Towards Regulating Large-Scale Multi-Enterprise Environments with Confidentiality Guarantees

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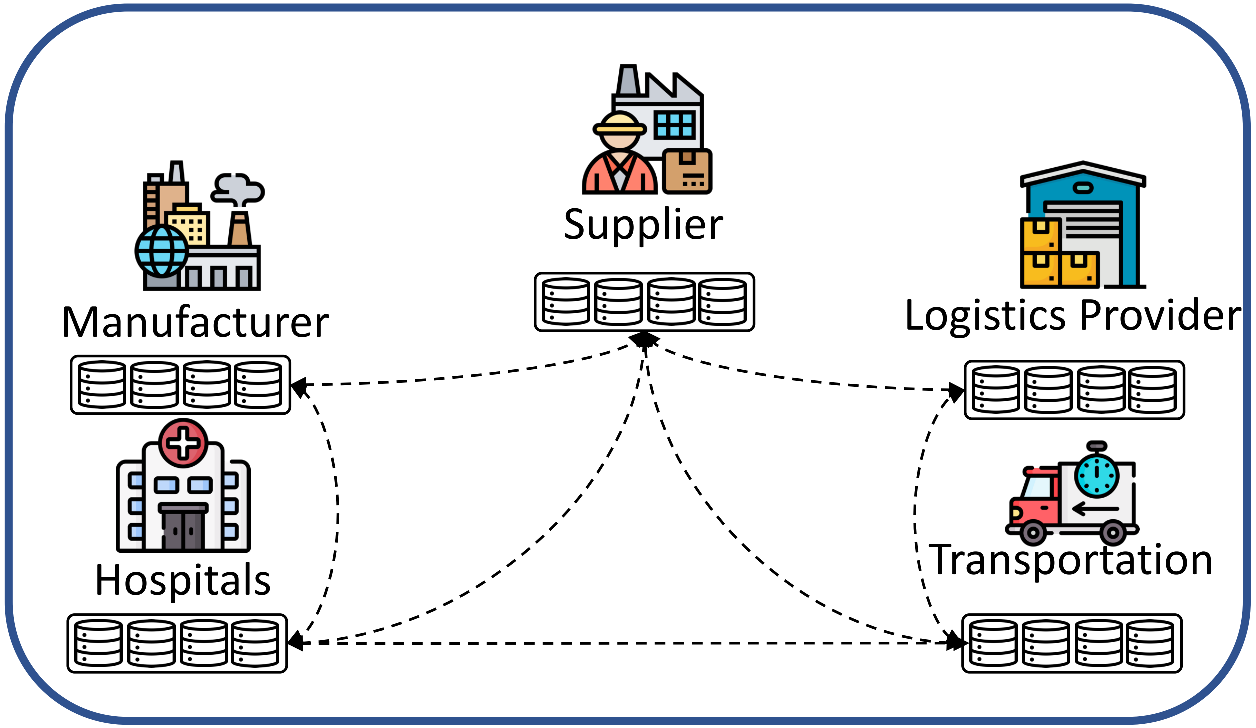
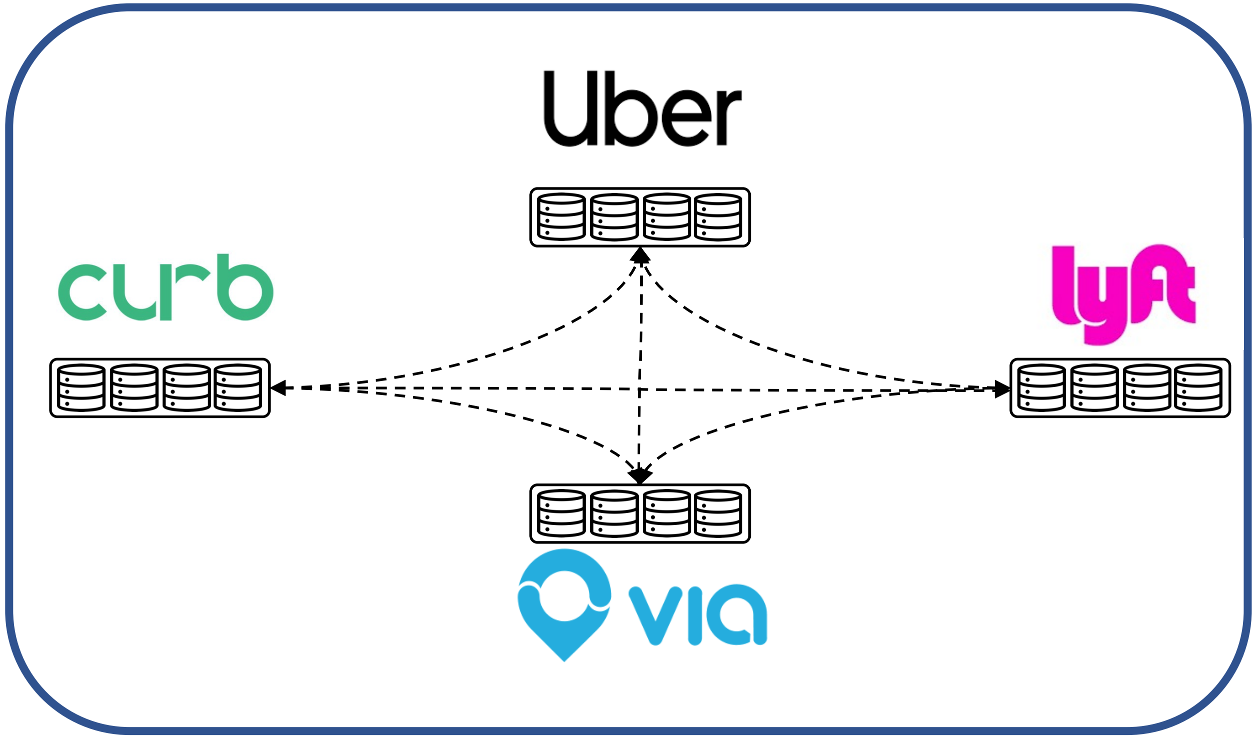
A set of known mutually distrustful entities

Multi-Enterprise Environments



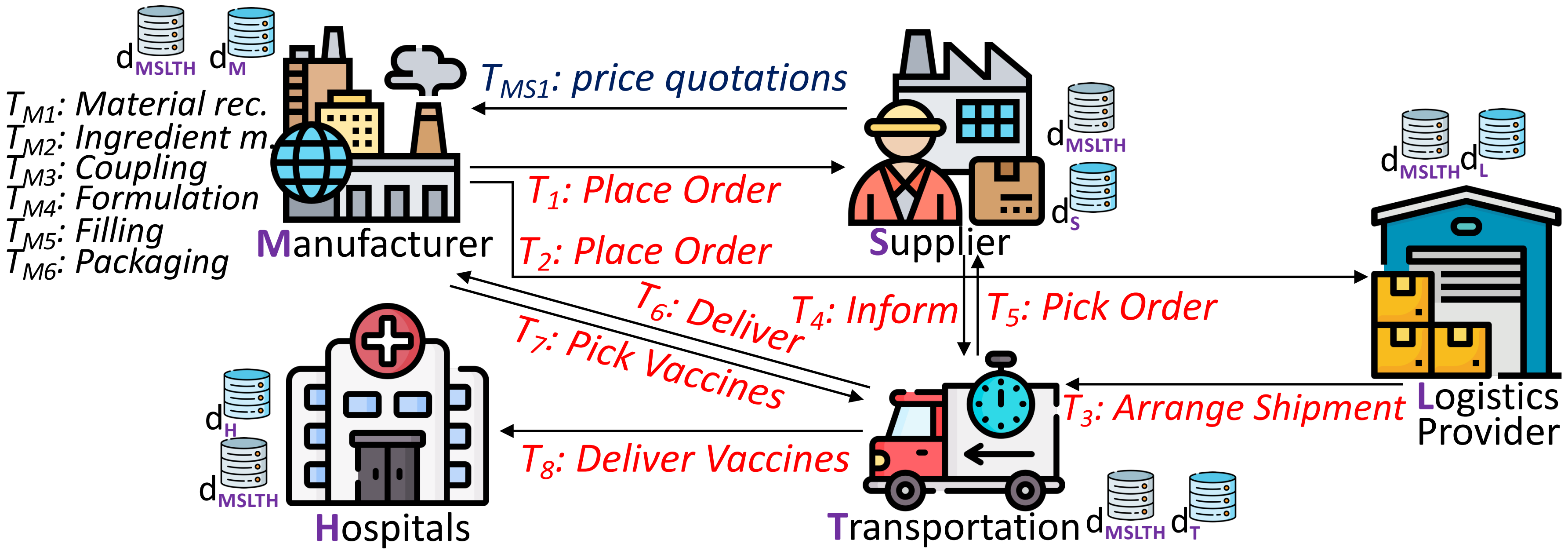
Supply Chain Management



Multi-Platform Crowdworking Environment

- Require collaboration among a set of mutually distrustful entities
- Internal and global regulations need to be enforced
- The confidentiality of data is paramount

CAPER [VLDB'19]

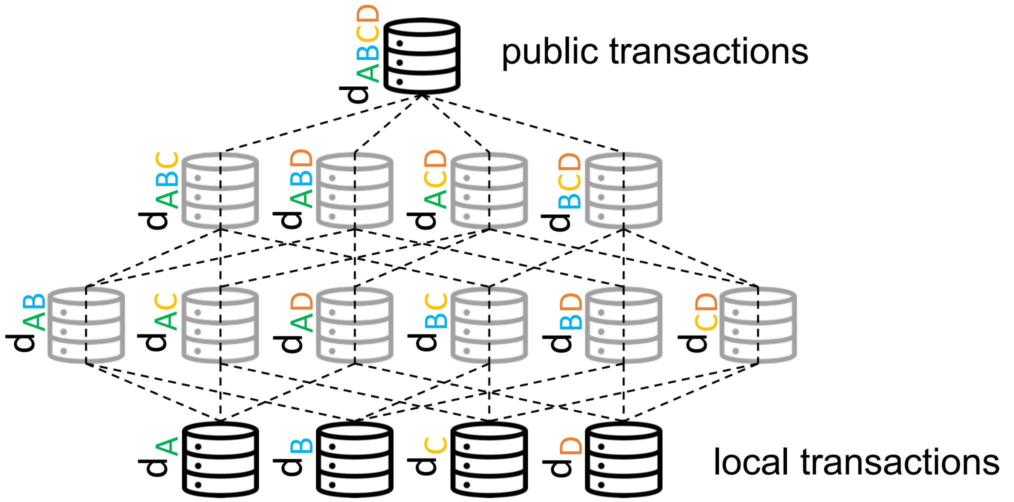


- Supports Local and global transactions
  - Global transactions are visible to all enterprises
  - Local transactions of each enterprise are confidential

What if a subset of enterprises are involved in a confidential collaboration?

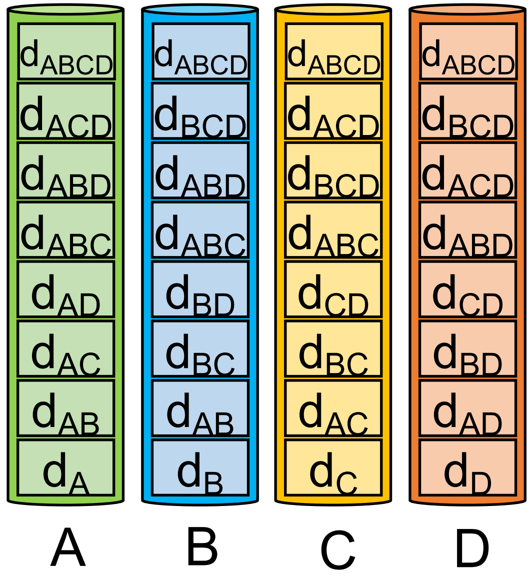
Qanaat: Confidential Collaborations across Enterprises [VLDB’22]

- A hierarchical data model consisting of a set of data collections
- Operational primitives
  - Write: transactions of d_X write only on the records of d_X
  - Read: transactions of d_X can read the records of d_Y if $X \subseteq Y$ (order-dependency)



public transactions

local transactions

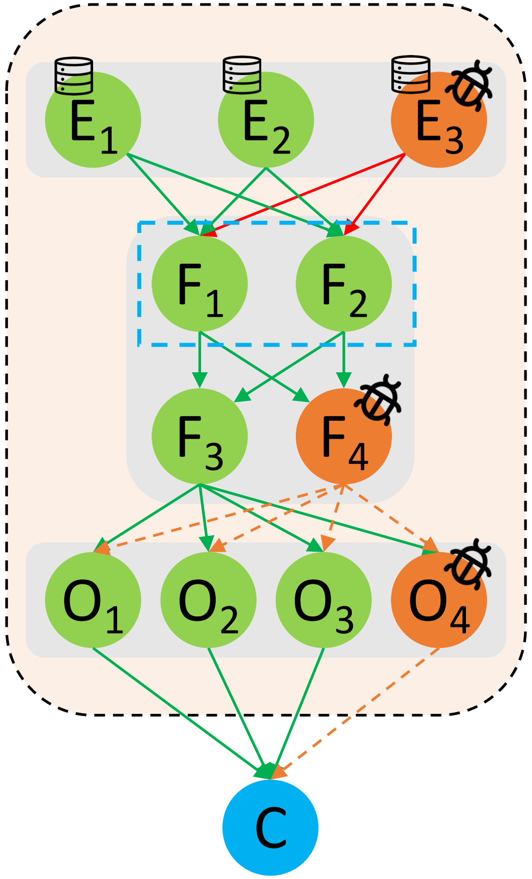


A	B	C	D
d_{ABCD}	d_{ABCD}	d_{ABCD}	d_{ABCD}
d_{ACD}	d_{BCD}	d_{ACD}	d_{BCD}
d_{ABD}	d_{ABD}	d_{BCD}	d_{ACD}
d_{ABC}	d_{ABC}	d_{ABC}	d_{ABD}
d_{AD}	d_{BD}	d_{CD}	d_{CD}
d_{AC}	d_{BC}	d_{BC}	d_{BD}
d_{AB}	d_{AB}	d_{AC}	d_{AD}
d_{A}	d_{B}	d_{C}	d_{D}

What if the infrastructure includes malicious nodes?

Confidential Data Leakage Prevention

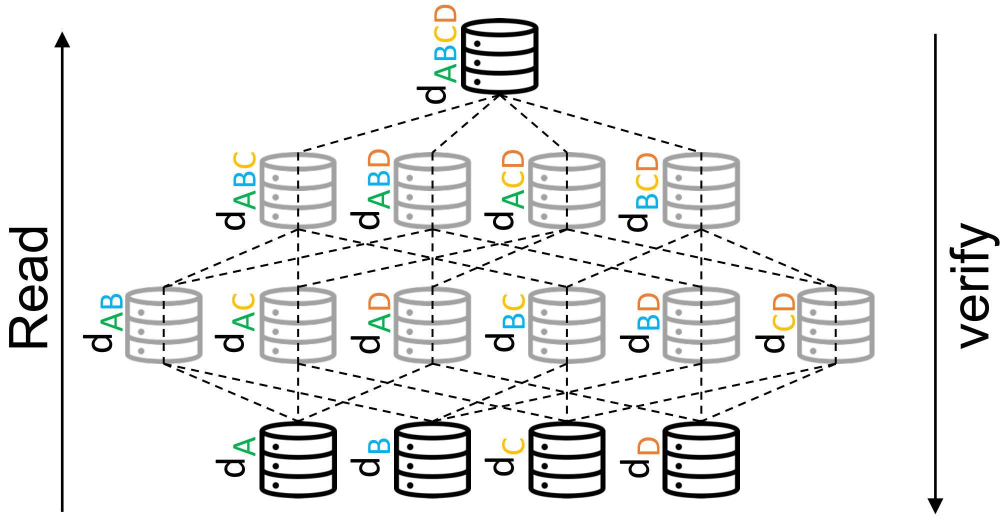
- Malicious nodes can violate data confidentiality
  - leaking requests, replies, or data stored and processed
- Privacy firewall mechanism
  - Separates ordering node from execution nodes
    - $3f + 1$ ordering nodes and $2g + 1$ execution nodes
      - Assuming f faulty ordering and g faulty execution nodes
  - Adds a privacy firewall in between
    - Consists of a set of $h + 1$ rows of $h + 1$ filters (h faulty filters)
  - Network configuration physically restricts communication paths between ordering nodes, filters, and execution nodes
  - A malicious node can either access confidential data or communicate freely with clients *but not both*



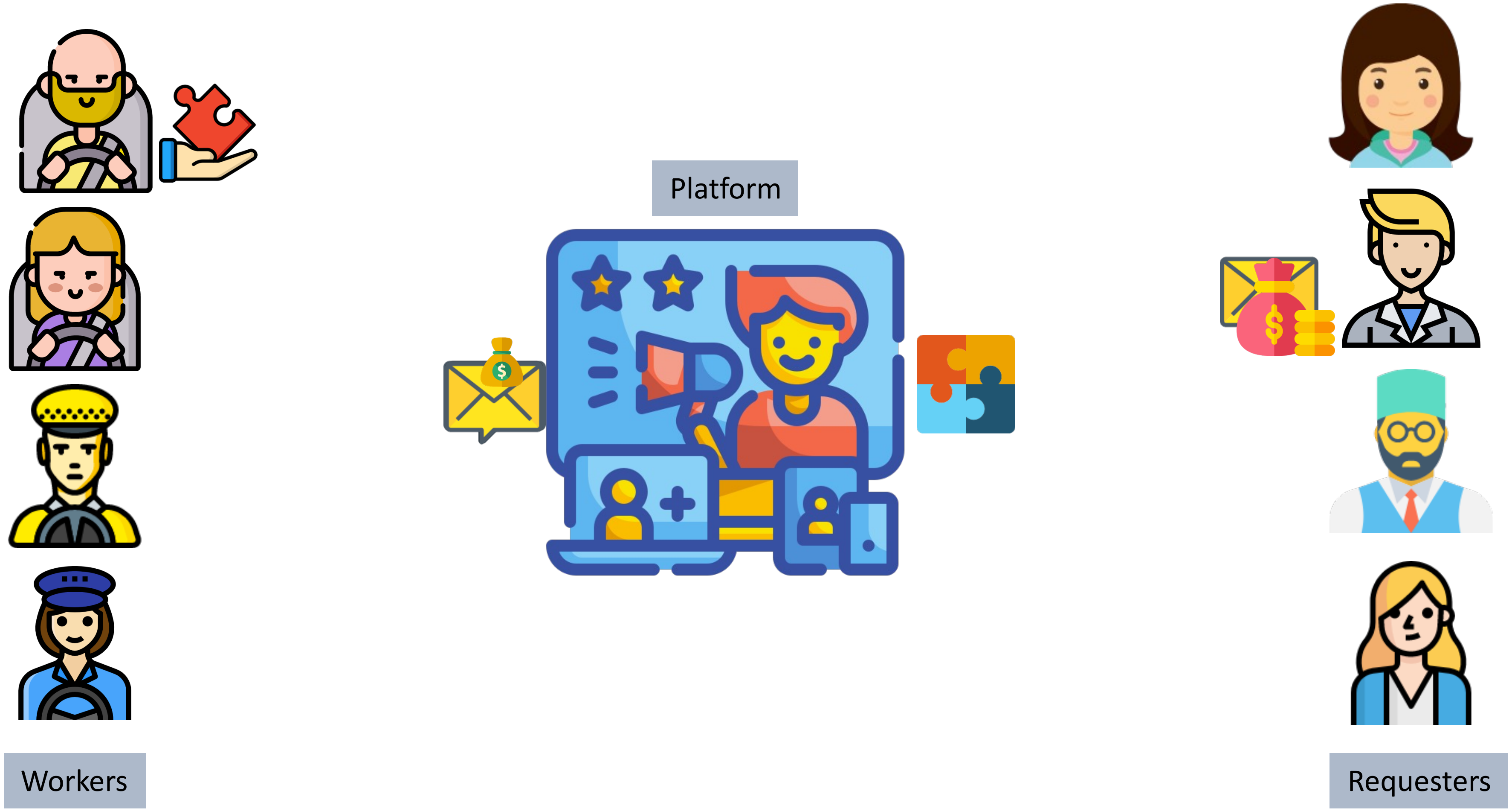
Data Verifiability

- Qanaat supports Read and Write operations
  - Write: the same data collection
  - Read: superset data collections (order-dependency)

What if we need to verify private data?



Crowdworking Environment



Platform

Workers

Requesters

- Envisioned as key technological components of the future of work

Guaranteeing the compliance of crowdworking platforms with regulations

"Whereas universal and lasting peace can be established only if it is based upon social justice; . . . for example, by **the regulation of the hours of work** . . . "

preamble of the constitution of the International Labor Organization
[Commission on International Labor Legislation, 1919]

Figure: Members of the Commission on International Labor Legislation to the Paris Peace Conference (1919).

The Fair Labor Standards Act

was signed by President Franklin D. Roosevelt on June 25, 1938.

FLSA: Total work hours of a worker per week may not exceed 40 hours

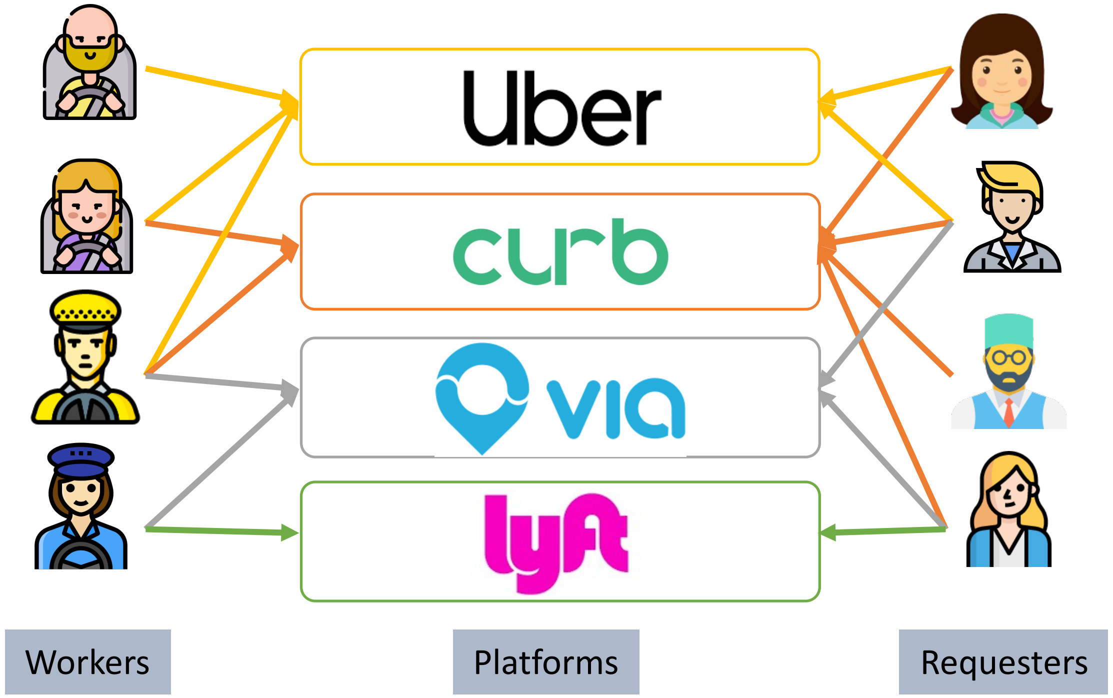
In California, Assembly Bill 5 (AB5) entitles workers to greater labor protections, such as minimum wage laws, sick leave, and unemployment and workers' compensation benefits.

CA Proposition 22 imposes its set of regulations, e.g., requires a worker to work at least 25 hours per week to qualify for healthcare subsidies.

WE WANT THE 40 HOUR WEEK
VOTE NO ON PROP. 22
PROP.22: SUPPORT GIG DRIVERS AND FOOD DELIVERY WORKERS
STOP EXPLOITATION OF GIG WORKERS. Vote NO
ATU VOTE NO PROP 22

There is more than one platform …

- Workers often work on several platforms
- Requesters submit tasks on multiple platforms



Privacy of Participants

- No participant obtains or infers any information beyond what is needed
    - A driver who works for both Uber and Lyft, does not want either of them know that she works for the other.
- How to enforce regulations?
    - Reconcile transparency with privacy

Problems

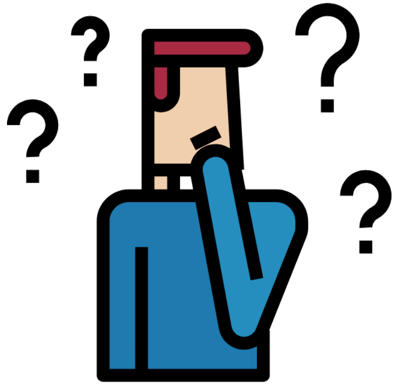
Guarantee the compliance of crowdworking platforms with regulations

- Local (per platform) regulations exist: maximum driving time per day

Transparent and Privacy-preserving regulation enforcement

Collaboration among mutually distrustful platforms

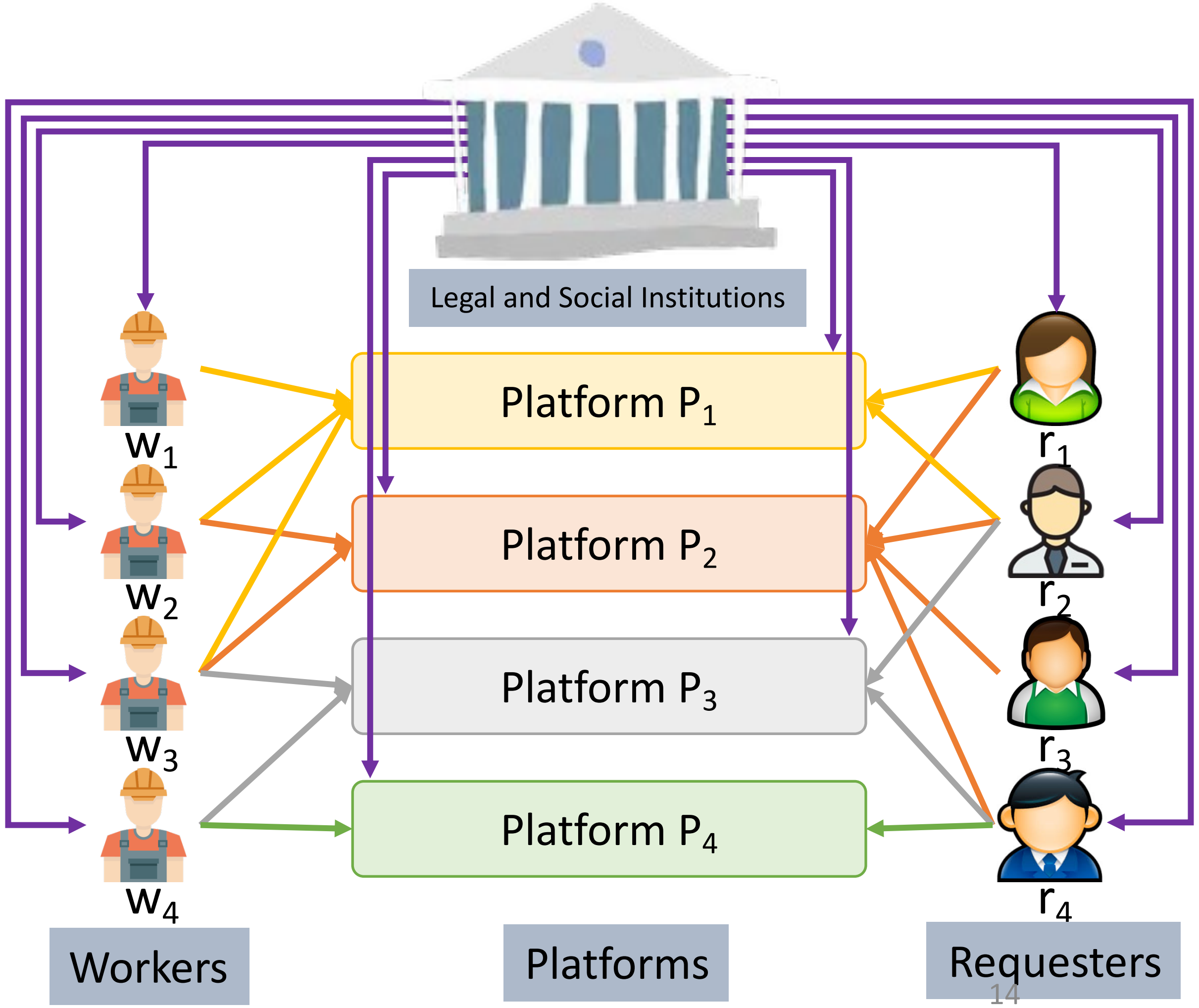
- Enforcement of global regulations
- Complex tasks that may need multiple contributions



Our Vision for Future Regulated Multi-Enterprise Systems [WWW'21]

- **Goal: Enforce regulations on multi-platform crowdworking environments while preserving privacy**

- Three main design dimensions
- D1: Type of supported regulations
  - Express as `SQL` constraints over a universal table
  - e.g., aggregate or not/ has join or not
  - Verifiable vs. enforceable
- D2: Privacy guarantees given to participants
  - pluggable disclosures (received/involved)
- D3: Architecture of the system
  - Centralized registration authority
  - Decentralized state management



A Simple Token-Based System

- Inspired by e-cash systems, regulations are implemented by managing budgets per participant
- Lightweight, single-use, and anonymous tokens

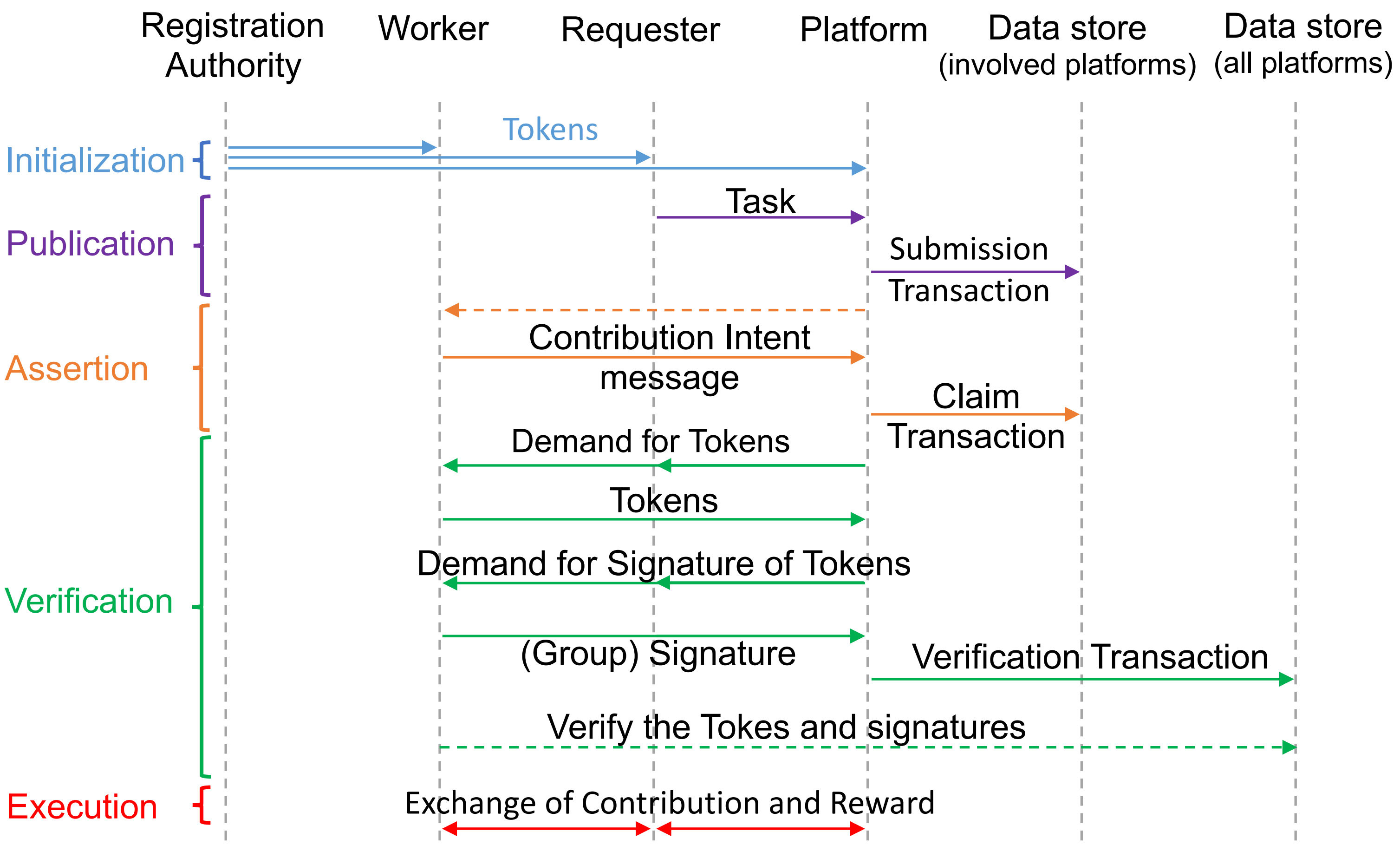
The registration authority refreshes participants tokens periodically

- GENERATE: initializing the budgets and refilling them
    - Enforceable and Verifiable tokens
- SPEND: spending portions of the budgets
- PROVE: providing proof for verifiable regulations to a third party
- CHECK: checking whether a given spending is allowed or not
- ALERT: reporting dubious spending

Execution Sequence

Tasks:
Internal
Cross-Platform

Transactions:
Submission
Claim
Verification



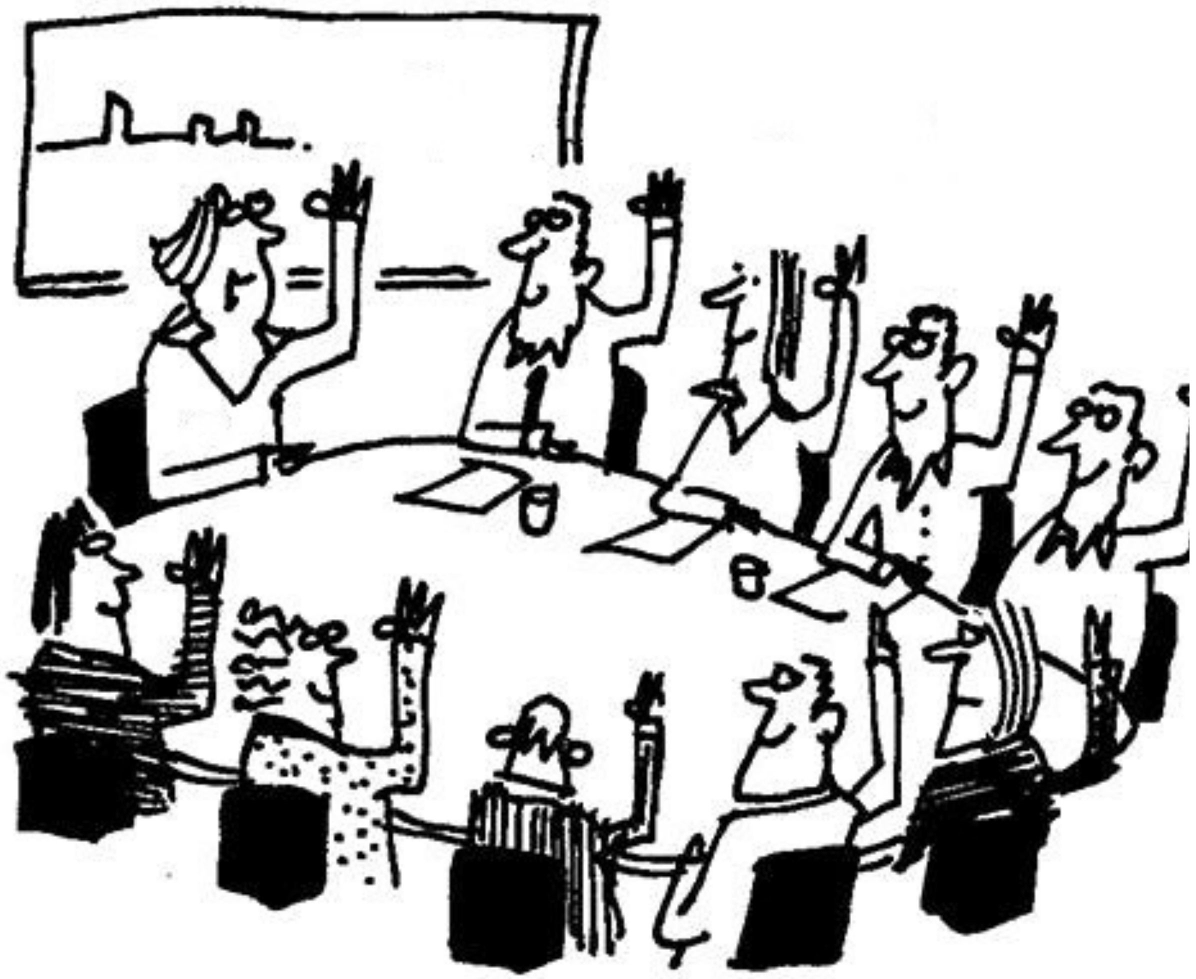
Reaching Consensus [SIGMOD'21]

Local Consensus: pluggable and depends on the failure model of nodes

Cross-Platform Consensus: Among the involved platforms

Global Consensus: Requires the participation of all platforms

Transaction/Task	Internal	Cross-Platform
Submission	Local	Cross-Platform
Claim	Local	Cross-Platform
Verification	Global	Global



Conclusion

Enforcing regulations on a set of mutually distrustful enterprises

Preserving the privacy of participants

- Hierarchical data model

Confidential data leakage prevention

- Privacy firewall mechanism

Collaboration among enterprises

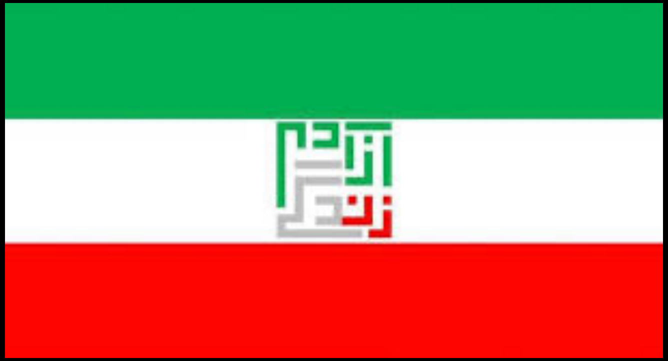
- Distributed consensus protocols

Expressing and modeling regulations

- `SQL` constraints over a universal table

Private data verification

- Token-based systems or zero-knowledge proofs



Women. Life. Freedom

#MahsaAmini

Questions?

I'm on (academic) job market this year!