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Enforcing User Privacy in Web Applications using Erlang

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User Privacy in Web Applications

- Which is longer, the United States Constitution or Facebook's Privacy Policy?
  - Facebook's Privacy Policy: 5,830 words
  - United States Constitution: 4,543 words

[NYT, May 12, 2010]

- Twitter 0 followers bug
  - Tweet "accept," followed by "@" and user name
  - The other user starts following you automatically (!)

[Official Twitter Blog, May 10, 2010]

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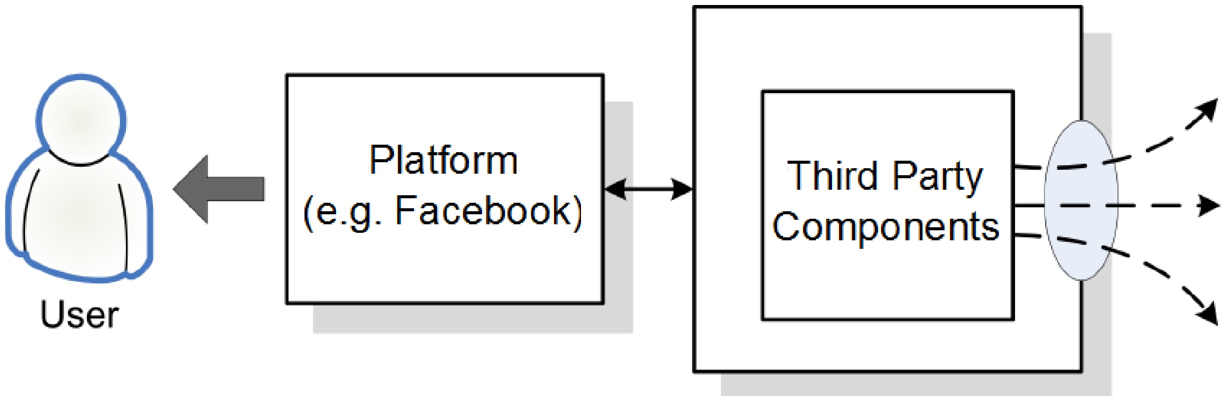
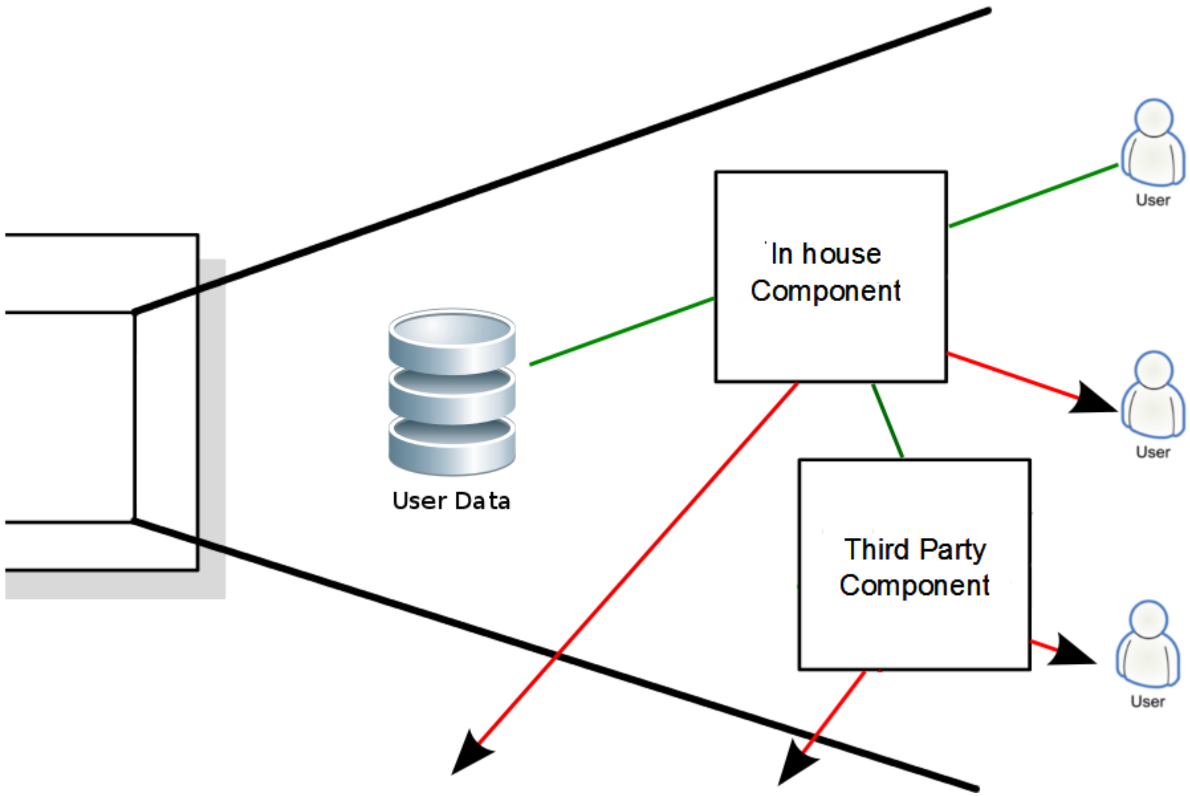
User Privacy in Web Applications



- User data privacy must be guaranteed independently of the application's functional correctness

User Privacy in Web Applications



- ➢Code should access only relevant user data and keep them isolated from other users' data

Use Case: Privacy in Microblogging

A microblogging system should guarantee:

1. *Messages from a publisher component shall be delivered only to authorised subscribers' components.*
   [User A's messages will only go to Users B and C]

2. *Authorised subscribers shall not be disclosed to any other publisher or subscriber component.*
   [User B will not know about User C]

3. *Subscription authorisation requests from a subscribing component shall be delivered only to the relevant publisher's component.*
   [Only User A can authorise a new User D]

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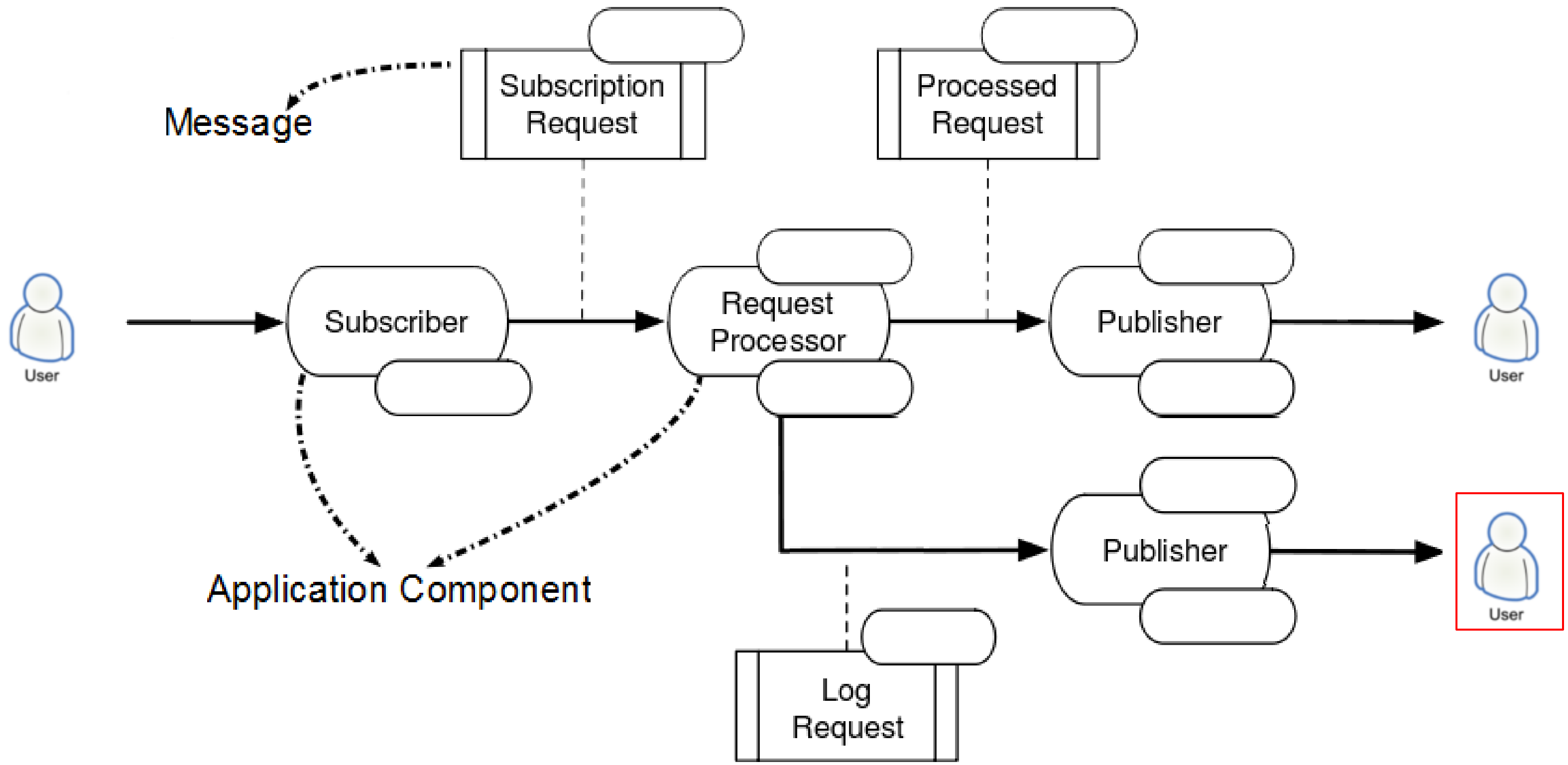
IFC for Microblogging



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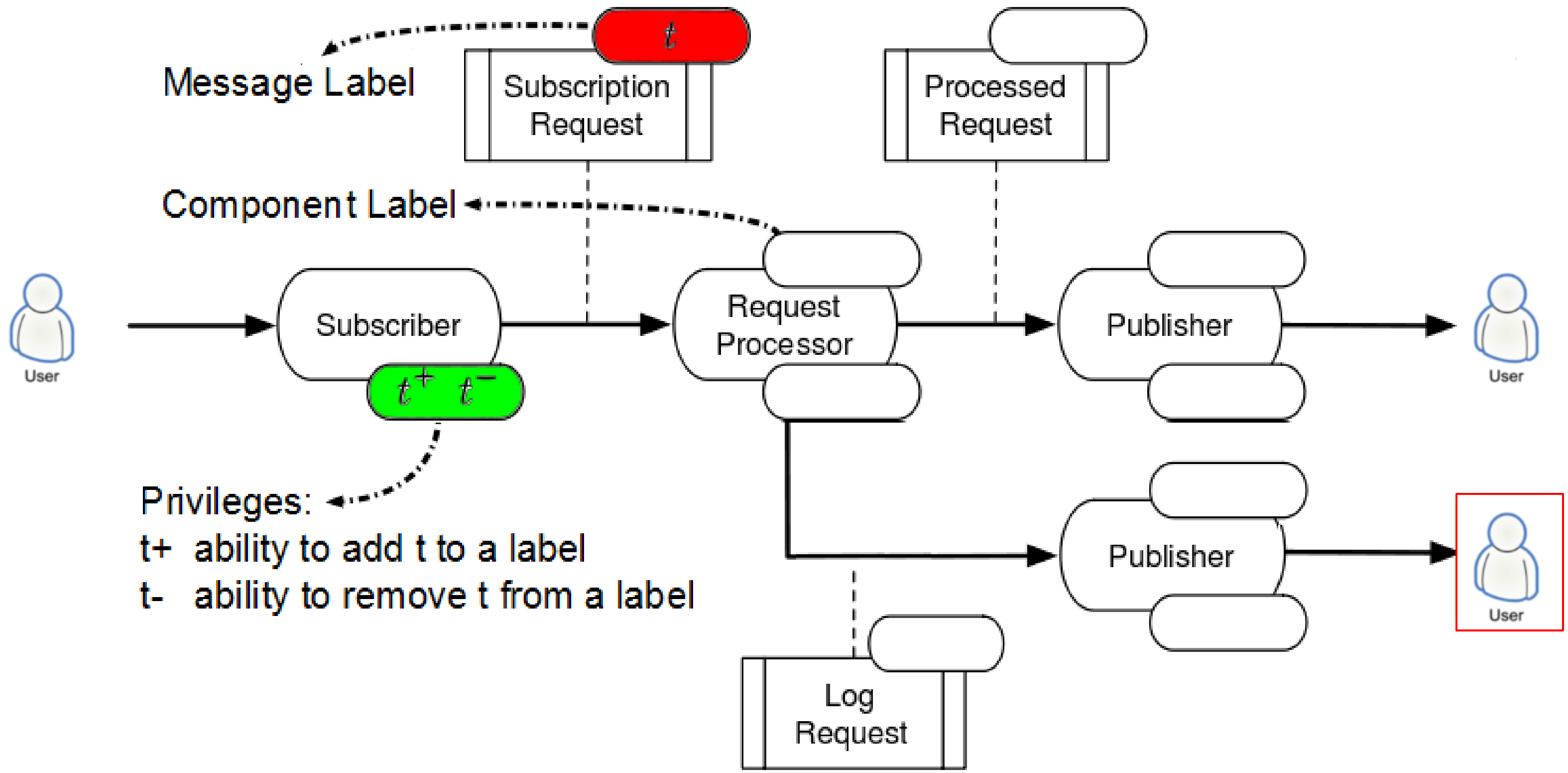
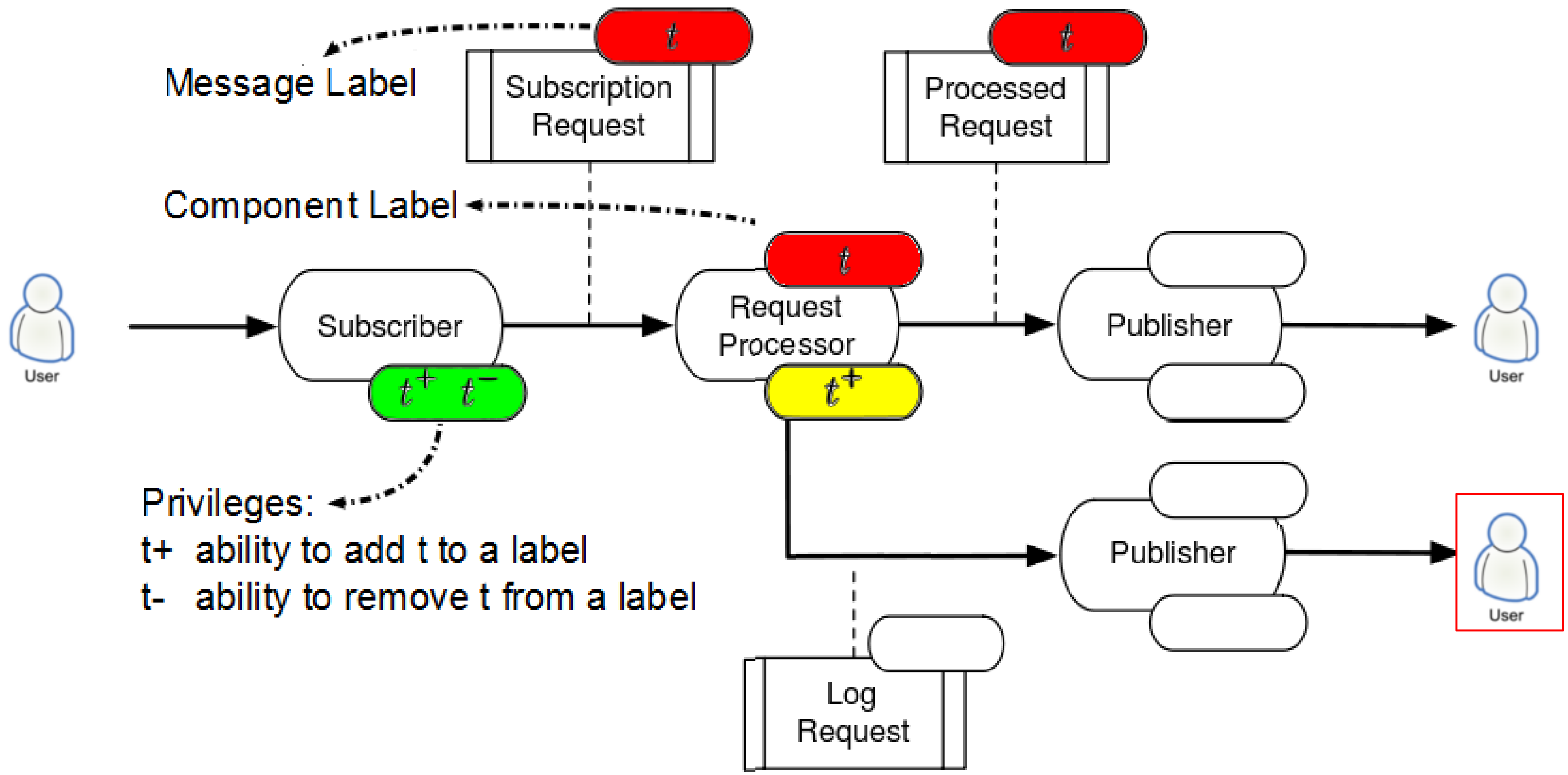
IFC for Microblogging



Privileges:
t+ ability to add t to a label
t- ability to remove t from a label

IFC for Microblogging



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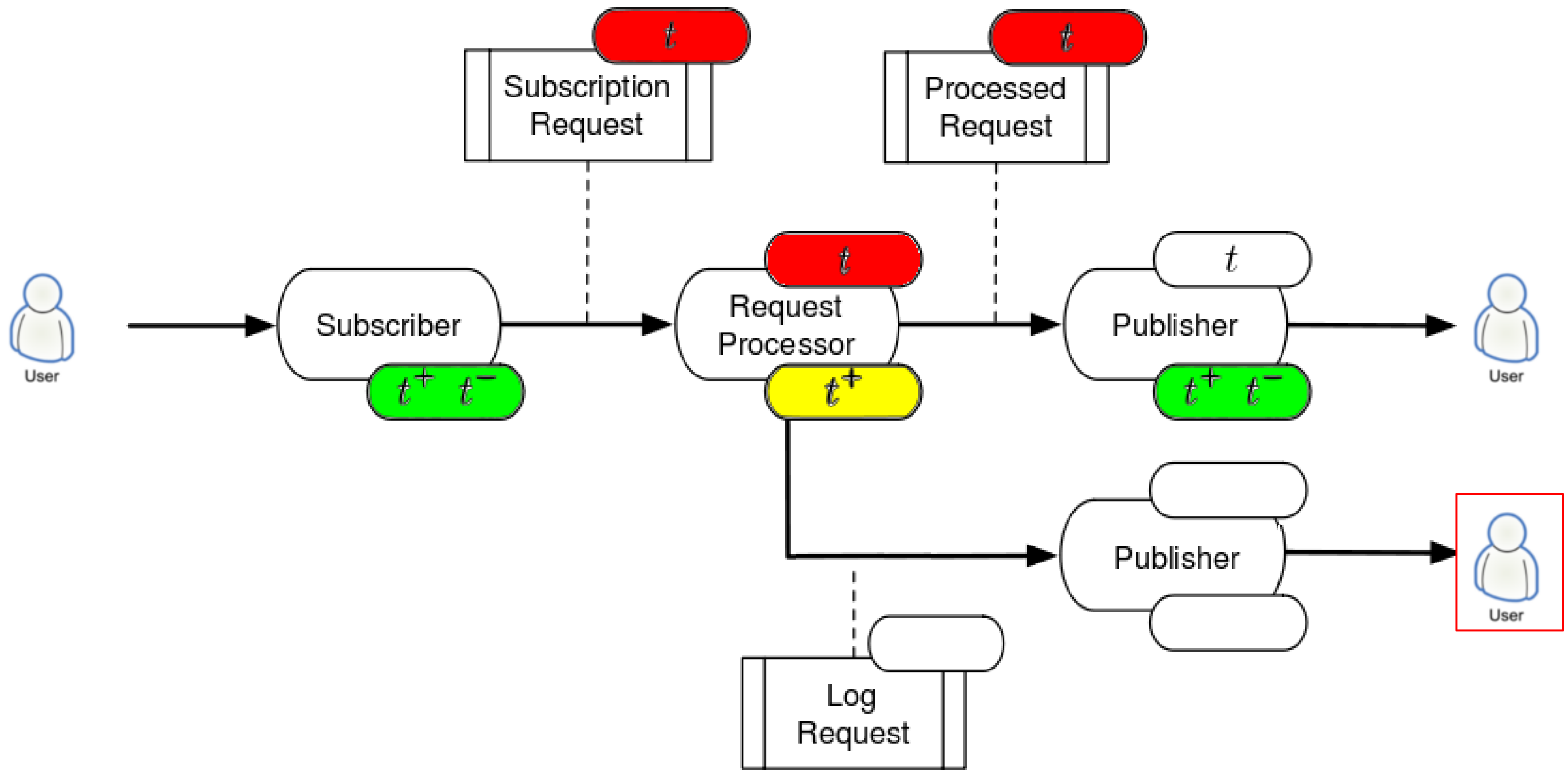

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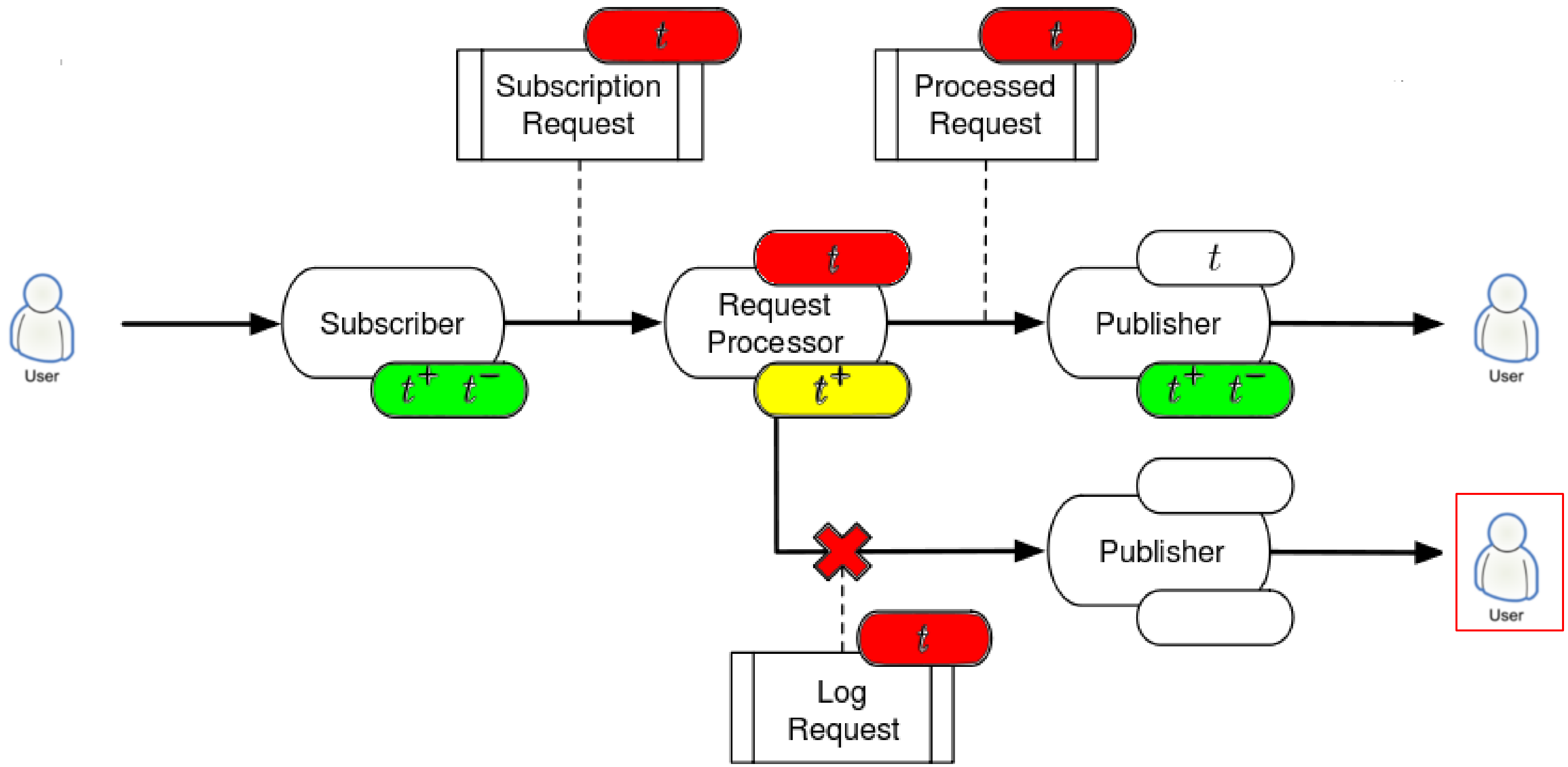
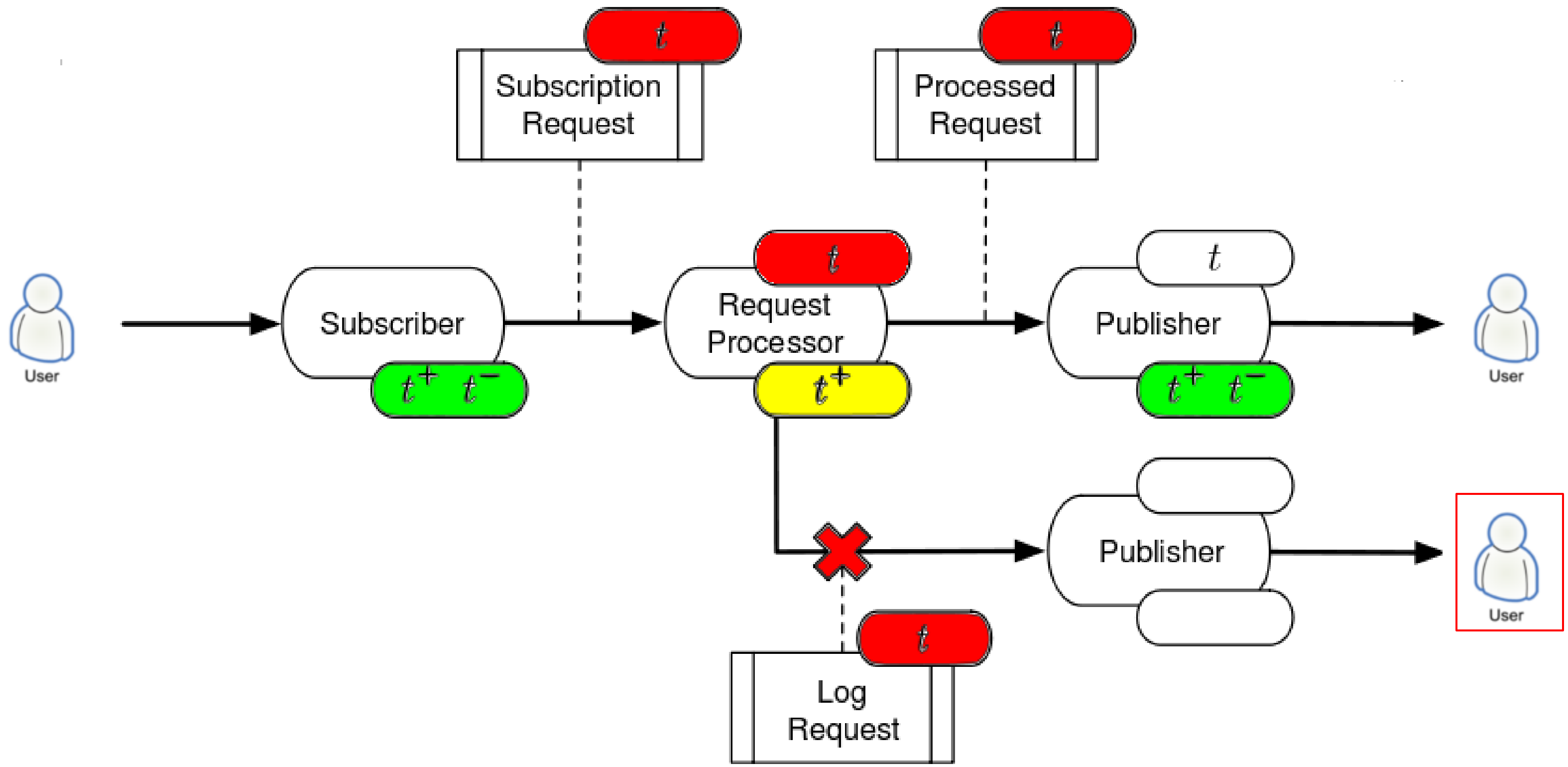


IFC for Microblogging



What happens when data belonging to different users has to be processed by a <u>single</u> component?

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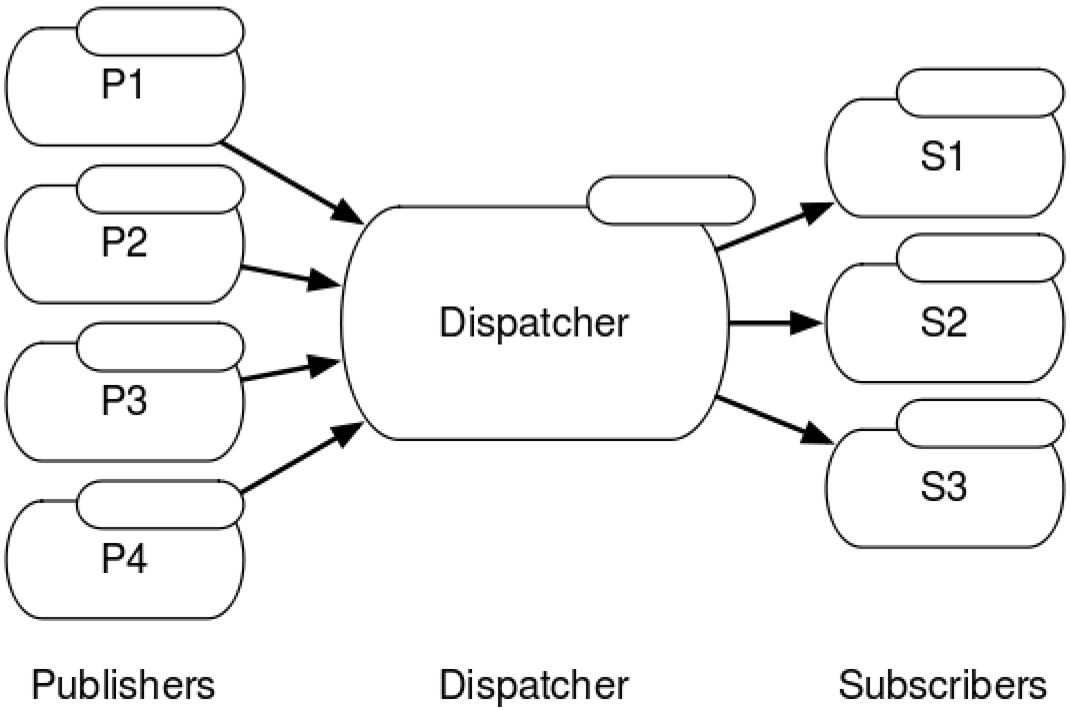
Microblogging: The Dispatcher

Multiple publishing components have to use a single dispatcher to reach the relevant subscriber components



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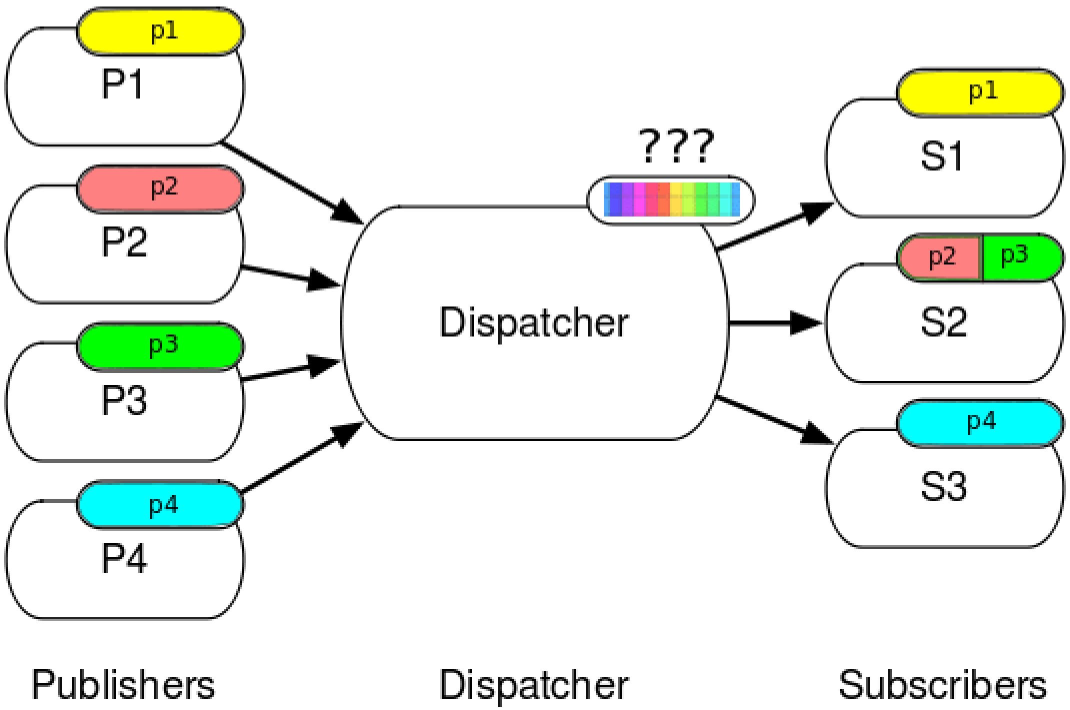

Solution

- Each User's data must be kept separate, but applications are usually monolithic
- Compartmentalize the application in multiple isolated components, one per user
- Granularity?

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Language	Isolation	Issue
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Java	OS Threads	Limited isolation: static fields, object locks, runtime channels
PHP JavaScript	OS Processes	Spawning a new runtime on top of spawning a new OS process

Erlang

- Sequential Part:
  functional language, single assignment, dynamic typing
- Concurrency:
  share nothing concurrency, message passing

- Erlang is great for IFC
  - Isolation is free
  - Asynchronous message passing can be naturally combined with label checks
  - Processes are lightweight (~100B, runtime implementation)

Erlang: Example

- Sender Process:

```
test(0) -> done;
test(N) ->
   pid=spawn(primeTester),
   pid ! {calculate, self(), N},
   receive
      {result, Result}->
         io:format("~w",[Result])
   end,
   test(N-1)
 end.
```

Spawning processes is __fast__!

You ~~can~~ want to have __lots__ of them!

- Receiver Process:

```
primeTester() ->
  receive
    {calculate, Pid, Number} ->
       Result = isPrime(Number),
       Pid ! {result, Result}
  end.
```

Async message passing is the __only way__ of communication!*

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Supporting IFC in Erlang

- Attach labels to pids
- `new_tag()`

  creates a new tag for the calling process
- `spawn(TagsAdd, TagsRemove, ...)`

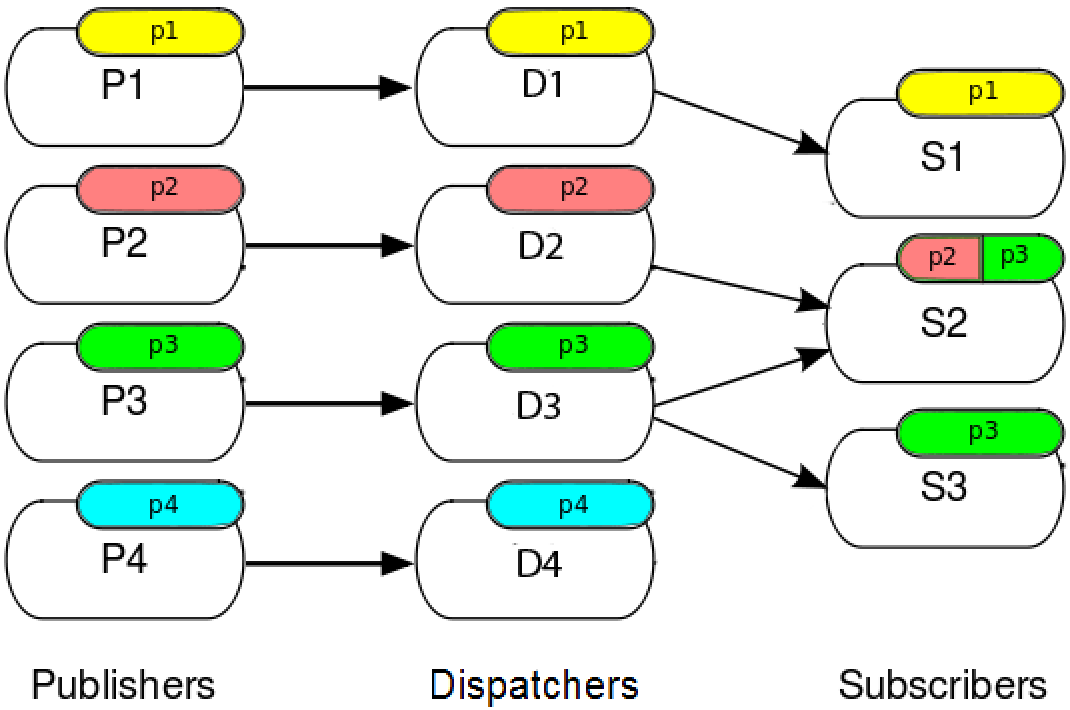
  changes the tags of the spawned process (≠ caller's tags)
- `send(TagsAdd, TagsRemove, ...)`

  changes the tags of the message (≠caller's tags)
  checks labels
- `delegate(PidReceiver, Tag, Type)`

  gives privileges over a tag to another process

Erlang for Microblogging I

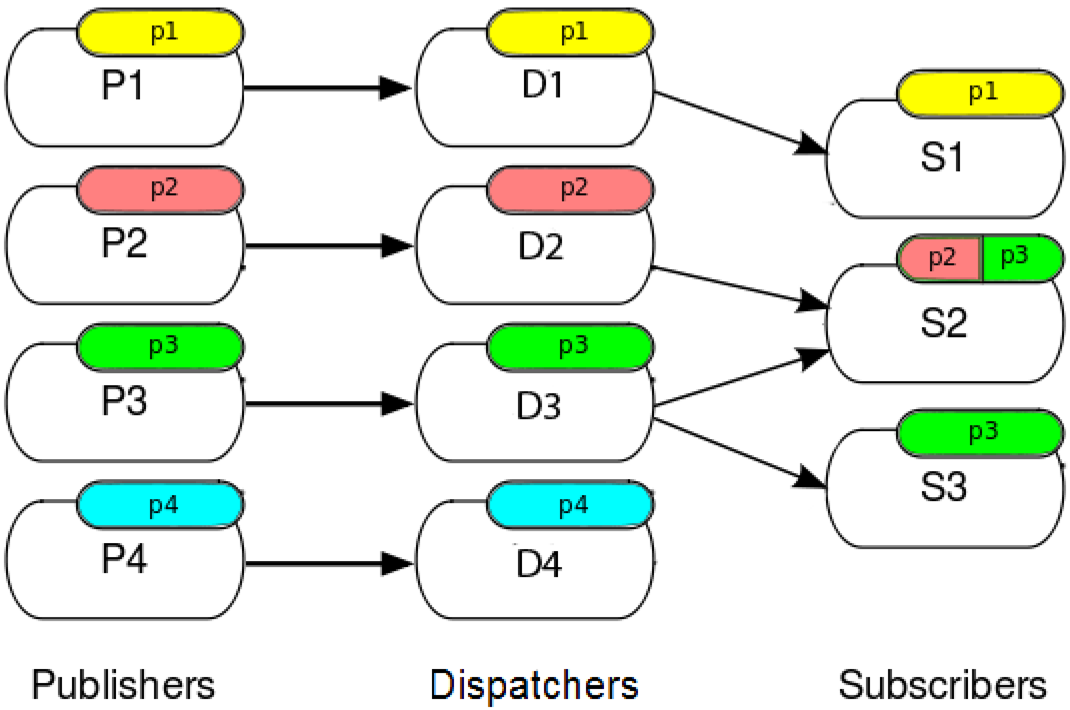
1. *Messages from a publisher shall be received only by authorised subscribers.*



(untrusted code)

Erlang for Microblogging I

2. *Authorised subscribers shall not be disclosed to any other publisher or subscriber.*



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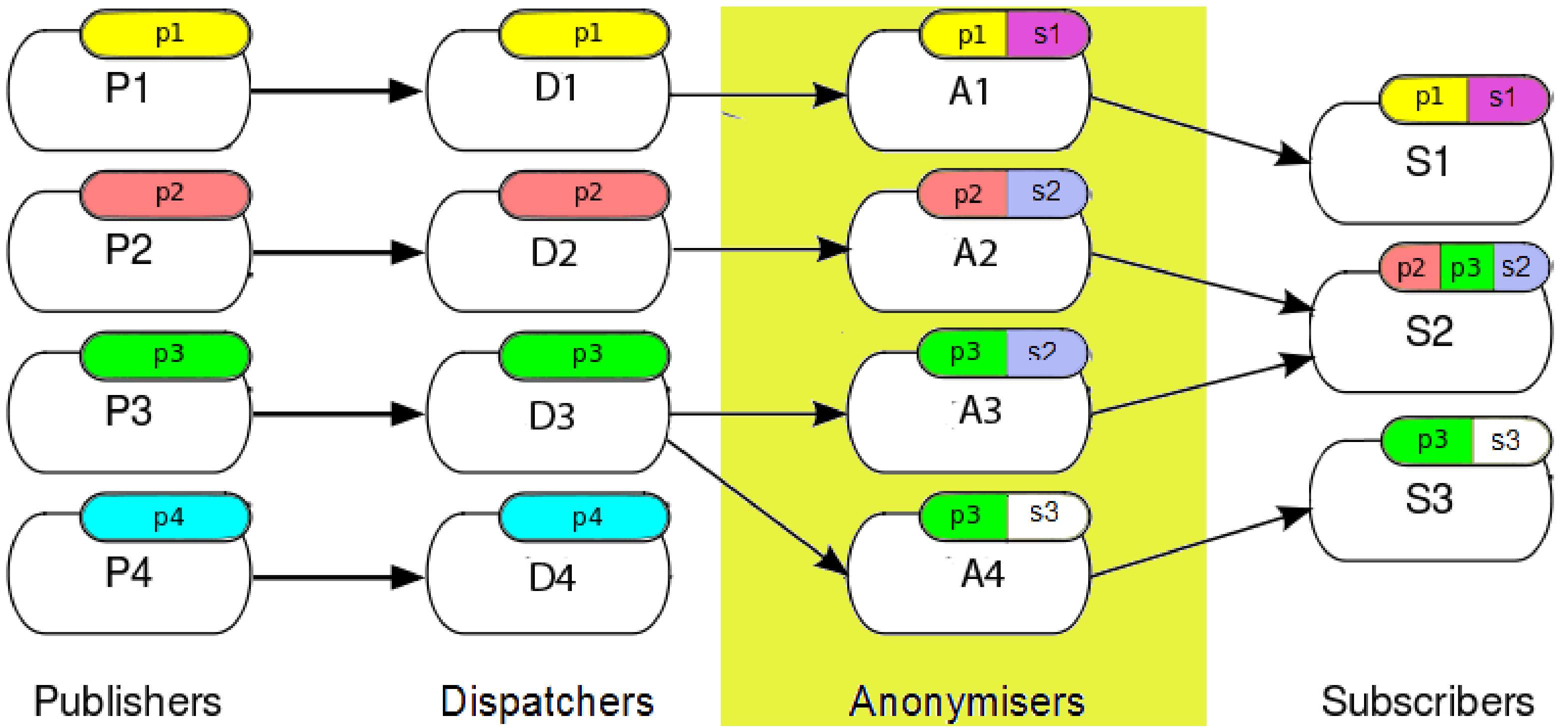
Erlang for Microblogging II

2. *Authorised subscribers shall not be disclosed to any other publisher or subscriber.*



(bug prevention)

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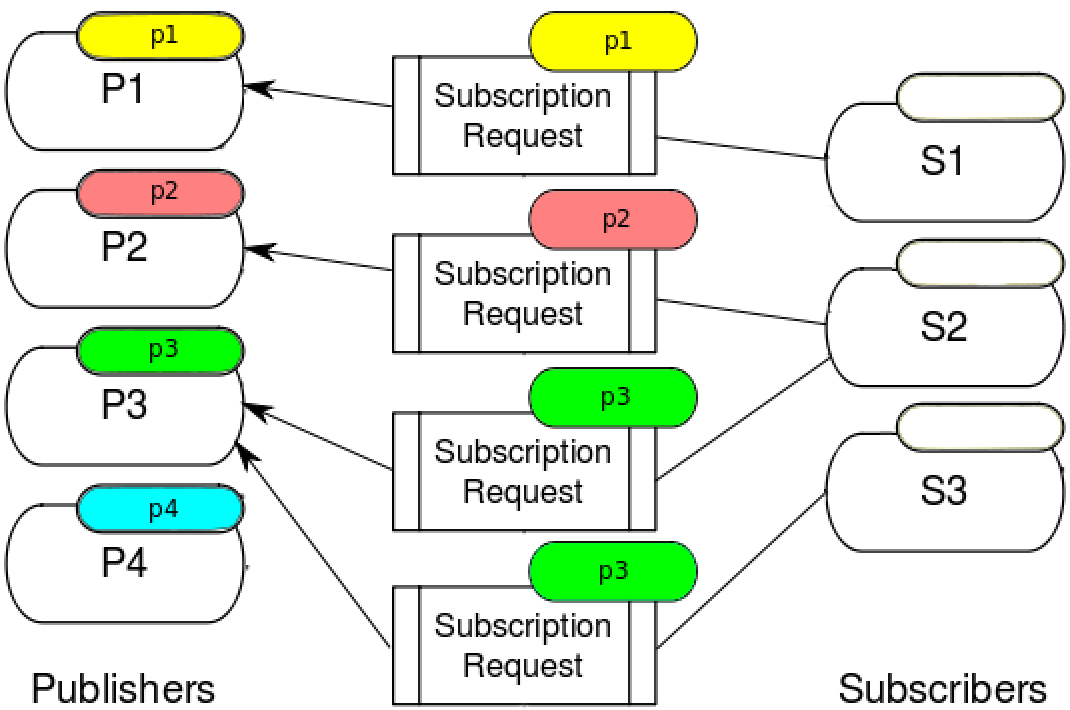
Erlang for Microblogging III

3. *Subscription authorisation requests from subscribers shall be delivered only to the relevant publisher.*



(bug prevention)

Experimental Setup

- Erlang Library that provides the IFC API
- Measure throughput in terms of messages per second
- #publishers=#subscribers, 10 subscriptions/subscriber
- Ignored orthogonal issues like message persistence

Comparison between:

- *Python*
  [represents scripting languages]
- *Erlang (no IFC)*
  [Dispatcher per publisher, better multicore performance]
- *Erlang (IFC)*
  [Anonymisers plus label checks]
- *Erlang (IFC + caching)*
  [cache and reuse of label checks]

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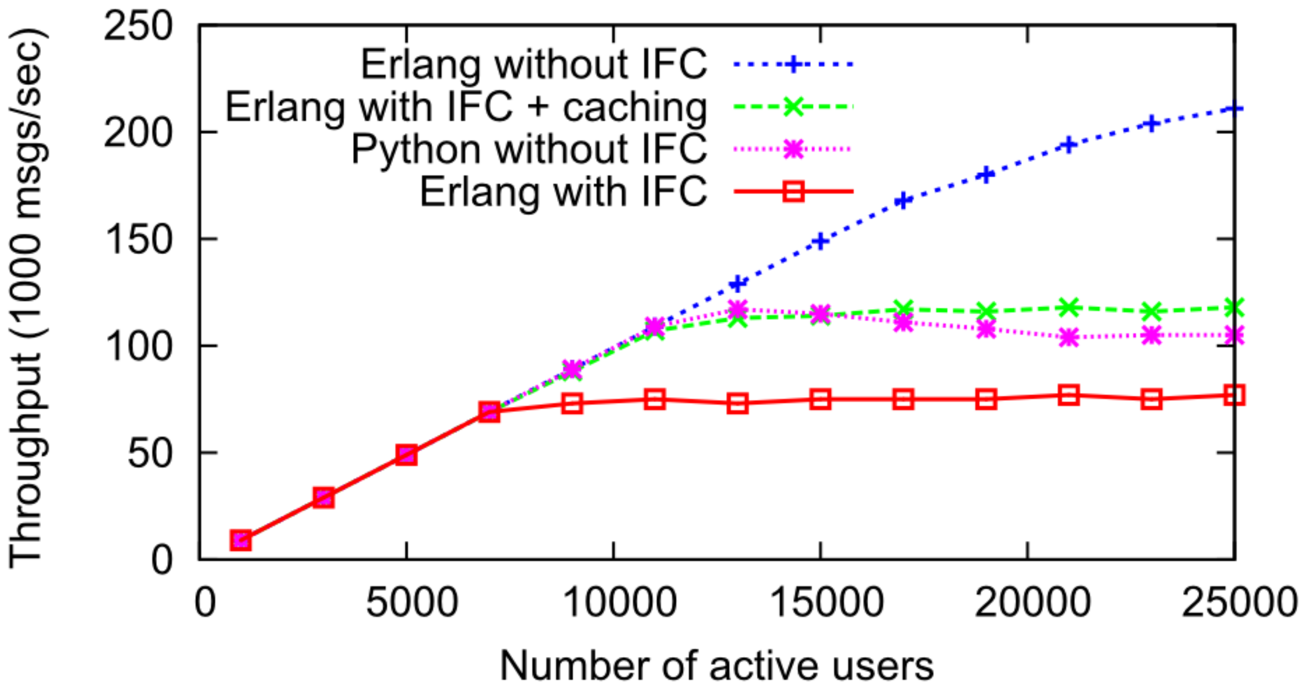
Evaluation



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Limitations & Discussion

- **Complexity**
  - Applications have to handle tags/privileges manually
  - Deciding upon a tag allocation scheme is challenging
  - Handling tags routines must be correct for secure operation
  - Policy languages may come to the rescue

- **Persistence**
  - Messages must be stored permanently
  - Fetching and storing data but be compatible with labels
  - Extend Mnesia to be label aware

- **Scalability**
  - Inactive users must be offloaded from RAM
  - Scalability depends upon the ability to keep in memory only the required state
  - Introduce a primitive to hibernate/restore a process

Conclusion

Erlang is an attractive approach for web applications that use IFC to provide privacy guarantees:

- Isolation of components is free
- Asynchronous message passing is the norm in IFC systems
- Scales well in multicore architectures

Web applications can provide IFC-enabled Erlang APIs and hosting facilities for untrusted extensions

- The web application has to disseminate tags to components according to the relationships between users
- Tags can enforce that the third-party extensions do not violate high level policy

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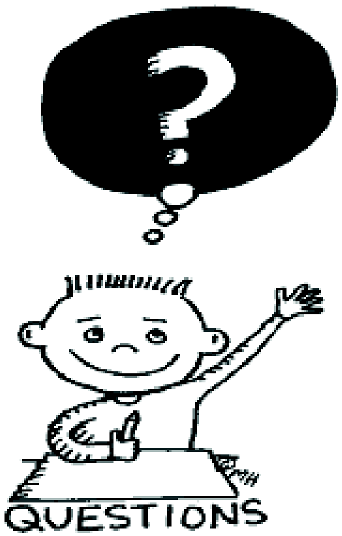
The End



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Related Work

[How are Erlang Processes Lightweight? 2006]

- Stack frames can be resized/moved (mem)
- User-level, efficient caching when switching (time)
- Lack of shared state means no locking (time)

[xBook09]

- Uses a subset of JavaScript on the server side
- Recreates Erlang’s communication model

[Abestos05]

- Lightweight OS Processes, one per user
- Cooperative Scheduling