Mail filtering on huge mail servers with j-chkmail

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Plan

- Huge servers
- Content and behaviour filtering
- Filter real life in huge servers
- Filter scaling – j-chkmail's content and behaviour filtering
- Cooperation between behaviour and content filtering
  - Scalable Adaptive Delay Greylisting
- Server protection
- Results
- Conclusions

Medium / huge mail servers...

- Many thousand users
- Handling many hundreds of thousands messages each day
- Handling many gigabytes each day
- Typically – university campus gateway

Medium / huge mail servers

- Heterogeneous population : computer scientists, physicians, sociologists, purchaser... -> *hard to define what a typical mailbox looks like !*
- Users are unknown to mail server administrator -> *filters are hard to tune !*
- It's usual to have filtering being done on gateways (a place where user mailbox information isn't available) to protect storage servers
- Security issues – ideal target for attacks
- Reliability issues (availability, downtime, ...)
- Low level hardware/OS constraints – limited resources (file descriptors, processes, disk I/O and network bandwidth, ...)

(Parenthesis : SMTP dialog)

```
    martins@calloway:~> telnet paris smtp
    Trying 194.214.158.200...
    Connected to paris.
    Escape character is '^]'.
<-  220 paris.ensmp.fr ESMTP Sendmail 8.12.8/8.12.7/JMMC
->  helo calloway.ensmp.fr
<-  250 paris.ensmp.fr Hello calloway [194.214.158.171], pleased to meet you
->  mail from:joe@ensmp.fr
<-  250 2.1.0 joe@ensmp.fr... Sender ok
->  rcpt to:martins
<-  250 2.1.5 martins... Recipient ok
->  rcpt to:tartonpion
<-  550 5.1.1 tartonpion... User unknown
```

Envelope

```
->  data
<-  354 Enter mail, end with "." on a line by itself
->  From: Antoine
->  To: Sebastien
->  Subject: test telnet
->
->  C'est un test, je dis !
->  .
<-  250 2.0.0 h2QBmFBx017626 Message accepted for delivery
->  quit
<-  221 2.0.0 paris.ensmp.fr closing connection
    Connection to paris closed by foreign host.
    martins@calloway:~>
```

Message body

Behaviour filters

- Checks how some “parameter” evolves with time (not completely true)
- Learns with the past -> spend memory to save CPU cycles
- Reject connections (or stop tests) before checking message body (SMTP DATA command)
- Some examples :
  - RBLs – known spam sources, open relay servers, ...
  - Spamtraps – email addresses “distributed” only to spammers...
  - Connection rate : bursts versus connections exponentially distributed over time
  - Greylisting : does SMTP client tries sending again after temporary failure DSNs ?
  - ...
- Also, some RFC 2821 conformity checks : EHLO, greet_pause, ... (not really behaviour)

Content filtering

- Filtering is done based mainly on the content of SMTP DATA command : headers and message body
- Many different techniques ranging from *pattern matching* to *natural language processing*
- Each new connection or message is a new event – no history
- Content filtering consumes much more resources than behaviour filtering

Content filtering

- Pattern Matching
  - Checks if any of defined regular expressions can be found in incoming message.
  - Hard to maintain – maintainer shall check all received *SPAMs* to find pertinent patterns.
  - Resource consuming – each expression is matched against entire message.
  - Low efficiency
- URL filtering
  - Checks if URLs found in incoming message are present on URL blacklist.
  - Easier to maintain – semi automatic (scripts + validation) extraction of URLs from a bunch of received *SPAMs.*
  - Very fast – only URLs found in message are checked against a large blacklist database.
  - Very efficient : results from SURBL database are better than 80 % for detection rate and less than 0.5% for false positive rate.
  - Independent of SPAM/HAM corpus – Listed URLs never appears in HAM (surbl strategy).

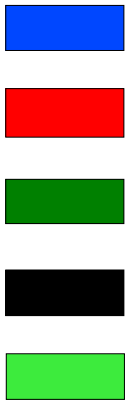
Content filtering

- Bayesian filters – *Bogofilter*, ...
  - Probability of being a SPAM – combines the probability of each word being a SPAM word
- Heuristic filters – *SpamAssassin*, ...
  - Many very diversified tests – message score is the sum of scores for succeeded tests
  - Tests with positive and negative weights – score evaluation isn't monotonic
- Bayesian and heuristic filters are based on statistical data from user mailbox : they learn how **your** mailbox looks like. Classification is optimal if incoming traffic matches **your** mailbox.

Life at huge servers – top hits

# 1	127535	URIBL_WS_SURBL
# 2	127101	URIBL_SBL
# 3	125917	URIBL_JP_SURBL
# 4	120728	URIBL_OB_SURBL
# 5	96849	BAYES_99
# 6	95827	RCVD_IN_BL_SPAMCOP_NET
# 7	90406	HTML_MESSAGE
# 8	71017	URIBL_SC_SURBL
# 9	46927	MIME_HTML_ONLY
#10	36806	URIBL_AB_SURBL
#11	33822	RCVD_IN_XBL
#12	30930	MIME_BOUND_DD_DIGITS
#13	30649	MPART_ALT_DIFF
#14	28472	URIBL_AH_DNSBL
#15	26638	RCVD_IN_SORBS_DUL
#16	26621	DRUGS_ERECTILE
#17	26394	MSGID_FROM_MTA_HEADER
#18	24615	RCVD_IN_DSBL
#19	23977	MSGID_FROM_MTA_ID
#20	23690	RCVD_IN_SORBS_SPAM
#21	22457	RCVD_IN_NJABL_DUL
#22	21115	RCVD_IN_NJABL_PROXY
#23	21013	RCVD_IN_SBL
#24	20262	X_MESSAGE_INFO
#25	18044	HTML_FONT_BIG

...



IP RBL

URL RBL

Bayesian filter

Heuristic filter

Pattern Matching

Data from prolocation.net
6 hours – 440K messages
January 2005
Thanks to Raymond Dijkxhoorn

We can see that ...

- SURBL check is the most effective criteria
- While hundreds of checks are executed, very few are enough to detect most of the incoming spam
- External criteria (URL and IP blacklists) and bayesian checks are more effective than others
- Some unreliable heuristic checks appear with high frequency (HTML_MESSAGE and MIME_HTML_ONLY)

A word about RBLs

```
----------------------------------------
mail-abuse.org                  : 175396
 -- 127.1.0.1          :   1180
 -- 127.1.0.2          : 168244
 -- 127.1.0.3          :    855
 -- 127.1.0.4          :    302
 -- 127.1.0.6          :     35
 -- 127.1.0.8          :   3820
 -- 127.1.0.9          :     22
 -- 127.1.0.10         :    875
 -- 127.1.0.12         :     60
 -- 127.1.0.14         :      3
```

- Using mail-abuse is equivalent to the policy : “I don't accept connections from ISP end users”

Filter scaling

- Resource consumption (CPU, memory, ...) shall grow slower than traffic level, or at most at the same rate.
- Remove all external dependencies (DNS, network checks) – faster and securer.
- Use only reliable criteria - avoid methods depending from typical user mailbox
- Compromise between doing well and doing fast.
- Do, whenever possible, behaviour checking – faster than content checking.
- Don't loose time – Little's Law says : *mean number of processes grows with connection rate and stay time.*
- **And the must** : the filter shall learn while it works – use memory to save CPU cycles.

j-chkmail behaviour filtering

- A set of very fast checks – connection rate, bounce rate, spamtraps, harvesting, RFCs compliance, greylisting, handling time (CPU usage), volume, ...
- Three levels of persistent history :
  - Recent : 20 minutes – activity of all SMTP clients
  - Medium : 5 hours – bad or dubious behaviours
  - Long : some days (on disk) – confirmed bad behaviour (usually from log files)
- A kind of Real Time Blacklist ! – connection is rejected if bad behaviour over some hours or too resource consuming over some minutes.
- Behaviour filtering doesn't block too much spam, but protects the server against surges (greylisting is an exception to both – will talk about later).

j-chkmail content filtering

- URL filtering
  - surbl.org database – BerkeleyDB and DNS versions. BerkeleyDB is faster when running with fast SCSI disks and enough cache memory.
- Pattern matching
  - Very few expressions (~150)
  - Complement other checks (immediate needs or really stable/reliable expressions)
- Heuristics
  - Very few criteria (31 in the last snapshot and number being reduced)
  - Prefer effective criteria (high detection and low false positive rates).
  - Only positive weight checks – monotonic score evaluation
    - False positive rate is higher than other filters : message whitening is let to final user (address book, known message sources, ...)

j-chkmail content filtering – seem by user

- The goal is qualitative : help message classification by final user
- False positives resulting from the lack of negative weight criteria are compensated by “user address book”.
- What happens to messages ?
  - Message is rejected by the server if score exceeds some threshold
  - If accepted, message score is presented at some header (X-j-chkmail-score)
  - User configures his MUA to :
    - Put messages coming from known users in normal Inbox
    - Put messages with high scores in SPAM mailbox
    - Otherwise put message in normal Inbox

Behaviour and content filtering cooperation

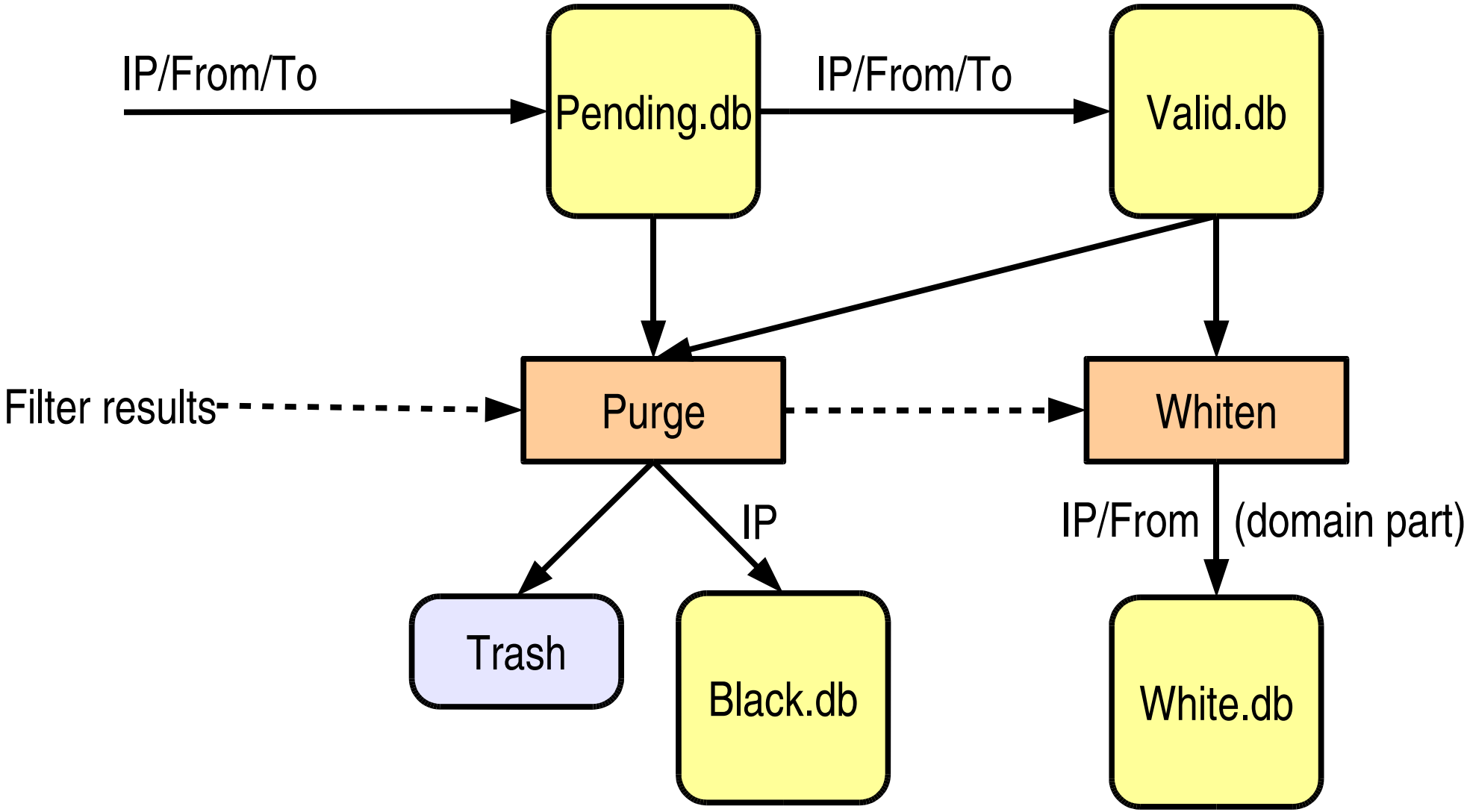
- Content -> Behaviour
  - Behaviour thresholds are lowered for clients sending SPAM or virus detected by content check.
    - Ex : connection rate limit for this client is divided by two if mean content score for its messages, evaluated over past 10 minutes, is too high, or if virus detected
- Behaviour -> Content
  - Some behaviour checks don't block connections but contribute to heuristic score

- WARNING – avoid closed loops, otherwise the filter may become unstable

Nice example : Adaptive Delay Greylisting Under validation

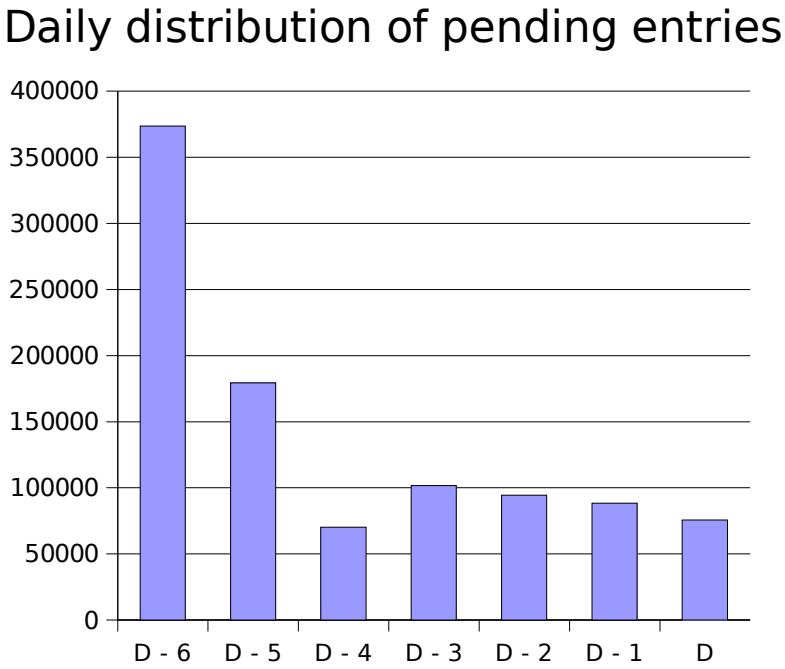
- Greylisting, by itself, isn't scalable : number of database records grows with recipient rate (faster than message/connection rate)
- Security vulnerability – easy to poison database
- Basic idea – eliminate redundancy
  - DB records lifetime is reduced for clients with confirmed bad behaviour or some non priority client (null sender/bounces, DNS resolution, ...)
    - 192.87.30.2:joe@terena.nl:joe@ensmp.fr vs 205.158.62.177:joe@terena.nl:joe@ensmp.fr
  - Recent pending records are removed for clients with surges of dubious behaviours on short history (virus, spams, harvest, ...)
  - Limit the number of pending records per *IP* address
  - Greylisting database content is periodically scanned to detect very bad and very good behaviours.

Adaptive Delay Greylisting



Adaptive Delay Greylisting

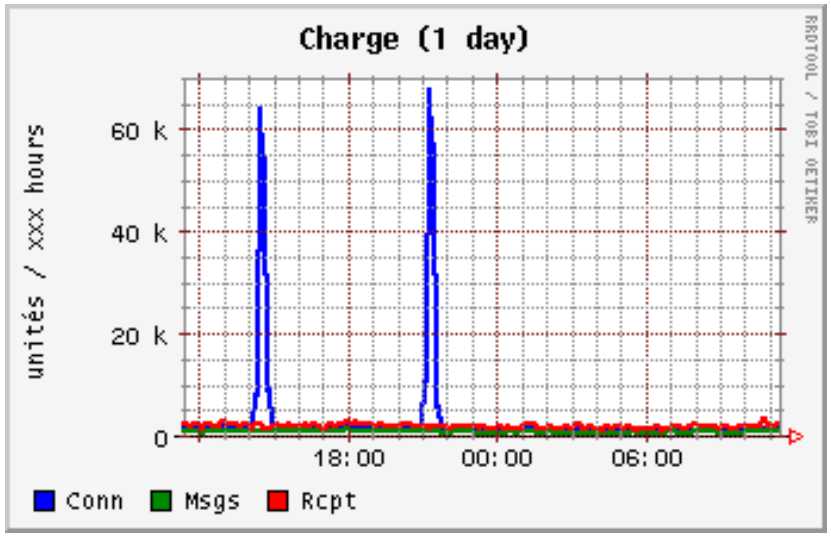
- Limited simulation on data from domain jussieu.fr (~ 500 000 connections a day)
- Pending entries database – 430614 records over last 5 days
  - Age limiting : bounces (3971), DNS resolution (111619), domain-name/email matching (250535), max entries exceeded (1761)
  - Number of records removed : 367886
  - Pending triplets DB size reduced to 62728 records (~ 15 %)
- Algorithms and prototype under validation at ensmp.fr – improving reliability on black and white lists generation



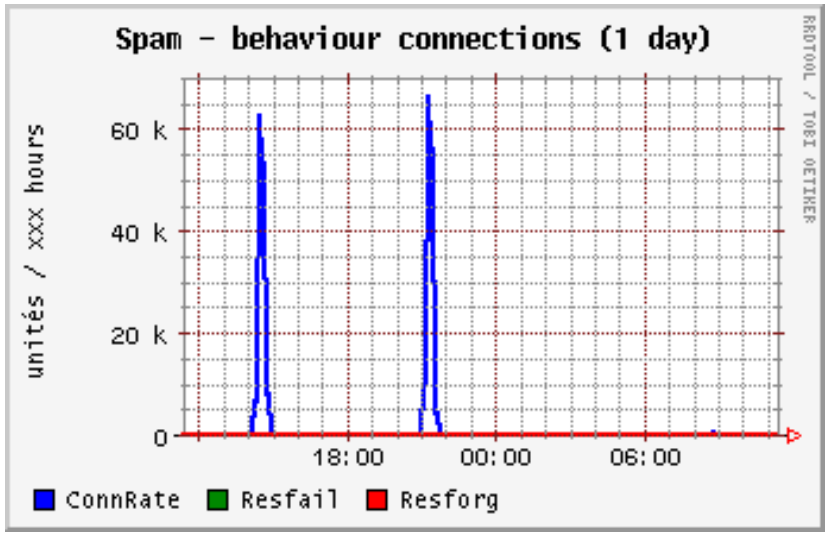
j-chkmail – server protection

- Auto restart
  - Filter status is periodically checked by the supervisor – if it detects a problem, cleaning up is done and a new filter instance is started over.
- Connection rate control (per client SMTP).
- Simultaneous open connections control (per SMTP client).
- Global load measurement.
- When load is high, access is granted in a priority basis...

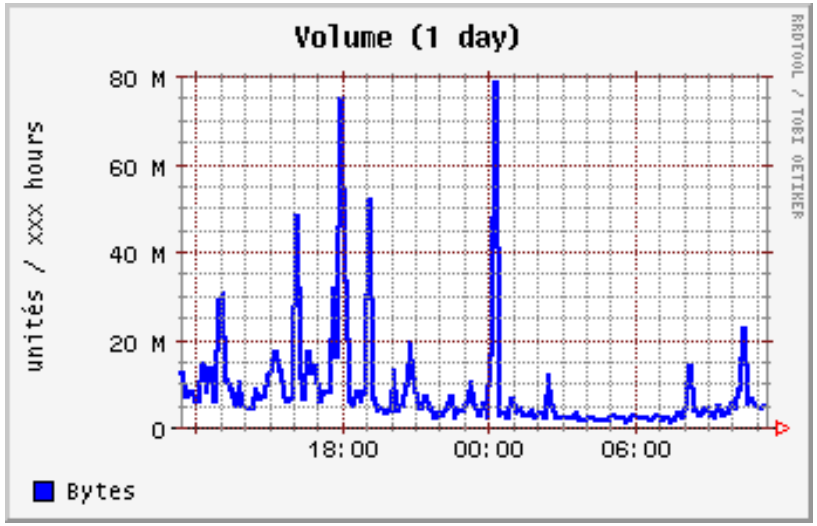
j-chkmail – connection rate surges



Incoming



Filtered



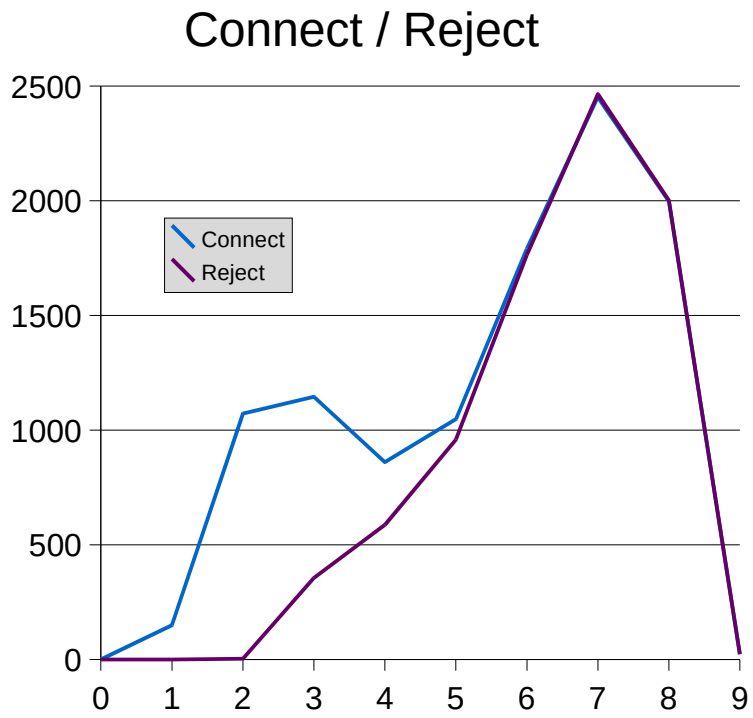
Volume data shows :

no impact on normal traffic

Connection rate control in action

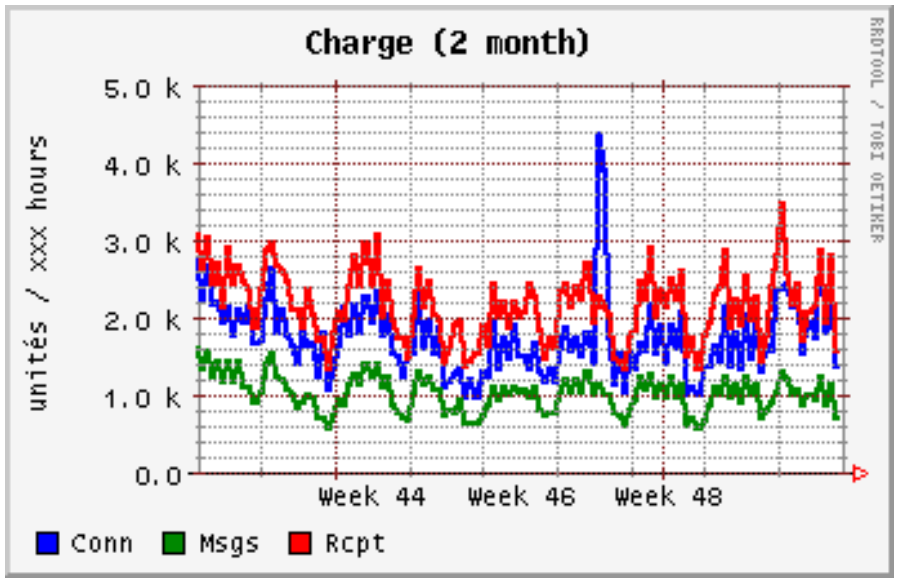
- 10536 connections in 8 minutes
- 238 clients from network 66.216.119.0/24
- Each client made [28 – 67] connections
- Peak : 86 connections in the same second
- 15 messages rejected by content filtering
  `www.rapiddealsbyemail.com`
- 8156 connections rejected by connection rate – maximum allowed : 10 connections / 10 min
- **No HAM lost : “Poor's man QoS”**

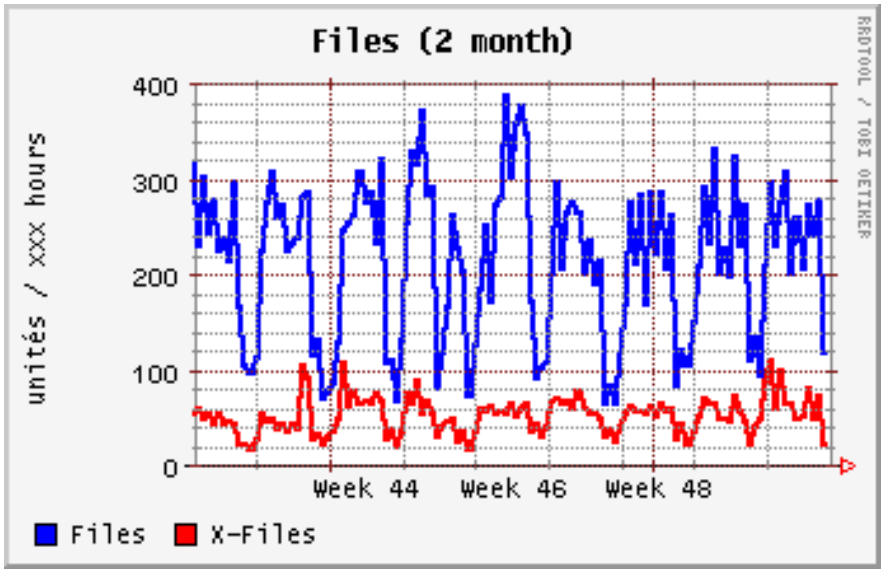
Data from paris.ensmp.fr – April 2003



Virus filtering

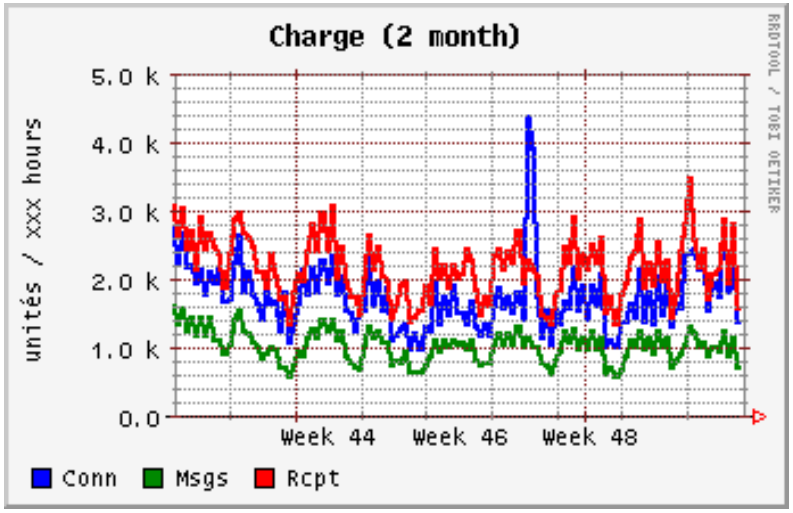
- File extension based filtering (.exe, .pif, ...) - much faster than virus scanner, as check is done only on file name, not file content
- External antivirus (ClamAV, ...)

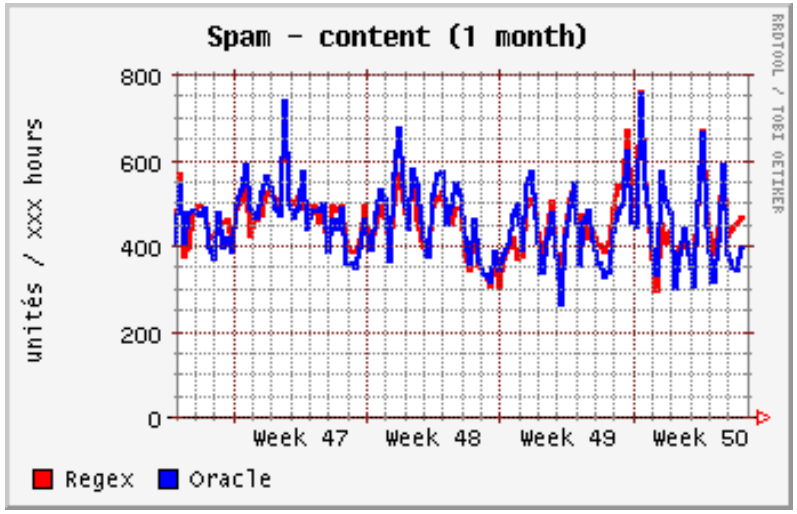




j-chkmail - Monitoring

```
martins@paris:~> j-printstats -q -l 6h | more
Version                          : Joe's j-chkmail v1.7
*** Summary
 First Connection   : Sun Jun  6 17:33:11 2004
 Last Connection    : Sun Jun  6 23:33:09 2004
 Connections        :    9393
 Gateways           :    4258
 Throttle Max       :     445 / 10 min (for the server)
 Throttle Max       :     100 / 10 min (for a single gateway)
 Duration (sec)     :   0.005  16.931 7226.787 206.110 (min mean max std-dev)
 Work (sec)         :   0.001   0.028    1.803   0.150 (min mean max std-dev)
...
```





j-chkmail behaviour on servers

- ensmp.fr
  - 2000 users, 60000 connections / day
  - 1 Sun E280R, Solaris 9, 2 x Sparc III 900 Mhz

```
   PID %CPU %MEM   VSZ   RSS    SZ   CLS     LWP NLWP PSR S COMMAND
28872  0.9  0.5 19072 18352 2384    TS       1    9   - S /usr/sbin/j-chkmail
```

- jussieu.fr
  - 50000 users, 400000 connections / day
  - 4 mail servers under FreeBSD - j-chkmail + milter-greylist + Sophos

```
 PID USERNAME  PRI NICE   SIZE    RES STATE  C   TIME   WCPU    CPU COMMAND
 1827 smmsp     96    0 29172K 26772K select 0  40:45  3.52%  3.52% j-chkmail
```

- pobox.sk
  - 15000 messages / hour - 1 Sun V65Z, 2.8 GHZ, under Linux
  - j-chkmail + clamd

```
USER       PID  PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
smmsp     1727  16   0  6072 1692 3172 S  0.0  0.2   0:00.10 j-chkmail
smmsp    21448  16   0  145m  36m  11m S  0.0  3.6   0:07.82 j-chkmail
```

j-chkmail typical filtering results

- Typical SPAM filtering figures with j-chkmail :
  - Mean connection handling time : ~ 30 ms on a Sun E280R (2 x Sparc III 900 Mhz)
  - Behaviour filtering – blocks 15-20 % of incoming spam
    - Main interest is server protection
  - Greylisting – rejects 50-80 % of remaining spam
  - Content filtering – rejects/tag 70 – 80 % of remaining spam
  - Heuristic filtering – tags some more spam, but gives some false positives

Conclusions

- On huge servers, users satisfaction is the better filter efficiency measure
- There are more available data about spam on your mail servers than you may imagine.
- Do you want to improve your filter ? “Learn while work” - this means : do real-time analysis on filtering results.
- If you can use only three filtering criteria, the good choices are :
  - connection rate control
  - greylisting,
  - URL filtering (surbl.org)
- j-chkmail : for the author, a test bench for ideas on mail filtering

Thanks to...

- Tibor Weis : pobox.sk and tuzvo.sk
- Sebastien Vautherot : jussieu.fr
- Dennis Peterson
- Raymond Dijkxhoorn : prolocation.net / surbl.org
- Jeff Chan : surbl.org