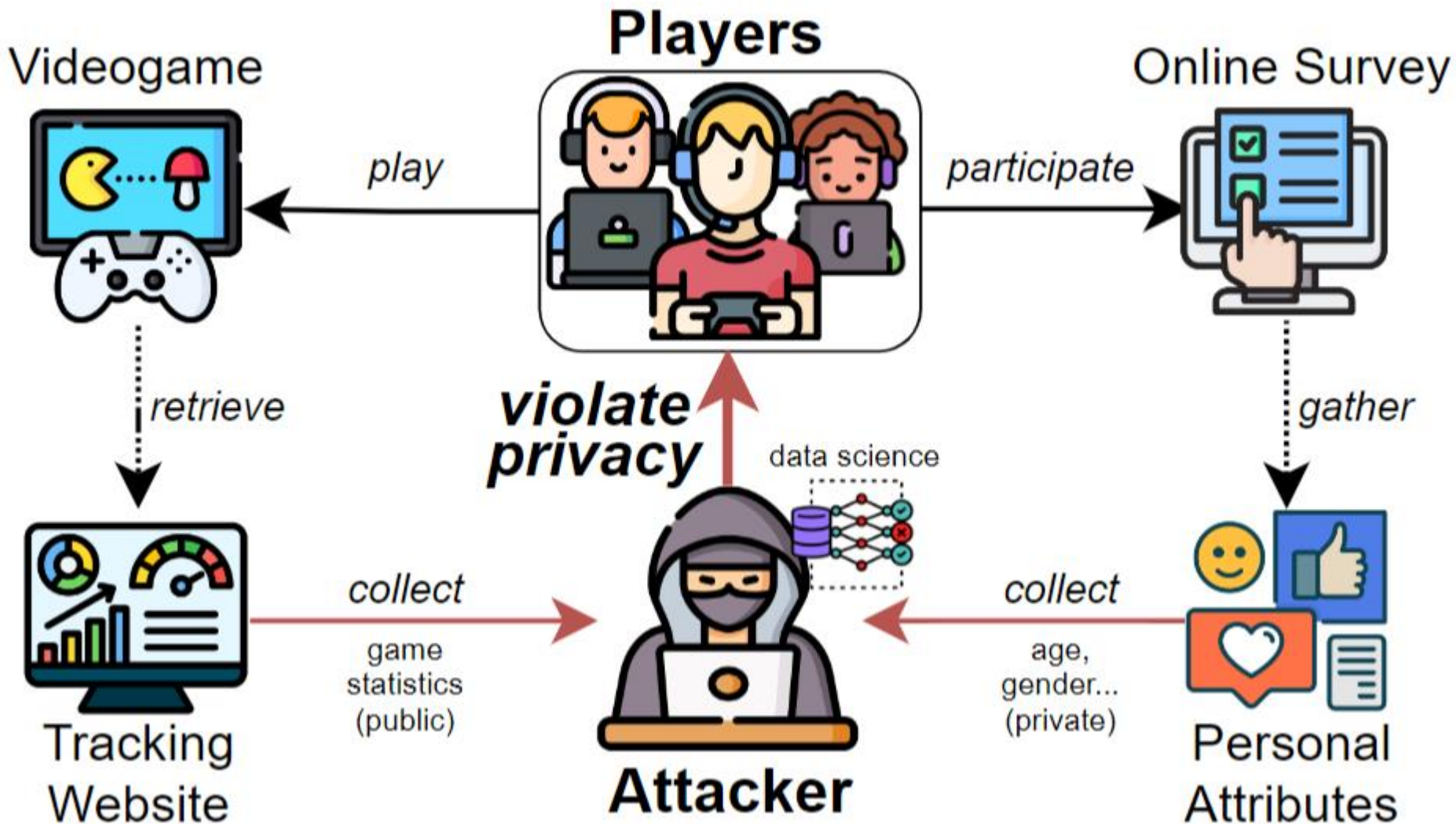
# Attribute Inference Attacks in Games



# Attribute Inference Attacks in Games – How?



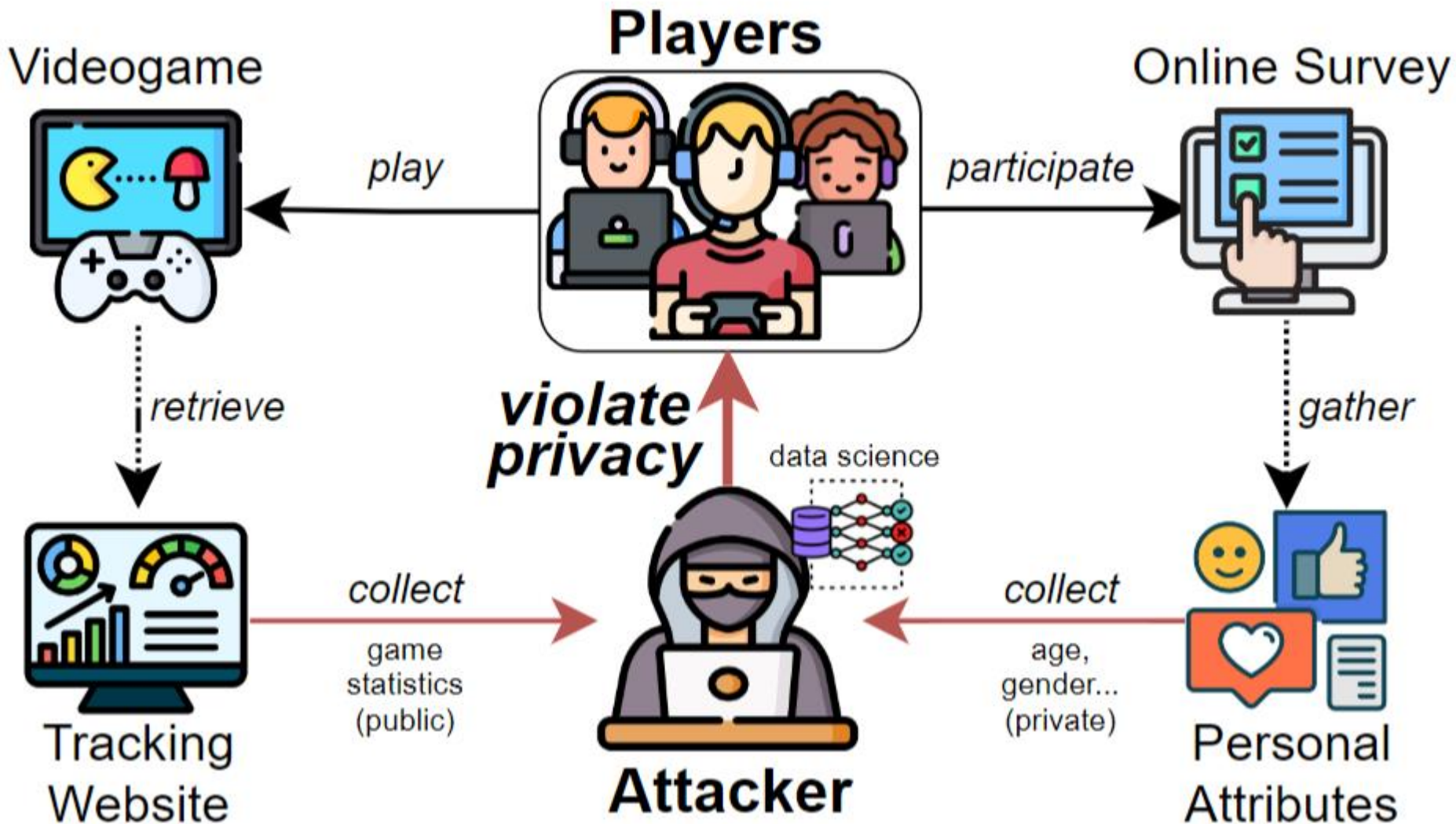
# Attribute Inference Attacks in Games – Subtle?



AIA allow attackers to infer private attributes of OTHER players!



# Attribute Inference Attacks in Games – Why?



**Targeted Ads** [19]: G. Johnson, et al., "Privacy-centric digital advertising: Implications for research," Customer Needs and Solutions, 2022  
**Bullying** [20]: P. C. Ferreira, et al., "Exploring empathy in cyberbullying with serious games," Computers & Education, 2021

# AIA (and Privacy) in Gaming research

- Attribute Inference Attacks have been known by the security community since 2016 [12]
- *However, AIA (and privacy in general) are somewhat overlooked in game-related literature*

[12]: Gong, Neil Zhenqiang, and Bin Liu. "You are who you know and how you behave: Attribute inference attacks via users' social friends and behaviors." USENIX Security Symposium 2016

# AIA (and Privacy) in Gaming research

- Attribute Inference Attacks have been known by the security community since 2016 [12]
- *However, AIA (and privacy in general) are somewhat overlooked in game-related literature*
  
- We looked into the 682 publications of IEEE CoG (2018—2023):
  - **No paper** mentions “Attribute Inference Attacks”
  - Only 20 papers (3%) mention “privacy” at least once...
  - ...but **only one paper** actually hints at potential privacy issues
  
- We expanded our search to include other venues (found through Google Scholar), but the conclusions do not change.

[12]: Gong, Neil Zhenqiang, and Bin Liu. "You are who you know and how you behave: Attribute inference attacks via users' social friends and behaviors." USENIX Security Symposium 2016

# Analysis of Video Games

We investigated the gaming landscape to identify which games are more likely to be at risk of AIA.

## Selection Criteria

- Popularity  
20 top online multiplayer games,  $\geq 20k$  concurrent players
- Tracking Website  
publicly available, potentially AIA-usable in-game statistics
- Prior Survey  
previous surveys related to the game with  $\geq 200$  responses
- Correlations Found  
literature-proven correlations between in-game and off-game data

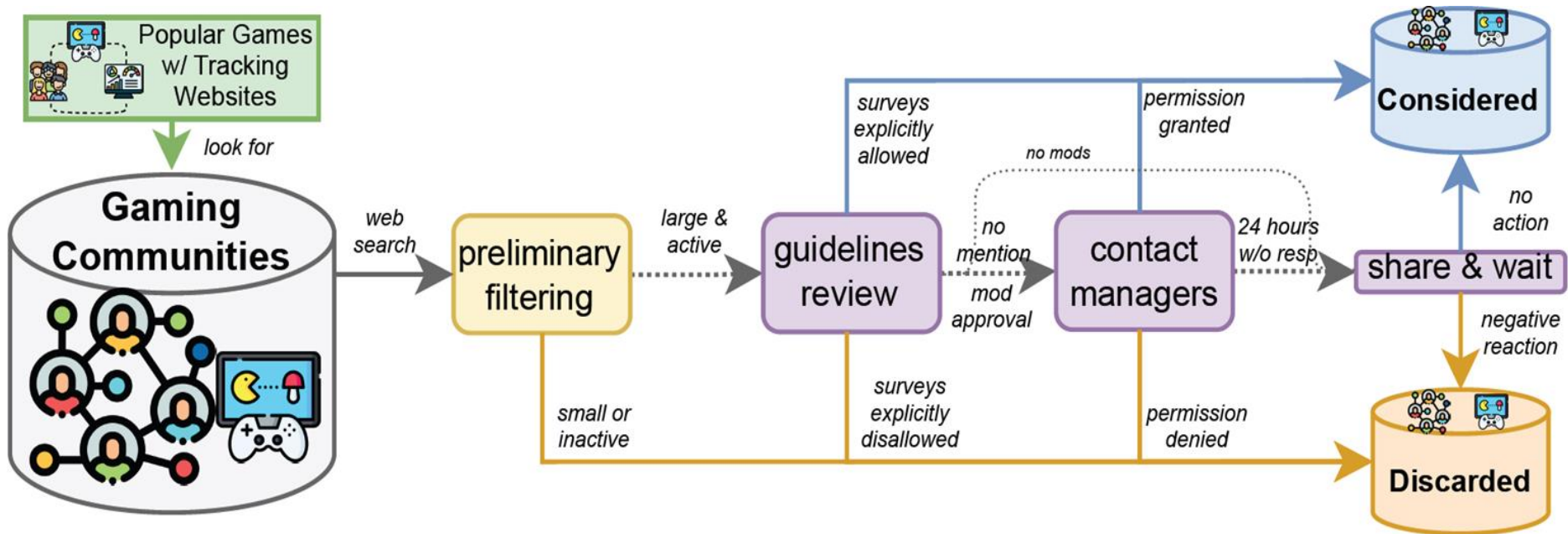
# AIA-prone Video Games

Game	Popularity	Tracking	Prior	Correl.
	Active – Concurr	Website?	Survey?	Found?
LoL	142M – 900K		3.7k	[9]
WoW	32M – 250K		500	[32]
CSGO	31M – 900K		13k	[33]
Fortnite	237M – 1.15M		1k	[34]
PUBG	320M – 200K		4.4k	[35]
OW2	25M – 350K		3.2k	[33]
Valorant	24M – 600K		1.4k	[36]
CoD:WZ	71M – 300K		751	[37]
RS:S	10M – 120K		4.8k	[33]
Destiny2	14M – 50K		450	[38]
DOTA2	14M – 430K		7.3k	[7]
Apex	52M – 250K		296	
RktLg	85M – 220K		6k	
GTA:O	24M – 110K		1.9k	
BF2042	300K – 15K			[24]
FIFA	5M – 50K			
Minecraft	169M – 900K		4k	
Roblox	213M – 1.5M		1.5k	
HeartStone	6M – 370K		21k	
Wildlands	370K – 5K			

# Analysis of Gaming Communities

We disseminated a survey to investigate AIA-related themes in various gaming communities of AIA-prone games.

## Community Selection Procedure



# Considered Communities

Community Large and Active	Survey Allowed?	Admin Response?	Msgs Sent
truegaming 🎮	✓		
SampleSize 🎮	✓		
JoyFreak 🗨️	✓		
Rainbow6 🎮	✍️	👍	1
wow 🎮	✍️	👍	1
leagueoflegends 🎮	✍️	👍	6
VALORANT 🎮	✍️	👍	3
youtubegaming 🎮	✍️	👍	1
Overwatch 🎮	✍️	🕒	5
GameTheorists 🎮	?	🕒	1
videogames 🎮	?	🕒	1
consoles 🎮	?	🕒	1
AskGames 🎮	?	👍	1
Instant Gaming 🗨️	?	👍	1
RocketLeague 🎮	?	👍	3
gamers 🎮	?	👍	1
ubisoft 🎮	?	—	2
PC Gamer 🗨️	?	—	
COD Forums 🗨️	?	—	
Valorant Forums 🗨️	?	—	
GTA Forums 🗨️	?	—	

# Survey Results

## Key Findings

- Validity (strict validation)
  - $n = 579 \rightarrow 460$  (~80%) usable for AIA
  - (we do not report more results to avoid helping attackers)



# Survey Results

## Key Findings

- Validity (strict validation)
  - $n = 579 \rightarrow 460$  (~80%) usable for AIA
  - (we do not report more results to avoid helping attackers)
- Privacy Awareness
  - 88% are aware that their game data are being collected (76% “may” know about AIA)
  - BUT: 58% have never worried about their anonymity in online gaming
  - 57% did not explicitly choose to share their game data (or do not know)
  - *24% would even choose to publicly share their personal data*

# Our Vision (and Implications)

## Calls for Action

### ○ Researchers

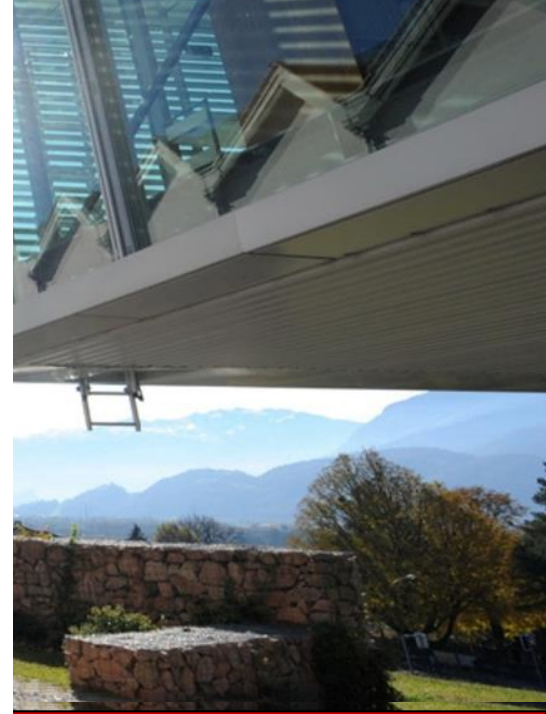
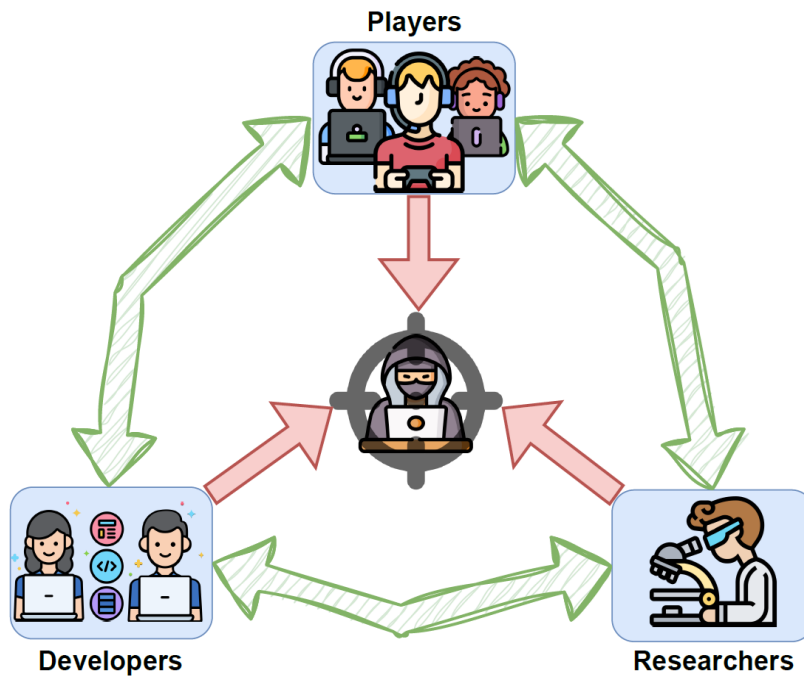
- adopt privacy-oriented mindset, embrace social aspects of gaming communities, recognise AIA;
- transfer findings to developers and players;

### ○ Developers

- introduce & communicate privacy-preserving features into games and TWs;
- uptake scientific findings;

### ○ Players

- develop awareness to privacy-related issues, voice criticism;
- employ & demand privacy-preserving features;



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## Survey Results (Privacy Awareness)

