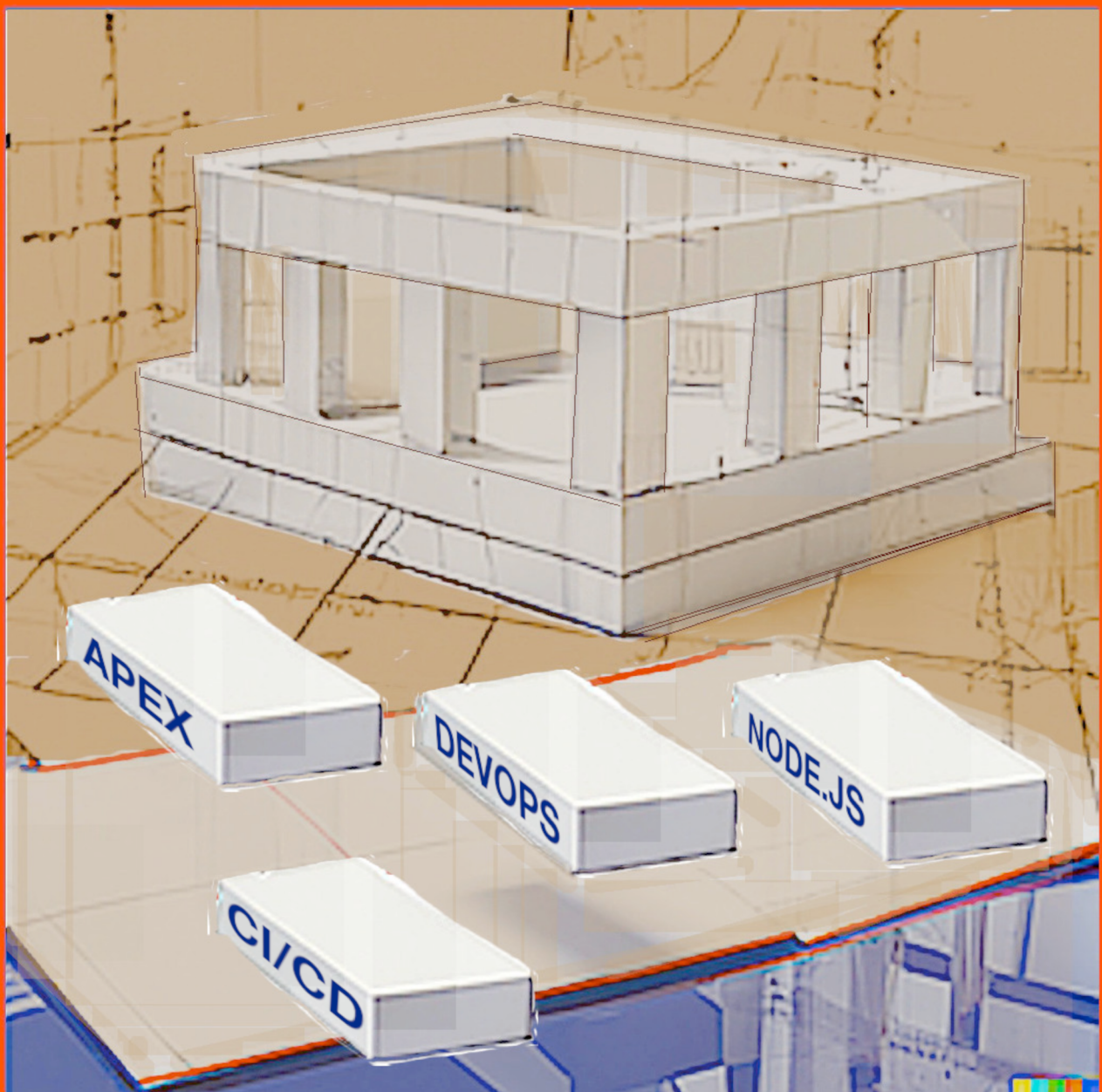


# How to Build an Oracle Database Application

*Quick but not Dirty*

by Gert-Jan Paulissen



# How to build an Oracle database application

Quick but not dirty; with or without a front-end built with Oracle APEX or a Node.js framework like React, Angular or Vue.

Gert-Jan Paulissen

This book is for sale at <http://leanpub.com/build-oracle-apex-application>

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# Foreword

The Oracle Database is so much more than only a database. It is a powerful platform for data centric applications – and not just a SQL compliant data store that many believe it to be. Gert-Jan recognized this early on and fully embraced that platform to make the most of it. To not just develop code but to build great applications. In larger teams, with complex functionality, a sizable data model and meant to run and evolve for many years.

Gert-Jan may have had his focus on Oracle Database and the technologies in and around that platform, but he kept close track of what happened outside this field. He spotted, explored and adopted & adapted concepts, ways of working and even tooling from the open source community and other technology stacks. Software engineering topics traditionally somewhat overlooked by Oracle Database developers are “his thing”. Logging, version control, debugging, automated build, testing, code quality, error handling, deployment: essential elements of professional software Dev and Ops – on top of a sound application architecture.

In this book, Gert-Jan shares a piece of his mind, both in the literal sense as well as a little bit in the way the expression is commonly understood. He tells us about his believes, about how all things Oracle should be done. And he explains how he came to that believe, sharing experiences from a 25+ year career of constantly improving his ways of building Oracle Database applications. His believes are strong and he is not afraid to be bold.

I have worked with Gert-Jan on several occasions. I have been impressed with his perseverance, his independence of mind and creativity and ability to think outside the box. He is diligent in making things work and in sharing his findings – as he does in this book. The many real life experiences he describes provide a nice background to better appreciate the recommendations he shares. I am sure you will get plenty of inspiration and new insights from Gert-Jan's writing. You will perhaps realize challenges you did not even know you had – and approaches for dealing with those challenges.

At times, the book feels almost like a conversation between reader and author. Like a tour guide, Gert-Jan points out relevant sights, provides some background and personal experiences. And on reading this book, I frequently felt the need to enter into a dialog with my personal guide. To get things clarified, to take the discussion even further and sometimes to offer an alternative solution and together arrive at the ultimate way of working. The book is a constant invitation to reassess your thinking and ways of working. That makes it quite valuable.

Congratulations Gert-Jan on this milestone. Thank you for putting your thoughts into writing and helping all of us become better Oracle application builders. Dear reader: I hope and expect you will find inspiration and insights that help you in your professional journey.

Lucas Jellema

# Preface

## Why this book and why now?

In February 2021 a former manager of mine complimented me on LinkedIn for my Blog about Oracle APEX and translations. His message was that it is good to share knowledge, just as he was doing himself. And yeah, I whole-heartedly agree. And when my now ex-boss wanted me to write about how I build Oracle database applications from the beginning till the end, I thought let's Blog about it before I leave the company. The funny thing is that I was introduced to my ex-boss by another former manager that shares the same first name. Thanks Harm I and II, for your gentle words and support throughout my career. Thank you ex-boss for pushing me to write a Blog about "How to build an Oracle database application". And after starting my own company I thought that a book might even be more appropriate, given the feedback I got.

So I wrote some articles on LinkedIn which were read by a former colleague, Peter de Vaal, He wanted to write a book about the Oracle database in modern IT architectures and about DevOps too. We decided to join forces but to split the work: he would focus on the database architecture and new features and I would work out the DevOps part. The two books together will give you a jump start in developing and deploying well-designed Oracle applications.

Even at an early stage in my career I invented solutions for not installing applications manually. Sometimes the boss/manager/team did not see the value added right away but after some time they got convinced, well almost all of them. In the Oracle Designer era, I repeated this while working on an assignment for the ING bank in Amsterdam. And in 2015 when I was working for pension fund MN in The Hague, The Netherlands, I joined the Continuous Integration team and started to assemble the ideas I am going to present to you here.

This book should enable you to build a serious Oracle database application. And you can always contact or hire me if you need more help.

## Who is this book for?

This book is meant for back-end and front-end developers alike who'd like to build their Oracle database applications better. They will learn which tools to use and how, how to collaborate in a team and how to deploy. And above all how to reduce the number of manual tasks by automating as much as possible.

It is also meant for non-developers like (project) managers, Scrum masters, QA engineers, testers and so on. They will learn how an Oracle database application should be built, how a development team and process should be constructed, how a team can develop in parallel and how tests can be written and executed before deploying everything automatically.

## How to read this book?

The first part, Designing the build plan, describes the essential ingredients of a build plan at a high level. As such it will be interesting for all readers.

The second part, Implementing the build plan, focuses on the details of the tools and techniques presented. It will probably be most interesting for developers.

The third part, Testing the build plan, applies the approach presented to existing Oracle APEX applications. It serves to validate that approach and will result in a software project that can be deployed into the Cloud. I think it will interest all readers.

## Typographic conventions

Links to pertinent resources and web sites are added inline, like the following link to [Maven](https://maven.apache.org/)<sup>1</sup>, and can be viewed directly by clicking on them in eBook formats, or by following the URL in the footnotes.

I will use `Constant width` for filenames, file extensions, executables, environment variables, UI items like buttons or menu options, code samples and commands either inline (for example: `mvn help:help [command]`), or in a code block (with or without line numbers) like:

```
$ mvn help:help
```

The dollar sign (\$) above means that a command is run under your normal, non-root user account.

Sometimes, asides are added to highlight further information about a specific topic:



Informational asides provide extra information.



Warning asides warn about common pitfalls and how to avoid them.



Tip asides give tips for deepening your understanding or optimizing your use of the information presented.

---

<sup>1</sup><https://maven.apache.org/>

## Please help improve this book!

New revisions of this book are published on a regular basis. If you think a particular section needs improvement, please post an issue in the [PATO issue queue](https://github.com/paulissoft/oracle-tools/issues)<sup>2</sup> or contact me via Twitter [@gpaulissen](https://twitter.com/gpaulissen)<sup>3</sup>.

## About the author

Gert-Jan Paulissen has been working as a developer since he graduated from university (Eindhoven, the Netherlands) in 1989. In 1996 he started to work with Oracle for various Dutch companies. In 2017 he moved to France where he joined Capgemini Sogeti France as a senior test automation engineer and in 2019 he was hired as an Oracle expert by a software company from Paris. In 2021 he started his own company, Paulissoft. Besides programming Gert-Jan has another passion: playing the card game bridge.

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<sup>2</sup><https://github.com/paulissoft/oracle-tools/issues>

<sup>3</sup><https://twitter.com/gpaulissen>

# I Designing the build plan

This content is not available in the sample book. The book can be purchased on Leanpub at <http://leanpub.com/build-oracle-apex-application>.

# 1. Introduction

## 1.1 What's in a name?

A title is important and I hope that it describes well what I want to share with you in this book. It is not so much about how to use the back-end part (Oracle database) with or without a front-end built with Oracle APEX or Node.js frameworks like React, Angular or Vue. It is much more about the tools, techniques and best practices around them in order to build, deploy and maintain an Oracle database application efficiently and correctly.

I have used the word **build** on purpose and not something like develop because I see an analogy with building a house. You don't build a house by just buying parts like a door and some tools. No, you need a **plan**, an **architecture** if you prefer. And how often I see people beginning with creating a table, a GUI screen and then they think they are doing well. Maybe their boss/client is happy because s/he sees something visible but in my opinion they just started without a plan. You just **DON'T** start with a door and some tools when you need to build a house, so do not make the same **mistake** when you build an Oracle application.

And there are other build analogies:

- the tool [Ant](https://ant.apache.org/)<sup>1</sup> needs a **build** file to execute tasks;
- the Unix programs are usually installed after they are being **built** from source.

## 1.2 Philosophy

I believe very much in the Unix approach of handling tasks. In Unix there are a lot of simple tools that each on their own perform their task very well. I like that approach so much because it enables you to use the same tools over and over again. A win-win for you and your boss or client. Of course you may decide to replace a tool but the idea is clear. And to be honest I do not like to learn another methodology or tool every year. I advance but not too fast and not too slow either. I assume that you do not rebuild your house every time there are new techniques available.

An example of this Unix approach is deploying your Oracle application software. I use [Flyway](https://flywaydb.org/documentation/getstarted/why)<sup>2</sup> because that is a tool based on a simple idea: it executes database migration scripts automatically and stores the result of the execution in a history table so Flyway knows what has been installed in order to determine what to install the next time. It is even not necessary to install version N+1 first if the latest version installed was N, you can immediately continue with N+2 (or N+3 or ...). Simple and predictable, so I see no reason to use another tool. I hope this convinces you to **never** again execute database migration scripts **manually**. Of course I

---

<sup>1</sup><https://ant.apache.org/>

<sup>2</sup><https://flywaydb.org/documentation/getstarted/why>



have looked at the Supporting Objects feature of APEX but I think it is only suitable for (demo) applications with a small number of database objects that do not change. As soon as you build a real application you will create a lot more database objects like packages and views and it becomes too difficult to use APEX Supporting Objects, at least that is my opinion. And do not forget that APEX is just a front-end so if you decide to replace it with another front-end you also have to find another tool to run the migration scripts. So embrace the Unix philosophy and use Flyway to run database migration scripts.

Another important point is to use the power of the Oracle Database. It is an expensive product but very powerful so use it thoroughly and get used to it. Take lessons, follow courses, read books, read Blogs but **invest** in it. It will really help you to build better.



A site that I can really recommend is the [Oracle Dev Gym](#)<sup>3</sup> where you can take quizzes and classes on Oracle technology: PL/SQL, SQL, Java, modeling and so on. The site has been created by Steven Feuerstein and his team.

As you can imagine I also believe in DRY, an acronym of Don't Repeat Yourself or in other words do **not** COPY+PASTE. Another thing I can advise you is "Doing things right the first time". This quote is from Philip Bayard Crosby in 1926. In other words take your time to do it right the first time so you won't need a second time (which you normally do not get anyway). Another acronym I really like is KISS or Keep It Simple Stupid.

The last point is that we should be very vigilant regarding security, so just apply all the best practices there are.

## 1.3 Standing on the shoulders of giants

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If I have seen further it is by standing on the shoulders of Giants.  
–Isaac Newton in 1675

---

I have to mention Oracle gurus like Tom Kyte and Steven Feuerstein but I should surely mention a fellow Dutchman, Rob van Wijk, who has written Blogs about [implementing business rules](#)<sup>4</sup> in 2008 and [Professional Software Development using Oracle Application Express](#)<sup>5</sup> in 2013. We are living in 2021 now and things have advanced but I have used his ideas to lay the foundation.

In this book I will refer to quite a lot of material written by other people. I do think that it is important to mention the work of others so you can verify yourself but also to show that I was happy to have learned from them. It won't surprise you that I embrace Open-source.

---

<sup>3</sup><https://devgym.oracle.com/pls/apex/f?p=10001:20011:::20011::>

<sup>4</sup><http://rwijk.blogspot.nl/2008/07/implementing-business-rules.html>

<sup>5</sup><http://www.rwijk.nl/AboutOracle/psdua.pdf>

## 1.4 Tools, techniques and best practices

### Oracle Database and Oracle APEX

I have used [Virtualbox](https://www.virtualbox.org/)<sup>6</sup> and the prebuilt virtual machine [Database App Development VM](https://www.oracle.com/downloads/developer-vm/community-downloads.html)<sup>7</sup> from Oracle for my development environment. I strongly believe in having a separate database for each developer while developing. I do not want to interfere with others and I do not want others to interfere with me while I work. At a later stage you can always use an integration or test database to see if everything works well together.



Since Oracle 12c with its introduction of the multi-tenant architecture, it is possible to create a pluggable database per developer and keep it in sync with another reference database. See also [Multitenant : Overview of Container Databases \(CDB\) and Pluggable Databases \(PDB\)](https://oracle-base.com/articles/12c/multitenant-overview-container-database-cdb-12cr1)<sup>8</sup>.

### Oracle SQL Developer Data Modeler

Maybe less well known than its big brother Oracle SQL Developer but a tool that allows you to build a great model (plan) of your database application. You can use various modeling techniques like Entity Relationship Modeling and a lot, lot more. It even allows you to create database scripts or migration scripts that you may use in Flyway.

A book I can recommend is [Oracle SQL Developer Data Modeler for Database Design Mastery](https://www.goodreads.com/book/show/23871562-oracle-sql-developer-data-modeler-for-database-design-mastery)<sup>9</sup> by [Heli Helskyaho](https://helifromfinland.blog/)<sup>10</sup>.

### Version control

This is absolutely necessary in my humble opinion. Use whatever tool you like, Git or Subversion for instance, but **use** it. How often I needed to compare a script with an older version I can not tell you, but it was often. And sometimes I had to just to throw away a concept to start over. And that is just a small part of the advantages of a version tool. When you work in a team it is a “sine qua non”.

### Maven

[Apache Maven](https://maven.apache.org/index.html)<sup>11</sup> is a software project management and comprehension tool. Based on the concept of a project object model (POM), Maven can manage a project’s build, reporting and documentation from a central piece of information.

So Maven will be the tool to automate several tasks like running Flyway, exporting and importing APEX applications or running unit tests.

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<sup>6</sup><https://www.virtualbox.org/>

<sup>7</sup><https://www.oracle.com/downloads/developer-vm/community-downloads.html>

<sup>8</sup><https://oracle-base.com/articles/12c/multitenant-overview-container-database-cdb-12cr1>

<sup>9</sup><https://www.goodreads.com/book/show/23871562-oracle-sql-developer-data-modeler-for-database-design-mastery>

<sup>10</sup><https://helifromfinland.blog/>

<sup>11</sup><https://maven.apache.org/index.html>

## Flyway

Already described, integrates very well with the tools above. A tool that must be mentioned as well is Liquibase that is integrated in Oracle utilities like Oracle SQL Developer and Oracle SQLcl client. The reason I prefer Flyway is that it is more flexible and based on SQL scripts (that can be generated by the database). Liquibase on the other hand requires you to define your database structure changes using (annotated) changesets. For instance, every time you change a package body, you need to create a different file. Flyway on the other hand allows you to just change the script file when it is a repeatable migration (a replaceable object).

## Oracle SQL Developer

You can see this quote on [the Oracle SQL Developer home page](#)<sup>12</sup>:

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Oracle SQL Developer is a free, integrated development environment that simplifies the development and management of Oracle Database in both traditional and Cloud deployments. SQL Developer offers complete end-to-end development of your PL/SQL applications, a worksheet for running queries and scripts, a DBA console for managing the database, a reports interface, a complete data modeling solution, and a migration platform for moving your 3rd party databases to Oracle.

---

Of course there are commercial products like TOAD and PL/SQL Developer and some developers prefer them over SQL Developer, but SQL Developer is usually very much up-to-date with new Oracle database features.

## utPLSQL

A PL/SQL unit testing framework originally developed by Steven Feuerstein, we now have [version 3](#)<sup>13</sup>. An impressive piece of work and easy to use. In the Java community it is normal to unit test but not so in the Oracle community. This tool may convince you!

## Perl

I have learned [Perl, the Practical Extraction and Report Language](#)<sup>14</sup>, a long time ago and it still helps me with doing some scripting tasks. So there is no reason for me to switch to Python or something else.

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<sup>12</sup><https://www.oracle.com/database/technologies/appdev/sqldeveloper-landing.html>

<sup>13</sup><http://utplsql.org/utPLSQL/latest/>

<sup>14</sup><https://strawberryperl.com/>

## Ant

Ant - just mentioned before - interacts well with Maven due to its Maven plugin and is sometimes needed to accomplish things Maven can not do (well).

## DevOps

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DevOps is a set of practices that works to automate and integrate the processes between software development and IT teams, so they can build, test, and release software faster and more reliably.

–Atlassian

---

The tools and techniques I have described can be used from simple to complex. So from a single person running Maven from the command line to a team using [Jenkins](#)<sup>15</sup> and the free artifact repository [Nexus](#)<sup>16</sup> to build a [Continuous Deployment](#)<sup>17</sup> pipeline based on Maven. Or, since everything now moves to the cloud, DevOps in the cloud.

## 1.5 Introducing Paulissoft Application Tools for Oracle (PATO)

Over the years I have written (or maintained) a lot of code that has been used in the various companies I worked for. A large part has been published as Open Source on:

1. [the GitHub page of my own company Paulissoft](#)<sup>18</sup>
2. [TransferWare, an Open-Source web site with utilities donated by Transfer Solutions, Leerdam, The Netherlands.](#)<sup>19</sup>



Together with my former colleague Peter de Vaal from Transfer Solutions, I created TransferWare in 2002 on [Sourceforge](#)<sup>20</sup>. Lately we have moved relevant parts to GitHub.

I hesitated for a long time about the name for the first collection of Open Source: I have long named it Oracle Tools but to prevent confusion and problems with Oracle Corporation, I have changed the name to Paulissoft Application Tools for Oracle, abbreviated as PATO. As a nice

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<sup>15</sup><https://www.jenkins.io/>

<sup>16</sup><https://www.sonatype.com/nexus/repository-oss>

<sup>17</sup><https://www.atlassian.com/continuous-delivery/principles/continuous-integration-vs-delivery-vs-deployment>

<sup>18</sup><https://github.com/paulissoft>

<sup>19</sup><https://github.com/TransferWare>

<sup>20</sup><https://sourceforge.net/projects/transferware/>

coincidence it is also the last name of a once promising footballer, [Alexandre Pato](#)<sup>21</sup>. Let's hope that the tools won't suffer the same fate.



I have not changed the name of the PATO GitHub repository (it is still `oracle-tools`) since a lot of projects refer to that repository name in their Maven or Jenkins code.

Check out the link below to find out more about building Oracle database applications:

- [PATO documentation on GitHub Pages](#)<sup>22</sup>

If you want to have an overview of the PATO and TransferWare repositories that can be helpful while building an Oracle database application, please have a look at [Appendix C - PATO and TransferWare repositories](#).

## 1.6 Conclusion

In this chapter I have given an overview of the people, ideas and tools that have inspired me to write this book and to develop the Paulissoft Application Tools for Oracle (PATO). Let's move on to the next chapter to set things up.

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<sup>21</sup>[https://en.wikipedia.org/wiki/Alexandre\\_Pato](https://en.wikipedia.org/wiki/Alexandre_Pato)

<sup>22</sup><https://paulissoft.github.io/oracle-tools/>

## 2. Start me up

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### 2.2 Setting up the environment

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## Oracle SQL Developer Data Modeler

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## Creating the PATO schema

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## Installing database objects

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### PATO

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### Setup the workspace

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### Create workspace DEV\_WKS

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### (Re)move application 138

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### Configure the authorization

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### 3.2 Scope of a build plan

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### 3.3 Software architecture

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## DevOps

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## What version?

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## The front-end

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## Conclusion

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## 3.6 Development tools

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## 4.2 Jenkins

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## 5. Database *migrations*

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### 5.1 Why *migrations*?

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### 5.2 How does Flyway work?

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#### Callbacks

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#### Incremental *migrations*

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#### Repeatable *migrations*

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#### Repeatable *migrations* with a naming scheme based on the object type

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#### Repeatable *migrations* with a naming scheme based on the dependency order

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## 5.3 DML

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## 5.4 Preferred order of *migrations*

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## 5.5 Why not Liquibase?

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## 5.6 Project folder layout

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### Directory apex

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### Directory conf

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### Directory db

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## Mapping database structure to folder layout

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## **Common schemas**

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## **Application schemas**

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## 6. Oracle SQL Developer Data Modeler

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### 6.1 Best user experience on Windows

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### 6.2 Data Modeling related concepts

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#### Business Rules

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#### Surrogate keys

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#### Super and subtypes

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#### Many-to-many relations

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## 6.3 Best practices

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### Global configuration settings

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### Glossary

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### Logical Model configuration settings

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### Surrogate keys

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### Subtypes implementation

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## Use the PATO Custom Library and Custom Transformations Scripts

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## Data Modeler Configuration & Version Control

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### One data modeling software project for all applications

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### Synchronize the Data Modeler configuration using a Perl script

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## 6.4 Tasks

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## Design the logical and relational model

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### Logical model

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### Relational model

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## Check the Design Rules

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## Generate DDL

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## Create incremental migration scripts

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# 7. Mapping architecture to code

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## 7.1 Business rules

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## 7.2 Business rule mapping

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### Attribute Rules

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### Tuple Rules

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### Entity Rules

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### Unique Identifier

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## **Other Entity**

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## **Inter-Entity Rules**

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## **Relationship**

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## **Restricted Relations**

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## **Other Inter-entity**

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## **Dynamic Data Constraint Rules**

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## Authorization Rules

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## 7.3 Alternatives for checking complex business rules

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## Standard views with a check option

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## Refresh fast on statement

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## De-normalization

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## Conclusion

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## 7.4 Database object naming conventions

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## 7.5 Accessing database schema objects

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## DATA

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## EXT

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## API

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## UI

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## 7.6 Database Security

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### Set-up context and privileges

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### Add the policy

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### Enable the policy

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### Create a predicate function

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## **Create a procedure to set the context**

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## **Set the context in the front-end**

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## 8. Testing

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### 8.1 V-model of software development

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### 8.2 utPLSQL

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#### Introduction

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#### Best practices

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#### Where to place test code?

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#### Flyway

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#### Configuration package

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## Examples

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### **A package specification with a function/procedure to unit test**

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### **A package body with a function/procedure to unit test**

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## Hands-on experience

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### **Installation**

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### **Run the test**

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## 9. Debugging

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### 9.1 Why DBUG?

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### 9.2 History of DBUG

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#### DBUG C library

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#### No debugging and/or tracing

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#### Function level tracing

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#### Function level tracing and debugging

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#### Debugging a break point

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## **DEBUG PL/SQL library**

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## **9.3 Later enhancements**

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## **9.4 Installation**

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# 10. Error handling

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## 10.1 An APEX error handling solution

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### Oracle constraint violations

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### A reserved PTO exception

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### No translation found

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## 10.2 How to raise a custom error?

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### DATA\_API\_PKG.RAISE\_ERROR

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### DATA\_API\_PKG.RAISE\_ERROR\_OVERLAP

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## 10.3 APEX messages

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## 10.4 How to store APEX messages?

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## 10.5 Conclusion

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# 11. Code quality

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## 11.1 Standard Oracle functionality

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### PL/SQL warnings

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### PL/Scope

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## 11.2 PATO code quality check

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## 12. Advanced Topics

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### 12.1 Collaboration

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#### APEX

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#### Database

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### 12.2 Multiple APEX application systems

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### 12.3 Uploading spreadsheet documents

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#### Using it in another application system

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### 12.4 Translating APEX applications

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# 13. Project set-up

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## 13.1 Folder layout

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## 13.2 Root folder

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## 13.3 Maven folder

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## 13.4 Apex folder

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### Folder <app\_X>/src/export

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### Folder <app\_X>/src/translate

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## 13.5 Configuration folder

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## File env.properties

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## File flyway-app.conf

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## File apex.properties

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## File db.properties

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## File flyway-db.conf

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## 13.6 Database folder

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### Folder <schema\_X>/src/admin

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### Folder <schema\_X>/src/dml

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### Folder <schema\_X>/src/full

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## **Folder <schema\_X>/src/incr**

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## **13.7 Conclusion**

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# 14. Continuous Deployment

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## 14.1 Requirements

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### Automated

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### Flexible

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### Complete

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## 14.2 Install Jenkins

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## 14.3 Configure Jenkins

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### Manage Plugins

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## Configure System

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## Environment variables

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## Jenkins Templating Engine

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## Manage Credentials

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## ORACLE\_TOOLS on development

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## GitHub authentication

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## Manage Nodes and Clouds

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## 14.4 Test the GitHub SSH connection

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## 14.5 Run the Jenkins deployment job

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## Jenkins Templating Engine

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### Pipeline configuration

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### Pipeline script

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### Pipeline library

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## Create the pipeline job

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### Development folder

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### Job - General

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### Job - Build Triggers

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### Pipeline

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## Build the pipeline job

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## 14.6 Conclusion

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# III Testing the build plan

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# 15. Example project 1, Sample Database Application

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## 15.1 Setting up the project structure

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### Install the APEX Sample Database Application

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### Cloning PATO

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### Create an examples project

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### The root POM

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### The database POM

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### The APEX POM

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## 15.2 Generate scripts

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### Database

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### APEX

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## 15.3 Re-install the application

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### Using install.sql

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### Using the GUI

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### Create incremental scripts

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### Create DML scripts

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## Run the GUI

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## APEX

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## 15.4 Test the installation scripts

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## 15.5 Conclusion

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# 16. Example project 2, Incident Tracking

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## 16.1 Install the APEX Sample Database Application

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## 16.2 Modify the project structure

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## 16.3 Modify the Sample Database Application POMs

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### Create a `db/pom.xml`

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### Change the `db/sample-database-application/pom.xml`

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### Create a `db/incident-tracking/pom.xml`

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## Create an `apex/pom.xml`

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## Change the `apex/sample-database-application/pom.xml`

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## Create an `apex/incident-tracking/pom.xml`

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# 16.4 Generate scripts

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## Database

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## Load the data

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## APEX

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# 16.5 Conclusion

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# 17. Example projects, Continuous Deployment

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## 17.1 Set up the project structure

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## 17.2 Setting up Jenkins

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# Appendices

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# Appendix A - Custom transformations

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# Appendix B - Jenkins installation

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## Installation of Jenkins as a service on Linux

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### General

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### Install Jenkins

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## Installation of Jenkins with Docker Compose

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## Post install actions

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### Install plugins automatically

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### Install plugins manually

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## **Admin user**

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## **Final steps**

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# **Appendix C - PATO and Transferware repositories**

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