SBA Research

Object Capabilities and Their Benefits for Web Application Security

IKT-Sicherheitskonferenz

Michael Koppmann – 2022-09-15

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

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Motivation

- Vulnerabilities cost companies multiple billion U.S. dollars a year
- Some vulnerabilities are more common than others
- OWASP publishes "Top Ten" list
  - A01:2021-Broken Access Control
  - A03:2021-Injection
  - A07:2021-Identification and Authentication Failures

Access Control Lists and Ambient Authority

	/etc/passwd	/home/alice/secret.txt	/home/bob/shared.txt
Alice	{read}	{read, write}	{read}
Bob	{read}	{}	{read, write}
Carol	{read}	{}	{}

Ambient Authority

- Designation and authorization are separate
- Everything can call an object
- The identity of the caller is used for authorization

Object Capabilities and POLA

- Communicable,
- unforgeable,
- token of authority

A capability is a reference to an object, along with an associated set of access rights.

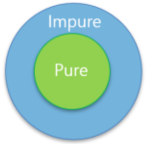
POLA = *Principle of Least Authority*

Research Questions

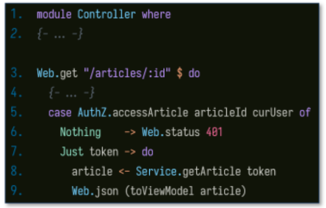
- Can vulnerabilities in authorization systems be prevented by design?
- Is a capability-based system at least as secure as an ACL one?
- Can the web be used as a platform for exchanging security tokens?
- How compatible is this with the rest of the ACL-based ecosystem?

Example: Purely Functional Programming

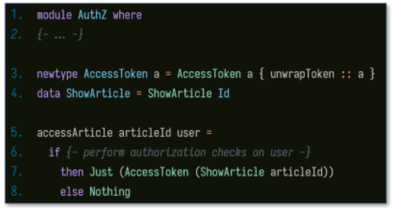
- Pure functions:
  - only rely on input arguments and are deterministic
  - do not perform side-effects like writing to a file or printing to the console, etc.
  - are safe by default as they do not require authority
- Impure functions:
  - perform side-effects but are less composable
  - percentage in code base is kept small to improve auditability
  - authority is granted by passing in arguments



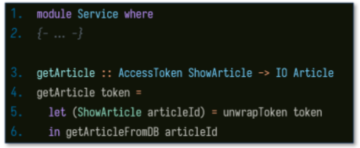
Example: Types as Capabilities



```haskell
module Controller where
{- ... -}

Web.get "/articles/:id" $ do
  {- ... -}
  case AuthZ.accessArticle articleId curUser of
    Nothing    -> Web.status 401
    Just token -> do
      article <- Service.getArticle token
      Web.json (toViewModel article)
```



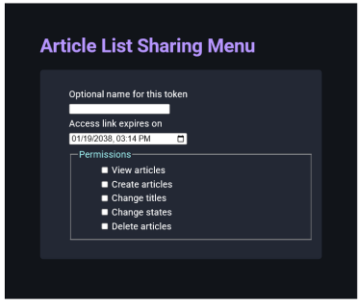
```haskell
module AuthZ where
{- ... -}

newtype AccessToken a = AccessToken a { unwrapToken :: a }
data ShowArticle = ShowArticle Id

accessArticle articleId user =
  if {- perform authorization checks on user -}
    then Just (AccessToken (ShowArticle articleId))
    else Nothing
```



```haskell
module Service where
{- ... -}

getArticle :: AccessToken ShowArticle -> IO Article
getArticle token =
  let (ShowArticle articleId) = unwrapToken token
  in getArticleFromDB articleId
```

Example: URLs as Capabilities

Fine-grained permission levels



Article List Sharing Menu

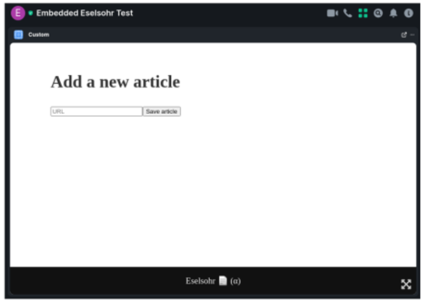
Optional name for this token

Access link expires on

01/19/2038, 03:14 PM

Permissions
- ■ View articles
- ■ Create articles
- ■ Change titles
- ■ Change states
- ■ Delete articles

Embeddability



Add a new article

https://eselsohr.example.org/articles/shared-links?acc=A4LMCKUVYTGCIYVIIWLFWQYGYDKF

Conclusion

- OCAP style programming prevents certain security vulnerabilities by design
- No significant drawbacks compared to ACL could be observed
- Current browsers lack the ability to protect capabilities in URLs:
  - Hyperlinks between web applications can leak capabilities
  - Secure capability transport within the same application is possible
- OCAP style applications do not require specialized frameworks

Master Thesis

https://repositum.tuwien.at/handle/20.500.12708/18849

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