Peer-to-Peer Consensus via Authoring Reputation

www.freechains.org

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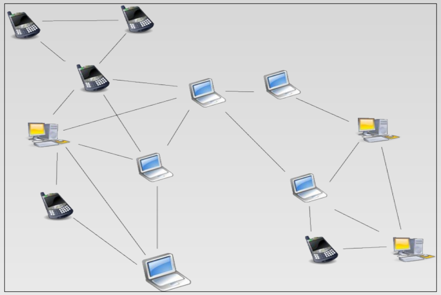
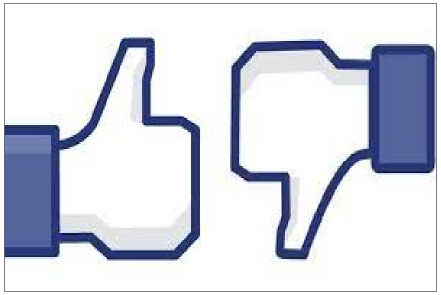
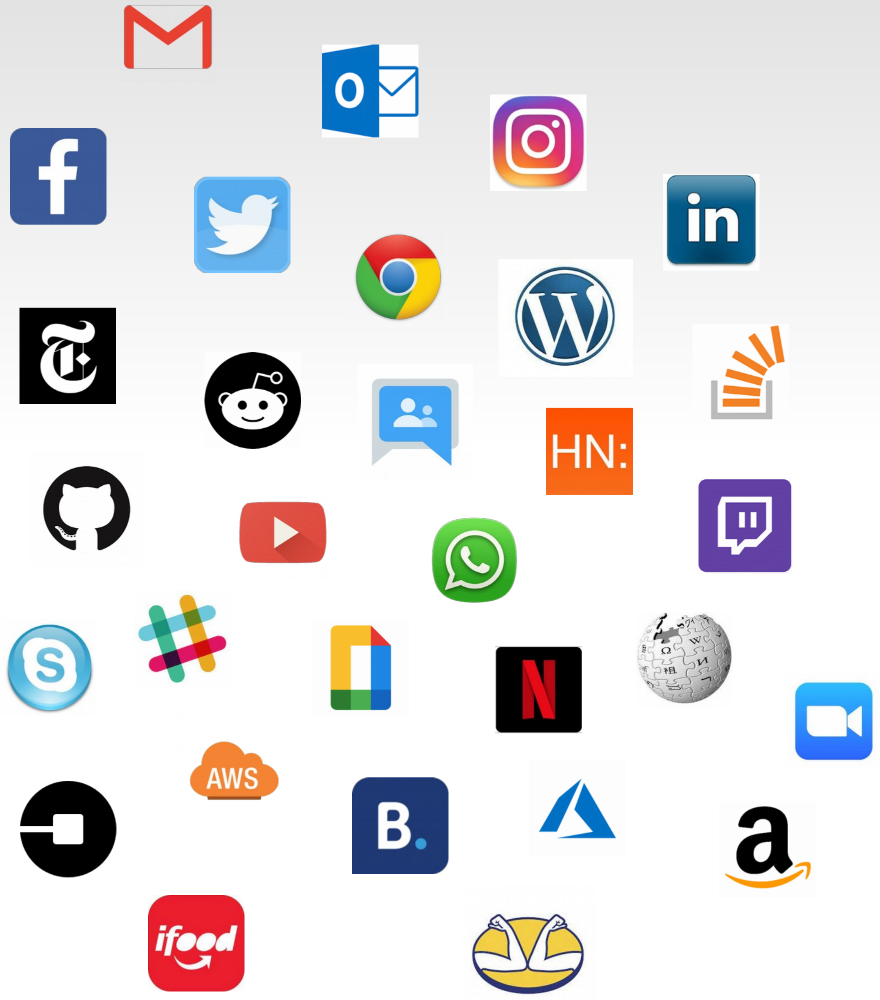




- Peer-to-Peer network
- Content created by users
- Reputation based on authoring
- Consensus based on reputation

Content Publishing

- E-mail
- Social media
- Webpages, News, Blogs
- Forums, Mailing lists
- Collaborative platforms
- Media streaming
- Instant Messages, Chat
- Teleconference
- Cloud Storage
- Services (delivery, auction)



Internet Centralization

- Very few companies...
  - Collect and control our data
  - “Algorithmize” our consumption
  - Obstruct competition

The Big Five
“FAAMG”

Peer-to-Peer Alternatives

- Eliminate intermediaries
- Push responsibilities to users (data & connectivity)
- New challenges!
  - no authority
  - no infrastructure

₿

Tor

IPFS

BitTorrent™

Public Forums

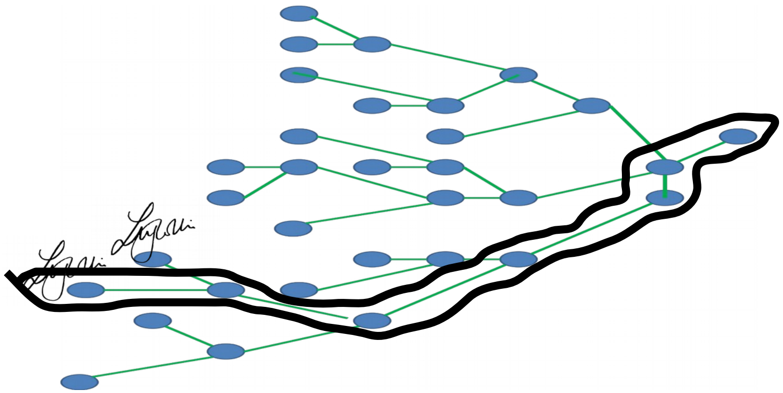
- Untrusted (possibly malicious) communication
  - abuse: excess, SPAM, fake news, illegal content
- Messages should…
  1. reach all users (even those temporarily disconnected)
  2. arrive in a consistent order
  3. be respectful and on topic

Consensus via Authoring Reputation

- Peer-to-Peer systems?
  - Bitcoin (1,2) ✔

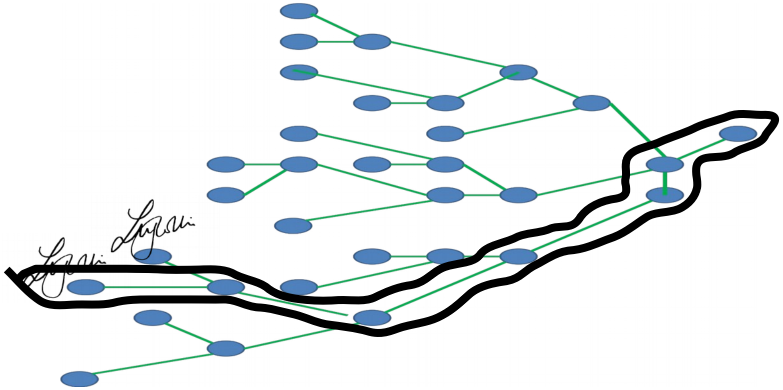
Bitcoin

- Permissionless consensus protocol
- Scarce virtual assets (*bitcoin tokens*)
- Proof-of-work to reach consensus and earn *bitcoins*
- Solves the *double-spending* problem
- No subjective judgment about transactions



Our Proposal

- Permissionless consensus protocol
- Scarce virtual assets (*reps tokens*)
- Authoring reputation to reach consensus and earn *reps*
- Solves the *double-spending* problem
- Subjective judgment about posts (likes & dislikes)



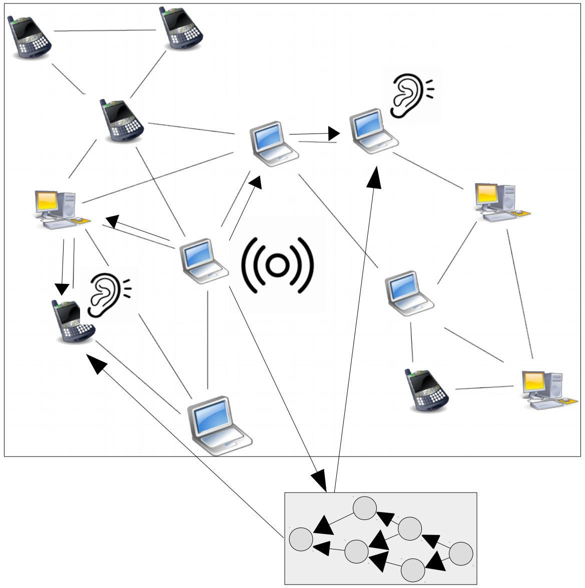
Contributions

- Make decentralized public forums viable
  - Reputation & Consensus mechanism
  - Depends exclusively on human work
  - Any system that structure messages as DAGs
  - Supports local-first software
  - *Freechains* peer-to-peer system
- Support CRDTs in collaborative platforms
  - Causal order (DAGs) + Total order (consensus)

Freechains

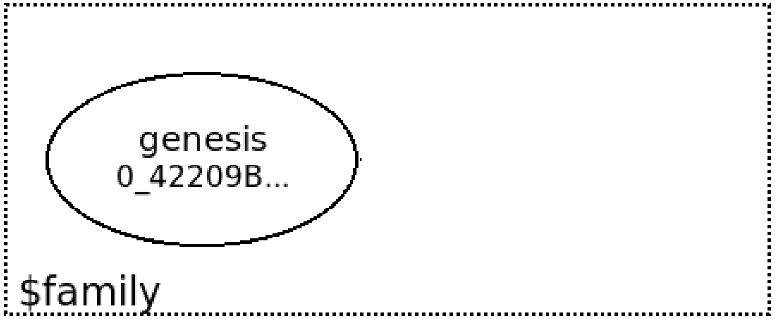
- Topic-based *pubsub*, Unstructed P2P
- Topic (*chain*) is a replicated Merkle DAG

Type	Prefix	Examples
Private Group	$	- E-mails - WhatsApp groups - Backup of documents.
Public Identity	@	- News sites - Streaming services - Public profiles in social media
Public Forum	#	- Q&A forums - Chats - Consumer-to-consumer sales



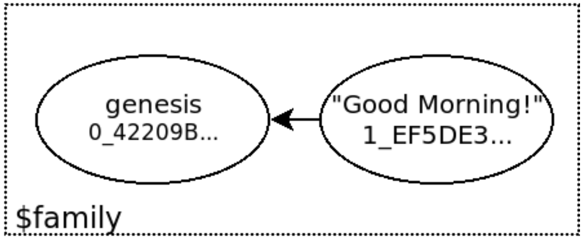
Demo – Private Group

```
> freechains-host start /tmp/freechains/
Freechains v0.8.4
Waiting for connections on Host(…, port=8330)...

> freechains crypto shared 'senha-muito-forte'
FD6C47C27F5CF6839EDE047CE7EE4285E633E26CBA929913

> freechains chains join '$family' FD6C47…
42209BBF280D4444E39ECEA199C23037058D4F66629D90D7BF1B8C9088B8D0ED

> freechains chain '$family' post inline 'Good morning!'
1_EF5DE364B7F9C0D40550E01FB9AB510F4AFFBBD79DF54302B68B7DB2ECD3F550
```



Demo – Private Group
(Peer 2)

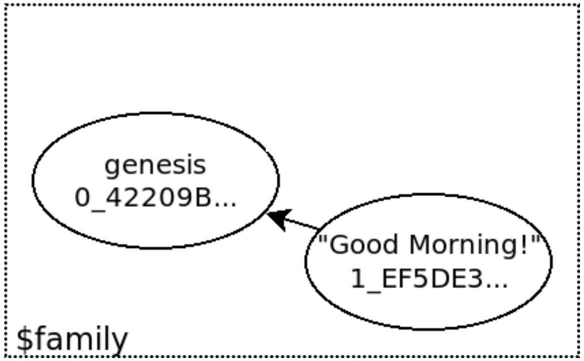
```
> freechains-host --port=8331 start '/tmp/8331/'
Freechains v0.8.4
Waiting for connections on Host(…, port=8331)...

> freechains --port=8331 crypto shared 'strong-password'
FD6C47C27F5CF6839EDE047CE7EE4285E633E26CBA929913

> freechains --port=8331 chains join '$family' FD6C47…
42209BBF280D4444E39ECEA199C23037058D4F66629D90D7BF1B8C9088B8D0ED

> freechains --port=8331 peer localhost:8330 recv '$family'
1/1

> freechains --port=8331 chain '$family' heads
1_EF5DE364B7F9C0D40550E01FB9AB510F4AFFBBD79DF54302B68B7DB2ECD3F550

> freechains --port=8331 chain '$family' get payload 1_EF5DE3…
Good Morning!
```



Forks

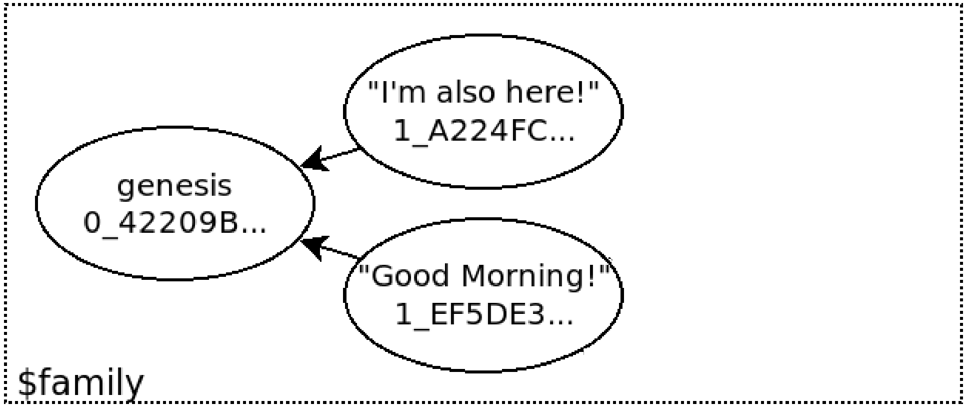
- Typical DAGs are not lists (local-first *dApps*)
  - Fundamental obstacle for consensus

```
> freechains --port=8331 chains join '$family' FD6C47…
42209BBF280D4444E39ECEA199C23037058D4F66629D90D7BF1B8C9088B8D0ED

> freechains --port=8331 chain '$family' post inline "I'm also here!"
1_A224FCA3F66E1A1CD68812AA51DCAF6699DA1ABC44561D37AB1EE1001AB429A

> freechains --port=8331 peer localhost:8330 recv '$family'
1/1
```



Likes and Dislikes

```
...

> freechains crypto pubpvt 'my-password'
328B7D… 35CA69…

> freechains chain '$family' like 1_EF5DE36… --sign=35CA69…
2_DDA222EDFD4BE333CF2017D54E91900806DF5006CAC35DFB3E97CD0690EDB22E

> freechains chain '$family' reps 1_EF5DE36…
1
```



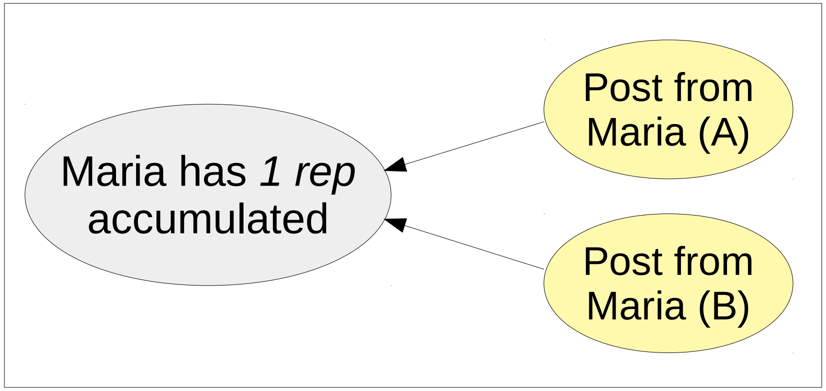
Public Forums

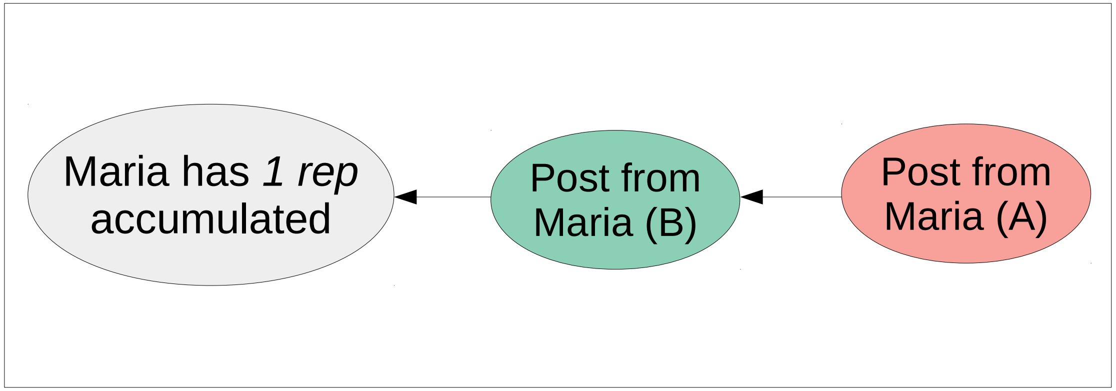
- **Permissionless** public forums
- Sybil attacks
  - generate fake IDs and disseminate SPAM
- Token *reps* to post and rate content
  - New posts expend *reps*
  - Old posts award *reps*
    - human work immune to *automation*
  - Likes & Dislikes transfer *reps*

Operation	Effect	Goal
Emission	Old posts award *reps* to author.	Encourage content authoring.
Expense	New posts deduct *reps* from author temporarily.	Discourage excess of content.
Tranfer	Likes & dislikes transfer *reps* between authors.	Highlight content of quality. Combat abusive content.

Reputation & Consensus

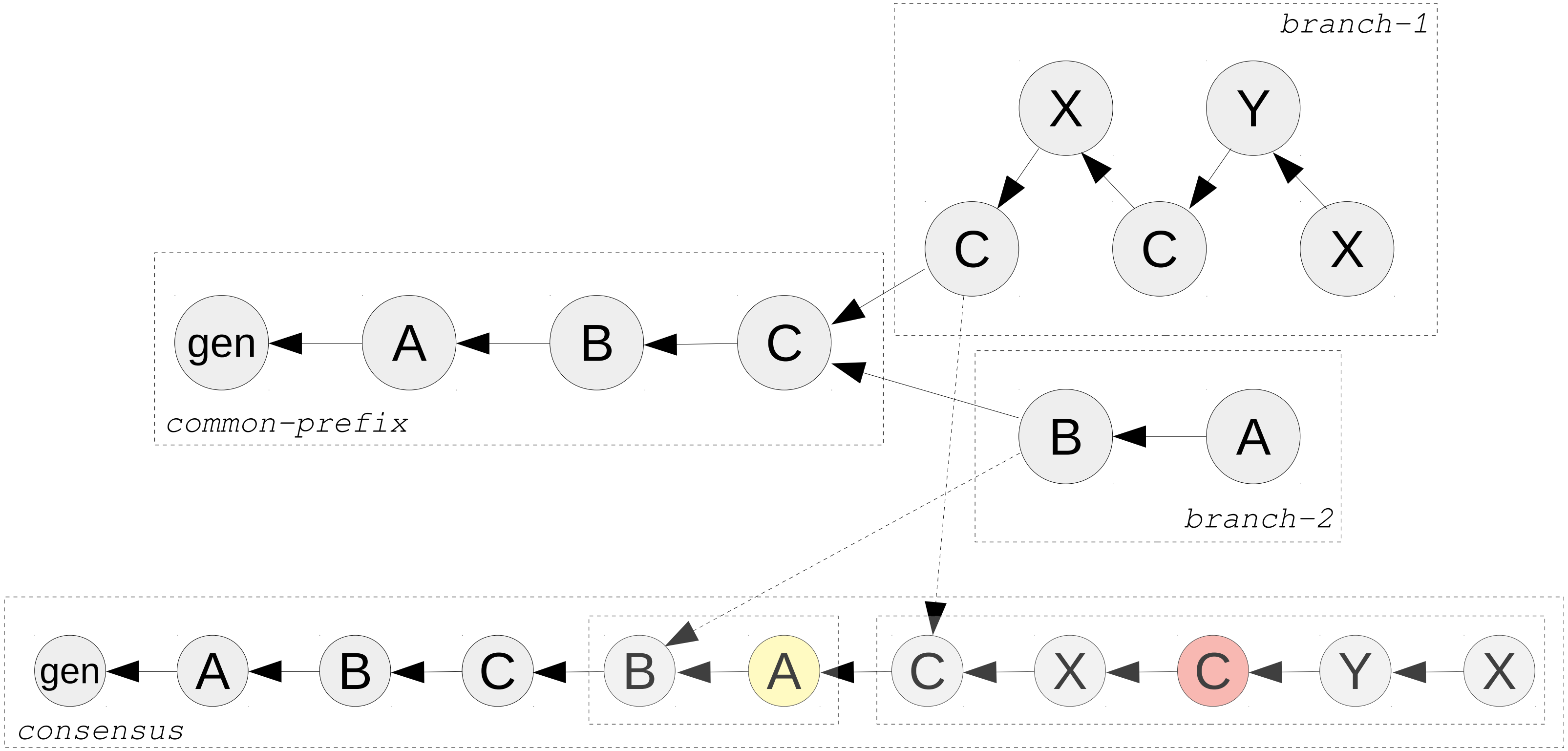
- Scarce operations are not yet sufficient
  - ✓ Sybils
  - ✗ Conflicting operations (double spend)
- Need for consensus
  - But how to determine a total order among messages?





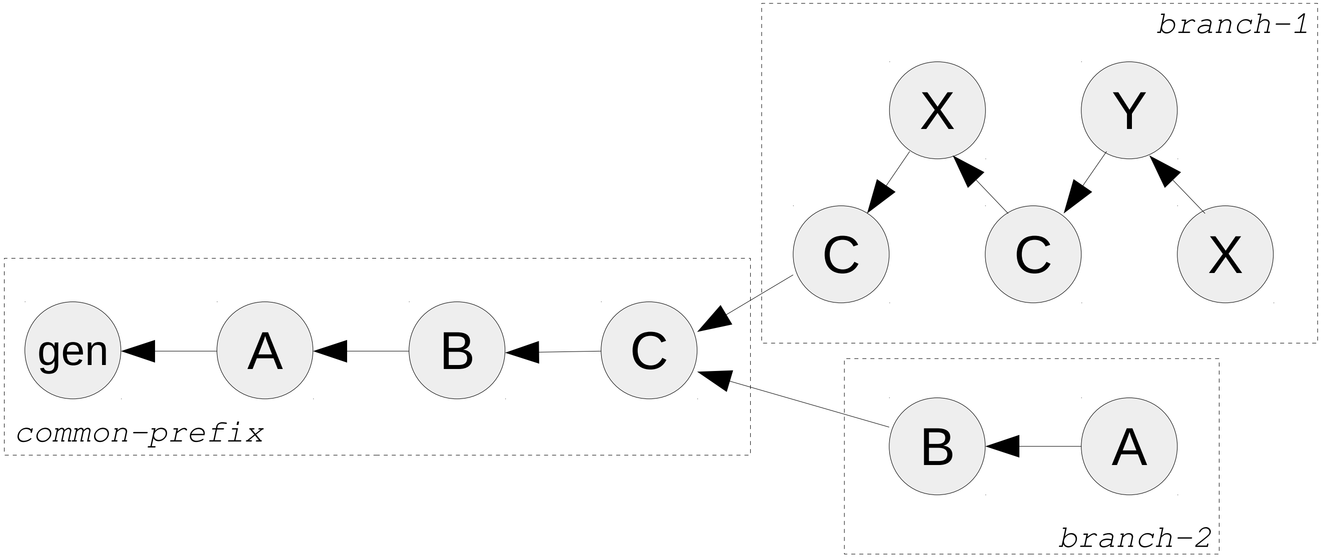
Consensus Criteria

- Favor branches with more reputation
  - `c-prefix`: `reps(A)+reps(B) > reps(C)`
  - `branch-1`: C high activity
  - `branch-2`: A/B low activity



Consensus Criteria

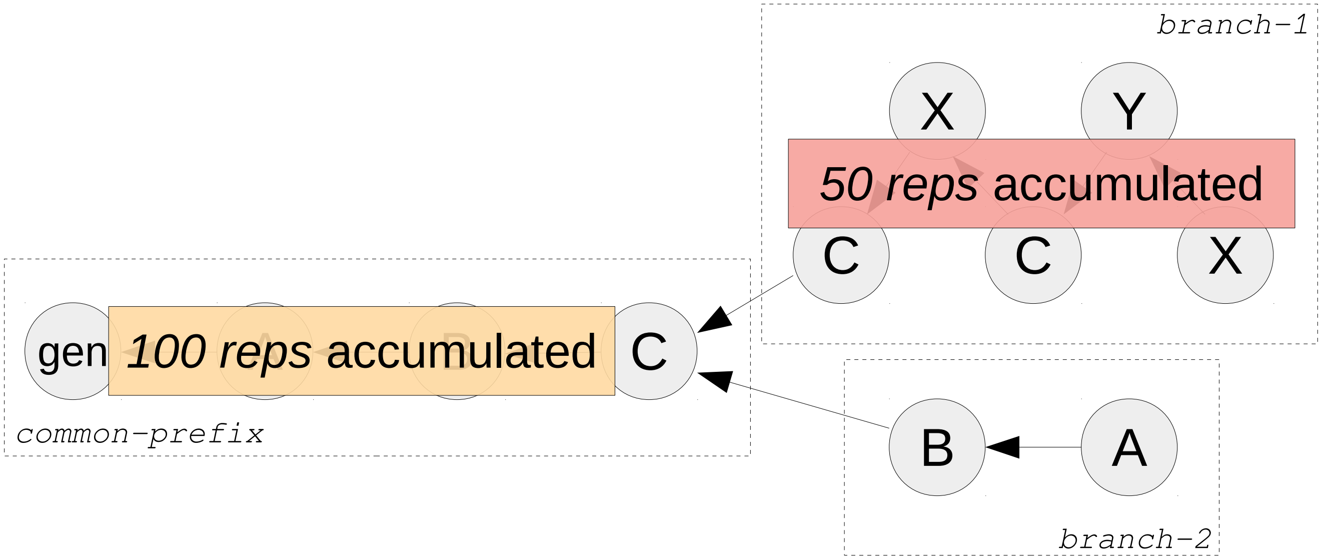
- Favor branches with more reputation
- Blocks after a failure “never existed”
- Peers may need to reorder blocks
- What if `branch-1` is legit?



Consensus Criteria

a) Branch with more reputation is ordered first

b) Hard fork if other branch has 50%+ reputation



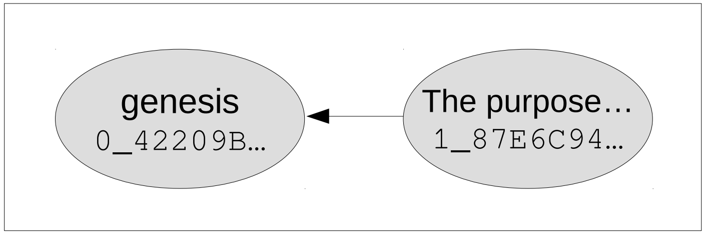
Freechains – Public Forums

Operation	Effect	Goal
Emission	Old posts award *reps* to author.	Encourage content authoring.
Expense	New posts deduct *reps* from author temporarily.	Discourage excess of content.
Tranfer	Likes & dislikes transfer *reps* between authors.	Highlight content of quality. Combat abusive content.

Emission	1.a	pioneers	*+30 reps* to pioneers
	1.b	old post	*+1 rep* to author (>24h)
Expense	2	new post	*-1 rep* to author (0-12h)
Tranfer	3.a	like	*-1 rep -> +1 rep*
	3.b	dislike	*-1 rep -> -1 rep*
Constraints	4.a	min	+1 rep to post
	4.b	max	+30 reps max
	4.c	size	128Kb max

Demo – Public Forum

```
> freechains crypto pubpvt 'pioneer-password'
ADB56B… CBBA77…

> freechains chains join '#forum' ADB56B…
42209BBF280D4444E39ECEA199C23037058D4F66629D90D7BF1B8C9088B8D0ED

> freechains chain '#forum' post --sign=CBBA77… \
    inline 'The purpose of this chain is...'
1_87E6C94F232F7182B6E1DF3ACE48DAC08BA999A7CEA3A4FF08DED9AA18C78FE2
```



```
Pioneer: 30 reps  (1.a)
         29 reps  (2)
         30 reps  (2)
```

Emission	1.a	pioneers	*+30 reps* to pioneers
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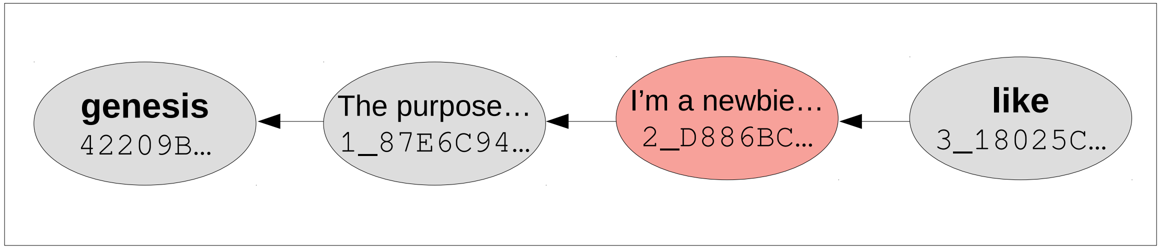
```
> freechains crypto pubpvt 'new-author-password'
5DCF47… EFA735…

> freechains chain '#forum' post --sign=EFA735… \
    inline "I'm a newbie..."
2_D886BC6DDD6343BB7A01B33270158BE45DE47358B48CF7C2F46D5EAEE8D52806

> freechains chain '#forum' like 2_D886BC… --sign=CBBA77…
3_18025C6A9FDC322762EF9BA8A3B1D24973D2271077F9777D4645D5B6F435BBA8
```



```
Pioneer: 30 reps
         29 reps   (3.a)
         30 reps   (1.b)
Newbie:   0 reps
         -1 reps   (2)
          0 reps   (3.a)
          1 reps   (2)
          2 reps   (1.b)
```

Emission	1.a	pioneers	*+30 reps* to pioneers
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Expense	2	new post	*-1 rep* to author (0-12h)
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Constraints	4.a	min	+1 rep to post
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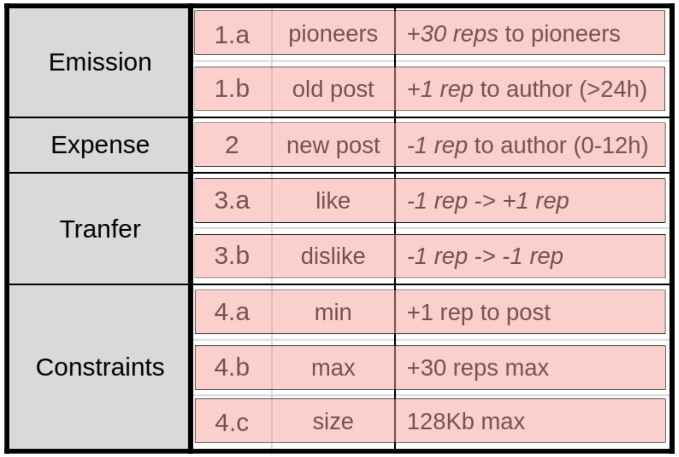
Reputation System

- Rule **pioneers (1.a)** bootstraps chains
- Rule ***old post (1.b)*** stimulates authoring
- Rule ***new post (2)*** prevents SPAM with dynamic cost
- Rule ***like (3.a)*** welcomes new users at a cost
- Rule ***dislike (3.b)*** censors abusive content
- Rule ***min (4.a)*** blocks Sybils
- Rule ***max (4.b)*** stimulates rating and decentralization
- Rule ***size (4.c)*** prevents DDoS



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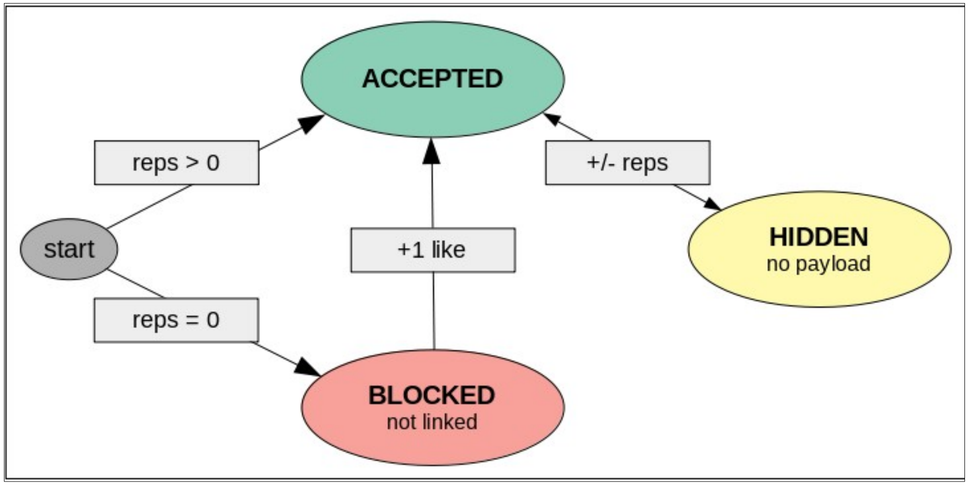
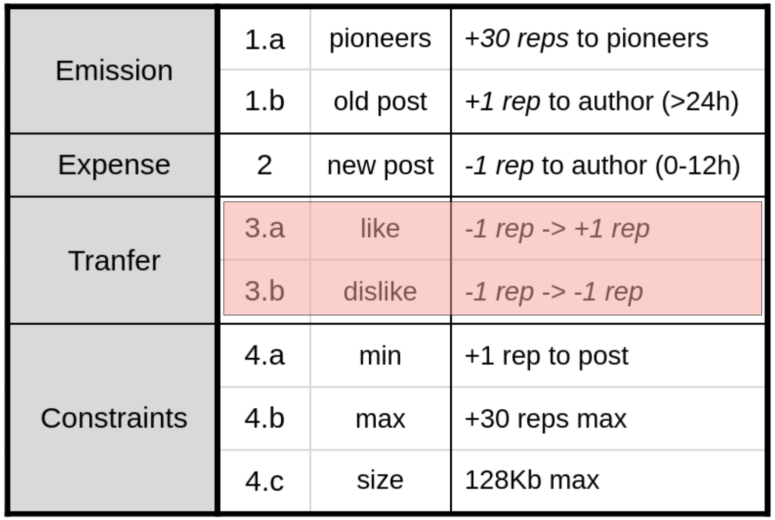
Likes & Dislikes

1. Welcoming new users
2. Measuring quality of posts
3. Censoring abuse (SPAM, fake news, etc)

- Post is hidden with at least 3 dislikes and less likes





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Reputation & Consensus

- P2P permissionless consensus based on reputation
- Reputation:
  - Generation is expensive
  - Verification is cheap (and distributed)
- Consensus:
  - Human authoring ability as a scarce resource
  - vs extrinsic resources (dispendious, opaque, oddly distributed)

Contributions

- Make decentralized public forums viable
  - Reputation & Consensus mechanism
  - Depends exclusively on human work
  - Any system that structure messages as DAGs
  - Supports local-first software
  - *Freechains* peer-to-peer system

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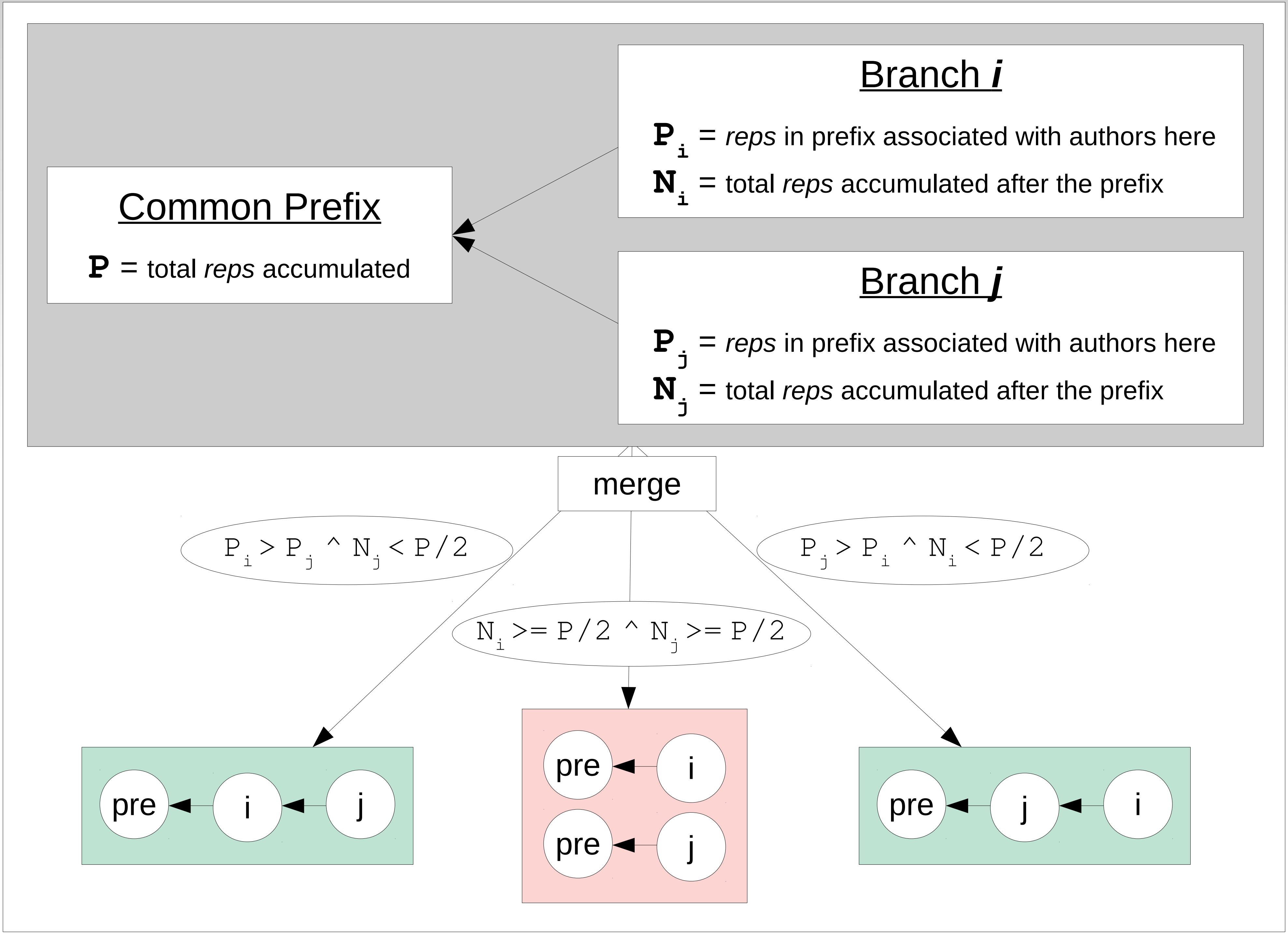


Common Prefix

$\mathbf{P}$ = total *reps* accumulated

Branch *i*

$\mathbf{P}_i$ = *reps* in prefix associated with authors here

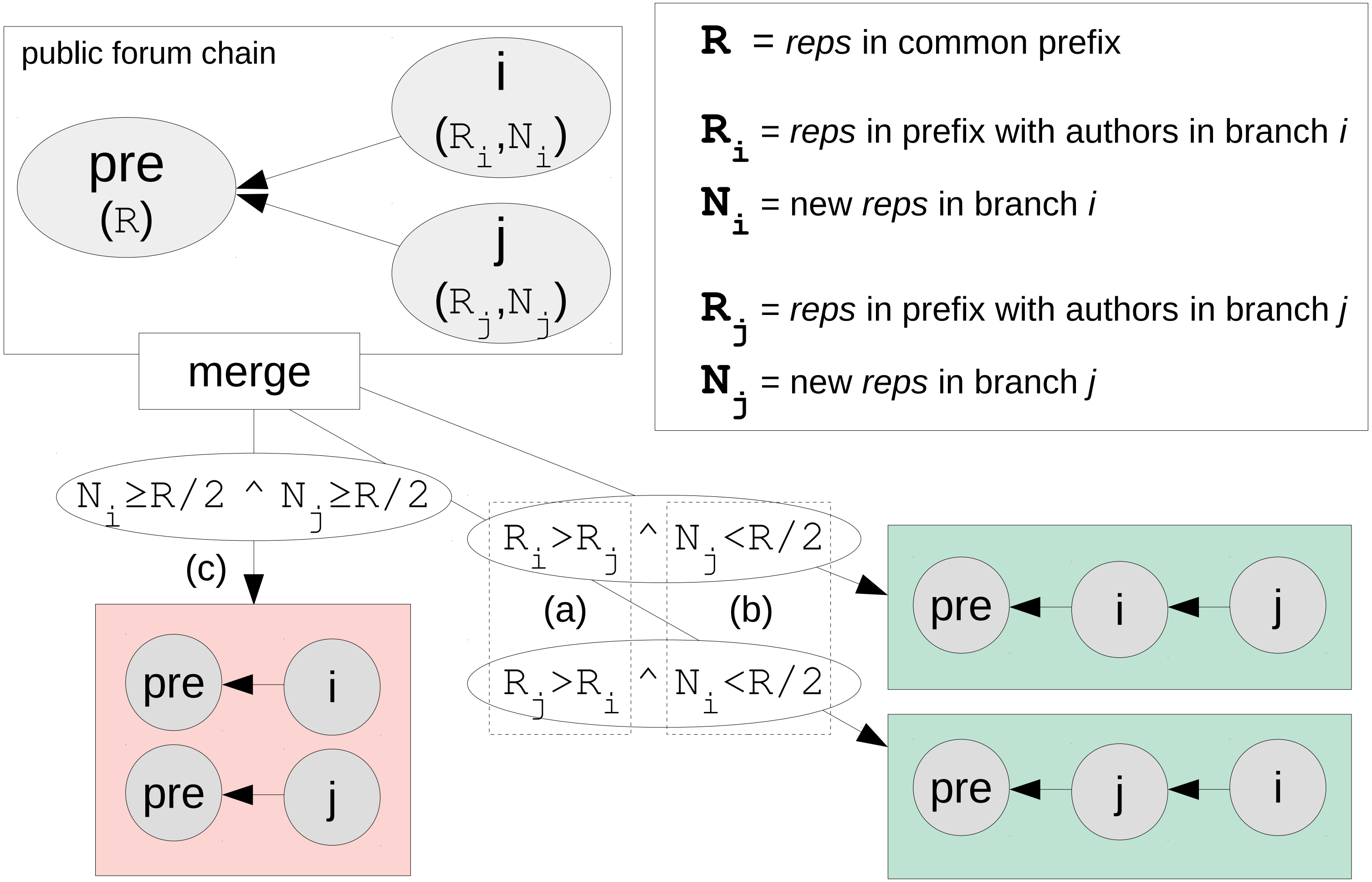
$\mathbf{N}_i$ = total *reps* accumulated after the prefix

Branch *j*

$\mathbf{P}_j$ = *reps* in prefix associated with authors here

$\mathbf{N}_j$ = total *reps* accumulated after the prefix

merge
$P_i > P_j \wedge N_j < P/2$
$N_i >= P/2 \wedge N_j >= P/2$
$P_j > P_i \wedge N_i < P/2$
pre
i
j
pre
i
pre
j
pre
j
i



R = *reps* in common prefix

$\mathbf{R_i}$ = *reps* in prefix with authors in branch *i*

$\mathbf{N_i}$ = new *reps* in branch *i*

$\mathbf{R_j}$ = *reps* in prefix with authors in branch *j*

$\mathbf{N_j}$ = new *reps* in branch *j*