Addressing Challenges in the Acquisition of Secure Software Systems with Open Architectures

Walt Scacchi and Thomas Alspaugh
Institute for Software Research
University of California, Irvine
Irvine, CA 92697-3455 USA

Overview

- Challenges of securing open architecture (OA) systems
- Specifying security requirements for software systems
- Case study: Specifying secure software product lines within an OA software ecosystem for enterprise systems
- Discussion and conclusions

Challenges of securing open architecture (OA) systems

Security challenges

- Security threats to software systems are increasingly multi-modal and distributed across system components.
- Physically isolated systems are vulnerable to external security attacks, via portable storage devices like USB drives, modified end-user devices, and social engineering techniques.
- What makes an OA system secure changes over time, as new threats emerge and systems evolve.
- Need an approach *to continuously assure the security of evolving OA systems* that is practical, scalable, robust, tractable, and adaptable.

Software systems/components evolve: what to do about security?

- Individual components evolve via revisions (e.g., security patches)
- Individual components are updated with functionally enhanced versions;
- Individual components are replaced by alternative components;
- Component interfaces evolve;
- System architecture and configuration evolve;
- System functional and security requirements evolve;
- System security policies, mechanisms, security components, and system configuration parameter settings also change over time.

Current security approaches

- Mandatory access control lists, firewalls;
- Multi-level security;
- Authentication (including certificate authority and passwords);
- Cryptographic support (including public key certificates);
- Encapsulation (including virtualization), hardware confinement (memory, storage, and external device isolation), and type enforcement capabilities;
- Secure programming practices;
- Data content or control signal flow logging/auditing;
- Honey-pots, traps, sink-holes;
- Security technical information guides for configuring the security parameters for applications and operating systems;
- Functionally equivalent but diverse multi-variant software executables.

What acquisition research is needed for security?

- How to *verify* the security of OA system designs throughout acquisition life cycle: system development, deployment, and post-deployment support.

- How to *validate* the effectiveness of OA system security measures and knowledge of vulnerabilities into the ongoing development for systems in an operational, testable form that system integrators and administrators can employ, and acquisition program managers can assess.

Specifying the security requirements for software systems

Carefully specifying security policy obligations and rights

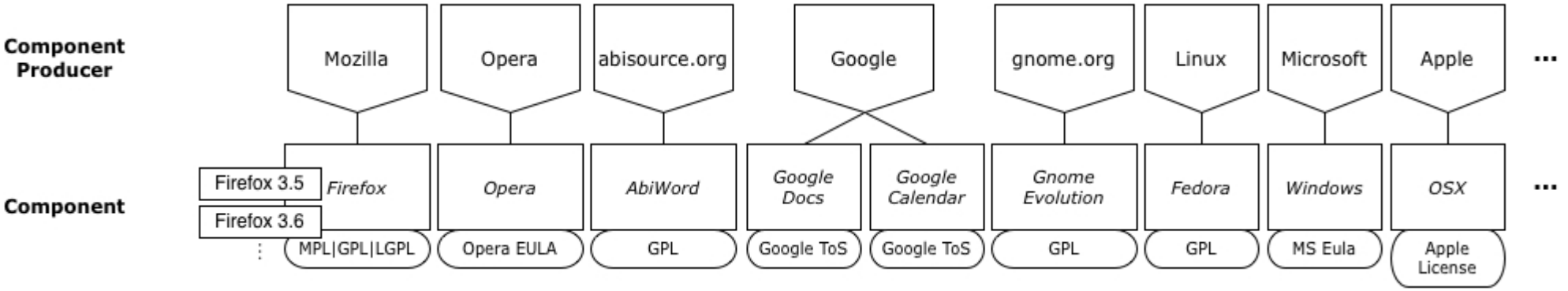
- The obligation for a user to verify his/her authority to see compartment T, by password or other specified authentication process
- The obligation for all components connected to specified component C to grant it the capability to read and update data in compartment T
- The obligation to reconfigure a system in response to detected threats, when given the right to select and include different component versions, or executable component variants.
- The right to read and update data in compartment T using the licensed component
- The right to add, update, replace specified component D in a specified configuration
- The right to add, update, or remove a security mechanism
- The right to update security policy L.

Case Study:
Securing software product lines within an OA software ecosystem for enterprise systems

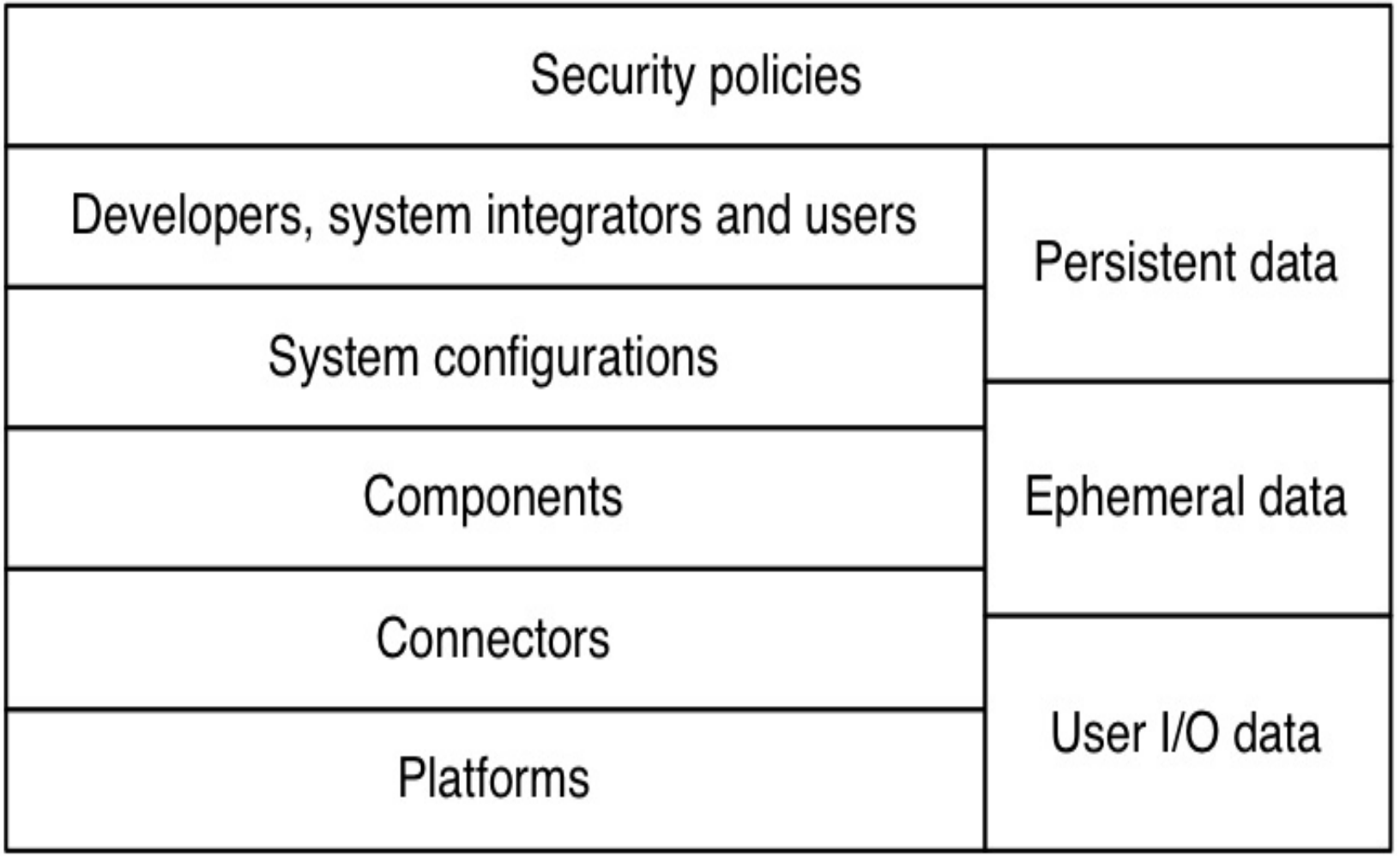
Software product lines?

- When functionally similar software components, connectors, or configurations exist,
- Such that equivalent alternatives, versions, or variants may be substituted for one another, then
- We have a strong relationship among these OA system elements that is called a *software product line*.

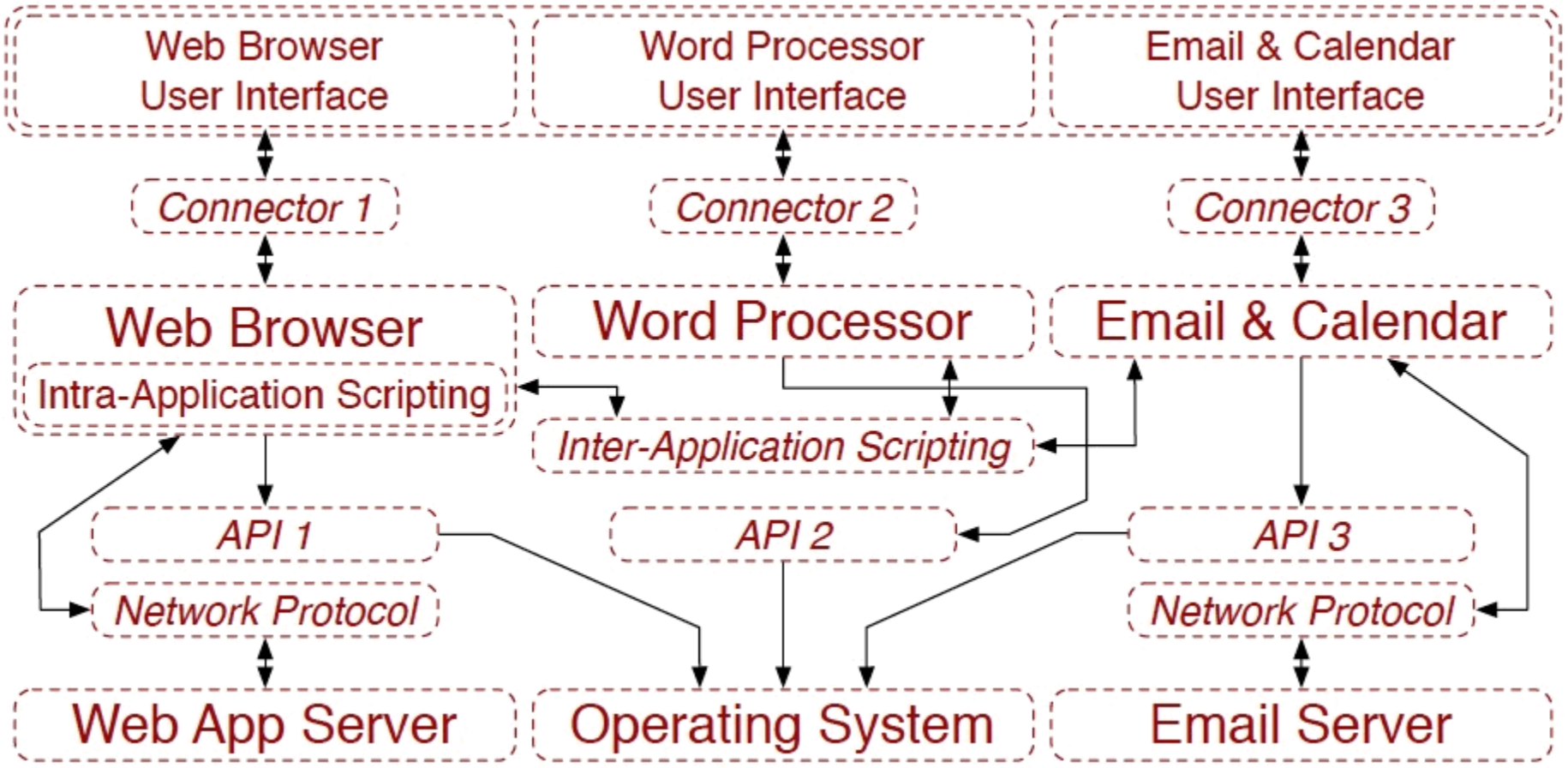
Software ecosystem of producers and the software components for an enterprise system



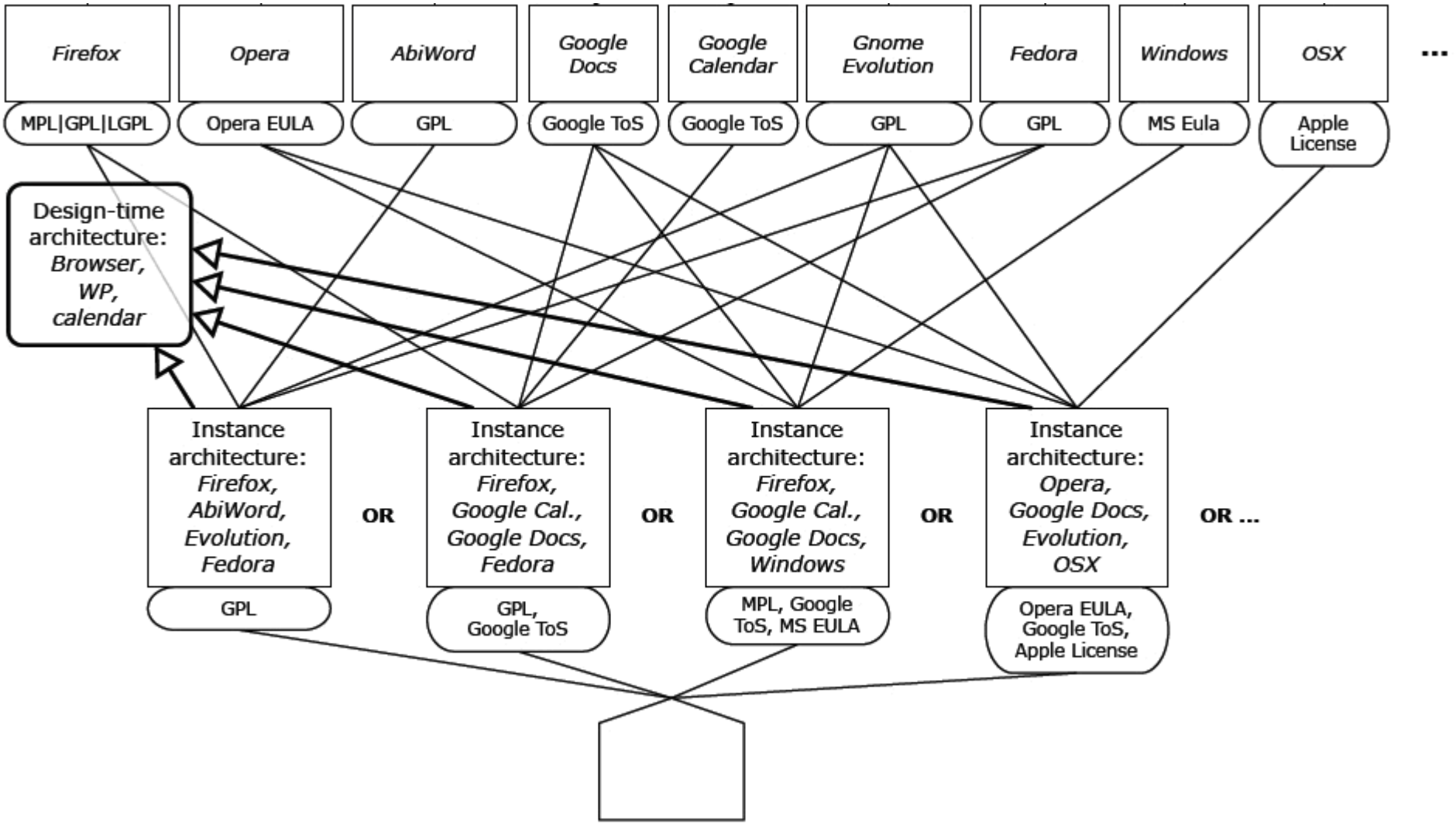
Framework for specifying multi-level OA system security policy



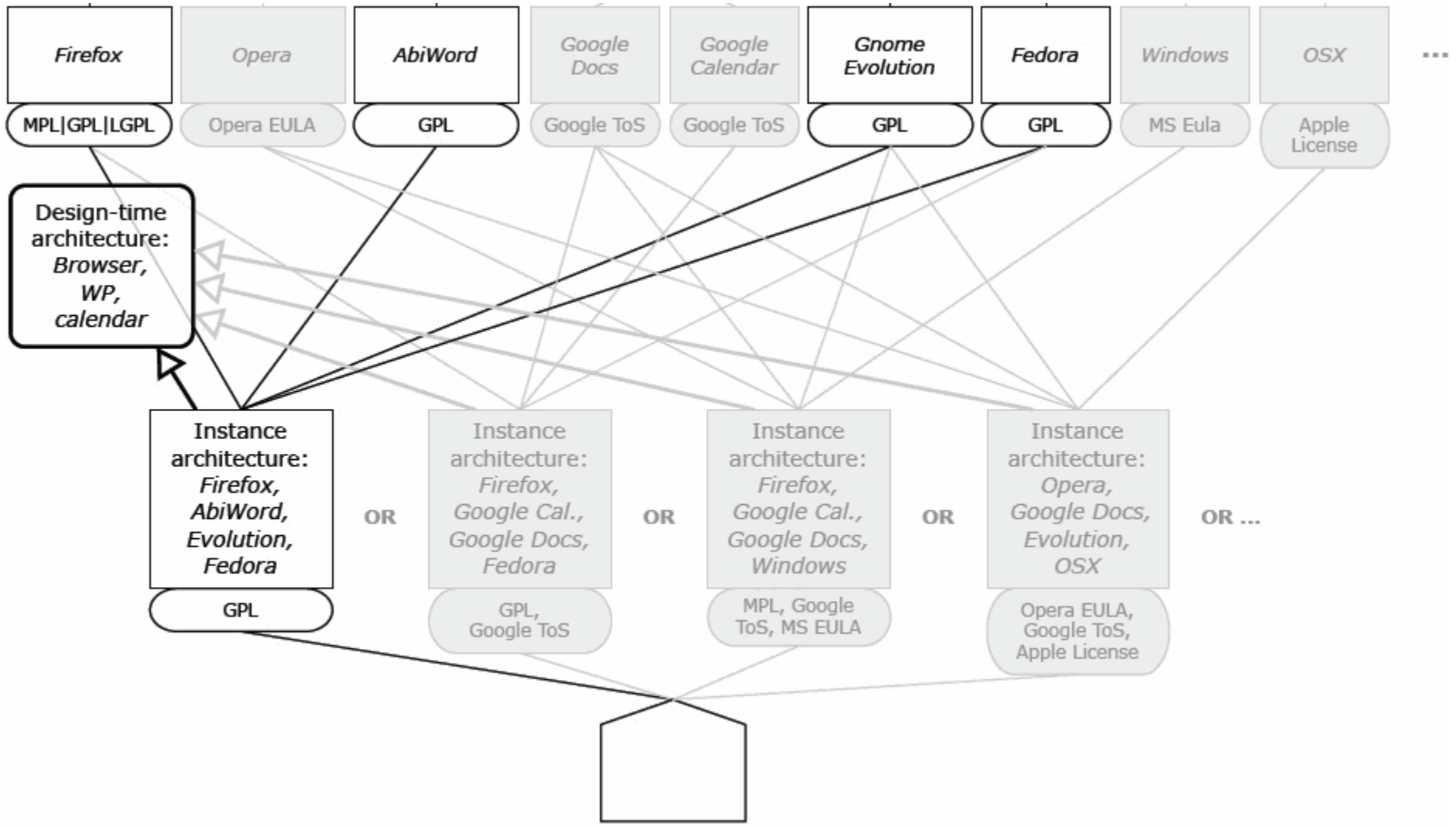
A *design-time* specification of an OA enterprise system that accommodates multiple alternative system configurations



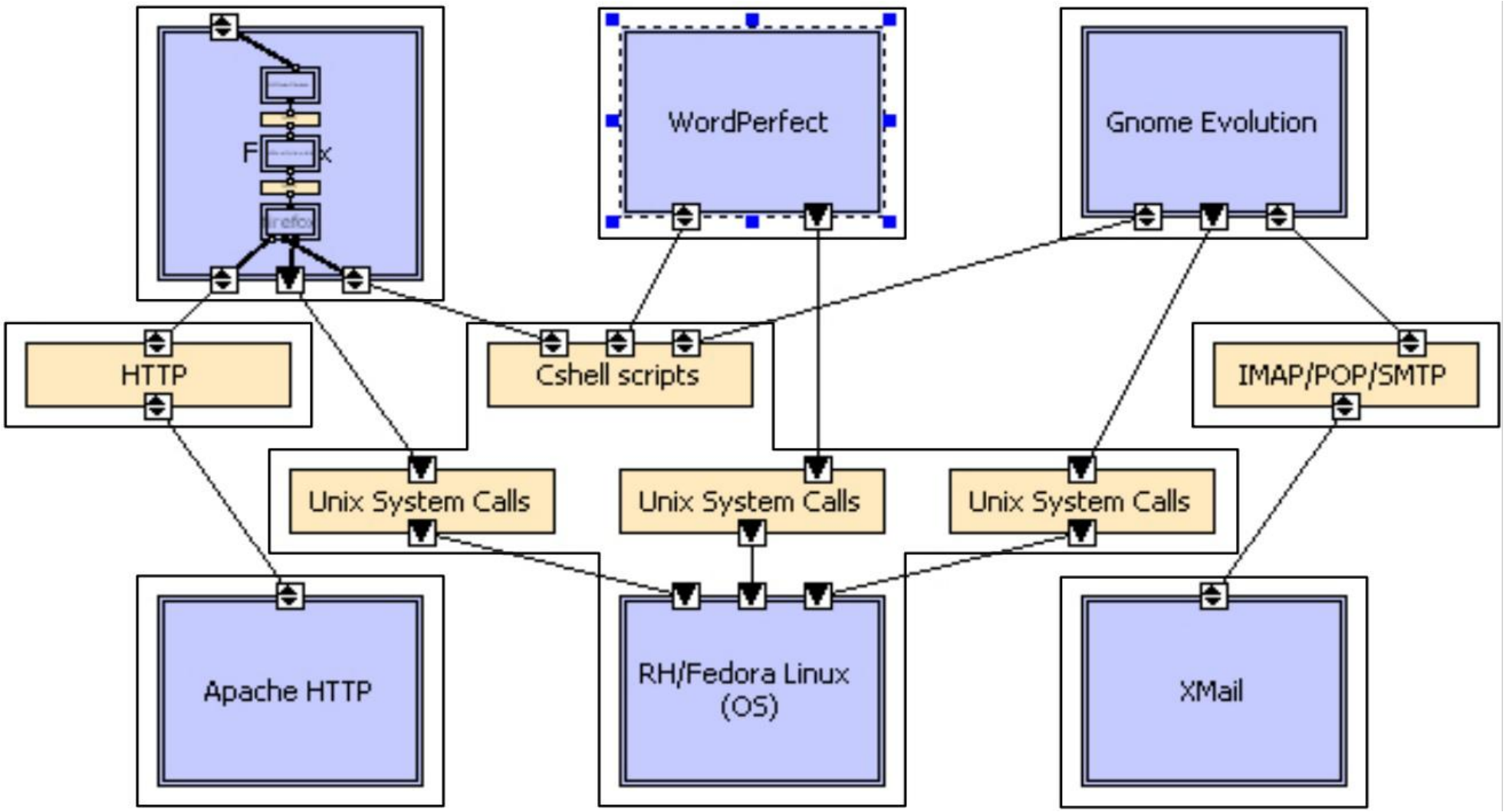
Software product line that provides alternative, functionally similar components compatible with the reference design-time architecture



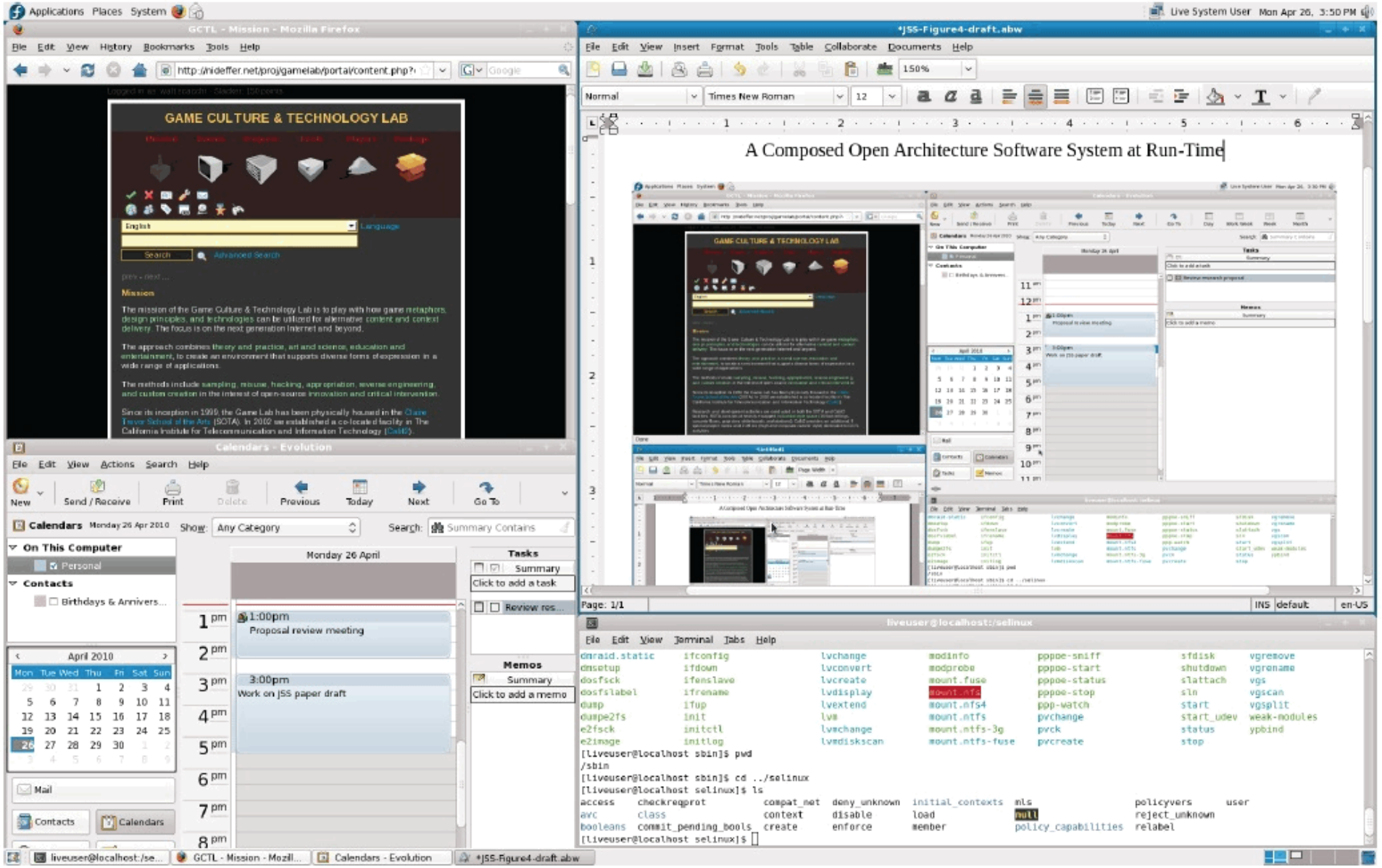
A *build-time deployment selection* among alternative components that produce an integrated enterprise system within the product line



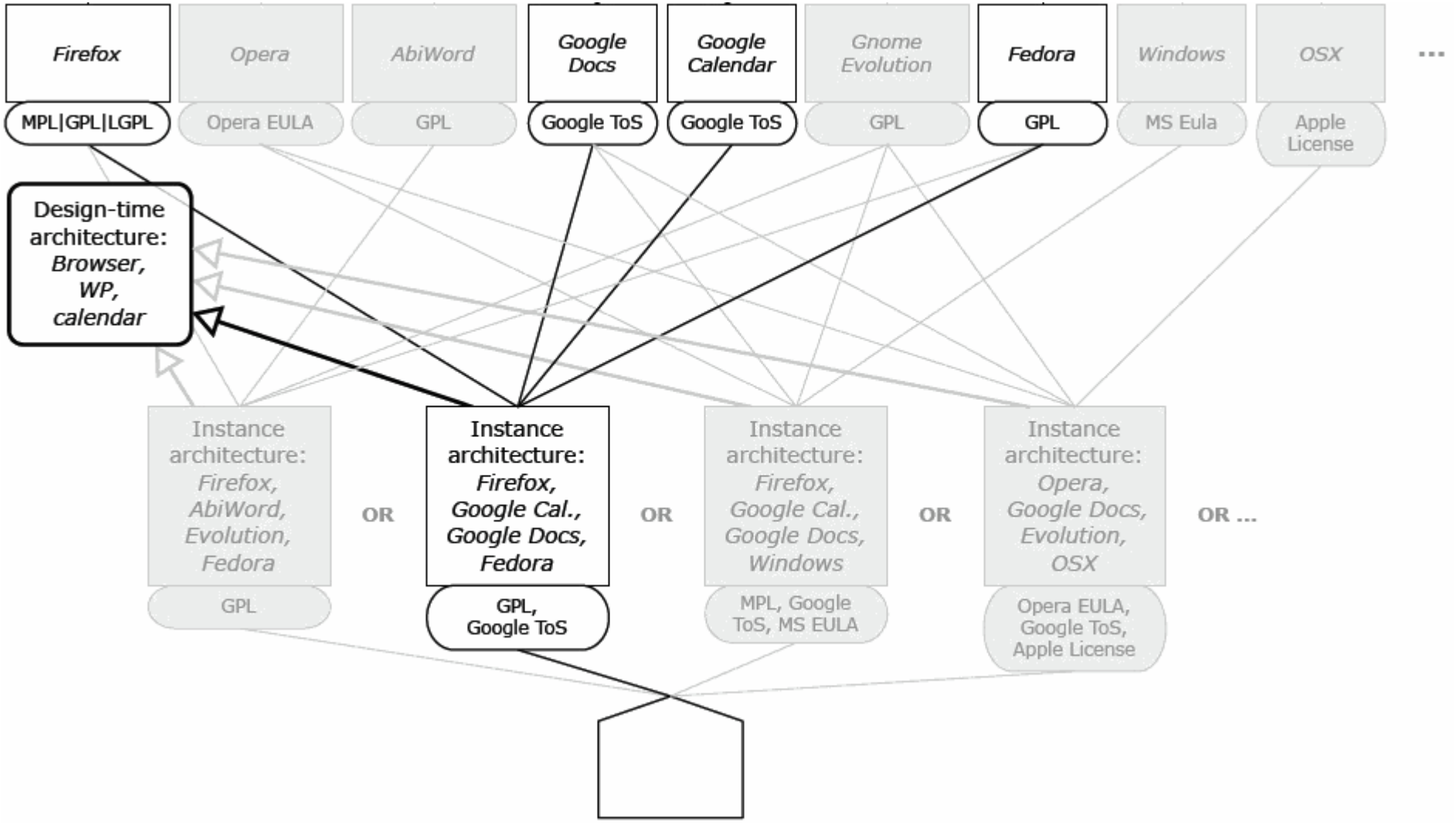
A security capability specification encapsulating the run-time configuration instance via multiple virtual machines (e.g., using *Xen*)



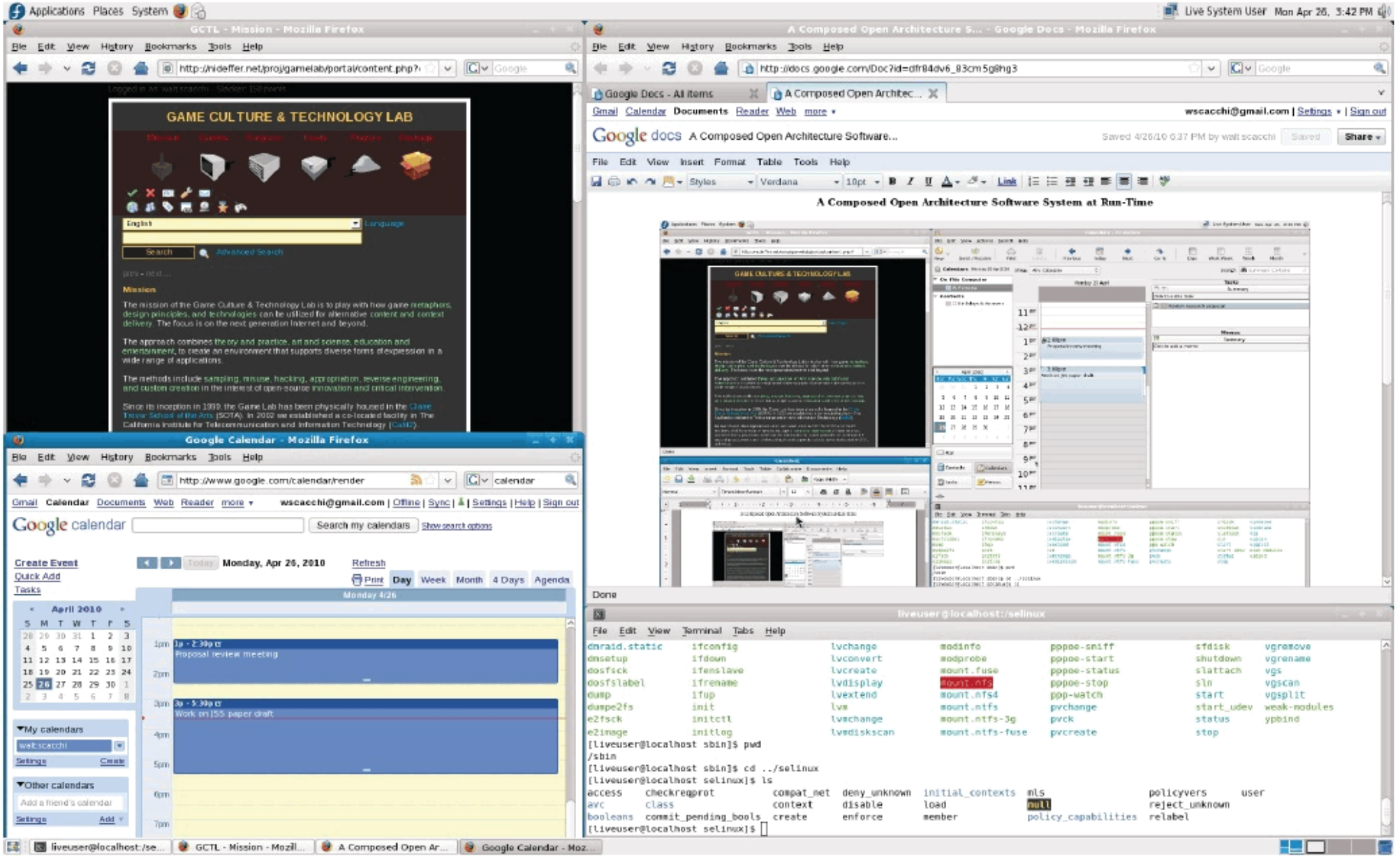
An end-user *run-time deployment version* of selected components within enterprise system product line utilizing security library, **SELinux**, for enforcing mandatory obligations and rights.



Updated *post-deployment system configuration*, using alternative but functionally similar components within enterprise system product line



An end-user view of the updated alternative run-time system configuration



Discussion and conclusions

Discussion

- Our goal is to develop and demonstrate a new approach to address challenges in the acquisition of secure OA software systems.
- Program managers, acquisition officers and contract managers will increasingly be called on to provide review and approval of security measures that are employed during the design, implementation, and deployment of OA systems.
- We seek to make this a simpler, more transparent, and more tractable process.

Conclusions (1)

- Our research demonstrates how complex OA systems can be designed, built, and deployed with alternative components and connectors into functionally similar system versions, to realize for overall system security.
- We described a scheme to specify and realize OA system configurations that are compatible with existing security mechanisms.
  - Our scheme does not assume that individual system elements must be secure before inclusion into the secured OA system's configuration.
- Central to our scheme are software product line concepts integrated with security mechanisms.
- We provided a case study that reveals how to specify a secure OA enterprise system product line accommodating diverse needs of software producers and developers, system integrators, users and acquisition managers.

Conclusions (2)

Next steps:

- Articulate the *process* how to simply and transparently specify and assess OA system security using streamlined security policies.
- Develop and demonstrate a prototype *automated environment* that can support the modeling and analysis of OA system security policies and alternative version OA system configurations, in ways that address the diverse needs of acquisition managers, system integrators and end-users.

Acknowledgements

Research described in this presentation was supported by grant #N447602-12-1-0004 from the Acquisition Research Program at the Naval Postgraduate School, and from grant #0808783 from the National Science Foundation. *No review, approval, or endorsement implied*.