Twitch Chat Fingerprinting

David Hasselquist, Linköping University & Sectra Communications, Sweden

Christian Vestlund, Sectra Communications, Sweden

Niklas Johansson, Sectra Communications, Sweden

Niklas Carlsson, Linköping University, Sweden

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Conference (TMA), Enschede, The Netherlands, June 2022

LINKÖPING UNIVERSITY

WASP | WALLENBERG AI, AUTONOMOUS SYSTEMS AND SOFTWARE PROGRAM

SECTRA

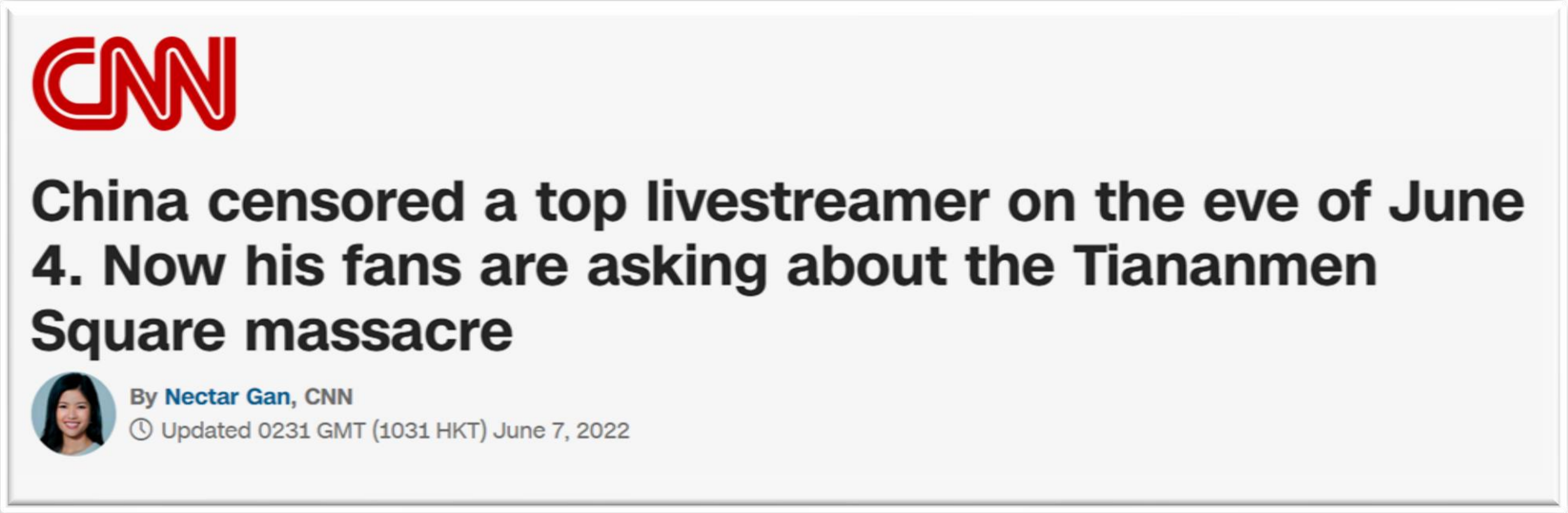
Motivation

- Live streaming accounts for major part of internet activity
- Live streaming provides first viewer advantage and interaction
- Users should be able to freely browse the internet
- The streaming content we choose can reveal much about us
- An adversary capable of determining our activity presents a privacy threat

Examples: governmental monitoring/censorship

- Mass surveillance to identify protesters or users with specific opinions

Examples: governmental monitoring/censorship



CNN

China censored a top livestreamer on the eve of June 4. Now his fans are asking about the Tiananmen Square massacre

By Nectar Gan, CNN

Updated 0231 GMT (1031 HKT) June 7, 2022

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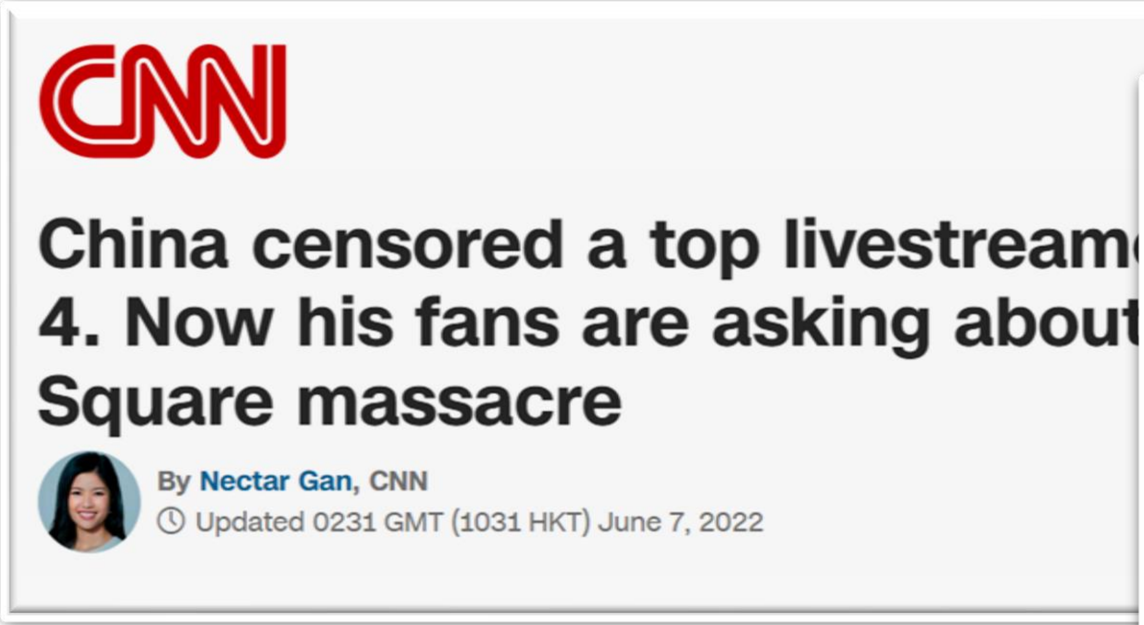

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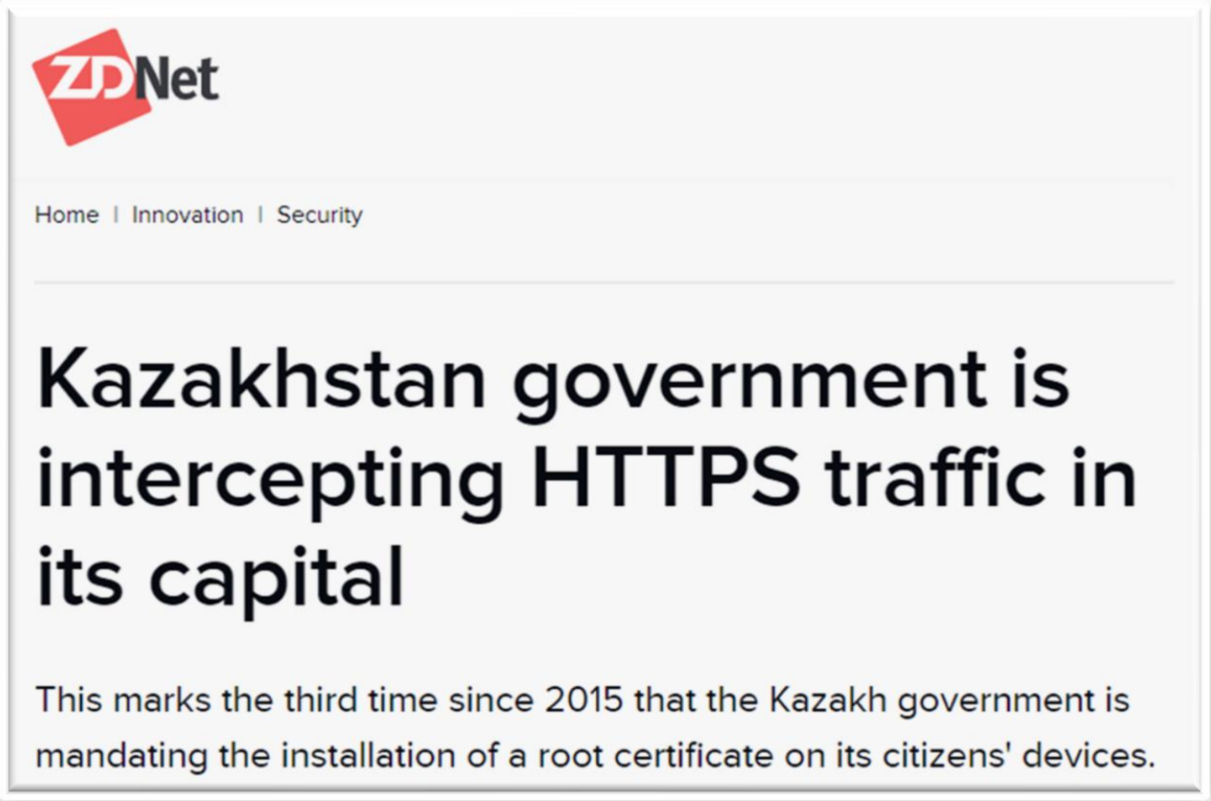


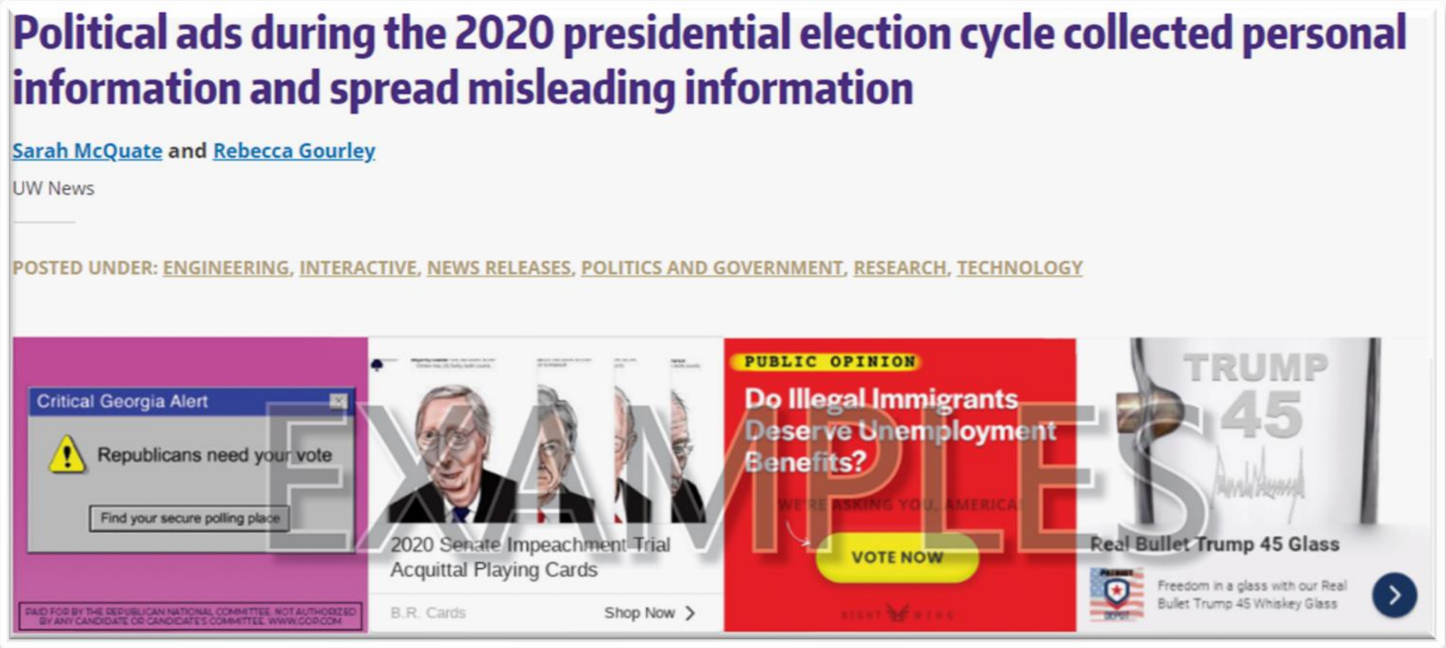
Kazakhstan government is intercepting HTTPS traffic in its capital

This marks the third time since 2015 that the Kazakh government is mandating the installation of a root certificate on its citizens' devices.

Examples: political misinformation

- Campaigns targeting users with particular interests or biases with advertisements or (mis)information

Examples: political misinformation



Political ads during the 2020 presidential election cycle collected personal information and spread misleading information

Sarah McQuate and Rebecca Gourley

UW News

POSTED UNDER: ENGINEERING, INTERACTIVE, NEWS RELEASES, POLITICS AND GOVERNMENT, RESEARCH, TECHNOLOGY

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TRUMP 45
Real Bullet Trump 45 Glass
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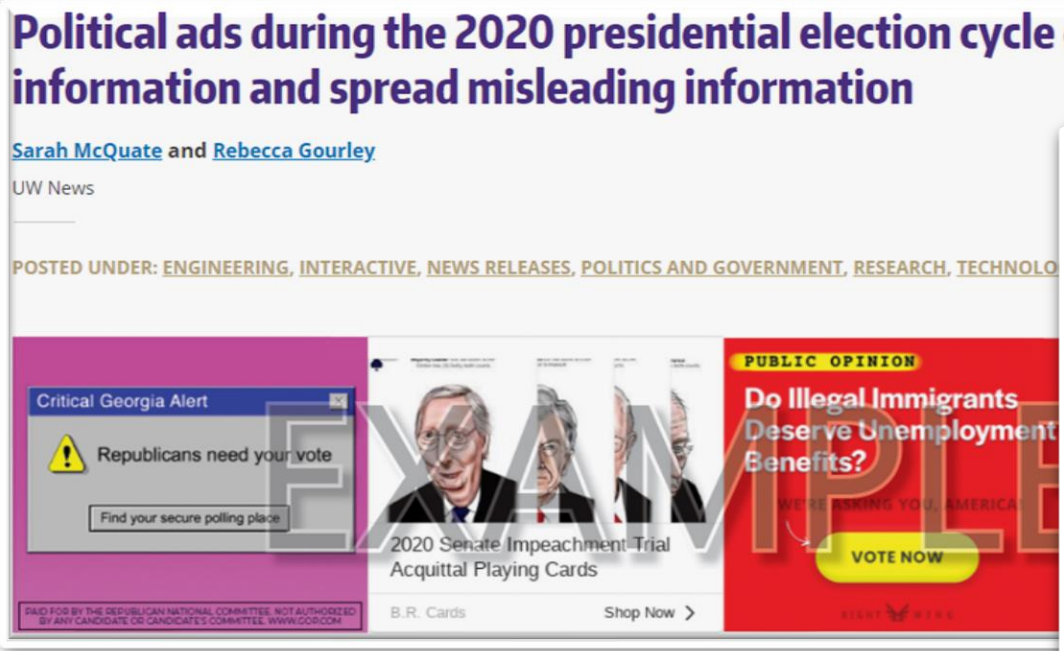

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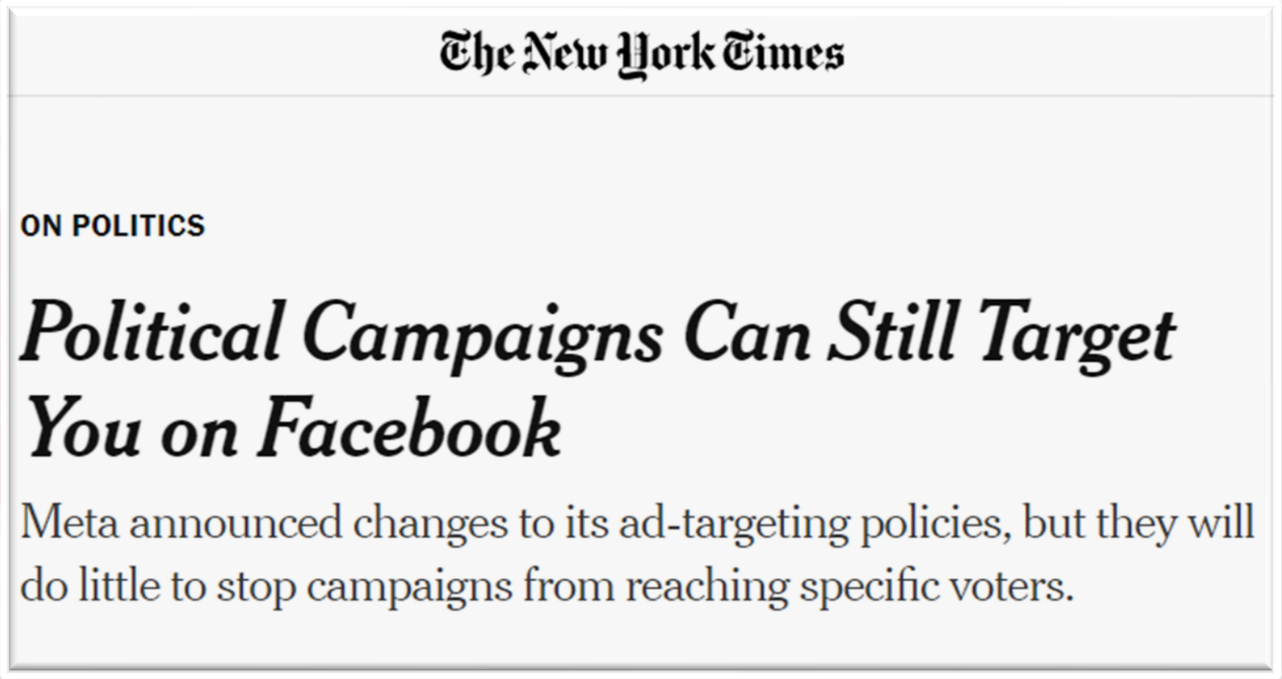


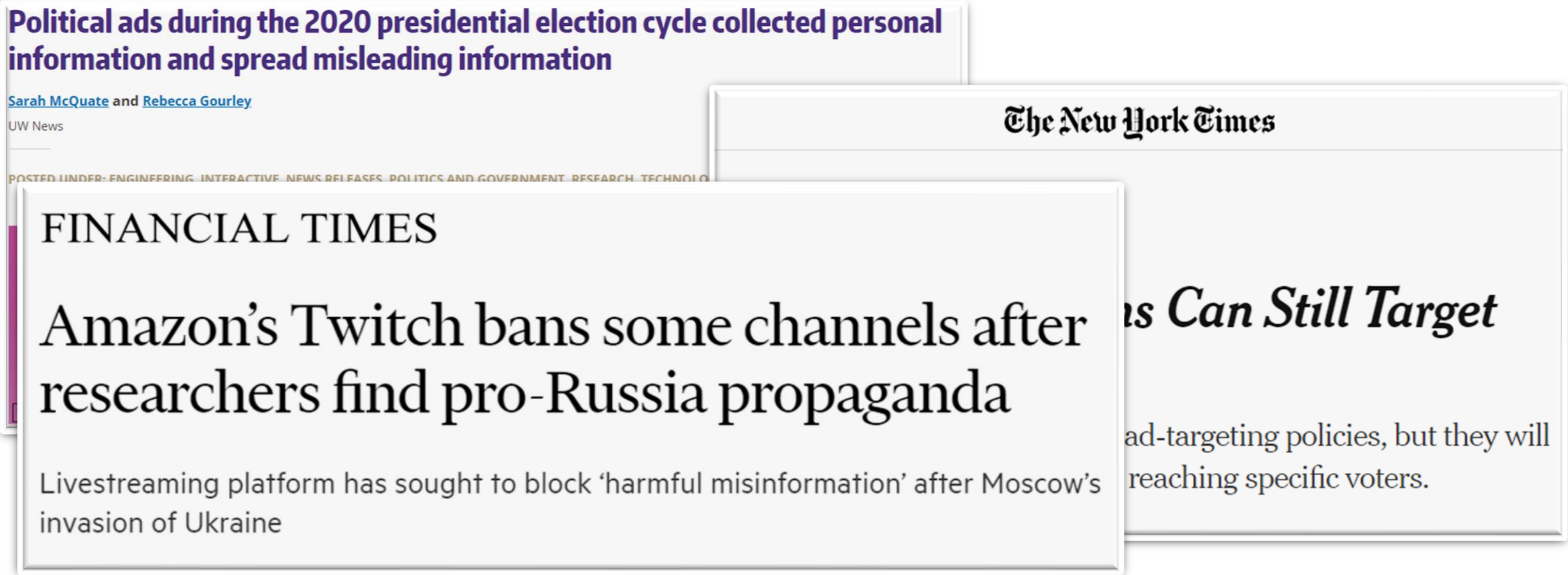
The New York Times

ON POLITICS

Political Campaigns Can Still Target You on Facebook

Meta announced changes to its ad-targeting policies, but they will do little to stop campaigns from reaching specific voters.

Examples: political misinformation



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FINANCIAL TIMES

Amazon's Twitch bans some channels after researchers find pro-Russia propaganda

Livestreaming platform has sought to block 'harmful misinformation' after Moscow's invasion of Ukraine

Contributions

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- Provide insights for websites and users to better protect their privacy

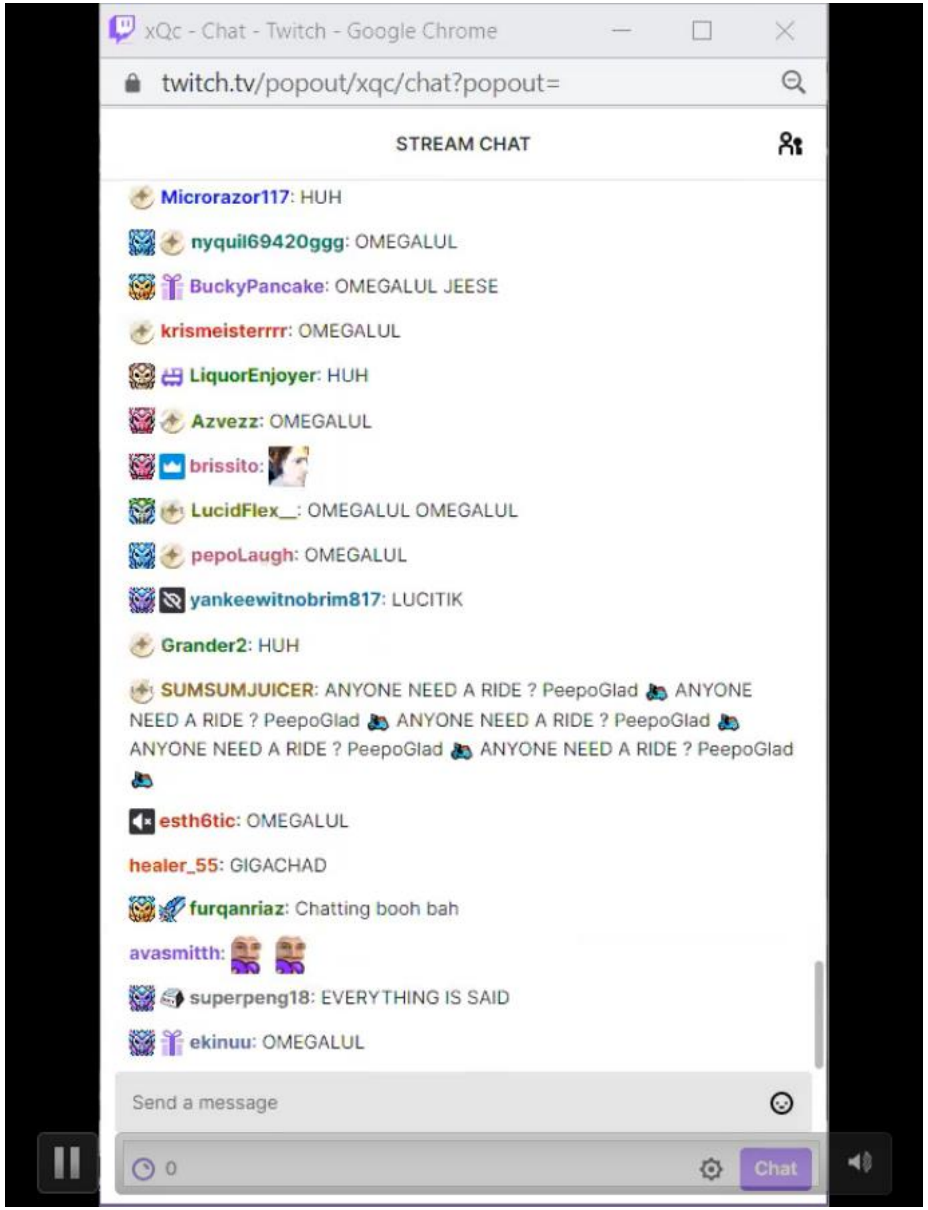
Fingerprinting

- Related work has identified on-demand video using Variable Bit Rate (VBR) encoding
- Twitch uses Constant Bit Rate (CBR) encoding by default
  - Video patterns does not leak information
- Encrypted chat messages as a side-channel
  - Allows interaction with stream

Twitch chat

Twitch chat

- » Distinguishable patterns between streams
  - » Packet size
  - » Packet timing (relative)
- » Two users watching the stream have similar network patterns
- » Users identifiable based on their encrypted network patterns



xQc - Chat - Twitch - Google Chrome

twitch.tv/popout/xqc/chat?popout=

Microrazor117: HUH

nyquil69420ggg: OMEGALUL

BuckyPancake: OMEGALUL JEESE

krismeisterrrr: OMEGALUL

LiquorEnjoyer: HUH

Azvezz: OMEGALUL

brissito:

LucidFlex_: OMEGALUL OMEGALUL

pepoLaugh: OMEGALUL

yankeewitnobrim817: LUCITIK

Grander2: HUH

SUMSUMJUICER: ANYONE NEED A RIDE ? PeepoGlad ANYONE NEED A RIDE ? PeepoGlad ANYONE NEED A RIDE ? PeepoGlad ANYONE NEED A RIDE ? PeepoGlad ANYONE NEED A RIDE ? PeepoGlad

esth6tic: OMEGALUL

healer_55: GIGACHAD

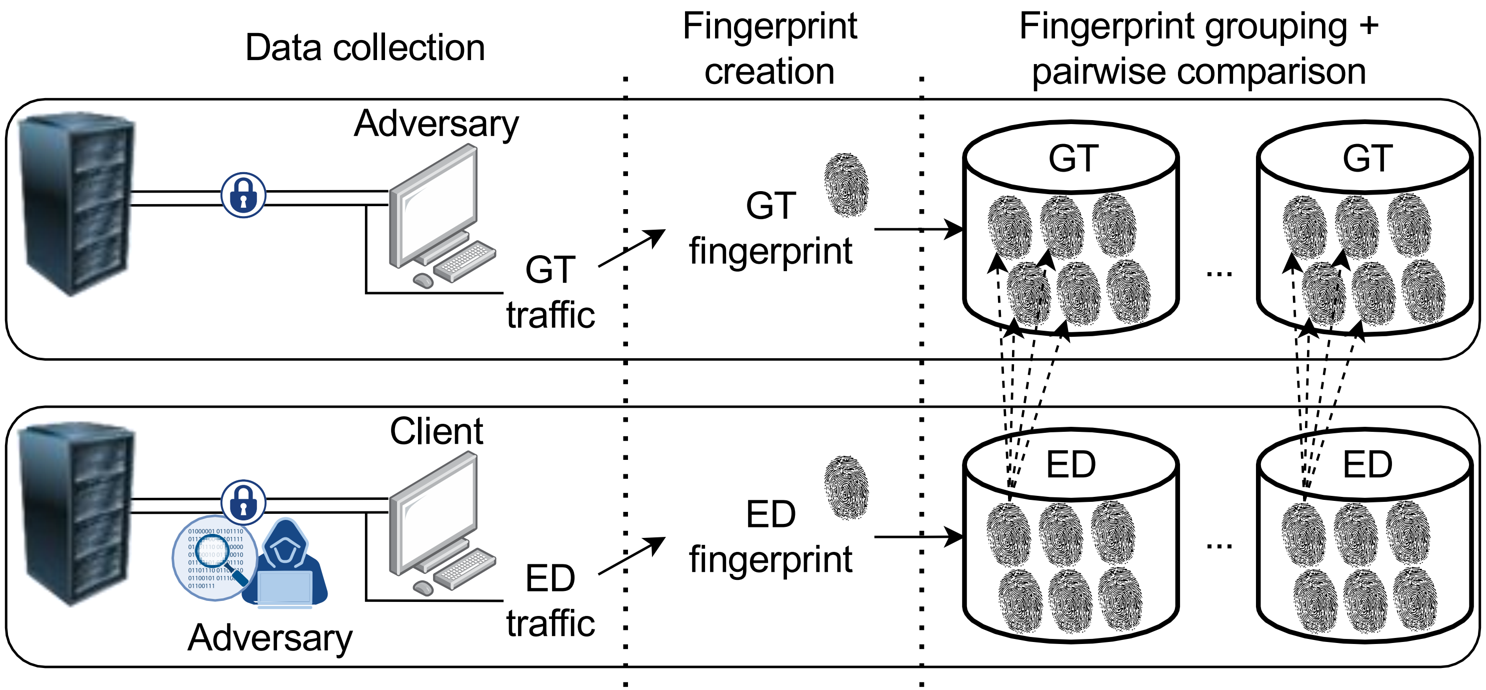
furqanriaz: Chatting booh bah

avasmitth:

superpeng18: EVERYTHING IS SAID

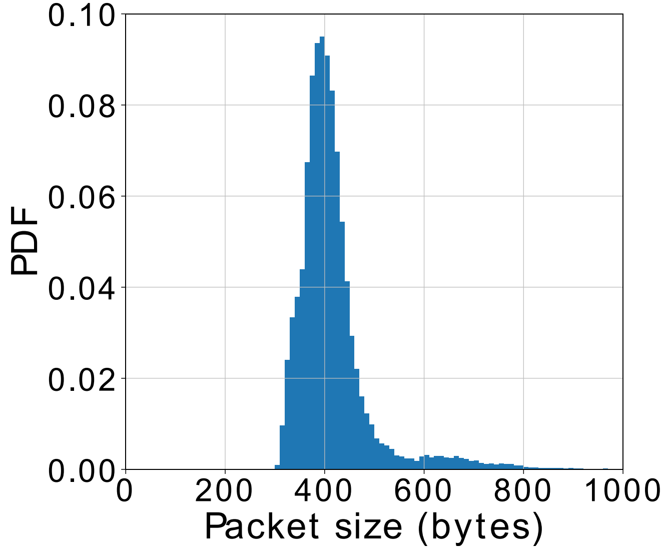
ekinuu: OMEGALUL

System overview



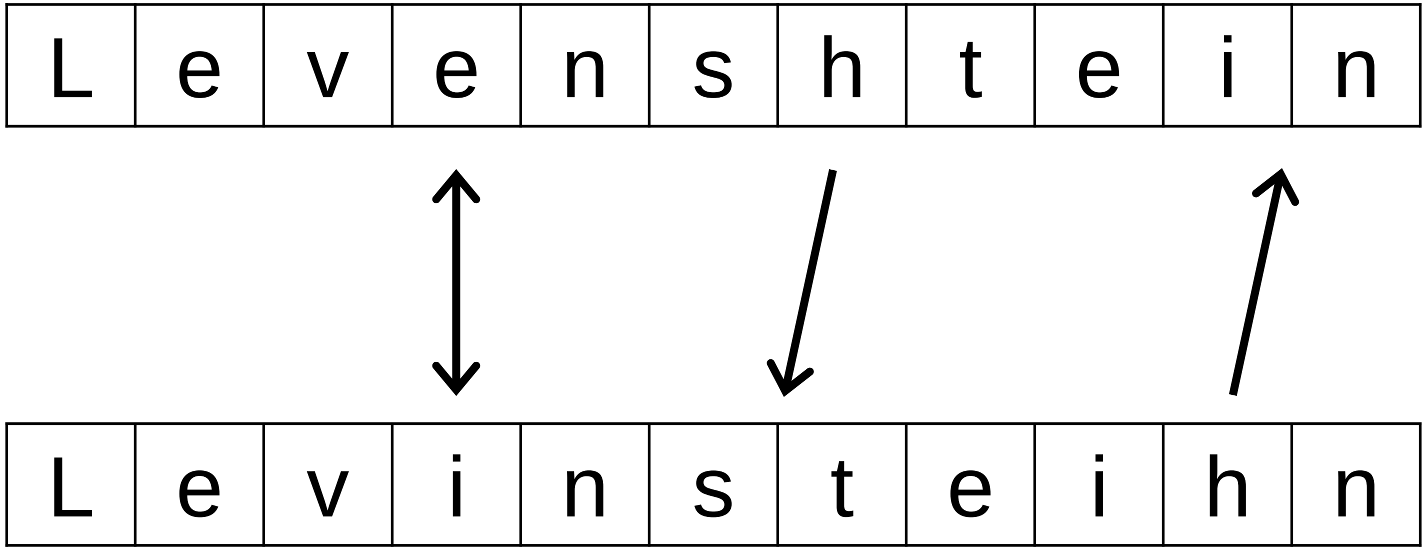
Data extraction: Twitch

- Video and chat data are delivered separately
- IP addresses for chat messages resolve to *ec2-[ip].us-west-2.compute.amazonaws.com*
- Internet Relay Chat and WebSocket Secure protocol with URL *irc-ws.chat.twitch.tv*
- Periodical resolve request URL
- Packet size distribution if IP addresses not available



Edit distance

- 3 operations
  - Substitution
  - Insertion
  - Deletion



L	e	v	e	n	s	h	t	e	i	n
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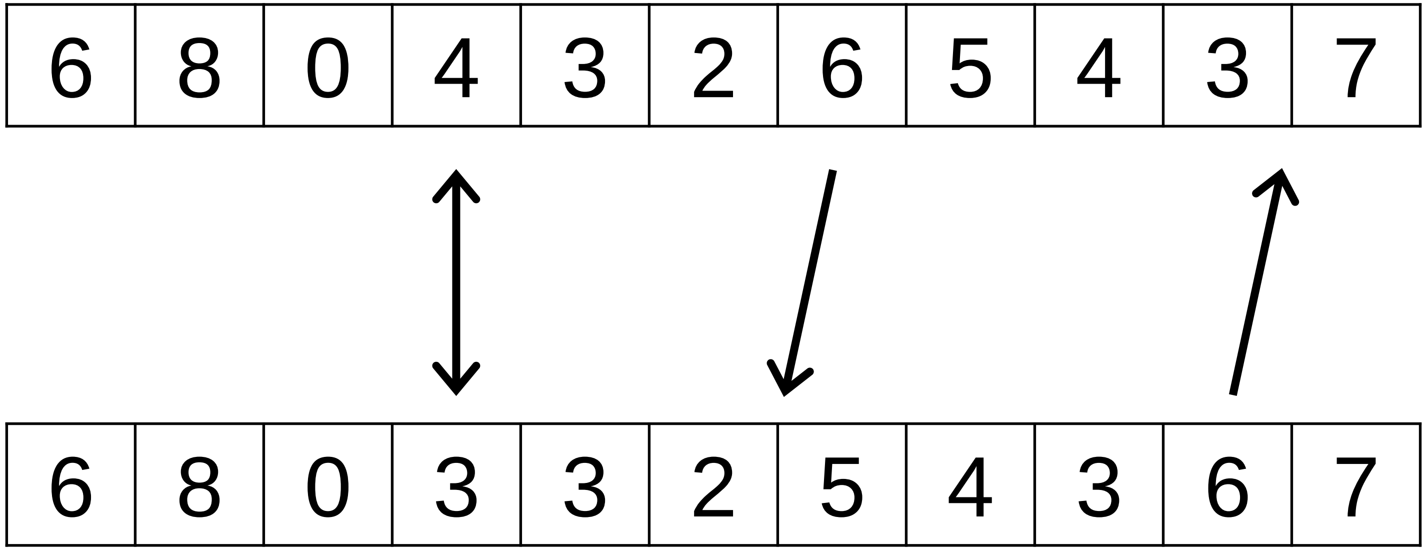

6	8	0	4	3	2	6	5	4	3	7
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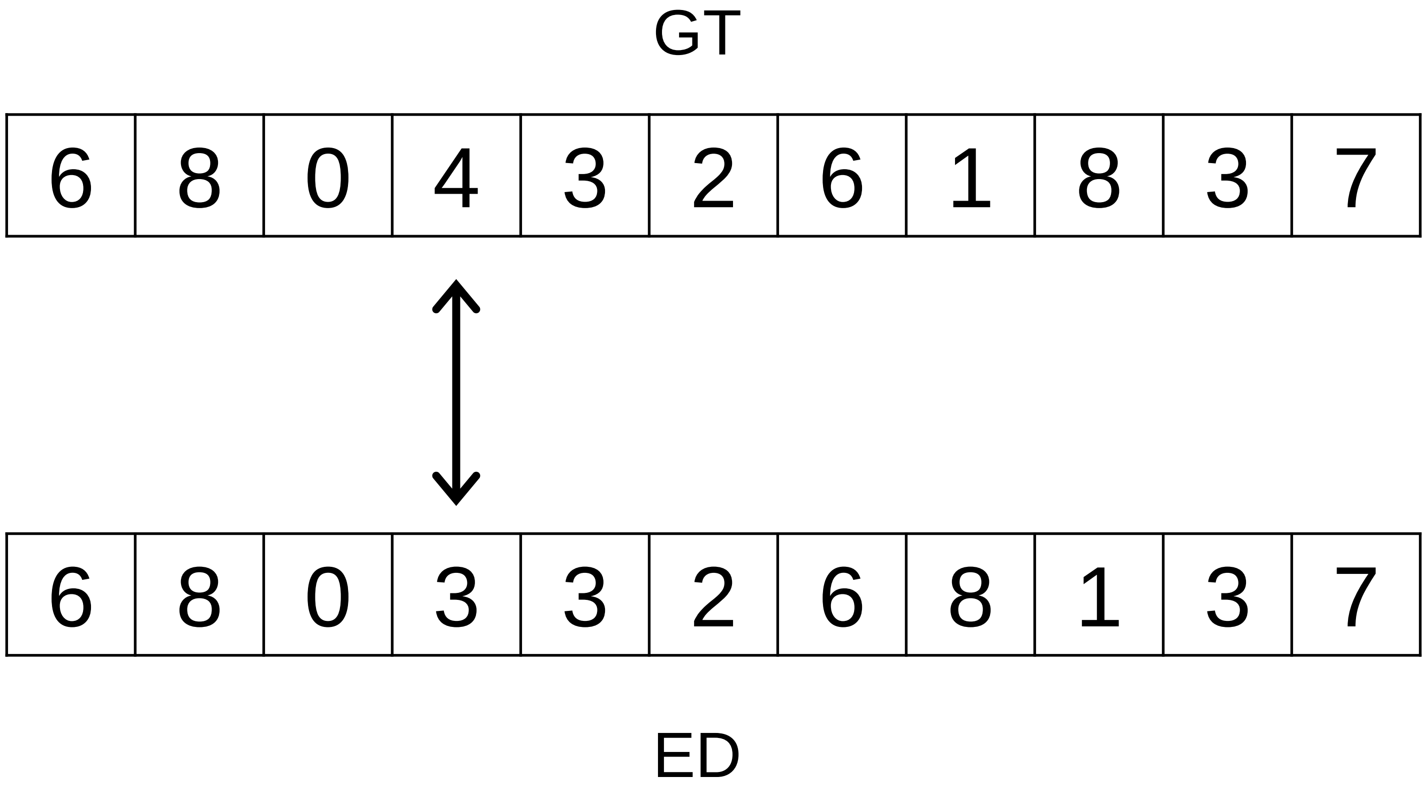
Edit distance

$$C_i = \frac{|\mathrm{GT}_i - \mathrm{ED}_i|}{\mathrm{GT}_i} = 0.25$$



GT

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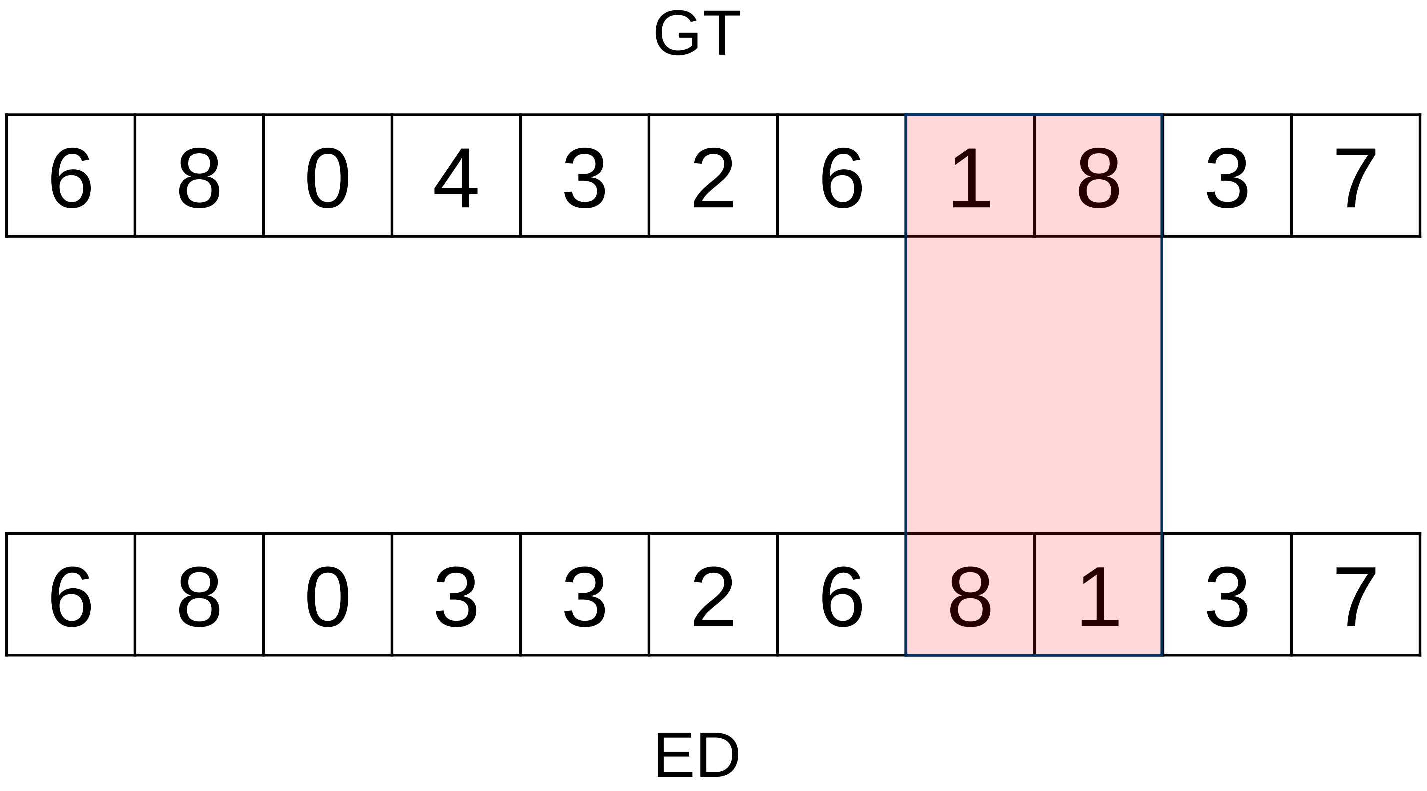

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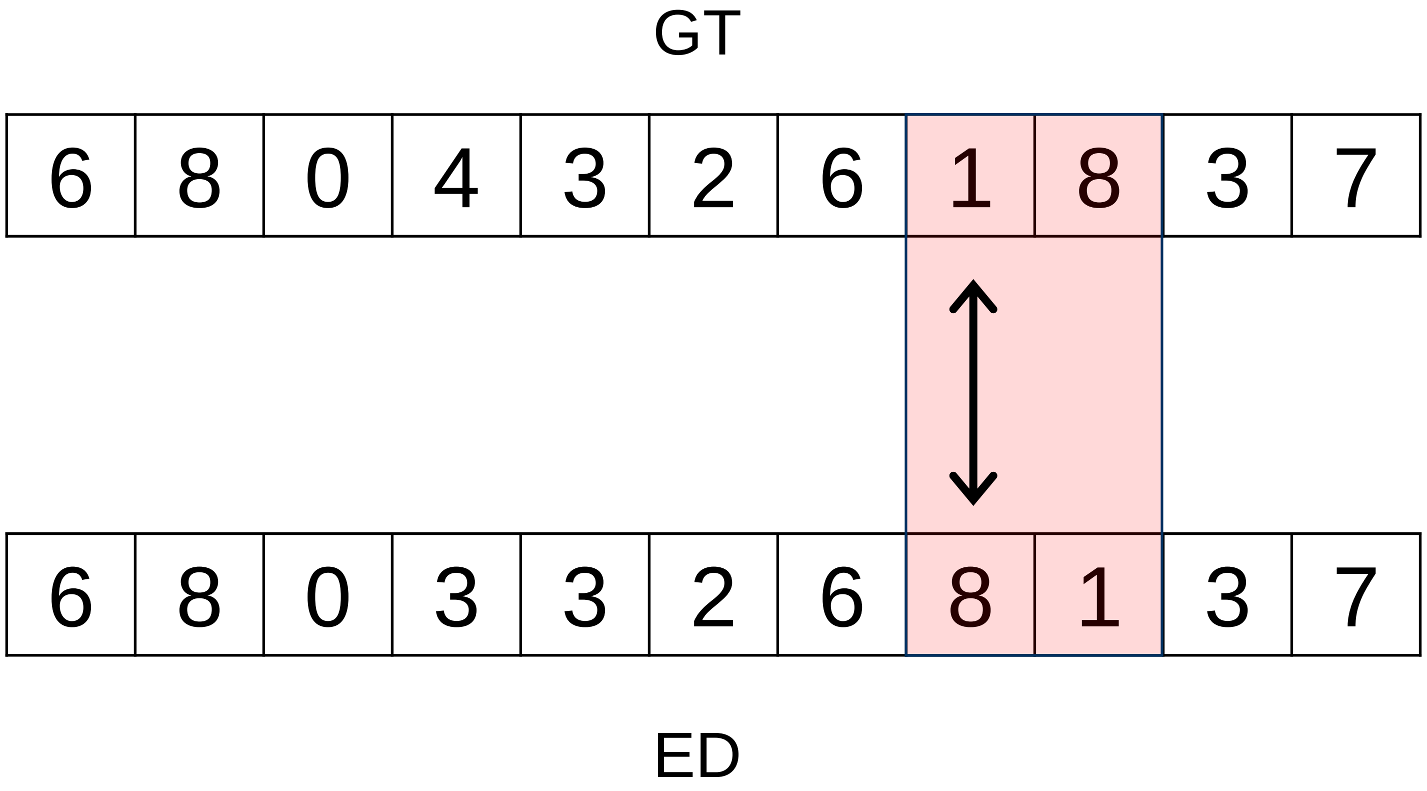
$$C_i = \text{min(left, mid, right)}$$



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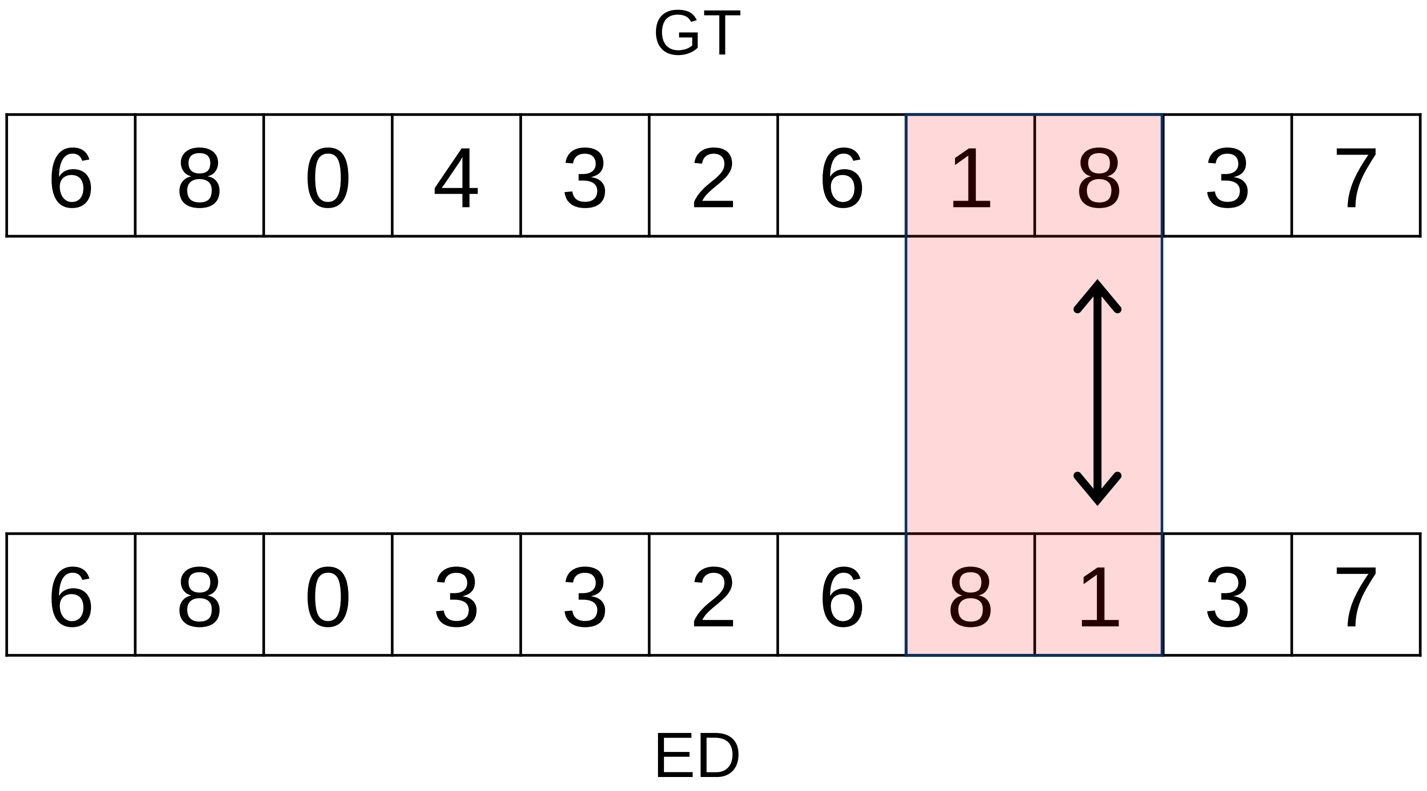

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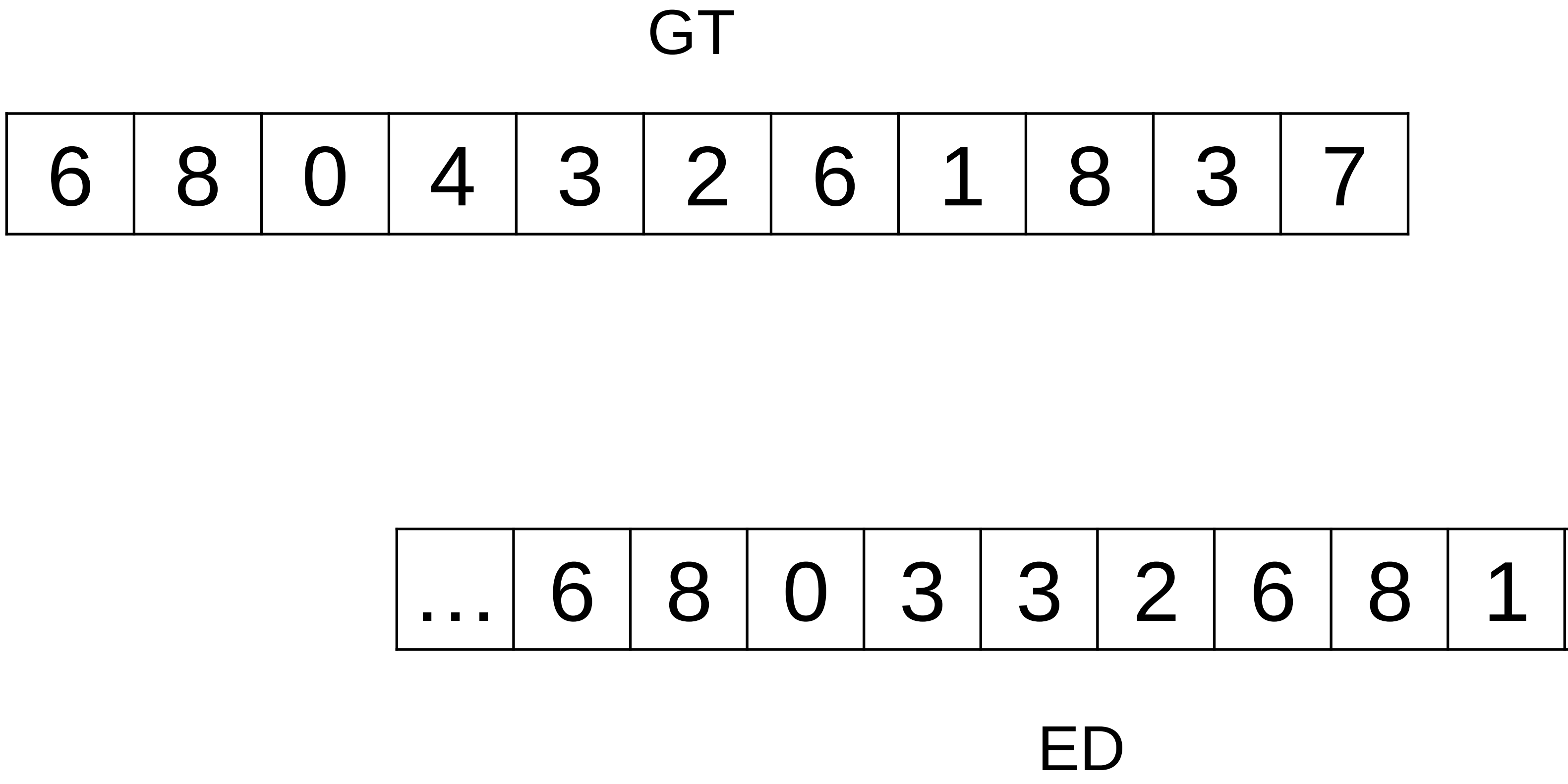
Offset up to 10 seconds



GT

6	8	0	4	3	2	6	1	8	3	7

…	6	8	0	3	3	2	6	8	1

ED

Fingerprint comparison

- Each ED compared to all GT
  - $d = \{d_1, d_2, \dots, d_{1000}\}$

- Relative classifier
  - $d_2/d_1 > \mu$

- Absolute classifier
  - $d_1 < \lambda$

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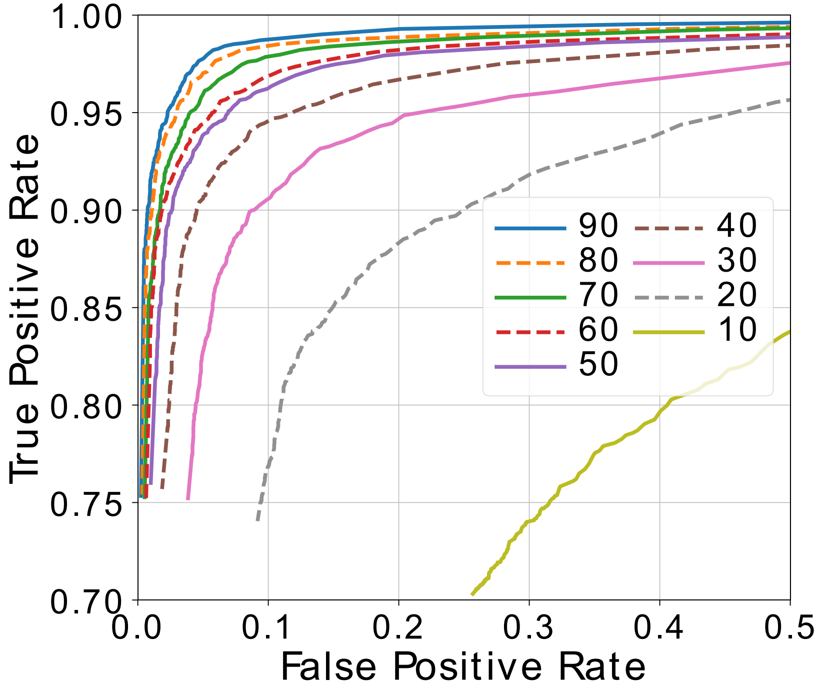
Example:

$d = \{20, 180, 185, \dots\}$ $\mu = 2.00$ $\lambda = 10$

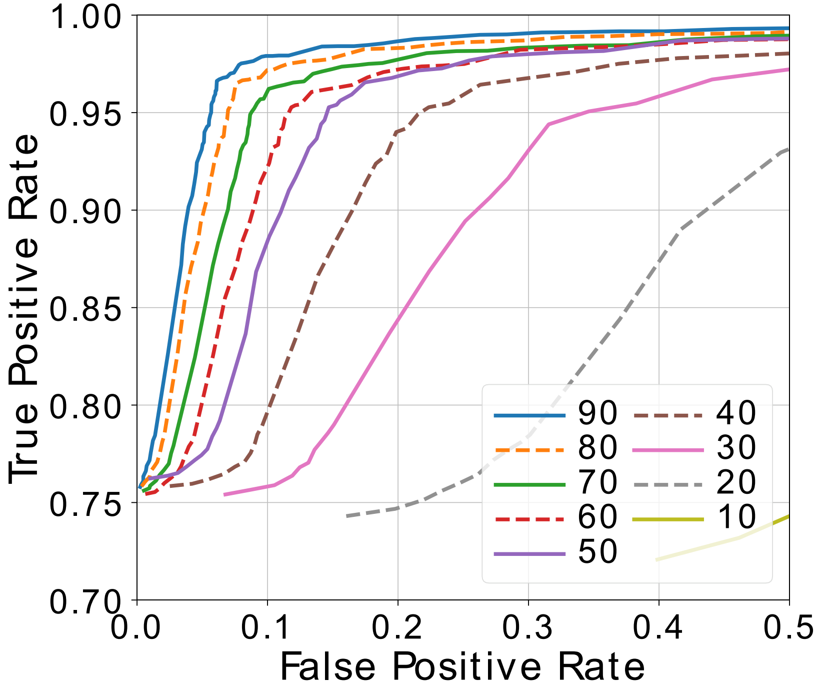
Relative: $\frac{180}{20} > 2.00$

Absolute: $20 \nless 2.00$

Example results: attack duration



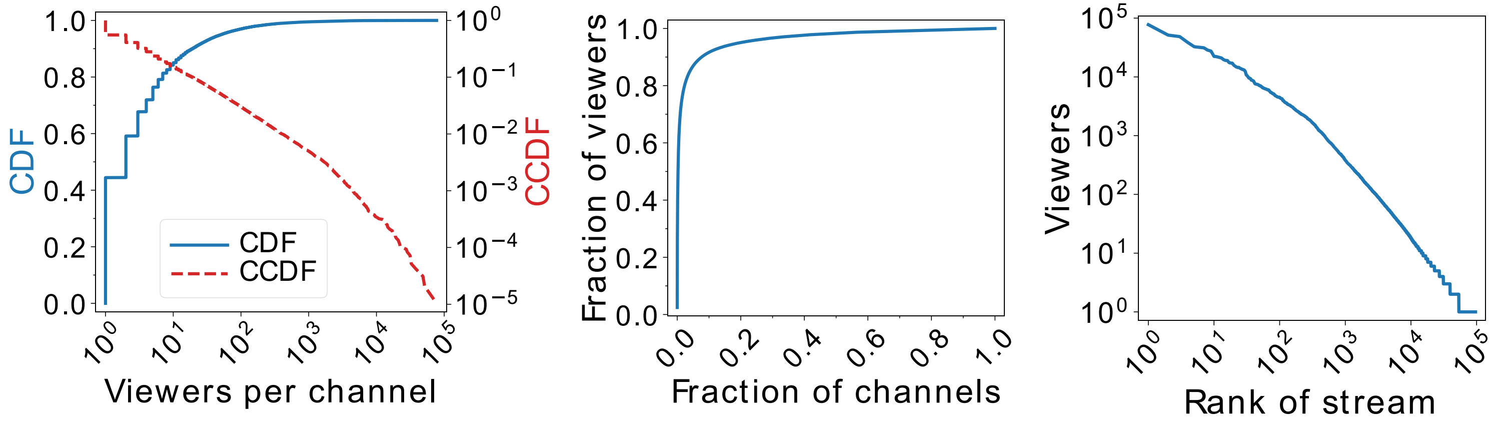
- Relative classifier
- Diminishing improvements
- F1-score 0.966 for 90 seconds

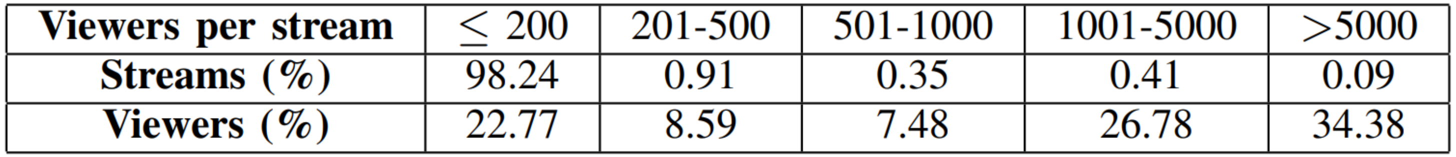


- Absolute classifier
- F1-score 0.953 for 90 seconds

Stream popularity: Twitch

- Viewer distribution is heavy tailed
  - Pareto principle





Viewers per stream	$\leq$ 200	201-500	501-1000	1001-5000	>5000
Streams (%)	98.24	0.91	0.35	0.41	0.09
Viewers (%)	22.77	8.59	7.48	26.78	34.38

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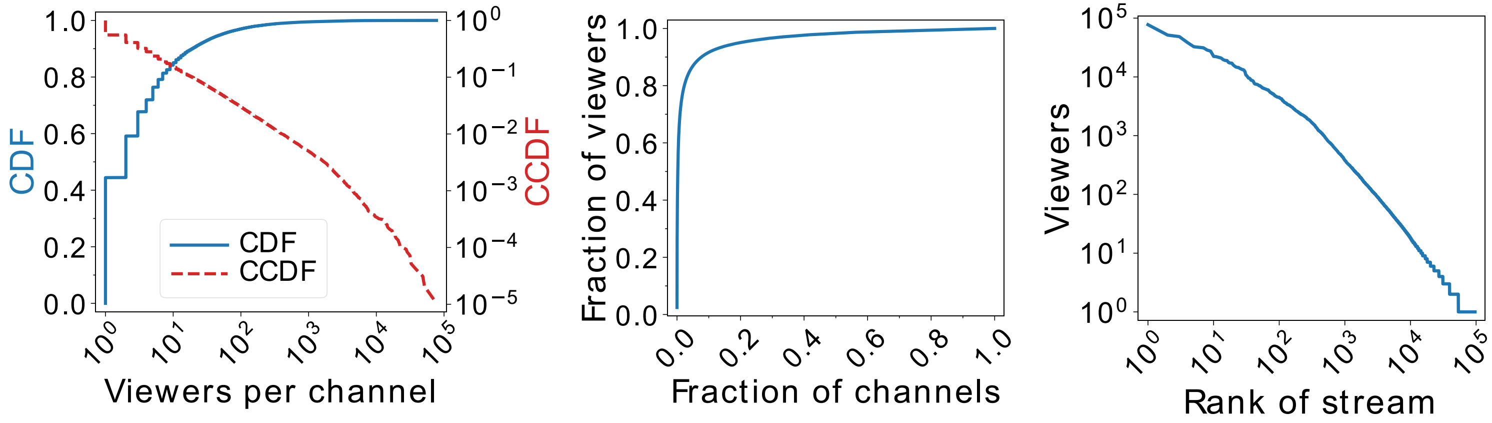

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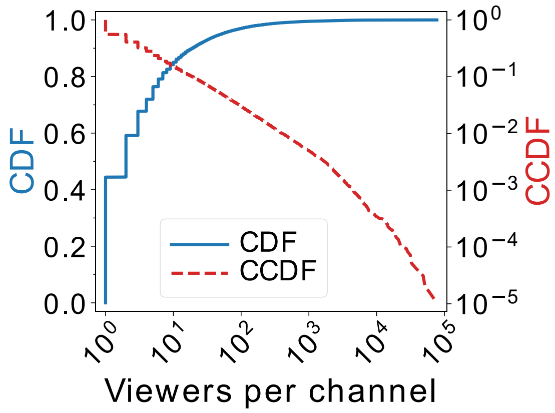
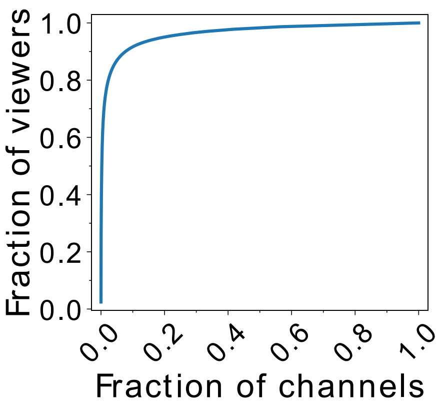
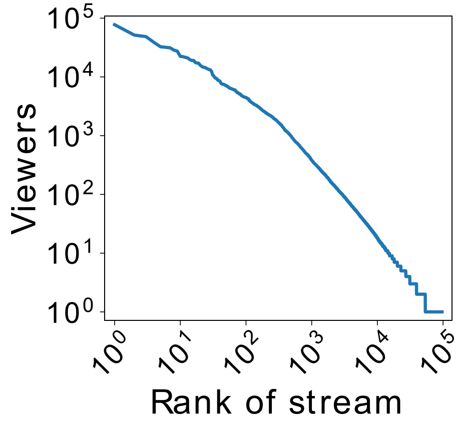
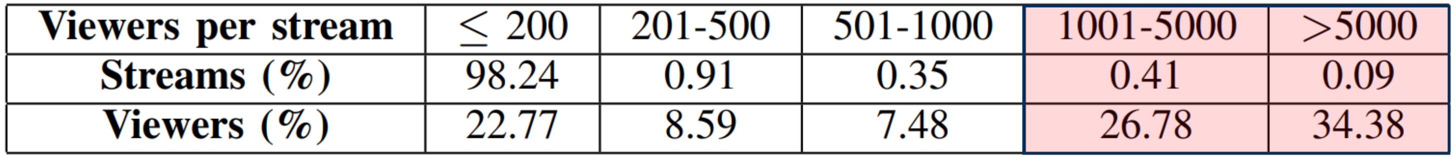
  - 0.5% of channels have more than 1000 viewers and 61% of all viewers









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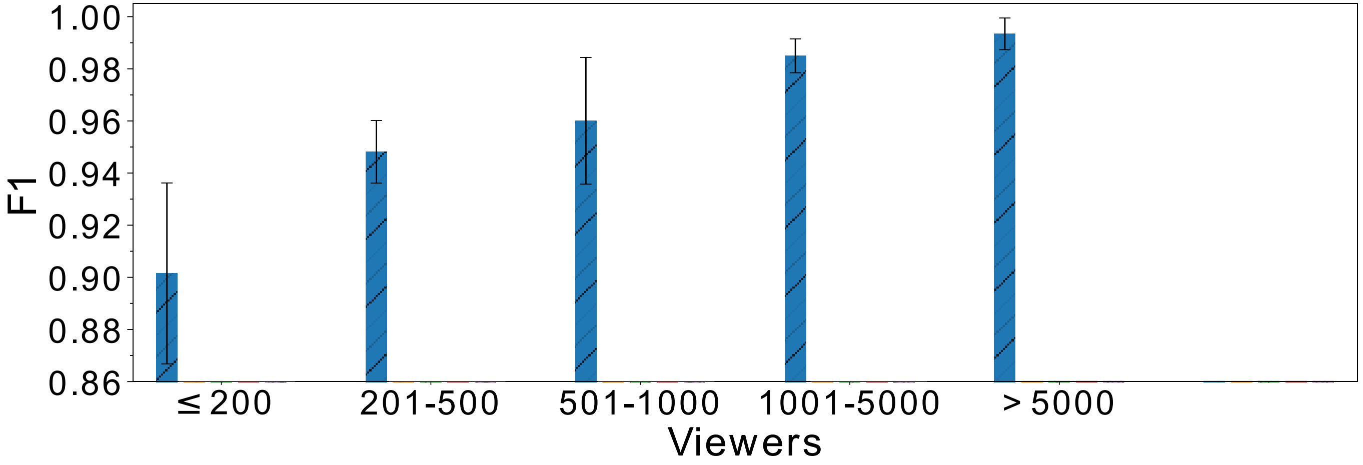

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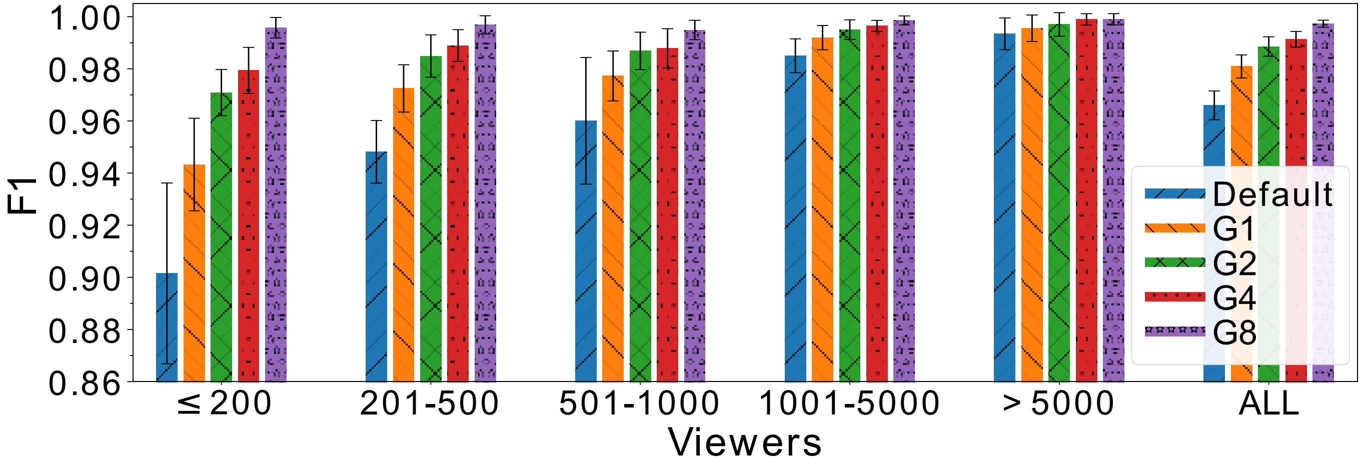
- Accuracy can be increased by interacting with the stream

- F1-score improves from 0.90 to 0.97 by inserting two additional chat messages



Countermeasures

- Five countermeasures
  - Campus-based off-the-shelf VPN
  - OpenVPN
  - Client timing
  - OpenVPN + padding
  - OpenVPN + padding + client timing

Countermeasure: client timing

- TCP Zero Window packets
  - Modification of TCP receive window

- Two random parameters
  - Silent/zero period t_z
  - Normal period t_n

- Burst of packets at start of t_n

- Larger silent period decreases accuracy at the cost of data freshness and traffic bursts

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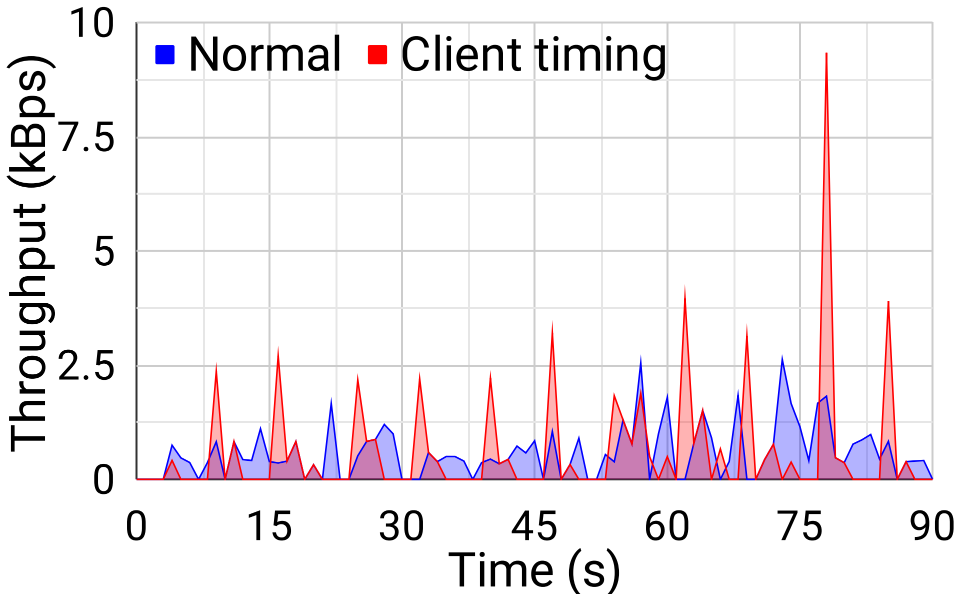
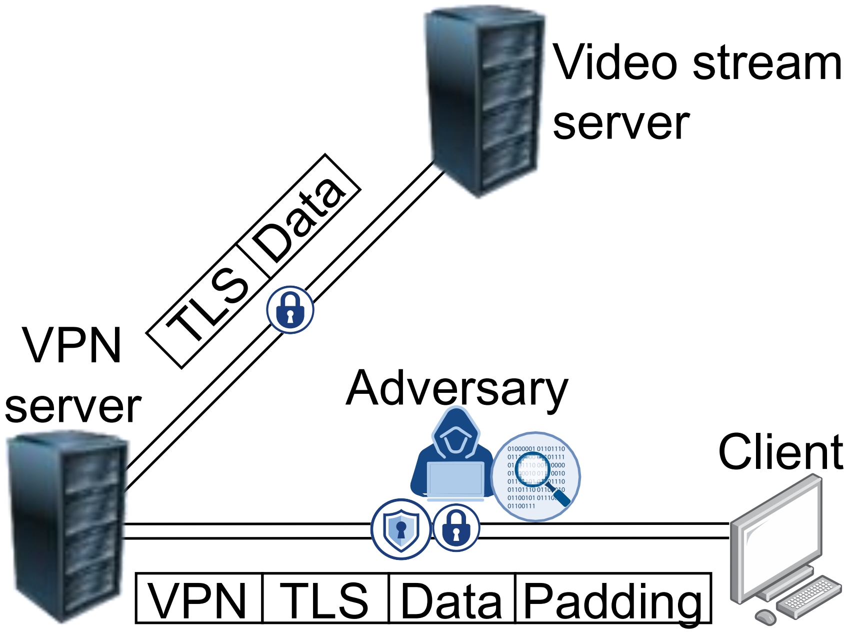


$t_z = 5 \quad t_n = 2$

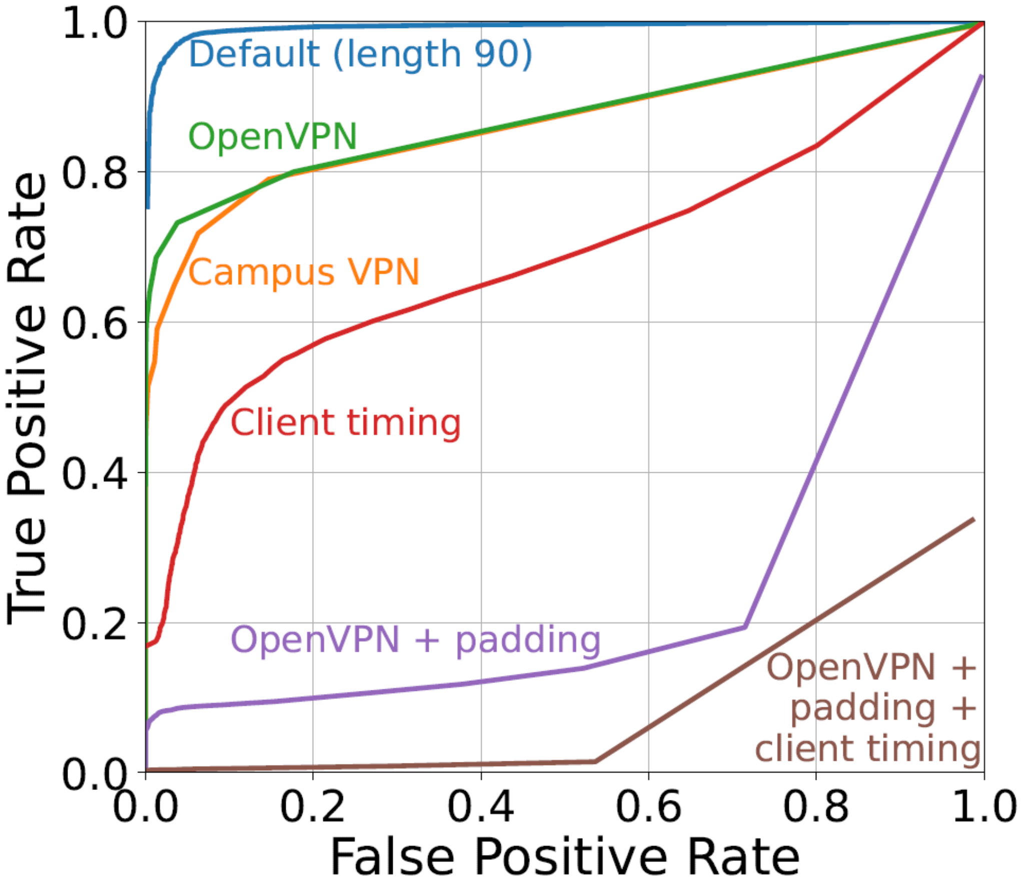
Countermeasure: padding



Countermeasure: results

- Best F1-scores
  - Default: 0.966
  - OpenVPN: 0.826
  - Campus VPN: 0.810
  - Client timing (5, 2): 0.637
  - OpenVPN + padding: 0.152

- Best protection achieved using a combination of countermeasures



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