

Representing Software Architectures for Large Scale Systems

Jeff Garland
President & CTO
CrystalClear Software, Inc
2001-Aug-10

Executive Summary

This paper will focus representing the architecture of large-scale systems. UML has a rich set of primitives and extensibility. While some authors have addressed tried to address the use of UML for large-scale systems [1][2][3], little has been written about good representations for large-scale systems. This paper introduces the layered package diagram, which has proven to be a useful view for understanding the logical architecture of large-scale systems.

Problems for Modeling Large Scale Systems

Large-scale systems commonly come with a host of complications, including:

- large amounts of source code (typically millions of lines)
- high complexity of interaction between components
- extensive use of off-the-shelf components
- use of multiple languages
- large numbers of developers (often hundreds, often geographically distributed)
- multiple persistence mechanism (files, relational databases, object databases)
- distribution of components over several hardware platforms
- high amounts of concurrency

Each of these attributes makes a common understanding of system architecture amongst team members and stakeholders more difficult.

The architect faced with designing, managing development, and communicating a large-scale system needs useful views of the system. It is simply naive to believe that modeling all the classes and methods of the system is a possible or useful way to view the logical architecture. Typical UML references such as The Unified Modeling Language User Guide [4] or UML Distilled [5] will not provide much guidance.

Layered Package Diagram

The Basic Diagram

The layered package diagram is used as a central view to represent a software system compile-time logical architecture. This view can be used to communicate multiple system aspects to different project stakeholders. As such, it is a nice complement to other types of diagrams that describe other aspects of the overall system architecture.

Traditional architecture diagrams often include a "layered view" of the system. These are easy to "understand" views for non-software participates. However, for the software developers the layered view compactly represents a critical aspect of the software logical architecture: build time dependencies.

The layered package diagram is an adaptation of the layer diagram using UML is to group packages into "related layers". This diagram is similar to the "Tiers View" suggested by Doug Smith[6], except that the diagram does not attempt to explicitly represent dependencies. However, by implication packages in higher layers depend on lower layers but not the other way around. Note that a higher layer package is not required to depend on lower layer packages, but might.

Figure 1 provides an example of the layered package diagram. The lowest layer consists of third party packages such as database and user interface libraries. The second layer represent libraries maintained by the project to simplify common programming tasks. The third layer consists of packages that provide components specific to the problem domain. Finally, the top layer provides applications or components realized by combining the

lower layers.

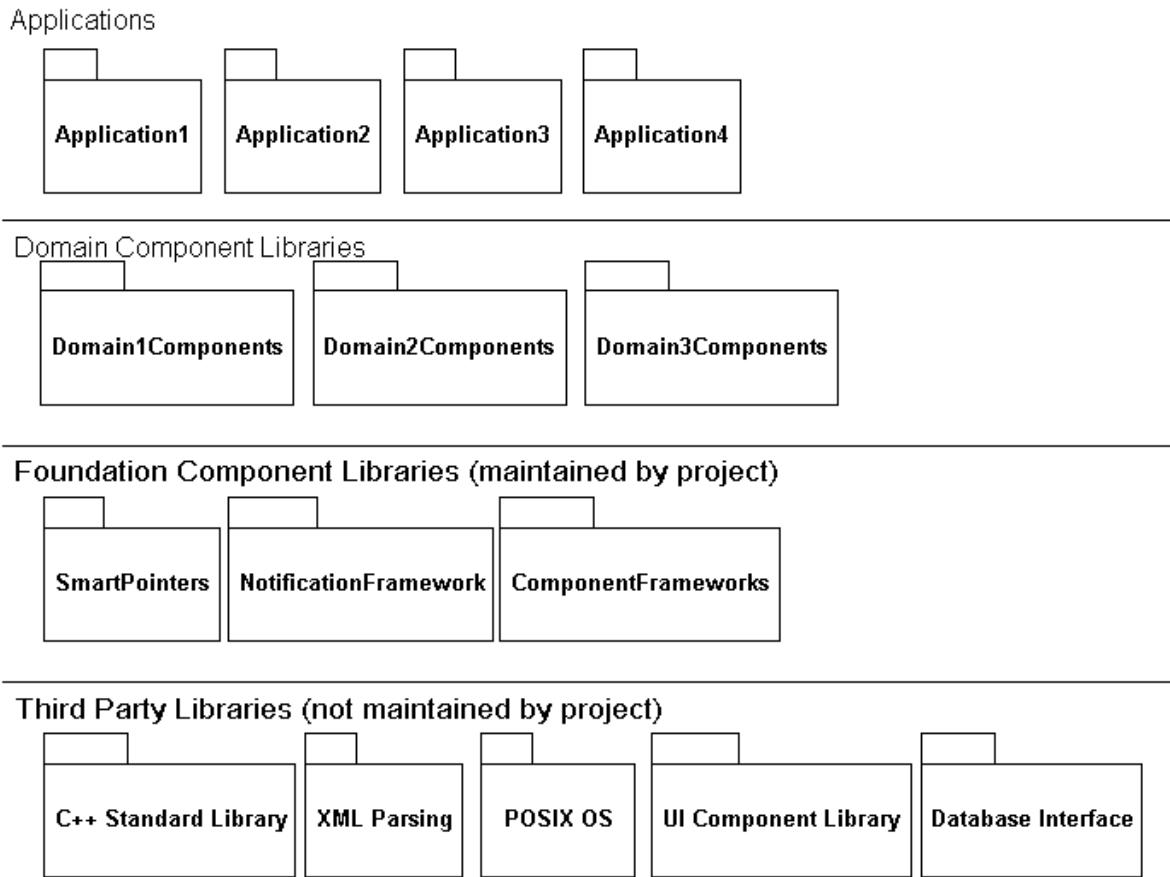


Figure 1: Layered Package Diagram

The example in Figure 1 does not represent the only possible set of layers. A system may have more or less layers and different logical relationships. The guiding principle, however, is that the upper layers should depend on the lower layers and not vice versa.

Supplementing the layered package diagram with dependency tables or other package level dependency mechanisms is valuable so that the details of individual packages can be explored as needed. The overview diagram can be used as a starting point for more detailed dependency exploration.

Extending for other Purposes

Architects are frequently asked to provide managers and others with auxiliary information about the system. The layered package diagram can provide a handy framework for communicating such information. For example, Figure 2 provides an example of the layered package diagram annotated to describe the languages used to implement various elements of the system. In addition, coloring is used to highlight packages that have deliveries as part of the first phase of development.

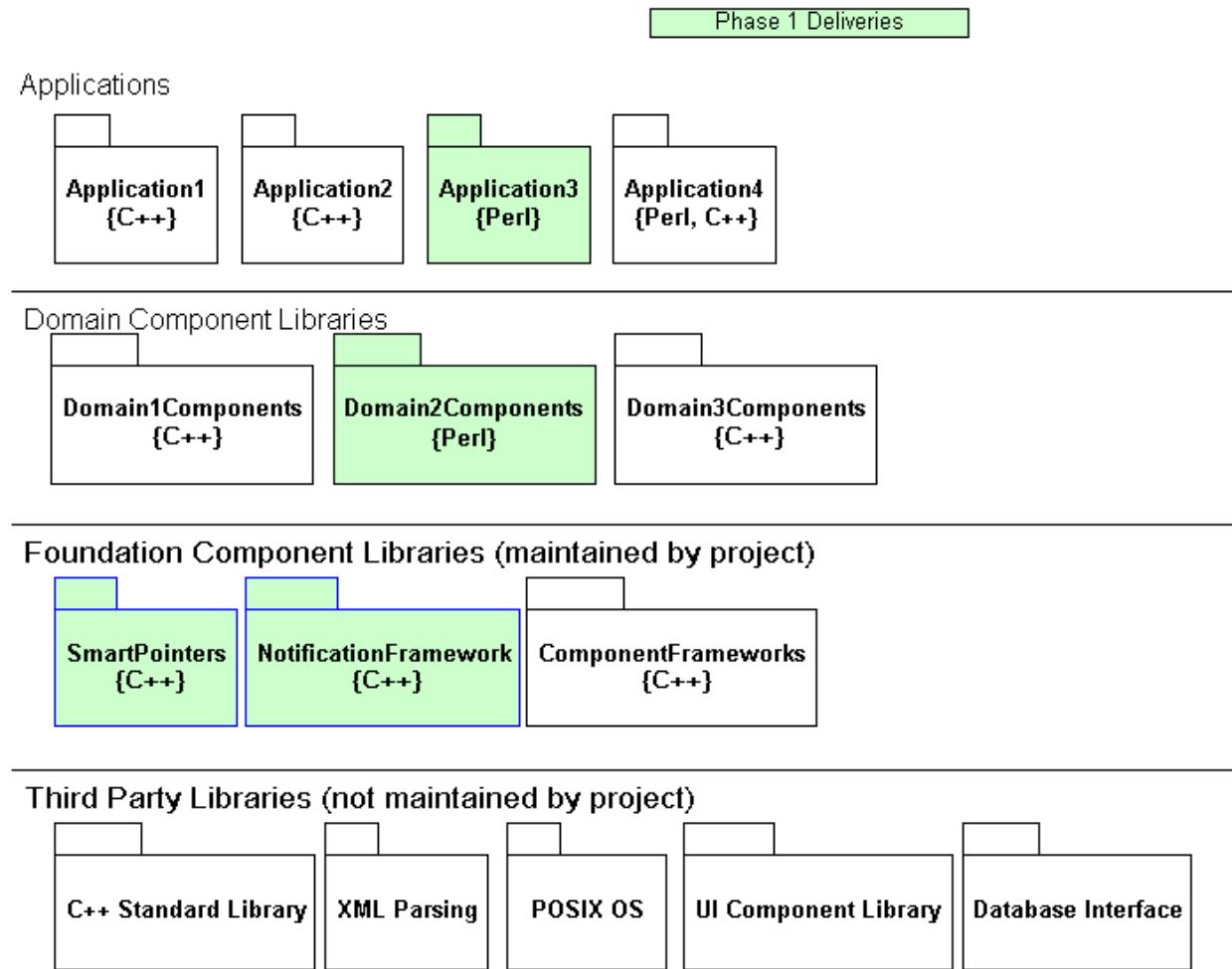


Figure 2: Layered Package Diagram with Language and Phasing Annotation

Advantages of the Layered Package Diagram

This diagram is useful for a number of reasons. First, it provides a high level view of a large system. Second, it provides an opportunity to see a view of many components and basic dependency structure without a maze of dependency arrows. From a development point of view, the expectation is that packages at the bottom of the diagram will have many dependent packages and hence instability in these packages can cripple development in higher layers. In addition, the lower layers serve as reusable assets that can be utilized for many types of software projects.

One of the primary advantages of the layered package diagram is that it can be used to communicate with different project stakeholders with differing degrees of technical understanding.

Issues with the Layered Package Diagram

One problem with this diagram is the possible interpretation of strict layering. Although it may seem to imply strict layering, that is not the intent. That is, it is possible that a package at the top of the diagram depends directly on the lowest level. In reality, each layer is simply another package. Figure 3 provides a UML diagram that shows the semantics of the previous layered view. Actually drawing the dependency structure in the bigger view is cumbersome and detracts from the goals of the view.

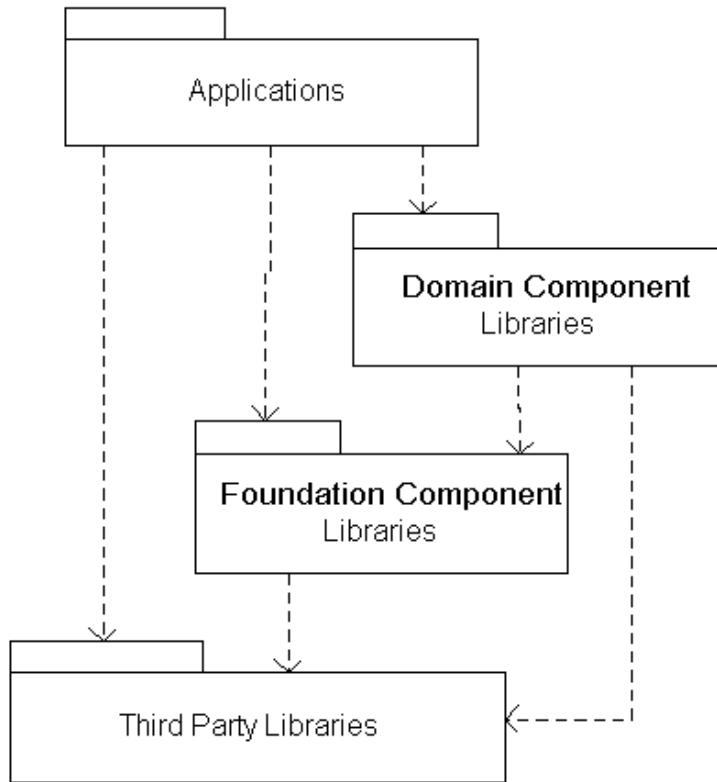


Figure 3: Dependency Semantics of Layered Package Diagram

One other problem with the diagram is the scalability of this diagram. Even with the simplifications provided, in massive systems with hundreds of packages other simplification approaches must be used. For example, several layered package diagrams may be required to represent the overview of various logical system domains or application groups. Each layered package diagram in this case only provides a partial snapshot of the system structure.

Communication by Omission

The layered package diagram gains scalability for large systems not by what it includes, but by what it represents implicitly. The biggest problem with large-scale systems is the number of elements and interconnections. Large numbers of components and interconnections easily overwhelm both creators and consumers of UML diagrams. The layered package diagram gains scalability because the location of a package on the

diagram implies the dependency semantics. This is very different from UML, which has explicit representation for all elements and relationships.

Conclusions

This paper introduces the layered package diagram as a central diagram for the representation of logical architecture in large-scale systems. This is just one of several views architectural views needed to effectively represent large-scale system architectures. The layered package diagram scales to larger systems by using positioning to describe dependencies semantics instead of explicit notation. In addition, the layered package diagram can be utilized to summarize different aspects by use of coloring or labeling.

References

- [1] P. Lago, P. Falcarin, "UML Requirements for Distributed Software Architectures". In Proc. of the 1st International Workshop on Describing Software Architecture with UML, (co-located with ICSE'2001), Toronto, Canada, May 2001.
- [2] C. Hofmeister, R. L. Nord, D. Soni, Describing Software Architecture with UML, Proceedings of the First Working IFIP Conference on Software Architecture., 1999 IFIP, Published by Kluwer Academic Publishers.
- [3] Kruchten, Philippe, "Modeling Component Systems with the Unified Modeling Language", A position paper presented at the International Workshop on Component-Based Software Engineering., 1998.
- [4] Booch, Grady, et. al., "The Unified Modeling Language User Guide", Addison-Wesley, 1997.
- [5] Fowler, Martin, et. al., UML Distilled, Second Edition, "Addison-Wesley, 2000.
- [6] Smith, Douglas, "Realizing Architecture through Realizing Use Cases", Proceedings of UML World 2000, Jun 12, 2000, pp. 1131-1165.

© CrystalClear Software 2001, All Rights Reserved

Last modified: Fri Aug 10 05:57:18 Eastern Daylight Time 2001