Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

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PrivacyDates: A Framework for More Privacy-Preserving Timestamp Data Types

GI Sicherheit 2022, 7. April

Agenda

Goal:
Present a **Framework** that makes it easier to **avoid full-precision timestamps** in app data models.

- Why necessary

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- Implementation of our Framework
- Cost of application

Setting the scene: How would you design that app?

Example: Design of a **chat app**.

User Stories:

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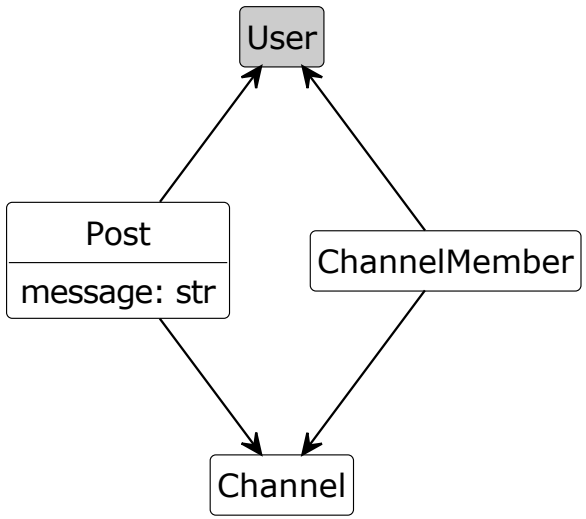

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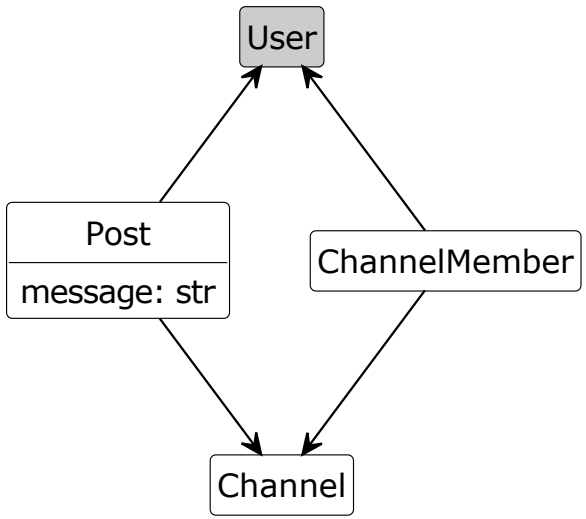

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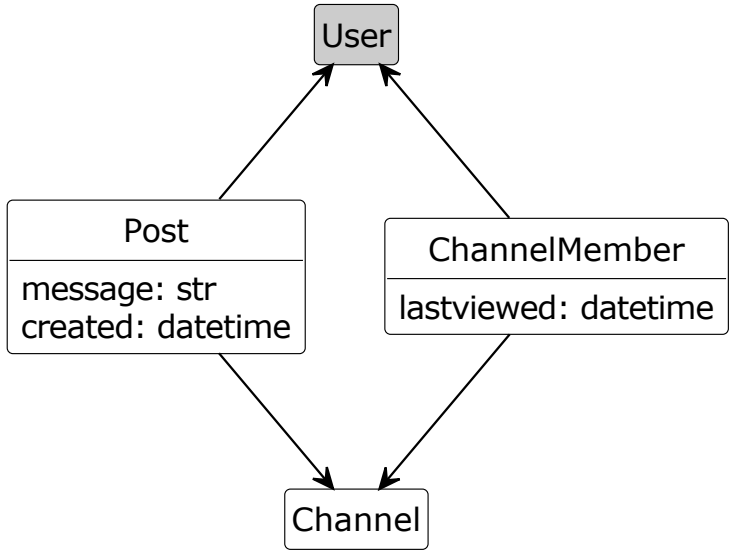

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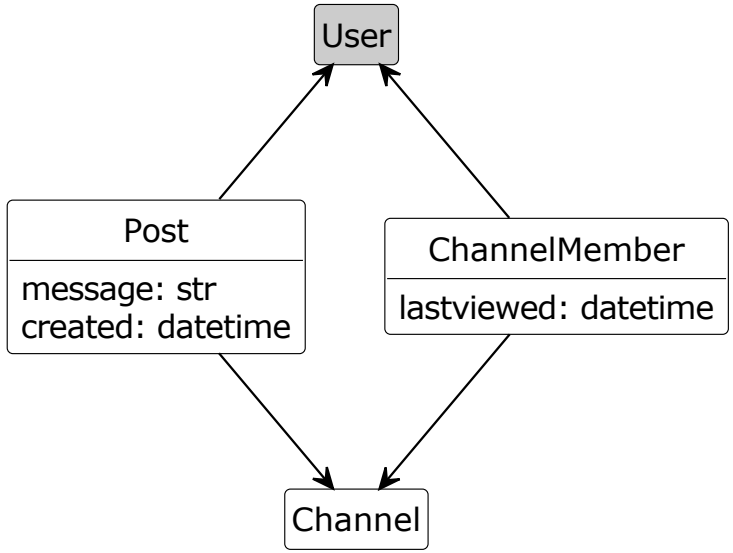

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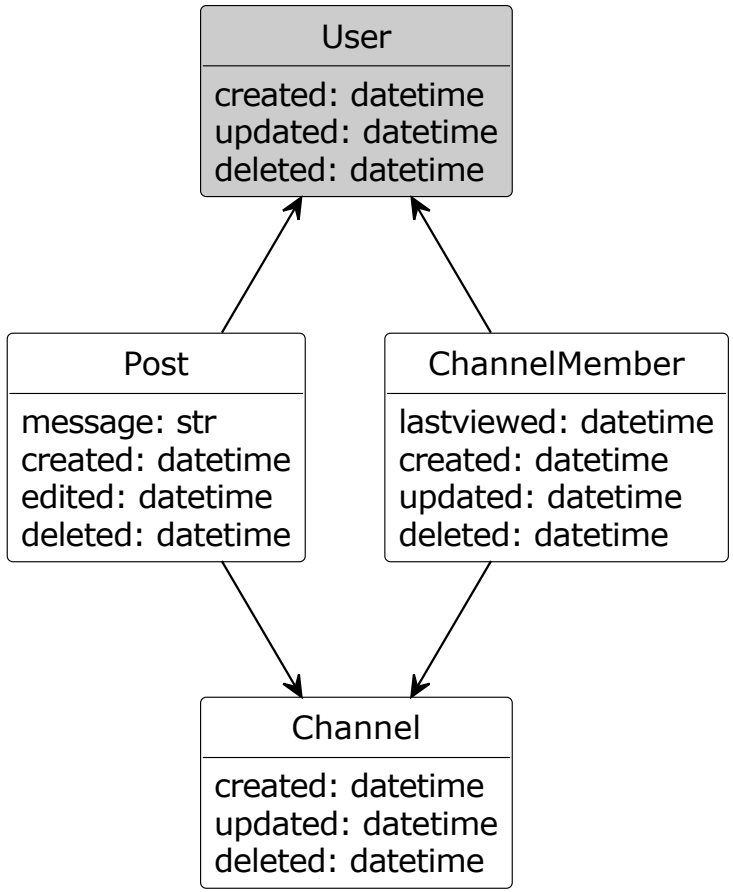

Prior Work: How are timestamps used in data models?

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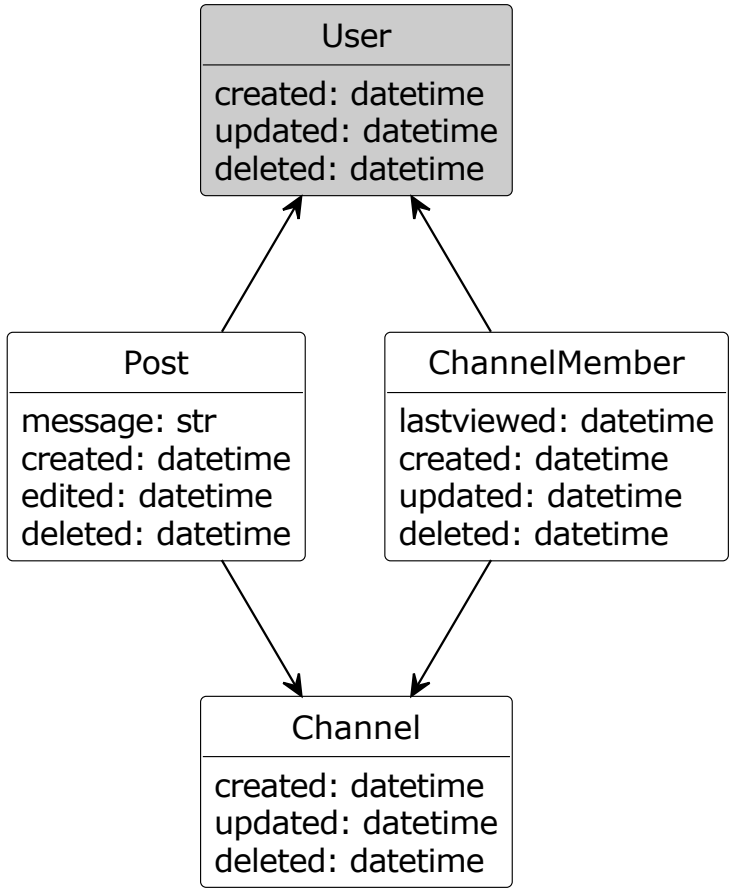
Source code analysis and UI inspection of Mattermost[a]



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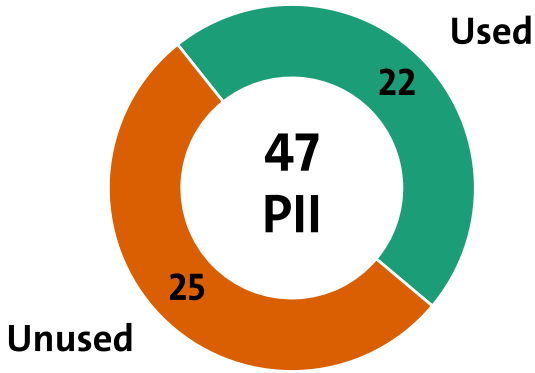

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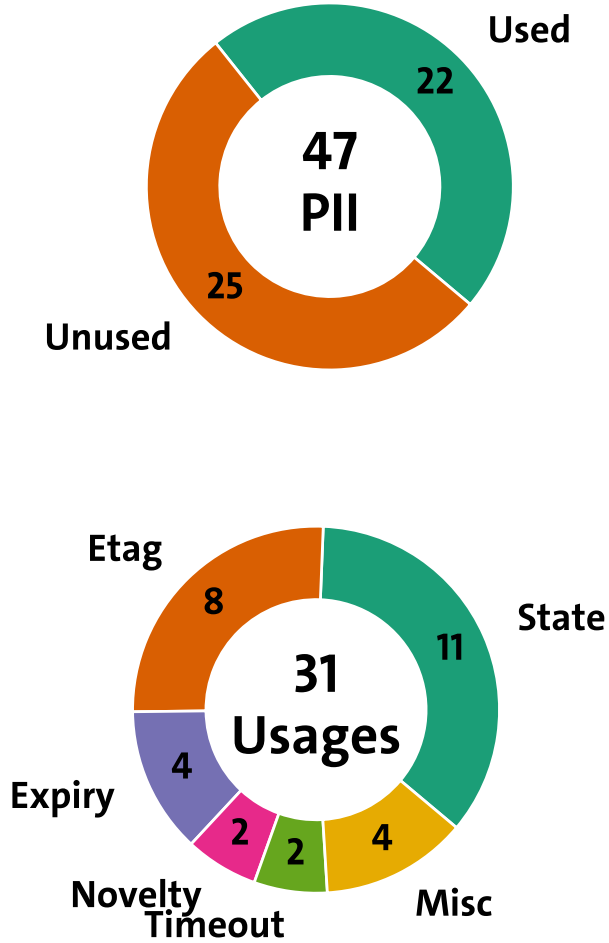
  - >50% no programmatic use
  - most not visible on UI either
- Many timestamp use cases allow for less sensitive **alternatives**



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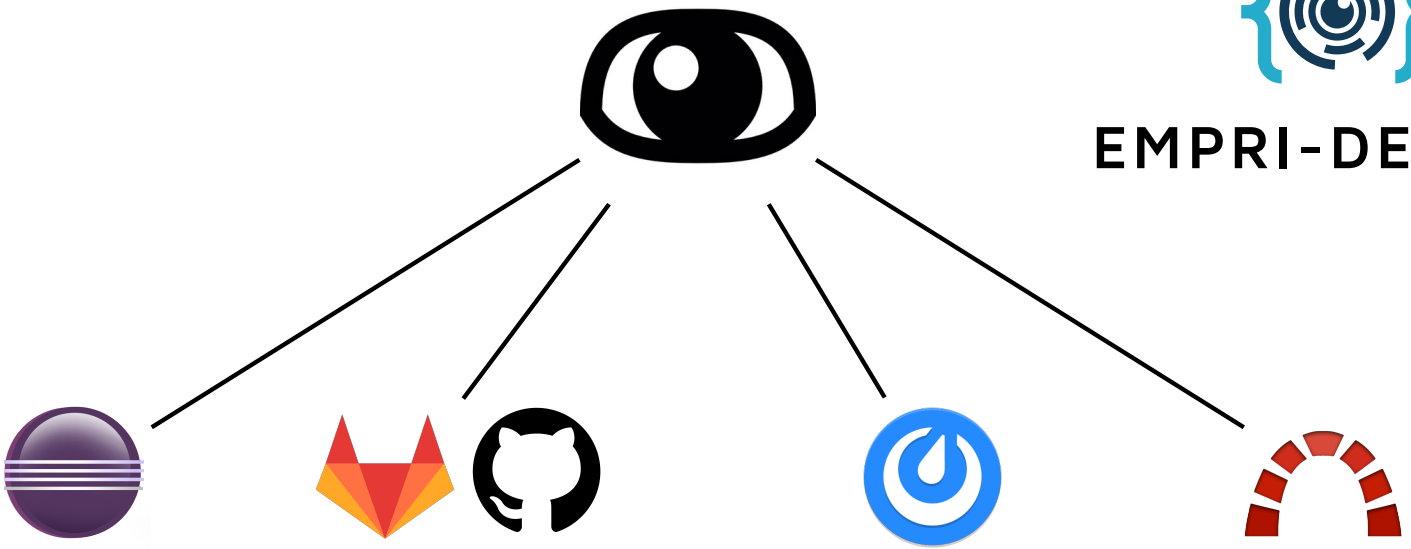

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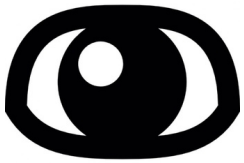
Attacker Model: Curious Employer / Supervisor / Colleague



Motivation Monitor and assess performance and well-behaviour of employees

Capabilities

- Unrestricted access to all persisted application data (databases, filesystems)
- Cannot extend the capabilities of applications

Design Process

Approach:

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Identified Alternatives:

1. timestamp with statically reduced precision
   $\rightarrow$ **Rough Date**
2. timestamp with dynamically reduced precision over time
   $\rightarrow$ **Vanishing Date**
3. pseudo-timestamp that is just a context-aware counter
   $\rightarrow$ **Ordering Date**

Design Validation

Can we accommodate all timestamp use with those 3 alternatives?

ToE Taiga[1] (project management app)

Method

1. Located all timestamp uses in code (model/API exposure) by source code and documentation inspection
2. Classified semantics and purpose

Model Field	Occurrences	Used in Models	Exposed via API
DateTimeField	170	48	41
DateField	15	3	3
TimeField	5	0	0

Table: Usage of date-related Django model fields in Taiga's back-end.

[1] https://www.taiga.io

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Revision Combined type date + ordering

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Rough Date

A timestamp with static precision reduction.

API:

```
created_at = RoughDateField(hours=1)
```

Example:

original	2021-11-08 15:17
rough date (1h)	2021-11-08 15:00

Implementation:

- easy to adopt
- compatible with original `DateTimeField`

Vanishing Date

A timestamp with dynamically reduced precision over time.

API:

```
created_at = VanishingDateField(
  policy=make_policy([
    Precision(hours=1),
    Precision(days=1, after_hours=3),
    Precision(months=1, after_days=7),
  ])
)
```

Example:

Step	Current Time	Stored Date	Next Due Date
Creation/1st Red.	2021-11-08 15:17	2021-11-08 15:00	2021-11-08 18:00

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Example:

Step	Current Time	Stored Date	Next Due Date
Creation/1st Red.	2021-11-08 15:17	2021-11-08 15:00	2021-11-08 18:00
2nd Reduction	2021-11-08 18:01	2021-11-08 00:00	2021-11-15 00:00

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A timestamp with dynamically reduced precision over time.

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3rd Reduction	2021-11-15 00:03	2021-11-01 00:00	-

Vanishing Date: Implementation

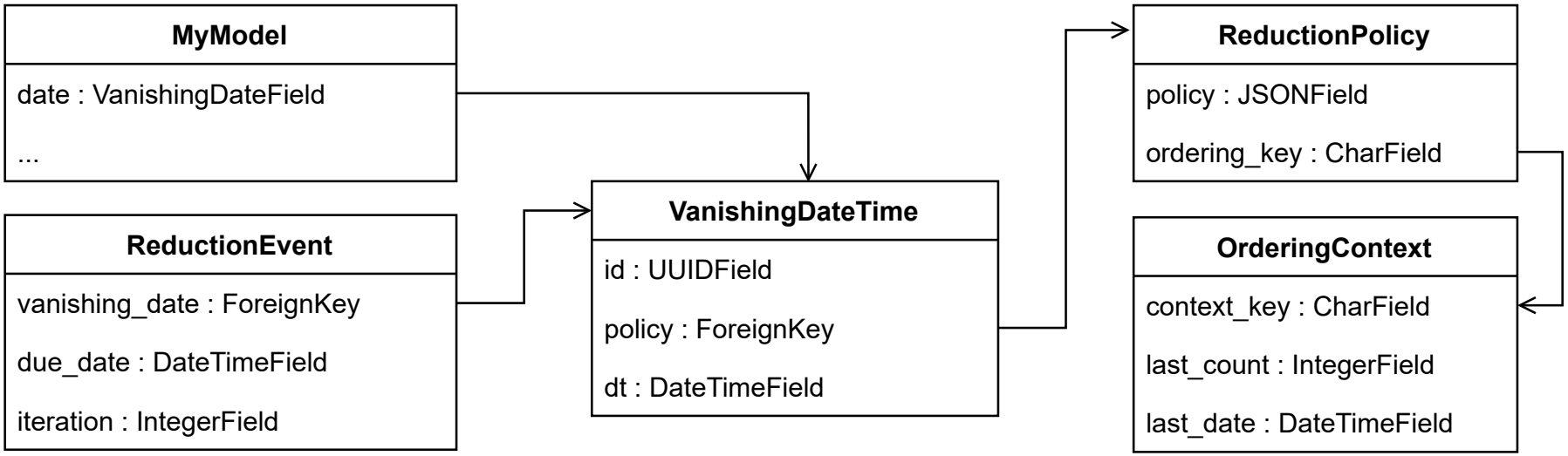


Figure: Architecture of vanishing date auxiliary models

- UUIDs instead of AutoField as primary keys to avoid insertion chronology leaks
  But: databases may still maintain insertion order
- Transparent policy reuse to preserve storage
- Models with vanishing date are identified via a mixin

Ordering Date

Not actually a timestamp but a sequence number with context isolation

API:

```
class MyModel(models.Model):
    created_at = OrderingDateField(hashed=True)

def do_something():
    my_instance = MyModel(
        created="my-context-key",
    )
    # ...
```

Implementation:

- Context keys identify the sequence number context
- Auxiliary model keeps track of context state
- Optional hashing for sensitive context keys

Combined Type: Vanishing and Ordering

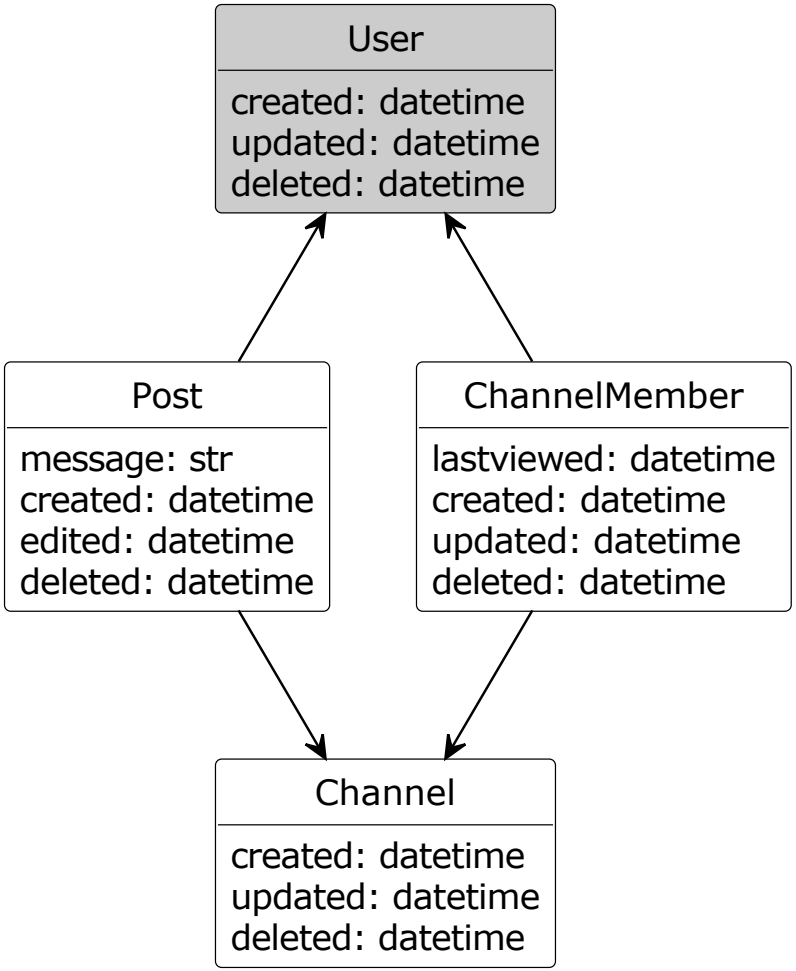
Idea: Use sub-second part to hold context counter

Original	**Vanishing** 1. Iteration [5 sec]	**Vanishing+Order** 1. Iteration [5 sec]	**Vanishing+Order** 2. Iteration [30 sec]
12:20:11:673320	12:20:10:000000	12:20:10:000000	12:20:00:000000
12:20:14:313406	12:20:10:000000	12:20:10:000001	12:20:00:000001
12:20:17:248323	12:20:15:000000	**12:20:15:000002**	**12:20:00:000002**
12:20:33:040852	12:20:30:000000	12:20:30:000000	12:20:30:000000
12:20:35:917632	12:20:35:000000	12:20:35:000001	12:20:30:000001

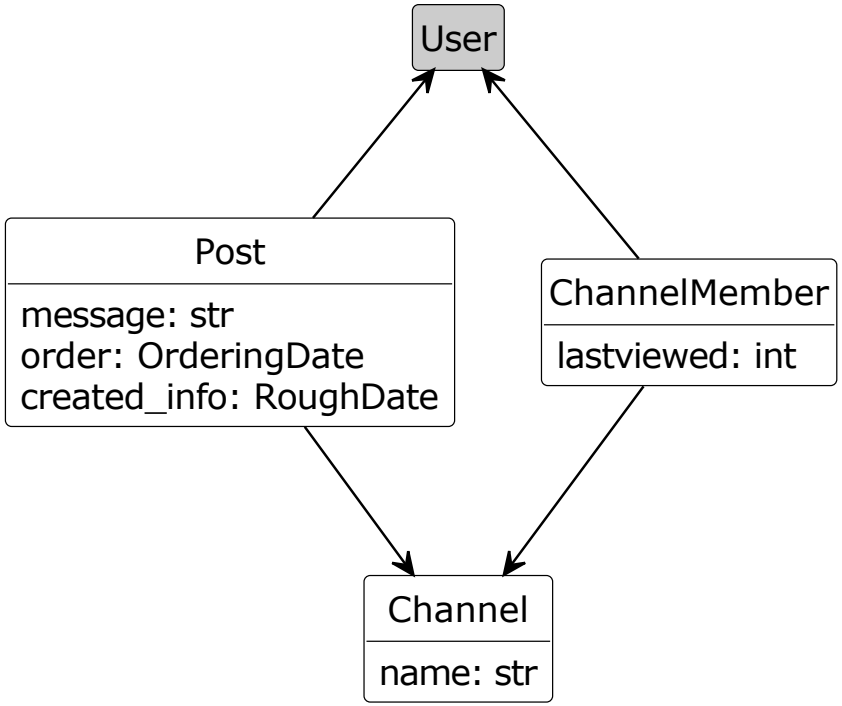
bold = counter reset

Application on Chat Example

Now



With Privacy Dates



- Channel name could be context key

Evaluation

- Practicality
  - Integrated in Taiga 6.0.7
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- Storage Cost

Type	**Size [bytes]**	**Factor of** `DateTimeField`
`RoughDateField`	8	1.0
`VanishingDateField`	142	17.75
`OrderingDateField`	4	0.5

Limitations & Future Work

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- Chronology Leaks trough DB insertion order possible

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Future Work:

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- Evaluate usability in developer study
- Reduce storage cost for vanishing date

Summary: Findings & Contribution

Presented a **Framework** that makes it easier to **avoid full-precision timestamps** in app data models.

- Designed timestamp alternatives based on prior work
- Validates design on Taiga
- Implemented framework for Django (open source on GitHub)
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- Evaluated framework practicality and cost
- Learnt: DBMS needs to play along

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Contact

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I'd be happy to hear from you!

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