Pro JPA 2 in Java EE 8

An In-Depth Guide to Java Persistence APIs

—

Third Edition

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Mike Keith
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Apress®

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To my wife Darleen, the perfect mother, and to Cierra, Ariana, Jeremy, and Emma, who brighten my life and make me strive to be a better person.

—Mike

To Anthony, whose boundless creativity continues to inspire me. To Evan, whose boisterous enthusiasm motivates me to take on new challenges. To Kate, who proves that size is no object when you have the right attitude. I love you all.

—Merrick

I would like to dedicate this book to the memory of my beloved late mother Maria Augusta Ciniglio. Thanks mom for all the great things you taught me, for making me a good person, for making me study to become a computing scientist, and for the great memories you left me. You will be loved and missed forever. I love you mom. RIP.

—Massimo

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Mike Keith was the co-specification lead for JPA 1.0 and a member of the JPA 2.0 and JPA 2.1 expert groups. He sits on a number of other Java Community Process expert groups and the Enterprise Expert Group (EEG) in the OSGi Alliance. He holds a Master's degree in Computer Science from Carleton University, and has over 20 years experience in persistence and distributed systems research and practice. He has written papers and articles on JPA and spoken at numerous conferences around the world. He is employed as an architect at Oracle in Ottawa, Canada, and is married with four kids and two dogs.

Merrick Schincariol is a consulting engineer at Oracle, specializing in middleware technologies. He has a Bachelor of Science degree in Computer Science from Lakehead University, and has more than a decade of experience in enterprise software development. He spent some time consulting in the pre-Java enterprise and business intelligence fields before moving on to write Java and J2EE applications. His experience with large-scale systems and data warehouse design gave him a mature and practiced perspective on enterprise software, which later propelled him into doing Java EE container implementation work.

Massimo Nardone has more than 24 years of experience in Security, Web/mobile development, cloud, and IT architecture. His true IT passions are security and Android.

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Finally I want to thank Mario Faliero, a good friend and the technical reviewer of this book, for helping me make a better book.

CHAPTER 1

Introduction

Enterprise applications are defined by their need to collect, process, transform, and report on vast amounts of information. And, of course, that information has to be kept somewhere. Storing and retrieving data is a multibillion dollar business, evidenced in part by the growth of the database market as well as the emergence of cloud-based storage services. Despite all the available technologies for data management, application designers still spend much of their time trying to efficiently move their data to and from storage.

Despite the success the Java platform has had in working with database systems, for a long time it suffered from the same problem that has plagued other object-oriented programming languages. Moving data back and forth between a database system and the object model of a Java application was a lot harder than it needed to be. Java developers either wrote lots of code to convert row and column data into objects, or found themselves tied to proprietary frameworks that tried to hide the database from them. Fortunately, a standard solution, the Java Persistence API (JPA), was introduced into the platform to bridge the gap between object-oriented domain models and relational database systems.

This book introduces version 2.2 of the Java Persistence API as part of the Java EE 8 and explores everything that it has to offer developers.

Maintenance release of JPA 2.2 started during 2017 under JSR 338 and was finally approved on June 19, 2017.

Here is the official Java Persistence 2.2 Maintenance release statement:

"The Java Persistence 2.2 specification enhances the Java Persistence API with support for repeating annotations; injection into attribute converters; support for mapping of the `java.time.LocalDate`, `java.time.LocalTime`, `java.time.LocalDateTime`, `java.time.OffsetTime`, and `java.time.OffsetDateTime` types; and methods to retrieve the results of `Query` and `TypedQuery` as streams."

[1] **Electronic supplementary material** The online version of this chapter (https://doi.org/10.1007/978-1-4842-3420-4_1) contains supplementary material, which is available to authorized users.

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One of its strengths is that it can be slotted into whichever layer, tier, or framework an application needs it to be in. Whether you are building client-server applications to collect form data in a Swing application or building a website using the latest application framework, JPA can help you provide persistence more effectively.

To set the stage for JPA, this chapter first takes a step back to show where we've been and what problems we are trying to solve. From there, we will look at the history of the specification and give you a high-level view of what it has to offer.

Relational Databases

Many ways of persisting data have come and gone over the years, and no concept has more staying power than the relational database. Even in the age of the cloud, when "Big Data" and "NoSQL" regularly steal the headlines, relational database services are in consistent demand to enable today's enterprise applications running in the cloud. While key-value and document-oriented NoSQL stores have their place, relational stores remain the most popular general-purpose databases in existence, and they are where the vast majority of the world's corporate data is stored. They are the starting point for every enterprise application and often have a lifespan that continues long after the application has faded away.

Understanding relational data is key to successful enterprise development. Developing applications to work well with database systems is a commonly acknowledged hurdle of software development. A good deal of Java's success can be attributed to its widespread adoption for building enterprise database systems. From consumer websites to automated gateways, Java applications are at the heart of enterprise application development. Figure 1-1 shows an example of a relational database of user to car.

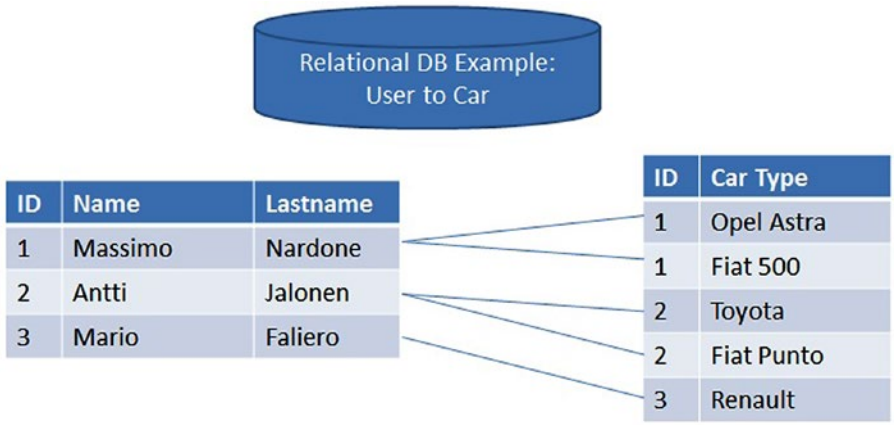

Figure 1-1. *User to car relational database*

Object-Relational Mapping

"The domain model has a class. The database has a table. They look pretty similar. It should be simple to convert one to the other automatically." This is a thought we've probably all had at one point or another while writing yet another Data Access Object (DAO) to convert Java Database Connectivity (JDBC) result sets into something object-oriented. The domain model looks similar enough to the relational model of the database that it seems to cry out for a way to make the two models talk to each other.

The technique of bridging the gap between the object model and the relational model is known as object-relational mapping, often referred to as O-R mapping or simply ORM. The term comes from the idea that we are in some way mapping the concepts from one model onto another, with the goal of introducing a mediator to manage the automatic transformation of one to the other.

Before going into the specifics of object-relational mapping, let's define a brief manifesto of what the ideal solution should be.

- *Objects, not tables*: Applications should be written in terms of the domain model, not bound to the relational model. It must be possible to operate on and query against the domain model without having to express it in the relational language of tables, columns, and foreign keys.
- *Convenience, not ignorance*: Mapping tools should be used only by someone familiar with relational technology. O-R mapping is not meant to save developers from understanding mapping problems or to hide them altogether. It is meant for those who have an understanding of the issues and know what they need, but who don't want to have to write thousands of lines of code to deal with a problem that has already been solved.
- *Unobtrusive, not transparent*: It is unreasonable to expect that persistence be transparent because an application always needs to have control of the objects that it is persisting and be aware of the entity lifecycle. The persistence solution should not intrude on the domain model, however, and domain classes must not be required to extend classes or implement interfaces in order to be persistable.

- *Legacy data, new objects*: It is far more likely that an application will target an existing relational database schema than create a new one. Support for legacy schemas is one of the most relevant use cases that will arise, and it is quite possible that such databases will outlive every one of us.
- *Enough, but not too much*: Enterprise developers have problems to solve, and they need features sufficient to solve those problems. What they don't like is being forced to eat a heavyweight persistence model that introduces large overhead because it is solving problems that many do not even agree *are* problems.
- *Local, but mobile*: A persistent representation of data does not need to be modeled as a full-fledged remote object. Distribution is something that exists as part of the application, not part of the persistence layer. The entities that contain the persistent state, however, must be able to travel to whichever layer needs them so that if an application is distributed, then the entities will support and not inhibit a particular architecture.
- *Standard API, with pluggable implementations*: Large companies with sizable applications don't want to risk being coupled to product-specific libraries and interfaces. By depending only on defined standard interfaces, the application is decoupled from proprietary APIs and can switch implementations if another becomes more suitable.

This would appear to be a somewhat demanding set of requirements, but it is one born of both practical experience and necessity. Enterprise applications have very specific persistence needs, and this shopping list of items is a fairly specific representation of the experience of the enterprise community.

The Impedance Mismatch

Advocates of object-relational mapping often describe the difference between the object model and the relational model as the impedance mismatch between the two. This is an apt description because the challenge of mapping one to the other lies not in the similarities between the two, but in the concepts in each for which there is no logical equivalent in the other.

In the following sections, we present some basic object-oriented domain models and a variety of relational models to persist the same set of data. As you will see, the challenge in object-relational mapping is not so much the complexity of a single mapping but that there are so many possible mappings. The goal is not to explain how to get from one point to the other, but to understand the roads that may have to be taken to arrive at an intended destination.

Class Representation

Let's begin this discussion with a simple class. Figure 1-2 shows an `Employee` class with four attributes: employee ID, employee name, start date, and current salary.

Figure 1-2. *The Employee class*

Now consider the relational model shown in Figure 1-3. The ideal representation of this class in the database corresponds to scenario (A). Each field in the class maps directly to a column in the table. The employee ID becomes the primary key. With the exception of some slight naming differences, this is a straightforward mapping.

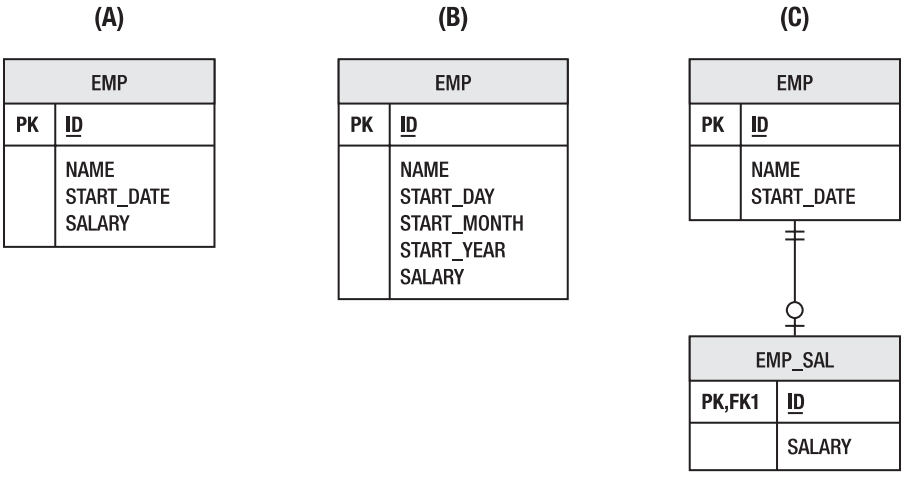

Figure 1-3. *Three scenarios for storing employee data*

In scenario (B), we see that the start date of the employee is actually stored as three separate columns, one each for the day, month, and year. Recall that the class used a `Date` object to represent this value. Because database schemas are much harder to change, should the class be forced to adopt the same storage strategy in order to remain consistent with the relational model? Also consider the inverse of the problem, in which the class had used three fields, and the table used a single date column. Even a single field becomes complex to map when the database and object model differ in representation.

Salary information is considered commercially sensitive, so it may be unwise to place the salary value directly in the `EMP` table, which may be used for a number of purposes. In scenario (C), the `EMP` table has been split so that the salary information is stored in a separate `EMP_SAL` table. This allows the database administrator to restrict `SELECT` access on salary information to those users who genuinely require it. With such a mapping, even a single store operation for the `Employee` class now requires inserts or updates to two different tables.

Clearly, even storing the data from a single class in a database can be a challenging exercise. We concern ourselves with these scenarios because real database schemas in production systems were never designed with object models in mind. The rule of thumb in enterprise applications is that the needs of the database trump the wants of the application. In fact, there are usually many applications, some object-oriented and some based on Structured Query Language (SQL), that retrieve from and store data into a single database. The dependency of multiple applications on the same database means that changing the database would affect every one of the applications, clearly an undesirable and potentially expensive option. It's up to the object model to adapt and find ways to work with the database schema without letting the physical design overpower the logical application model.

Relationships

Objects rarely exist in isolation. Just like relationships in a database, domain classes depend on and associate themselves with other domain classes. Consider the `Employee` class introduced in Figure 1-2. There are many domain concepts that could be associated with an employee, but for now let's introduce the `Address` domain class, for which an `Employee` may have at most one instance. We say in this case that `Employee` has a one-to-one relationship with `Address`, represented in the Unified Modeling Language (UML) model by the `0..1` notation. Figure 1-4 demonstrates this relationship.

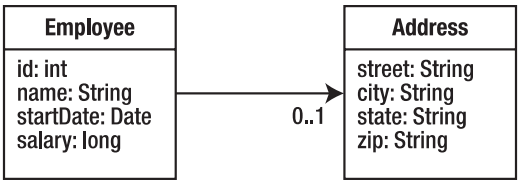

Figure 1-4. *The Employee and Address relationship*

We discussed different scenarios for representing the `Employee` state in the previous section, and likewise there are several approaches to representing a relationship in a database schema. Figure 1-5 demonstrates three different scenarios for a one-to-one relationship between an employee and an address.

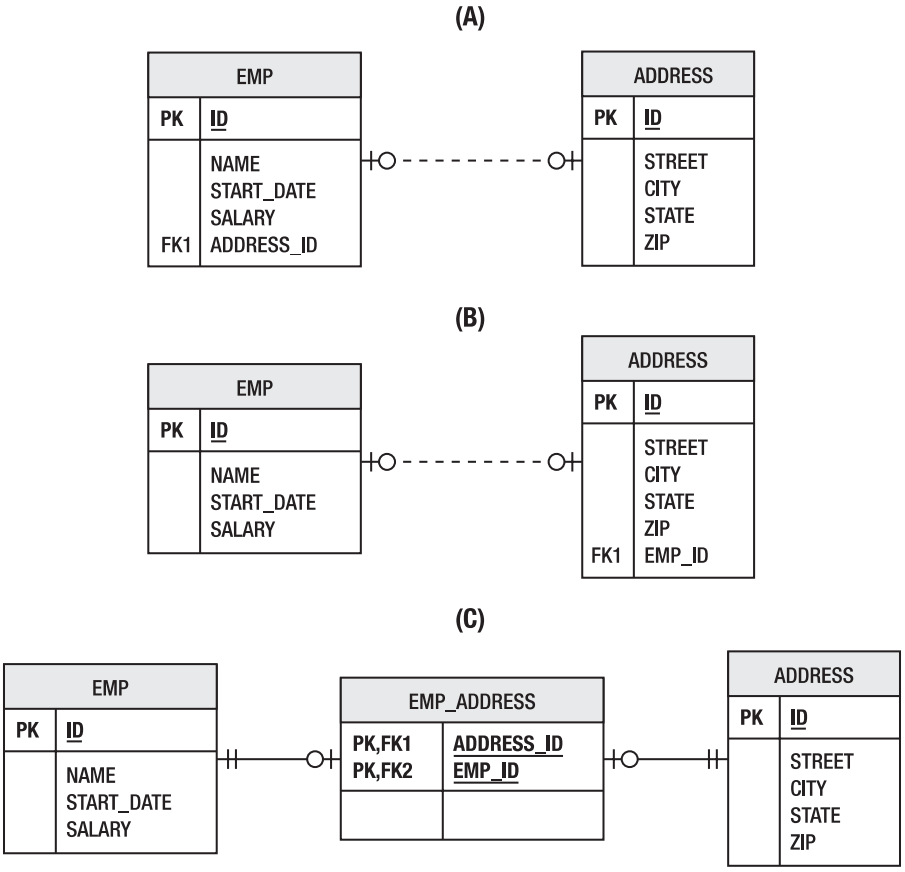

Figure 1-5. *Three scenarios for relating employee and address data*

The building block for relationships in the database is the foreign key. Each scenario involves foreign key relationships between the various tables, but in order for there to be a foreign key relationship, the target table must have a primary key. And so before we even get to associate employees and addresses with each other we have a problem. The domain class `Address` does not have an identifier, yet the table that it would be stored in must have one if it is to be part of relationships. We could construct a primary key out of all of the columns in the `ADDRESS` table, but this is considered bad practice. Therefore, the `ID` column is introduced, and the object relational mapping will have to adapt in some way.

Scenario (A) of Figure 1-5 shows the ideal mapping of this relationship. The `EMP` table has a foreign key to the `ADDRESS` table stored in the `ADDRESS_ID` column. If the `Employee` class holds onto an instance of the `Address` class, the primary key value for the address can be set during store operations when an `EMPLOYEE` row gets written.

And yet consider scenario (B), which is only slightly different yet suddenly much more complex. In the domain model, an `Address` instance did not hold onto the `Employee` instance that owned it, and yet the employee primary key must be stored in the `ADDRESS` table. The object-relational mapping must either account for this mismatch between domain class and table or a reference back to the employee will have to be added for every address.

To make matters worse, scenario (C) introduces a join table to relate the `EMP` and `ADDRESS` tables. Instead of storing the foreign keys directly in one of the domain tables, the join table holds onto the pair of keys. Every database operation involving the two tables must now traverse the join table and keep it consistent. We could introduce an `EmployeeAddress` association class into the domain model to compensate, but that defeats the logical representation we are trying to achieve.

Relationships present a challenge in any object-relational mapping solution. This introduction covered only one-to-one relationships, and yet we have been faced with the need for primary keys not in the object model and the possibility of having to introduce extra relationships into the model or even associate classes to compensate for the database schema.

Inheritance

A defining element of an object-oriented domain model is the opportunity to introduce generalized relationships between like classes. Inheritance is the natural way to express these relationships and allows for polymorphism in the application. Let's revisit the `Employee` class shown in Figure 1-2 and imagine a company that needs to distinguish between full-time and part-time employees. Part-time employees work for an hourly rate, while full-time employees are assigned a salary. This is a good opportunity for inheritance, moving wage information to the `PartTimeEmployee` and `FullTimeEmployee` subclasses. Figure 1-6 shows this arrangement.

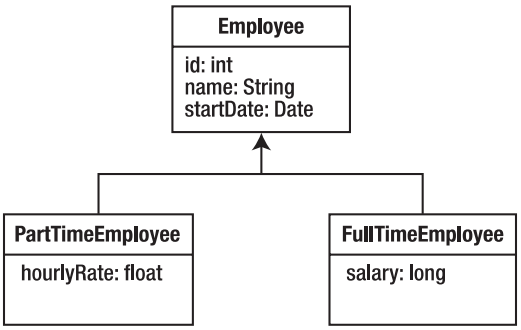

Figure 1-6. *Inheritance relationships between full-time and part-time employees*

Inheritance presents a genuine problem for object-relational mapping. We are no longer dealing with a situation in which there is a natural mapping from a class to a table. Consider the relational models shown in Figure 1-7. Once again, three different strategies for persisting the same set of data are demonstrated.

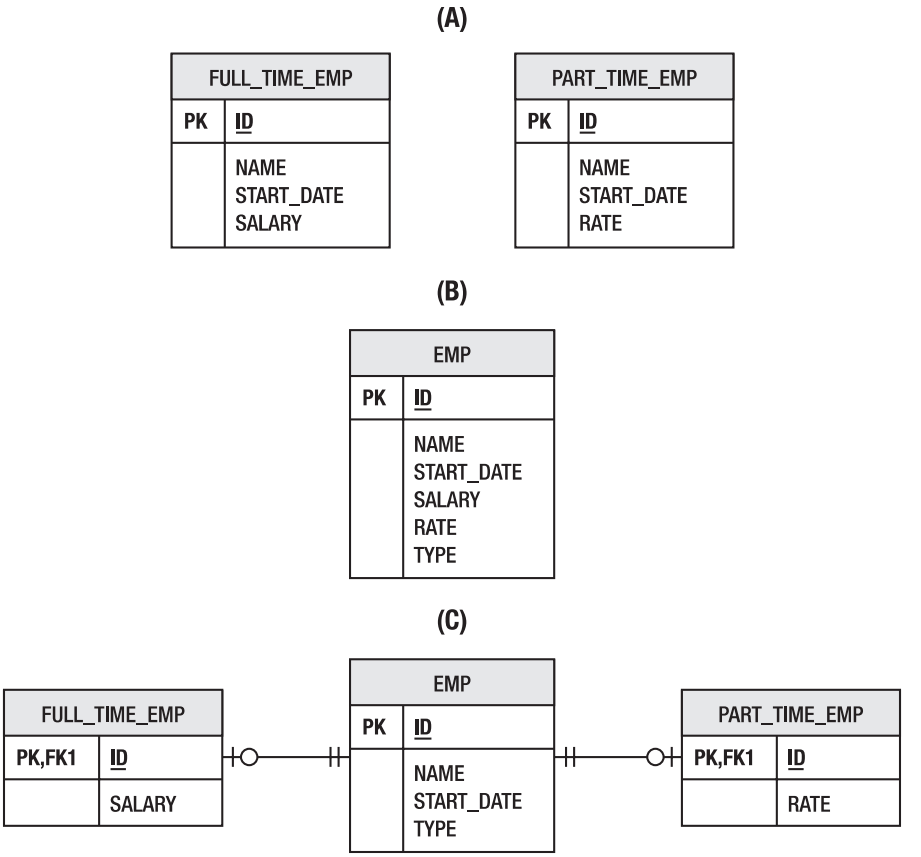

Figure 1-7. *Inheritance strategies in a relational model*

Arguably the easiest solution for someone mapping an inheritance structure to a database would be to put all of the data necessary for each class (including parent classes) into separate tables. This strategy is demonstrated by scenario (A) in Figure 1-7. Note that there is no relationship between the tables (i.e., each table is independent of the others). This means that queries against these tables are now much more complicated if the user needs to operate on both full-time and part-time employees in a single step.

An efficient but denormalized alternative is to place all the data required for every class in the model in a single table. That makes it very easy to query, but note the structure of the table shown in scenario (B) of Figure 1-7. There is a new column, `TYPE`, which does not exist in any part of the domain model. The `TYPE` column indicates whether the employee is part-time or full-time. This information must now be interpreted by an object-relational mapping solution to know what kind of domain class to instantiate for any given row in the table.