#### GNUnet

presentation for  $\overline{D}C^{10}$ 

by

— not disclosed due to DMCA —

# GNUnet Requirements

- Anonymity
- Confidentiality
- Deniability
- Accountability
- Efficiency

# **Applications**

- anonymous sharing of medical histories
- distributed backups of important data
- ad-hoc communication between small devices
- and others

#### Infrastructure

We call GNUnet a network because:

- file-sharing is just one possible application
- most components can be re-used for other applications:
  - \* authentication
  - ★ discovery
  - ★ encrypted channels
  - ★ accounting
- the protocol is extensible and extentions are planned

### Related Work

Network	Gnutella[1, 4]	Chord[24]	Freenet[•]	MojoNation[17]
Search	bf-search	compute	df-search	broker
Anonymous	no	no	yes	no
Accounting	no	no	no	yes
File-Sharing	direct	migrated	insert	insert

Chord[24], Publius[15], Tangler[16], CAN[19] and Pastry[21, 7] are equivalent from the point of view of this discussion.

#### **Outline of the Talk**

- 1. Encoding data for GNUnet
- 2. Searching in GNUnet
- 3. Anonymity in GNUnet
- 4. Accounting in GNUnet

# **Encoding in GNUnet**

- Requirements
- Trees
- Blocks
- Limitations
- Benefits

### Problems with existing Systems

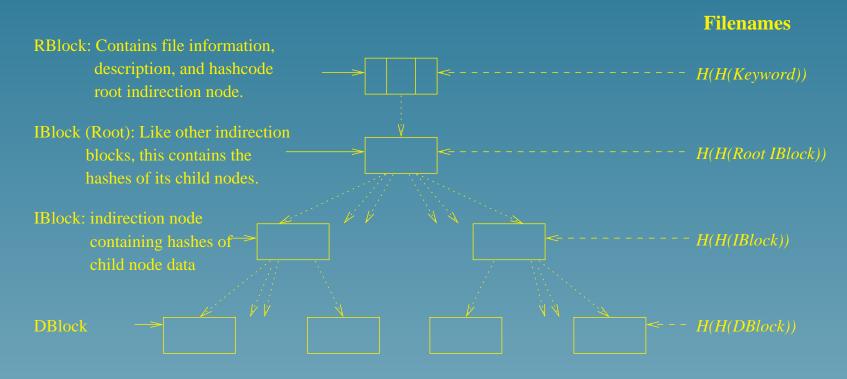
- Content submitted in plaintext, or
- content must be inserted into the network and is then stored twice, in plaintext by the originator and encrypted by the network (e.g. Freenet[9]);
- in some systems, independent insertions of the same file results in different copies in the network (e.g. Publius[15])

### **Encoding data for GNUnet: Requirements**

- intermediaries can not find out content or queries
- hosts can send replies to queries and deny knowing what the query or the content was for
- keep storage requirements (and bandwidth) small

## **Tree Encoding**

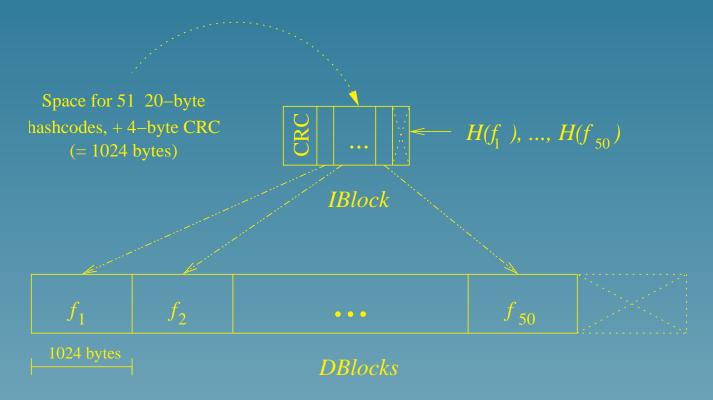
Files in GNUnet are split into 1k blocks for the transport[i]:



Encoding of the entire file

## **Block Encoding**

The hash of 51 blocks and a CRC are combined to an *IBlock*:



Encoding of the entire file

### "Algorithm"

- ullet split content into 1k blocks B (UDP packet size!)
- lacksquare compute  $\overline{H(B)}$  and H(H(B))
- ullet encrypt B with H(B), with Blowfish
- store  $E_{H(B)}(B)$  under H(H(B))
- ullet build inner blocks containing H(B)
- ullet root-node R contains description, file-size and a hash

#### Limitations

- If the keywords can be guessed... participating hosts can decrypt the query.
- If the exact data can be guessed... participating hosts can match the content.
- This is intended to reduce storage costs!

#### **Benefits**

- encryption of blocks independent of each other
- inherent integrity checks
- multiple (independent) insertions result in identical blocks
- very fast, minimal memory consumption
- little chance of fragmentation on the network
- small blocksize enables us to make traffic uniform and thus traffic analysis hard

# Searching in GNUnet

- Requirements
- Boolean queries
- Searching: Triple-Hash
- Routing
- Anonymity preview

### Problems with existing Systems

- Centralized, or
- easy to attack by malicious participants.
- Queries in plaintext, or
- hard to use keys.
- Not anonymous, or
- malicious participants can send back garbage without begin detected.

### Requirements

- retrieve content with simple, natural-language keyword
- guard against traffic analysis
- guard against malicious hosts
- do not expose actual query
- do not expose key to the content
- be unpredictable
- support arbitrary content locations
- be efficient

#### **Ease of Use**

GNUnet must be easy to use:

- search for "mp3" AND "Metallica" AND "DMCA"
- GNUnet returns list of files with description
- user selects interesting file
- GNUnet returns the file

### Encrypting the root-node R

For each file, the user specifies a list of keywords to gnunet-insert. Then:

- ullet For each keyword  $\overline{K}$ :
- lacksquare GNUnet saves  $\overline{E}_{H(K)}(R)$  under  $\overline{H(H(K))}$ .

If the user searchs for "foo" and "bar":

- Search for "foo", search for "bar".
- Find which root-nodes that are returned are for the same file (= top-level hash). Display those.

## **Searching: Intuition**

- Key for block B is H(B).
- Filename for block B is H(H(B)).
- Intuition: ask for H(H(B)), return  $E_{H(B)}(B)$ .
- Problem: malicious host sends back garbage, intermediaries can not detect

## Triple-Hash

- Send query: H(H(H(B))).
- Reply is  $\{H(H(B)), E_{H(B)}(B)\}.$
- Malicious host must at least have H(H(B)) and thus probably the content.
- It is impossible to do better together with anonymity and confidentiality of query and content for sender and receiver.

### Routing

- keep a table of hosts that we are connected with
- forward query to n randomly chosen hosts
- select n based on load and importance of the query
- keep track of queries forwarded, use time-to-live to detect loops
- bias the random choice of the hosts slightly towards a Chord-like metric.
- take metric into account when migrating content

### GNUnet: Traffic Analysis Nightmare

- Group several queries to one larger packet.
- Introduce delays when forwarding.
- Packets can contain a mixture of queries, content, nodediscovery, garbage, etc.
- Make all packets look uniform (in size).
- Encrypt all traffic. Add noise if idle.

# **Open issues**

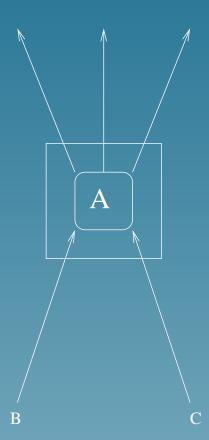
Approximate queries.

# Anonymity in GNUnet

- Techniques to achieve anonymity
- Attacks
- Efficiency
- A new perspective
- GNUnet is malicious

# **Building Blocks**

- indirections[25]
- random delays[10]
- noise[11, 22]
- confidential communication[18]



## **Attacks on Anonymity**

- traffic analysis[]
- timing analysis
- malicious participants
- statistical analysis[20, 23]

## **Efficiency**

If nodes indirect queries and replies, this has serious efficiency implications:

For n indirections, the overhead in bandwidth (and encryption time) is n-times the size of the content.

# Money Laundering

Let's illustrate GNUnet's perspective[5] with the example of money laundering. If you wanted to hide your financial traces, would you:

- Give the money to your neighbor,
- expect that your neighbor gives it to me,
- and then hope that I give it to the intended recipient?

Worse: trust everybody involved, not only that we do not steal the money but also do not tell the FBI?

#### Banks!

In reality, banks are in the best position to launder money:

- Take 1.000.000 transactions from customers,
- add your own little transaction,
- and better not keep any records.

As long as not *all* external entities cooperate against the bank, nobody can prove which transaction was ours.

## Why indirect?

- Indirections do not protect the sender or receiver.
- Indirections can help the indirector to hide its own traffic.
- If the indirector cheats (e.g. by keeping the sender address when forwarding) it only exposes its own action and does not change the anonymity of the original participants.

## **Key Realization**

Anonymity can be measured in terms of

- how much traffic from non-malicious hosts is indirected compared to the self-generated traffic
- in a time-interval small enough such that timing analysis can not disambiguate the sources.

## GNUnet: anonymity for free

From this realization, we can motivate GNUnet's anonymity policy:

- indirect when idle,
- forward when busy,
- drop when very busy.

merely forwarding.



# Accounting in GNUnet

- Goals
- Requirements
- Human Relationships!
- Digital Cash?
- Transitivity
- Open issues

#### **Common Problems**

- No accounting: easy to mount DoS attack[12]
- Overpricing legitimate use[2]
- Centralization[8]
- Lack of acceptance for micropayments
- Patents

#### **Goals**

- Reward contributing nodes with better service.
- Detect attacks:
  - ★ detect flooding,
  - ⋆ detect abuse,
  - ★ detect excessive free-loading, but
  - \* allow harmless amounts of free-loading

# Requirements

- No central server (rules out [17, 1]).
- No trusted authority (problem of initial accumulation, see [13]).
- Everybody else is malicious and violates the protocols.
- Everybody can make-up a new identity at any time.
- New nodes should be able to join the network.

# **Human Relationships**

- We do not have to trust anybody to form an opinion.
- Opinions are formed on a one-on-one basis, and
- may not be perceived equally by both parties.
- We do not charge for every little favour.
- We are grateful for every favour.
- There is no guarantee in life, in particular Alice does not have to be kind to Bob because he was kind to her.

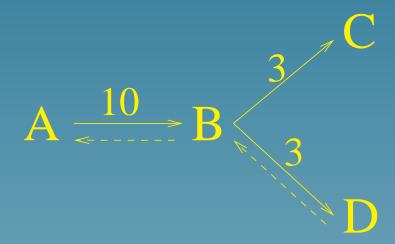
# **Excess-based Economy**

GNUnet's economy[14] is based on the following principals:

- if you are *idle*, doing a favour for free does not cost anything;
- if somebody does you a favour, remember it;
- if you are *busy*, work for whoever you like most, but remember that you paid the favour back;
- have a neutral attitude towards new entities;
- never dislike anybody (they could create a new identity anytime).

# **Transitivity**

If a node acts on behalf on another, it must ensure that the sum of the charges it may suffer from other nodes is lower than the amount it charged the sender:



Transitivity in the GNUnet economy.

# Open Issues

- if a node is idle, it will not charge the sender;
- if a node delegates (indirects), it will use a lower priority than the amount it charged itself;
- if an idle node delegates, it will always give priority 0.
- A receiver can not benefit from answering a query with priority 0.
- If the priority is 0, content will not be marked as valuable.

## Conclusion

- GNUnet is a cool system for privacy.
- GNUnet can already be used.
- GNUnet could get much better.

## GNUnet Online

# http://www.ovmj.org/GNUnet/

Welcome Contact FAQ Download Documentation Papers Links

### **About GNUnet**

GNUnet is an anonymous, distributed, reputation based network. A first service implemented on top of the networking layer allows censorship-resistant file-sharing.

GNUnet is part of the <u>GNU project</u>. Our official GNU website can be found at <a href="http://www.gnu.org/software/GNUnet/">http://www.gnu.org/software/GNUnet/</a>. GNUnet can be downloaded from this site or the <u>GNU mirrors</u>.

### News

#### 18/06/02: v0.4.2 released

Again, the focus was on bugs, this time on bugs that cost us efficiency, everything from bad TTL checks to too frequent key exchanges. New features:

- new tool gnunet-stats to display node status information
- · access control for the trusted TCP port, no more need to firewall it!
- DNS lookup for NAT-boxes that change their IPs (thanks to David Hansen)
- bounded exponential backoff for TTLs (improves resuming of long-standing download requests once content becomes available again)

#### 08/06/02: And another one: v0.4.1

This is mostly a bugfix release, but we have also new features:

- automated download of the inital hostlist via http on startup
- · mime-type and filename used by the GTK GUI
- support for libextractor 0.0.3 which is now highly recommended.

Bugfixes include segfaults in gnunet-insert with multiple keywords, a CRC problem in the GTK GUI and some minor efficiency improvements.

### 02/06/02: v0.4.0 released

The new version comes with more changes than ever, but you should also see significant improvements:

## GNUnet resources

- FAQ
- Mailinglists
- Mantis
- README
- Sources
- WWW page

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