OPA: Language Support for a Sane, Safe and Secure Web

David Rajchenbach-Teller
Head of R&D
MLstate
David.Teller@mlstate.com
twitter.com/mlstate
+33 1 55 43 76 55

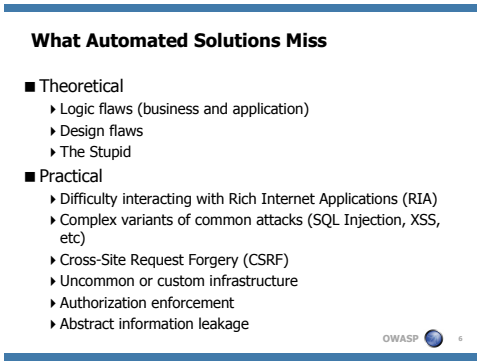
OWASP
June 24th, 2010

The OWASP Foundation
http://www.owasp.org

What Automated Solutions Miss

- Theoretical
  - Logic flaws (business and application)
  - Design flaws
  - The Stupid
- Practical
  - Difficulty interacting with Rich Internet Applications (RIA)
  - Complex variants of common attacks (SQL Injection, XSS, etc)
  - Cross-Site Request Forgery (CSRF)
  - Uncommon or custom infrastructure
  - Authorization enforcement
  - Abstract information leakage

What it's all about



"Automated vs. Manual: You can't filter The Stupid"
Charles Henderson, David Byrne
AppSec DC 2009 + 2010

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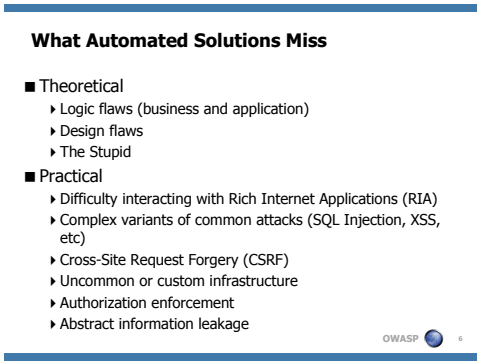

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"Oh, yeah?"
The MLstate team
AppSec Research 2010

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- General approach
- Keeping in the ~~Smart~~ Useful
- Filtering out the ~~Stupid~~ Fragile
- Lessons and Future

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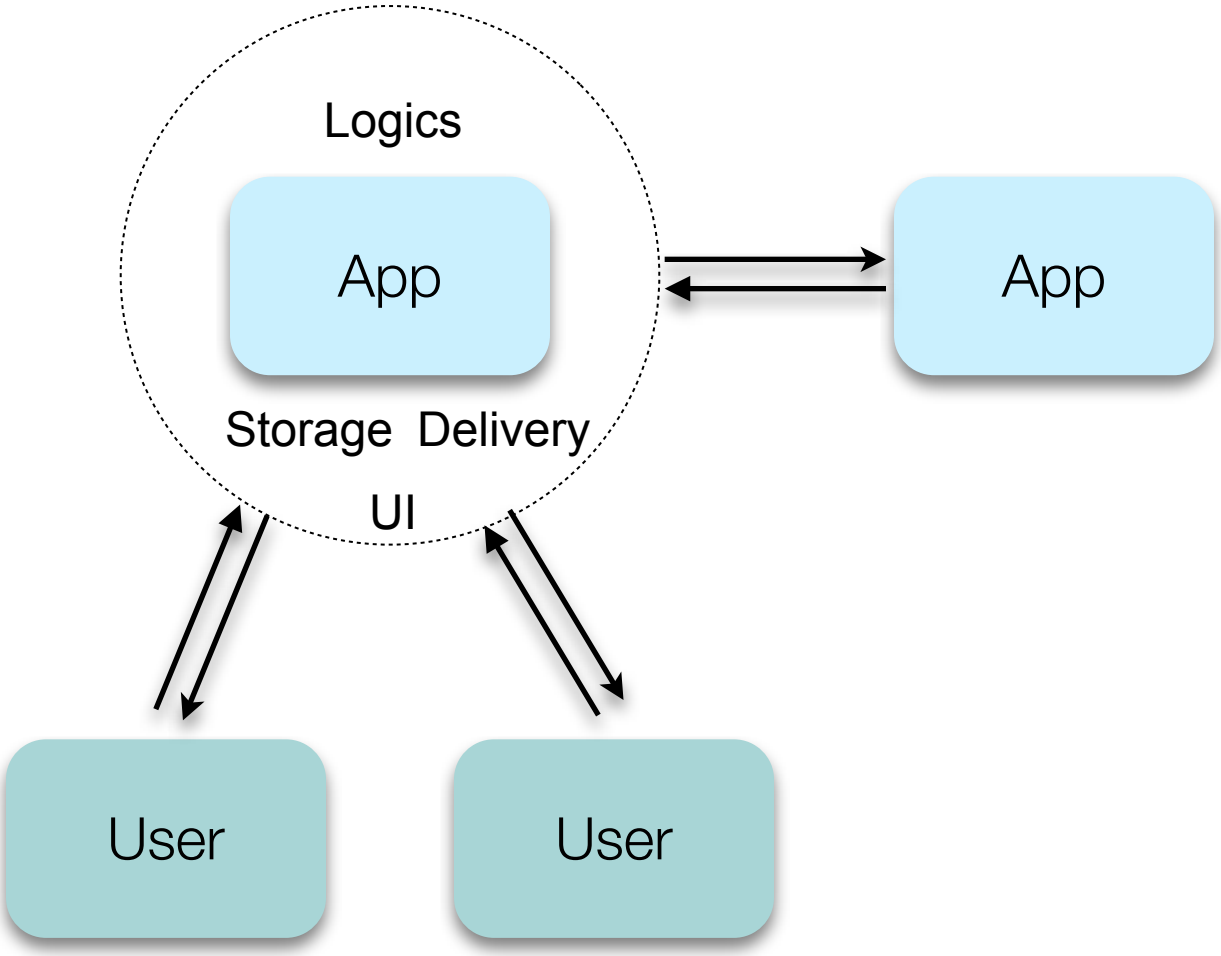
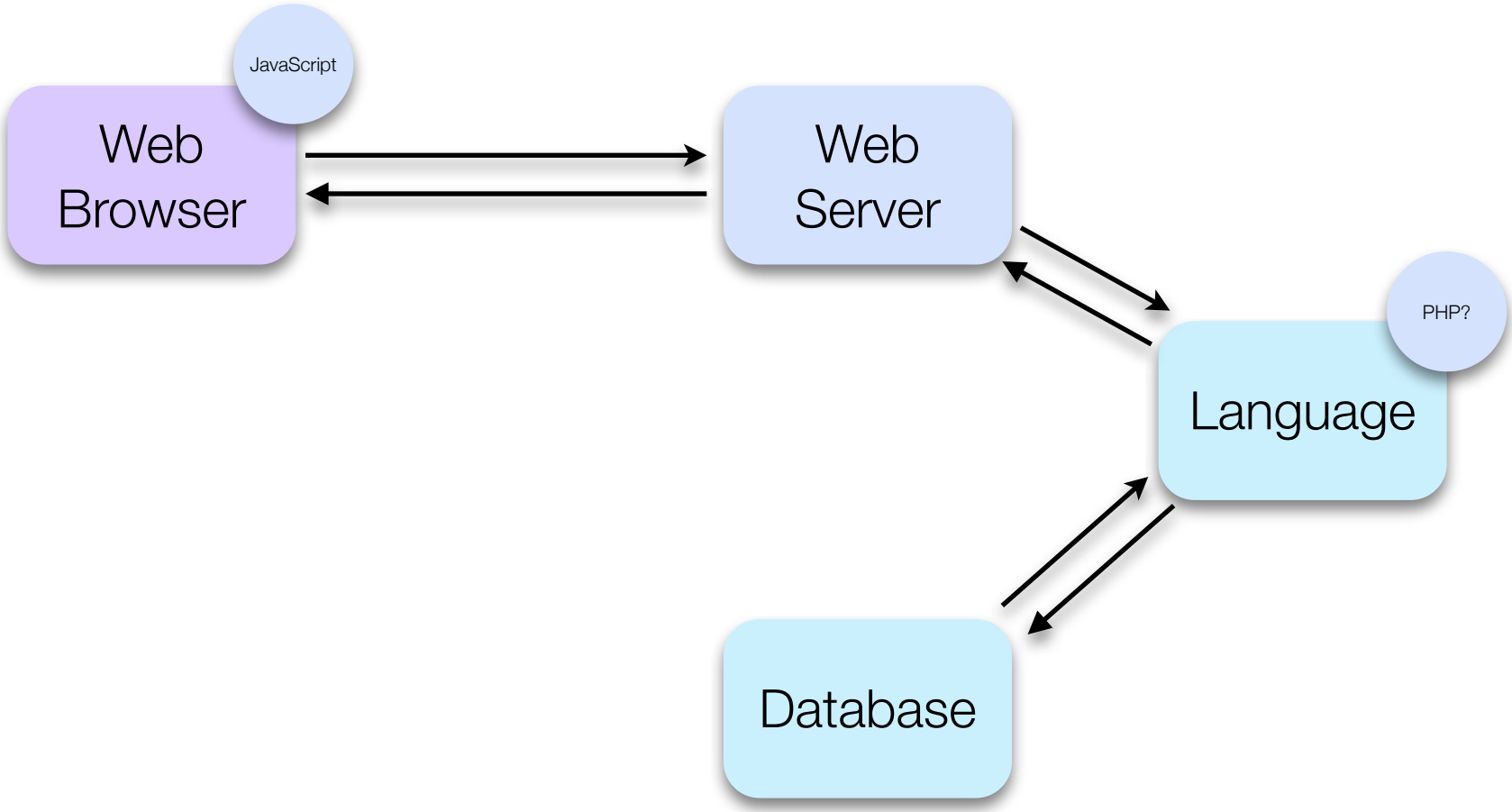
Web Applications (high-level design)



Web Applications (what we see)



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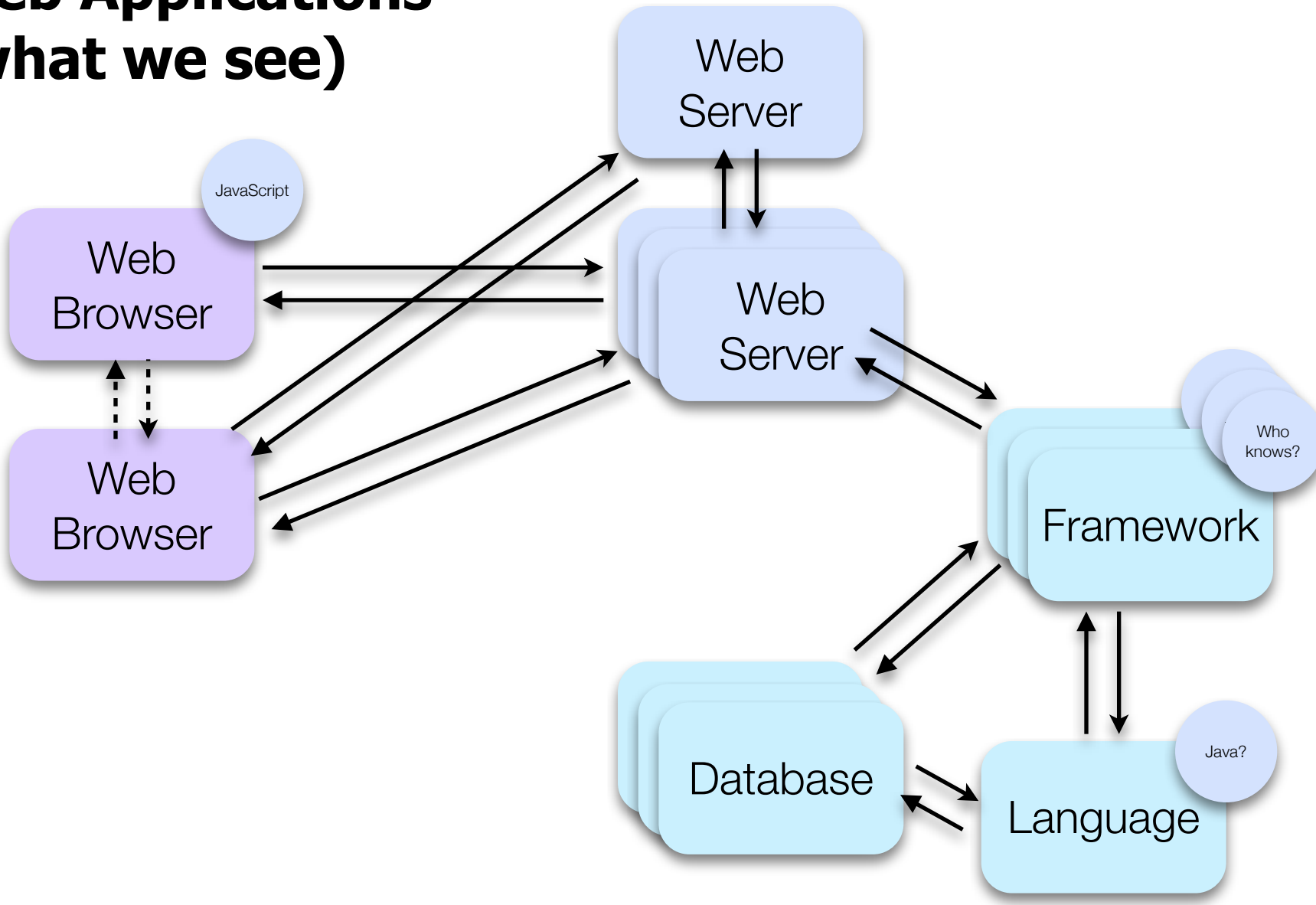

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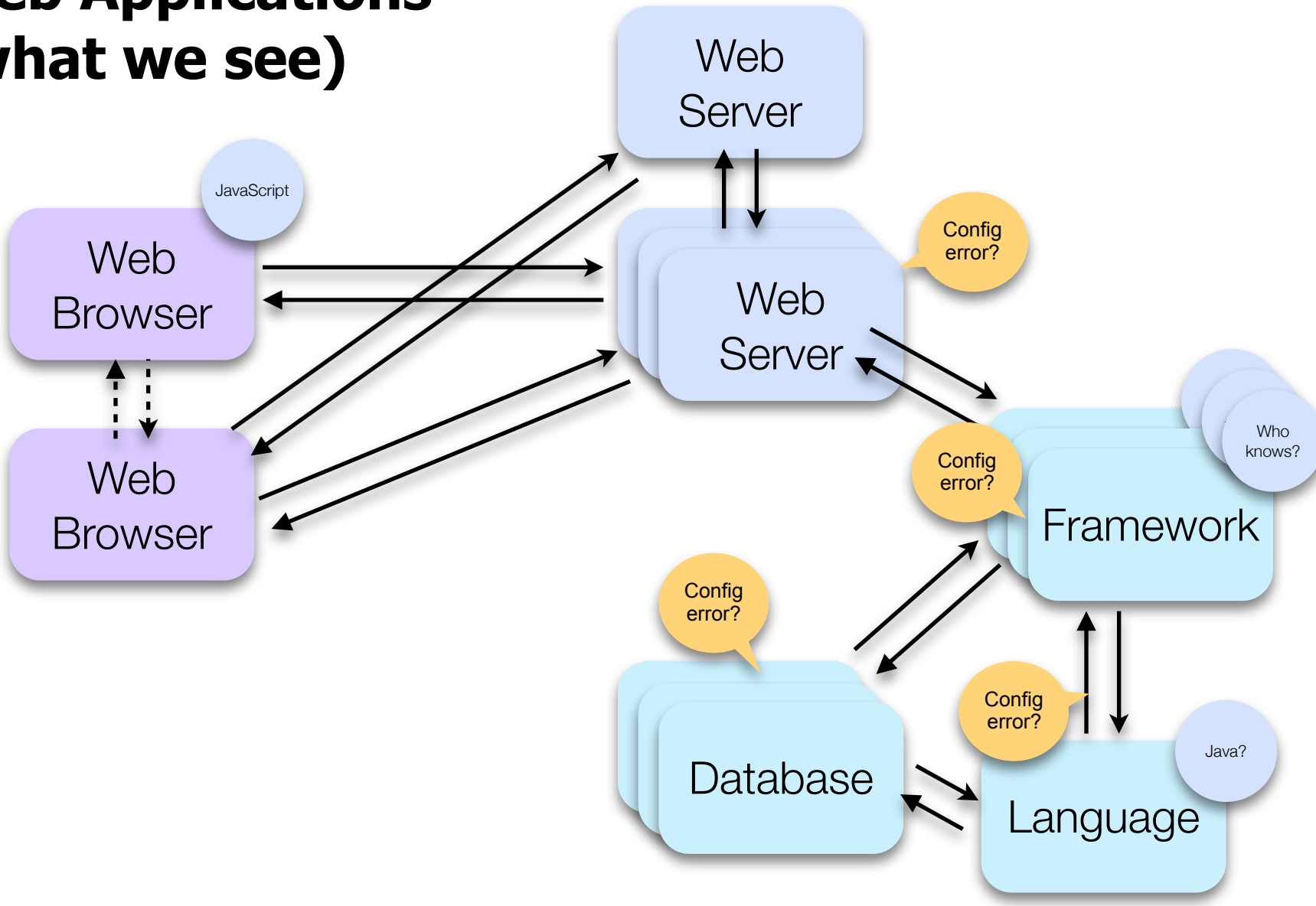

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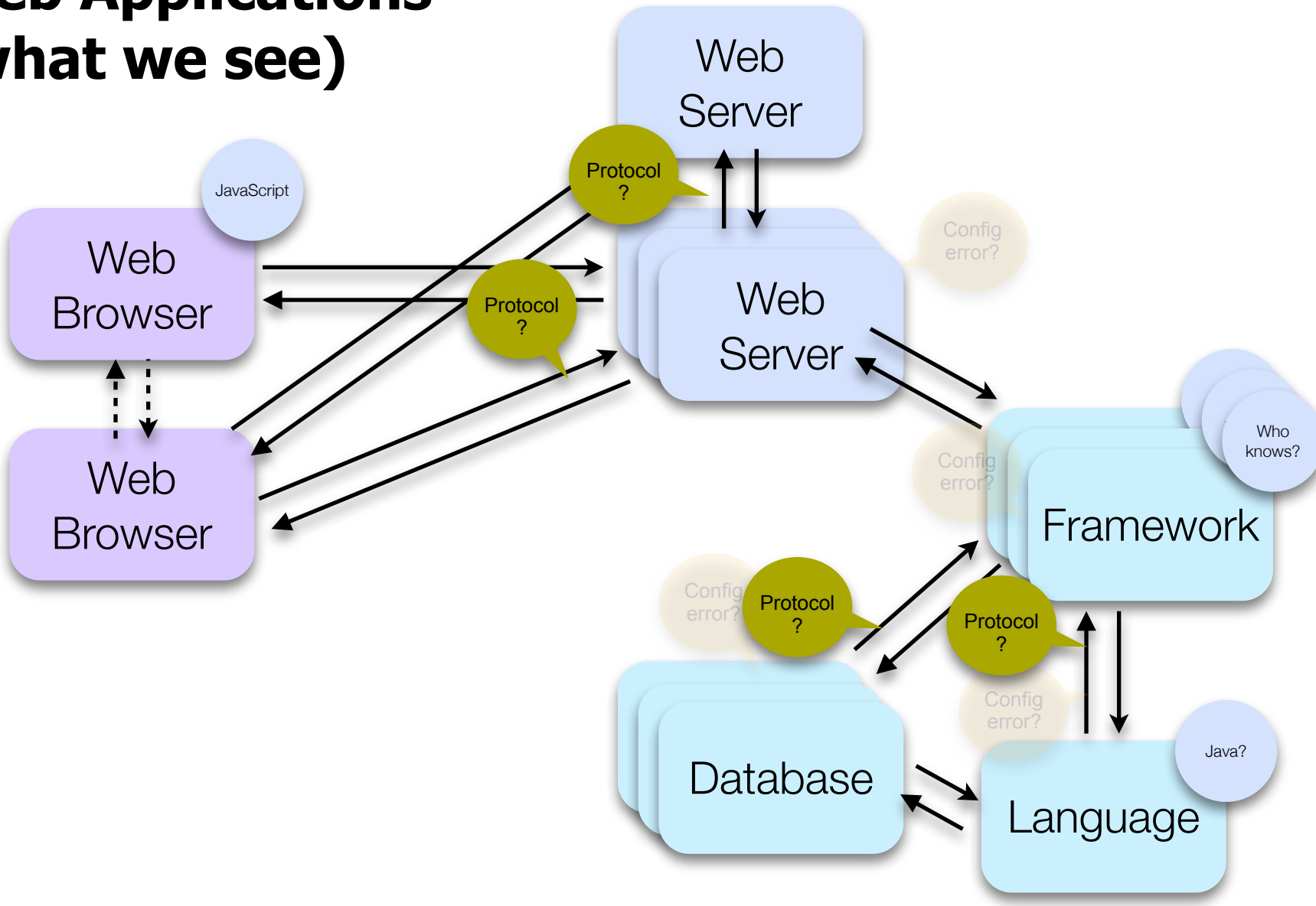

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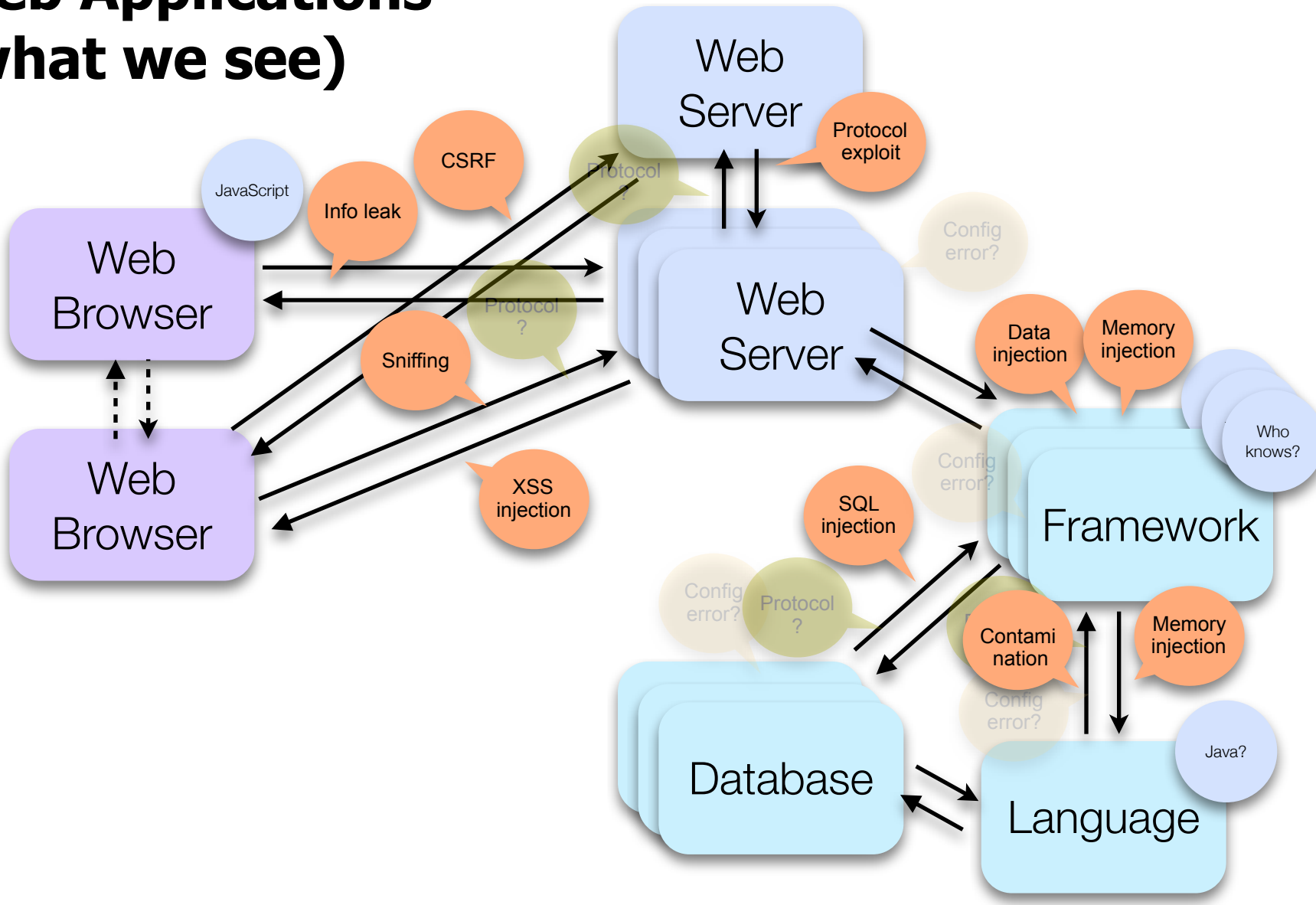

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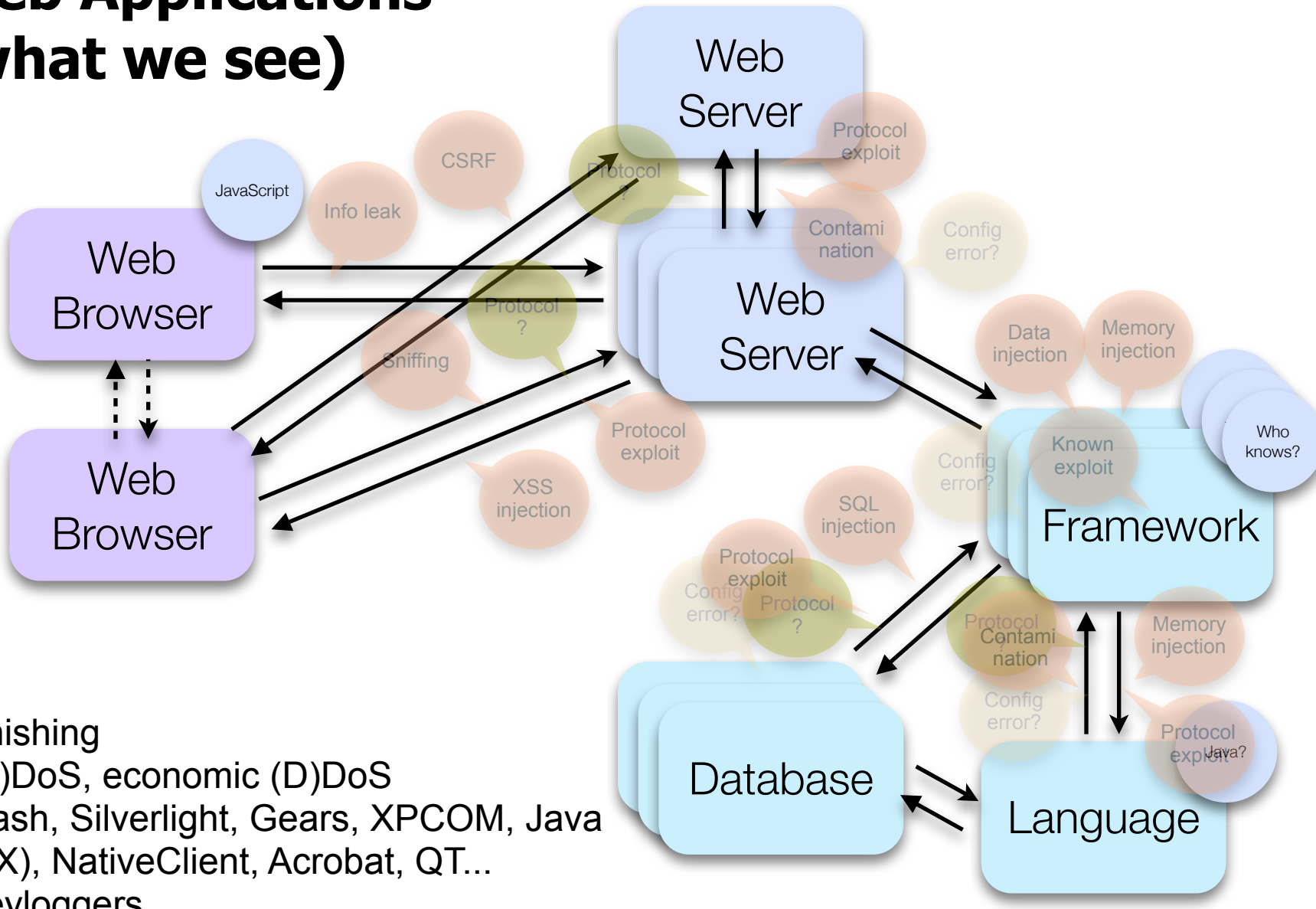

+ Phishing
+ (D)DoS, economic (D)DoS
+ Flash, Silverlight, Gears, XPCOM, Java (FX), NativeClient, Acrobat, QT...
+ Keyloggers
+ ...

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"It's not him, it's you. You should design your tool so that Joe can't do anything stupid."
Ferengi Rule of Acquisition #408, contd.

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"What if the problem is that Joe Developer is stupid?"
(Joe Meta-Developer)

"Haven't I answered that question already?"
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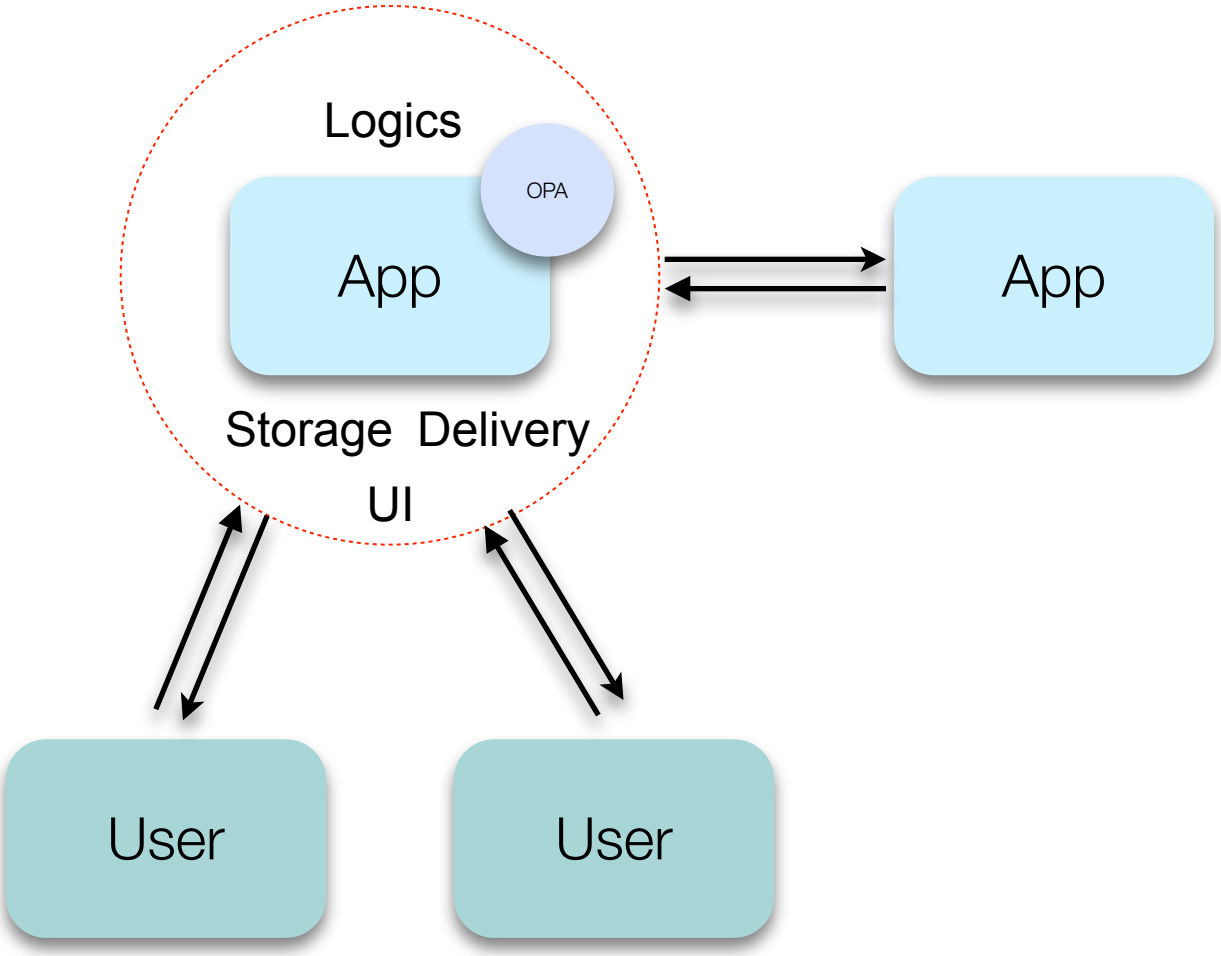
"...oh, and don't forget to make sure that Joe can still use the tools!"
Ferengi Rule of Acquisition #408, contd.

Web applications (with OPA)



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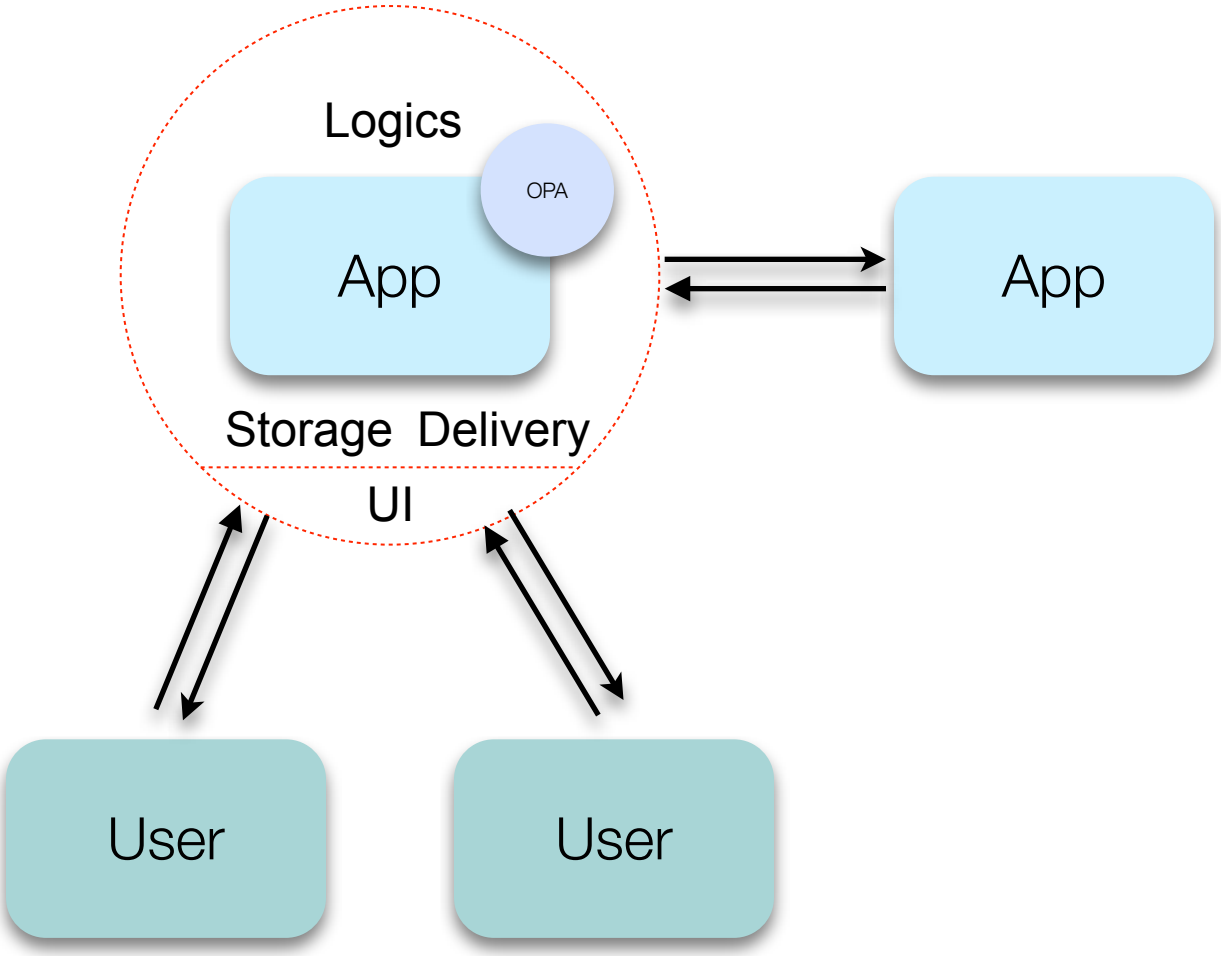

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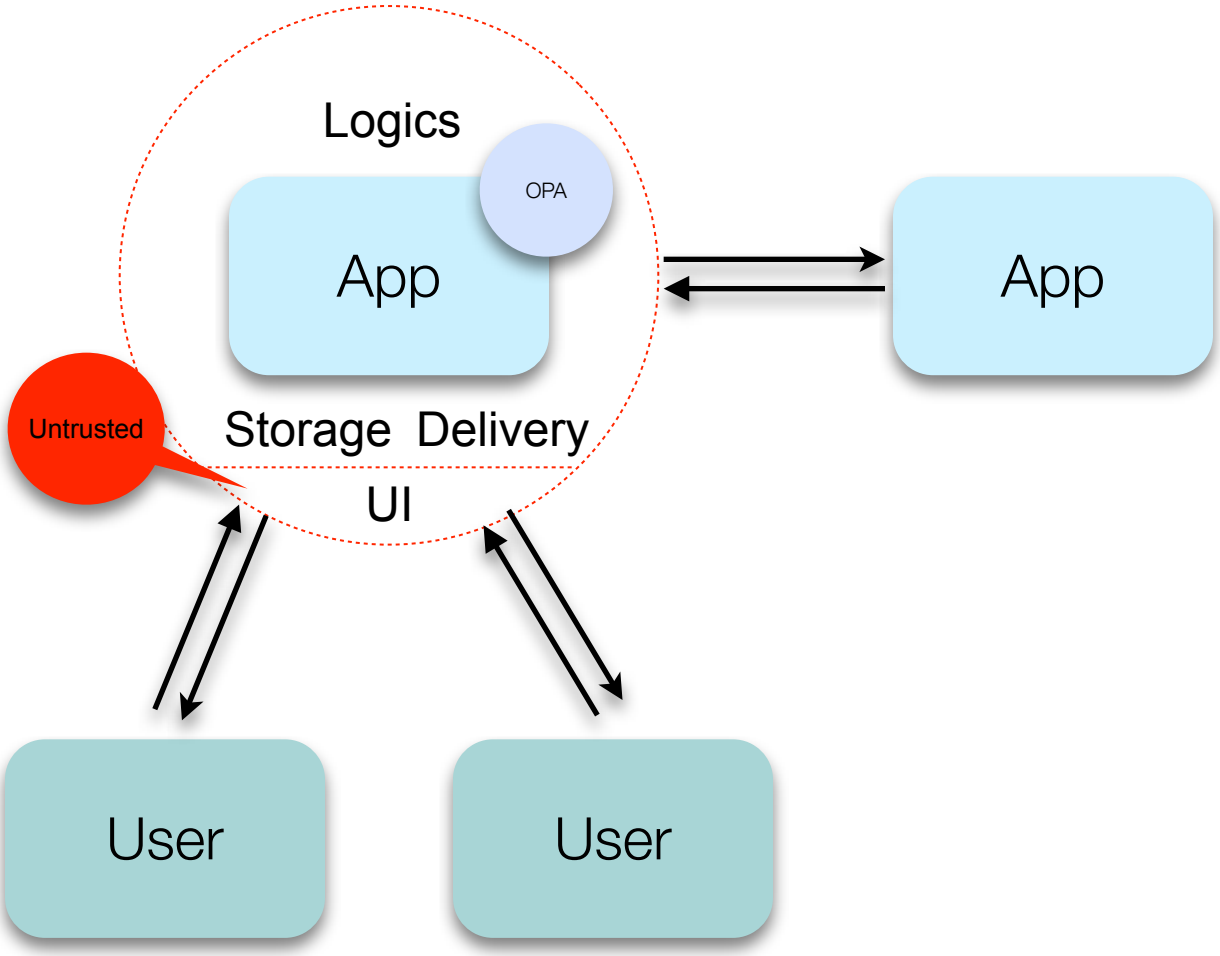

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Joe doesn't need to know

Simpler than LAMP

Joe doesn't need to know

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Hello, web

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```
server = one_page_server("Hello, web", -> <>Hello, web</>)
```

Complete web application.

1) Compile
`opa hello.opa`

2) Run
`./hello.exe`

3) Test
browse `http://localhost:8080`

URL shortener (22 loc)

```
db /abbrevs: intmap(string)
db /abbrevs[_] = "/"

make_shorter(url:string):string =
  key = Db.fresh_key(/abbrevs)
  do /abbrevs[key] <- url
  "{key}"
_ = @server(make_shorter)

do_shorten(_) =
exec([#shortened <- make_shorter(Page.getVal(#origin))])

urls = parser
| "/" dest=Rule.integer ->
    Resource.redirection_page("Please wait a second",
           <div class="loading">(loading...)</>,{address_moved},0,/abbrevs[dest])
| .* ->
    Resource.html("MLstate redirector",
    <>Please enter a URL you wish to shorten<br/>
    <input id="origin"/><button onclick={do_shorten}>Shorten</button>
    <div id="shortened"></div>
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Database

Control

UI

Nice web chat

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connect(callback) = Network.add(Session.make_callback(callback), room)
make_broadcaster(id) = _ -> Network.broadcast({~id message=Page.get_value(#entry)}, room)

styled_page(title, body) = (
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user_update(x:mess) = (
  line = <div class="opa-line">
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  do exec([#show +<- line ])
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   styled_page("Chat",  //Display
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server    = Server.make(Resource.add_auto_server(resources, urls))
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Real-time web

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URLs

There's more

- Games
- Productivity tools
- Development tools
- Security applications
- e-Commerce applications
- …

Things we can do (and check!)

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Programmable security policies

Ajax SOAP Complex database

...

Comet XML processing

Fine-grained sessions Time-unlimited rollback

Distribution

Multitasking

Higher-order database

User interface Concurrent transactions

WSDL

Higher-order programming

Data history

Capabilities

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  Resource.full_page(title, body,
  <link rel="stylesheet" type="text/css" href="resources/css.css" />, {success}, [])
)


user_update(x:mess) = (
  line = <div class="opa-line">
    <div class="opa-wrap"><div class="opa-user">{x.id}:</div>
    <div class="opa-message">{x.message}</div></div>
  </div>
  do exec([#show +<- line ])
  Page.set_scroll_top(Page.get_height(#show)+Page.get_scroll_top(#show), #show)
)


start(connexion) = (
   id = String.sub(0, 8, Server.get_user(connexion) ? "Unknown")
   broadcast = make_broadcaster(id)
```

```
styled_page("Chat",  //Display
  <script onload={_ -> connect()} />
  <div id="header"><div id="logo">
  <div id="show"></div>
  <input id="entry"/>
  <div class="opa-button" onclick={broadcast}>Send!</div>
)
```

Per-user capability?*

```
server     = Server.make(Resource.add_auto_server(resources, urls))
```

Transparent protections

```
type mess = {id: string; message: string}
room = Network.empty():Network.network(mess)
connect(callback) = Network.add(Session.make_callback(callback), room)
make_broadcaster(id) = _ -> Network.broadcast({~id message=Page.get_value(#entry)}, room)

styled_page(title, body) = (
  Resource.full_page(title, body,
  <link rel="stylesheet" type="text/css" href="resources/css.css" />, {success}, [])
)


user_update(x:mess) = (
  line = <div class="opa-line">
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  </div>
  do exec([#show +<- line ])
  Page.set_scroll_top(Page.get_height(#show)+Page.get_scroll_top(#show), #show)
)


start(connexion) = (
   id = String.sub(0, 8, Server.get_user(connexion) ? "Unknown")
   broadcast = make_broadcaster(id)
   styled_page("Chat",  //Display
     <script onload={_ -> connect()}/>
     <div id="header"><div id="logo"></div></div>
     <div id="show"></div>
     <input id="entry"/>
     <div class="opa-button" onclick={broadcast}>Send!</div>
   )
)

urls      = parser .* -> start
resources = @static_include_directory("resources")
server    = Server.make(Resource.add_auto_server(resources, urls))
```

More

A1-Injection	A6-Security Misconfiguration
A2-Cross Site Scripting (XSS)	A7-Insecure Cryptographic Storage
A3-Broken Authentication and Session Management	A8-Failure to Restrict URL Access
A4-Insecure Direct Object References	A9-Insufficient Transport Layer Protection
A5-Cross Site Request Forgery (CSRF)	A10-Unvalidated Redirects and Forwards

More

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What Automated Solutions Miss

- Theoretical
  - Logic flaws (business and application)
  - Design flaws
  - The Stupid
- Practical
  - Difficulty interacting with Rich Internet Applications (RIA)
  - Complex variants of common attacks (SQL Injection, XSS, etc)
  - Cross-Site Request Forgery (CSRF)
  - Uncommon or custom infrastructure
  - Authorization enforcement
  - Abstract information leakage

What Automated Solutions Miss

other

- Theoretical
  - Logic flaws (business and application) (in progress)
  - Design flaws
  - The Stupid (what we do best)
- Practical
  - ~~Difficulty interacting with Rich Internet Applications~~ (RIA) (been there, done that)
  - Complex variants of common attacks (~~SQL Injection~~, ~~XSS~~, etc) (been there, done that)
  - Cross-Site Request Forgery (CSRF) (in progress)
  - ~~Uncommon or custom infrastructure~~ (abstract&specify them away!)
  - ~~Authorization enforcement~~ (been there, done that)
  - ~~Abstract information leakage~~ (been there, done that)

OPA: Language Support for a Sane, Safe and Secure Web

- General approach
- Keeping in the ~~Smart~~ Useful
- Filtering out the ~~Stupid~~ Fragile
- Lessons and Future

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Theoretical foundations

- Building on 30+ years of research in formal methods & language theory.
- Key for precise analysis.
- Key for precise optimizations.

False positives

- False positives are annoying but not that bad -- as long as they are predictable and there's a workaround.
- Experienced developers make safety/security mistakes quite often.
- False positives often later reveal themselves as **true** positives.

Future

- Eliminate CSRF.
- Extend per-application security policy.
- Extend per-library/per-data safety policy.
- Plenty of additional features!
- Hiring you?

That’s all, folks!

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Thanks and apologies to David Byrne & Charles Anderson
for hijacking their slides

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