Leverage Oracle SQL and PL/SQL to Simplify Development of Any User Interface Application
Using Thick Database Techniques

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quovera NYOUG

Agenda

- What is Thick Database?
- Thick Database techniques
- Level of Thick

Appendix A – More About Business Rules
Appendix B – Code Samples

Slides are available on the Quovera website.

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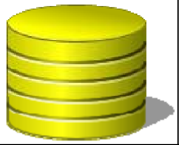
Thick Database

A.k.a., "Thick Database **Approach**" or "Thick Database **Paradigm**"

- A code development strategy
  - Maximize use of database code to simplify the user interface
  - The user's device (client) runs minimal code
- Name plays off the term "thin client"
  - A "Year of the Internet" term
  - Means most processing occurs on a server
  - Slightly outmoded now
- Thick database means "thin client"



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Provenance

- Topic is rarely seen now, but not new
  - Using database features to enforce data integrity defined by business rules is obvious
- Started trending many years ago
  - ODTUG Business Rules Symposium Day 2001
    - Organized by Dr. Paul Dorsey of Dulcian, Inc. – 2001-2004
  - Thoughts evolved into Thick Database
    - Sessions starting around 2006

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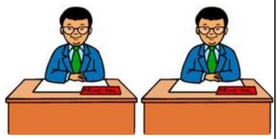
Topic is Still Active

- Dulcian.com
  - Look in Resources | Conference Presentations - Thick Database
- Mike Smithers' Blog
  - https://mikesmithers.wordpress.com/tag/thick-database-paradigm/
- "Fill the Glass Episode 3 with Cary Millsap & Toon Koppelaars"
  - https://vimeo.com/128613885
- Bryn Llewellyn, Oracle Product Manager
  - https://blogs.oracle.com/plsql-and-ebr/entry/why_use_pl_sql

Guiding Principle

- Database code that implements business rules
- Database views to represent complex business objects
  - Each view has an accompanying application programming interface (API)
    - Written in PL/SQL
  - Interaction is with view and API



What is a Business Rule?

- *A statement of a behavior, definition, or constraint that allows an organization to achieve its goals.*
- Systems analysis is all about determining business rules
  - Often *business requirements* are equated with business rules
- Used to communicate business with business users
- A full definition of business rules can identify all aspects of an application
  - Possible exceptions: technical details like development software, server specifics

Topic is expanded in Appendix A.

Sample Business Rules

- *An employee is active in one and only one department at a time.*
- *The employee's job end date must be on or after the job start date.*
- *The value of the "State" portion of an address in the United States must be from the list of US states (including the District of Columbia).*
- *Saving a change to an employee record archives the old version of the record in a history table.*
- *Only managers can view salaries other than their own for staff in their department.*

Thick Benefits

- Application accuracy
  - Business rules match application code
  - Test plans can be generated from business rules
- Productivity
  - Can greatly simplify user interface code
- Code reusability
  - Ease of application maintenance
- Better performance
  - Code is close to data storage – fewer messages, easy access
  - Views also reduce the number of round trips needed
- Proper use of staff
  - User interface developers can concentrate on UI code
  - Database code developers can concentrate on database code to support the UI

Simplifies User Interface Work

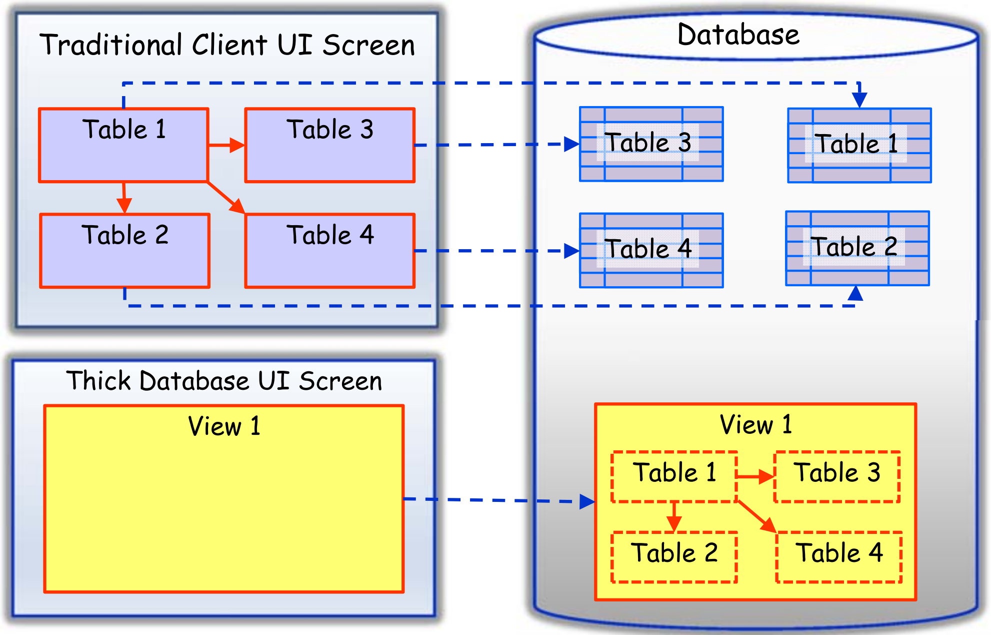
- Database views can represent multiple tables
  - Arbitrarily complex logic
  - Aggregate functions: MAX(), COUNT()
  - Set operators: UNION, MINUS
  - Calculation functions: first_salary()
  - Even: a PL/SQL function cast as a table
- One view per application UI page
  - The page submit commits the entire page
  - Reminds one of mainframe “block submit”
  - Back end code deals the data into the proper tables

```
                    cfdisk (util-linux 2.[illegible])

                       Disk Drive: /dev/sda
               Size: [illegible] bytes, [illegible] GB
       Heads: 255   Sectors per Track: 63   Cylinders: [illegible]

   Name        Flags      Part Type  FS Type          [Label]        Size (MB)
 ------------------------------------------------------------------------------
   sda1        Boot       Primary    ntfs                            [illegible]
                          Pri/Log    Free Space                        [illegible]
   sda2                   Primary    vfat                           [illegible]
   sda3                   Primary    ntfs             [?programs]   [illegible]
                          Pri/Log    Free Space                     [illegible]

   [Bootable]  [ Delete ]  [  Help  ]  [Maximize]  [ Print  ]
   [  Quit  ]  [  Type  ]  [ Units  ]  [ Write  ]
                       Illegal command
            Toggle bootable flag of the current partition
```

Some Changes Require Less Rewriting

- UI technology changes
  - If code is in database, only UI needs rewriting
  - Application logic in database can carry forward
- Table refactoring
  - For example, if a set of tables used in UI views is normalized into more tables
    - Joins and query of view can be updated
    - UI may not need to change

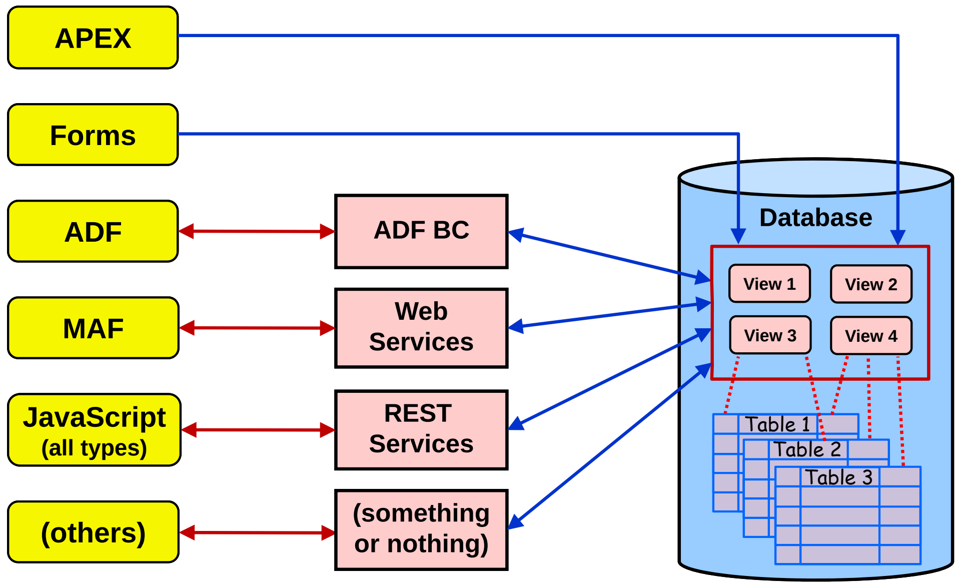
Traditional vs. Thick Database UIs



Front-end Tool "Agnostic"

- Application Express (APEX)
- Application Development Framework (ADF)
- Mobile Application Framework (MAF)
- Forms
- JavaScript
  - – JavaScript Extension Toolkit (JET)
  - – Mobile Application Accelerator (MAX)
  - – Application Builder Cloud Service (ABCS)
- PL/SQL Toolkit
- PHP: Hypertext Processor (PHP)
- Rails
- ColdFusion
- (whatever)

Tools' Use of Thick Database



Drawbacks

- Time and effort required
  - – Design and set up
  - – Documenting standards
  - – Instructing staff
- Requirements on the IT shop side
  - – Architect/database designer
  - – Expert coder
    - Develop generic code "engines" to run and/or generate business rules code
- Need buy-in from management
  - – For all of the above

When Not to Use Thick Database

- If your organization is dedicated to "database independence"
  - – Changing from Oracle to SQL Server, for example
  - – This is a BIG DEAL
  - – Forces applications to use ANSI SQL only
    - Applications are "thicker" than the database
- If your applications have few or simple business rules
  - – Overhead of Thick Database may not be worthwhile

Agenda

- What is Thick Database?
- Thick Database techniques
- Level of Thick

TripAdvisor Review: Waldorf Astoria Hotel

The towels were so thick there I could hardly close my suitcase.

—Yogi Berra

Database Components

- Tables – the usual
  - No grants or synonyms to other schemas
- Table API packages
  - INSERT, UPDATE, DELETE, (SELECT) procedures
  - Call business rules validation code
- Views on the tables
  - Queries can be arbitrarily complex
- INSTEAD OF triggers on the views
  - Call the table API procedures

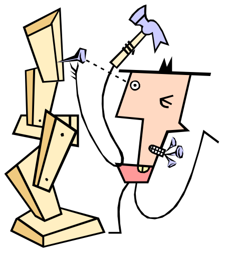


Table API

- A PL/SQL package per table
  - All data modification (“DML”) is accomplished through procedures
    - INS()
    - UPD()
    - DEL()
    - LCK()
- Procedures are called only from INSTEAD OF view triggers
- No grants to table at all

Demo 1

Optional Table API Components

- A function can act as SELECT
  - A bit trickier and not always necessary
  - Virtual Private Database policies can filter data to all SELECT statements instead
- Package enforcement global variable
  - Trigger uses it to prevent “DML” statements outside of the package
    - Applies only to table owner because table no grants
  - Access only by Table API

Demo 1

Code samples are available on the Quovera website.

Package Enforcement Trigger

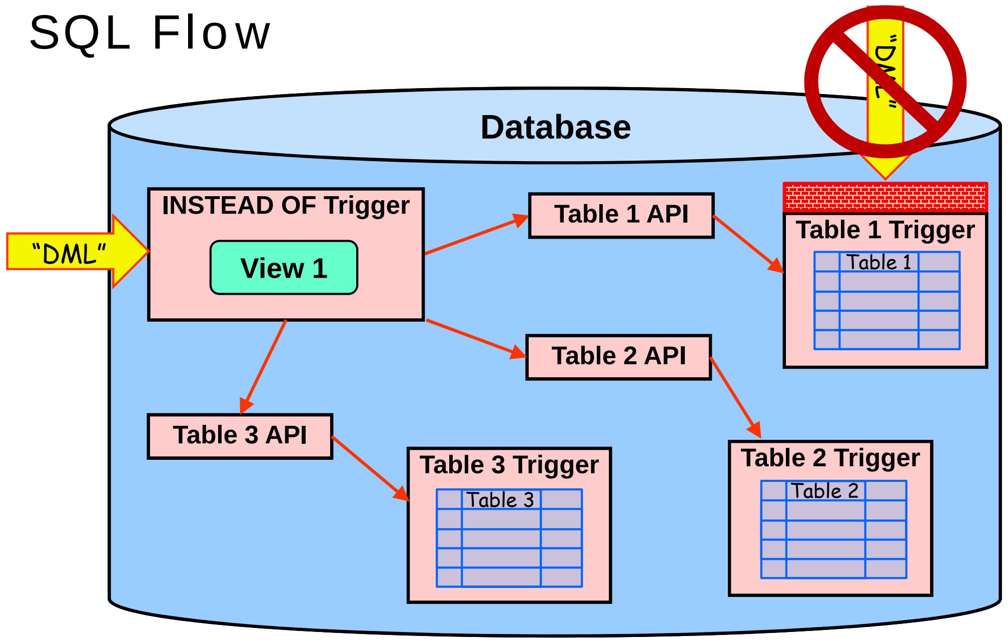
```
CREATE OR REPLACE TRIGGER employees_trbr
   BEFORE INSERT OR UPDATE OR DELETE
   ON employees
   FOR EACH ROW
BEGIN
   --
   IF NOT employees_pkg.g_allow_dml
   THEN
      RAISE_APPLICATION_ERROR(-20199,
         'You may not issue INSERT, UPDATE, or ' ||
         'DELETE statements to this table.');
   END IF;
   -- other code for validating rules
END employees_trbr;
```

Database Views and Triggers

- Views on tables requiring access
- INSTEAD OF triggers on the views
  - INSERT, UPDATE, DELETE row-level trigger
    - Call Table API procedures
  - Except: cross-row validation requires statement-level triggers

Demo 2

SQL Flow



Generate the Stub Code

- It's all cookie cutter stuff at the start
  - Table API – triggers and packages
  - View INSTEAD OF trigger
- Use a prebuilt generator
  - http://www.dbartisans.com/oracle/docs/PLSQL_Frameworks_and_Libraries.pdf
  - Steven Feuerstein, for example

Available for free
- PL/Generator (before that, PL/Vision)
  - http://archive.stevenfeuerstein.com/puter/gencentral.htm

Seems to be inactive
- QXNO productized into QCGU (Quest CodeGen Utility)
  - http://quest-codegen-utility.software.informer.com/
  - Includes GUI interface

Attempt at a community effort
- https://community.oracle.com/community/database/developer-tools/oddgen

- Or roll your own generator

Demo 3

Do You Need an Oracle Database?

- No, but…
  - A central location for business rules code is necessary
    - Best in a database
  - Views are needed to hide details of the data storage
    - INSTEAD OF triggers may not be available
    - So application may be responsible for calling the central code
  - Table API concept may be possible
    - Allow access to views not tables

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How Thick Do You Go?

Complexity, Flexibility

1. Application code only
   - **Conservative** Thick Database Approach
2. Business rules repository for documentation
   - **Modified** Thick Database Approach
3. Code generation from the repository
   - **Extreme** Thick Database Approach
4. Applying business rules at runtime from repository definitions only
   - **Ultra-extreme** Thick Database Approach

All use views, table APIs, and INSTEAD OF triggers

Some Decision Points

- Conservative
  - Small shop, few applications
- Modified
  - Medium-sized shop, few “architects” (generic code authors)
- Extreme
  - Upfront time for investing in setup is available
- Ultra-extreme
  - Super-talented generic code authors
  - Team that can dedicate to this approach – analysts

How to Transition to Thick Database

- Like applying any other standard while “in flight”
- Apply it 100% to new applications
- Can apply it to existing application enhancements
- Can start small
  - Incorporate user interface interaction with database views

Oracle Does Not Support Plowing

Too thick to drink,
too thin to plow.

—Common saying about
Nebraska's Platte River

Summary

- The Thick Database approach can improve productivity, system performance, application accuracy, UI simplicity, security
- Thick Database is driven by business rules
- Components:
  - Table triggers, minimal grants to tables
  - Database views with INSTEAD OF triggers, table APIs
- Different levels of business rules support: conservative, modified, extreme
- Incorporating it requires some ramp-up time
  - Use a phased approach

- **Books co-authored with Dr. Paul Dorsey, Avrom Roy-Faderman, & Duncan Mills**

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Appendix A: More About Business Rules

What is a Business Rule?

- *A statement of a behavior, definition, or constraint that allows an organization to achieve its goals.*
- Systems analysis is all about determining business rules
  - Often *business requirements* are equated with business rules
- Used to communicate business with business users
- A full definition of business rules can identify all aspects of an application
  - Possible exceptions: technical details like development software, server specifics

Business Rules Categories

- Business definition
  - A statement that explains a fact relevant to the business, for example:
    - *An employee is active in one and only one department at a time.*
- Data validation
  - A statement that describes how data is verified, for example:
    - *The employee's job start date must be on or after the job start date.*

More Business Rule Categories

- Allowed values
  - Related to data validation
  - Defines field values from a fixed list (hard coded or in a table) or range, for example,
    - *The value of the "State" portion of an address in the United States must be from the list of US states (including the District of Columbia).*
- System Behavior
  - A statement that guides the internal actions in the system, for example:
    - *Saving a change to an employee record archives the old version of the record in a history table.*

Another Business Rule Category

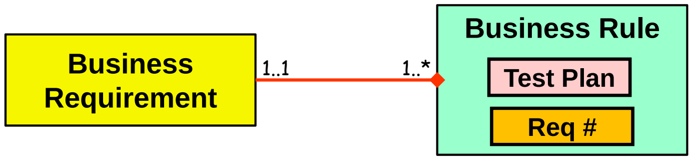
- Data privileges
  - Selective to users or (better) roles
  - Defines access to view or modify certain data, for example,
    - *Only directors can update salaries for staff in their division.*
    - *Only managers can view salaries other than their own for staff in their department.*
    - *Personal data for clients, such as credit card numbers and Medicaid IDs, are only visible to staff who have been cleared to view it.*
    - *Staff may only view profile information for clients in the department's territory.*

Sample Business Rules

- *An employee is active in one and only one department at a time.*
- *The employee's job end date must be on or after the job start date.*
- *The value of the "State" portion of an address in the United States must be from the list of US states (including the District of Columbia).*
- *Saving a change to an employee record archives the old version of the record in a history table.*
- *Only managers can view salaries other than their own for staff in their department.*

Test Plans and Business Rules

- Business rules statements can be used as or linked with test plans
- Generation of test plans is then just a report
- Each business requirement will be properly tested



Where to Place the Business Rules Code?

- Environments these days are multi-tier
  - Database tier
  - Middle tier
    - Application server/web server (SOA, web services, ESB, etc.)
  - Client tier
    - Web browser
    - Mobile device
- Code can be located on one or more tiers

Primary Assumption

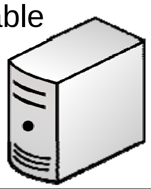
- Standard relational database constraints are ALWAYS used to protect data integrity
  - Primary key
  - Foreign key
  - Unique key
  - Check constraints
    - NOT NULL
    - Value- or function-base (optional)
- This is true regardless of the database vendor

Code on the Client Tier

- Web application consideration:
  - Since HTML is *not* a programming language, you need JavaScript for this
- Benefits
  - Fast feedback to user: very friendly
  - No processing at all on database or middle tiers
- Drawbacks
  - Difficult to maintain business rules documentation
  - Some browsers handle JavaScript differently
  - Possible need to repeat code for each app
    - Potential for omission in a single app
  - Not centralized

Code on the Middle Tier

- Business rules code is in the middle tier
  - That is, if there is a middle tier
    - For example, APEX has none
  - ADF
    - Java and XML files for the application
    - Declarative validation rules, EO, VO, App module code
- Benefits
  - Saves database server CPU time
  - Returns messages to user faster and friendlier
- Drawbacks
  - Each app needs to repeat the code for a particular table
  - Requires database roundtrip messages
  - Documenting or checking business rules requires visiting many files unless you use a Rules Engine or other repository



Code on the Database Tier

- Thick Database approach
  - Views
  - Table API code
    - Triggers and procedures (and policies) that enforce rules
- Benefits
  - Data integrity is enforced for all applications
  - Business rules code can be generated from metadata or, at least, documented from one source
  - Maintenance requires only database changes
    - Application modification may not be needed
  - Primary language is PL/SQL
- Drawbacks
  - Handling return messages from the database in a friendly way is not a default
  - Places complete burden of validation of data on the database server – possibly more CPU time taken

So, Which is Best?

- Depends on the application
- Database tier (Thick Database) ensures data integrity
  – Any application
- Middle tier saves database round trips
  – If processing only on middle tier
- Client tier provides best interactivity
  – Immediate feedback to user
  – Also saves database round trips

Feature Comparison

1 (no support) to 10 (the best support)

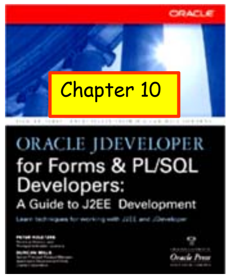
Location of Business Rules Code / Feature	Client Computer	Application Server	Database Server
User interactivity	10	7	5
Saves client computer resource usage **	2	10	10
Saves roundtrip message to client computer		10	10
Saves application server resource usage **	10	2	10
Saves roundtrip message to application server	10		10
Saves database server resource usage **	10	10	2
Saves roundtrip message to database server	10	10	
Ease of maintenance (dependency analysis, adding, updating, reporting) *	2	5	10
Reuse of code	2	5	10
Assurance that business rules are applied to all applications	5	5	10
Total	61	64	77

* Assumes that the business rules repository is not used at runtime or to generate code.

** This feature reflects use of that tier for business rules purposes

Suggestion

- *Modified Database-centric Approach*
  – Always code rules in the database
  – Selectively duplicate business rules in the middle tier and client tier
    - Carefully consider each rule
    - Know and document that you are duplicating rules
    - Can even turn off database rule for a transaction if it has been run on the client side
  – Consider using a BR repository tool
    - Home grown or Oracle Business Rules
- Guiding principles
  – Use database code when possible
    - It is the closest to the data == most efficient
  – Save database round trips when possible
    - Client side can check data type, for example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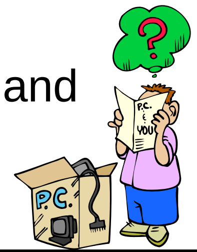
Chapter 10
ORACLE JDEVELOPER for Forms & PL/SQL Developers:
A Guide to J2EE Development

Some Challenges

- Identifying business rules
- Stating them accurately
- Representing the business rules in system programmatic code
- Defining and maintaining business rules statements
- Communicating rules to users
- Synchronizing programmatic code and the business rules repository



Appendix B: Code Samples

EMP_DETAILS_VW View

```
CREATE OR REPLACE FORCE VIEW emp_details_vw
AS
   SELECT emp.employee_id,
          emp.job_id,
          emp.manager_id,
          emp.department_id,
          dept.location_id,
          loc.country_id,
          emp.first_name,
          emp.last_name,
          emp.salary,
          emp.commission_pct,
          emp.email,
          emp.phone_number,
          emp.hire_date,
          emp.created_date,
          emp.created_by,
          emp.modified_date,
          emp.modified_by,
          dept.department_name,
          jb.job_title,
          loc.city,
          loc.state_province,
          cntry.country_name,
          reg.region_name
   FROM   employees emp, departments dept,
          jobs jb, locations loc,
          countries cntry, regions reg
   WHERE  emp.department_id = dept.department_id
   AND    dept.location_id = loc.location_id
   AND    loc.country_id = cntry.country_id
   AND    cntry.region_id = reg.region_id
   AND    jb.job_id = emp.job_id;

COMMENT ON TABLE EMP_DETAILS_VW IS 'An all-inclusive view of an employee including all
organization levels and current job description.';
```

EMP_DETAILS_VW_TRBR Trigger

```
CREATE OR REPLACE TRIGGER emp_details_vw_trbr
   INSTEAD OF DELETE OR INSERT OR UPDATE
   ON emp_details_vw
   FOR EACH ROW
DECLARE
BEGIN
   IF INSERTING
   THEN
      employees_pkg.ins(
         :NEW.employee_id,
         :NEW.first_name,
         :NEW.last_name,
         :NEW.email,
         :NEW.phone_number,
         :NEW.hire_date,
         :NEW.job_id,
         :NEW.salary,
         :NEW.commission_pct,
         :NEW.manager_id,
         :NEW.department_id,
         :NEW.created_by,
         :NEW.created_date,
         :NEW.modified_by,
         :NEW.modified_date);
   ELSIF UPDATING
   THEN
      employees_pkg.upd(
         :NEW.employee_id,
         :NEW.first_name,
         :NEW.last_name,
         :NEW.email,
         :NEW.phone_number,
         :NEW.hire_date,
         :NEW.job_id,
         :NEW.salary,
         :NEW.commission_pct,
         :NEW.manager_id,
         :NEW.department_id,
         :NEW.created_by,
         :NEW.created_date,
         :NEW.modified_by,
         :NEW.modified_date);
   ELSE -- DELETING
      employees_pkg.del(
         :NEW.employee_id);
   END IF;
   --
END emp_details_vw_trbr;
```

EMPLOYEES_PKG Package

```
CREATE OR REPLACE PACKAGE employees_pkg
IS
   --
   g_allow_dml    BOOLEAN DEFAULT FALSE;
   --
   PROCEDURE ins (
      p_employee_id  employees.employee_id%TYPE,
      p_first_name  employees.first_name%TYPE,
      p_last_name  employees.last_name%TYPE,
      p_email  employees.email%TYPE,
      p_phone_number  employees.phone_number%TYPE,
      p_hire_date  employees.hire_date%TYPE,
      p_job_id  employees.job_id%TYPE,
      p_salary  employees.salary%TYPE,
      p_commission_pct  employees.commission_pct%TYPE,
      p_manager_id  employees.manager_id%TYPE,
      p_department_id  employees.department_id%TYPE,
      p_created_by  employees.created_by%TYPE,
      p_created_date  employees.created_date%TYPE,
      p_modified_by  employees.modified_by%TYPE,
      p_modified_date  employees.modified_date%TYPE);
   --
   PROCEDURE upd(
      p_employee_id  employees.employee_id%TYPE,
      p_first_name  employees.first_name%TYPE,
      p_last_name  employees.last_name%TYPE,
      p_email  employees.email%TYPE,
      p_phone_number  employees.phone_number%TYPE,
      p_hire_date  employees.hire_date%TYPE,
      p_job_id  employees.job_id%TYPE,
      p_salary  employees.salary%TYPE,
      p_commission_pct  employees.commission_pct%TYPE,
      p_manager_id  employees.manager_id%TYPE,
      p_department_id  employees.department_id%TYPE,
      p_created_by  employees.created_by%TYPE,
      p_created_date  employees.created_date%TYPE,
      p_modified_by  employees.modified_by%TYPE,
      p_modified_date  employees.modified_date%TYPE);
   --
   PROCEDURE del (
      p_employee_id employees.employee_id%TYPE);
   --
   PROCEDURE lck (
      p_employee_id employees.employee_id%TYPE);
   --
END employees_pkg;
CREATE OR REPLACE PACKAGE BODY employees_pkg
IS
   --
   --
   FUNCTION check_insert_rules(
      p_employee_id  employees.employee_id%TYPE,
      p_first_name  employees.first_name%TYPE,
      p_last_name  employees.last_name%TYPE,
      p_email  employees.email%TYPE,
      p_phone_number  employees.phone_number%TYPE,
      p_hire_date  employees.hire_date%TYPE,
      p_job_id  employees.job_id%TYPE,
      p_salary  employees.salary%TYPE,
      p_commission_pct  employees.commission_pct%TYPE,
      p_manager_id  employees.manager_id%TYPE,
      p_department_id  employees.department_id%TYPE,
      p_created_by  employees.created_by%TYPE,
      p_created_date  employees.created_date%TYPE,
      p_modified_by  employees.modified_by%TYPE,
      p_modified_date  employees.modified_date%TYPE)
      RETURN VARCHAR2
   IS
      v_error_message VARCHAR2(10000);
   BEGIN
      IF p_hire_date < jobs_pkg.job_start_date(p_department_id)
      THEN
         -- "Employee Hire Date must be on or after the job start date."
         v_error_message := message_pkg.message_text(500);
      END IF;
      --
      IF NOT util_pkg.check_list_value(
            'US_STATE', departments_pkg.address_state(p_department_id))
      THEN
         v_error_message := v_error_message || ' ' || message_pkg.message_text(501);
      END IF;
      --
      RETURN v_error_message;
   END check_insert_rules;
   --
   --
   PROCEDURE ins (
      p_employee_id  employees.employee_id%TYPE,
      p_first_name  employees.first_name%TYPE,
      p_last_name  employees.last_name%TYPE,
      p_email  employees.email%TYPE,
      p_phone_number  employees.phone_number%TYPE,
      p_hire_date  employees.hire_date%TYPE,
      p_job_id  employees.job_id%TYPE,
      p_salary  employees.salary%TYPE,
      p_commission_pct  employees.commission_pct%TYPE,
      p_manager_id  employees.manager_id%TYPE,
      p_department_id  employees.department_id%TYPE,
      p_created_by  employees.created_by%TYPE,
      p_created_date  employees.created_date%TYPE,
      p_modified_by  employees.modified_by%TYPE,
      p_modified_date  employees.modified_date%TYPE)
   IS
      v_error_message   VARCHAR2(10000);

   BEGIN
      g_allow_dml := TRUE;
      -- Or put this call in the table trigger
      v_error_message := check_insert_rules(
                p_employee_id,
                p_first_name,
                p_last_name,
                p_email,
                p_phone_number,
                p_hire_date,
                p_job_id,
                p_salary,
                p_commission_pct,
                p_manager_id,
                p_department_id,
                p_created_by,
                p_created_date,
                p_modified_by,
                p_modified_date);
      --
      IF v_error_message IS NULL
      THEN
         INSERT INTO   employees(
                   an employee_id,
                   first_name,
                   last_name,
                   email,
                   phone_number,
                   hire_date,
                   job_id,
                   salary,
                   commission_pct,
                   manager_id,
                   department_id,
                   created_by,
                   created_date,
                   modified_by,
                   modified_date)
         VALUES (
                   p_employee_id,
                   p_first_name,
                   p_last_name,
                   p_email,
                   p_phone_number,
                   p_hire_date,
                   p_job_id,
                   p_salary,
                   p_commission_pct,
                   p_manager_id,
                   p_department_id,
                   p_created_by,
                   p_created_date,
                   p_modified_by,
                   p_modified_date);
      ELSE
         RAISE_APPLICATION_ERROR(-20298, v_error_message);
      END IF;
      --
      g_allow_dml := FALSE;
   EXCEPTION
      WHEN OTHERS
      THEN
```

```
      g_allow_dml := FALSE;
      --
      RAISE_APPLICATION_ERROR(-20299, 'Error inserting: '||SQLERRM);
END ins;
--
--
PROCEDURE upd(
   p_employee_id  employees.employee_id%TYPE,
   p_first_name  employees.first_name%TYPE,
   p_last_name  employees.last_name%TYPE,
   p_email  employees.email%TYPE,
   p_phone_number  employees.phone_number%TYPE,
   p_hire_date  employees.hire_date%TYPE,
   p_job_id  employees.job_id%TYPE,
   p_salary  employees.salary%TYPE,
   p_commission_pct  employees.commission_pct%TYPE,
   p_manager_id  employees.manager_id%TYPE,
   p_department_id  employees.department_id%TYPE,
   p_created_by  employees.created_by%TYPE,
   p_created_date  employees.created_date%TYPE,
   p_modified_by  employees.modified_by%TYPE,
   p_modified_date  employees.modified_date%TYPE)
IS
BEGIN
   g_allow_dml := TRUE;
   --
   -- TODO: Add call to check_update_rules() when it is created. See ins().
   --
   UPDATE employees
   SET
      first_name = p_first_name,
      last_name = p_last_name,
      email = p_email,
      phone_number = p_phone_number,
      hire_date = p_hire_date,
      job_id = p_job_id,
      salary = p_salary,
      commission_pct = p_commission_pct,
      manager_id = p_manager_id,
      department_id = p_department_id,
      created_by = p_created_by,
      created_date = p_created_date,
      modified_by = p_modified_by,
      modified_date = p_modified_date
   WHERE employee_id = p_employee_id;
   --
   g_allow_dml := FALSE;
EXCEPTION
   WHEN OTHERS
   THEN
      g_allow_dml := FALSE;
      --
```

```
         RAISE_APPLICATION_ERROR(-20299, 'Error updating: '||SQLERRM);
   END upd;
   --
   --
   PROCEDURE del (
      p_employee_id employees.employee_id%TYPE)
   IS
   BEGIN
      g_allow_dml := TRUE;
      --
      --
      -- TODO: Add call to check_delete_rules() when it is created. See ins().
      --
      DELETE FROM employees
      WHERE employee_id = p_employee_id;
      --
      g_allow_dml := FALSE;
   EXCEPTION
      WHEN OTHERS
      THEN
         g_allow_dml := FALSE;
         --
         RAISE_APPLICATION_ERROR(-20299, 'Error deleting: '||SQLERRM);
   END del;
   --
   --
   PROCEDURE lck (
      p_employee_id employees.employee_id%TYPE)
   IS
      v_dummy PLS_INTEGER;
   BEGIN
      g_allow_dml := TRUE;
      --
      SELECT 1
      INTO   v_dummy
      FROM   employees
      WHERE  employee_id = p_employee_id
      FOR UPDATE;
      --
      g_allow_dml := FALSE;
   EXCEPTION
      WHEN OTHERS
      THEN
         g_allow_dml := FALSE;
         --
         RAISE_APPLICATION_ERROR(-20299, 'Error locking: '||SQLERRM);
   END lck;
   --
   --
END employees_pkg;
```

Appendix B: Code Samples

EMPLOYEES_TRBR Trigger

```
CREATE OR REPLACE TRIGGER employees_trbr
   BEFORE INSERT OR UPDATE OR DELETE
   ON employees
   FOR EACH ROW
DECLARE
   v_error    VARCHAR2(2000);
BEGIN
   --
   IF NOT employees_pkg.g_allow_dml
   THEN
      RAISE_APPLICATION_ERROR(-20199, 'You may not issue INSERT, UPDATE, or ' ||
         'DELETE statements to this table.');
   END IF;
   --
   -- Note: The following is an alternative to calling the
   --       business rules checks from the table API
   IF INSERTING
   THEN
      v_error := check_insert_rules(
                    :NEW.employee_id,
                    -- other column values
   ELSIF UPDATING
   THEN
      v_error := check_update_rules(
                    :NEW.employee_id,
                    -- other column values
   ELSE  -- DELETING
      v_error := check_delete_rules(
                    :NEW.employee_id,
                    -- other column values
   END IF;
   --
   IF v_error IS NOT NULL
   THEN
      -- fails the trigger and the statement
      RAISE_APPLICATION_ERROR(-20199, v_error);
   END IF;
   --
END employees_trbr;
```

Table API Code Generation Snippets

```
-- Column list
SELECT LOWER(column_name)||',' col
FROM   user_tab_columns
WHERE  table_name = 'EMPLOYEES'
ORDER BY column_id;

-- VALUES list
SELECT 'p_'||LOWER(column_name)||',' col
```

```
FROM   user_tab_columns
WHERE  table_name = 'EMPLOYEES'
ORDER BY column_id;

-- Parameter list
SELECT 'p_'||LOWER(column_name)||'  employees.'||LOWER(column_name)||'%TYPE,' col
FROM   user_tab_columns
WHERE  table_name = 'EMPLOYEES'
ORDER BY column_id;

-- Update columns
SELECT LOWER(column_name)||' = '||
       'p_'||LOWER(column_name)||',' col
FROM   user_tab_columns
WHERE  table_name = 'EMPLOYEES'
ORDER BY column_id;

-- INSTEAD OF trigger parameters
SELECT ':NEW.'||LOWER(column_name)||',' col
FROM   user_tab_columns
WHERE  table_name = 'EMPLOYEES'
ORDER BY column_id;
```