Bachelor's Thesis in Computer Science and Media

How does an Event Sourcing architecture compare to CRUD systems with an independent audit log, when it comes to scalability, performance and traceability?

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Ehrenwörtliche Erklärung

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here i use API

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2 Basics

2.1 WWW, Web APIs, REST

The World Wide Web (WWW) is a connected information network used to exchange data. Resources are can be accessed via Uniform Resource Identifiers (URIs) which are transferred using formats like JSON or HTML via protocols like HTTP. HTTP is a stateless protocol based on a request-response structure. It supports standardized request types, such as `GET` and `POST`, which convey a semantic meaning (Jacobs and Walsh 2004).

Web APIs are interfaces that enable applications to communicate. They use HTTP as a network-based API (Fielding 2000, p. 138). Modern APIs typically follow REST principles. REST stands for "Representational State Transfer" and describes an architectural style for distributed hypermedia systems (Fielding 2000, p. 76).

REST APIs adhere to principles derived from a set of constraints imposed by the HTTP protocol, for example. One such constraint is "stateless communication": Communication between clients and the server must be *stateless*, meaning the client must provide all the necessary information for the server to fully understand the request.

Furthermore, every resource in REST applications must be addressable via a unique ID, which can then be used to derive a URI to access the resource. Below are some examples for resources and URIs which could be derived from them:

- Book; ID=1; URI=`http://example.com/books/1`

- Book; ID=2; URI=`http://example.com/books/2`

- Author; ID=100; URI=`http://example.com/authors/100`

The "Hypermedia as the engine of application state (HATEOAS)" principle states that resources should be linked to each other. Clients should be able to control the application by following a series of links provided by the server (Tilkov 2007).

Every resource must support the same interface, usually HTTP methods (GET, POST, PUT, etc.) where operations on the resource correspond to one method of the interface. For example, a POST operation on a customer might map to the `createCustomer()` operation on a service.

Resources are decoupled from their representations. Clients can request different representations of a resource, depending on their needs (Tilkov 2007): a web browser might request HTML, while another server or application might request XML or JSON.

2.2 Layered Architecture Foundations

Layered Architecture is the most common architecture pattern in enterprise applications. Applications following a layered architecture are divided into *horizontal layers*, with each layer performing a specific role. A standard implementation consists of the following layers:

- Presentation: Handles requests and displays data in a user interface or by turning it into representations (e.g. JSON)

- Business: Encapsulates business logic

- Persistence: Persists data by interacting with the underlying persistence technologies (e.g. SQL databases)

- Database

A key concept in this design is layers of isolation, where layers are "closed", meaning a request must pass through the layer directly below it to reach the next, ensuring that changes in one layer do not affect others.

In a layered application, data flows downwards during request handling and upwards during the response: a request arrives in the presentation layer, which delegates to the business layer. The business layer fetches data from the persistence layer which holds logic to retrieve data, e.g. by encapsulating SQL statements.

The database responds with raw data, which is turned into a Data Access Object by the persistence layer. The business layer uses this data to execute rules and make decisions. The result will be returned to the presentation

layer which can then wrap the response and return it to the caller. (Richards 2015)

The data in layered applications is often times modeled in an *anemic* way. In an Anemic Domain Model, business entities are treated as only data. They are objects which contain no business logic, only getters and setters. Business logic is entirely contained in the business (or "service") layer. Fowler (2003) describes this as an object-oriented *antipattern*.

2.3   Domain Driven Design

Domain Driven Design (DDD) is a different architectural approach for applications. It differs from layered architecture primarily in the way the domain is modelled and the responsibilities of application services.

The core idea of DDD is that the primary focus of a software project should not be the underlying technologies, but the domain. The domain is the topic with which a software concerns itself. The software design should be based on a model that closely matches the domain and reflects a deep understanding of business requirements. (Evans 2004, pp. 8, 12)

This domain model is built from a *ubiquitous language* which is a language shared between domain experts and software experts. This ubiquitous language is built directly from the real domain and must be used in all communications regarding the software. (Evans 2004, pp. 24–26)

The software must always reflect the way that the domain is talked about. Changes to the domain and the ubiquitous language must result in an immediate change to the domain model.

When modeling the domain model, the aim should not be to create a perfect replica of the real world. While it should carefully be chosen, the domain model artificial and forms a selective abstraction which should be chosen for its utility. (Evans 2004, pp. 12, 13)

While Layered Architecture organizes code into technical tiers and is typically built on anemic domain models, often resulting in the *big ball of mud* antipattern (Richards 2015, p. V), DDD demands a Rich Domain Model where objects incorporate both data and the behavior or rules that govern that data. The code is structured semantically into bounded context and modules which are chosen to tell the "story" of a system rather than its technicalities. (Evans 2004, p. 80)

Entities (also known as reference objects) are domain elements fundamentally defined by a thread of continuity and identity rather than their specific attributes. Entities must be distinguishable from other entities, even if they share the same characteristics. To ensure consistency and identity, a unique

identifier is assigned to entities. This identifier is immutable throughout the object's life. (Evans 2004, pp. 65–69)

Value Objects are elements that describe the nature or state of something and have no conceptual identity of their own. They are interesting only for their characteristics. While two entities with the same characteristics are considered as different from each other, the system does not care about "identity" of a value object, since only its characteristics are relevant. Value objects should be used to encapsulate concepts, such as using an "Address" object instead of distinct "Street" and "City" attributes. Value objects should be immutable. They are never modified, instead they are replaced entirely when a new value is required. (Evans 2004, pp. 70–72)

Using a Rich Domain Model does not mean that there should be no layers, the opposite is the case. Evans (2004) advocates for using layers in domain driven designs. He proposes the following layers: (Evans 2004, p. 53)

- Presentation: Presents information and handles commands

- Application Layer: Coordinates app activity. Does not hold business logic, but delegate tasks and hold information about their progress

- Domain Layer: Holds information about the domain. Stateful objects (rich domain model) that hold business logic and rules

- Infrastructure layer: Supports other layers. Handles concerns like communication and persistence

Evans (2004, p. 75) points out that in some cases, operations in the domain can not be mapped to one object. For example, transferring money does conceptually not belong to one bank account. In those cases, where operations are important domain concepts, domain services can be introduced as part of model-driven design. To keep the domain model rich and not fall back into procedural style programming like with Anemic Domain Model, it is important to use services only when necessary. Services are not allowed to strip the entities and value objects in the domain of behavior. According to Evans, a good domain service has the following characteristics:

- The operation relates to a domain concept which would be misplaced on an entity or a value object

- The operation performed refers to other objects in the domain

- The operation is stateless

3   Related Work

4   Proposed Method

5   Implementation

6   Results

7   Discussion

Finally, I'm done.

Glossary

Anemic Domain Model The objects describing the domain only hold data, no logic. 5, 6

API API stands for *Application Programming Interface*. It describes the public interface of a module or service, often exposed over a network. 3

DAO Data Access Object. 4

DDD Domain Driven Design. 5

HATEOAS Hypermedia as the engine of application state. 4

HTML HyperText Markup Language. 4

HTTP HTTP stands for *Hypertext Transfer Protocol*. It is a protocol used in internet communication and was defined in RFC 2616 (*RFC 2616: HTTP/1.1* 2025). 3

JSON JavaScript Object Notation. 4

REST REST stands for *Representational State Transfer*. It is an architectural style for distributed hypermedia systems. 3

Rich Domain Model Objects incorporate both data and the behavior or rules that govern that data. 5, 6

URI Uniform Resource Identifier. 3

WWW World Wide Web. 3

XML Extensible Markup Language. 4

References

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