

# DClaims: A Censorship Resistant Web Annotations System

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Thesis to obtain the Master of Science Degree in  
**Information Systems and Computer Engineering**



## **Supervisors**

Prof. Nuno Miguel Carvalho Santos

Eng. David Miguel dos Santos Dias

- **Motivation**
- DClaims
  - Web Annotations
  - IPFS
  - Ethereum
  - Architecture
  - Implementation
- Demo
- Evaluation
- Project Outreach
- Conclusion

# Roadmap

## Roadmap

- **Motivation**
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# Motivation

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**People** use the web as one of their primary sources of information.

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**Often**, this information is  
Unreliable, Incomplete, False,  
Taken out of context.

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There are some efforts to **fix** this!

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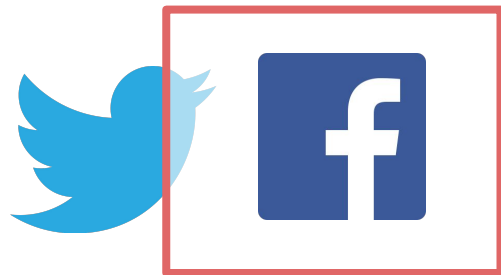
People use **comments** of their peers, or **websites**, to evaluate the statements in news articles.



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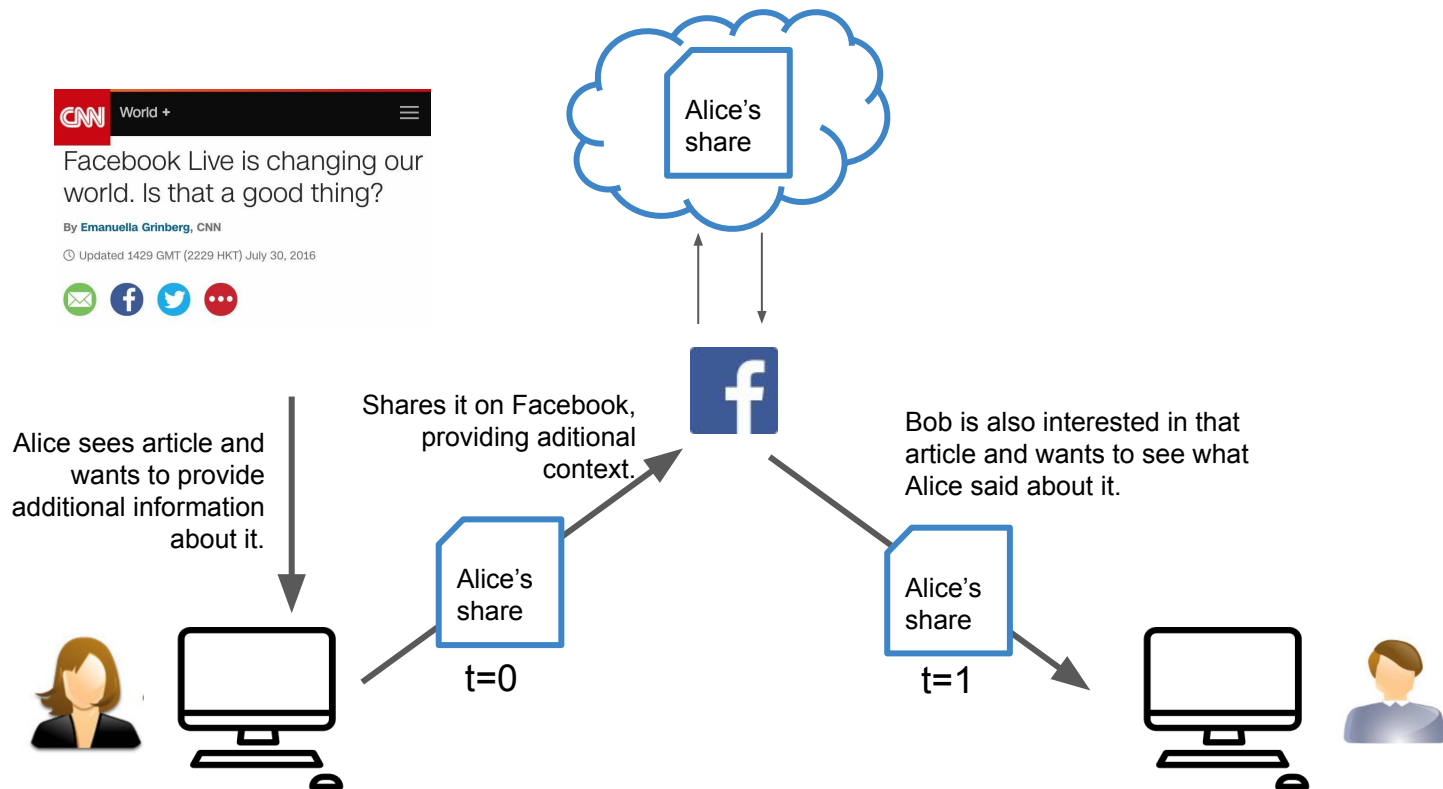
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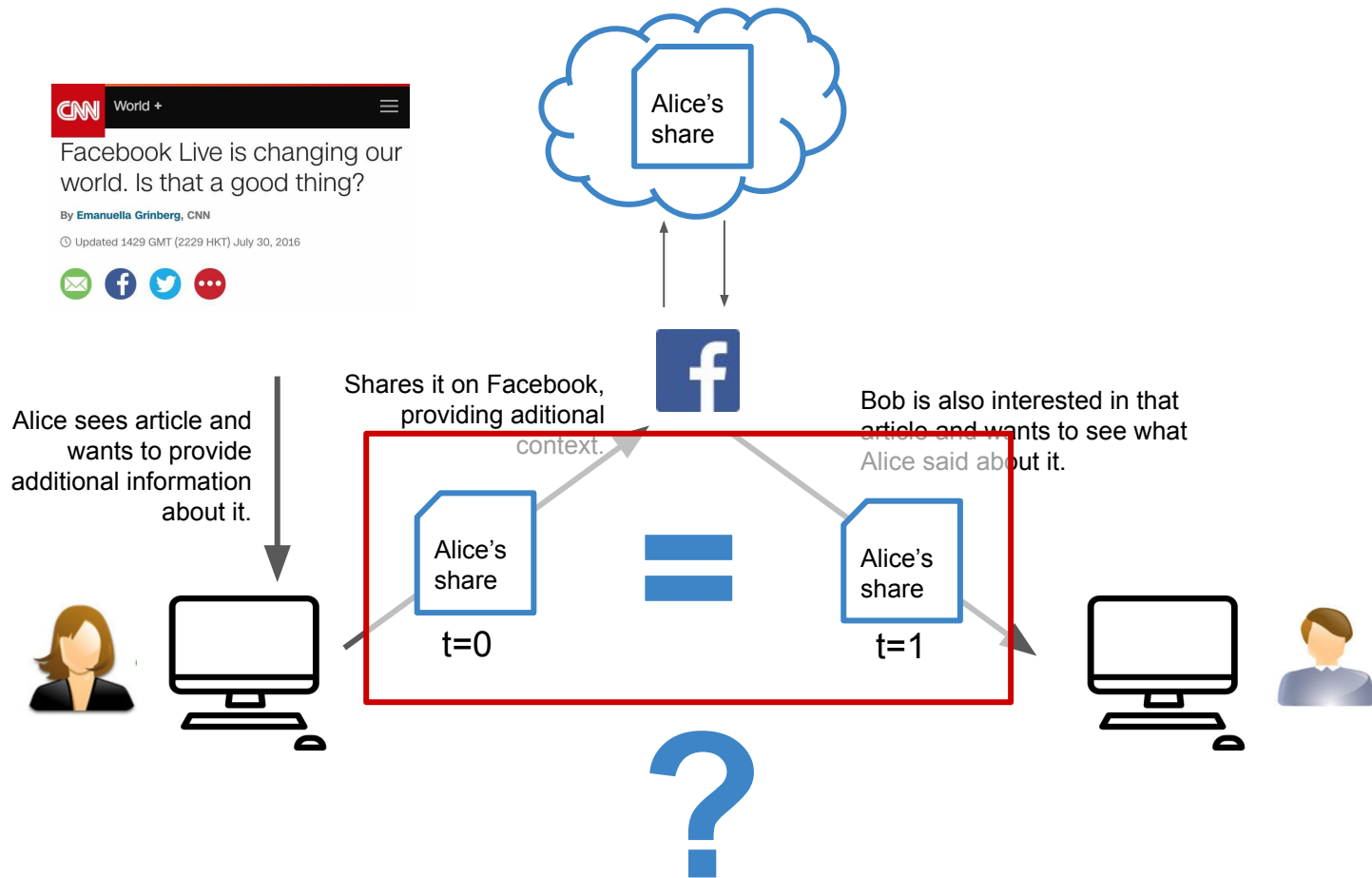
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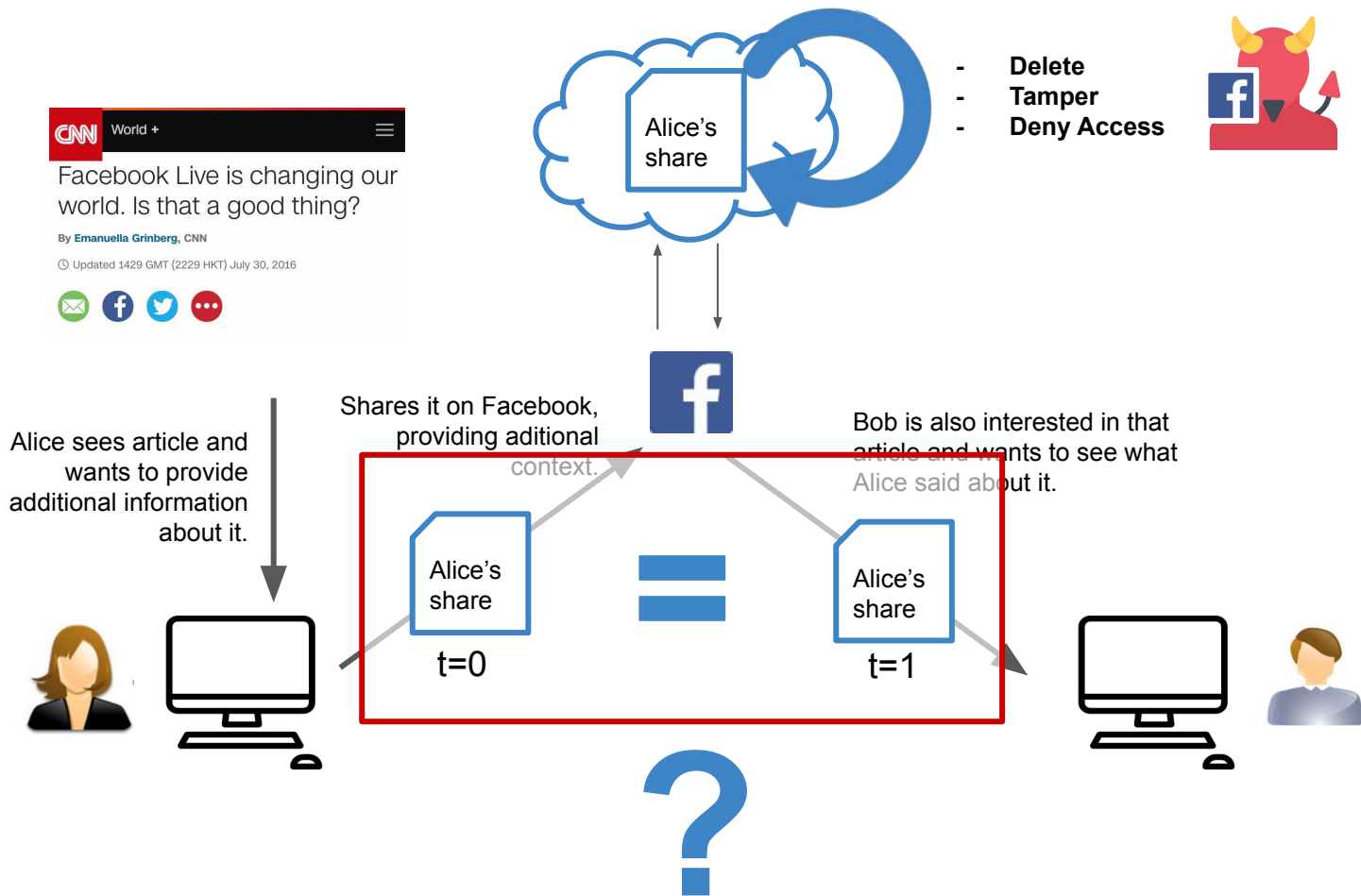
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## - Motivation

## - DClaims

### - Web Annotations

### - IPFS

### - Ethereum

### - Architecture

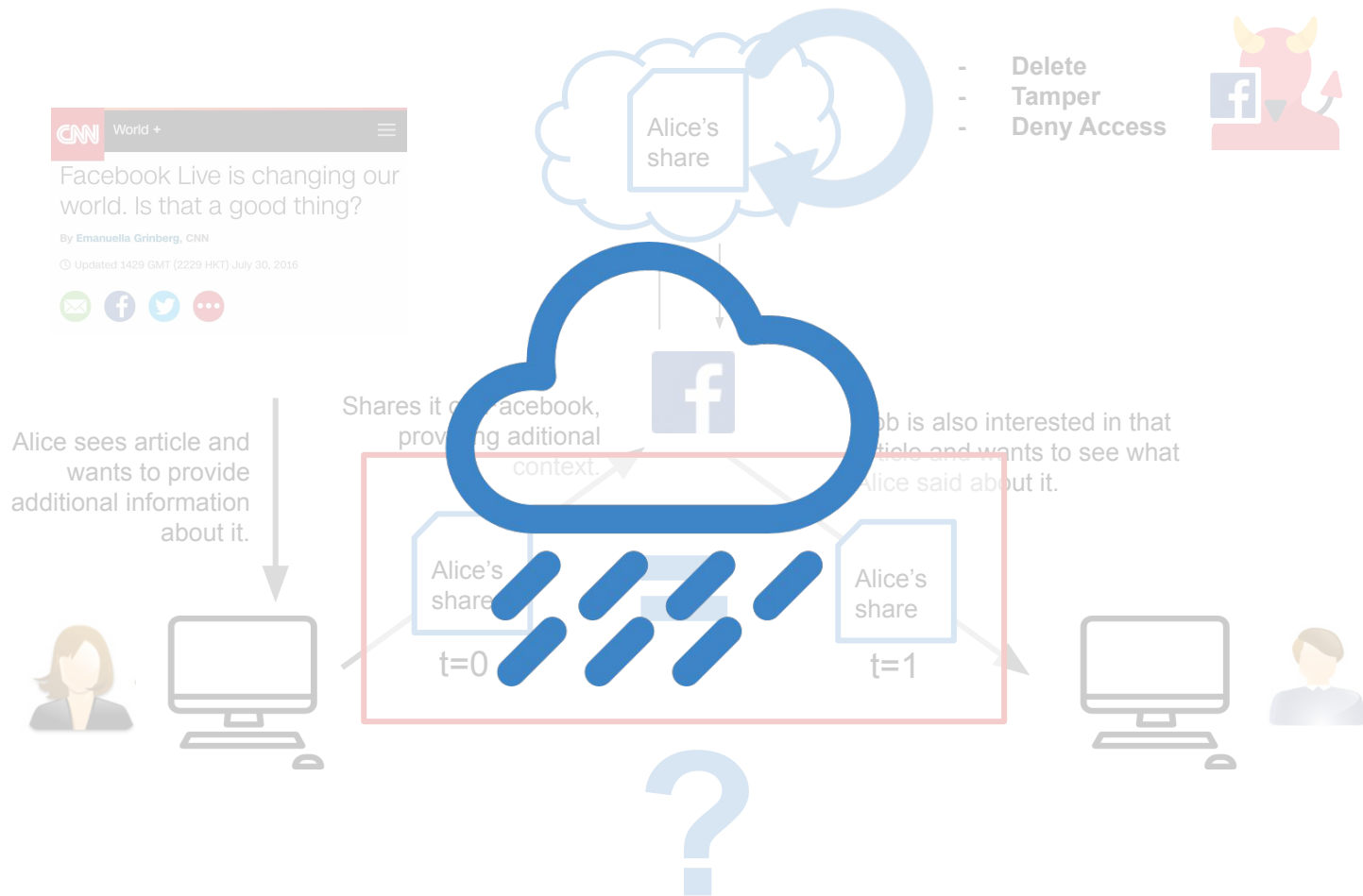
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## - Demo

## - Evaluation

## - Project Outreach

## - Conclusion



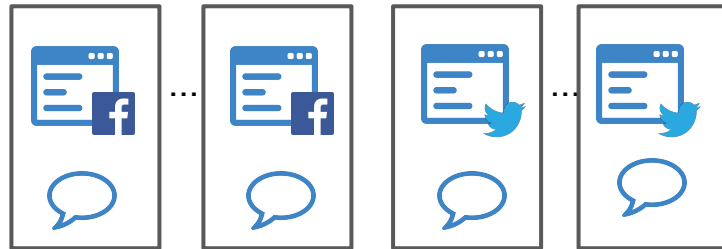
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## Dispersion of information



Original BBC-News  
article

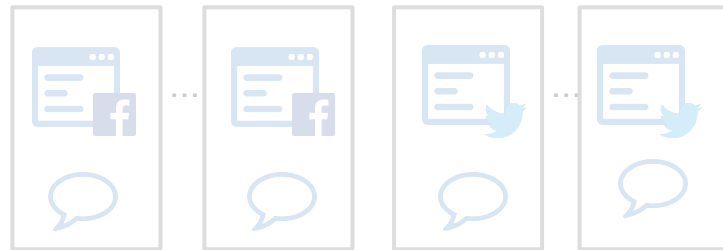


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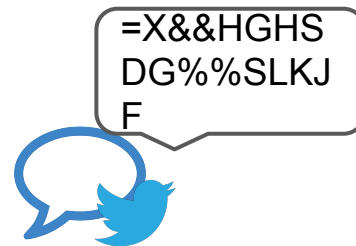
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Original BBC-News  
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Incompatibility

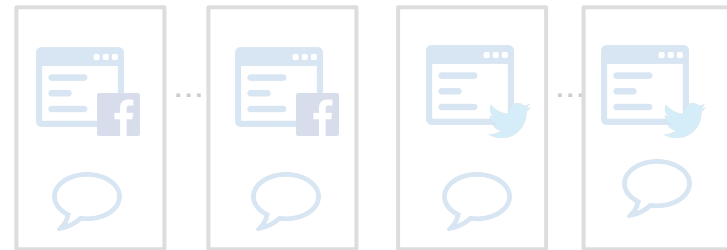


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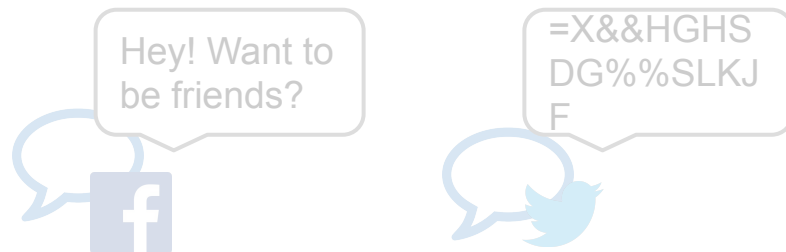
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**Dispersion  
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Original BBC-News  
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**Incompatibility**



**Centralized  
storage**



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Dispersion  
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## Genius lets you add **line-by-line** to any page on the Internet

### Annotate every web page

You can [install our Chrome extension](#), so Genius is with you everywhere you go. Or you can use [our Bookmarklet](#).

### Enable annotation on your own site

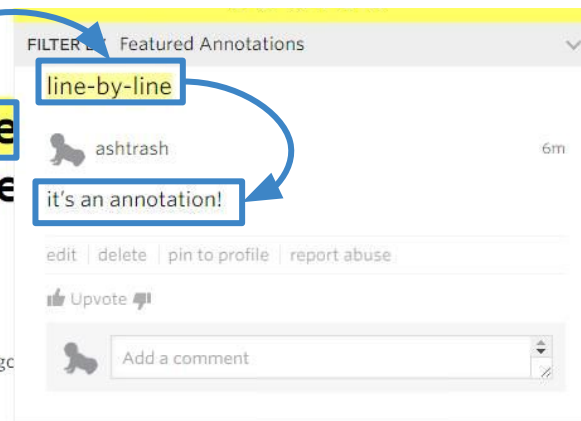
If you're a publisher, you can install a simple line of javascript to Genius-activate your

```
<script async src="//genius.codes"></script>
```

If your site runs on WordPress, make your posts annotatable with our [WordPress Plugin](#).

### Share annotated pages with everyone, no extension needed

Put [genius.it/](#) in front of any URL to annotate and read other Genius annotations on it. You don't need to download anything!



any page

ashtrash

Second annotation.

edit delete pin to profile report abuse

Upvote

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# DClaims

## A Censorship-Resistant Social Commentary System

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# Contributions

- DClaims: Censorship Resistant Social Commentary System
  - Web Annotations
  - IPFS
  - Ethereum
- Complete Implementation of the System
  - With support for real news websites
- Experimental Evaluation
  - User friendly
  - Efficient
  - Cost effective

## Roadmap

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## Builds upon three building blocks:

- Web Annotations
- IPFS
- Ethereum

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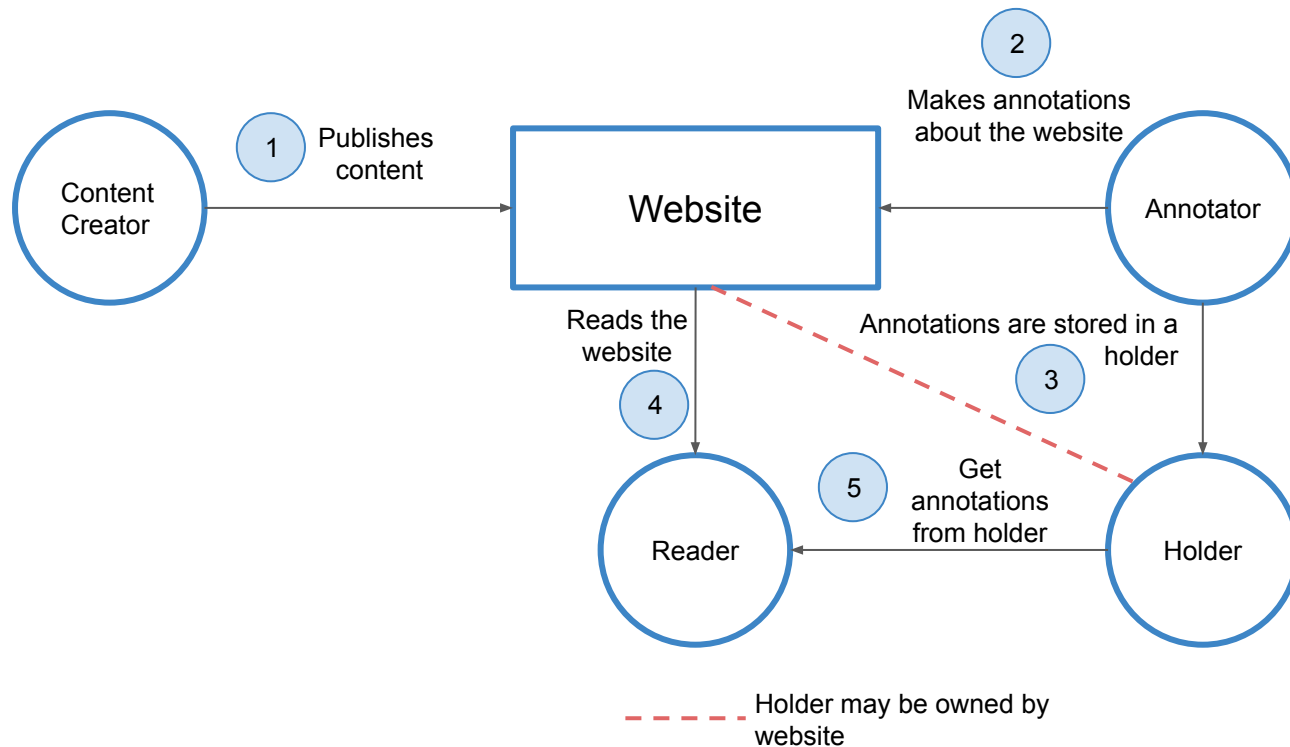
# Web Annotations

A new way to interact with the Web!

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## Web Annotations basic flow



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## Dispersion of information

Information is displayed  
directly on the **original**  
webpage

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## Dispersion of information

Information is displayed  
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## Incompatibility

The data format is a  
W3C **standard**



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## Dispersion of information

Information is displayed  
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## Incompatibility

The data format is a  
W3C **standard**



## Centralized storage

Data is stored in servers  
controlled by the Web  
Annotations service

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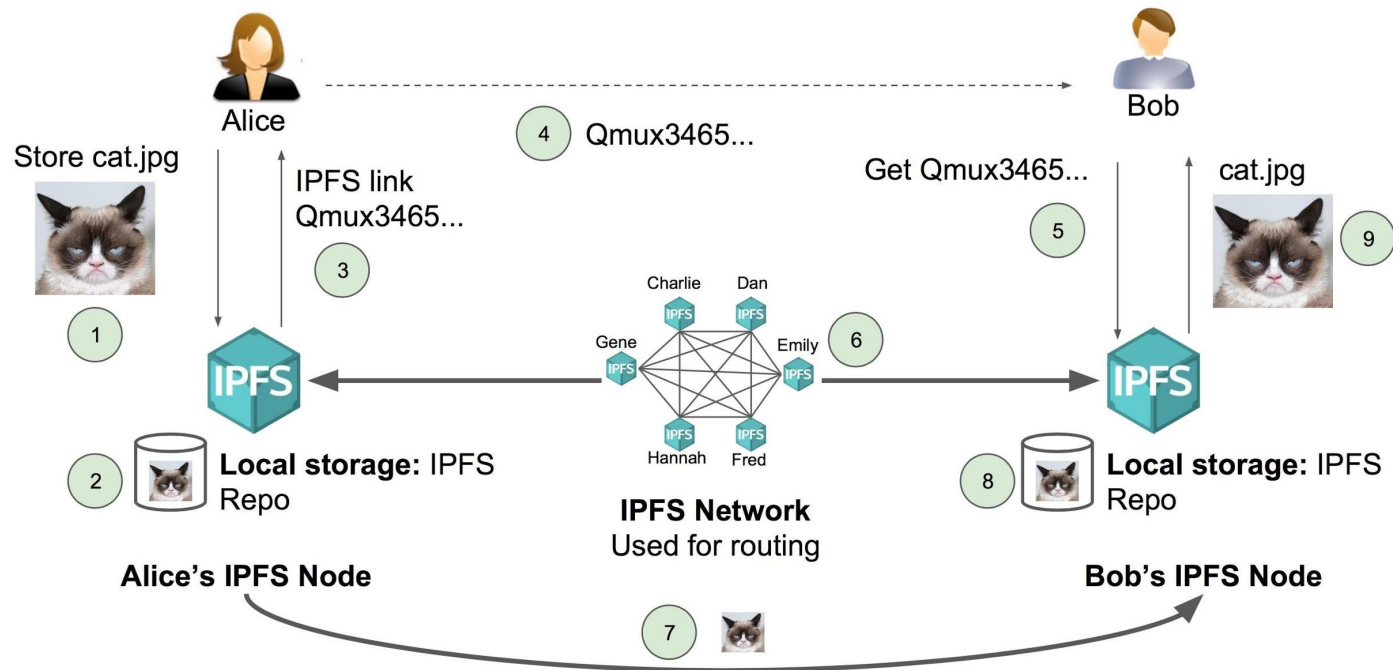
# IPFS + Ethereum

Decentralize transport and storage

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# IPFS



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# Ethereum

- Peer-to-peer network, which **maintains a state**.

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# Ethereum

- Peer-to-peer network, which **maintains a state**.
- The state is agreed upon by all nodes, through a **consensus protocol**, which implements game theory principles to **force nodes to be well-behaved**.

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# Ethereum

- Peer-to-peer network, which **maintains a state**.
- The state is agreed upon by all nodes, through a **consensus protocol**, which implements game theory principles to **force nodes to be well-behaved**.
- The **maintained state is a 256-bit virtual machine**, called Ethereum Virtual Machine (EVM).

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# Ethereum

- Peer-to-peer network, which **maintains a state**.
- The state is agreed upon by all nodes, through a **consensus protocol**, which implements game theory principles to **force nodes to be well-behaved**.
- The **maintained state is a 256-bit virtual machine**, called Ethereum Virtual Machine (EVM).
- Anyone can write **smart-contracts** (computer programs), which are run on the EVM in exchange for small fees, payed in Ether (the native currency of the Ethereum blockchain). **Ethereum is a world-computer**.

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# Censorship Resistance



- Logically **decentralised**
- Does not need **DNS** or rely on **CAs**
- **Only one node** needs to have the content
- All files are cryptographically **verified**



ethereum

- **Decentralised**
- **Trustless**
- Event ordering => **Freshness**



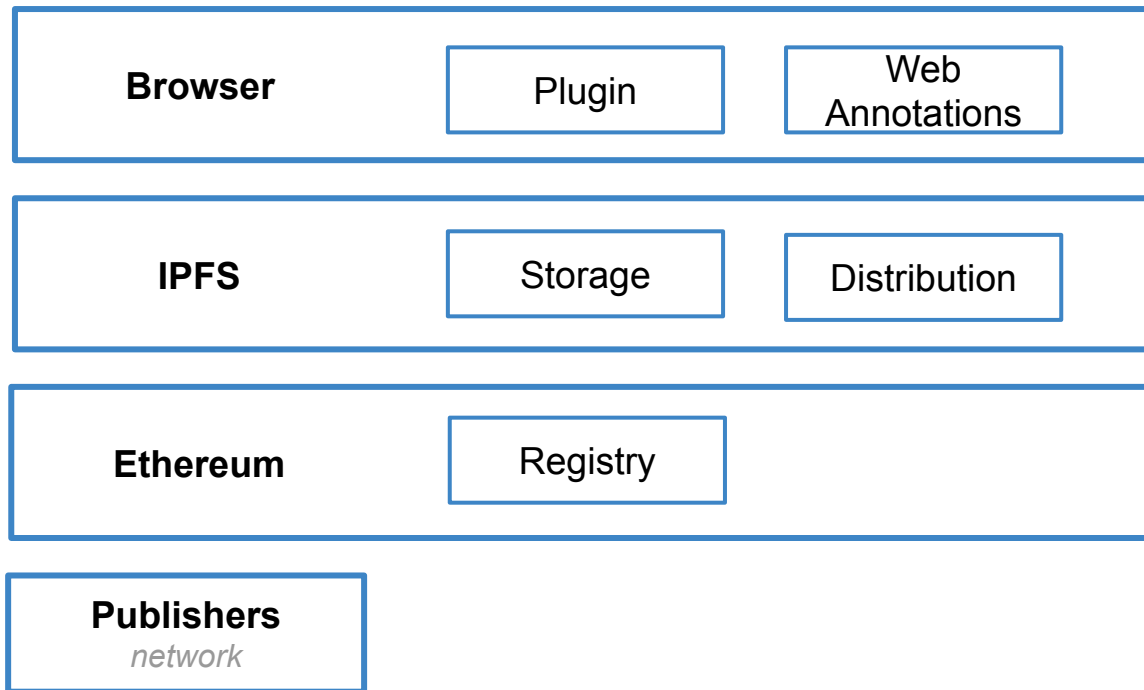
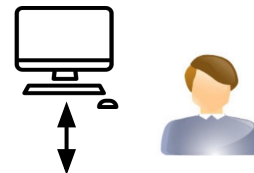
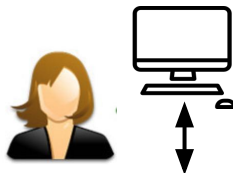
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# DClaims System Architecture

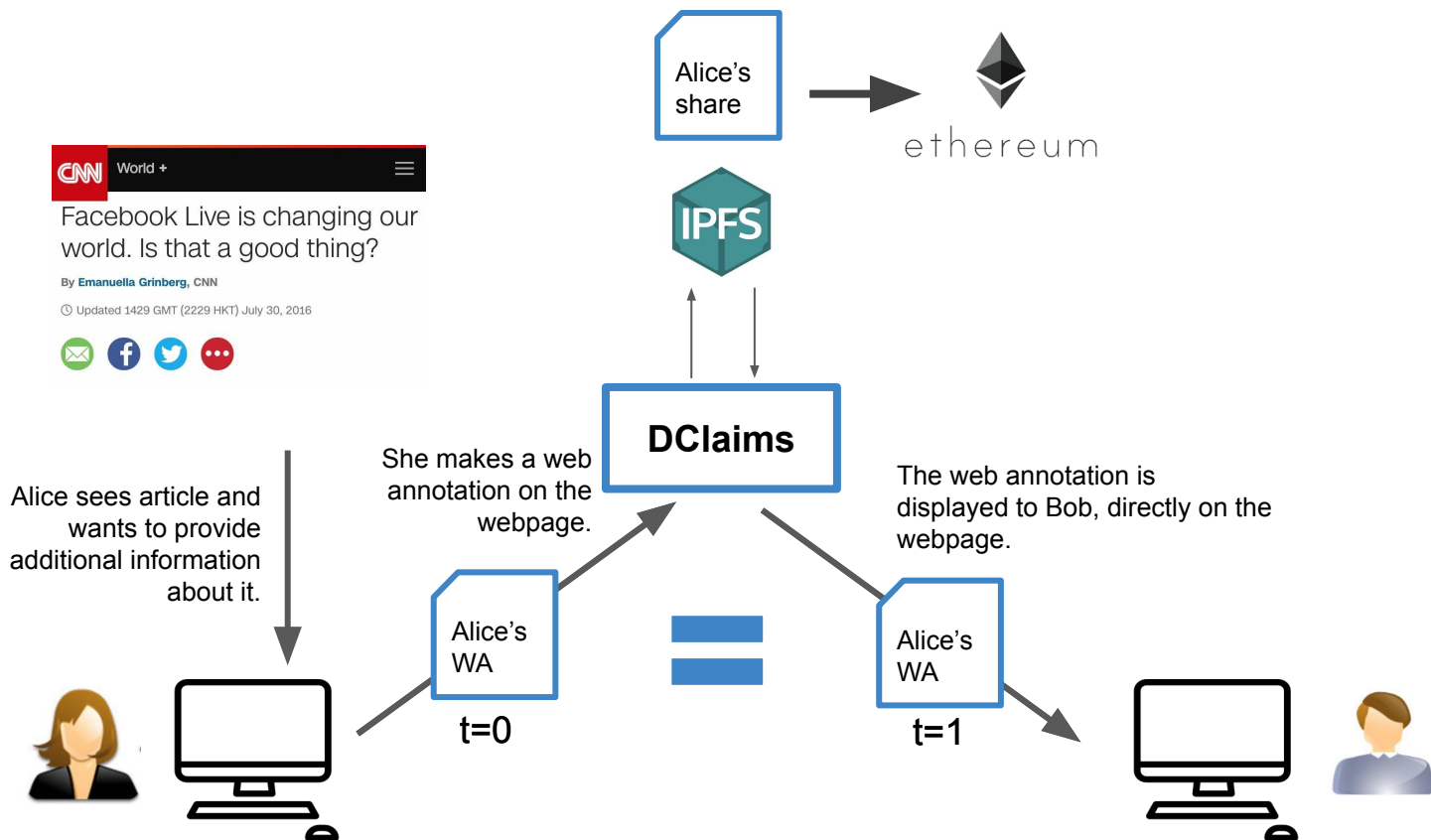
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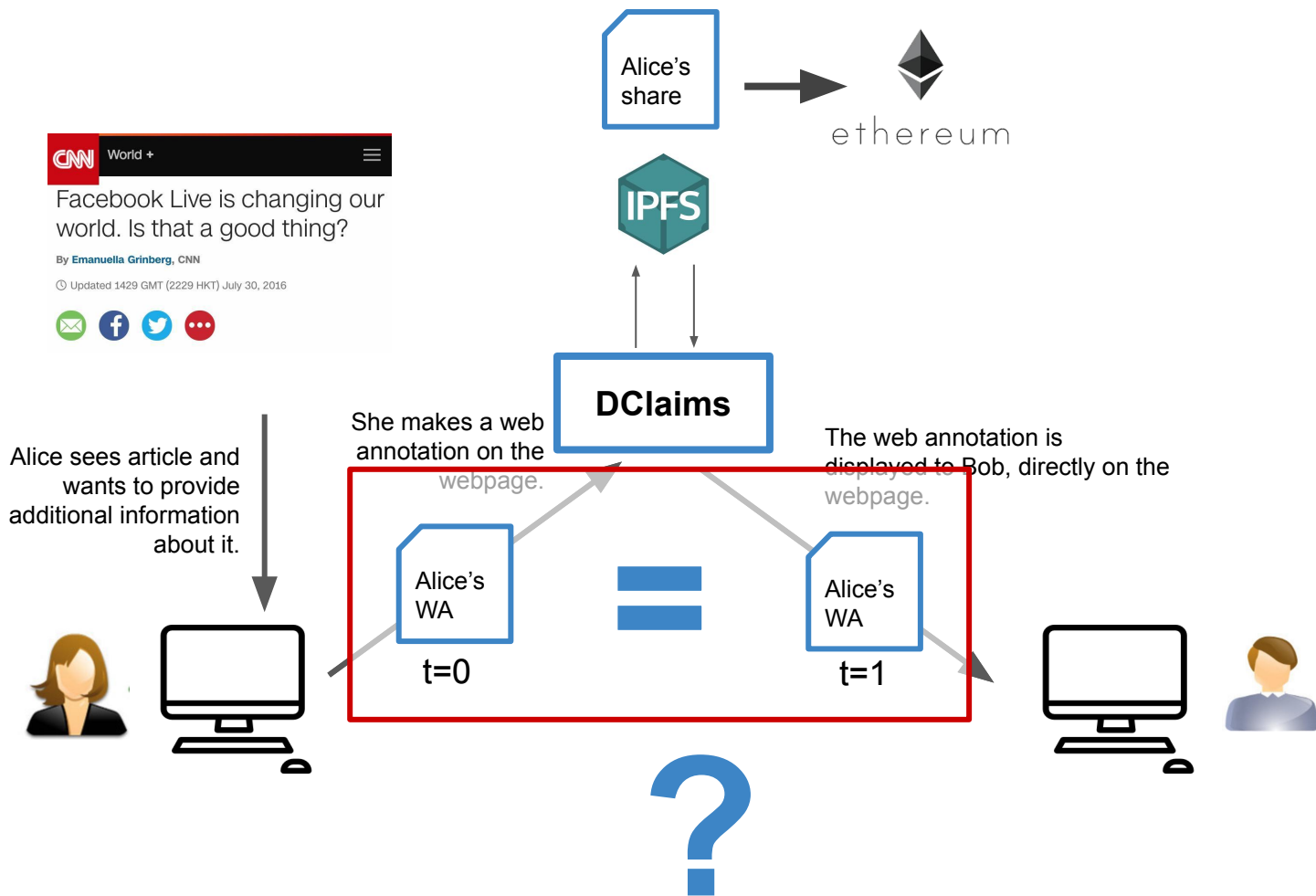
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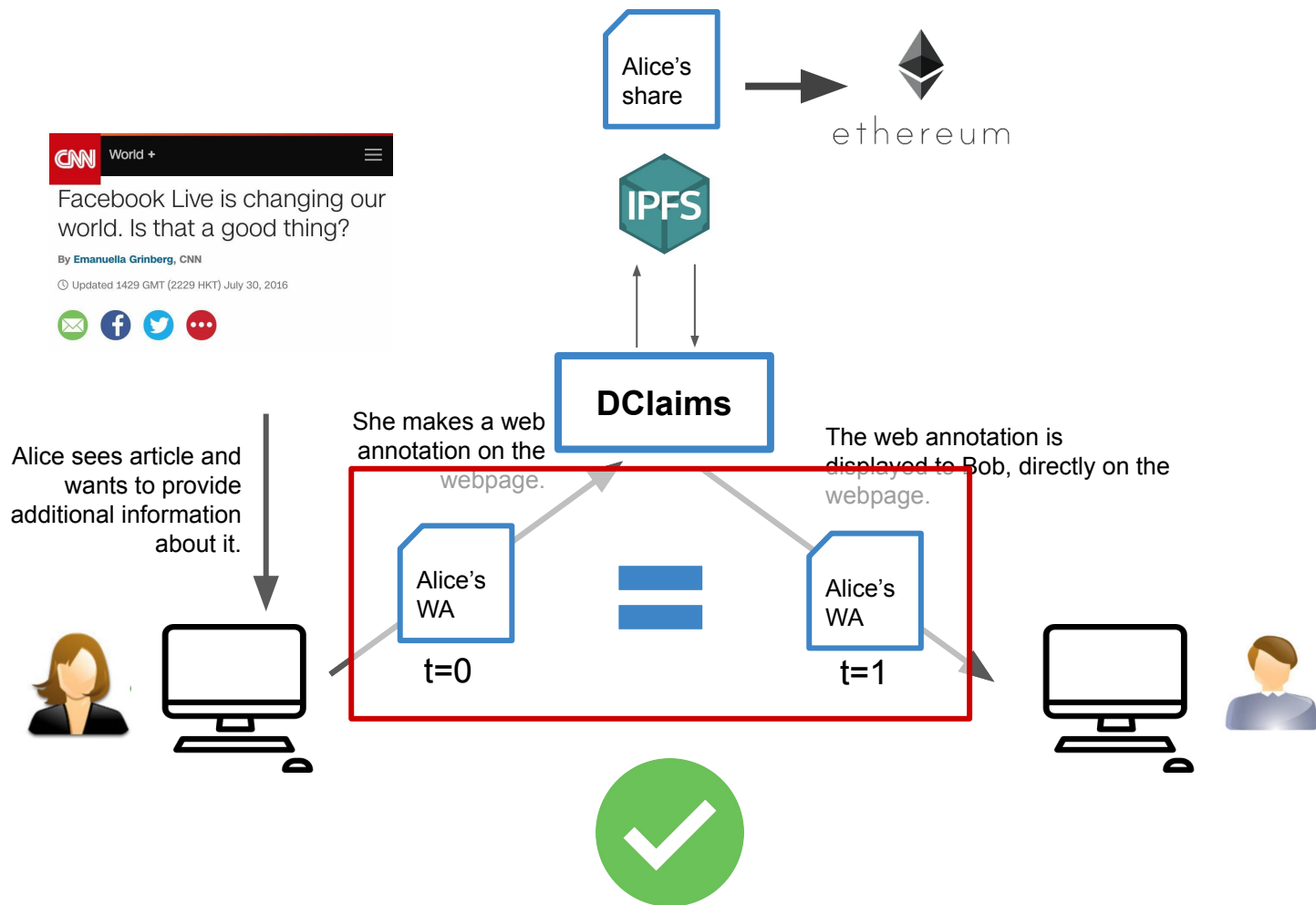
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**But this is oversimplified.**

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All the users need to run their own IPFS nodes **at all times!**



All the users need to pay for the Ethereum transactions...



This generates a lot of Ethereum transactions, which is a **bottleneck**, and **expensive!**

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All the users need to run their own IPFS nodes **at all times!**

## Solution:



All the users need to pay for the Ethereum transactions.

## The Publisher Network

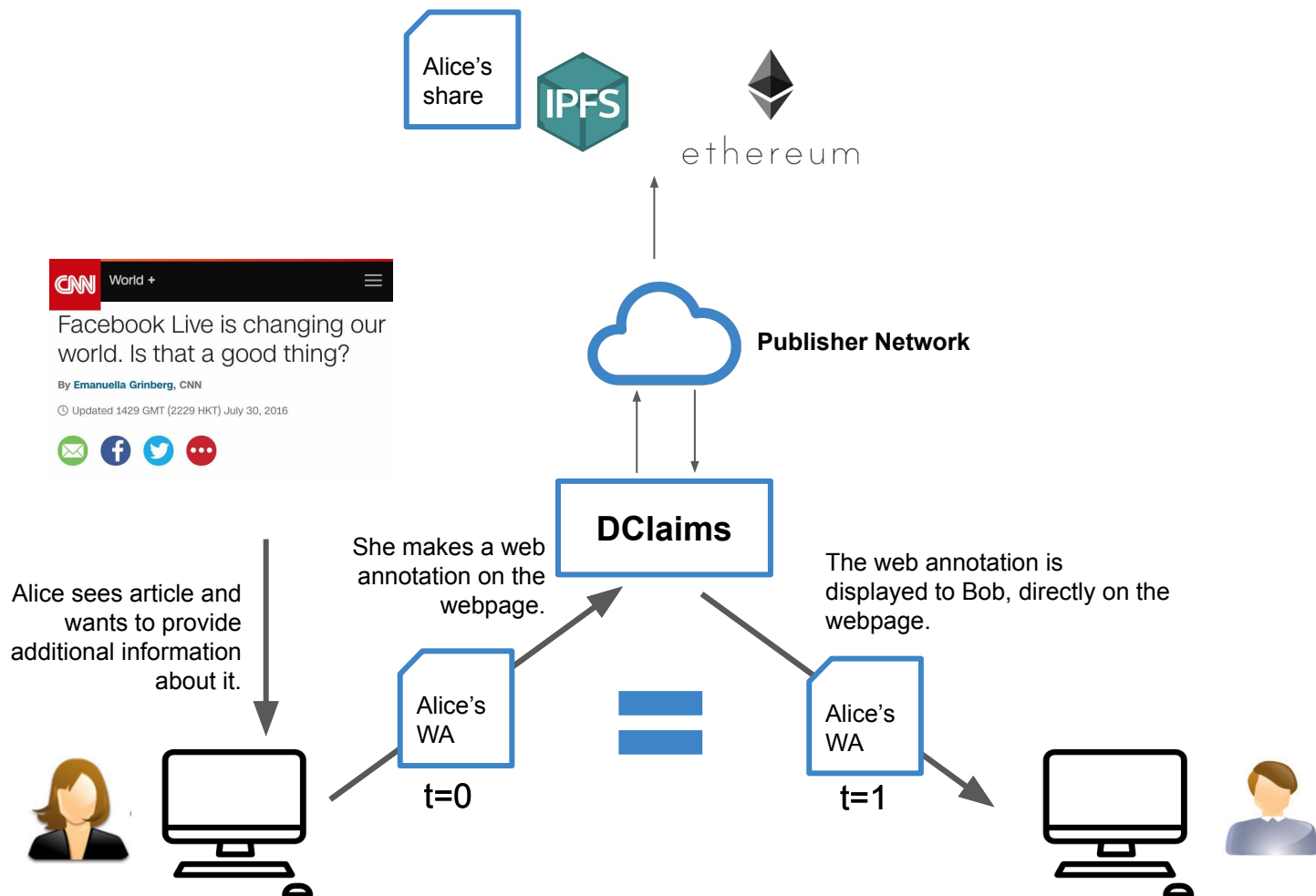


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All the users need to run their own IPFS nodes **at all times!**



Publishers run their **own** IPFS nodes, which **replicate** all the web annotations.



All the users need to pay for the Ethereum transactions...



This generates a lot of Ethereum transactions, which is a **bottleneck**, and **expensive!**

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All the users need to run their own IPFS nodes **at all times!**



Publishers run their **own** IPFS nodes, which **replicate** all the web annotations.



All the users need to pay for the Ethereum transactions...



Publishers buffer web annotations for the same websites, and issue them all at once.

- **Reduces** the number of transactions
- **Reduces** the overall **cost**



This generates a lot of Ethereum transactions, which is a **bottleneck**, and **expensive!**

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# Implementation

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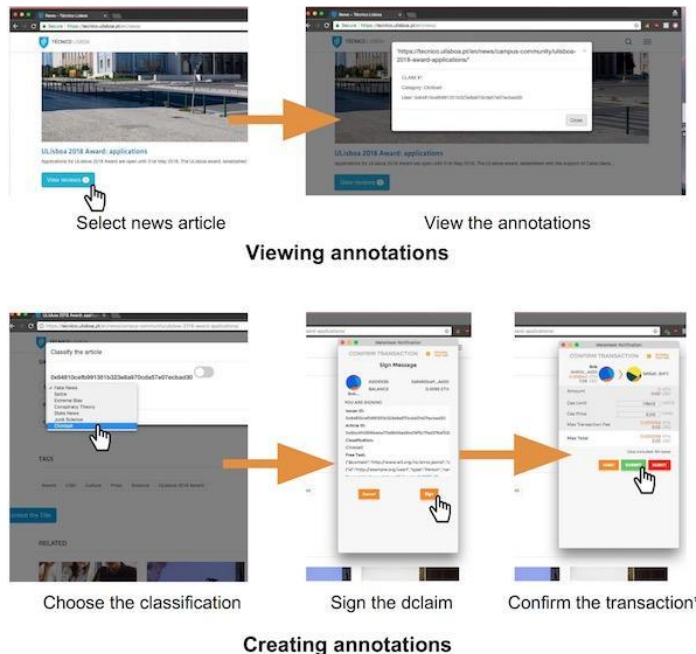
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## Implementation

- Ethereum Smart-Contract
- Backend: Publisher network
- Frontend: Browser Extension

## Software Stack

- Solidity (smart-contract)
- Node.js, Geth (backend)
- Javascript, Webpack (frontend)
- AWS EC2, Ansible, Vagrant, Docker (testing)

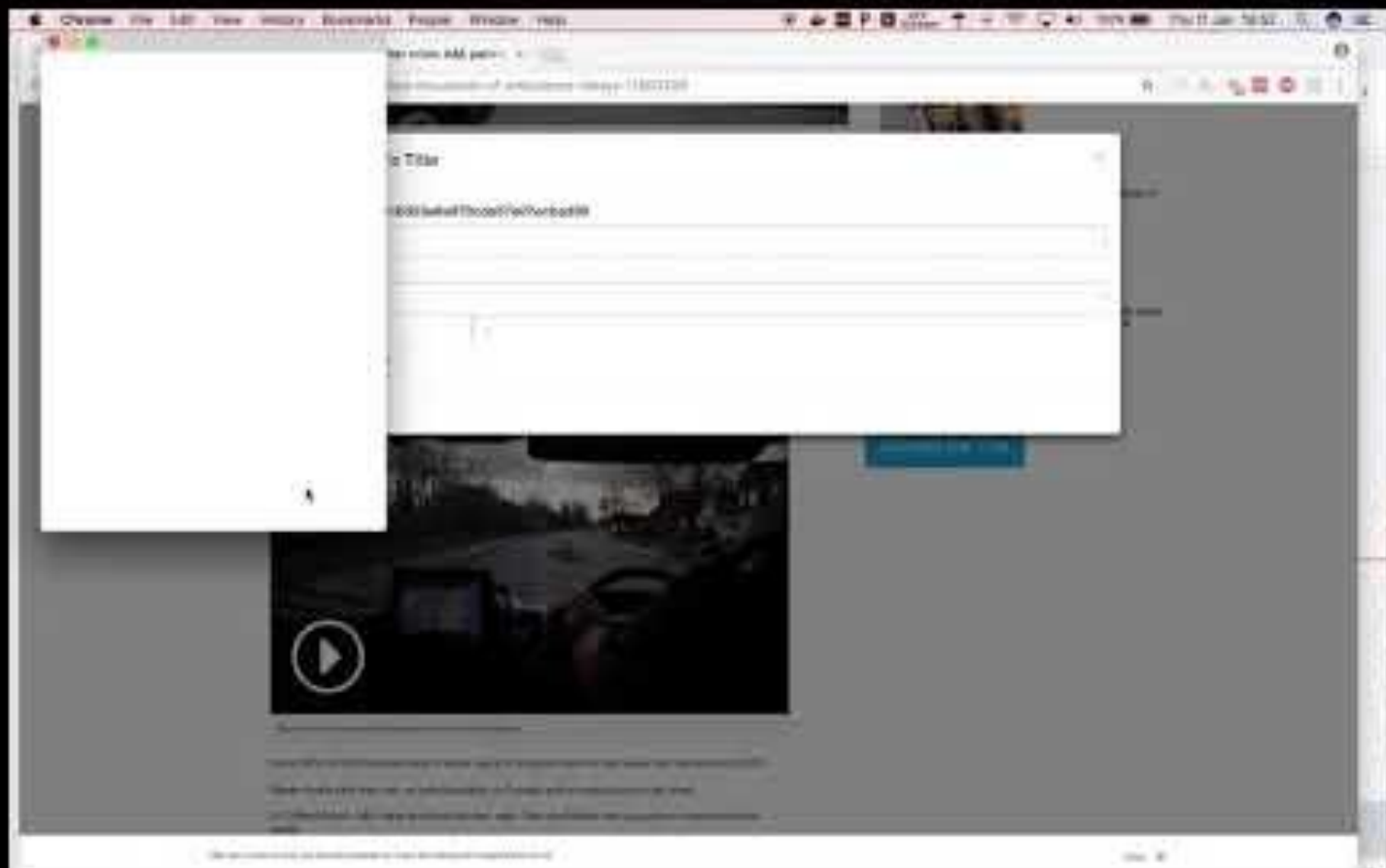


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# Demo

- The DClaims-News browser extension
- Powered by the DClaims-Core library
- Working on SkyNews' website.



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# Evaluation



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•**Q1:** Does it affect **user experience**?

- More webpage computations

•**Q2:** Does it **scale**?

- Can it handle high activity levels?
- Ethereum can only support 20 transactions per second

•**Q3:** Is it very **expensive**?

- Ethereum transactions are expensive

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# Web-Extension Performance

**Q1: Does it affect user experience?**

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TÉCNICO LISBOA

The  
New York  
Times



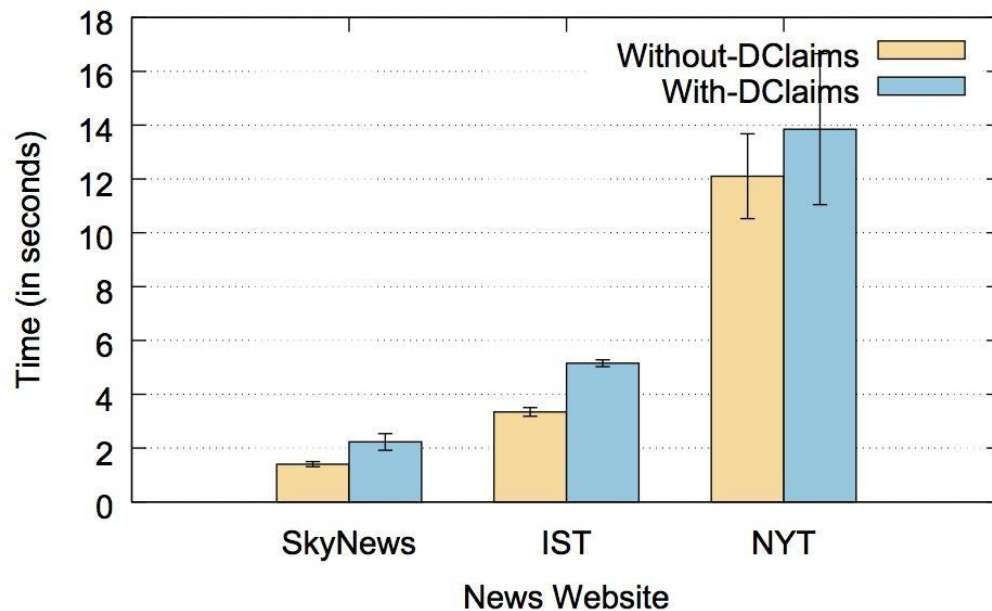
### Test Setup:

- Used it three different websites.
- Measured the overhead in each of them (30 reloads on the same machine).
- Microbenchmarks, where we vary the number of articles.

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### Loading time comparison in popular news websites.

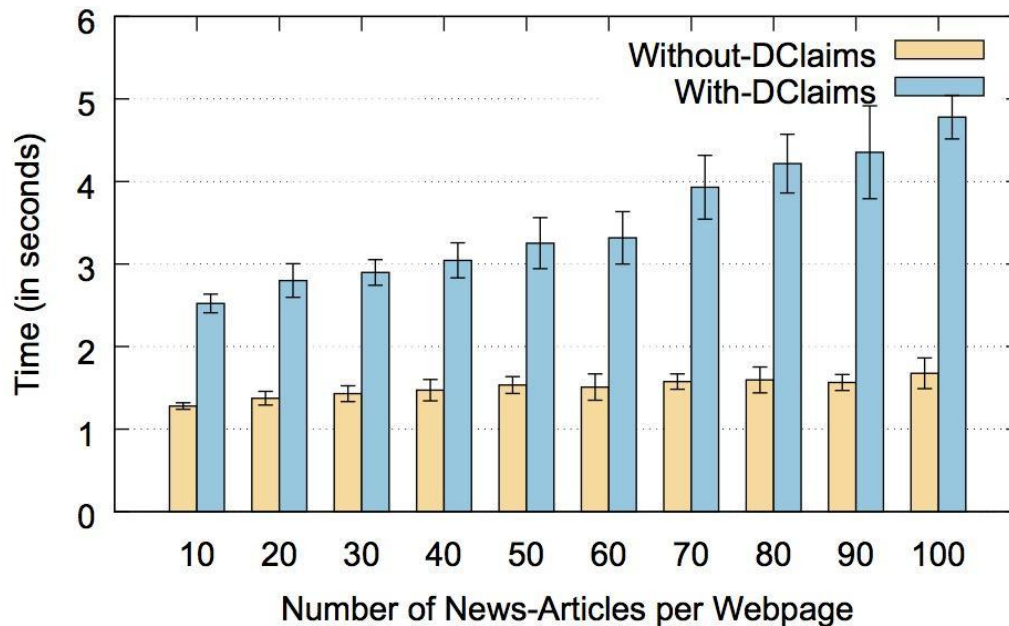


- Does not affect the user experience, main components take the same time to load. It's never more than 30%

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## Time to load a webpage as a function of the number of articles.



- Scales linearly with the number of articles.
- With 50 articles, the overhead is only 1,5 seconds.

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# Backend Performance

**Q2: Does it **scale**?**

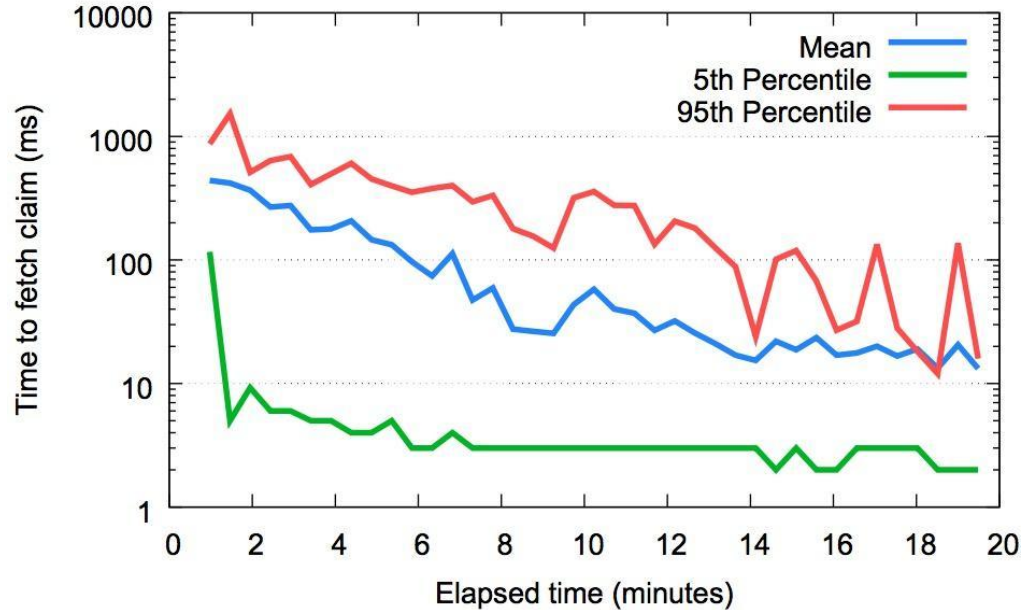
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### Test Setup:

- 60 nodes running DClaims
- Each node issued 5 dclaims
- Each node fetched dclaims for a random article, every 10 seconds, for 20 minutes.

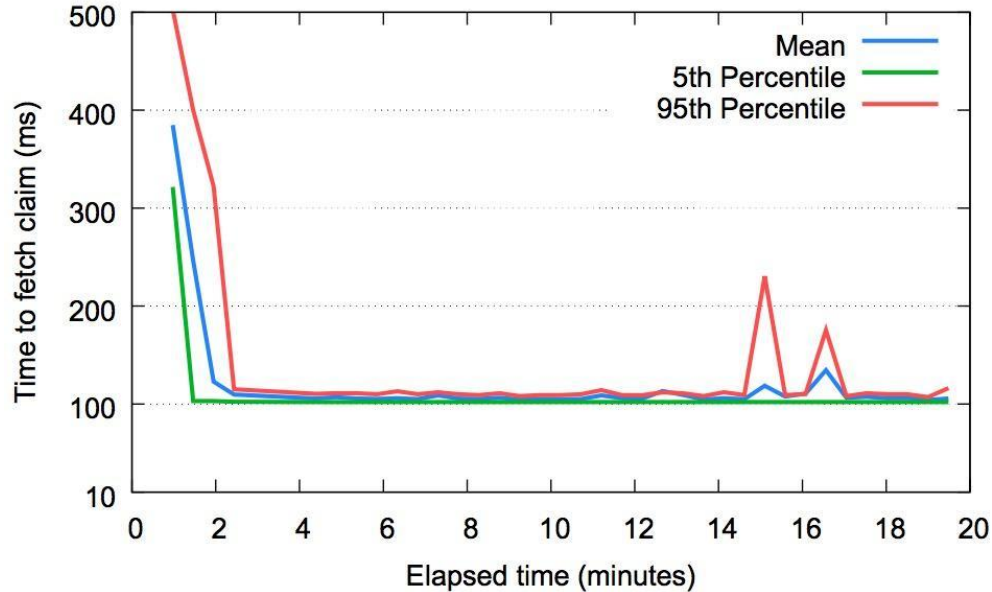
## Time to fetch individual claims from IPFS



- Over time, the elapsed time to fetch a claim decreases, as nodes start having cached copies.
- **After 4 min**, the time to fetch a claim reduces a lot, under 100ms



## Time to fetch claims links from Ethereum X



- The time to fetch data from Ethereum is constant.
- The high value in the beginning is due to the daemon initialising
- The high value in the end is due to a bug in the sync mode of the daemon.

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# Cost Analysis

## •Q3: Is it very expensive?

- Usually supported by siloed business models (user retention, advertising)
- We eliminate this central authority
- How much does it cost per user?

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# What is the expected level of activity?

## Test setup:

- Top 5 news pages (CNN, Fox News, NY Times, BBC News)
- Average rate of interactions (likes + reactions + comments) per post.
- Requirements per news organisation.

# Where is the cost coming from?

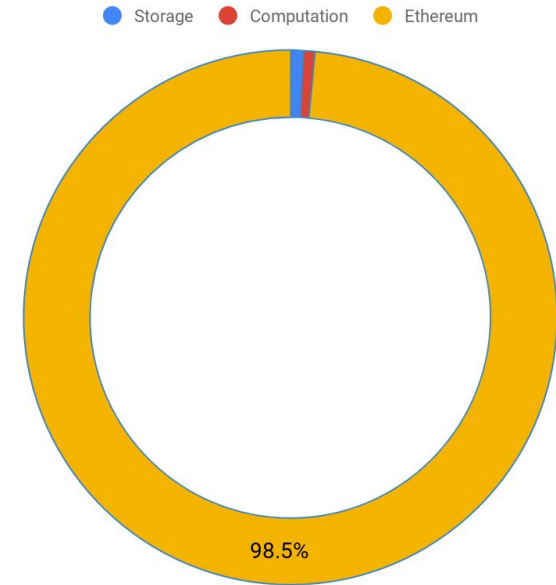
## Cost to run DClaims per News Organisation

Component	Cost (USD)
Storage	2 203
Computation	1 880
Ethereum	277 069
<b>Total</b>	<b>281 152</b>

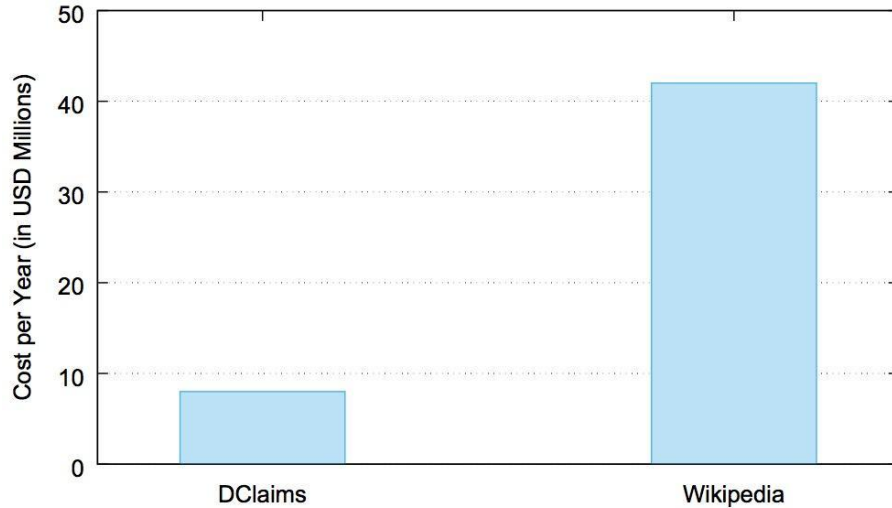
## Useful Metrics

Cost per 1000 Web Annotations	2.54
Cost per User (assuming 2.7M users)	1.0

## Cost Breakdown



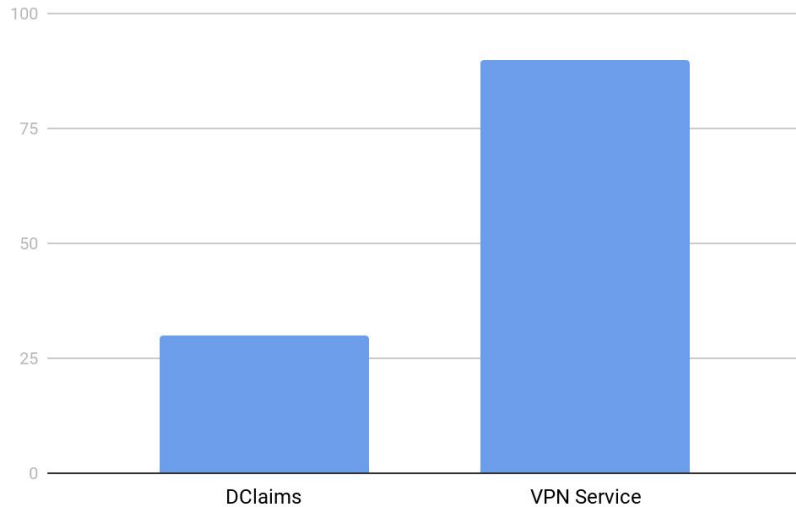
## Analysing DClaims' viability with a donation based financial model.



- Full scale deployment, assuming 30 news outlets the size of CNN.
- 20% the cost of Wikipedia, which is also donation based.
- Is this cost tolerable? It may be for the right use cases.

## Analysing DClaims' viability with a yearly subscription financial model.

Cost per User, per Year



- Users pay for VPN services, which are also in the censorship resistance family.
- DClaims costs 30% the price of these services.

## Roadmap

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# Conclusion

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- DClaims **fulfils** the requirements;
- The experimental evaluation says its usable, scales and is financially sustainable.
- There are two areas which can be improved:
  - **Replication**: Add more data redundancy,
  - **Financial Cost**: Will decrease when new Ethereum technologies are deployed (sharding, side-chains)
- For future work, adapt to **other types of applications**.



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## Invited Talks

- IPFS Lisbon Meetup 2018
- Protocol Labs Lisbon Hack Week 2018
- W3C Credentials Community Group (tbd)



Protocol Labs



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# Impact in Open-Source Community

- DClaims is 100% Open Source: <https://github.com/inesc-id/dclaims-pm>
- Blockcerts: Ethereum based revocation & IPFS Storage
- Rebooting the Web of Trust 2017 & 2018



Dan Hughes  
@mreybinned

Following

Revocation is one of the most difficult aspects of any verification process. In this paper, @itsjoaosantos and @kimdhamilton revisit the revocation aspect of @Blockcerts and consider decentralized approaches using Ethereum smart contracts.

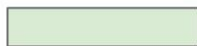
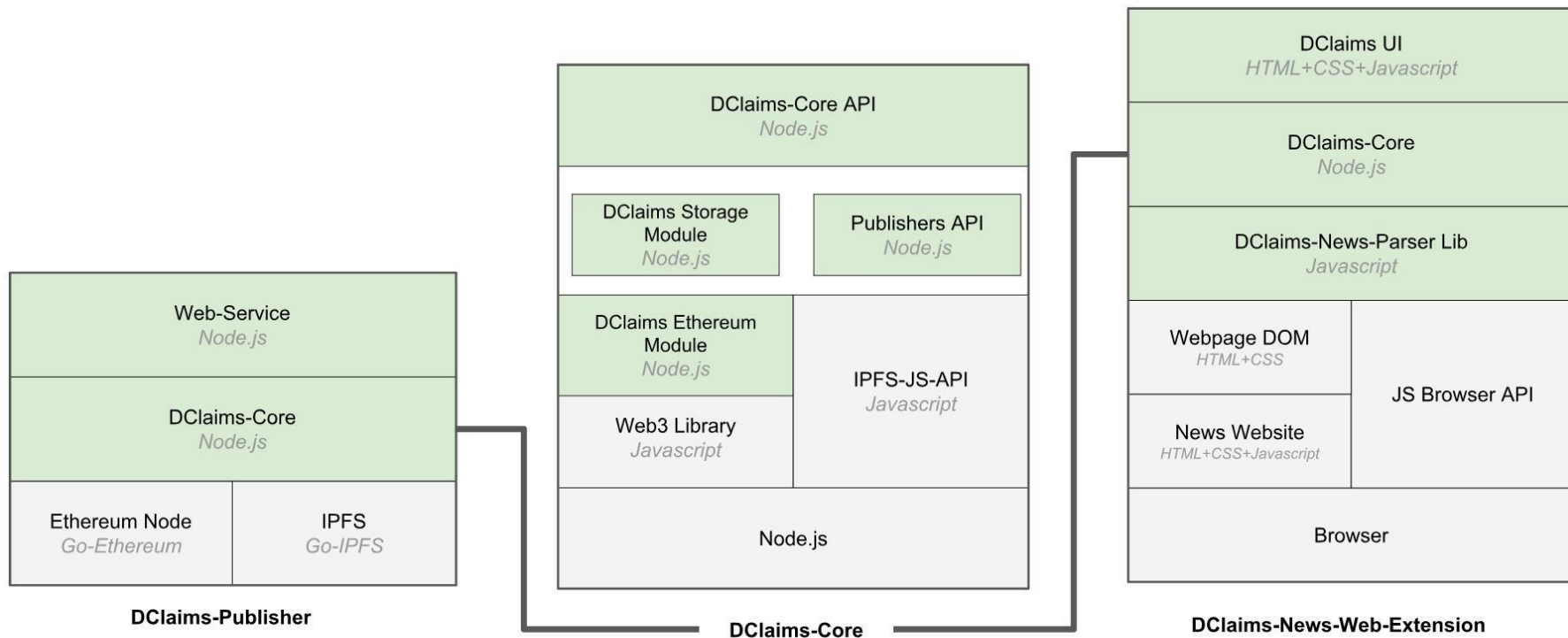
[github.com/WebOfTrustInfo](https://github.com/WebOfTrustInfo) ...



## Paper Submissions

- Submission to Rebooting the Web of Trust (Blockcerts revocation)
- Submission to Inforum 2018 (DClaims)

That's it. 😊



Software developed in the  
context of this project



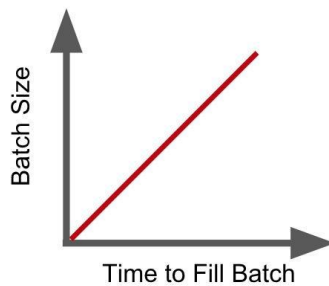
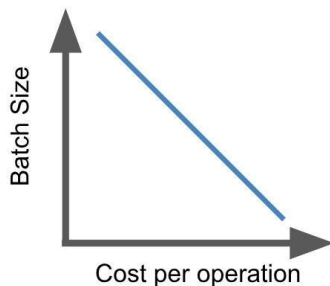
Previously existing software

# How does it scale?

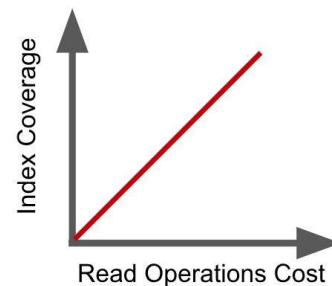
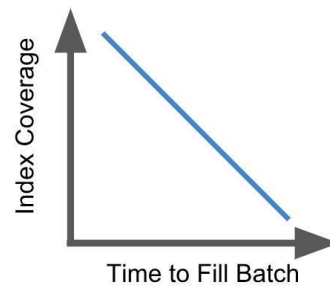
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### Batch Size Manipulation



### Index Cover Manipulation



### DCIaims-News

News Outlets with **high** activity level: *Large Batches & Low Index Coverage*

News Outlets with **low** activity level: *Small Batches & High Index Coverage*

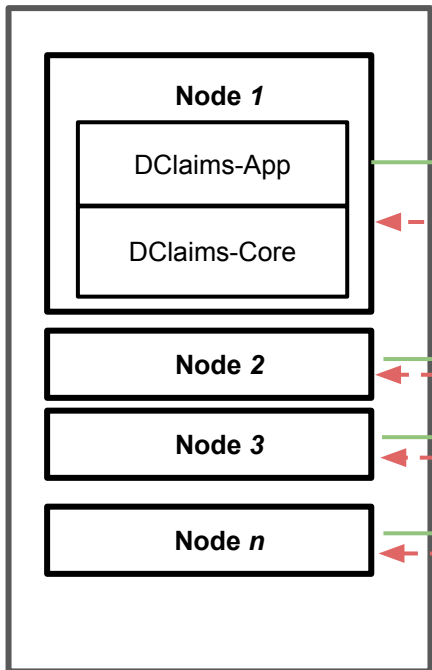
### Wikipedia

**High activity overall, but distributed through many articles:**

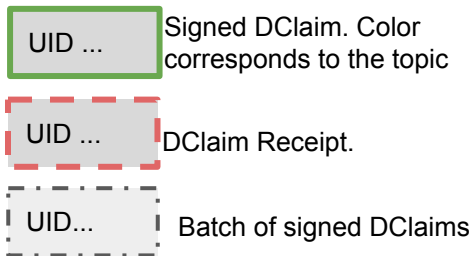
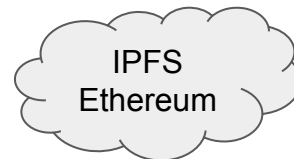
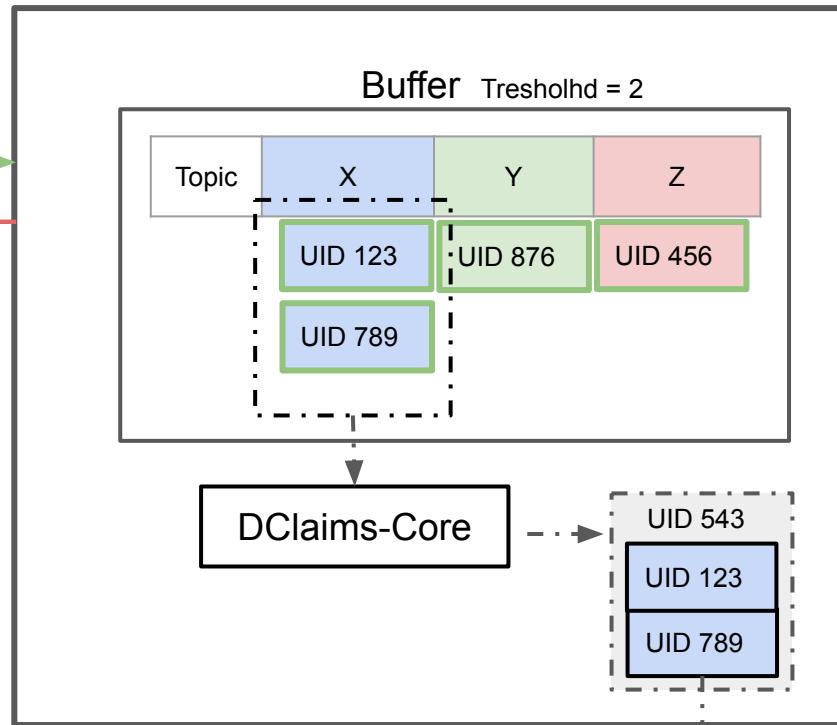
*Large Batches & High Index Coverage*

**Cost and performance can remain constant, using a smart combination of batch size and index coverage manipulation.**

## Application Nodes



## Publisher



- Step 1. Sending to Publisher
- Step 2. Receiving receipt
- Step 3. Batch issuance

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# Requirements:



- **Who created the annotation.**

- Authenticity & Integrity Assurances:



- **Same link to the annotation, independent of where it is stored.**

- Data Permanence & Portability



- **Should not be expensive**

- Financial Cost Efficiency

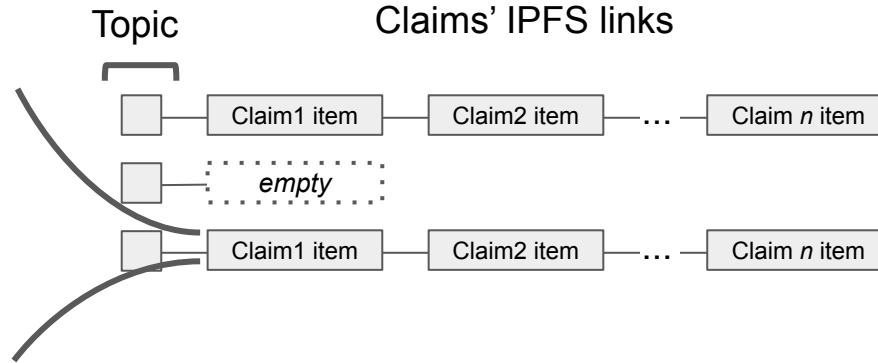
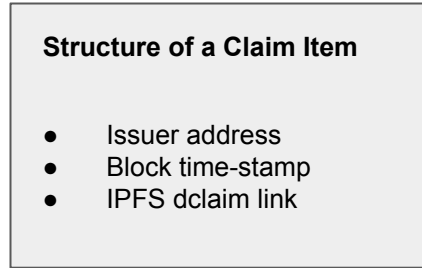


- **Handle the same level of activity as Facebook's news pages**

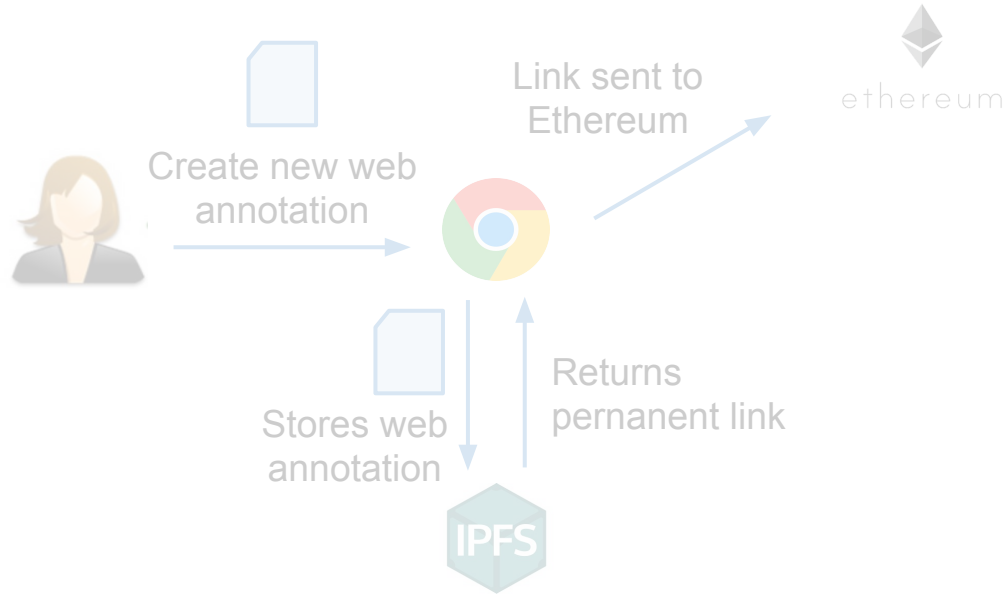
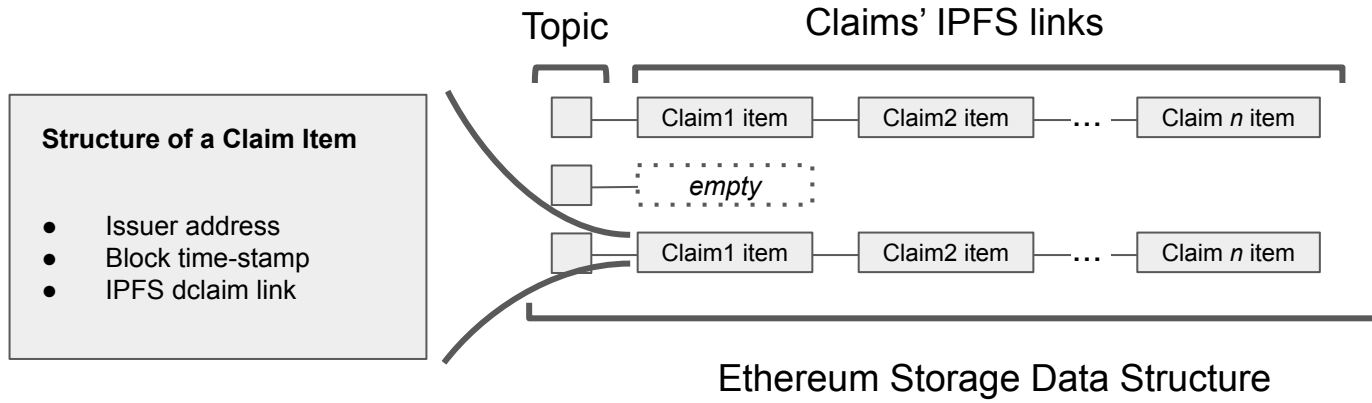
- Scalability



- **Compatibility With Standards**







## Roadmap

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The **Web** plays a **critical** role  
in informing modern  
societies.

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# 53% - 84%

Of UK citizens aged **18 - 44** use the **Web** as their primary source of information.

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## 2003 - US Invasion of Iraq

*“Official's Key Report On Iraq Is Faulted”*

<https://web.archive.org/web/20171023180238/http://www.washingtonpost.com/wp-dyn/content/article/2007/02/08/AR2007020802387.html>

## 2018 – US’ EPA Censorship on Climate Change Information

“Over the past year, terms like “fossil fuels”, “greenhouse gases” and “global warming” have been excised.”

<https://web.archive.org/web/20180319165205/http://time.com/5075265/epa-website-climate-change-censorship/>

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# How:

Eliminating **centralisation**  
points where a powerful actor  
can exert **pressure**.

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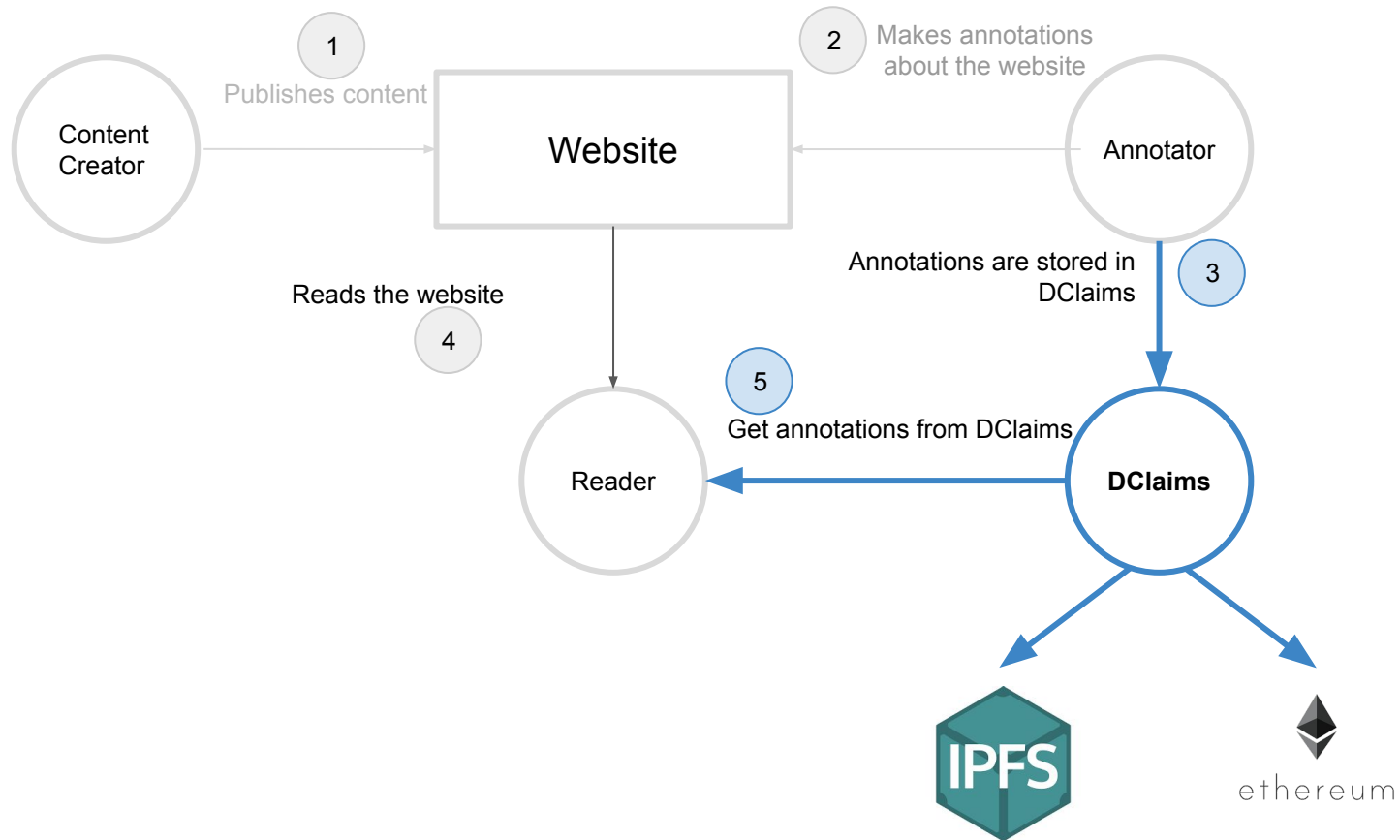


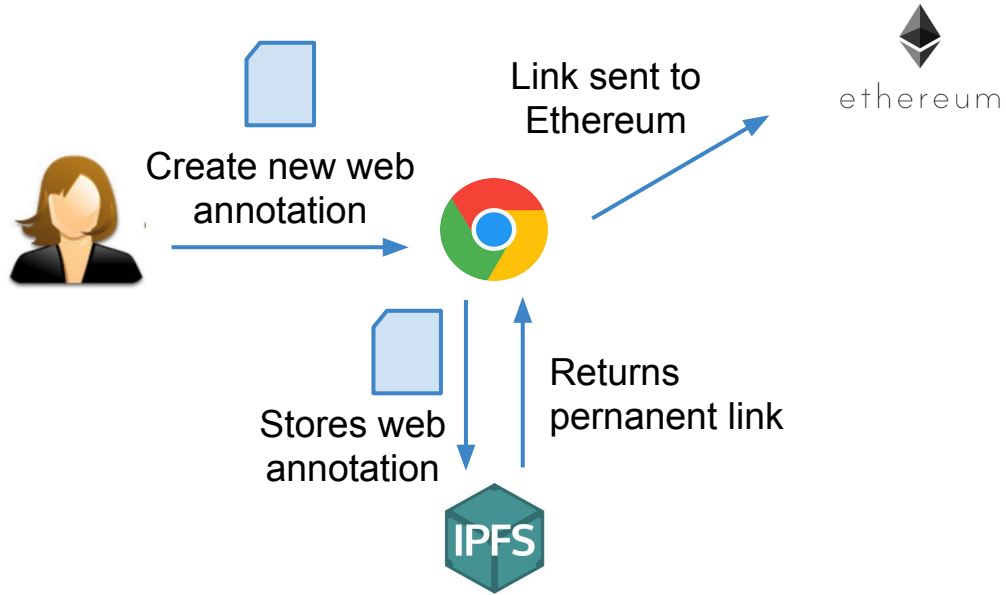
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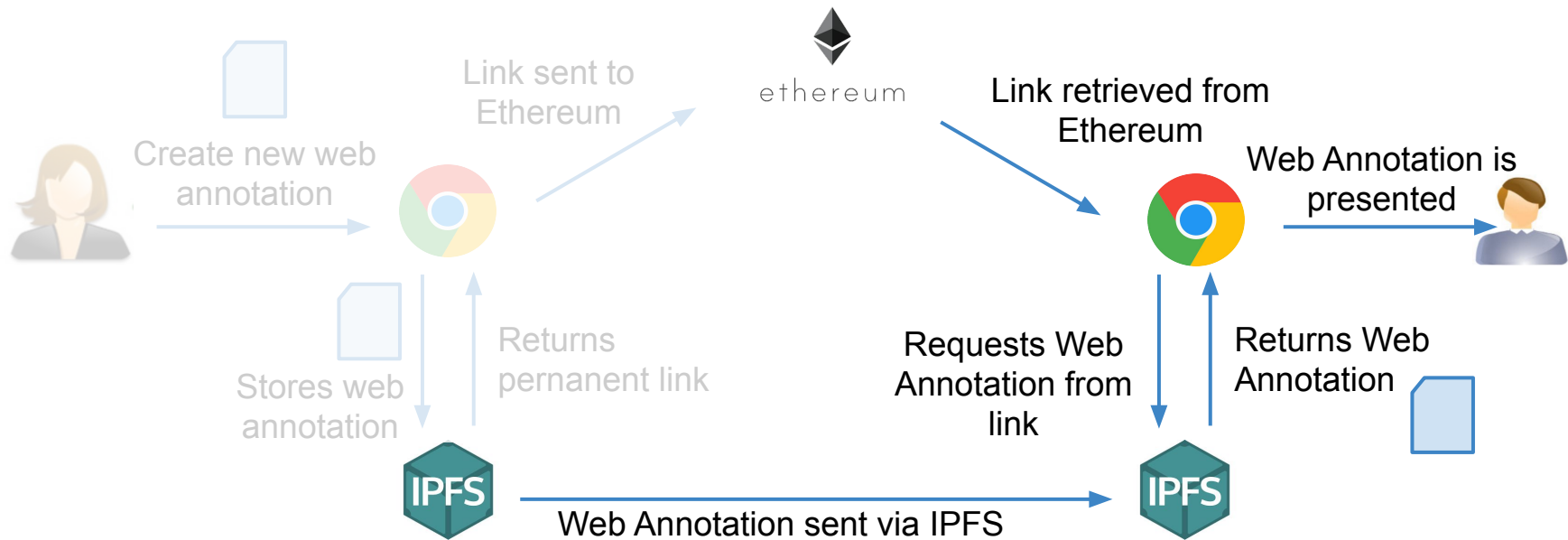
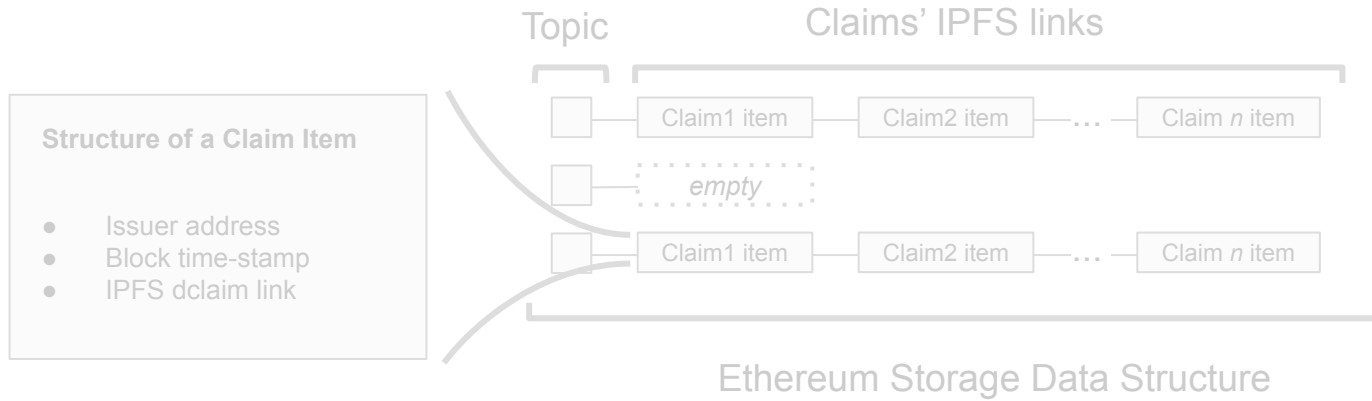
- Scalability

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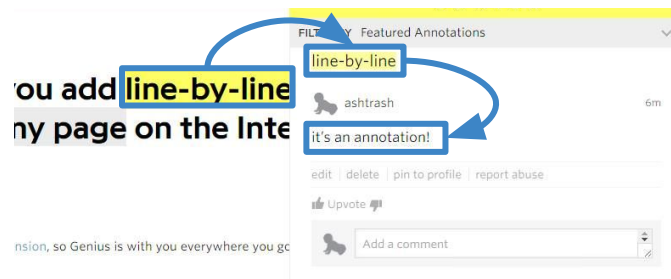
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# DClaims Data Format

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## W3C Web Annotation

- Resource
- Target
- ...

## DClaims - General Claim

- UID
- Type: ["dclaims-general-claim"]
- Issuer\_ID
- Date
- Topic
- Revocation
- **Signature**
- {Payload}

- **Signature** field provides integrity and authenticity assurances.

*Based on W3C's Verifiable Claims Data Format*

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# Storage and Discovery



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# Fact-Checking Websites



# Social Networks

