DYNAMIC DEBUGGING & INSTRUMENTATION OF PRODUCTION PL/SQL

Bill Coulam, dbartisans.com

A DAY IN THE LIFE OF A DBA

1. The CFO sends an irate email to the CIO, who calls your manager. It seems the finance department has been attempting to run the monthly reconciliation and transfer, but it is not returning. It's been running for 3 hours, but normally only takes 45 minutes. It's 2pm on Friday, and Chicago needs the figures before 3pm. All eyes are on you.
2. Your employer owns a chain of car dealerships, and it has come to his attention that at least one of his sales managers has been altering the sales contracts after entry into the system, adjusting the figures for the new car and trade-in, thus boosting the commission but keeping the overall contract the same amount. The owner wants to know who else has used their privileged account to pad their pockets in this manner.
3. Emails and calls are overwhelming your firm's CRM system. The busy dealer and customer websites are extremely sluggish, work is backing up, and tempers are flaring as the company loses about $3K per minute. Unfortunately, the database was the culprit about a year ago, so all fingers are pointing at you again. Guilty until proven innocent…
4. Most of the 4,000 sales reps for your telecom company are working just fine, but one rep in particular, Ana B., hasn't been able to use the APEX-based Sales and Promotions application in a day. Ana's supervisor circumvented the support desk and found your number. She wants you to help Ana get back to work ASAP.

How do you handle scenarios like this? Will it be a few minutes until you have the answer, or are you cancelling those weekend getaway plans?

Rather than paint a grim picture of how the above scenarios will play out in the typical Oracle shop, this paper will describe how smooth things could be if code is instrumented and show how it is done. We'll also briefly survey existing Oracle built-ins and open-source instrumentation libraries, building a list of minimal requirements you can employ to evaluate them or design your own. It is hoped the reader will catch the vision, download a library, install it and begin using it this very day.

INSTRUMENTION, EASY AND ESSENTIAL

Instrumentation is the process of fitting production applications with code that directs runtime context to some destination where it can be useful.

RUNTIME CONTEXT

The runtime context can be who, when, arguments, changes, elapsed time, remaining workload, errors, warnings, etc. These useful bits of runtime insight can be lumped into three categories of instrumentation:

Debugging – Lots of highly detailed messages that, when enabled, can show a troubleshooter the exact path a call took and all the parameter and variable values experienced during execution. Due to sheer volume, debug messages are typically disabled in production code, but can be dynamically enabled by changing a table-based or application context-based key value.

Logging – Permanently enabled messages generated by the code at runtime, logging valuable information the business may require. This information is typically larger-grained than the detailed debug messages, such as when a critical process started and stopped and how long it took (metrics), or warnings and errors detected and the values being processed at the time of the error.

Auditing – Data that exposes who changed what and when it was done. The audit data can be mixed in with the debug and log messages, but I've found it handy to keep audit data separate in a table set designed for tracking changes to rows and columns.

DESTINATION

The destination of the runtime context can be stdout, V$ views, a logging table, a log file on the database host, a queue for asynchronous publication and monitoring, a DBMS pipe, and other slower, more complex alternatives like HTTP, FTP and

UDP callouts. Most architects prefer logging within an anonymous transaction to a logging table, which immediately imparts all of the database's benefits upon it, e.g. it becomes sortable, mineable, partition-able, archive-able, recoverable, shareable and so on, all of which are harder or impossible when sending messages to files or other destinations.

USEFUL

Instrumentation can be seen as time-consuming and a chore, but it is not. It is much easier than writing unit tests, and only a little harder than writing inline comments. Spending the little extra time is worthwhile. The payback is enormous when things go wrong, as they sometimes do. Instrumented code is easy to measure, tune and troubleshoot. When called upon, it can provide all the information needed to easily diagnose performance, security or functional problems.

Instrumentation is a best practice in any programming language, and one of the clearest indicators of a mature software engineer, or artisan. It's easy, requires very little overhead, and will prove you to be a visionary and hero over and over as life, such as it is, happens to you and your company.

THE SAME DAY, INSTRUMENTED

Let's look at how addressing the situations in the first section can be passably pleasant when instrumentation is in place.

1. In the first scenario, you open V$SESSION and run your favorite query. Because the instrumentation took advantage of DBMS_APPLICATION_INFO, you can immediately see the active row that pertains to the finance process, because module, action and client_info are filled and show you the very package and routine where the process is at. Because you follow modular coding practices, that routine only does one thing, which is the update it is stuck on. How long does it normally take? A quick query against the logging table for that routine's metrics shows it consistently takes only a few seconds. You re-query V$SESSION and V$SESS_IO, but very little changes. It is probably waiting on something. Wait statistics can be great, but you run another query to check for DML locks. Sure enough, there is an uncommitted transaction against that table, coming from the CFO's desktop. A quick call confirms the now-contrite CFO forgot to commit or rollback a large update of a new column on the ledger before putting his machine to sleep to catch a cab to the airport. With permission, you kill his session, and the process completes a few minutes later.
2. In the second scenario you run a stored query against the column-level change audit table, looking for all changes to the contract tables. Within minutes you see the balancing updates coming from two sales managers, brothers actually, logged from their office workstations right after closing time each Saturday night.
3. In the third scenario, you calmly roll up your sleeves, and then attack the keys with the passion of a concert pianist, crafting a query against the logging table, looking for average response times for all modules over the last month. You run the same query but just for the last day and hour. In general, you see the response times of the calls into the database routines are unchanged. Phew! These results are emailed to the general manager who now sends the attack dogs after the network and app server administrators.
4. In the last scenario, the pressure isn't as great, but how does one debug the path of a single sales rep within all the stored PL/SQL that 3,999 other reps share and hit pretty hard, every minute of every day, concurrently. Easy! You get the rep's login ID and change the Debug value in the parameter table from "off" to "user=ana.b". Since the frontend application cooperates with the backend, the frontend user is identified upon every call into the database. As soon as Ana tries again what has been failing for her, the existing debug lines, peppered all over your production code, "wake up" and start logging detailed runtime context only for Ana. Within 10 seconds of observing incoming rows in the logging table, you see the problem; it was a permissions issue in the company directory server, as her entry was bungled by the previous night's directory replication. A quick call to the directory team fixes that and she's off and running again. You set the Debug toggle to "off" again and go back to a well-deserved lunchtime break, reading up on programming practices of the pros.

Good instrumentation, like good security and thorough testing, is never yearned for until it is far too late. The scenarios above are quite typical for any of us with a significant investment in Oracle and PL/SQL. Inevitably something will go wrong. When it does, instrumentation often means spending a few minutes on the problem instead of hours, days, or simply having to admit the needed information is not available.

We'll now look at a few built-in instrumentation features in Oracle and their limitations. This will inform the list of requirements for a good instrumentation framework.

EXISTING INSTRUMENTATION FEATURES IN ORACLE

Oracle offers a few built-in packages and tools for debugging and real-time insight into active sessions, but not logging or column-level auditing. There is not enough room to be exhaustive, so we'll briefly consider their uses and limitations. Attendees of the presentation will enjoy a short demo and discussion of each.

COLUMN-LEVEL AUDITING

Oracle's basic and fine-grained auditing features *seem* promising, but it turns out that neither provide column-level auditing that can track who changed a column value, what changed, and when. With every new version of Oracle I check the new features to see if column-level auditing is finally addressed. This anticipation was finally answered with Flashback Data Archive (aka Total Recall), introduced in 11g. This is an efficient method of tracking the changes to data over time and does not require massive undo space as did the older Flashback Query. However, this is a rather expensive extra cost option, and again takes considerable effort to get who, what and when into a friendly format.

So for most of us, Oracle effectively still does not have a built-in feature for column level auditing. We must build our own, which is, thankfully, not hard to do. The solution is per-table triggers that record who, when and what, the "what" being old and new column values upon DML events. If the audit data will be queried rarely, the audit tables can be designed generically to hold changes for multiple tables. But if the audit data will be queried frequently and response time must be fast, then a custom audit table per table being tracked is a better option.

METRICS

DBMS_UTILITY

DBMS_UTILITY.get_time() returns elapsed time in terms of hundredths of seconds[1]. Calling it once, doing processing, then calling it again, and subtracting the first from the second value gives us elapsed time down to hundredth of second granularity. If seconds is sufficient granularity, divide the result by 100, as seen in Fragment 1 below.

```
SET SERVEROUTPUT ON
DECLARE
   l_before  NUMBER;
   l_after   NUMBER;
   l_elapsed NUMBER;
BEGIN
   dbms_output.put_line('Daily Transfer: BEGIN');
   l_before := dbms_utility.get_time;
   dbms_lock.sleep(10); -- this is where your code would do useful things
   l_after := dbms_utility.get_time;
   l_elapsed := (l_after - l_before)/100;
   dbms_output.put_line('Daily Transfer: END '||CHR(9)||'Elapsed Time ['||l_elapsed||' seconds]');
END;
/
```

Code Fragment 1

Without DBMS_UTILITY.get_time, fine-grained metrics would be difficult or impossible for PL/SQL programs. Although one can write custom code to utilize DBMS_UTILITY.get_time every time metrics are desired (which should be everywhere), it is better to wrap its use in a logging/metrics framework API, so that timings are derived consistently

DEBUGGING AND LOGGING

DBMS_OUTPUT

When most Oracle developers think of debugging PL/SQL, their thoughts turn to DBMS_OUTPUT. This is like bringing the rusty, flatted BMX bike you had as a kid to a street race, instead of the Yamaha YZF-R1 superbike sitting unused in the garage. DBMS_OUTPUT, like Java's System.out.println, is known as a "poor man's" debugger.

DBMS_OUTPUT is often used to slowly, excruciatingly debug PL/SQL. Since characters placed in the buffer must be retrieved by a tool like SQL*Plus and TOAD to be useful, using DBMS_OUTPUT in Production is wasteful; the messages are

[1] Measured from an arbitrary point in time known internally to Oracle and irrelevant to us.

lost. However, the biggest limitation is that the buffer cannot be retrieved until after the code has executed, which renders it useless for real-time insight into program execution and state, as seen in the code below.

```
DROP SEQUENCE test_upd_sq;
DROP TABLE test_upd PURGE;

CREATE SEQUENCE test_upd_sq;

CREATE TABLE test_upd (
 ID INTEGER NOT NULL
,NAME VARCHAR2(100)
,mod_by VARCHAR2(100)
,mod_dt DATE
)
/
--------------------------------------------------------------------------------
INSERT INTO test_upd SELECT test_upd_sq.nextval, object_name, 'test', SYSDATE
  FROM all_objects
  WHERE ROWNUM <= 100;
COMMIT;

CREATE OR REPLACE PACKAGE table_api
AS
PROCEDURE upd_all_initcap;
END table_api;
/
CREATE OR REPLACE PACKAGE BODY table_api
AS

PROCEDURE upd_all_initcap IS
   l_loop_idx      NUMBER := 0;
BEGIN
   dbms_lock.sleep(8); -- pretend that a bunch of processing is being done
   FOR lr IN (SELECT * FROM test_upd) LOOP
      l_loop_idx := l_loop_idx + 1;
      dbms_output.put_line('About to update row# '||lr.id);
      UPDATE test_upd
         SET NAME   = INITCAP(NAME)
            ,mod_by = SYS_CONTEXT('userenv', 'client_identifier')
            ,mod_dt = SYSDATE
       WHERE ID = lr.id;
   END LOOP;
   COMMIT;

END upd_all_initcap;

END table_api;
/

PROMPT Calling table_api.upd_all_initcap. Wait for DBMS_OUTPUT to be retrieved from buffer...
SET SERVEROUTPUT ON SIZE 1000000
BEGIN
   table_api.upd_all_initcap;
END;
/
```

Code Fragment 2

A more appropriate use of DBMS_OUTPUT is a quick-and-dirty logging tool for transient anonymous blocks, often written during data exploration, unit testing and development. We use DBMS_OUTPUT within our automated database build system to read what happened in scripts that had anonymous PL/SQL blocks, piping the output to the build logs, which are further examined by the tool for build success or failure. Although it has its limitations, and far superior alternatives, it does have its uses and has been a staple of PL/SQL developers for almost two decades. If building, buying or adopting an instrumentation library, ensure that it includes the ability to output messages to stdout/screen.

DBMS_DEBUG AND DEBUGGING IDES

Traditional debugging is usually done within a programmer's IDE and allows the troubleshooter to step in/out of modules, run to breakpoint or condition or exception, add watches, change variables at runtime, peer into memory structures, view code execution in real-time, etc. PL/SQL has this capability too.

Since Oracle 7, there has been a debugging API that PL/SQL IDEs have used to provide the veritable debugging superbike. In Oracle 11g, this API is embodied in DBMS_DEBUG and DBMS_DEBUG_JDWP. The developer[2] uses her IDE to compile the package or trigger with debug info[3], places a breakpoint in the code object, and uses the IDE to initiate a debugging run of the stored object. With DBMS_DEBUG_JDWP it is possible to begin a session with some other application, and have the IDE "wake up" when it detects a connection entering that object. It is even possible to debug like this in Production if code is permanently or temporarily compiled for debug.

However, leaving objects compiled for debug in Production is not recommended. Performance can be impacted due to the overhead it imposes. But in my experience, the scariest thing was stability. On rare occasions I've had sessions hang, and hang in really nasty ways when debugging. The killing and cleanup of the affected sessions was tricky. This is not something you want to have happen in Production.

Personally I only use IDE debugging in development to hunt down the rare infinite loop, and to force certain codepaths for full coverage unit testing. In general it works very well, but there have been issues surrounding the debug API and its interactions with connection pools, listeners, RAC databases, firewalls and database version/host OS bugs. Most of these are now fixed, but is has left me a bit jaded. The biggest weakness of the JDWP flavor is that it does no good if the client application was not coded for remote debugging. Without client cooperation, it is impossible to connect a debugger to someone's active, problematic session, or even worse, sub-second session connections. In these cases the solution is to have the sessions report their own codepath and state with debugging messages. Since debugging could occupy an entire article on its own, I'll cut it short here. Just know that IDE debugging of PL/SQL programs should be a tool in your bag of tricks.

ORADEBUG

This "undocumented" but well-known utility does allow real-time peeking into other sessions, one of the things instrumentation should be able to do. Unfortunately, it is oriented more towards really low-level memory and process debugging and tracing. It is the stuff of Oracle wizards that peep and mutter. Oracle Support prefers that it not be used unless instructed to. That it requires SYSDBA privilege is another factor against using it for production instrumentation. There are many informative papers on this utility if still curious, but there are definitely far less obtuse ways of peering into the execution of active sessions.

DBMS_PROFILER

Like Oracle's debug API, the Profiler is wonderful, especially in an IDE like SQL Developer or TOAD that wraps the profiler in nice graphs, immediately pointing out hot spots and time hogs. However, like the debug feature, it is less useful for the sessions and routines being accessed by end users. It is better used while tuning in development where you have full control of the start of the session and what is called.

DBMS_ERRLOG

This package sure sounds like what we need for logging, but the name is somewhat misleading. It is only used to create a special DML error logging table. It is useful in its own right, but useless for the kind of logging we need.

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[2] The developer's account must have DEBUG CONNECT SESSION system privilege, but it appears that DEBUG ANY PROCEDURE is no longer needed unless debugging objects in others' accounts.

[3] Or manually issuing ALTER PACKAGE <pkg_name> COMPILE DEBUG PACKAGE | BODY

DBMS_ALERT

Despite the docs indicating DBMS_ALERT is useful for asynchronous notification of database events, its use is transactional; that is the waiting client can't see the desired event message until after the alerting session commits. This is an Achilles heel for instrumentation which needs to deliver its messages, even if the transaction fails and rolls back.

According to various sources, using alerts is also resource intensive. The client has to wait (blocks) and the server piece requires a pipe and a lock. Writing the event waiter in PL/SQL is problematic, unless the event message is written to a file or table via anonymous transaction to gain immediate visibility. Another option is to write an alert event listener in some other language that is not hindered by the limitations of transactions. PL/SQL Developer has an event monitor just like this. Unfortunately, I found that it takes about a second to get registered and return to waiting, as the signals that followed right after a prior signal were simply lost, as seen when running Fragment 3 below. Oracle docs warn about this possibility. The messages are limited to 1800 chars as well, which is OK, but a little limited when we'd like to take full advantage of VARCHAR2(4000) columns. Finally, session-specific metadata, like client_id isn't communicated across to another session. Taken together, DBMS_ALERT is unsuitable for instrumentation.

```
BEGIN
   dbms_session.set_identifier('bcoulam');

   dbms_alert.signal('DEBUG','BEGIN subroutine 1');
   COMMIT; -- commit required to send signal
   dbms_lock.sleep(10); -- do useful stuff here

   dbms_alert.signal('DEBUG','FINISH subroutine 1');
   COMMIT;
   --dbms_lock.sleep(2); -- comment this back in for FINISH message to show up

   dbms_alert.signal('DEBUG','BEGIN subroutine 2');
   COMMIT;
   dbms_lock.sleep(5);

   dbms_alert.signal('DEBUG','FINISH subroutine 2');
   COMMIT;
   --dbms_lock.sleep(2); -- comment this back in for FINISH message to show up

   dbms_alert.signal('DEBUG','Done');
   COMMIT;
END;
/
```

Code Fragment 3

DBMS_PIPE

DBMS_PIPE is actually promising. Sending messages is independent of the sending session's transaction. There is a level of security offered with private pipes that could be perfect for debug, timing and error logging within the application object-owning account. However, packing the messages is a little cumbersome, and it does not guarantee message delivery like AQ does. Furthermore, once the message is consumed it is automatically removed from the buffer and cannot be read again. One can send the message to a table or file where it can be read again, but that begs the question why the message wasn't sent directly to the table in the first place, bypassing the pipe entirely? Keeping the limitations in mind, DBMS_PIPE could still be a viable piece of infrastructure for getting instrumentation messages out of an application.

```
DECLARE
   l_result INTEGER := -1;
BEGIN
   dbms_session.set_identifier('bcoulam');
```

```
   l_result := dbms_pipe.create_pipe(pipename => 'DEBUGPIPE', private => TRUE);
   dbms_pipe.pack_message(item => 'BEGIN subroutine 1'); -- put data item into local buffer
   l_result := dbms_pipe.send_message('DEBUGPIPE'); -- send contents of local buffer to pipe
   dbms_lock.sleep(5); -- pretend to do something useful

   dbms_pipe.pack_message(item => 'FINISH subroutine 1');
   l_result := dbms_pipe.send_message('DEBUGPIPE'); -- send contents of local buffer to pipe

   dbms_pipe.pack_message(item => 'BEGIN subroutine 2');
   l_result := dbms_pipe.send_message('DEBUGPIPE'); -- send contents of local buffer to pipe
   dbms_lock.sleep(5);

   dbms_pipe.pack_message(item => 'FINISH subroutine 2');
   l_result := dbms_pipe.send_message('DEBUGPIPE'); -- send contents of local buffer to pipe

   dbms_pipe.pack_message(item => 'Done');
   l_result := dbms_pipe.send_message('DEBUGPIPE'); -- send contents of local buffer to pipe
   dbms_lock.sleep(2);

   dbms_pipe.purge('DEBUGPIPE'); -- not technically necessary, but good manners
   l_result := dbms_pipe.remove_pipe('DEBUGPIPE');
END;
/
```

Code Fragment 4

DBMS_APPLICATION_INFO

There are a few pieces of session metadata that, when set, are available in V$SESSION and a few other performance views. Since many performance views can join to V$SESSION by means of the sid+serial# or sqlid, availability in V$SESSION is typically sufficient. This metadata is labeled as *module*, *action*, *client_info* and *client_identifier*. The 11g package specification for DBMS_APPLICATION_INFO says all three can be up to 64 bytes long, but this is not true for module and action. Oracle still truncates their lengths to 48 and 32 bytes respectively. They are somewhat weak individually, but in combination they are powerful. Originally intended for 2-tier and client-server applications to identify themselves to the database, they can be put to great use inside PL/SQL programs to provide DBAs with low-overhead, highly useful, real-time, transaction-independent keyhole views into what the program is currently doing. This is particularly handy when debugging programs that are hanging or taking longer than expected. Setting these values is what I like to call "tagging" a session.

DBMS_APPLICATION_INFO's main routines are set_module(), set_client_info() and set_session_longops(). Initially set module *and* action with set_module(). As the transaction progresses and calls other sub-routines, update the action with set_action(). Use set_client_info() to track lower-level process detail, like the current load set name or customer ID being processed. Keep this value updated as the processing progresses.

To set the client_identifier, use DBMS_SESSION.set_identifier. Client_id is critical. It is used by authentication and security schemes, basic auditing, column-level auditing, tracing with DBMS_MONITOR and more. Ensure your n-tier and web applications are passing the user's login ID to the database to be stored in the client_identifier[4].

On certain resource intensive operations (like DML on more than 10,000 blocks) and certain parallel operations, Oracle automatically records how much work it has to do and how far along it is in the V$SESSION_LONGOPS view. With this info one can construct a query and even a frontend progress bar to publish how long database operations will take[5]. I find the ability to predict runtime very cool. Call set_session_longops() to explicitly write to V$SESSION_LONGOPS to follow the execution of your own scripts, DDL operations or DML statements, as in the code below.

---

[4] This is known as end-to-end identification. Oracle docs call it end-to-end metrics. I've given an entire presentation on this subject, so won't go into detail here.

[5] Note that the time_remaining value in the v$session_longops view should not be construed as 100% accurate. There are a number of variable that affect the accuracy of metrics in this view. One of them is recursive SQL statements (like index updates and such) which don't figure into the time remaining.

```
TRUNCATE TABLE test_upd;

INSERT INTO test_upd SELECT test_upd_sq.nextval, object_name, NULL, NULL
  FROM all_objects
  CROSS JOIN (SELECT LEVEL AS num FROM dual CONNECT BY LEVEL <= 3) lvl;
COMMIT; -- creates 20K to 30K rows on Oracle XE databases

CREATE OR REPLACE PACKAGE table_api
AS
PROCEDURE upd_all_initcap;
END table_api;
/
CREATE OR REPLACE PACKAGE BODY table_api
AS

PROCEDURE upd_all_initcap IS
   l_longops_rowid PLS_INTEGER := -1;
   l_longops_num   PLS_INTEGER;
   l_total_rows    INTEGER := 0;
   l_loop_idx      NUMBER := 0;
BEGIN
   -- pretend this is being done by the client application or at the top of the batch job
   -- I only include this here to demonstrate action and client_info changing over time
   dbms_application_info.set_module(module_name => 'table_api.upd_all_initcap'
                                   ,action_name => 'set client_id');
   dbms_application_info.set_client_info(client_info => 'Bill the Cat');
   dbms_lock.sleep(15); -- pause in order to bring up query on v$session
   dbms_session.set_identifier('Bill the Cat');

   SELECT COUNT(*)
     INTO l_total_rows -- needed for longops tracking
     FROM test_upd;

   dbms_application_info.set_action(action_name => 'loop all and update to initcap');
   FOR lr IN (SELECT * FROM test_upd) LOOP
      l_loop_idx := l_loop_idx + 1;
      dbms_application_info.set_client_info(client_info => 'updating ' || lr.id);
      UPDATE test_upd
         SET NAME   = INITCAP(NAME)
            ,mod_by = SYS_CONTEXT('userenv', 'client_identifier')
            ,mod_dt = SYSDATE
       WHERE ID = lr.id;
      dbms_application_info.set_session_longops(
       rindex      => l_longops_rowid -- first call should be -1, afterwards holds rowid of v
      ,slno        => l_longops_num -- used interally to communicate info between calls
      ,CONTEXT     => lr.id -- can be anything, we'll use it to store ID being processed
      ,op_name     => 'table_api.upd_all_initcap' -- the operation, limited to 64 chars
      ,target_desc => 'TEST_UPD' -- the target object of the DDL or DML statement
      ,totalwork   => l_total_rows -- total work you know the process must complete
      ,sofar       => l_loop_idx -- amount of work done so far
      ,units       => 'rows updated.'); -- units of measure for the values in totalwork and sofar
   END LOOP;
   dbms_application_info.set_client_info(client_info => NULL); -- cleanup client_info
```

```
   dbms_application_info.set_action(action_name => 'committing changes');
   COMMIT;
   dbms_lock.sleep(3); -- pause to observe effects in v$session
   dbms_application_info.set_module(module_name => NULL, action_name => NULL); -- cleanup the rest

END upd_all_initcap;

END table_api;
/

PROMPT Calling table_api.upd_all_initcap. Switch to another window and query V$SESSION,
V$SESSION_LONGOPS, V$SQL, and V$SQLAREA
SET SERVEROUTPUT ON SIZE 1000000
BEGIN
   table_api.upd_all_initcap;
END;
/
```

Code Fragment 5

While fragment 5 above is running, you can observe module, action, client_info and client_identifier changing as the session progresses using this simple query (or use a session window in OEM, TOAD or SQL Developer):

```
SELECT SID, serial#, username, taddr, lockwait, client_identifier, module, action, client_info,
osuser, machine, program, sql_id, wait_class, seconds_in_wait, state
  FROM v$session
 WHERE client_identifier = 'Bill the Cat';
```

Query 1

As the execution gets to the update loop[6], info will be put into V$SESSION_LONGOPS. This can be utilized like the query below to provide a fairly close approximation of a progress meter. Note however, that certain runtime response is not accounted for with this method of tracing, like recursive SQL for example.

```
-- Progress Bar query
SELECT s.module, s.action, s.client_info, s.client_identifier
      ,start_time AS "Started"
      ,'Operation: '||opname||' on '||NVL(target,NVL(target_desc,'--not given--'))||' is '||
       'Roughly ' || ROUND((((time_remaining+elapsed_seconds) - time_remaining) /
(time_remaining+elapsed_seconds)) * 100) ||'% Complete' AS "Progress"
      ,ROUND((time_remaining/60),1)||' minutes' AS "Remaining"
      ,vsql.sql_text
  FROM v$session_longops l
  JOIN v$session s ON l.sid = s.sid AND l.serial# = s.serial#
  JOIN v$sqltext vsql ON vsql.hash_value = s.sql_hash_value AND vsql.piece = 0
 WHERE s.client_identifier = 'Bill the Cat'
   AND l.time_remaining > 0
 ORDER BY start_time DESC;
```

Query 2

Drawbacks to calling DBMS_APPLICATION_INFO routines pertain to the durability of the tags. Sometimes they stay around too long (if the developer forgets to clear them out[7]). This is especially risky with client_identifier, which could accuse

[6] Fragment 5 was coded wastefully on purpose so it would take a while, thus allowing us to observe progress over time.

[7] If modifying your application's connection classes to pass the client_id, also modify them to clear package state, application contexts, and session tags before returning the database connection to the pool.

the wrong user as the changer of sensitive data. Sometimes they are cleared or overwritten prematurely. This is particularly tricky if one instrumented routine with tags calls another instrumented routine with tags. This wipes out the session tags from the calling routine, leaving the incorrect tags in place once control returns from the subroutine. So although DBMS_APPLICATION_INFO should be an integral part of an instrumentation library, it is no fun to type repeatedly and it should be wrapped in a library to handle nested tagging.

UTL_FILE

The UTL_FILE package provides the low-level API required of any logging solution that wishes to write to host files. As long as a file has been successfully opened in write or append mode, calling UTL_FILE.put_line will send a message to the file, formatted as desired[8], independent of the encompassing transaction. However, using all of UTL_FILE's constants, exceptions and routines is rather involved and prone to human error. It is best to wrap this in a custom file-logging API that hides much of the complexity for your developers.

DBMS_SYSTEM

SYS.DBMS_SYSTEM includes the ksdwrt() routine, which lets you write messages directly to the alert log, independent of the containing transaction[9]. It is the closest thing Oracle includes that almost matches our needs for logging. If the client identifier has been set, it will be used in the alert log entry, helping pinpoint *who* generated a particular message. A timestamp will be written, along with other session metadata like client module (program), client machine name and address, module, and host process ID. If we use the following call to log an error with instructions, we expect one line in the alert log:

```
SET SERVEROUTPUT ON SIZE 1000000
DECLARE
   l_facility INTEGER := 10125;
BEGIN
   -- pretend we're in a loop, reading all imported data from each plant across the globe,
   -- processing each one and that one facility didn't import data
   sys.dbms_system.ksdwrt(
    2
   ,'WARNING! Facility ' || l_facility ||' has no data to import. ' || CHR(10) ||
    '1> Check import table.' || CHR(10) ||
    '2> Check network connectivity between offices.' || CHR(10) ||
    '3> Call facility manager.');
END;
/
```

Code Fragment 6

But this is what we actually get:

```
<msg time='2012-02-22T02:10:35.868-07:00' org_id='oracle' comp_id='rdbms'
 client_id='' type='UNKNOWN' level='16'
 host_id='R9AXR65' host_addr='fe80::89da:1322:6c01:b142%10' module='PL/SQL Developer'
 pid='7944'>
 <txt>WARNING! Facility 10125 has no data to import.
 </txt>
</msg>
<msg time='2012-02-22T02:10:35.888-07:00' org_id='oracle' comp_id='rdbms'
 client_id='' type='UNKNOWN' level='16'
 host_id='R9AXR65' host_addr='fe80::89da:1322:6c01:b142%10' module='PL/SQL Developer'
 pid='7944'>
 <txt>1&gt; Check import table.
 </txt>
</msg>
<msg time='2012-02-22T02:10:35.888-07:00' org_id='oracle' comp_id='rdbms'
 client_id='' type='UNKNOWN' level='16'
 host_id='R9AXR65' host_addr='fe80::89da:1322:6c01:b142%10' module='PL/SQL Developer'
 pid='7944'>
```

[8] Up to 32K characters per line.

[9] The first parameter to ksdwrt must be 2 if writing to the alert log.

```
 <txt>2&gt; Check network connectivity between offices.
 </txt>
</msg>
<msg time='2012-02-22T02:10:35.889-07:00' org_id='oracle' comp_id='rdbms'
 client_id='' type='UNKNOWN' level='16'
 host_id='R9AXR65' host_addr='fe80::89da:1322:6c01:b142%10' module='PL/SQL Developer'
 pid='7944'>
 <txt>3&gt; Call facility manager.
 </txt>
</msg>
```

Listing 1

Oddly, each new line in your message is interpreted by ksdwrt as a separate message. The timestamp isn't even the same between them. This will make monitoring and mining of the alert log's application messages rather tricky. Further, note that normal characters are escaped with their HTML equivalents, making some messages hard to read outside of a browser.

DBMS_SYSTEM is not typically granted to non-SYSDBA accounts (for good reason). Writing to the alert log is not a great idea either. Plus you can't control the format of the log messages. Think very carefully before opening its use up to non-SYS accounts or roles.

METADATA GATHERING ROUTINES

There are a number of scattered helper routines and built-in functions that can return metatadata about the connected client, database host, database, instance, version, etc. These are things like DBMS_UTILITY.current_instance(), DBMS_DB_VERSION.version() and release(), and SYS_CONTEXT('USERENV','<attribute>') which offers a host of values describing the current session. These should be included in your instrumentation library so that they get used and used consistently when logging messages.

REQUIREMENTS OF AN INSTRUMENTATION LIBRARY

Having reviewed some typical emergency scenarios and the limitations of built-in Oracle instrumentation, a clearer picture of instrumentation requirements begins to form.

1. Simple API to measure elapsed time. Ideally allow multiple running timers and nested timers (in case one instrumented routine calls another).
2. Simple API to log a message that is independent from the calling transaction. Must be configurable to output to the screen and a logging table. Good if file output is also offered. Output to named DBMS_PIPE or FTP server is nice-to-have, but not essential. Allow different types of messages so that debug messages are ignored until requested. Excellent if debug messages can be enabled for a given user, PL/SQL object, named business process or active session.
3. Standardized, simple method to log and handle exceptions and user-defined error messages.
4. Simple API to write to files on the host system. Should be able to write many lines at a time to aid performance.
5. Simple API to tag/untag sessions and track long operations. Ideally allow nested tagging (in case one instrumented routine calls another).
6. Some aids to ease the creation of column-level audit tables and triggers.
7. Routines to simplify the retrieval of session, client and database metadata. Meant to be used independently and transparently by the logging API, but can be called directly as well.

EXISTING INSTRUMENTATION LIBRARIES

Before designing a custom instrumentation library, it is a good idea to survey the current market and determine if any already satisfy requirements. Ten years ago, there were about two choices. Today there are a number to choose from. Those that claim to be full PL/SQL application frameworks are lightly shaded.

Resource Name	License	Purpose	Location & Notes
Google Code	Free	Library of libraries	http://code.google.com/hosting/search?q=label:plsql
Feuerstein PL/SQL Obsession	Free	Repository of all things SF and PL/SQL	http://www.toadworld.com/sf
QCGU (Quest CodeGen Utility)	Free	Full framework, Standards, Scripts, Template Factory, Code Generation, etc.	http://codegen.inside.quest.com/index.jspa Latest incarnation of Feuerstein's vast reservoir of experience. (successor of QXNO, PL/Vision, and PL/Generator.)
PL/SQL Starter	Free	Full framework. Standards.	http://sourceforge.net/projects/plsqlframestart
Simple Starter	Free	Logging, Timing, Auditing, Debugging, Error Handling, etc.	Simplified PL/SQL Starter to just logging, timing and auditing components (and the low-level packages they depend on). Designed to be used in one schema. Install and begin using in under a minute.
GED Toolkit	$120-$1200	Almost full framework	http://gedtoolkit.com Includes APEX UI to administer jobs and tables. Monitor processing.
PL/Vision	Free	Framework, API Generator, + more	http://toadworld.com/Downloads/PLVisionFreeware/tabid/687/Default.aspx Replaced by QXNO and then QCGU. Not supported.
Log4ora	Free	Logging	http://code.google.com/p/log4ora/ Fresh, full-featured logging library. Alerts. AQ. Easy to use. Good stuff.
ILO	Free	Timing and Tuning	http://sourceforge.net/projects/ilo From the sharp minds at Hotsos
Quest Error Manager	Free	Error Handling	http://www.toadworld.com/LinkClick.aspx?link=685&tabid=153 Included in QCGU. But offered separately as well. Not supported.
Plsql-commons	Free	Collection of utilities, including logging	http://code.google.com/p/plsql-commons
Log4oracle-plsql	Free	Logging	http://code.google.com/p/log4oracle-plsql Seems like an active project, but could not find code to download…
Log4PLSQL	Free	Logging	http://sourceforge.net/projects/log4plsql Popular, but aging and complex log4j analog in PL/SQL
Logger	Free	Logging	http://sn.im/logger1.4 Recently orphaned when Oracle decommissioned its samplecode site. Simple. Easy to use.
Orate	Free	Logging	http://sourceforge.net/projects/orate Never used it, but has been around a while. Still active.

Table 1

Many of the above are quite good. Some are limited to just logging. Some are more complex to use than others. Whatever the choice, or combination of choices, after adopting the libraries and peppering production code with instrumentation, it should be child's play to examine the audit and logging tables, and enable debugging, when things go wrong, to immediately see:

- who called the routine, their IP address, client machine name, and client OS user name
- when they called the routine, how long the subroutines took, and how long the entire call took
- what the call accomplished, the number of iterations, the current iteration, the value(s) passed back
- parameter values passed into the routine, as well as changing and derived variables determined within
- old and new column values if data is changing
- path the call took through the control statements
- anomalies, warnings and errors detected, etc.

Wouldn't that be sweet?

In my decidedly biased opinion, the easiest offering to begin using, which satisfies the requirements on the previous page, is the "Simple" version of the open-sourced PL/SQL Starter Framework. The remainder of this paper will walk through the Simple Starter model, how to install and configure it, and provide examples of adding instrumentation to production code. Although this paper will demonstrate only one framework, it is hoped the reader will evaluate the other libraries for their merits and catch the vision of how easy it is to use any of them to add maturity and maintainability to applications.

PL/SQL "STARTER" FRAMEWORK: THE SIMPLE[R] VERSION

This seasoned PL/SQL framework has been covered in previous presentations at RMOUG and IOUG. It is a shared application infrastructure which can support many applications resident in different schemas on the same database. Even though it has been simplified over the last decade, due to its flexibility and set of 21 major services, it still requires 55 objects to operate and a 60 page document to explain in full. This is too much of a learning curve for some fast-moving developers and they give up prematurely.

So for this presentation, and for those who only want to use instrumentation in a single schema, the framework was slimmed down again to 17 objects, offering 7 major services. The seven libraries include those needed for instrumentation: Auditing, Metrics, Debugging/Logging and some "extras" like Standardized Error Handling, File Operations and Connection Metadata (without which the first four wouldn't function).

INSTALLATION AND CONFIGURATION

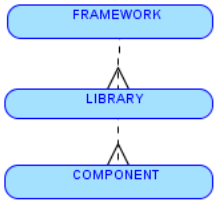
Go to SourceForge and search for PL/SQL Framework. It should be the first result, next to an icon depicting a warm loaf of bread raised with sourdough starter (yes, it was yummy). Click through to the project's homepage. Find and click "Browse all files". Then drill into the plsqlfmwksimple/2.1 folder.

- Download and unzip Simple.zip.
- If installing to an existing schema, open *__InstallSimpleFmwk.sql* and comment out the DROP USER and CREATE USER statements.
- Start SQL*Plus or a Command window in PL/SQL Developer as SYS and run *__InstallSimpleFmwk.sql*. It will run you through a few questions, and then create the objects it needs to function.

That's it! There is no further configuration required. If any of the choices weren't quite right, drop the schema and re-install. Some of the install choices are recorded in the APP_PARM table. You may adjust these as you see fit if directories or subfolders change.

INSTALLED OBJECTS

Frameworks are collections of related libraries, and *libraries* are collections of related components. A *component* is the finest-grain building block upon which a framework-based application is built. Logically this relationship looks like the model to the right:



Applied to database application frameworks, the component is implemented as an Oracle object, including triggers, types, tables, views and routines (I use the generic term *routine* when referring to a packaged function or procedure.) The library will often present its interface within a PL/SQL package. And the framework is the entire collection of packages and all the components of each.

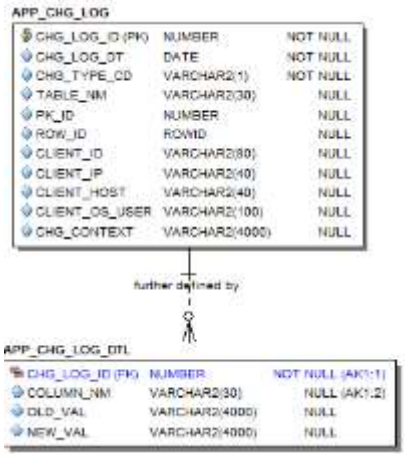
Within the Simple Starter Framework, one finds the following libraries. Although it is good to get familiar with all the components and read the extensive comments in the package specifications, one only need study the items below in red font to prepare to instrument: code:

Library	Main Routines	Supporting Objects and Notes
Auditing: **gen_audit_triggers.sql**		APP_CHG_LOG, APP_CHG_LOG_DTL (tables)
Metrics: **TIMER** (package)	**startme()** **stopme()** **elapsed()**	DBMS_UTILITY
Debugging, Logging and Error Handling: **LOGS** (package) EXCP (package meant to be used only by LOGS) APP_LOG_API (pkg meant to be used only by LOGS)	**err()** **warn()** **info()** **dbg()**	APP_LOG (table) TRIM_APP_LOG (scheduled job)
Connection Metadata: **ENV** (package)	**init/reset_client_ctx()** **tag/untag()** **tag_longop()**	DBMS_DB_VERSION, DBMS_APPLICATION_INFO, DBMS_SYSTEM, v$session and v$mystat.
File Operations: IO (package meant to be used primarily by LOGS)	write_line() write_lines(0 p()	UTL_FILE, DBMS_LOB
Dynamic (Table-Driven) Parameters/Properties: PARM (package)	get_val()	APP_PARM (table)

Extras (required for the seven libraries above to function): CNST, TYP, DDL_UTILS, DT, STR, NUM (packages)	These are libraries of application-wide constants and subtypes, build utility functions; date, string and number manipulation routines.

Table 2

COLUMN-LEVEL AUDITING



There are at least six different ways to record changes to data over time. Simple Starter takes a generic approach, with one table, APP_CHG_LOG recording the metadata about the row being changed. The child table, APP_CHG_LOG_DTL keeps one row of old/new values for each column changed in a row.

Once columns are identified that must be audited -- in particular financial and legal data -- it is very easy to start auditing them. Starter includes a script named *gen_audit_triggers.sql*. As the table-owning schema, run this script. It will output an audit trigger to a spooled file for each table[10] in the schema. Modify the resulting triggers, removing code that tracks changes to columns that are of no interest. Then compile the triggers. Fine-grained changes will now be tracked in the APP_CHG_LOG tables!

The best part about this framework-driven approach to auditing is the synergy with the ENV library. The audit triggers call upon the ENV functions to transparently record exactly which user made the change, when, which IP and box they connected from, etc.

The generic approach to auditing changed columns is fine for what I call "emergency auditing." This sort of audit data is only queried in emergencies, in the rare case the company is sued, or someone misappropriates funds, or a regulatory agency questions recent rate hikes, etc. The way the changes are stored "vertically", in the attributive APP_CHG_LOG_DTL table, makes it somewhat slow to retrieve and/or flatten the data into a single, more easily-read row of changes. Due to this performance drawback, if your application has requirements to frequently view changes, say for a history page or on-demand report, consider a materialized view on top of Starter's audit tables, or create a new custom audit table and trigger to populate it. For a typical custom audit table, a copy of the base table is created, replacing each base column with a pair of columns to record the old/new values.

PARTITIONING THE AUDIT TABLES

If you anticipate auditing large volumes of data, and you have license to Oracle Enterprise Edition with Partitioning, consider partitioning the two APP_CHG_LOG tables. This makes it trivial to drop months or years off the back end of the table as they age out of the corporate data retention period. The additional DDL to partition is commented out in the install script. It is written to 11g and takes advantage of reference partitioning for APP_CHG_LOG_DTL. If still using 10g, add chg_log_dt to APP_CHG_LOG_DTL and include that column in the range partitioning key.

METRICS

It is said that one cannot manage that which is not measured. If all of the system's database routines are sub-second, single-row operations, you might get by with have no timing instrumentation in place. However, anything longer or more complex than that should be timed. Taking timing measurements imposes virtually no overhead on the system, so leave timings in place in production code.

Starter's timing routines are kept in the TIMER package, which includes three simple routines: startme(), stopme() and the function elapsed().

Each of them takes a single parameter, which is the name of the thing being measured.

Each time startme() is called with a new name, a new "timer" is created. Naming each timer lets us have multiple timers all running at once. With this ability, each piece of a backend process can be timed: the overall driver or process, each routine called, their subroutines, loop iterations, etc. Timers can be sampled, or peeked into, by calling elapsed(). Once a timer has been stopped, the time returned by elapsed will be static. Timers can be restarted, although I've never found a reason to do so.

The elapsed times measured can be written statically using LOGS.info(), or dynamically by embedding them in LOGS.dbg() calls. Once timers are in place and recorded to table or file, the measurements can be monitored or mined to watch for system degradation or improvement, assist with application or database upgrade regression testing, etc.

[10] If auditing is needed only for a few tables, modify the WHERE filter in the script's driving SQL before running it.

If lazy or in a great hurry, the TIMER routines can be called without passing a timer name. If TIMER.startme is called without a name, a generic name will be generated for it. However, this defaulting means you are limited to just that one timer in that session. So always name your timers. Here is an example of TIMER in action:

```
timer.startme('outer loop');
FOR l_rec IN cur_load_waiting LOOP
   timer.startme('load');
   loader.process(l_rec);
   timer.stopme('load');
   logs.dbg('Processing load ID '||l_rec.id||' took '||timer.elapsed('load')||' seconds.');
END LOOP;
timer.stopme('outer loop');
logs.dbg('Loading took '||timer.elapsed('outer loop')||' seconds.');
```

Code Fragment 7

DEBUGGING AND LOGGING

The library for logging, debugging and recording metrics is the LOGS[11] package. Simple Starter allows one to log to the file system, a table, or the screen. It defaults to table and screen. The output destinations can be altered through the parameter *Default Log Targets* in APP_PARM, or dynamically through LOGS.set_log_targets(). I find logging to the screen useful in development, and logging to a generic logging table useful for all other environments.

Although the logging table model to the right seems busy, the only thing you really need worry about is what type of a log message it is, and the message itself. The rest of the fields are filled automatically by the LOGS library of routines, assuming ENV is being used correctly.

APP_LOG

LOG_ID (PK)	NUMBER	NOT NULL
LOG_TS	TIMESTAMP(6)	NOT NULL
SEV_CD	VARCHAR2(30)	NOT NULL
ROUTINE_NM	VARCHAR2(80)	NULL
LINE_NUM	NUMBER	NULL
LOG_TXT	VARCHAR2(4000)	NULL
CLIENT_ID	VARCHAR2(80)	NULL
CLIENT_IP	VARCHAR2(40)	NULL
CLIENT_HOST	VARCHAR2(40)	NULL
CLIENT_OS_USER	VARCHAR2(100)	NULL

ERRORS

Serious processing errors, raised as PL/SQL exceptions, are those that should probably halt processing right away. It is a best practice to ban the use of WHEN OTHERS in PL/SQL exception clauses, trapping only expected errors, allowing unexpected errors to immediately bubble to the top of the call stack, rollback the transaction and report where the error occurred. And yet almost every Oracle shop I've visited or worked in seems to have a love affair with WHEN OTHERS, capturing every exception, logging it, and then either accidentally or purposefully hiding the error.

If your code has some known exceptions it needs to trap and log, capture the known errors by exception name[12]. Do any necessary cleanup (like explicitly closing files and cursors). Then log the error and the context around it using LOGS.err(), which will automatically re-raise the error after writing to APP_LOG. See the example in code fragment 10 further below.

LOGS.err() can be called with no arguments. It will derive the exception from SQLERRM, log it, and re-raise the error. But most will want to include a little runtime context (parameters and variables) in the message being logged along with the error. Pass this into the first parameter of LOGS.err(). All the other metadata surrounding the client session, the package name, routine name, line number, user ID, and timestamp will be automatically recorded for you.

It is essential that your shop adopt and enforce the use of a rigorous standard for handling expected exceptions. The unconvinced reader is directed to Steven Feuerstein's online writings on this subject for the reasons behind this statement. Using LOGS.err() fulfills that best practice.

WARNINGS

Warnings are expected exceptions that may or may not warrant further attention. These are the sorts of conditions that should probably be reviewed in the next few hours to ensure it isn't a symptom of something worse, but in general, warning messages can wait. Error messages cannot.

To log a warning message, call LOGS.warn(). It carries the i_msg formal parameter as well, so additional context can be included along with the warning message.

---

[11] Despite a personal aversion to the plural form of entity names, the singular "LOG" could not be used as it was an Oracle keyword

[12] Use PRAGMA EXCEPTION_INIT to bind the local exception to the expected Oracle error number.

Informational Messages

Finally, there is application logging. This kind of logging is often used to form a historical data trail indicating how long some process took to run, which files were available at the time of process initialization, which organization is no longer found in the master data, etc. Anything you want permanently and immediately recorded about the session can use LOGS.info() to get a message stored into APP_LOG. This is the routine used to record timing metrics as well.

Debugging

The debugging component of the logging library is table-driven. It is meant to be dynamic, where you can turn on debug logging in Production (without compiling or invalidating anything) for a specific session, package, named process, job, schema or client identifier. With the Debug toggle turned off, all calls to LOGS.dbg consume miniscule overhead and are not observed. But when the toggle is on, the strings and variables passed to LOGS.dbg are logged to the current log targets for the application (see *Default Log Targets* in APP_PARM).

To turn it on for all objects, you simply update the value of the *Debug* parameter in APP_PARM to any case-insensitive positive string (on, y, Y, yes, TRUE, etc.). To turn it on for a user, update the parameter to "user=*userID*" where the userID matches the client ID passed to ENV.init_client_ctx by the application. Or the parameter can be "unit=*pl/sql object name(s)*" to observe debug messages only for the named object, or comma-separated list of objects. Or if you need to enable debug messages for an active session that may be having issues, update the parameter to "session=*sessionID.*" Then you only need wait the amount of time indicated by the *Debug Toggle Check Interval* parameter in APP_PARM, which defaults to 1 minutes. After that period has passed, debug messages will begin appearing in APP_LOG.

When I code, I first write the public interface's comment block, then the interface, then the tests, then the implementation. When coding the implementation, I first use pseudo-code in PL/SQL comments to outline the algorithm. Later, as I'm filling in the code I wrap the pseudo-code, along with context (like parameters and local variables) into calls to LOGS.dbg, like this:

```
logs.dbg('Processing salesperson '||l_rec.emp_name||'. Iteration '||l_idx);
```

This *accomplishes three things at the same time*: comments the code, provides built-in debug calls that can remain in production code, and enriches the debug calls with dynamic runtime context (something regular PL/SQL comments cannot do).

Monitoring, Tracing and Troubleshooting

A subset of the routines in the ENV package set the previously mentioned *module*, *action* and *client_info* values into session performance metadata and active session history. They are a wonderful way of providing real-time, dynamic views into what your program is actually working on. Looking at these values can tell you what it last started doing, provided the code is instrumented to identify the latest module or action before starting on the next step. ENV provides a simple interface to place these values into the session, and to remove them, named ENV.tag() and untag(). You should find these easier to type and remember than the DBMS_APPLICATION_INFO routines and their nuances.

```
env.tag('REPORTS.print_and_send_ps', 'Open cur_read_ps_db cursor');
logs.dbg('Reading and storing all problem/solution rows');
FOR l_rec IN ps_dml.cur_read_ps_db LOOP
   ...
END LOOP;
env.untag();
```

Code Fragment 8

ENV also now includes a routine that makes it smooth and simple to track long operations in the v$session_longops view, called ENV.tag_longop(). Examine this snippet, a revision of the manually instrumented code seen in fragment 5, but using the simple library calls:

```
CREATE OR REPLACE PACKAGE table_api
AS
PROCEDURE upd_all_initcap;
END table_api;
```

```
/
CREATE OR REPLACE PACKAGE BODY table_api
AS

PROCEDURE upd_all_initcap IS
   l_longop        env.t_longop;
BEGIN
   env.tag(i_info => 'set client ID');
   env.init_client_ctx('Bill the Cat');
   -- pretend this is being done by the client application or at the top of the batch job
   -- I only include this here to demonstrate action and client_info changing over time
   dbms_lock.sleep(10);

   env.tag(i_info => 'get TEST_UPD size');
   SELECT COUNT(*)
     INTO l_longop.total_work -- needed for longops tracking
     FROM test_upd;
   dbms_lock.sleep(5);

   env.tag(i_info => 'loop TEST_UPD and update to initcap');
   l_longop.op_nm := 'loop and update initcap';
   l_longop.units_of_measure := 'rows updated.';
   l_longop.work_target := 'TEST_UPD';
   env.tag_longop(l_longop); -- seed row, then do the operation

   FOR lr IN (SELECT * FROM test_upd) LOOP
      l_longop.work_done := l_longop.work_done + 1;
      env.tag(i_info => 'updating ' || lr.id);
      UPDATE test_upd
         SET NAME   = INITCAP(NAME)
            ,mod_by = SYS_CONTEXT('userenv', 'client_identifier')
            ,mod_dt = SYSDATE
       WHERE ID = lr.id;
      env.tag_longop(l_longop);
   END LOOP;
   env.untag; -- cleanup client_info

   env.tag(i_info => 'committing changes');
   COMMIT;
   dbms_lock.sleep(3);
   env.untag; -- cleanup the rest

END upd_all_initcap;

END table_api;
/

PROMPT Calling table_api.upd_all_initcap. Switch to another window and query V$SESSION and
V$SESSION_LONGOPS
BEGIN
   table_api.upd_all_initcap;
END;
/
```

Code Fragment 9

PUTTING IT ALL TOGETHER

Here is a chunk of example code showing the use of timing, application logging, error logging, monitoring and dynamic debug logging. This is taken from the ProblemSolutionApp folder of the *Simple.zip* file and will work if you also run *__InstallProblemSolutionApp.sql* file as your install schema (APP by default):

```
CREATE OR REPLACE PACKAGE reports
AS
rpt_div_line CONSTANT VARCHAR2(80) := RPAD('*',80,'*');
-- Pass an email address if on non-Prod
PROCEDURE print_and_send_ps(i_email_addr IN VARCHAR2 DEFAULT NULL);

END reports;
/

CREATE OR REPLACE PACKAGE BODY reports
AS

PROCEDURE print_and_send_ps
(
  i_email_addr IN VARCHAR2 DEFAULT NULL
)
IS

   CURSOR cur_read_ps_db IS
   SELECT prob_src_nm
         ,prob_key
         ,prob_key_txt
         ,prob_notes
         ,sol_notes
         ,seq
     FROM (SELECT ps.prob_src_id
                 ,ps.prob_src_nm
                 ,p.prob_key
                 ,p.prob_key_txt
                 ,p.prob_notes
                 ,ROW_NUMBER() OVER(PARTITION BY s.prob_id ORDER BY s.sol_id) AS seq
                 ,s.sol_notes
             FROM ps_prob p
             JOIN ps_prob_src ps
               ON ps.prob_src_id = p.prob_src_id
             JOIN ps_sol s
               ON s.prob_id = p.prob_id)
    ORDER BY prob_src_id
            ,prob_key
            ,seq;

   l_lines    typ.tas_maxvc2;
   l_email    CLOB := EMPTY_CLOB();
   l_filename VARCHAR2(128) := 'rpt_probsol_'||TO_CHAR(SYSDATE,'YYYYMMDD')||'.txt';
   l_loop_idx INTEGER := 0;

BEGIN
   excp.assert(i_email_addr IS NOT NULL,'Destination email address required.', TRUE);
```

```
   timer.startme('read_db_write_file');

   logs.dbg('Checking for file '||l_filename);
   IF (io.file_exists(l_filename)) THEN
      logs.dbg('Deleting file '||l_filename);
      io.delete_file(l_filename);
   END IF;

   env.tag(i_module => 'REPORTS.print_and_send_ps', i_action => 'Open cur_read_ps_db cursor',
i_info => '');

   logs.dbg('Reading and storing all problem/solution rows');
   FOR l_rec IN cur_read_ps_db LOOP

      DECLARE
         PROCEDURE handle_line(i_line IN VARCHAR2) IS
         BEGIN
            l_lines(l_lines.COUNT+1) := i_line;
            l_email := l_email || i_line || CHR(10);
         EXCEPTION
            WHEN OTHERS THEN -- I hate this, but use here for brevity of demo
               logs.err;
         END handle_line;
      BEGIN
         l_loop_idx := l_loop_idx + 1; -- placed to demo variable watches and conditional loops

         IF (l_lines.COUNT = 0) THEN -- Add header if nothing in report yet
            handle_line(str.ctr(RPT_DIV_LINE));
            handle_line(str.ctr('Printout of the Problem/Solution Database'));
            handle_line(str.ctr(TO_CHAR(SYSDATE, 'YYYY Month DD')));
            handle_line(str.ctr(RPT_DIV_LINE)
                        ||CHR(10));
         END IF;
         handle_line('Type [' || l_rec.prob_src_nm || '] Key [' ||
                     l_rec.prob_key || '] Error [' || l_rec.prob_key_txt || ']');
         handle_line('Comments:');
         handle_line(CHR(9) || l_rec.prob_notes);
         handle_line('Solution #'||l_rec.seq||':');
         handle_line(CHR(9) || l_rec.sol_notes || CHR(10));
         handle_line('-----------------------------------------');

      END;

   END LOOP;
   env.untag();

   logs.dbg('Writing '||l_lines.COUNT||' lines to file '||l_filename);
   io.write_lines(i_msgs => l_lines, i_file_nm => l_filename);

   timer.stopme('read_db_write_file');
   logs.info('Reading DB and writing file took '||timer.elapsed('read_db_write_file')||'
seconds.');

   -- Code used to email file here, but not possible on XE since Java engine not included
```

```
END print_and_send_ps;

END reports;
/
```

Code Fragment 10

CONCLUSION

Looking at the sample code above, it is hoped the reader can see how easy it is to take comments and wrap them in logs.dbg() calls, then add a little context to provide runtime perspective to the debug messages, a little tagging to enable easy troubleshooting, and at least two calls to logs.info() at the start and end to record timestamps and elapsed times. It didn't take more than a few minutes to fully instrument this otherwise bare code. If anything goes wrong with this process in the future, it could literally save hours to days of headscratching, downtime, poor-man's debugging in lower databases where the problem can't be replicated…you know, the usual.

Knowing that it takes only a couple minutes to download and install one of the open-source/free frameworks on the market, and start using it, it is my fondest wish the reader is inspired to do so now, today and not postpone any further the heavenly state that is instrumented code.