Temporal patterns of paedophile activity in a P2P network

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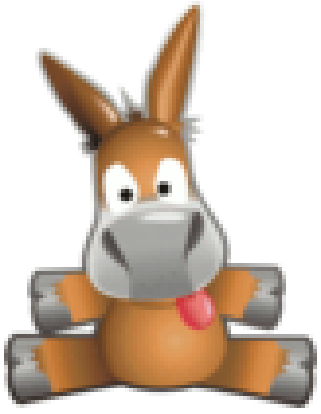
P2P systems and paedophile activity



- millions of users worldwide

Rationale

- Children victimization
- Danger for innocent users
- Policy making issues

Many claims

Very little is known

Goals

Help fight against P2P paedophile exchanges

- increase knowledge
- provide reusable tools (academics, LEA)

Analysis

- Rigorous quantification of queries
- Study of paedophile users
- Comparison between different P2P systems
- Temporal patterns

Challenges

- Appropriate data collection

  size, dynamics, poorly documented protocols

- Automatic detection tool

  hidden activity, several languages

- Rigorous statistical inference

  low amount of paedophile queries

- User identification

  partial information, unreliable

Outline

eDonkey system overview

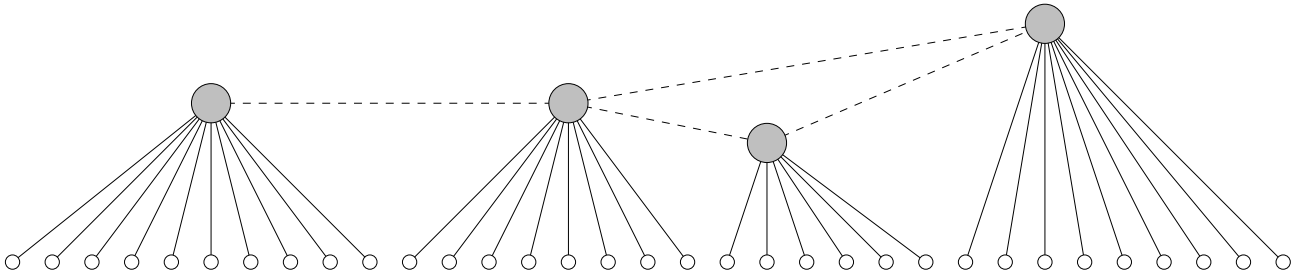


Figure: eDonkey network architecture

peer		server
keywords	$\longrightarrow$	
	$\longleftarrow$	filelist
file	$\longrightarrow$	
	$\longleftarrow$	providers

Measurements

- server
- client, queries
- client, honeypot

Collected data

- Queries submitted to eDonkey search engine
- Query: timestamp, user information (IP,...), keywords

- Five large datasets collected:

2007	10 weeks, 100 millions queries, 24 million IP addresses
2009-2012	147 weeks, 1,3 billion queries, 82 million IP addresses
KAD	10 days, 250 000 queries
ed2k-FR	60 days, 241 152 queries
ed2k-UA	60 days, 166 154 queries

Duly anonymised

Automatic detection tool

pagine
dvdrip xxx
carte europe pour pc pocket
medion
10yo boy hard sex
a long dimanche the passion
...
der wald ist nicht genug
black affaire
raygold
dans la lune
...

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...

- Matches 4 categories of paedophile queries
- Good performance (high precision, good recall)

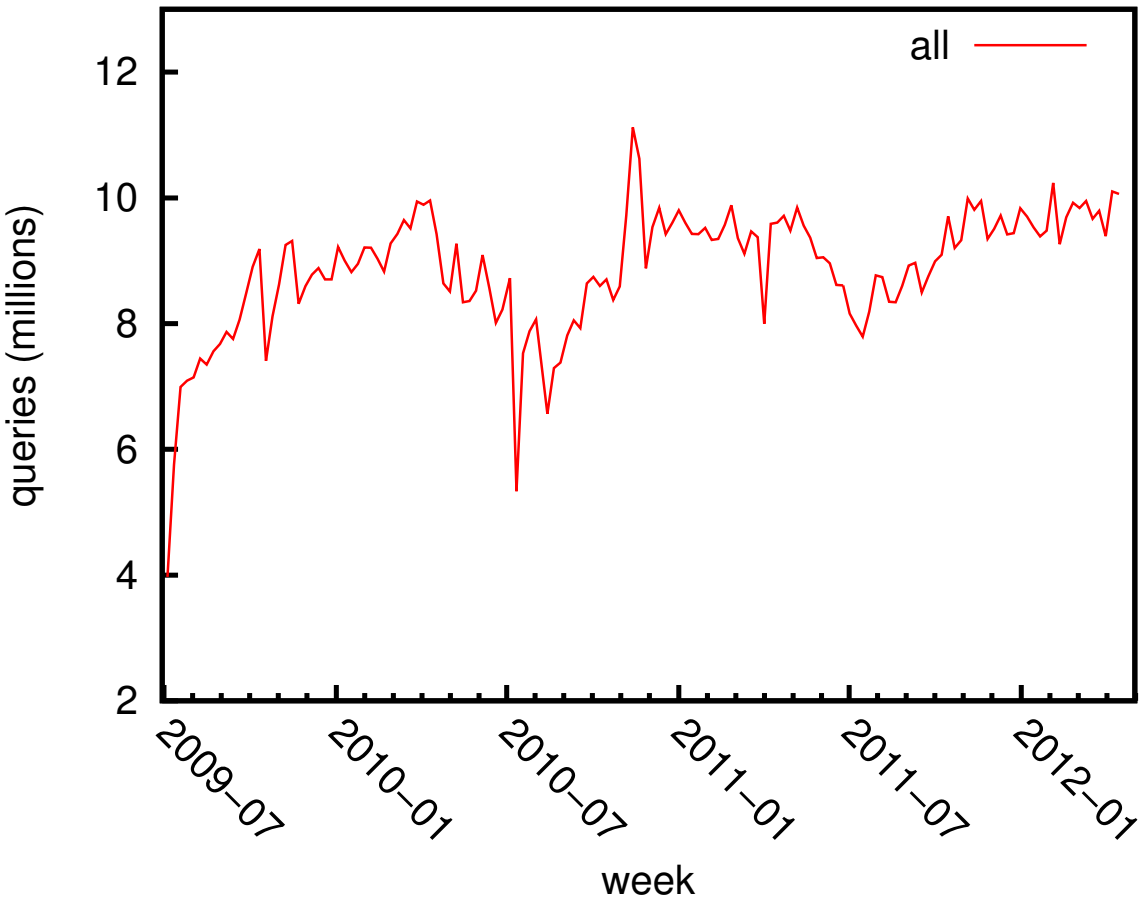
Outline

Motivation for studying temporal patterns

Main questions:

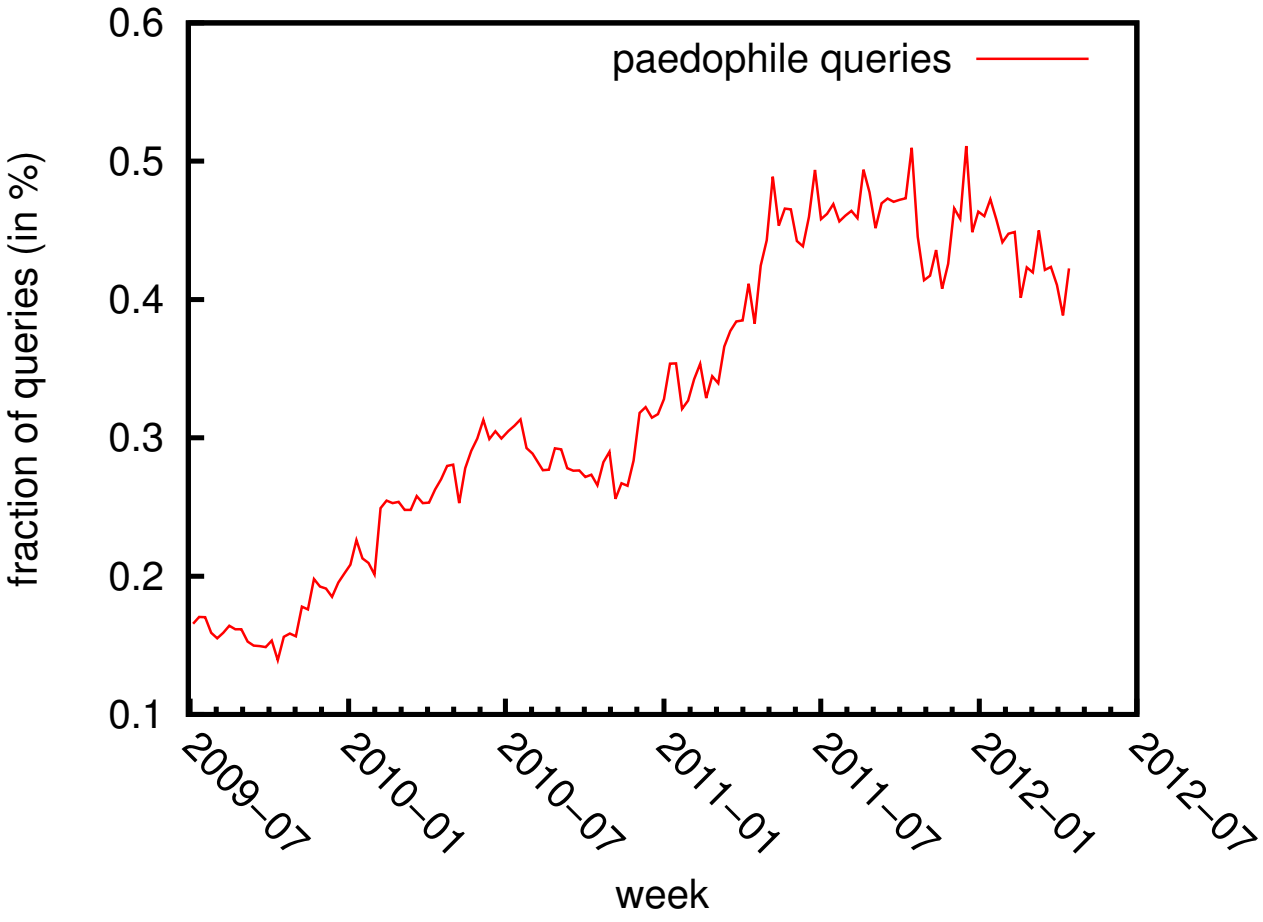
- Are paedophile exchanges increasing over the years?
- Are there more users participating?
- On a daily basis, are there peak hours for paedophile activity?
- Are they compatible with a traditionnal social life?

Global traffic on the server



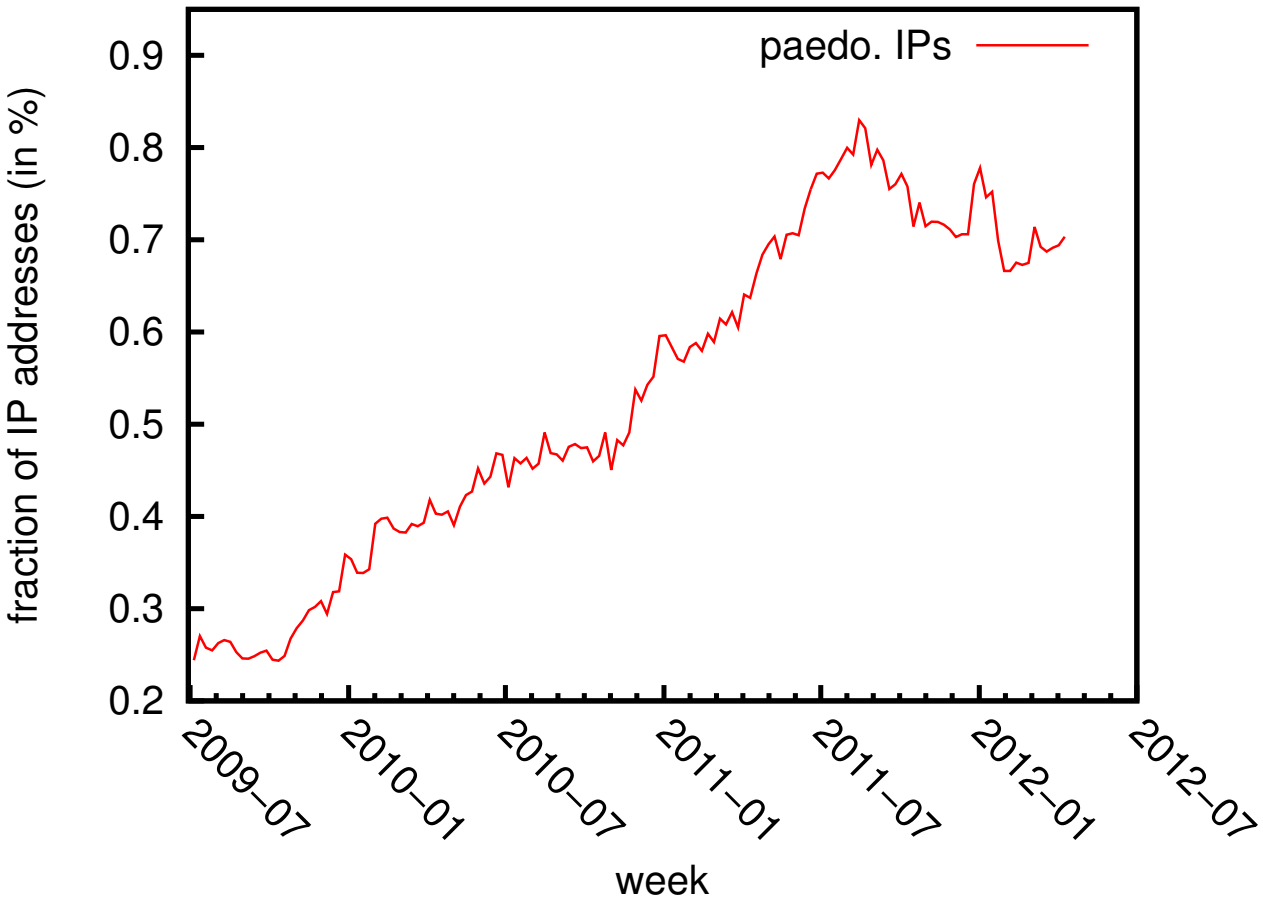
- Global traffic rather stable over 3 years, slight yearly trend

Fraction of paedophile queries



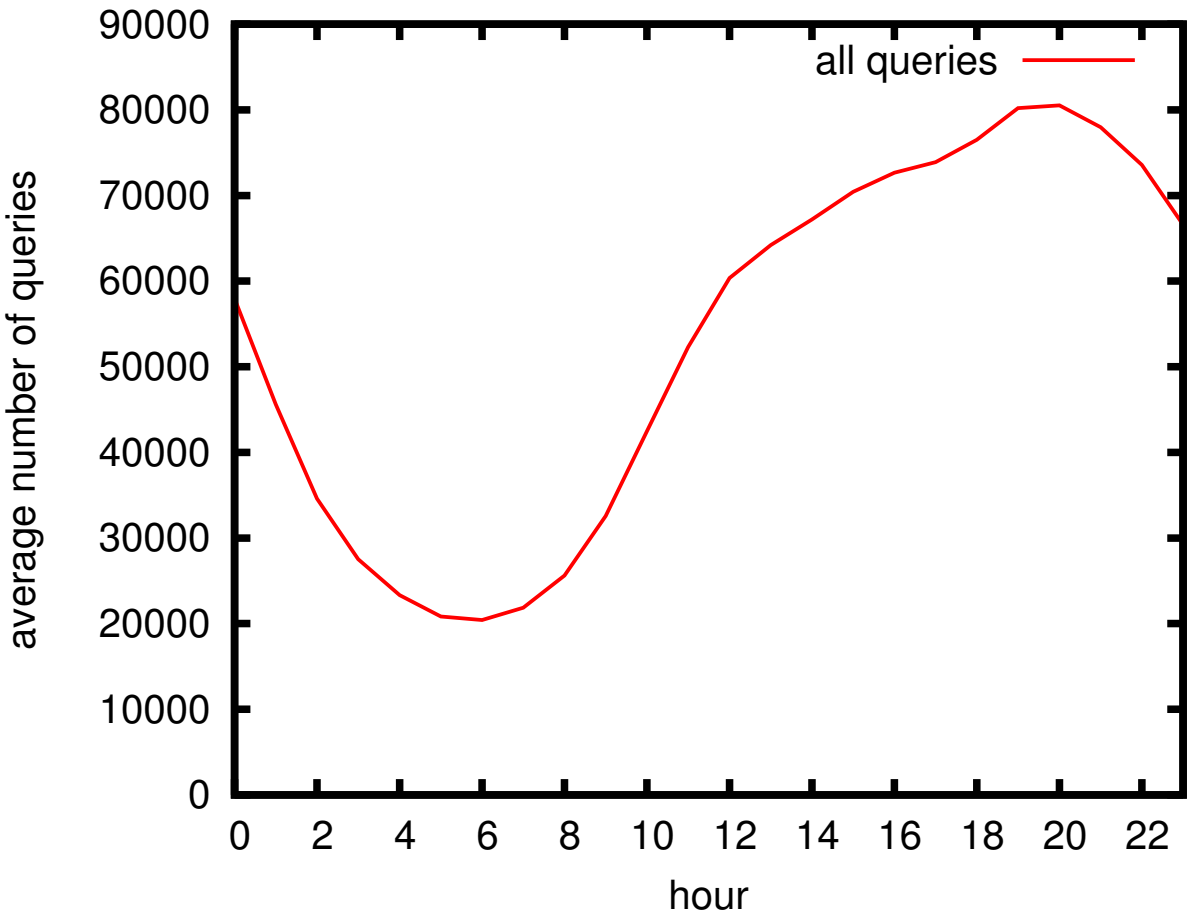
- Fraction of paedophile queries strongly increasing
- Underlying biases: publicity of specific keywords, content supply, national regulations

Fraction of paedophile users



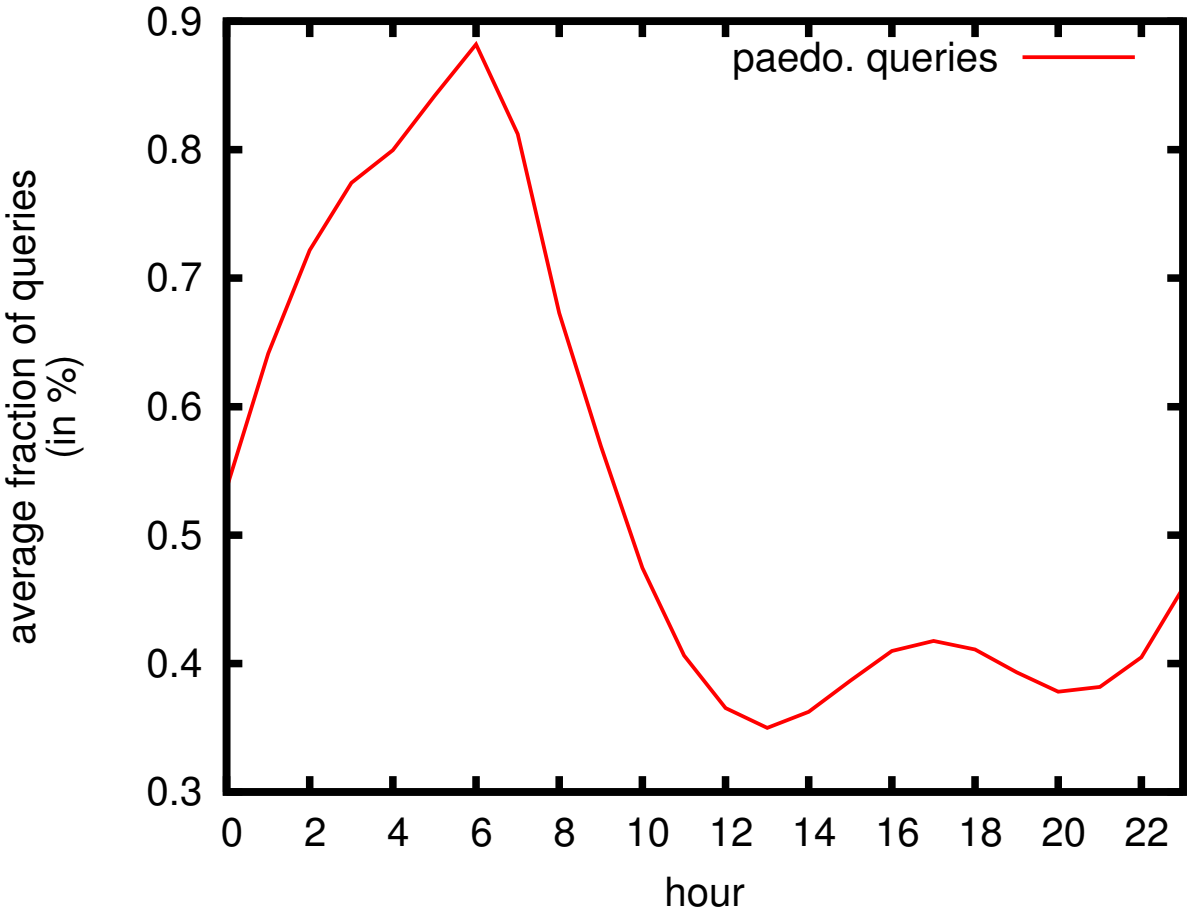
- Fraction of paedophile users also increasing
- More users seem to be involved in the exchanges

Daily traffic



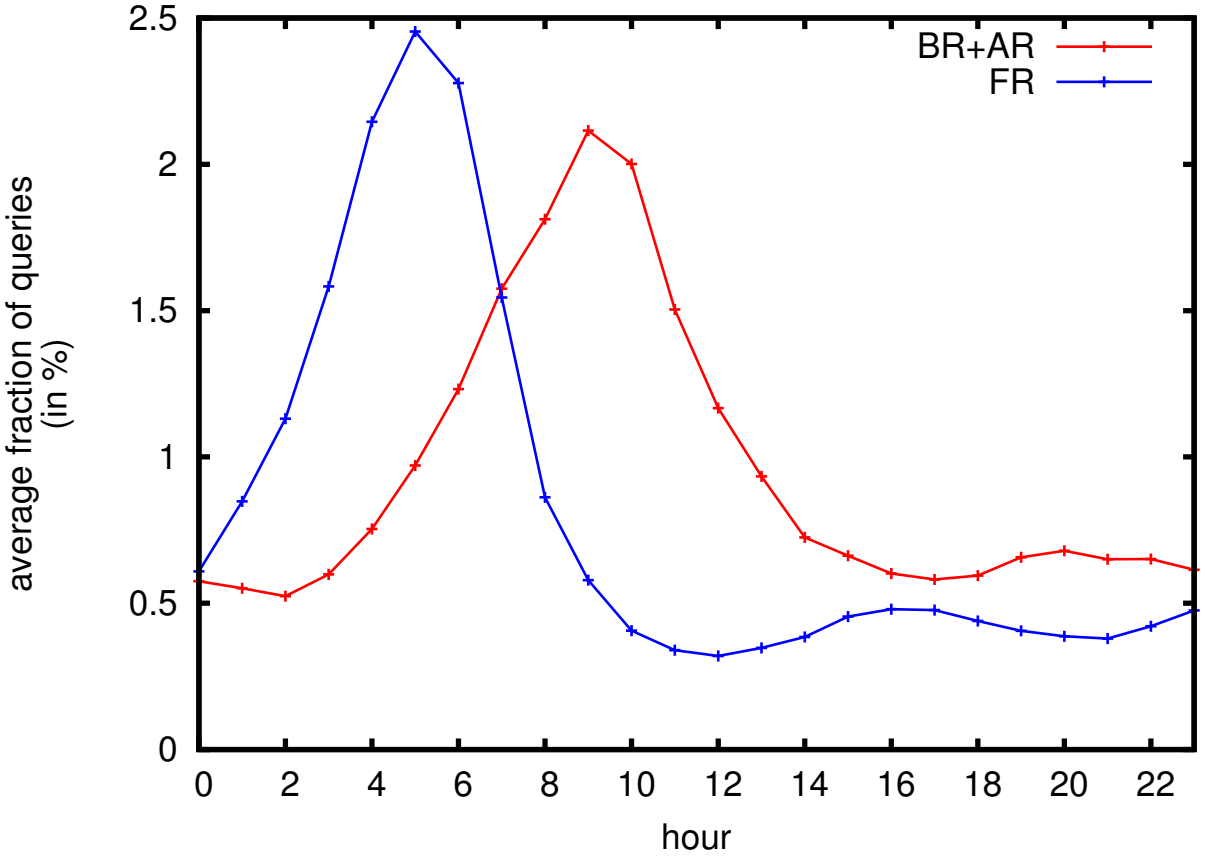
- Expected circadian cycle (day/night effect)

Fraction of paedophile activity



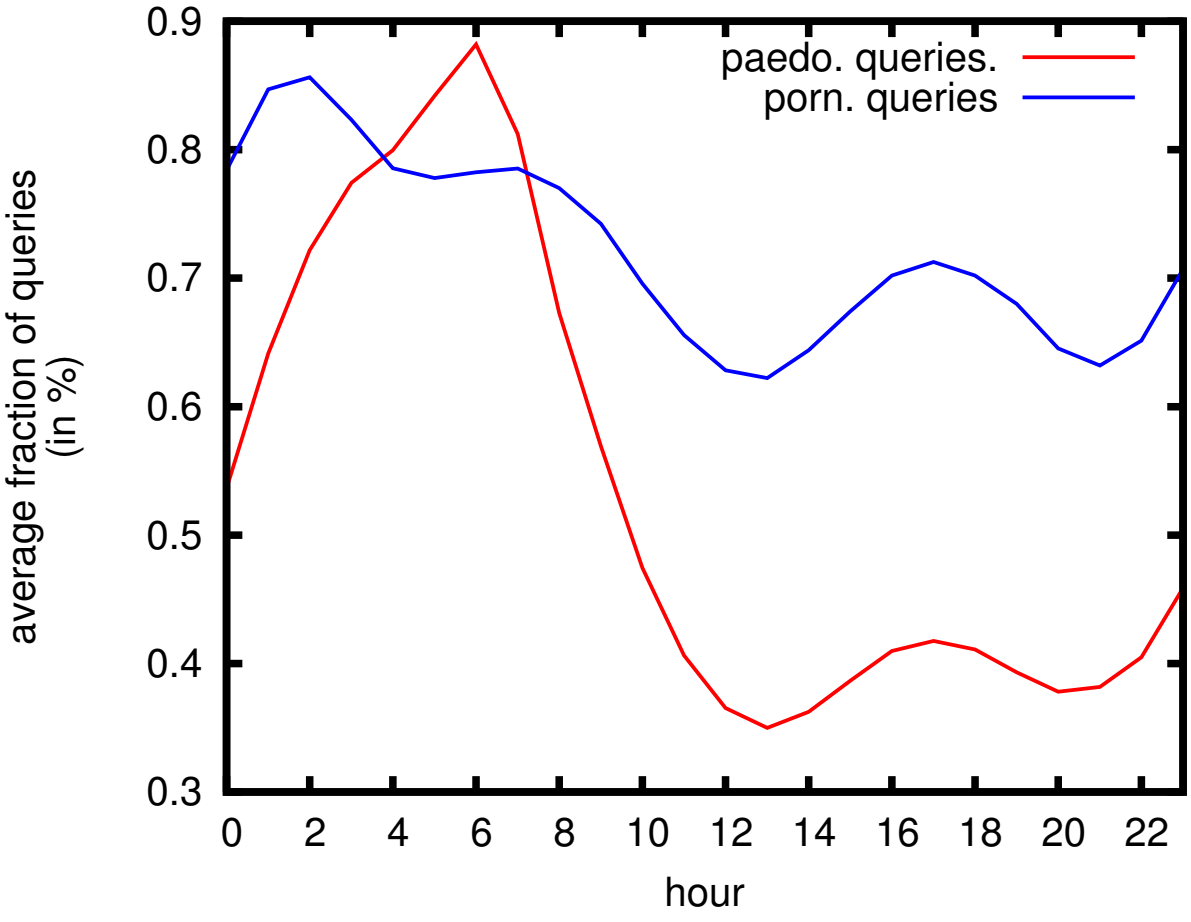
- The fraction of paedophile queries peaks at 6 AM
- Statistical artefact?

Country-based comparison



- Confirmation with country-based agregates (France vs {Arg+Brazil}, chosen because of languages and volumes of queries)

Pornography vs paedophile activity



- Demand for paedophile and traditional pornography differ

Outline

Conclusion

Patterns of paedophile activity

- Important growth of paedophile activity between 2009 and 2012
- Fraction of paedophile queries peaks at 6 AM
- Qualitative contribution with quantitative approach

Perspectives

- improve our tool with machine learning
- which would enable frequent updates, and avoid drift bias?
- IR question: how a topic is searched for over the years?

- infer users' social network and study it
- find data on real file exchanges (supply)

- collaborate with other disciplines to enhance our results
- use our large datasets (6 years, direct download)

Contact

Thank you for your attention.

Contact: raphael.fournier@lip6.fr

Antipaedo project

http://antipaedo.lip6.fr

Funded by European commission MAPAP project, French Research agency (ANR), Action Innocence Monaco

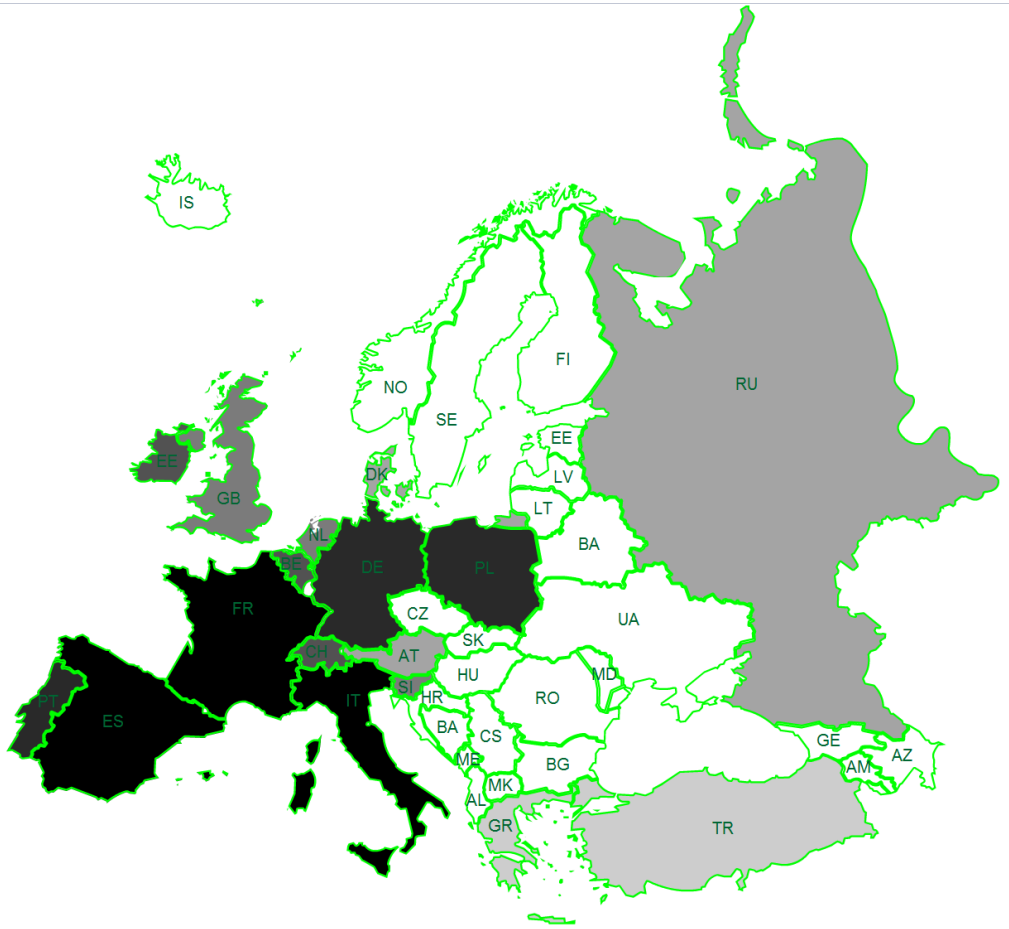
Geo-location: statistics

country	# queries	# paedo	ratio
IT	19569361	15426	0.08 %
ES	8881405	5177	0.06 %
FR	7583815	8059	0.11 %
BR	2795090	4849	0.17 %
IL	2139697	2618	0.12 %
DE	2093106	11238	0.54 %
KR	1386799	336	0.02 %
US	1053183	6184	0.59 %
PL	975170	1178	0.12 %
AR	810466	1465	0.18 %
CN	635392	337	0.05 %
PT	513327	434	0.08 %
IE	511185	54	0.01 %
TW	417893	138	0.03 %
BE	402565	646	0.16 %
CH	320054	1710	0.53 %
GB	319386	1698	0.53 %
NL	243646	1131	0.46 %
CA	241460	1233	0.51 %
SI	239572	167	0.07 %
MX	210504	1098	0.52 %
RU	200958	2712	1.35 %
AT	184248	977	0.53 %

Biased by:

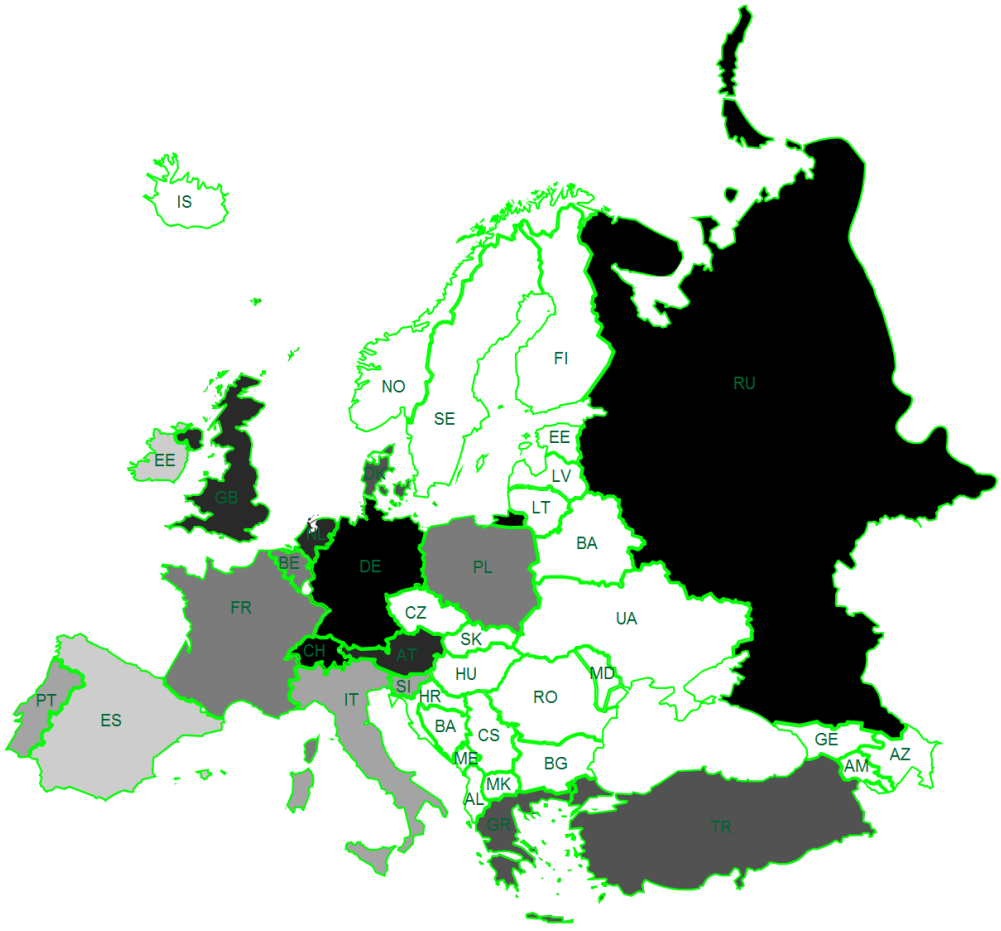
- language knowledge
- decoding problems

Geo-location: maps



queries

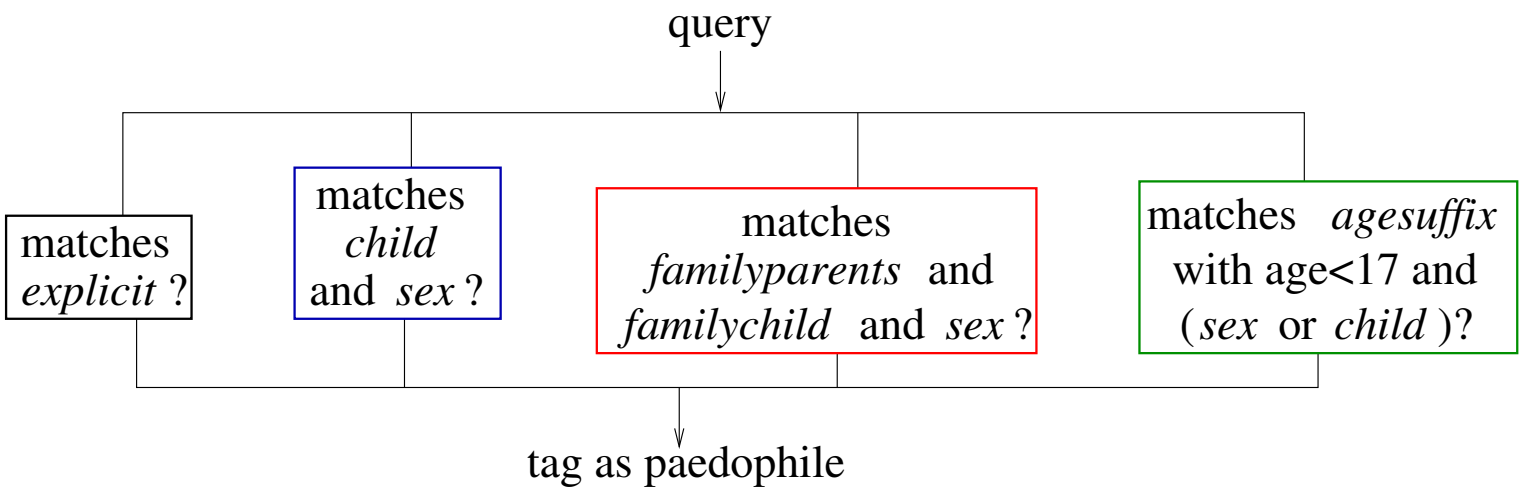
Geo-location: maps



ratio # paedophile queries / # queries

Tool design

- Set of rules based on law-enforcement knowledge
- Manual inspection of our datasets
- Improve until negligible changes
- 4 categories of paedophile queries



raygold little girl porno infantil incest mom son video 12yo fuck video

Quality

False positive

“sexy daddy destinys child”
contains “sexy”, “daddy” and “child”
but most likely a music-related query

False negative

“pjk 12yo”
contains paedophile keywords that we don’t search for

How to estimate false positive and false negative rates?

Tool assessment – Survey

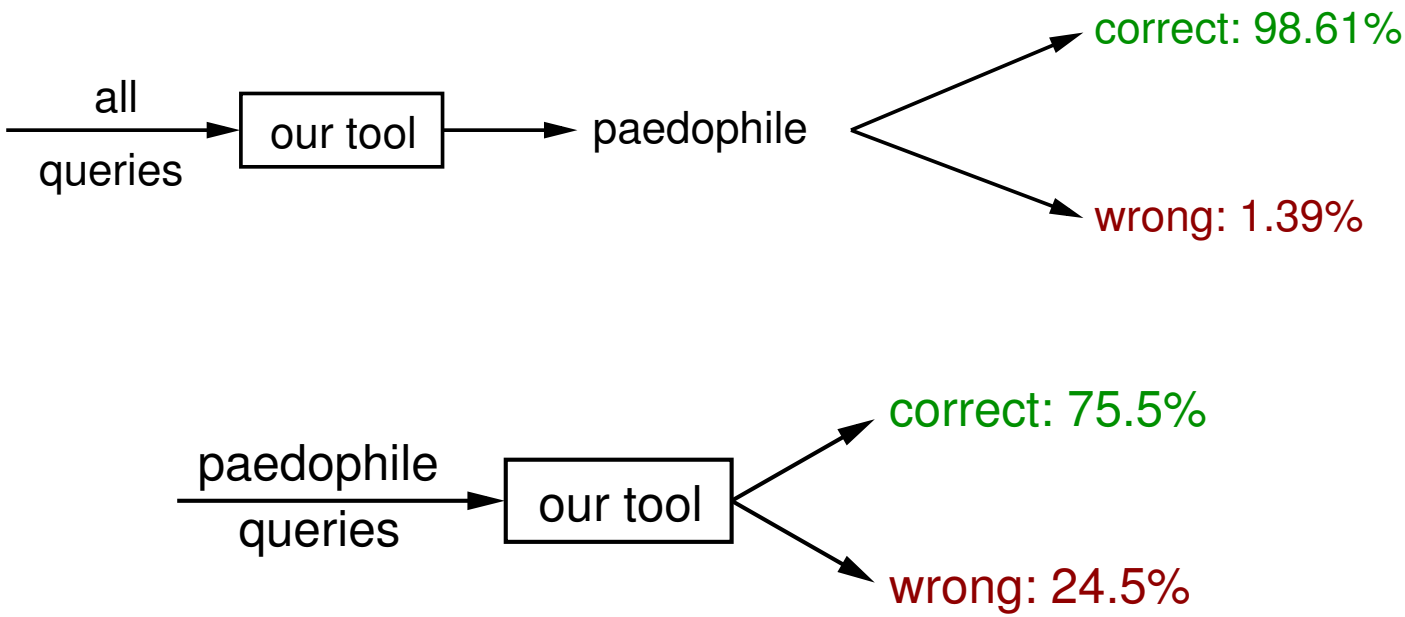
- Set of 21 volunteering experts
  from Europol, national authorities, NGOs
- Set of 3,000 randomly selected queries:
  - Paedophile
  - Not paedophile
  - *Neighbours* (submitted within the 2 previous or next hours of a paedophile query by the same user)
- Tag queries as *paedophile*, *probably paedophile*, *probably not paedophile*, *not paedophile* or *I don't know*

Tool assessment – Survey results

paedo	*prob. paedo*	*don't know*	*prob. not*	*not paedo*	total	relevance
1530	149	25	66	1230	3000	99.5
1381	247	125	580	667	3000	98.5
1679	89	2	113	1117	3000	99.1
1603	201	99	174	923	3000	99.0
1598	5	15	1	1381	3000	98.8
128	81	1	26	124	360	100.0
216	154	0	142	132	644	98.4
1624	126	16	165	581	2512	99.8
351	16	2	16	27	412	100.0
647	119	71	40	439	1316	98.4
1174	111	20	64	789	2158	99.1
335	17	1	70	166	589	97.5
641	383	4	112	753	1893	97.8
1071	546	2	453	928	3000	88.4
1554	197	28	327	894	3000	97.6
1506	120	6	25	393	2050	98.3
305	270	24	89	181	869	99.0
371	1017	496	570	546	3000	95.7
976	936	405	594	89	3000	96.6
344	12	10	70	156	592	98.3
845	139	323	175	182	1664	97.9

- Relevance rate: adequate knowledge of specific context

Assessment results



Assessment results

$$\frac{|P^+|}{|D|} = \frac{(1 - f'^+)}{1 - f^-} \cdot \frac{|T^+|}{|D|}$$

- P^+ : paedophile queries
- T^+ : tagged paedophile queries
- f'^+ : false positive rate
- f^- : false negative rate

Distinguishing users

Possible approximation:
user $\sim$ IP address

Problems

- Gateway/firewall (NAT) IP addresses
- Dynamic addresses allocation
- Several users per computer
- Several computers per user

Distinguishing users

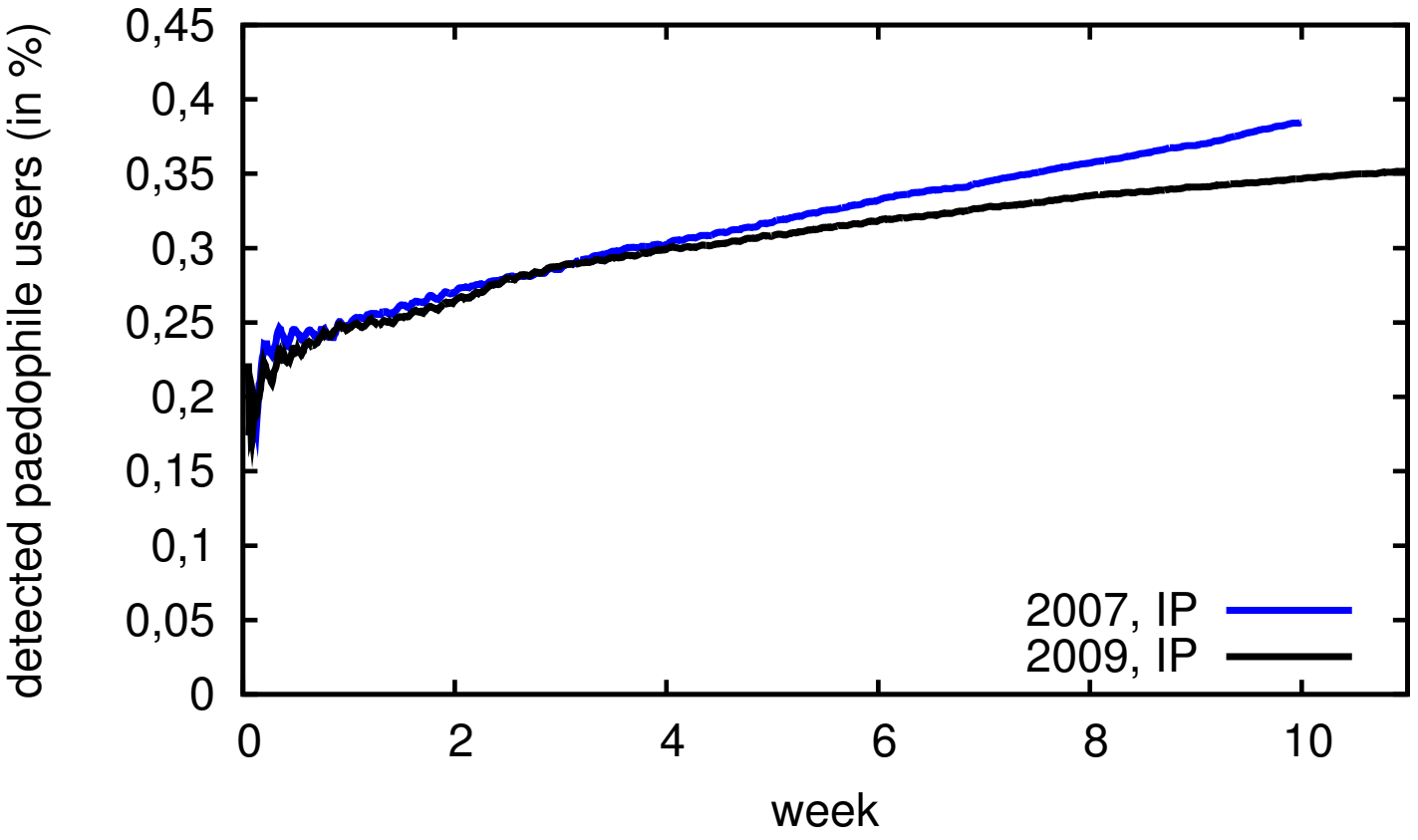
Paedophile user

- User paedophile after one paedophile query
- All dynamic/public IP addresses may be considered as paedophile *after some time*

3 methods:

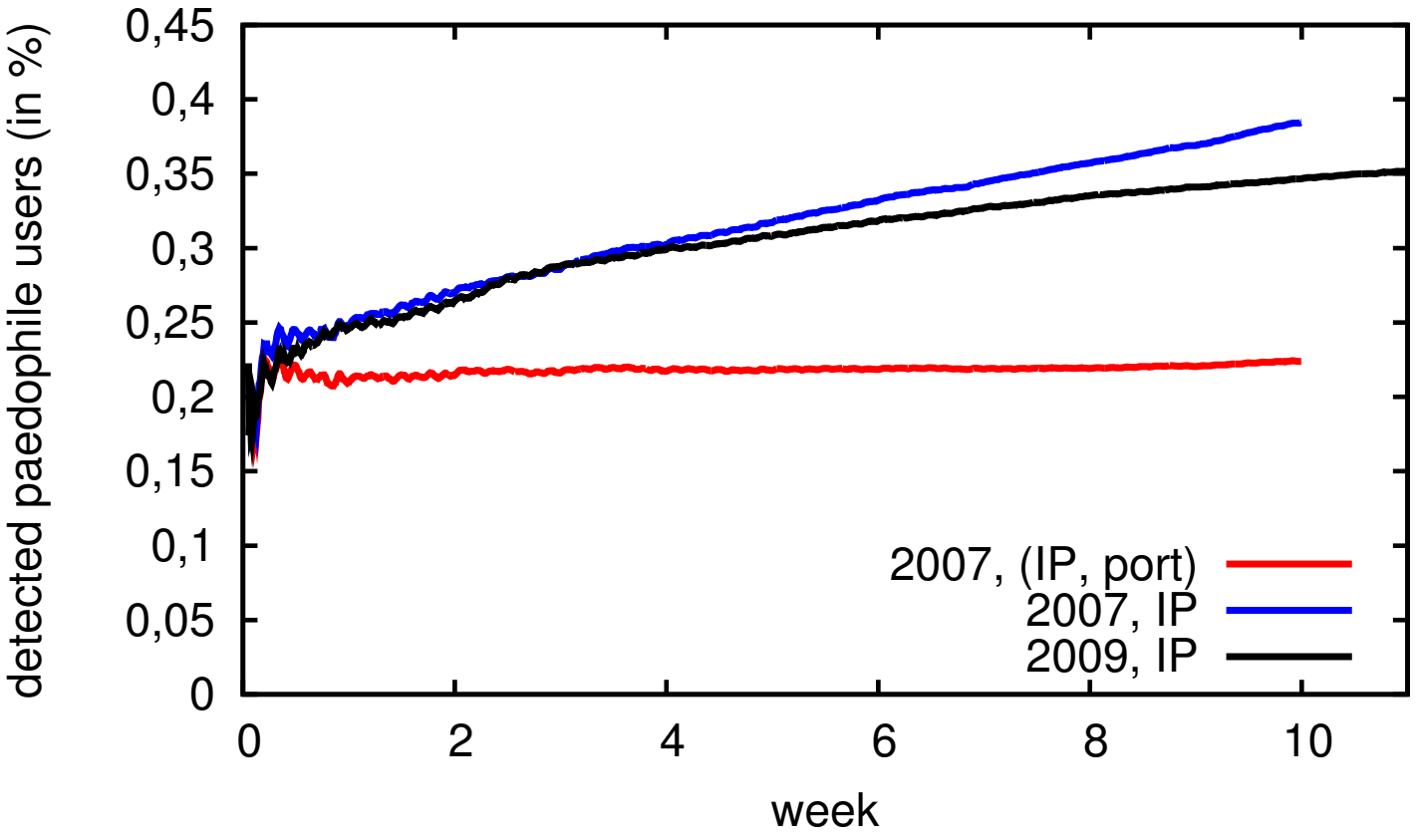
- User $\sim$ IP adress + connection port
- Measurement duration
- Sessions

User: IP *vs* (IP,port)



- (IP, port) reduces pollution (bias)

User: IP *vs* (IP,port)



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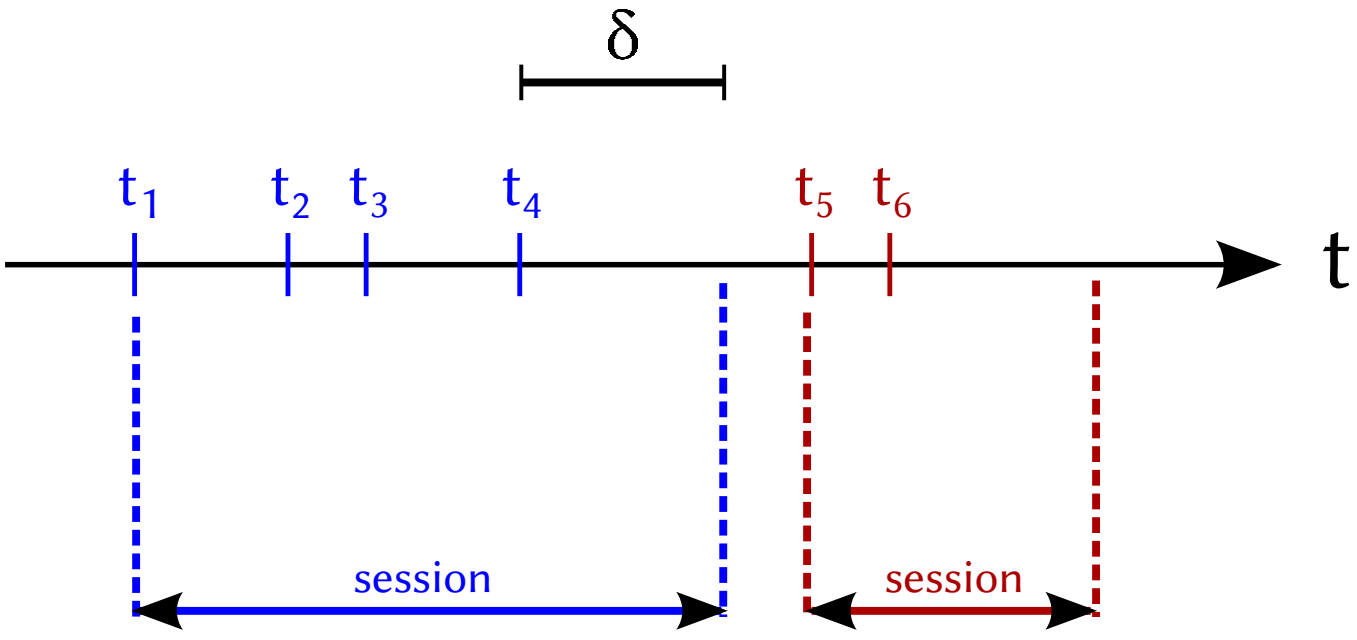
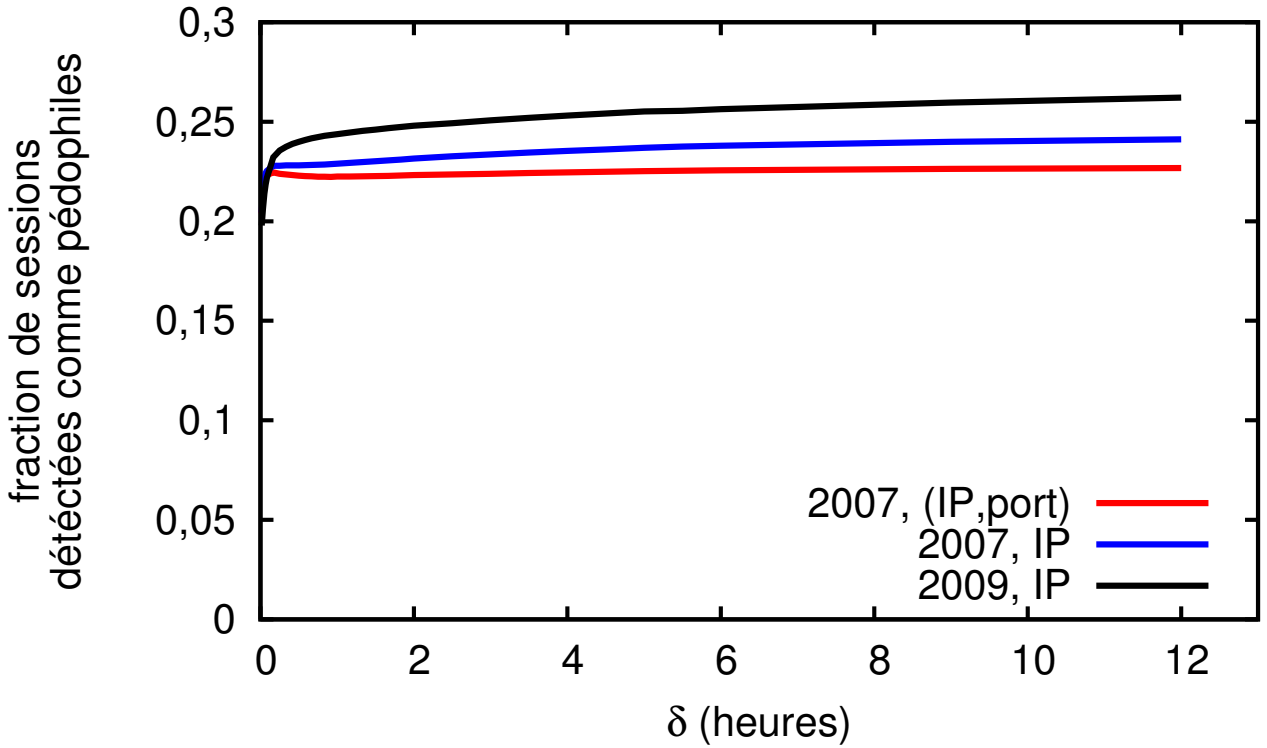
User: sessions



User: sessions



Fraction of paedophile users

Result

- Close to 0,22% for both datasets (2010)
- 1 paedophile user out of 450


Matthieu Latapy, Clémence Magnien, and Raphaël Fournier. Quantifying paedophile queries in a large P2P system. In *IEEE International Conference on Computer Communications (INFOCOM) Mini-Conference*, 2011.


Matthieu Latapy, Clémence Magnien, and Raphaël Fournier. Quantifying paedophile activity in a large P2P system. *Information Processing and Management*, In press, 2012.