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# The Challenge of Heterogeneously Licensed Systems in Open Architecture Software Ecosystems

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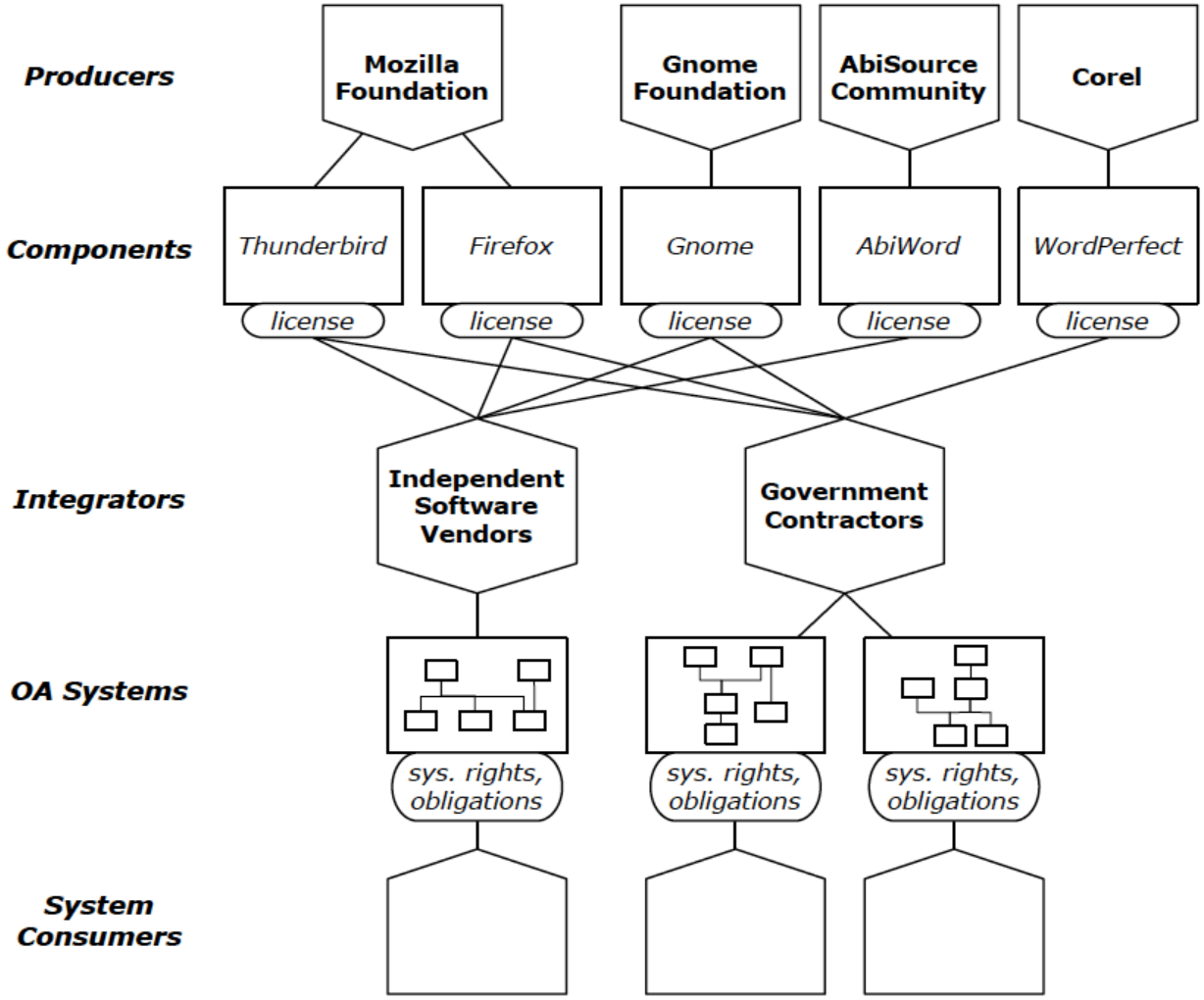
# Overview

- Background
- Developing Open Architectures (OAs)
- Software licenses, architectures, and analysis
- Discussion
- Conclusions

# Background

# OA software ecosystem – mapping rights and obligations from producers to consumers



# A heterogeneous software license for the *Unity 3D* software system

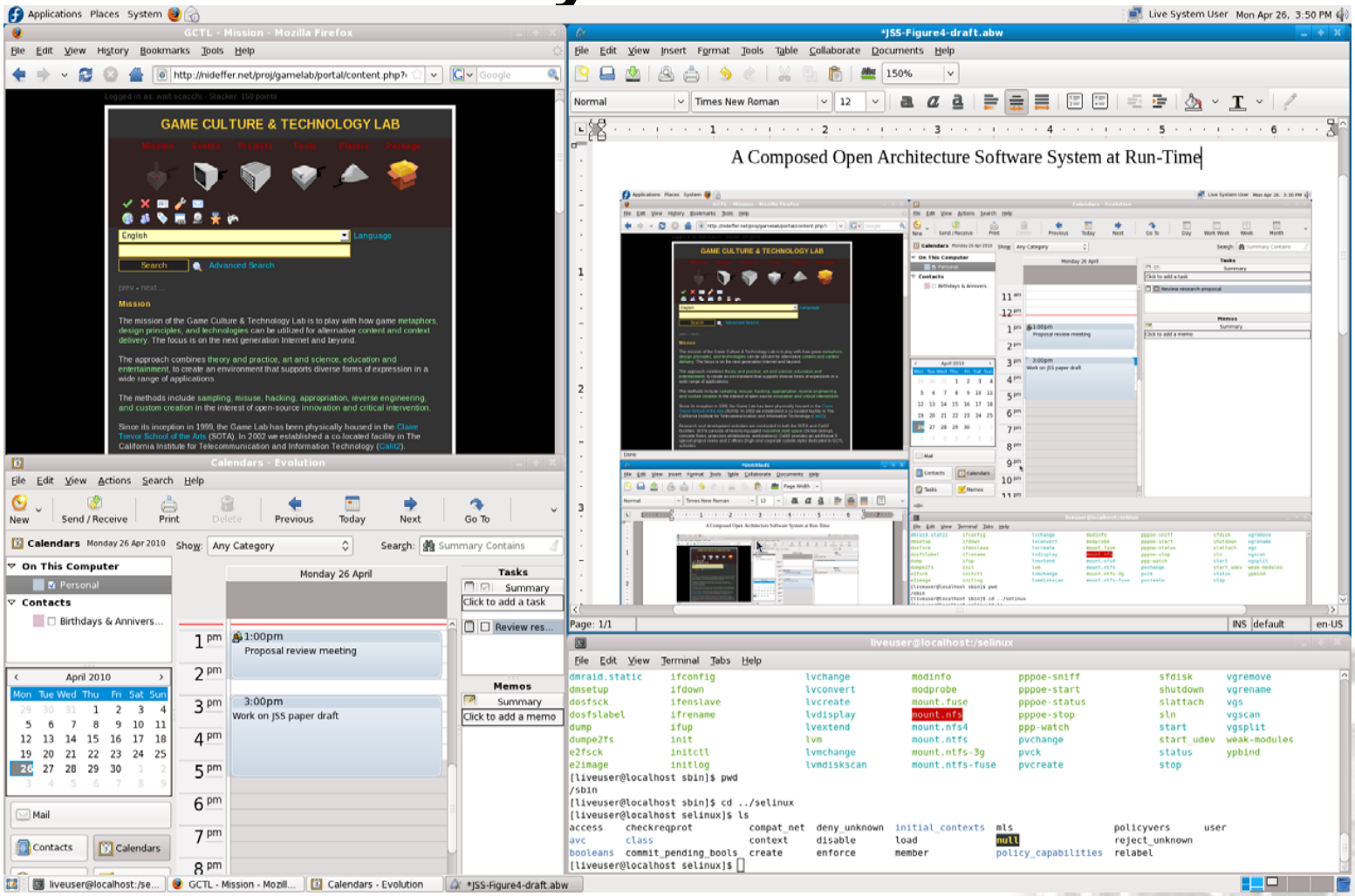
1. The Mono Class Library, Copyright 2005-2008 Novell, Inc.
2. The Mono Runtime Libraries, Copyright 2005-2008 Novell, Inc.
3. Boo, Copyright 2003-2008 Rodrigo B. Oliveira
4. UnityScript, Copyright 2005-2008 Rodrigo B. Oliveira
5. OpenAL cross platform audio library, Copyright 1999-2006 by authors.
6. PhysX physics library. Copyright 2003-2008 by Ageia Technologies, Inc.
7. libvorbis. Copyright (c) 2002-2007 Xiph.org Foundation
8. libtheora. Copyright (c) 2002-2007 Xiph.org Foundation
9. zlib general purpose compression library. Copyright (c) 1995-2005 Jean-loup Gailly and Mark Adler
10. libpng PNG reference library
11. jpeglib JPEG library. Copyright (C) 1991-1998, Thomas G. Lane.
12. Twilight Prophecy SDK, a multi-platform development system for virtual reality and multimedia. Copyright 1997-2003 Twilight 3D Finland Oy Ltd
13. dynamic bitset, Copyright Chuck Allison and Jeremy Siek 2001-2002.
14. The Mono C# Compiler and Tools, Copyright 2005-2008 Novell, Inc.
15. libcurl. Copyright (c) 1996-2008, Daniel Stenberg <daniel@haxx.se>.
16. PostgreSQL Database Management System
17. FreeType. Copyright (c) 2007 The FreeType Project (www.freetype.org).
18. NVIDIA Cg. Copyright (c) 2002-2008 NVIDIA Corp.

# Supporting OA with heterogeneously licensed system components

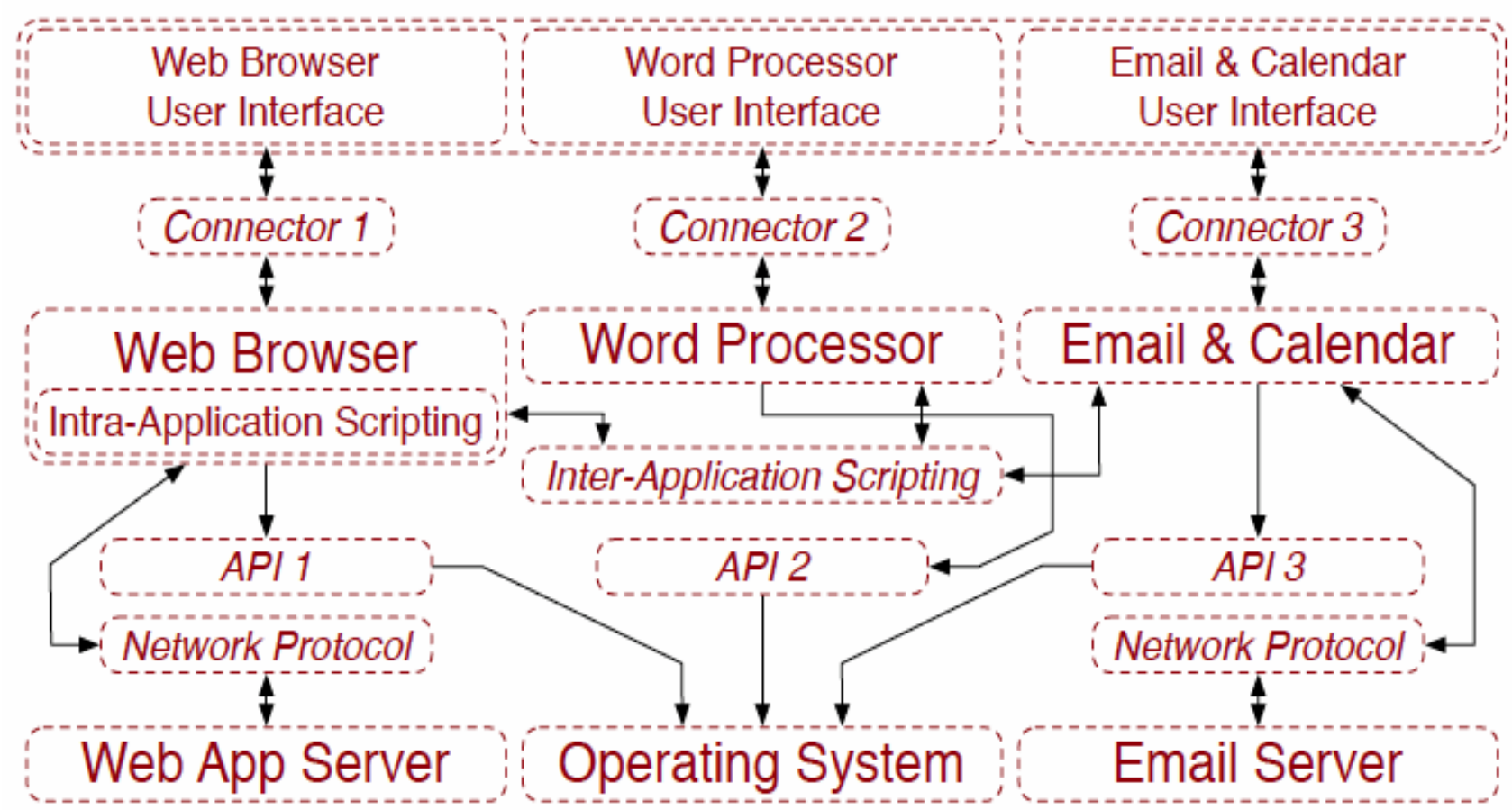
- Must account for design-time, build-time, and run-time architectures
- Must distinguish architect constructs relevant to software licenses, and license effects
- Must define license architecture
- Must provide automated environment for managing system and license architectures
- Must automate calculations of system license rights, obligations, architectures as they evolve

# Developing OA systems with heterogeneously licensed software components

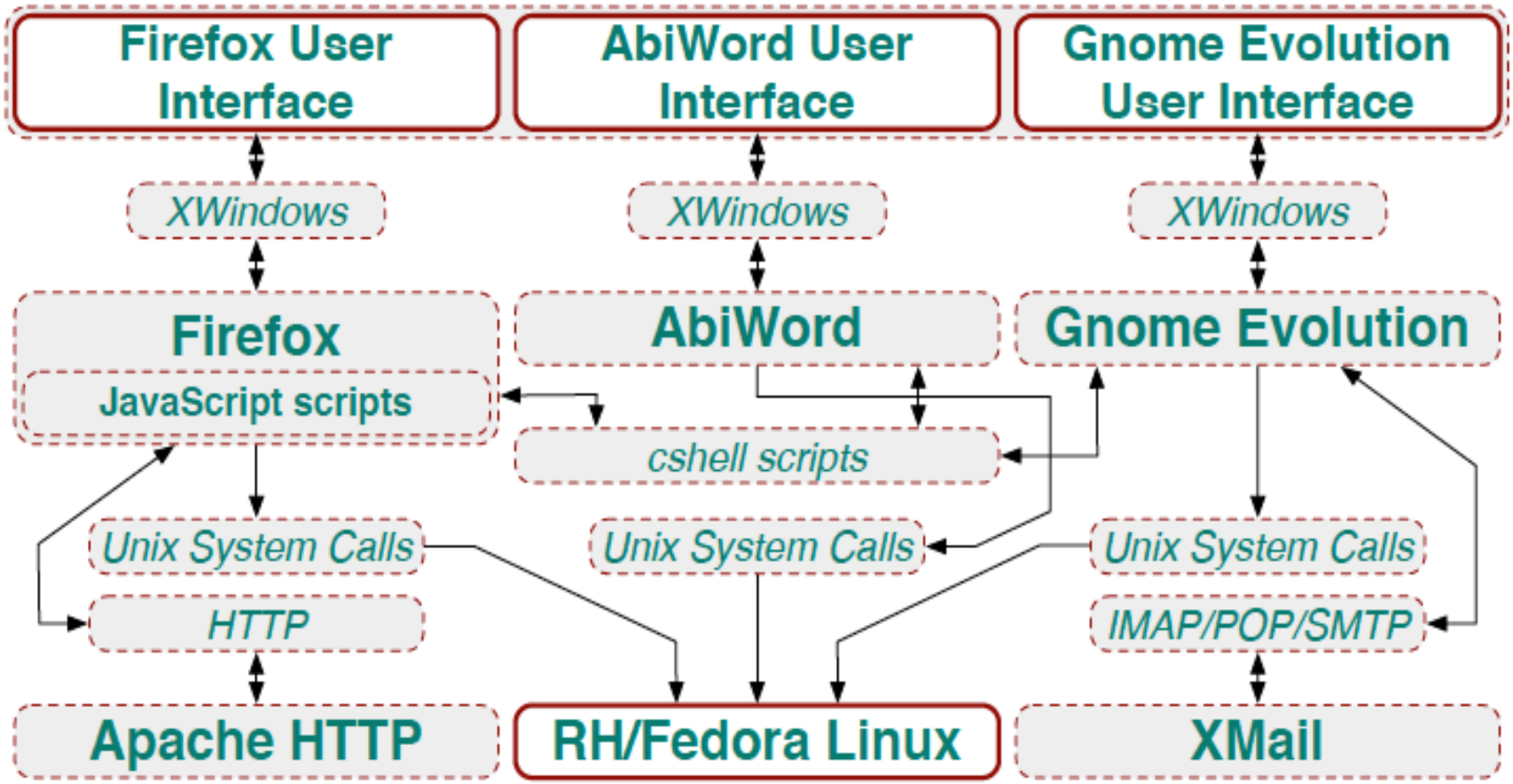
# A composed multi-component OA system



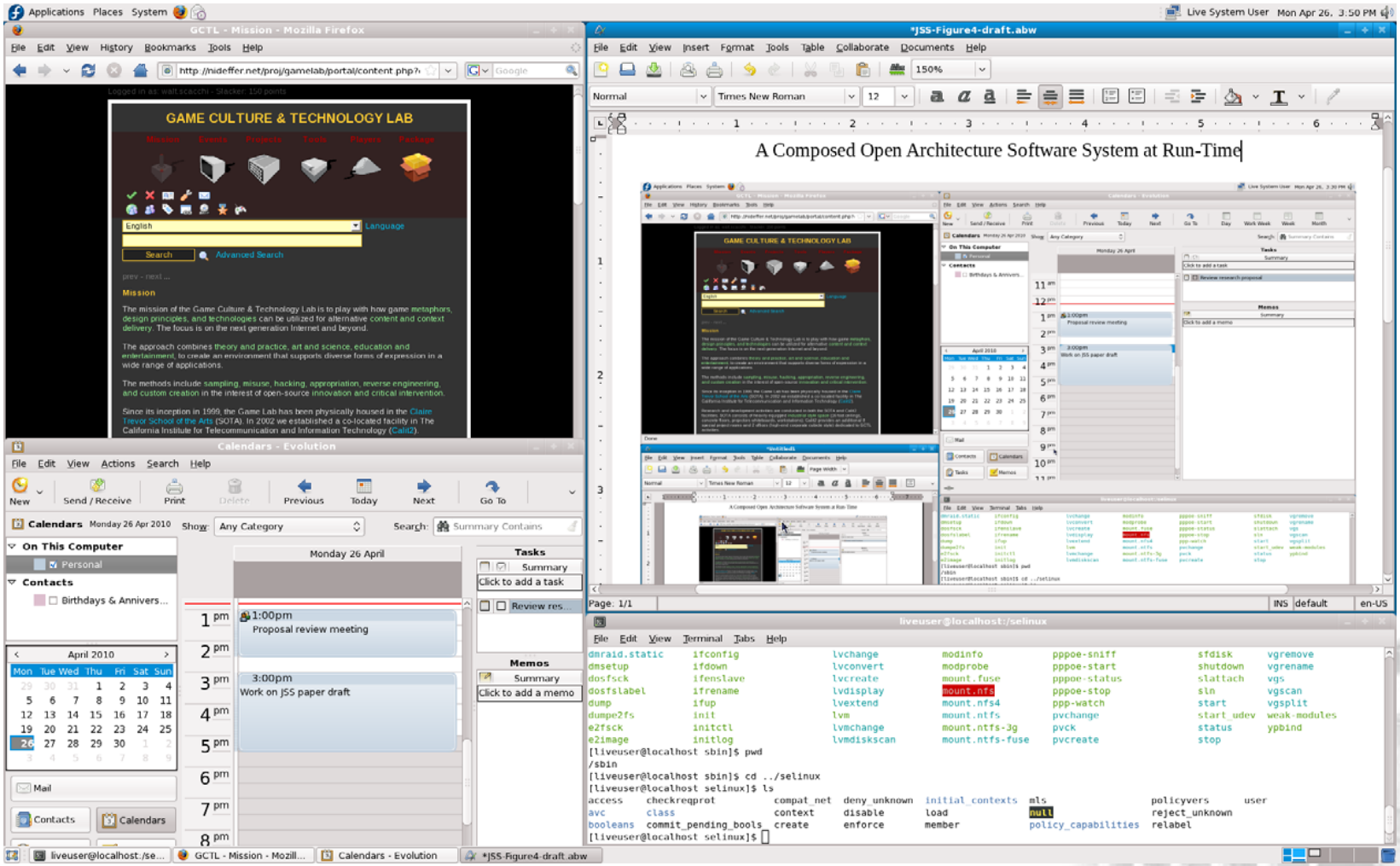
# Design-time architecture



# Build-time architecture



# Run-time architecture (user view)

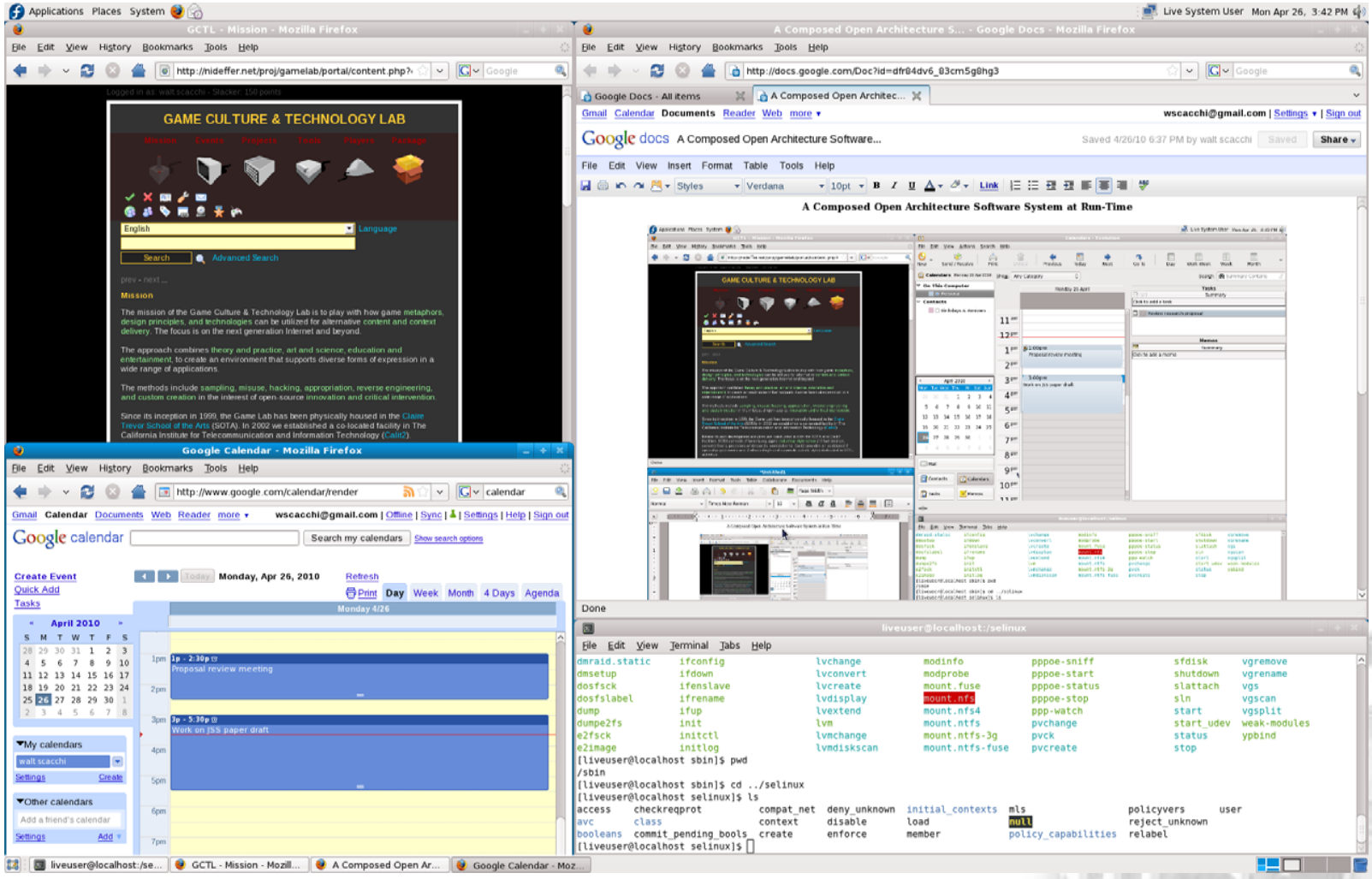


# Evolutionary changes in OA Systems

- Component evolution
- Component replacement
- Architecture evolution
- Component license evolution
- Change in desired rights or acceptable obligations

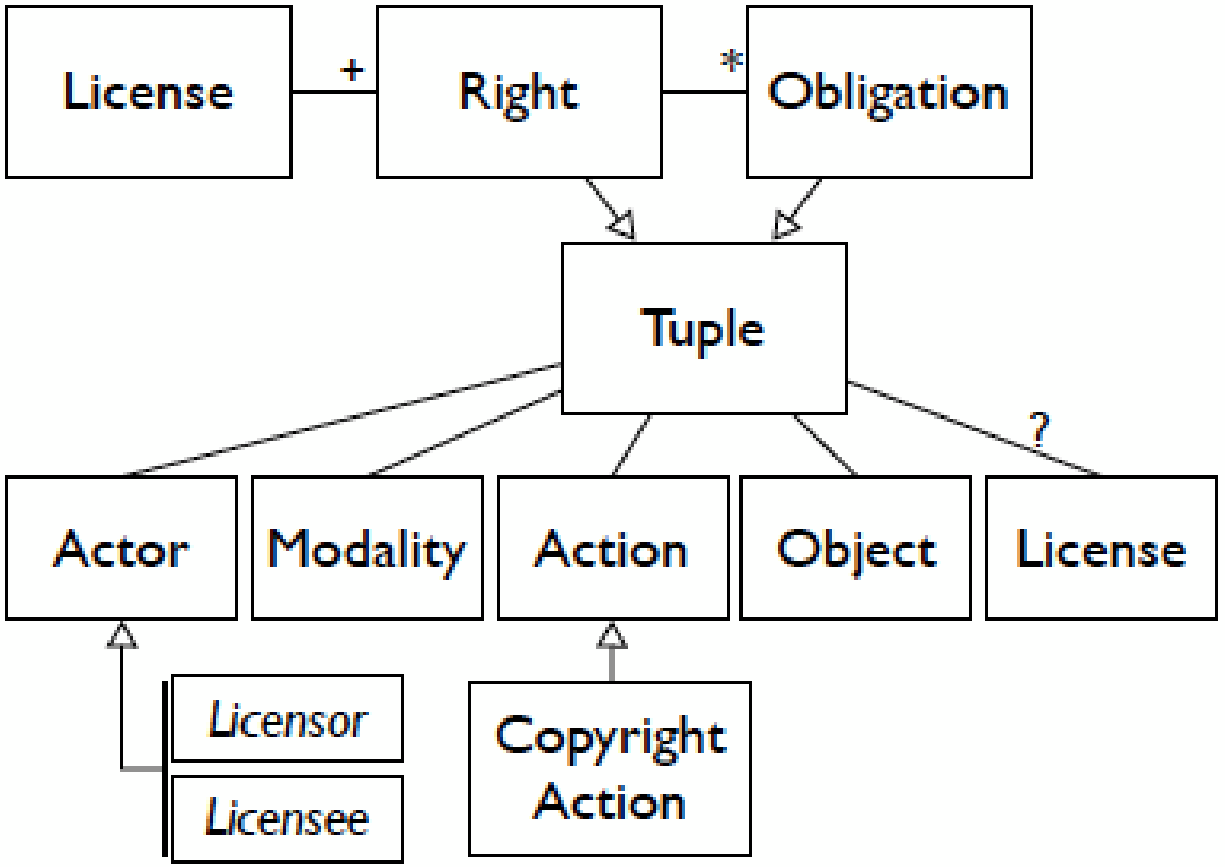
- Evolutionary changes reconfigure a system's software ecosystem!

# Component replacement and architecture evolution



# Software licenses, architectures, and analysis

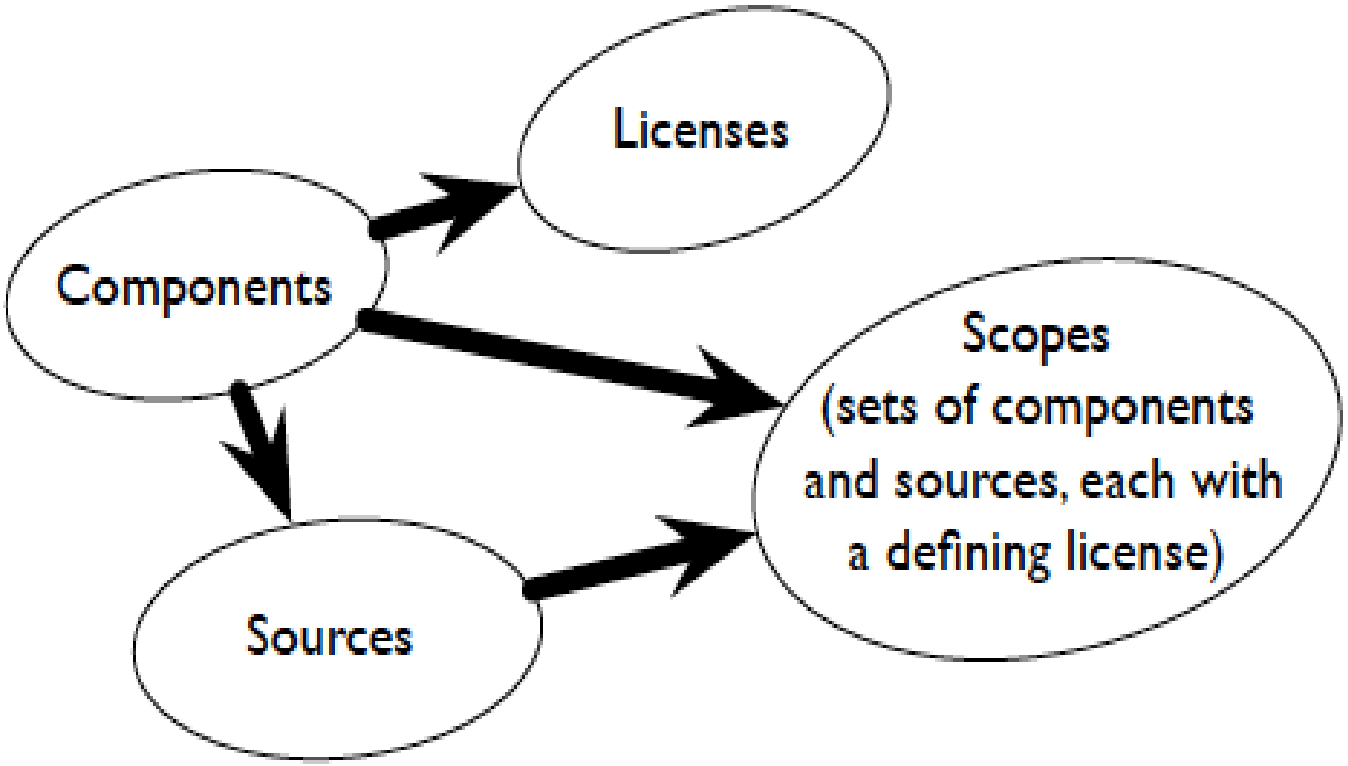
# Software license meta-model



# Logical modality and objects of software license rights and obligations

<table>
<tr><th></th><th>Modality</th><th>Object</th><th>License<br>(optional)</th></tr>
<tr><td rowspan="3">Abstract Right</td><td rowspan="3">May<br>or<br>Need Not</td><td>Any Under This License</td><td rowspan="3">This License<br>or<br>Object's License</td></tr>
<tr><td>Any Source Under This License</td></tr>
<tr><td>Any Component Under This License</td></tr>
<tr><td>Concrete Right</td><td rowspan="2">Concrete Object</td><td rowspan="2">Concrete License</td></tr>
<tr><td>Concrete Obligation</td><td rowspan="4">Must<br>or<br>Must Not</td></tr>
<tr><td rowspan="3">Abstract Obligation</td><td>Right's Object</td><td rowspan="3">Concrete License<br>or<br>Right's License</td></tr>
<tr><td>All Sources Of Right's Object</td></tr>
<tr><td>X Scope Sources</td></tr>
<tr><td></td><td></td><td>X Scope Components</td><td></td></tr>
</table>

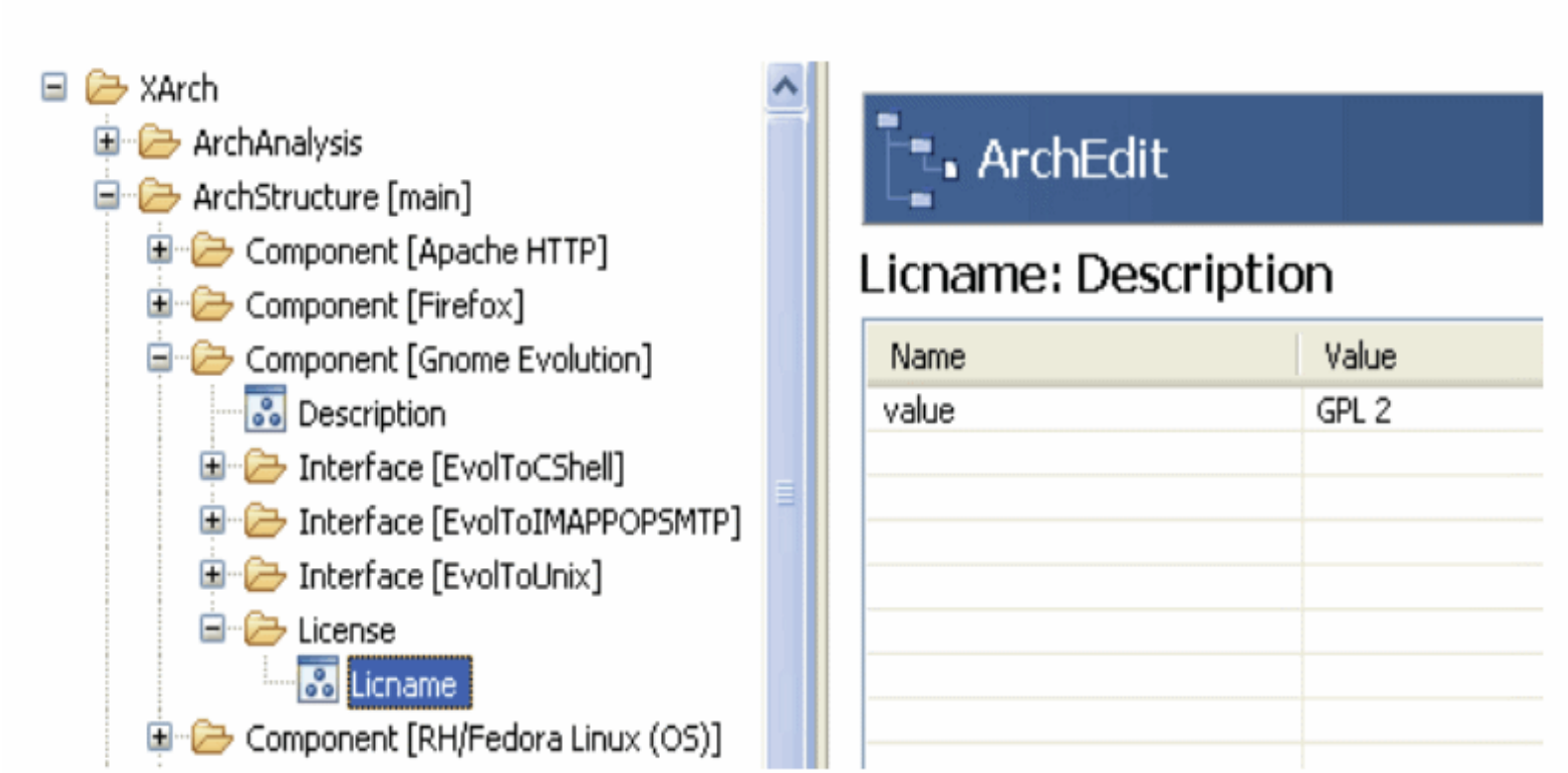
# The software license architecture meta-model



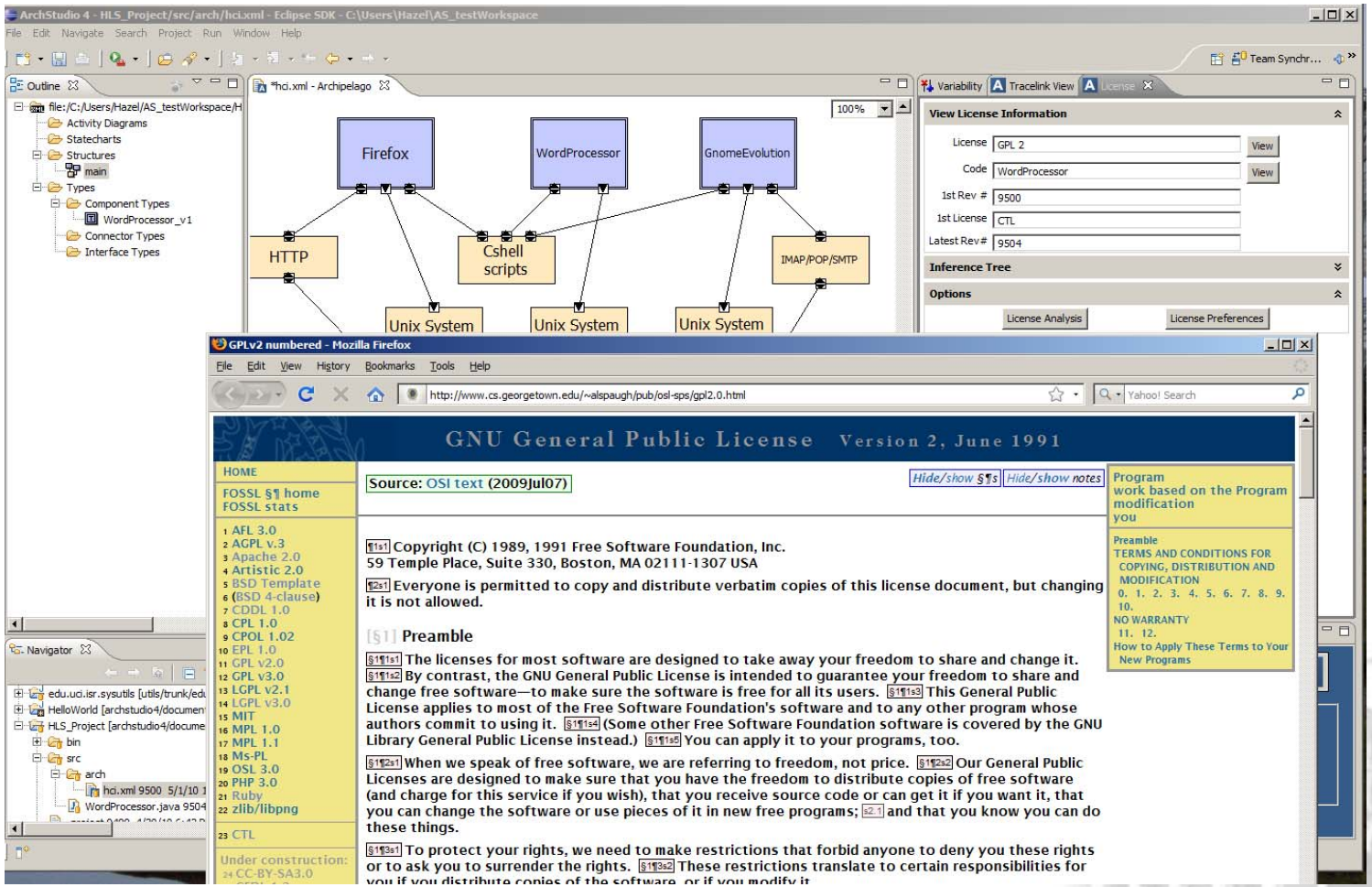
# Software license analysis

- License types:
  - Strongly reciprocal (GPL), weakly reciprocal (LGPL), academic (BSD), Terms of Service, Proprietary
- Propagation of reciprocal obligations
- Conflicting obligations
- Calculating obligations and rights

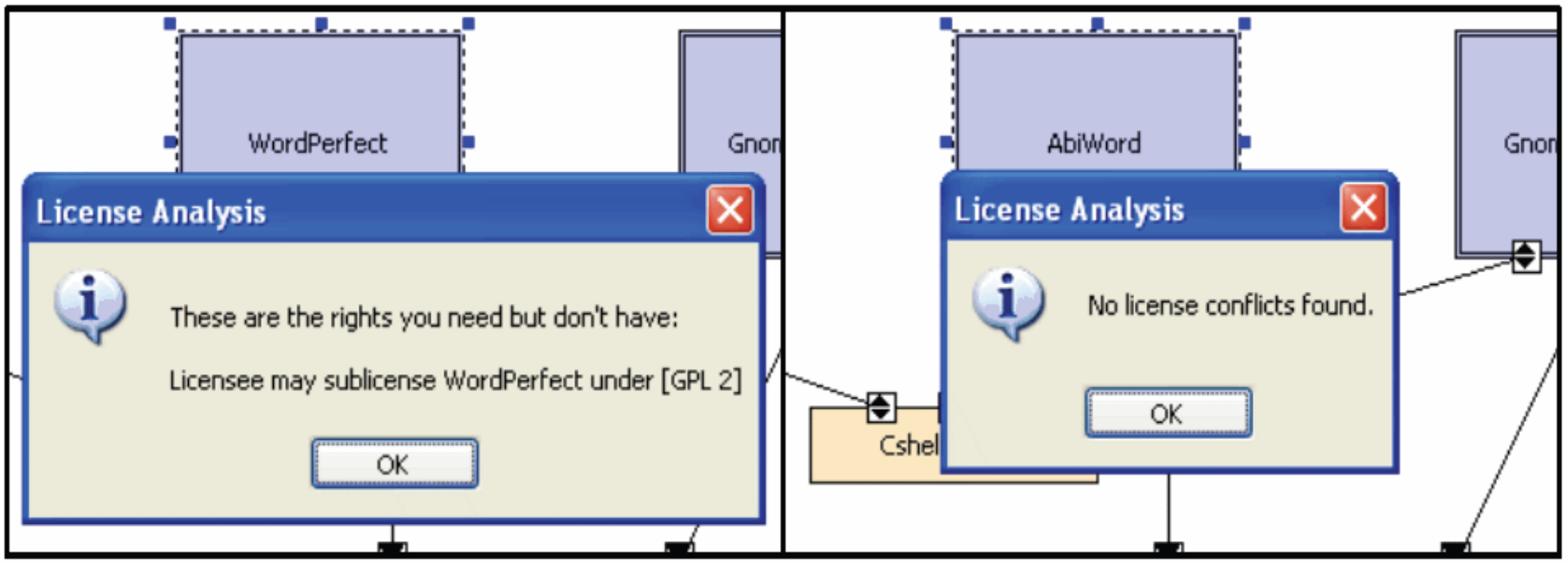
# Component license annotation prior to analysis



# License review during license analysis



# Results from license analyses with system component replacement



# Discussion

# Software product lines (SPLs) and OA systems

- An SPL may or may not be an OA system
- If SPL subject to single vendor/proprietary license, then lock-in is possible
- If OA system has design-time reference architecture and instantiated build-time architecture, then OA conforms to an SPL
- If SPL is based on OA with heterogeneously licensed components, then OA conforms to a *virtual SPL*, and works with our approach.

# Specifying and analyzing system security requirements as “licenses”

- Security capabilities can correspond to “rights and obligations” in licenses
- Should be possible to specify and analyze system *security architecture* that conform to a *security meta-model*, much like we do for software licenses
- Should be possible to develop computational tools and development environments that can analyze security at design-time, build-time, and run-time, as well as when the system evolves

# Conclusions

- Software component licenses and heterogeneously licensed systems becoming more widespread as we move to OA software ecosystems
- Our approach and tools demonstrate the ability to specify, model, and analyze such systems as they evolve, and are subject to diverse licenses
- Our approach is compatible with SPLs and can be extended to support system security licenses

# Acknowledgements

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