G54MDP
Mobile Device Programming

Lecture 10 – Storage

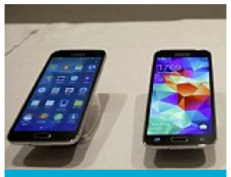

EXCLUSIVE - Wikileaks' lawyer


Newlywed who quit as a barrister to


Vulnerable children 'sold as prostitutes


Two hotel guests are found NOT


More than a quarter of London's


The Galaxy S5 isn't so perfect after all:

The Galaxy S5 isn't so perfect after all: MailOnline discovers that Samsung's flagship smartphone offers 6GB less storage than it claims

- **Smartphone was unveiled at Mobile World Congress in Barcelona along with Gear Fit - a wearable fitness device**
- **MailOnline reveals the 16GB Galaxy S5 only offers 10GB of space for personal files, photos and apps**
- **It has a 5.25-inch screen, 16MP camera and runs Android KitKat 4.4**
- **Comes in black, white, blue and gold and is dust and water resistant**

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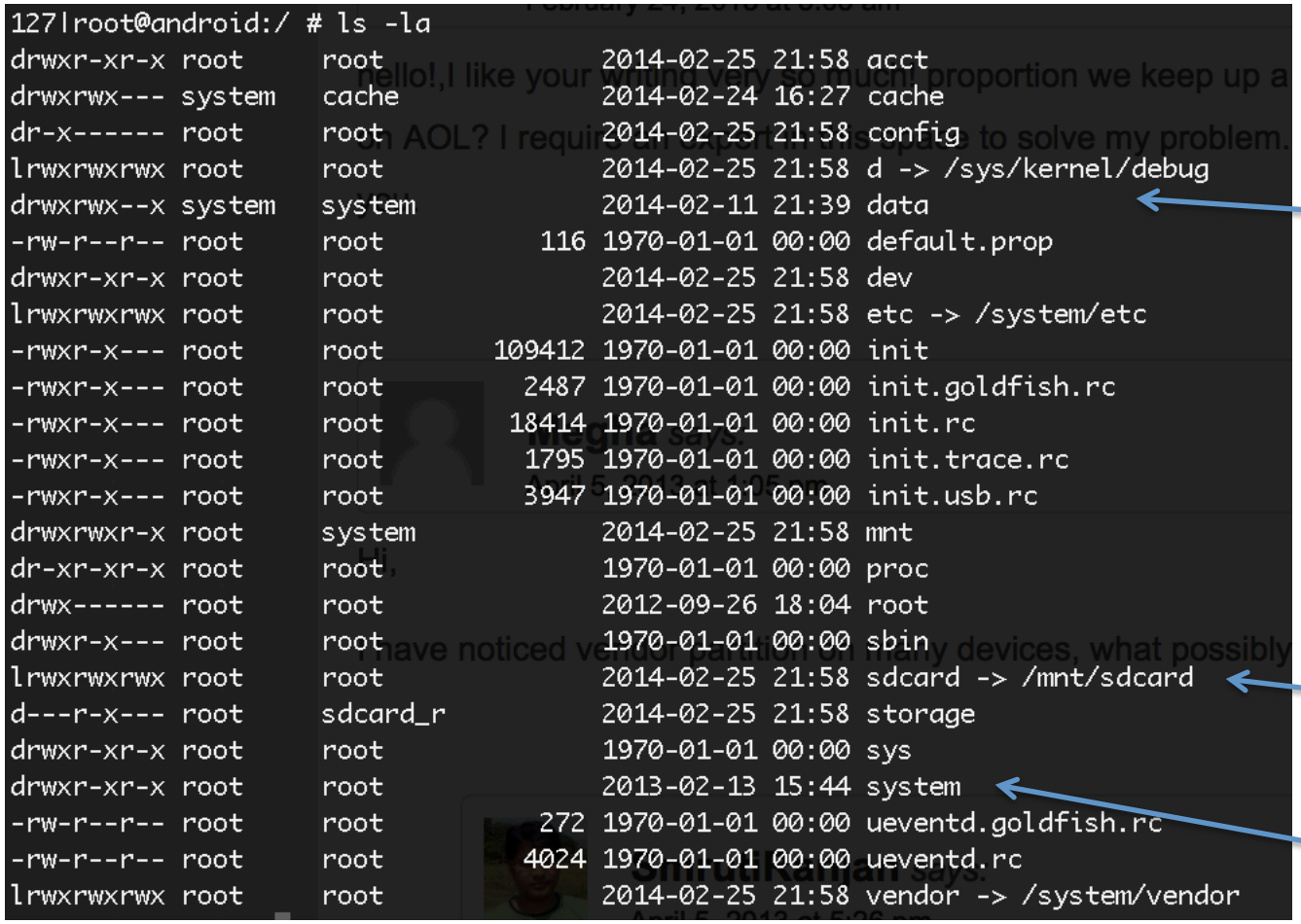
Logical Data Storage on Android

- File-based abstractions
  - Shared Preferences
    - Simple key value pairs
  - File-based storage
    - Internal Data Storage
      - Soldered RAM
      - Internal APK resources, temporary files
    - External Data Storage
      - SD Card
      - Large media files
  - SQLite Database
    - Structured data, small binary files
- Network
  - Shared contact lists, backups
  - SyncAdapter



"User" data – application data

"External" storage

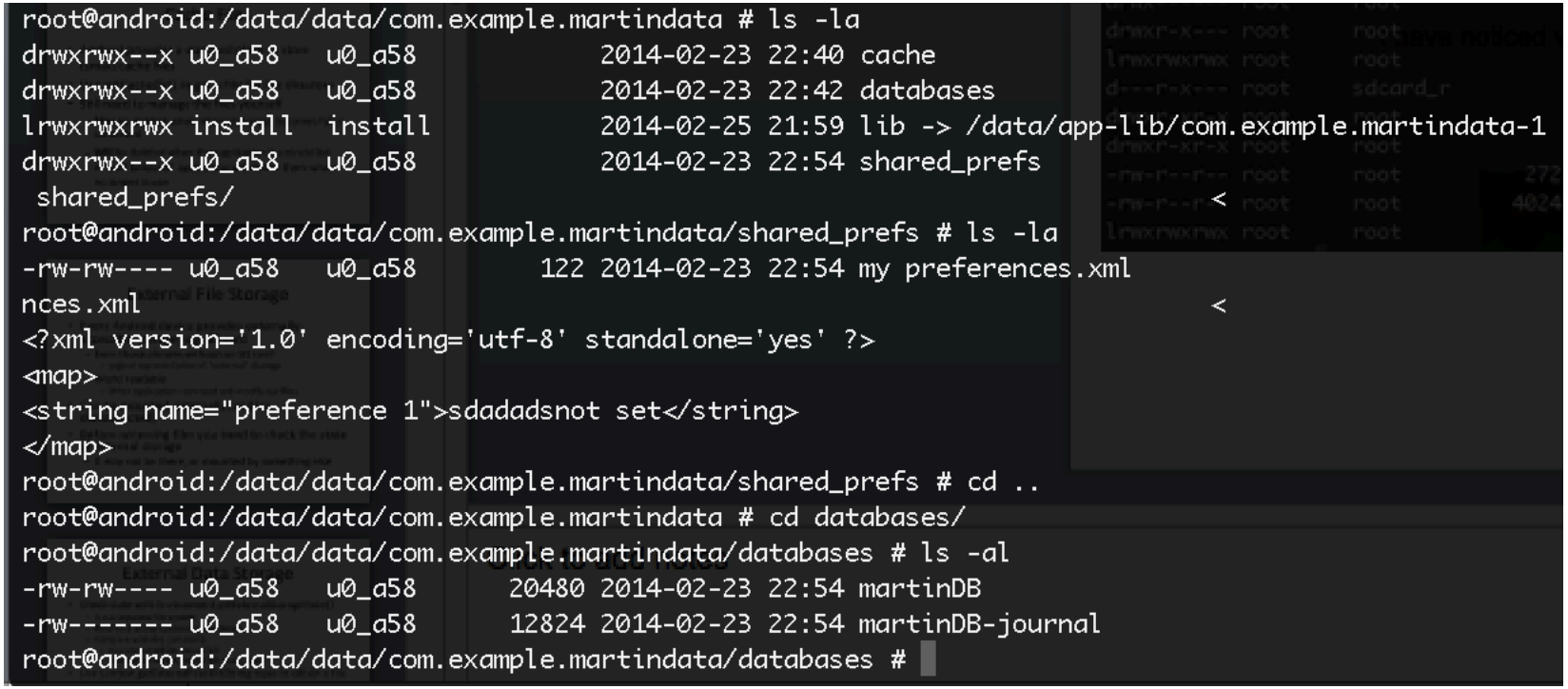
Android OS / libraries

Internal File Storage

- Internal Data storage is private to the app
  - Other apps (and the user) cannot access it
    - Kernel enforced user permissions
  - Removed on uninstall
  - Data is stored in Files
    - openRawResource
      - Can be used to read our own packaged resources
- Two methods are used to access files on internal storage
  - Context.openFileOutput(String name, int mode)
    - Returns a FileOutputStream
  - Context.openFileInput(String name)
    - Returns a FileInputStream
  - Don't forget to catch IOExceptions

Cache Files

- Android provides a standard place to store (small) cache files
- Use getCacheDir() to get a File for the directory
- Still need to manage the files yourself
  - **May** be deleted when internal storage becomes full / contested
  - **Will** be deleted when the application is uninstalled
  - A “well behaved” application will delete them when no longer in use
  - Recommended to use less than 1MB


root@android:/data/data/com.example.martindata # ls -la
drwxrwx--x u0_a58 u0_a58 2014-02-23 22:40 cache
drwxrwx--x u0_a58 u0_a58 2014-02-23 22:42 databases
lrwxrwxrwx install install 2014-02-25 21:59 lib -> /data/app-lib/com.example.martindata-1
drwxrwx--x u0_a58 u0_a58 2014-02-23 22:54 shared_prefs
shared_prefs/
root@android:/data/data/com.example.martindata/shared_prefs # ls -la
-rw-rw---- u0_a58 u0_a58 122 2014-02-23 22:54 my preferences.xml
nces.xml
<?xml version='1.0' encoding='utf-8' standalone='yes' ?>
<map>
<string name="preference 1">sdadadsnot set</string>
</map>
root@android:/data/data/com.example.martindata/shared_prefs # cd ..
root@android:/data/data/com.example.martindata # cd databases/
root@android:/data/data/com.example.martindata/databases # ls -al
-rw-rw---- u0_a58 u0_a58 20480 2014-02-23 22:54 martinDB
-rw------- u0_a58 u0_a58 12824 2014-02-23 22:54 martinDB-journal
root@android:/data/data/com.example.martindata/databases #

External File Storage

- Every Android device provides externally-accessible storage, e.g. SD card
  - Even those phones without an SD card
    - Logical representation of “external” storage
  - World readable
    - Other applications can read and modify our files
- Can be mounted externally (and/or disconnected)
- Before accessing files you need to check the state of external storage
  - It may not be there, or mounted by something else

External Data Storage

- Check state with Environment.getExternalStorageState()
  - It is a separate file system
  - Returns a String containing the details
  - Compare with the constants:
    - Environment.MEDIA_MOUNTED
    - Environment.MEDIA_MOUNTED_READ_ONLY
- Use Context.getExternalFilesDir(String type) to obtain a File for the directory
  - If you pass a type (it can be null) then returns a sub-directory of appropriate type
  - Used to enable the Media scanner to categorize material
  - Use File object returned to createNewFile()

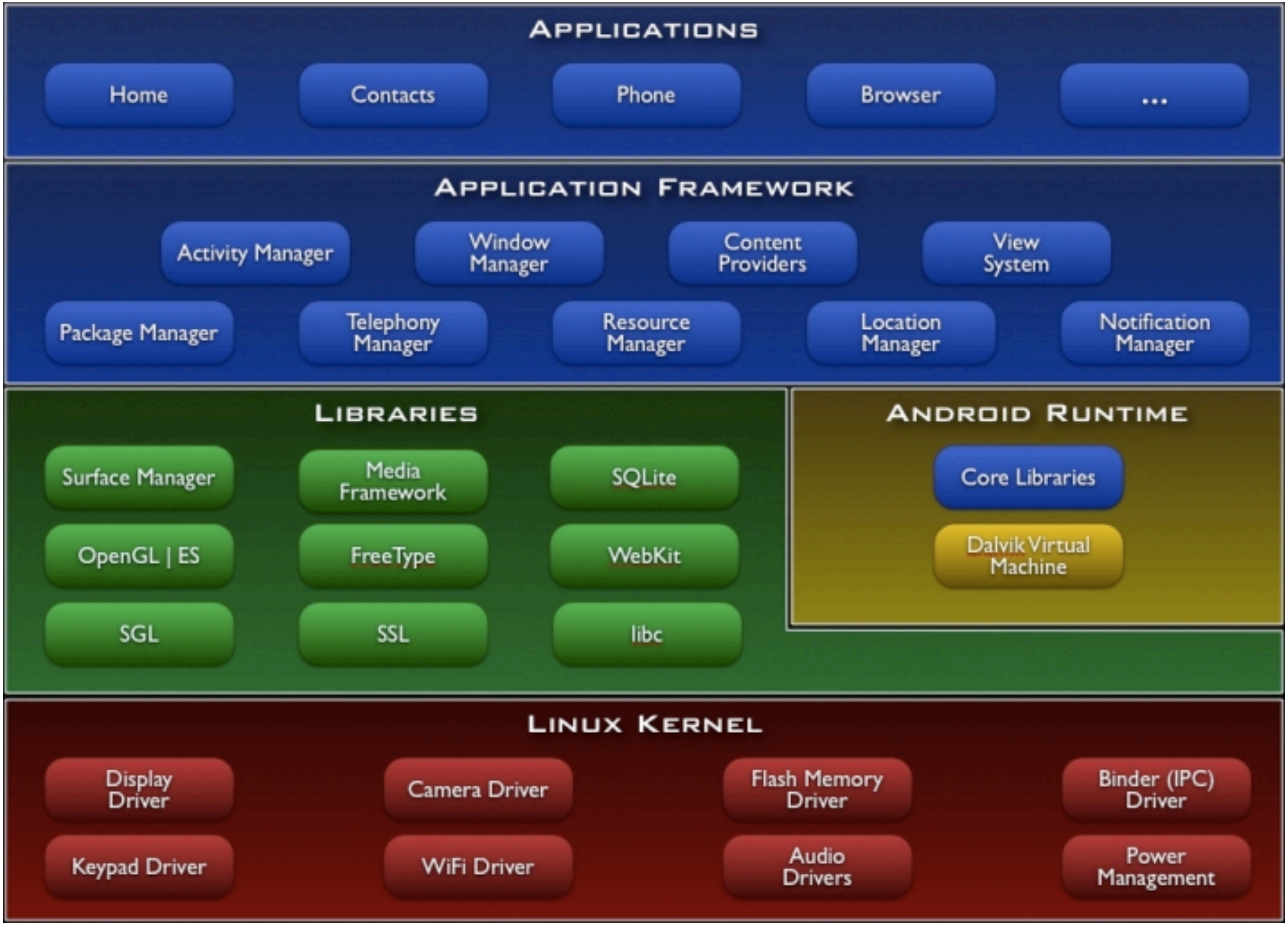
Fields		
public static String	DIRECTORY_ALARMS	Standard directory in which to the list of alarms that the user
public static String	DIRECTORY_DCIM	The traditional location for pict device as a camera.
public static String	DIRECTORY_DOWNLOADS	Standard directory in which to by the user.
public static String	DIRECTORY_MOVIES	Standard directory in which to user.
public static String	DIRECTORY_MUSIC	Standard directory in which to the regular list of music for the
public static String	DIRECTORY_NOTIFICATIONS	Standard directory in which to the list of notifications that the
public static String	DIRECTORY_PICTURES	Standard directory in which to user.
public static String	DIRECTORY_PODCASTS	Standard directory in which to the list of podcasts that the us
public static String	DIRECTORY_RINGTONES	Standard directory in which to the list of ringtones that the us

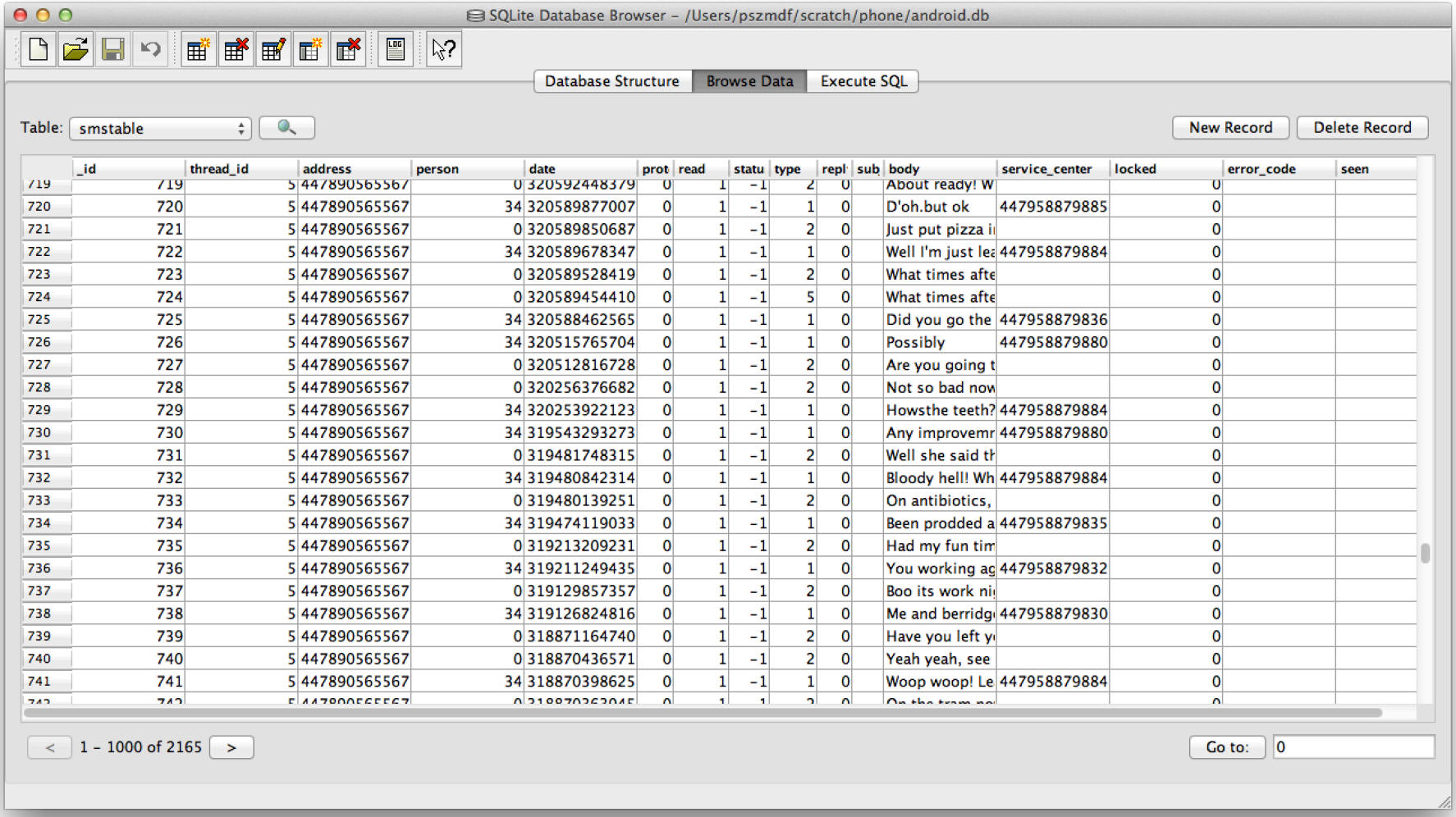
Structured Data

- Often the data we are storing is structured
- And we want to query it based on that structure
- Could store this in a file and write our own routines to access it
- Normally, we'd use a database to store it
  - E.g. An address book, music library
  - V.s. binary "blobs"
    - Images, mp3s
  - Media gallery?

Android Databases

- Android comes with local database support
  - Complete with the ability to run SQL queries
  - Each app's databases are local to it
- Uses SQLite
  - Public Domain software library
  - "A software library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine."
    - File based
  - "Most widely deployed software engine on the planet"


Applications
Home
Contacts
Phone
Browser
...
Application Framework
Activity Manager
Window Manager
Content Providers
View System
Package Manager
Telephony Manager
Resource Manager
Location Manager
Notification Manager
Libraries
Surface Manager
Media Framework
SQLite
OpenGL | ES
FreeType
WebKit
SGL
SSL
libc
Android Runtime
Core Libraries
Dalvik Virtual Machine
Linux Kernel
Display Driver
Camera Driver
Flash Memory Driver
Binder (IPC) Driver
Keypad Driver
WiFi Driver
Audio Drivers
Power Management


SQLite Database Browser – /Users/pszmdf/scratch/phone/android.db
Database Structure
Browse Data
Execute SQL
Table: smstable
New Record
Delete Record
_id thread_id address person date prot read statu type repl sub body service_center locked error_code seen
719 719 5 447890565567 0 320592448379 0 1 -1 2 0 About ready! W 0
720 720 5 447890565567 34 320589877007 0 1 -1 1 0 D'oh.but ok 447958879885 0
721 721 5 447890565567 0 320589850687 0 1 -1 2 0 Just put pizza i 0
722 722 5 447890565567 34 320589678347 0 1 -1 1 0 Well I'm just lea 447958879884 0
723 723 5 447890565567 0 320589528419 0 1 -1 2 0 What times afte 0
724 724 5 447890565567 0 320589454410 0 1 -1 5 0 What times afte 0
725 725 5 447890565567 34 320588462565 0 1 -1 1 0 Did you go the 447958879836 0
726 726 5 447890565567 34 320515765704 0 1 -1 1 0 Possibly 447958879880 0
727 727 5 447890565567 0 320512816728 0 1 -1 2 0 Are you going t 0
728 728 5 447890565567 0 320256376682 0 1 -1 2 0 Not so bad now 0
729 729 5 447890565567 34 320253922123 0 1 -1 1 0 Howsthe teeth? 447958879884 0
730 730 5 447890565567 34 319543293273 0 1 -1 1 0 Any improvemr 447958879880 0
731 731 5 447890565567 0 319481748315 0 1 -1 2 0 Well she said th 0
732 732 5 447890565567 34 319480842314 0 1 -1 1 0 Bloody hell! Wh 447958879884 0
733 733 5 447890565567 0 319480139251 0 1 -1 2 0 On antibiotics, 0
734 734 5 447890565567 34 319474119033 0 1 -1 1 0 Been prodded a 447958879835 0
735 735 5 447890565567 0 319213209231 0 1 -1 2 0 Had my fun tim 0
736 736 5 447890565567 34 319211249435 0 1 -1 1 0 You working ag 447958879832 0
737 737 5 447890565567 0 319129857357 0 1 -1 2 0 Boo its work ni 0
738 738 5 447890565567 34 319126824816 0 1 -1 1 0 Me and berridg 447958879830 0
739 739 5 447890565567 0 318871164740 0 1 -1 2 0 Have you left y 0
740 740 5 447890565567 0 318870436571 0 1 -1 2 0 Yeah yeah, see 0
741 741 5 447890565567 34 318870398625 0 1 -1 1 0 Woop woop! Le 447958879884 0
< 1 - 1000 of 2165 >
Go to: 0

Android and SQLite

- Wrapped up in two main classes
  - Database represented by SQLiteDatabase
    - Lets us run SQL queries on the database
  - Also provides SQLiteOpenHelper to help create the database

Using Databases

- SQLiteOpenHelper manages database creation and upgrades between versions
  - Create a subclass of it
  - Override onCreate to provide the code to create the database
  - Using SQL CREATE TABLE
  - Handled automatically
- Create an instance of our SQLiteOpenHelper subclass
- Obtain reference to SQLiteDatabase using:
  - getReadableDatabase()
  - getWriteableDatabase()
- Both return the same object, unless memory is low and can only open the DB readonly

Querying a Database

- SQLiteDatabase has many methods
- void execSQL()
  - used to run SQL queries that don't return anything
- More useful are query() and rawQuery()
  - These return a Cursor object that can be used to access the data
  - "Move" the Cursor around the results
  - Provides random access to the results

Querying a Database

- `Cursor rawQuery(String sql, String[] selectionArgs)`
  - processes a raw SQL query
  - `rawQuery("SELECT id, name FROM people WHERE name = ? AND id = ?", new String[] {”Martin", ”78"});`
- SQL has to be parsed so there is also query() where the SQL is exploded into separate strings
  - Simpler to construct a query programmatically
  - `Cursor query(String table, String[] columns, String selection, String[] selectionArgs, String groupBy, String having, String orderBy)`

Cursors

- Provides random access to results of a query
- Fairly self explanatory object
  - Enables you to step over all the rows returned by a query
  - Has a close() method to close the query when you are finished
    - don't wait for it to be garbage collected

abstract boolean	moveToFirst () Move the cursor to the first row.
abstract boolean	moveToLast () Move the cursor to the last row.
abstract boolean	moveToNext () Move the cursor to the next row.
abstract boolean	moveToPosition (int position) Move the cursor to an absolute position.
abstract boolean	moveToPrevious () Move the cursor to the previous row.

abstract float	getFloat (int columnIndex) Returns the value of the requested column as a float.
abstract int	getInt (int columnIndex) Returns the value of the requested column as an int.
abstract long	getLong (int columnIndex) Returns the value of the requested column as a long.
abstract int	getPosition () Returns the current position of the cursor in the row set.
abstract short	getShort (int columnIndex) Returns the value of the requested column as a short.
abstract String	getString (int columnIndex) Returns the value of the requested column as a String.

Databases in short

- Subclass SQLiteOpenHelper to create a database
- Use execSQL to create tables and insert data
- Use query to query the database and return multiple rows
- Manipulate a Cursor object to extract data from a query

Let’s have a look…

Content Providers

- Access to data is restricted to the app that owns it
  - Remember where the database file is?
  - If we want other apps to access our data, or we want to access other apps data
  - Then we need to provide or make use of a ContentProvider
    - Component number 3
    - Exposes data / content to other applications

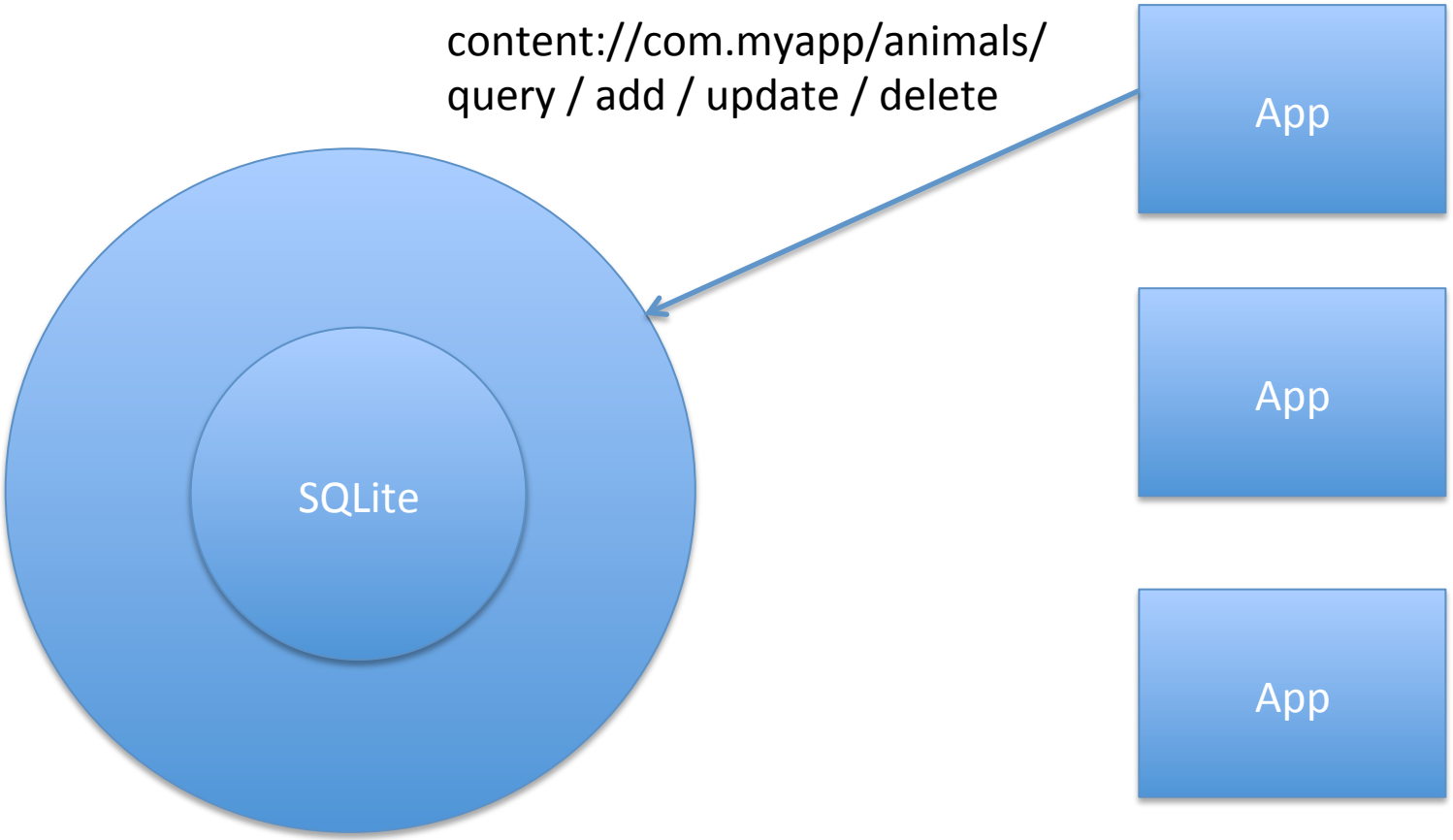
Content Providers

- Either create a new one (by sub-classing ContentProvider)
- Or add your data to an existing ContentProvider
- Android has default providers for common data
  - Contacts, video, images, music
  - Again, recall common mobile capabilities

Data Model

- ContentProviders enforce a specific data model
- Very similar to a relational database table
  - A collection of records
- Records are stored in rows, with each column providing different data fields
- Each record has a numeric id (in the field _ID) that uniquely identifies it
- Tables exposed via URI

Data Model


content://com.myapp/animals/
query / add / update / delete
App
App
App
SQLite

Creating a Content Provider

- Determine data structure
  - Structured data
    - Values, binary blobs up to 64k
    - Database
  - Large binary blobs
    - Files
  - Photos / media manager
- Subclass ContentProvider
  - Implement required methods
  - query, add, update, insert etc
  - onCreate
  - getType
    - What type of data are we providing?
- Tell Android we are a provider
  - Declare in the AndroidManifest

Contract

- Defines metadata pertaining to the provider
- Constant definitions that are exposed to developers via a compiled .jar file
  - Authority
    - Which app is responsible for this data
  - URI
  - Meta-data types
  - Column names
    - Abstraction of database architecture

Let’s have a look…

URI Matching

- All of these methods (except onCreate()) take a URI as the first parameter
  - The object will need to parse it to some extent to know what to return, insert or update
  - Android provides android.content.UriMatcher to simplify this
  - Does the calling application want all data from a table, or just a row, or a specific table?

Permissions

- By default our new provider requires no permissions
  - Can be accessed read/write by all other applications
  - Specify required permissions in the manifest entry
    - Can specify URI path-level permissions for fine grained access control
    - Can grant temporary permission to access certain URIs via code

      "Access to the mail should be protected by permissions, since this is sensitive user data. However, if a URI to an image attachment is given to an image viewer, that image viewer will not have permission to open the attachment since it has no reason to hold a permission to access all e-mail."

Network

- One last type of data storage
  - Get it off the phone, and into the cloud
- Implement a SyncAdapter
  - Appears in the “Accounts and Sync” menu in the OS
  - Synchronizes a local database / content provider with a remote server
  - Make use of a Service to push data in the background
- http://www.youtube.com/watch?feature=player_embedded&v=xHXn3Kg2IQE

References

- http://developer.android.com/guide/topics/data/data-storage.html
- http://developer.android.com/reference/android/database/sqlite/SQLiteDatabase.html
- http://developer.android.com/reference/android/database/Cursor.html
- http://developer.android.com/guide/topics/providers/content-provider-basics.html
- http://developer.android.com/training/sync-adapters/creating-sync-adapter.html