Hails: Protecting Data Privacy in Untrusted Web Applications

Daniel B. Giffin, Amit Levy, Deian Stefan, David Terei,
John Mitchell, David Mazières, and Alejandro Russo

github:develop

Web platforms are **great**!

They allow third-party developers to build apps that use our personal data.

Google Developers

foursquare DEVELOPERS

PCMAG.COM

Path Uploads Your Entire iPhone Contact List By Default

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WHAT THEY KNOW | October 17, 2010, 8:33 p.m. ET

Facebook in Privacy Breach

Top-Ranked Applications Transmit Personal IDs, a Journal Investigation Finds

Web platforms are **scary**!

They allow third-party developers to build apps that use our personal data.

Symantec. | Connect

COMMUNITY: Security | Blogs | Security Response

Facebook Applications Accidentally Leaking Access to Third Parties - Updated

The GitHub Blog

March 4, 2012 mojombo

Public Key Security Vulnerability

Trust concerns

- Don’t know the developers
  - Cannot determine trustworthiness of apps
- They may be malicious or security-unaware
- Building secure web apps is hard
  - Even well-meaning authors cannot be trusted

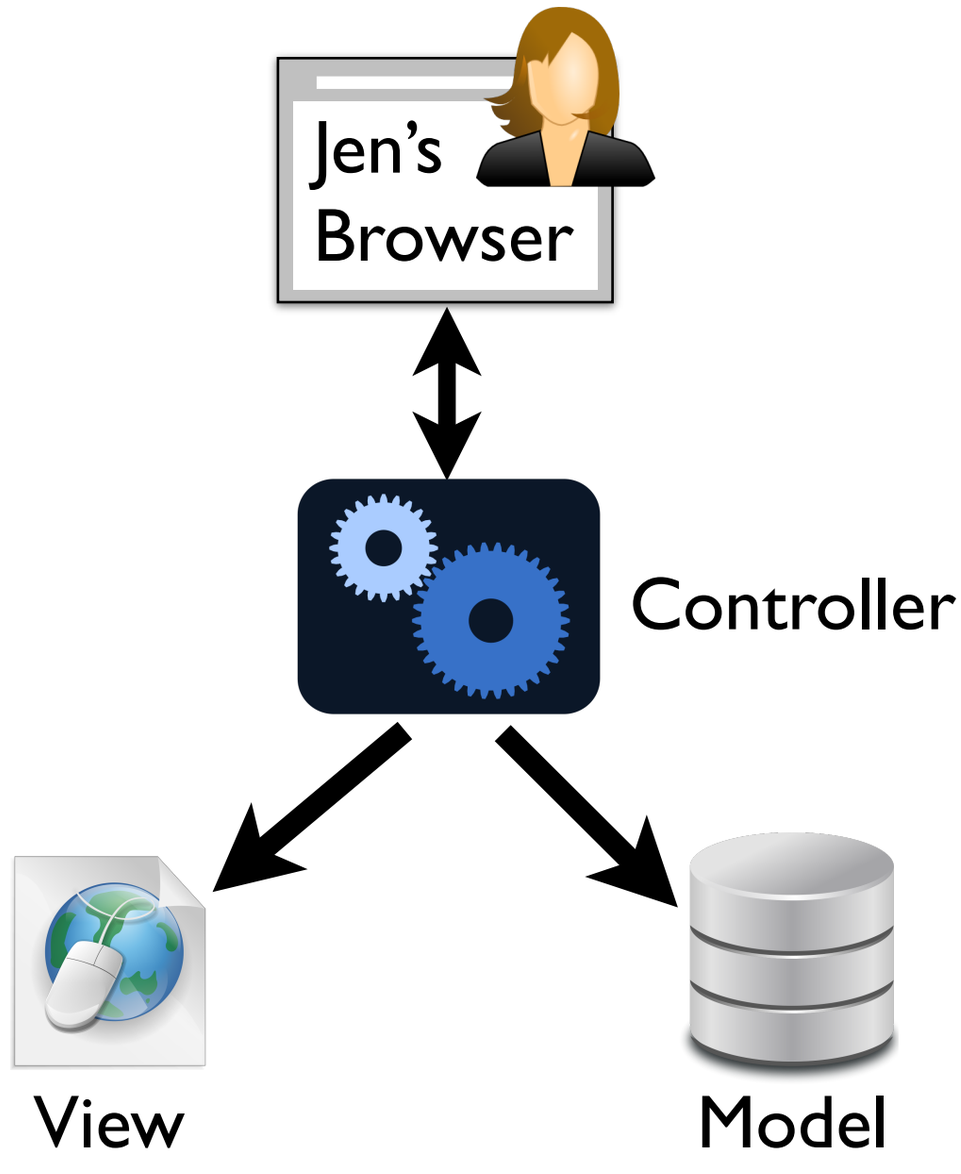
Typical App Design

Use popular MVC paradigm

Model: interface to data

View: renders pages

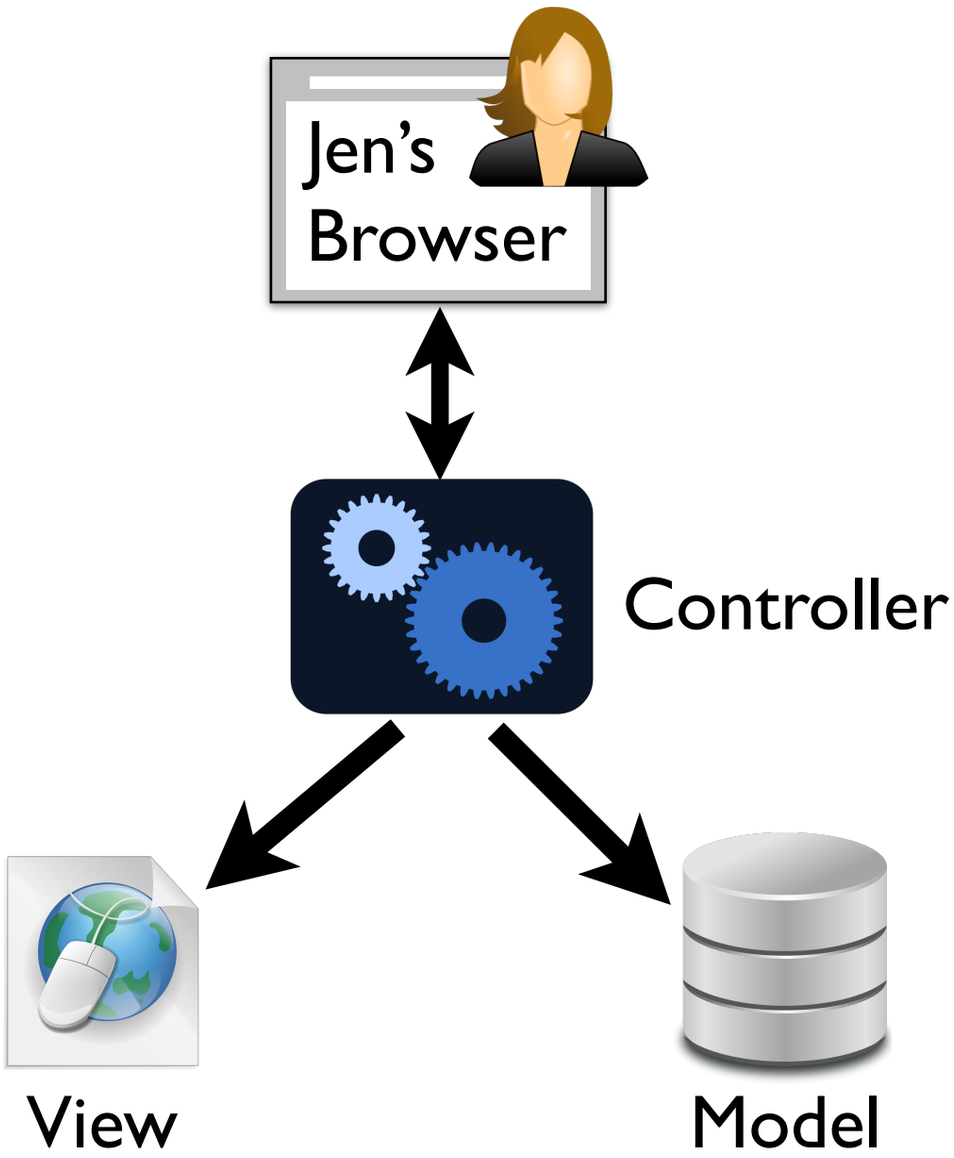
Controller: handles and responds to HTTP requests



Typical App Design

How is security policy specified and enforced?

- E.g., *only Jen's friends may see her email address*



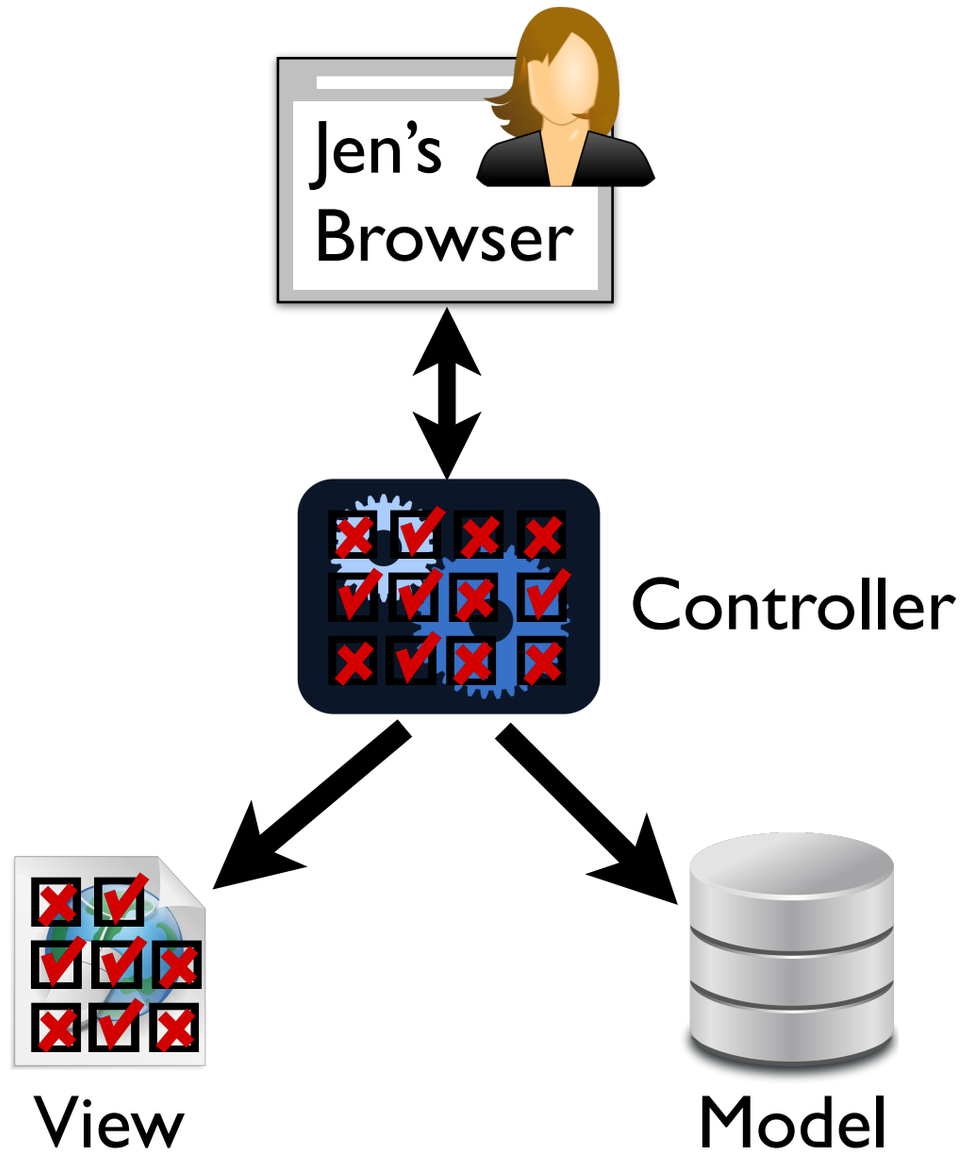
Typical App Design

How is security policy specified and enforced?

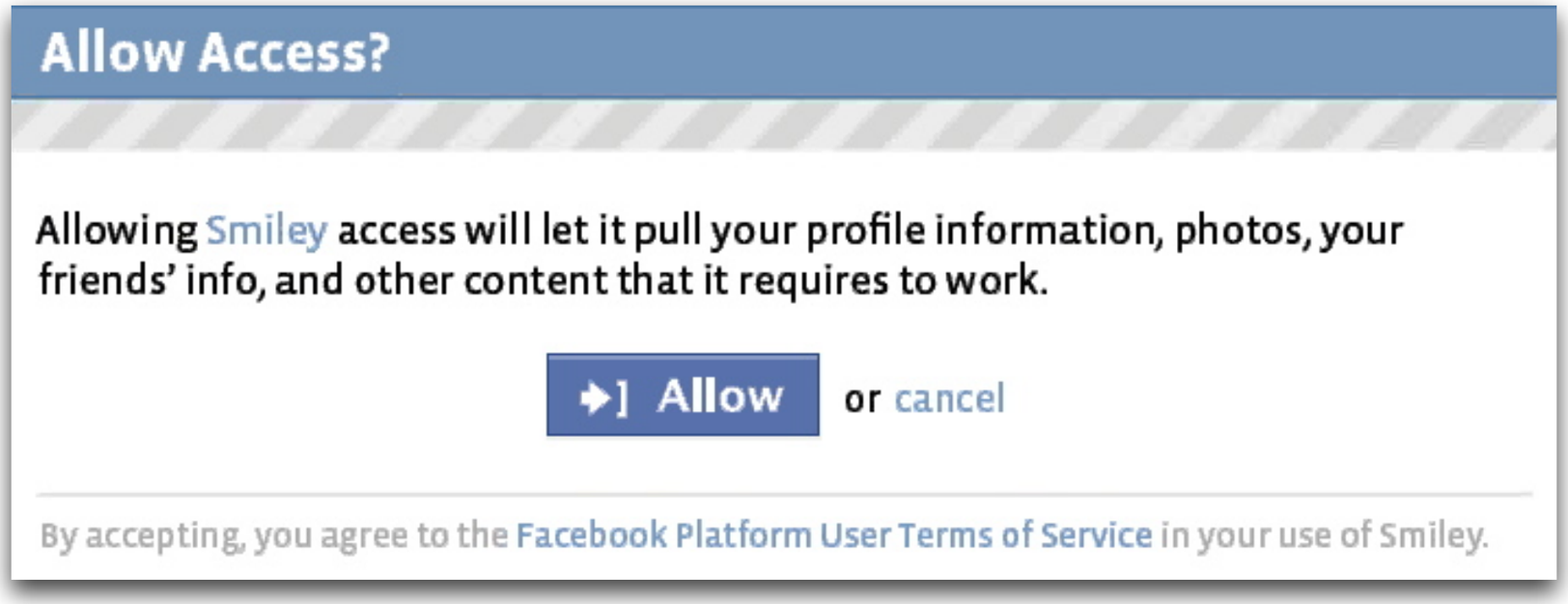
- E.g., *only Jen's friends may see her email address*

Intertwined throughout code

➠ Error prone and not scalable



Platform ~~solutions~~



Can decide to give an app access to data, but can't control how the app uses your data.

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Path Uploads Your Entire iPhone Contact List By Default

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Is there any hope for privacy on platforms?

Symantec. | Connect

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March 4, 2012 mojombo

Public Key Security Vulnerability

Change the hosting model

- Current model
  - App developers host their own apps
  - Platform enforces security: terms of service
- New model
  - Platform provider hosts apps
  - Platform enforces security: information flow control

Hails: A web platform framework

- Security policy is explicit and first-class
  - Specified as single concise module
- Users still trust core platform components
- Apps are untrusted
  - Language-level information flow control guarantees apps always obey policy

What makes Hails different?

Aeolus, HiStar, Nexus, Jif, Ur/Web, ...

- No guide for structuring applications
- Policies are hard to write
- Not appropriate for dynamic systems, e.g., web
- Modify entire application stack

Goals

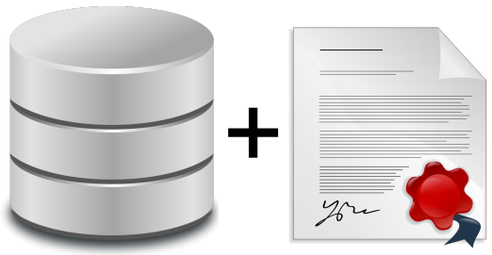
- Deployable today!
- Usable by web developers
- Suitable for building extensible web platforms
  - Enforcing policy across untrusted apps

Adding Policy to MVC

- New paradigm: Model-**Policy**-View-Controller
- Policy specified alongside data model
- No policy code in View or Controller

Two categories of code

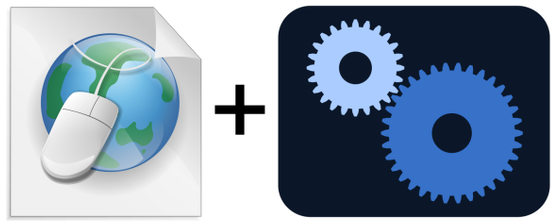
Models-Polices (MPs)



Specify data model and policy on data

- Users trust MPs they use to handle data

Views-Controllers (VCs)



Implement UI and other functionality

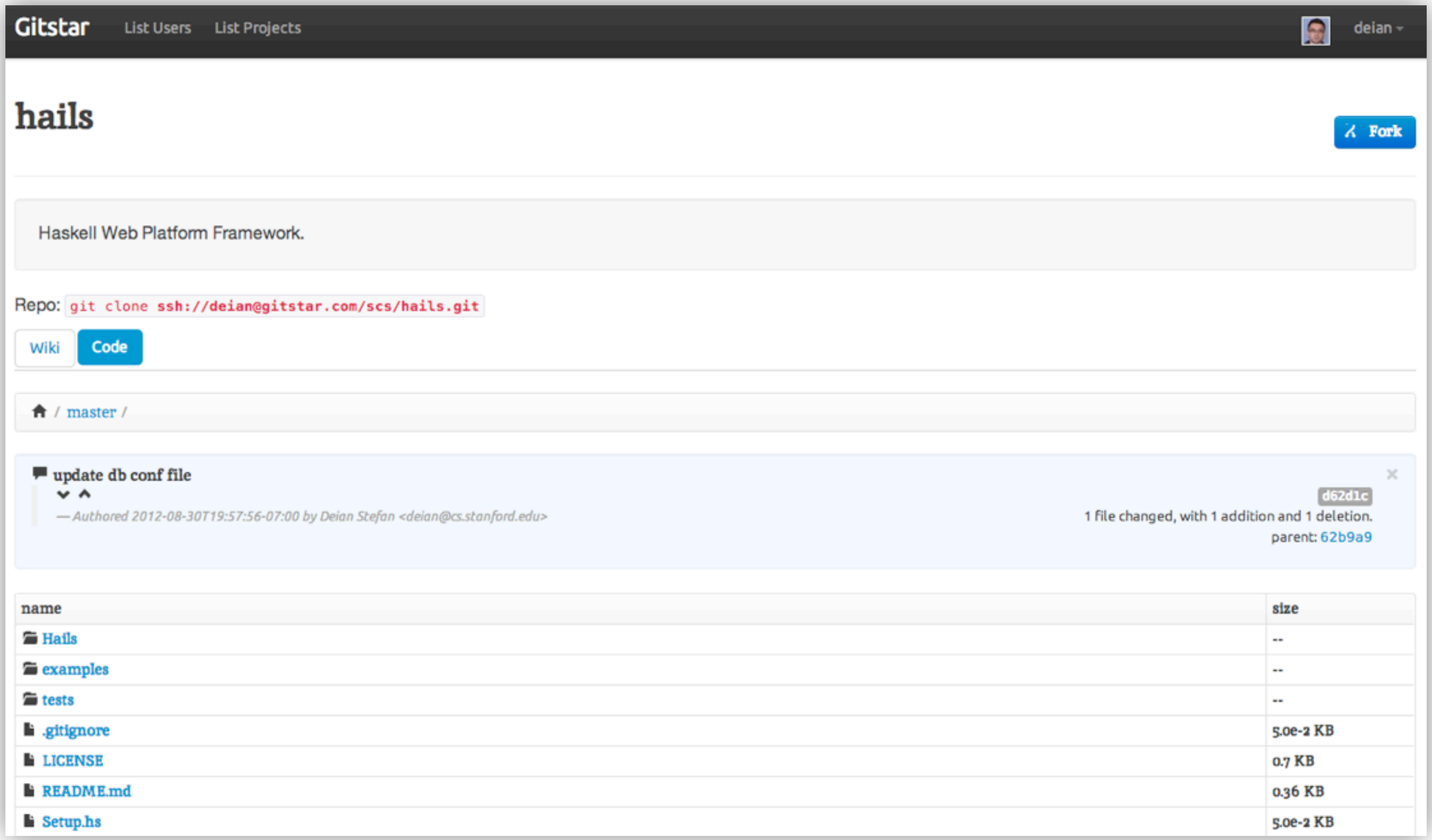
- Users need not trust VCs

Policy enforced globally

Information flow control

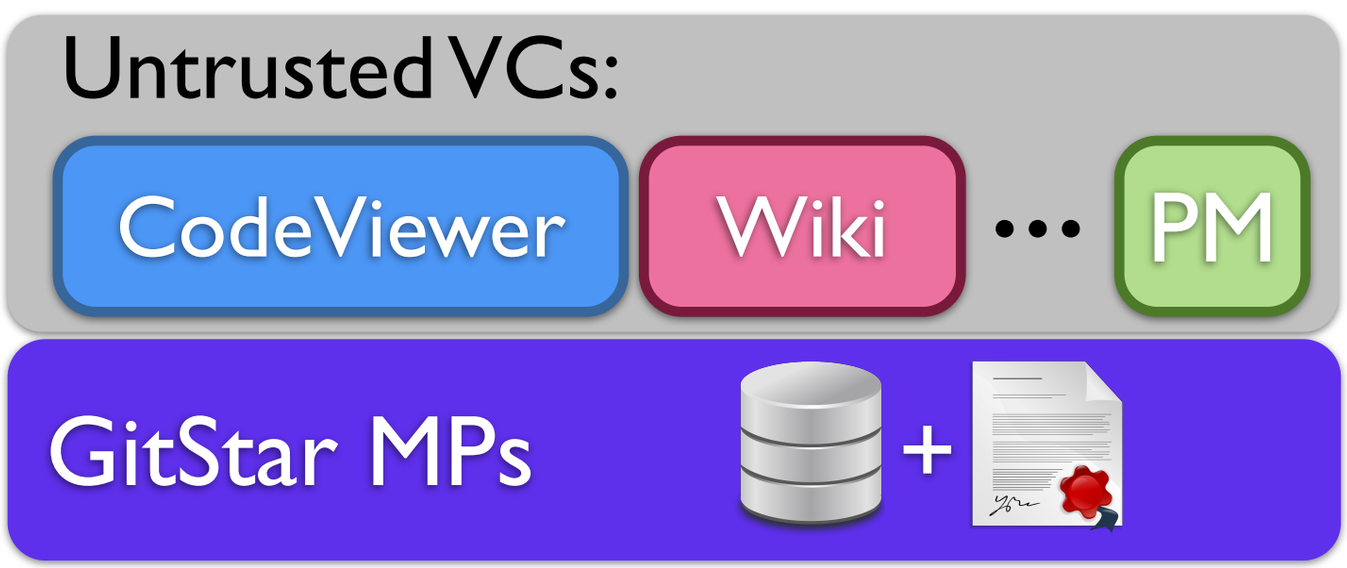
- Policy specifies where data can flow
  - **Wrong:** app can't read Jen's email address because it may leak it to Eve
  - **Right:** app can read Jen's email, but only reveal it to Jen, Alice or Bob
- Policy follows data through system
- Runtime enforces policy end-to-end
  - E.g., when making HTTP request

Case study: GitStar

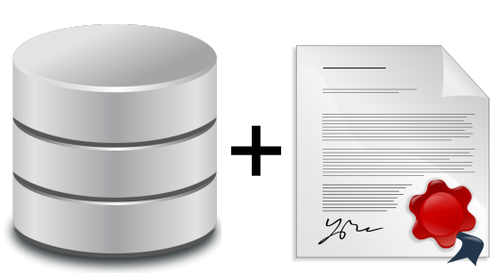


Case study: GitStar

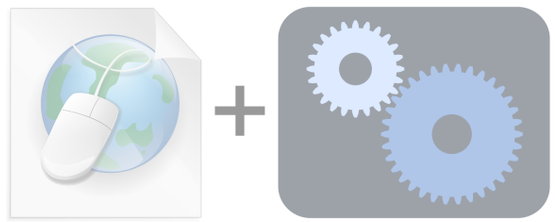
- GitStar provides
  - MPs that specify projects and users
  - VC for managing projects and users
- Third-party authors provide
  - Code viewer
  - Wiki
  - Follower app
  - etc.



Model-Policy



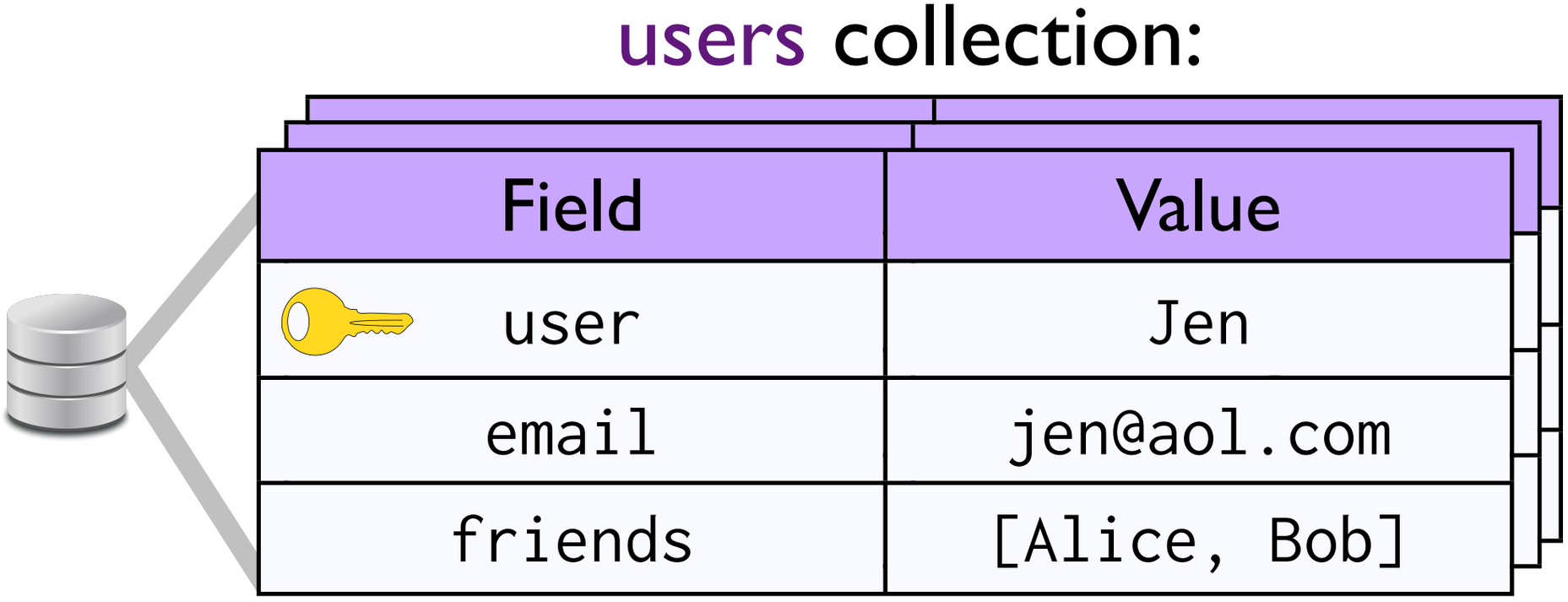
View-Controller



Model-Policy (MP)

Data model: document-oriented

- **Collection:** set of documents
- **Document**: set of field-value pairs



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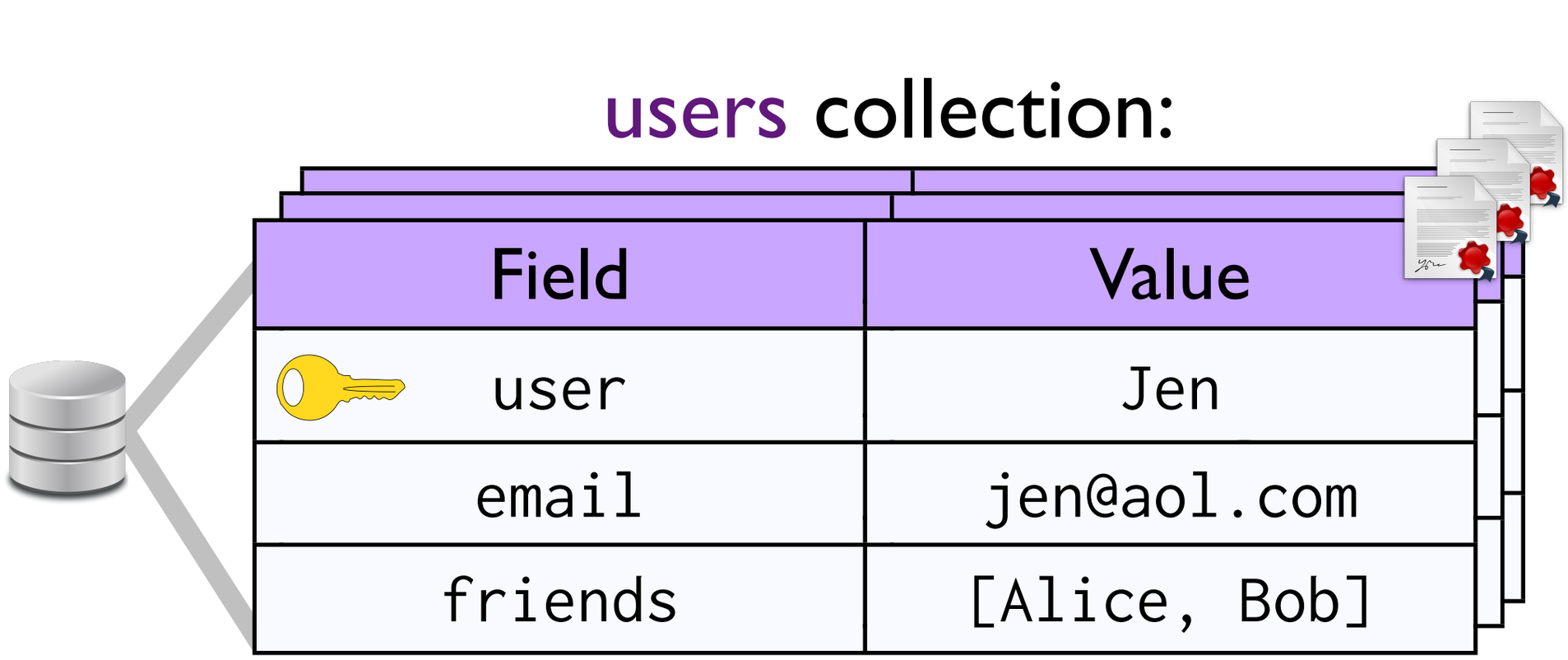


Model-Policy (MP)

- Policy specifies restrictions on:
  - Collections, documents, fields
  - E.g., *only Jen may modify her profile*
  - E.g., *only Jen and her friends may read her email address*
- Policy composes
  - E.g., *to read document you must be able to read the collection*

Example: Enforcing policy

- MP:

Field	Value
user	Jen
email	jen@aol.com
friends	[Alice, Bob]

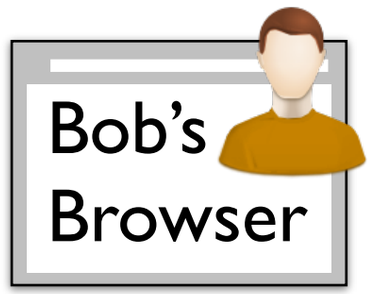
Policy: Only Jen, Alice and Bob can read

GitStar User MP +

- Eve's untrusted address book VC:

AddrBook

Example: Enforcing policy



Eve's spam server

Eve's server

AddrBook

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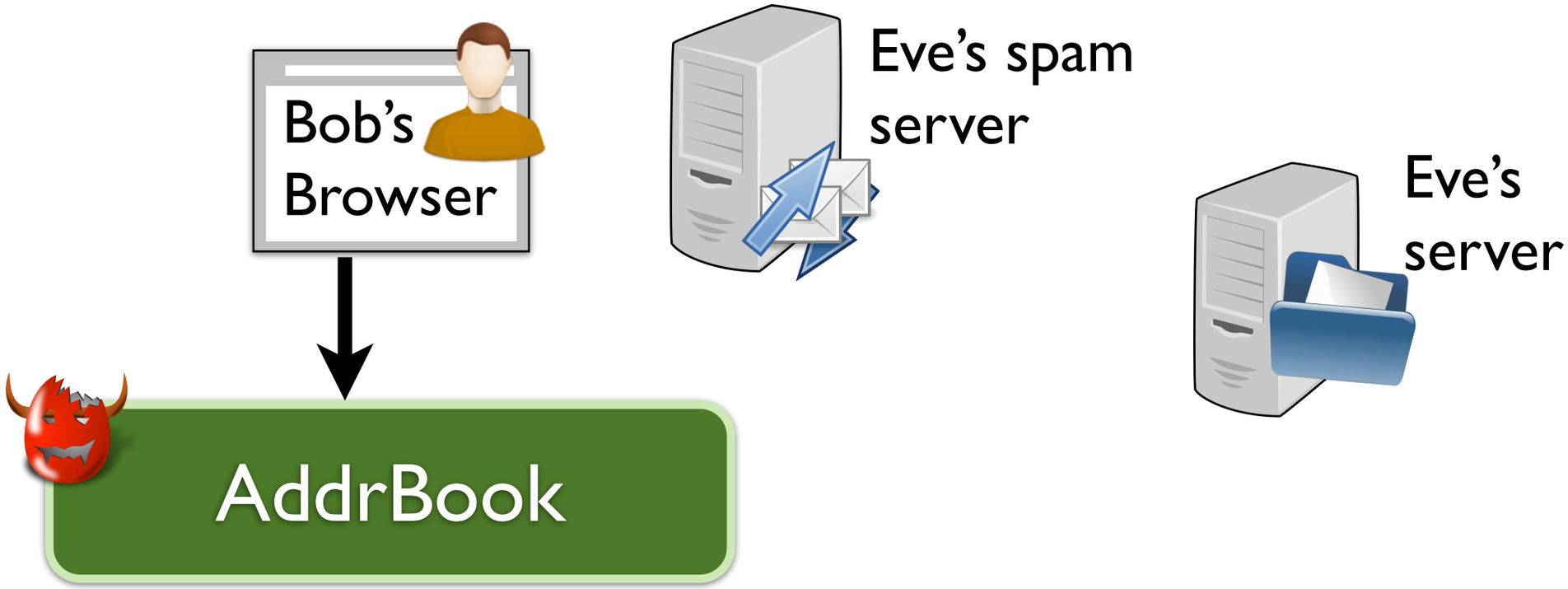
Example: Enforcing policy



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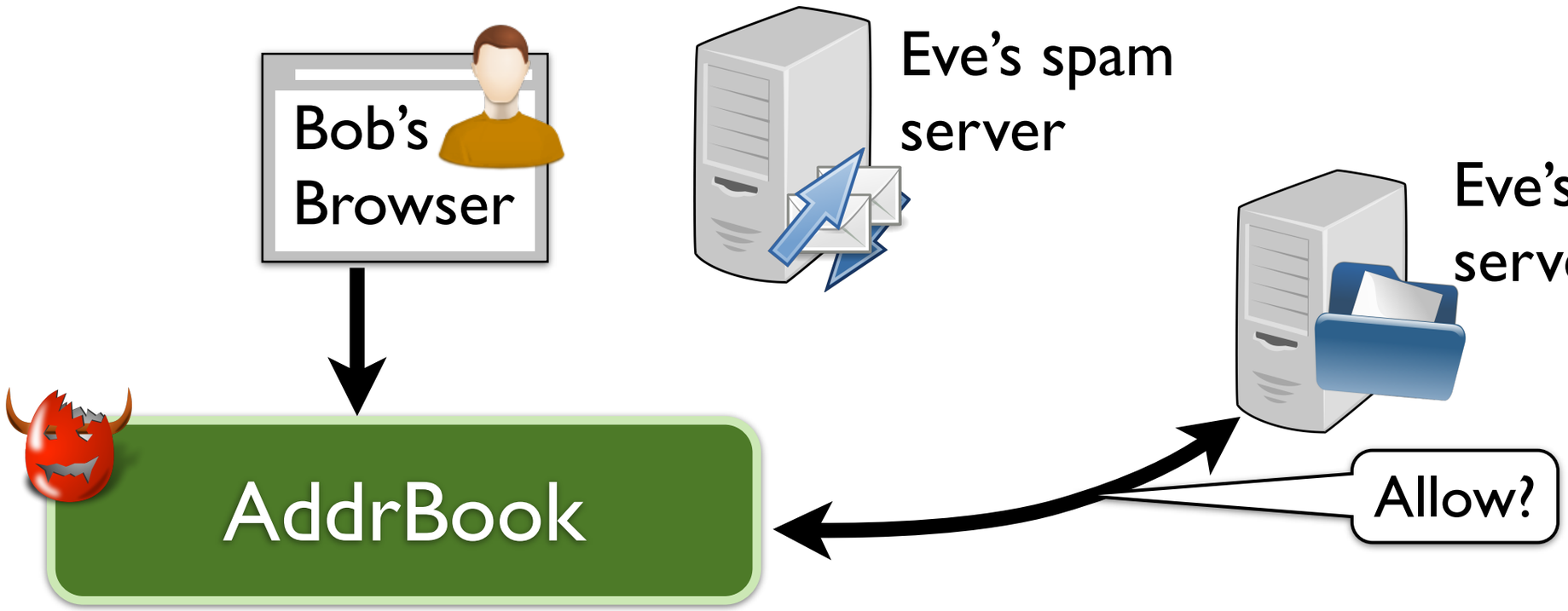

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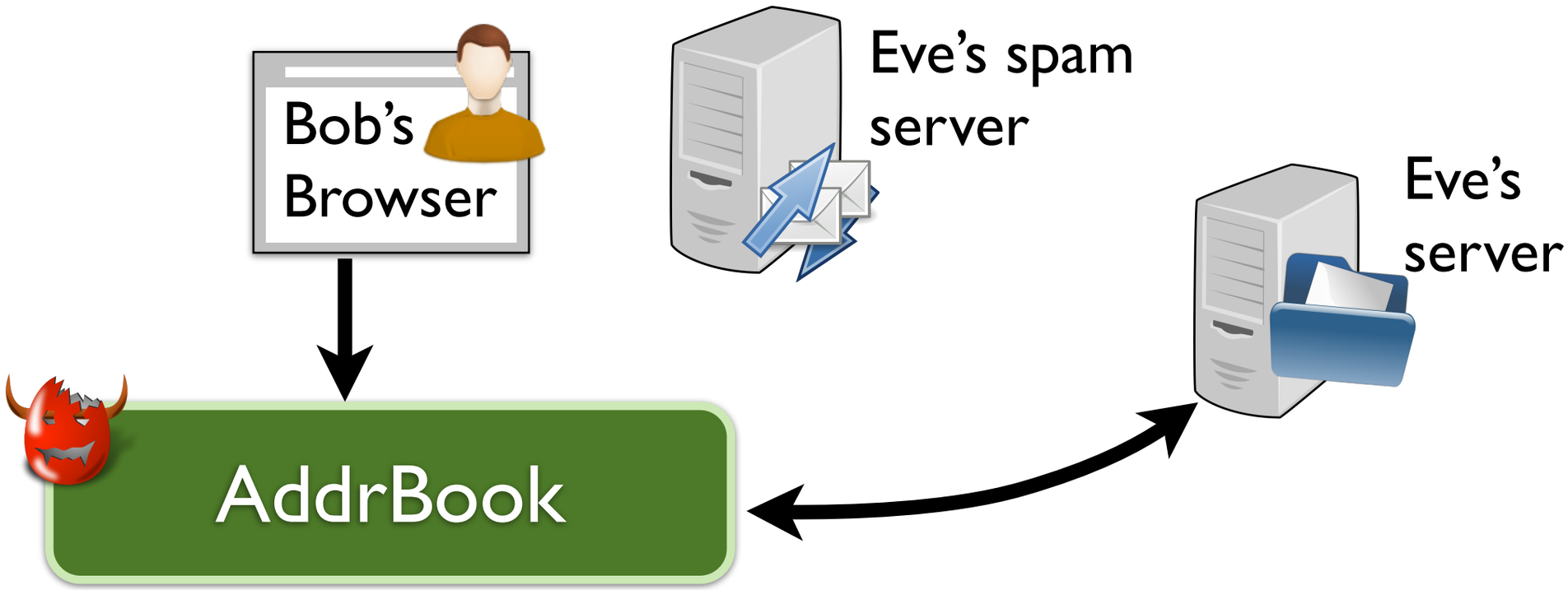

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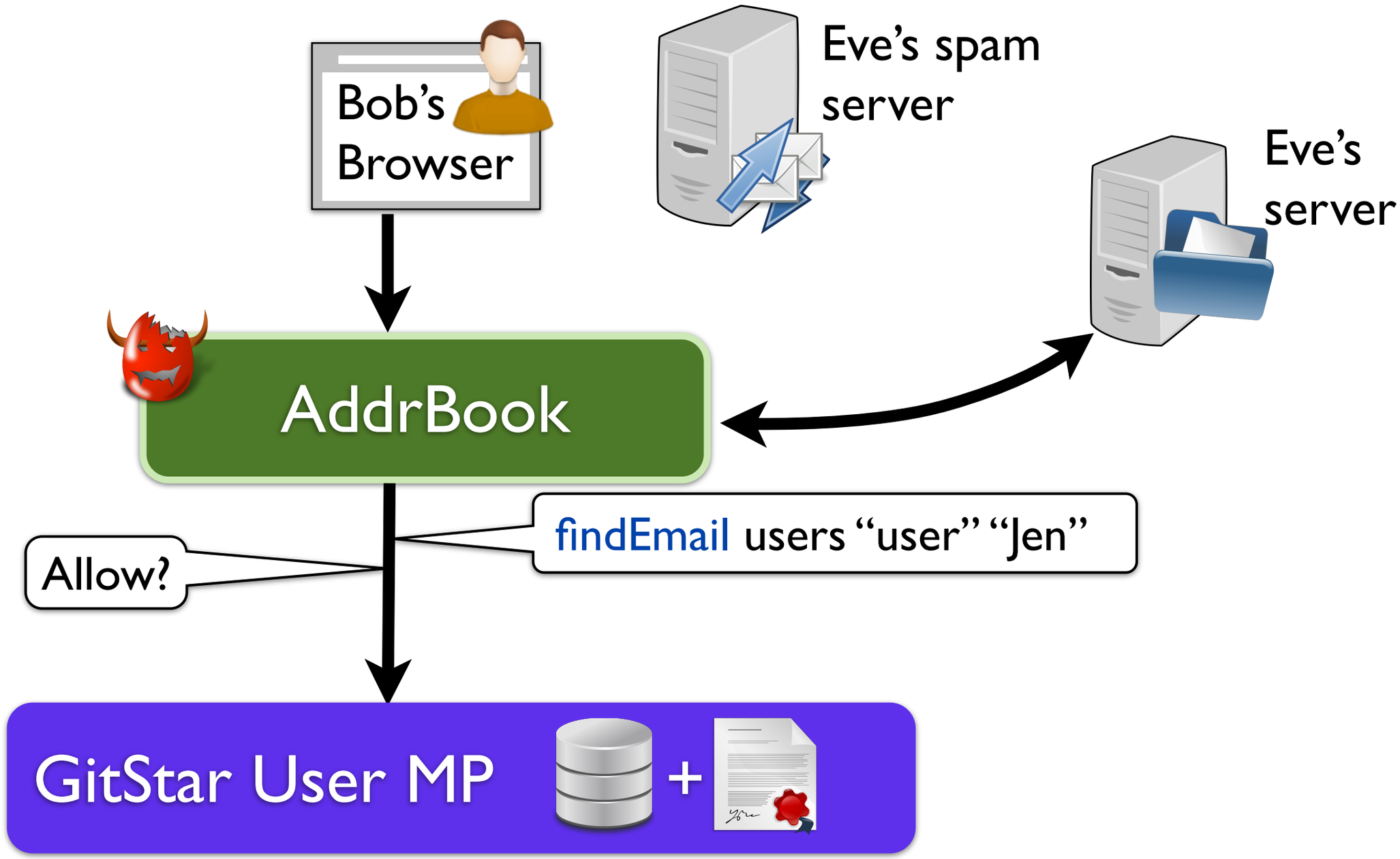

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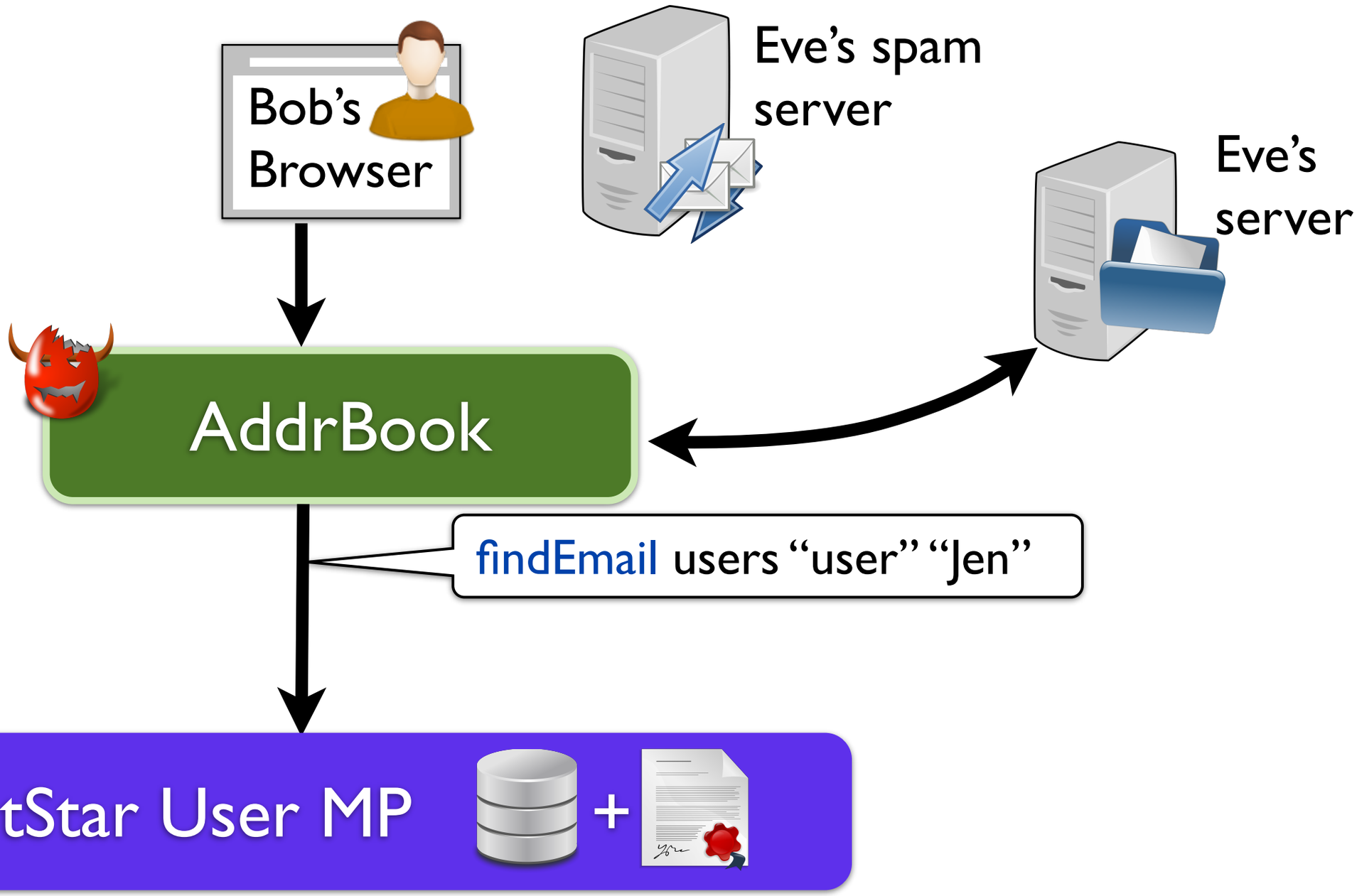

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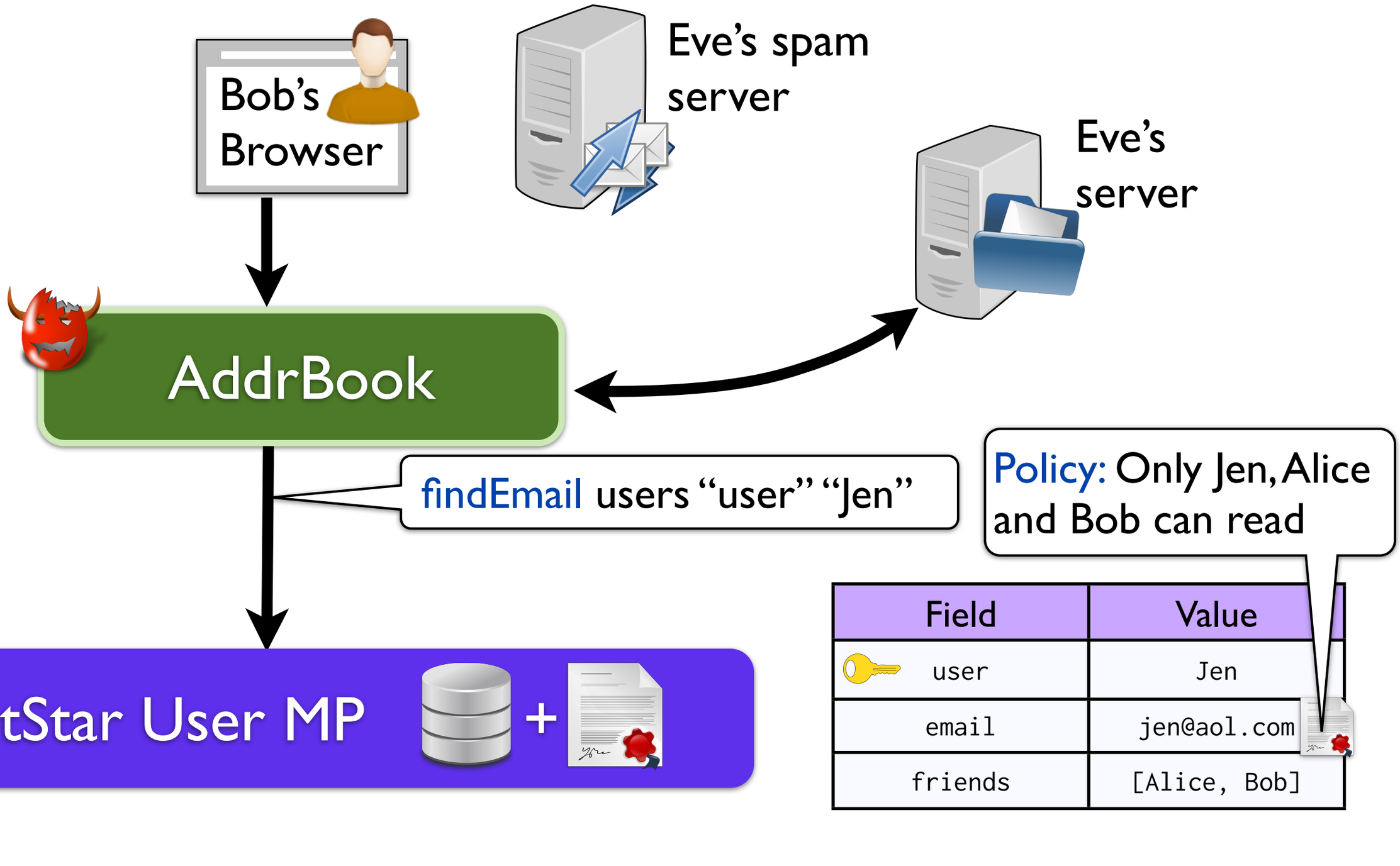

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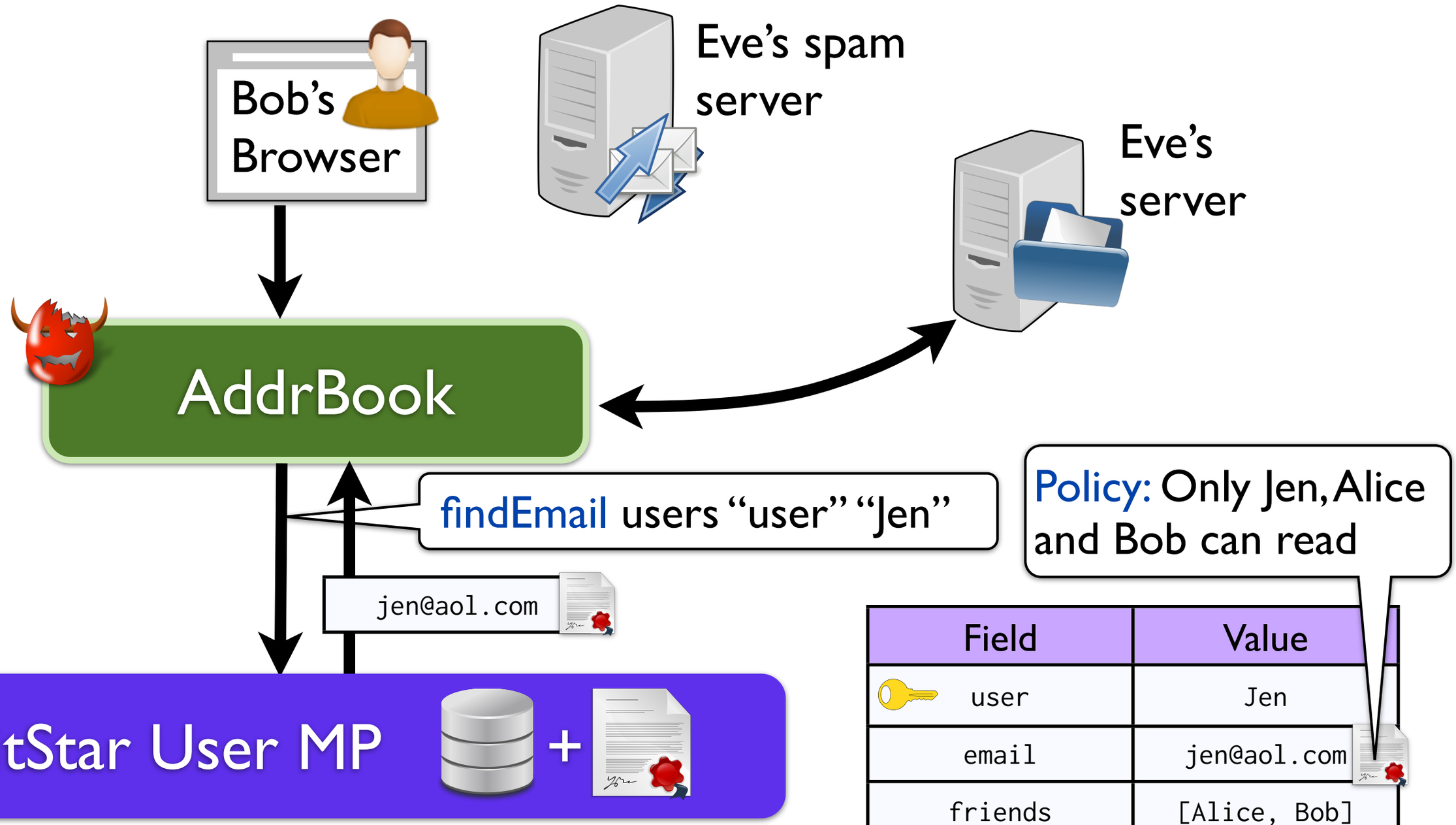

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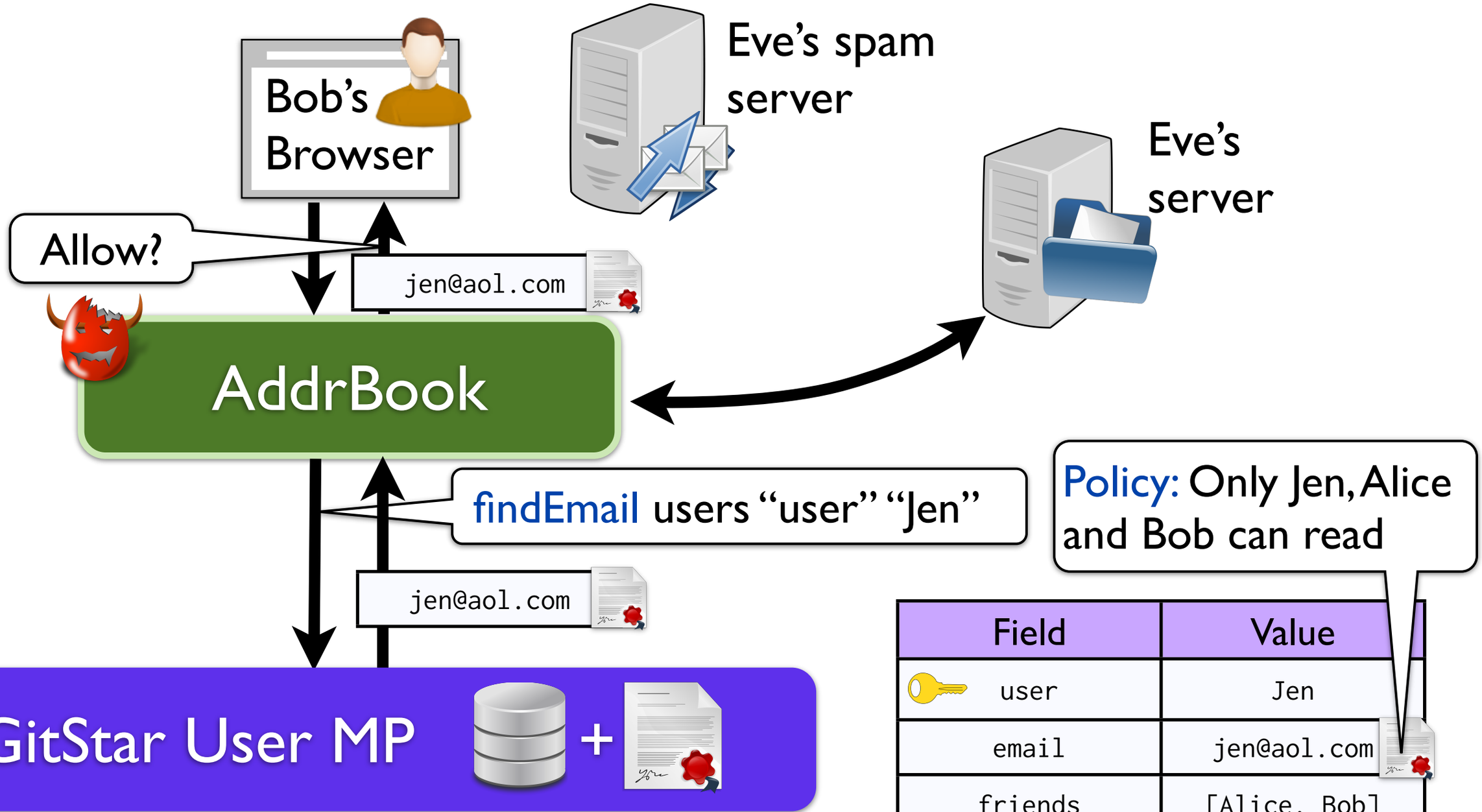

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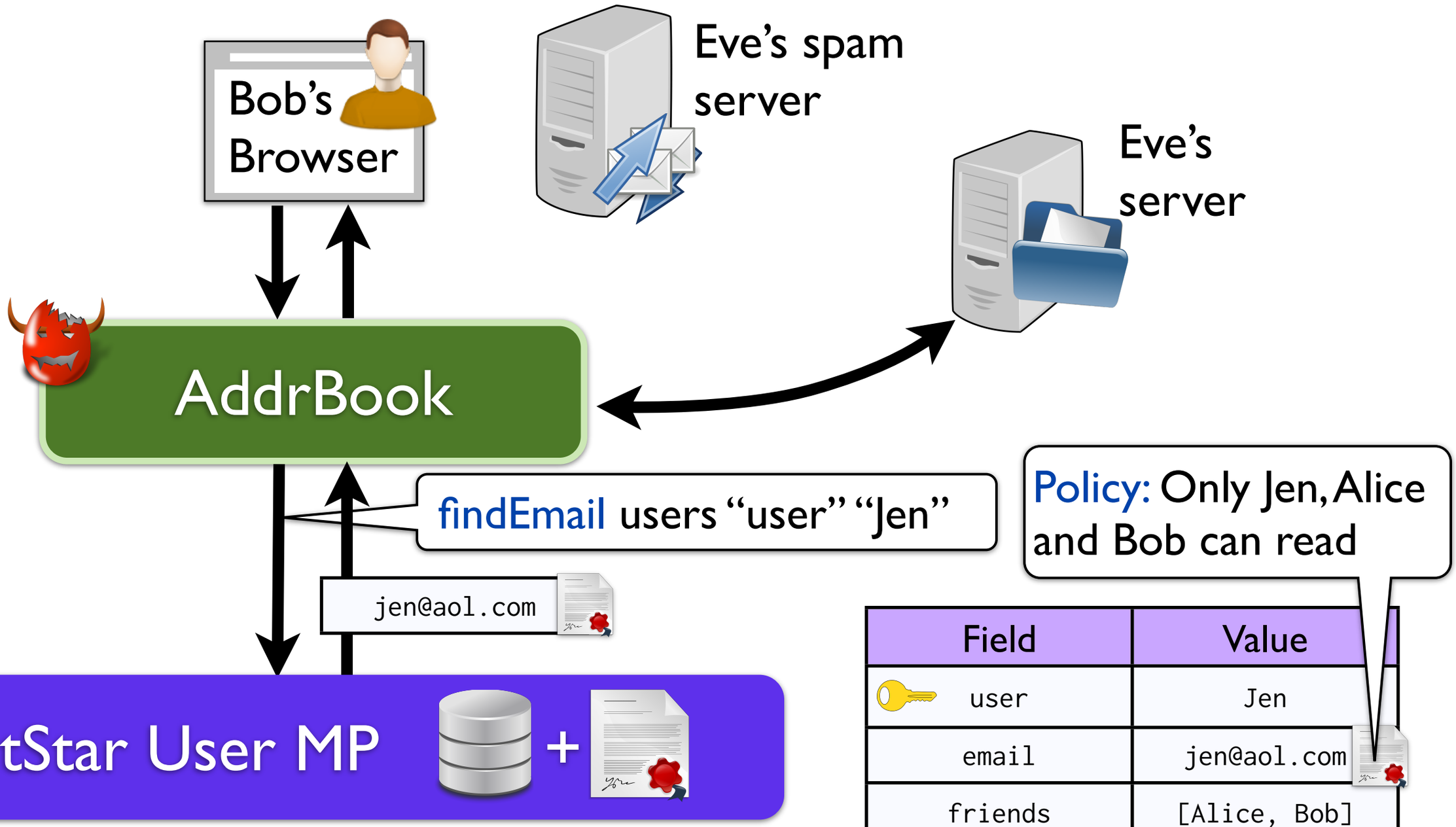

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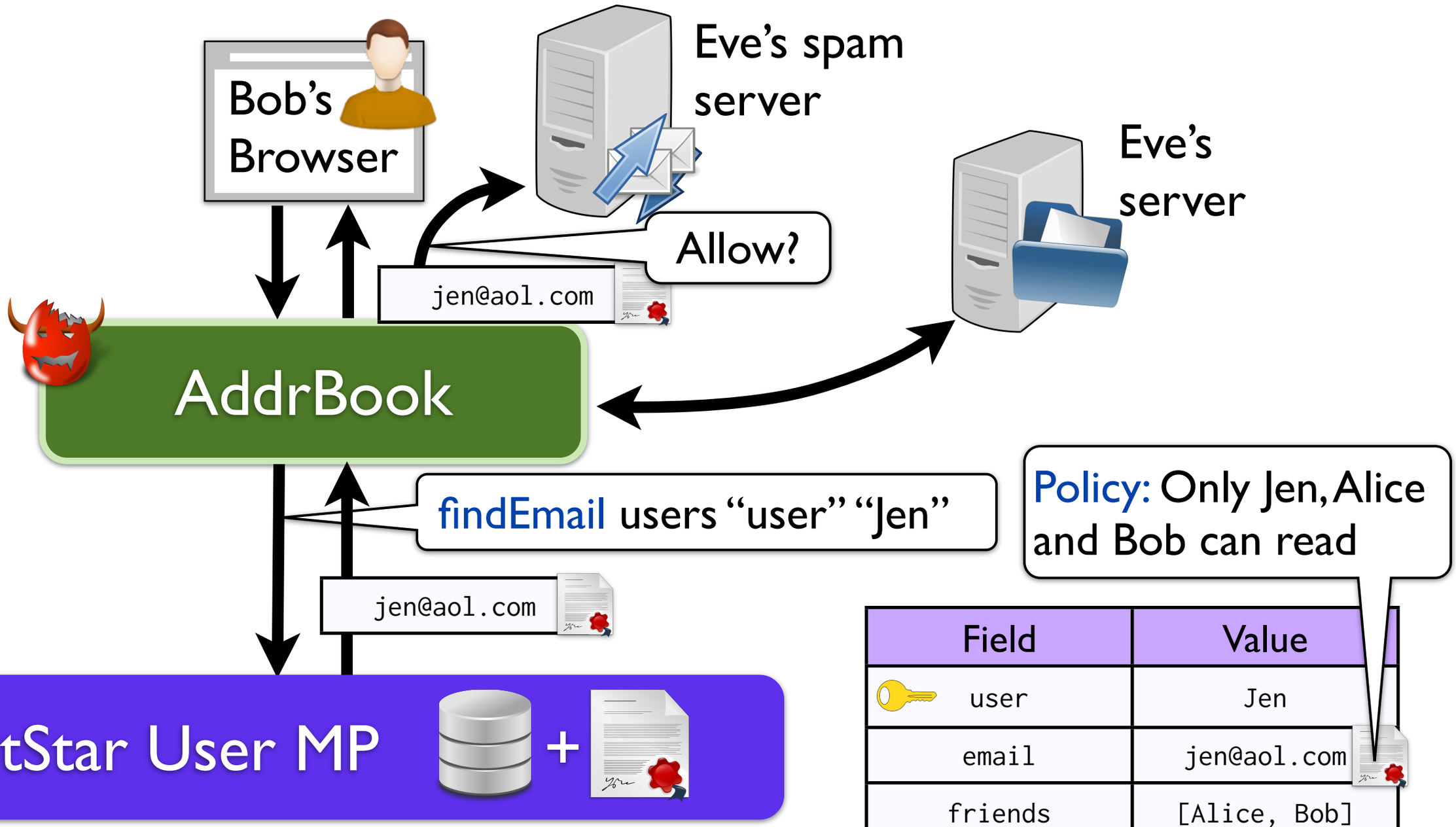

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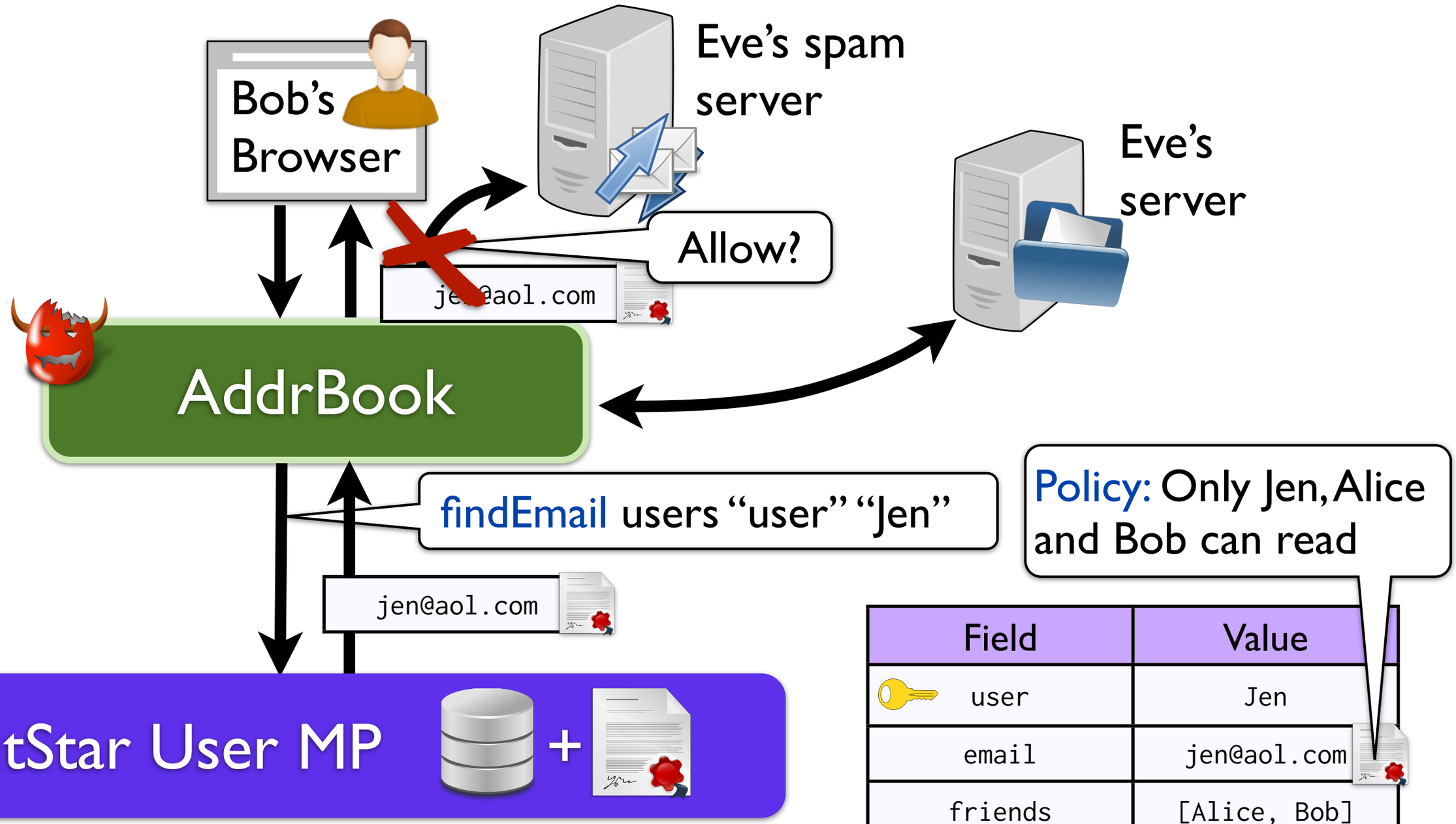
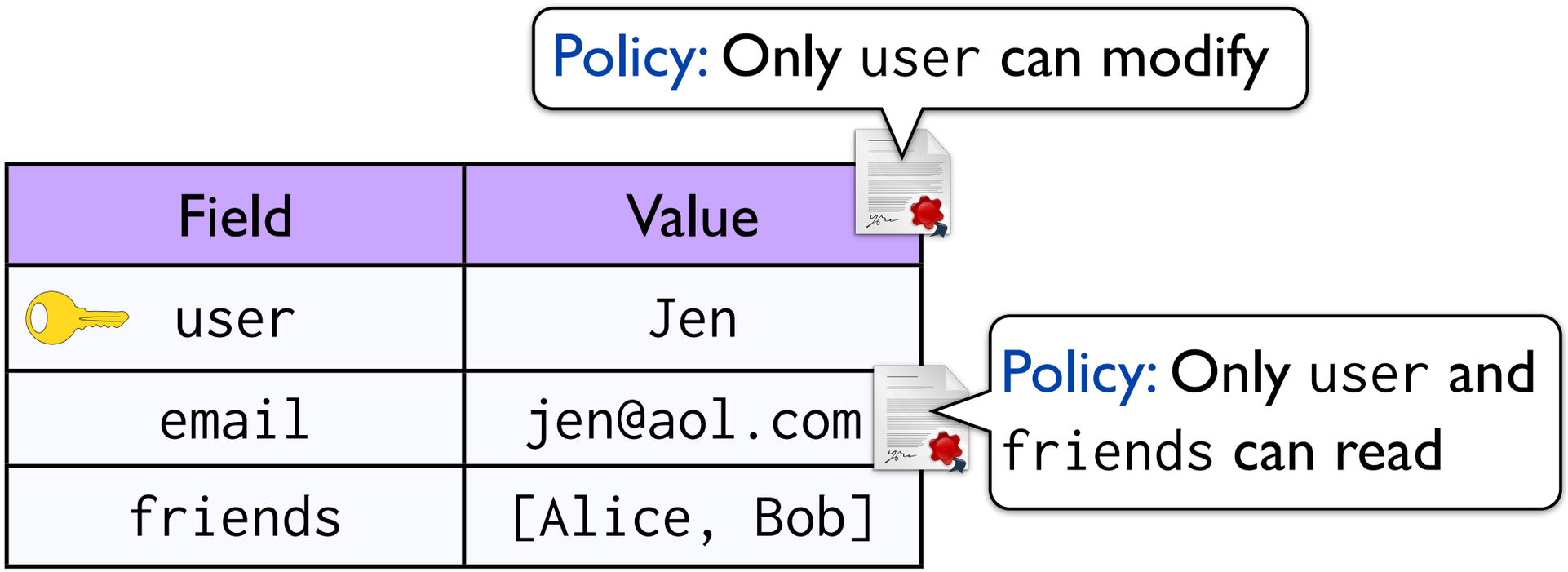


Policy specified in terms of data

Web app data models already encode policy

- Ownership
- Relationships between users
- ...



Example: Policy specification

```
collection “users” $ do
    access $ do
      readers ==> anybody
      writers ==> anybody
    field “user” key
    document $ λdoc -> do
      readers ==> anybody
      writers ==> (“user” `from` doc)
    field “email” $ labeled $ λdoc -> do
      readers ==> (“user” `from` doc)
                ∨ fromList (“friends” `from` doc)
      writers ==> anybody
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Collection is public

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Index documents by user names

Example: Policy specification

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Only Jen can modify document fields

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    writers ==> anybody
```

Only Jen, Alice and Bob can read Jen's email address

Example: Policy specification

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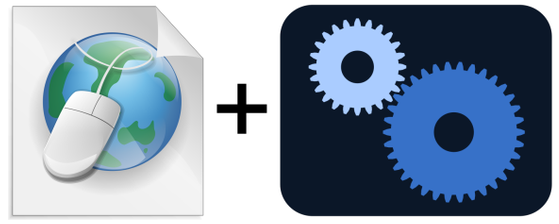
Model-Policy

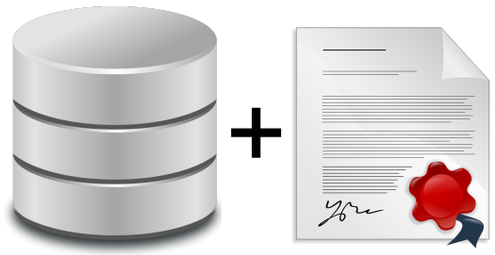
View-Controller



View-Controller (VC)

- A VC is a request handler
- Provide application functionality
  - E.g., source code browser, blog editor, …
- Invoke MPs to store/fetch user data
- Bugs in VCs are never vulnerabilities
  - Runtime enforces security policy

Model-Policy



View-Controller

Implications of MPVC

- Users: choose VCs based on functionality
- Devs: build apps on top of existing user-data
  - Models and policies are reusable

www.gitstar.com/scs/hails

Gitstar List Users List Projects deian

hails

Haskell Web Platform Framework.

Repo: `git clone ssh://deian@gitstar.com/scs/hails.git`

Wiki Code

Code viewer VC

/ master / examples / SimpleParams.hs

```
1.  {-# LANGUAGE OverloadedStrings #-}
2.  module SimpleParams (server) where
3.
4.  import qualified Data.ByteString.Lazy.Char8 as L8
5.
6.  import           LIO
7.  import           LIO.DCLabel
8.  import           Hails.HttpServer
9.  import           Hails.Data.Hson
10.
11. server :: Application
12. server _ lreq = do
13.   req <- unlabel lreq
14.   let ldoc = labeledRequestToLabeledDocument lreq
15.   doc <- unlabel ldoc
16.   return $ case pathInfo req of
17.     ("login":_) -> Response temporaryRedirect307
18.                            [("x-hails-login",""),(hLocation,"/")] ""
19.     _ -> Response ok200 [] $ topHtml (labelOf lreq, req) (labelOf ldoc, doc)
```

www.gitstar.com/scs/hails

Gitstar List Users List Projects

hails

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Wiki Code

Wiki VC

Home Pages

Hails: Protecting Data Privacy in Untrusted W

Hails is a platform and web framework that leverages Information Flow Control (IFC) to support u applications interacting and processing private data.

Resources

- Brief motivation and architecture overview
- Tutorial (slightly outdated)

Installation

You can compile and install Hails as usual with `cabal-dev`:

```
$ cabal-dev instal-deps
$ cabal-dev install
```

Launching an app

If you define your main application (named `server`) in `YourAppModule.hs`, you can launch it with

GitStar Project MP + 

Implementation

- Hails is a Haskell library
  - Quick turnaround on API design
  - Developers can use existing tools and libraries
- Hails runtime system
  - Provides HTTP server that invokes VC
  - Enforces information flow at the language-level

Evaluation: Usability

✓ MPVC simplifies reasoning about security when building a platform

✓ Hails renders common security bugs futile

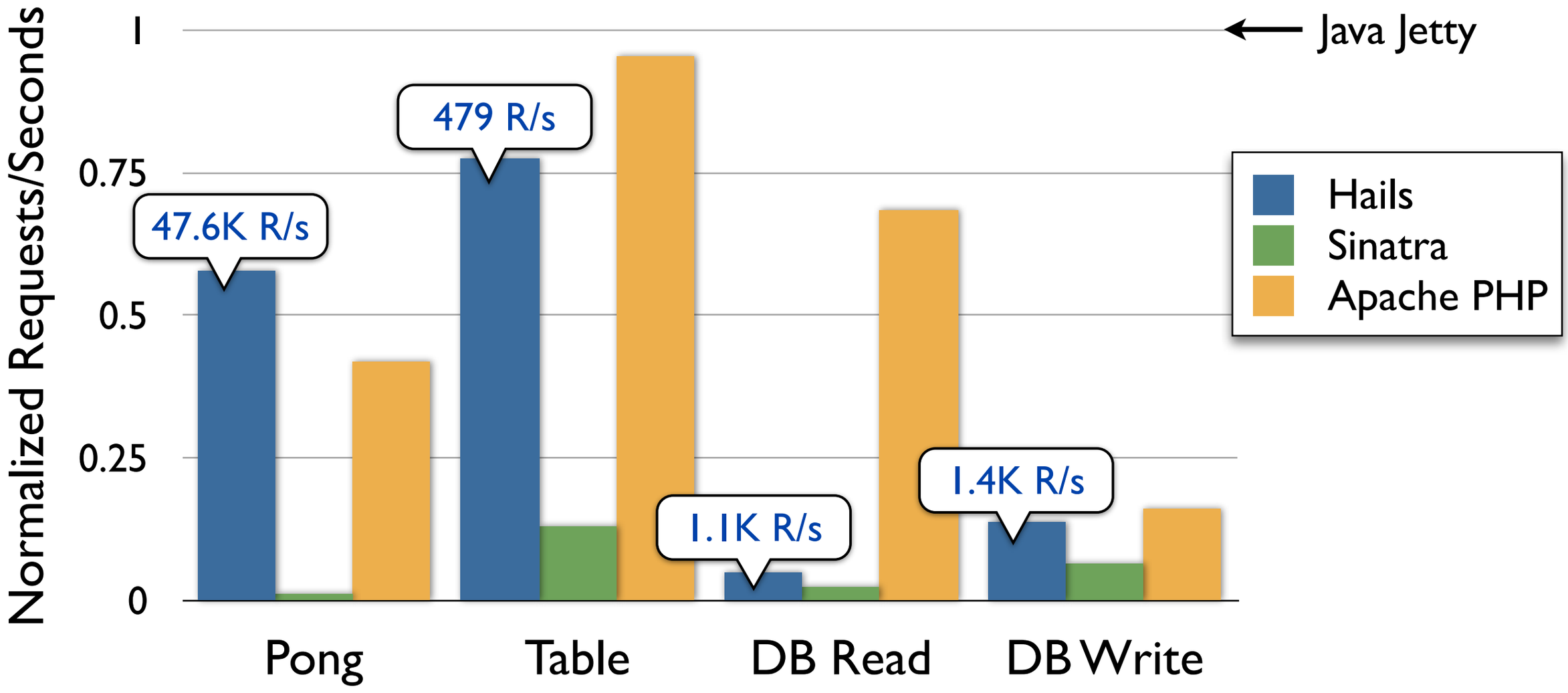
E.g., mass assignment vulnerability

✗ Need scaffolding tools

✗ ~~Writing raw policy is hard~~

✓ Writing policy with DSL is simpler

Performance evaluation



Conclusions

- Current platforms: functionality vs. privacy
- Hails platforms guarantee security across apps
  - Host apps on platform
  - Make policy explicit
  - Enforce policy with information flow control

http://gitstar.com http://hails.io

```
$ cabal install hails
```