Android lecture 4

Background processing, Scheduling, Broadcasts, Adapters

Background processing

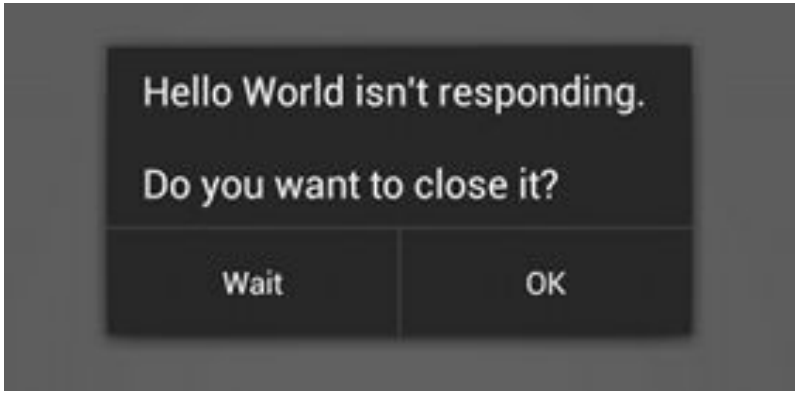
“Some people, when confronted with a problem, think, “I know, I’ll use threads,” and then two they hav erpoblesms.”

https://nedbatchelder.com/blog/201204/two_problems.html

Background processing

- Threads
- Handler
- AsyncTask - Deprecation in Android 11
- ~~Loader~~ deprecated API 28
- Kotlin coroutines
- RxJava

Motivation



Keep your application responsive

Background processing

- Avoid long running operations on Main/UI thread
  - Files, database, network
- Most component runs on Main thread by default
- 5 second to ANR (10s BroadcastReceiver)

Background processing

- Main thread = UI thread
- Never block UI thread

Background processing - issues

- Activities can be restarted
- Memory leaks
- Crashes

Thread

- java.lang.Thread

```
Thread() {
    override fun run() {
        // Long running operation
            . . .
    }
}.start()
```

- Standard java thread
- Simple way how to offload work to the background
- UI can’t be updated from background

Handler

- android.os.Handler
- Sends and processes messages
- Instance is bound to thread/message queue of the thread creating it
  - Scheduling messages and Runnables to be executed at some point in future
  - Enqueue an action to be performed on different thread

Handler

Receiving message on UI thread

- Overriding `handleMessage(Message)`

```
val handler = object : Handler() {
    override fun handleMessage(msg: Message?) {
        Txt_username_value.text =
                msg.data.getString("data_key")
    }
}
```

Send message from background

- Obtain message is more effective than create new instance
- Requires reference to handler

```
val message = handler.obtainMessage()
message.arg1 = 1001
handler.sendMessage(message)
```

Looper and Handler

- Looper
  - Class that runs a message loop for a thread
  - UI thread has its own Looper
    - Looper.getMainLooper()
- Handler
  - Provides interaction with the message loop

HandlerThread

- Holds a queue of task
- Other task can push task to it
- The thread processes its queue, one task after another
- When queue is empty, it blocks until something appears

Async task

- android.os.AsyncTask
- Simplify running code on background
- `AsyncTask<Params, Progress, Result>`
  - Params - The type of the parameters sent to the task upon execution
  - Progress - type of progress unit published during background operation
  - Result - type of result of background operation

AsyncTask - methods

- `onPreExecute()`
  - UI thread, before executing, show progress bar
- `doInBackground(Params...)`
  - Background thread
  - `publishProgress(Progress...)`
  - Returns Result
- `onProgressUpdate(Progress...)`
  - UI thread
  - For updating progress, params are values passed in `publishProgress`
  - `onPostExecute(Result)`
  - UI thread
  - Returned value from `doInBackground` is passed as parameter

AsyncTask - canceling

- `cancel(boolean)` - Cancel execution of task
- `isCancelled()` - call often in `doInBackground` to stop background processing as quick as possible
- `onCancelled(Result)` - called instead of `onPostExecute()` in case task was cancelled

Memory leaks

- Activity runs AsyncTask which takes long time, meanwhile configuration change happens
- Anonymous and non-static inner class still keeps reference to Activity => Activity can’t be garbage collected => activity leaks

Memory leaks - Solutions

- Disable configuration changes in manifest
  - Don’t do this, it just hides another bugs
- ~~Retain activity instance~~
  - ~~Using `onRetainNonConfigurationInstance()` and `getLastNonConfigurationInstance()` deprecated~~
- WeakReference to activity/fragment or views
- Task as static inner class
- TaskFragment
  - Fragment without UI and called `setRetainInstance(true)`
- ~~AsyncTaskLoader~~
- ViewModel + LiveData

Demo time

- Splash screen
- Async task load user
- Async task load user repositories
- Async task load user repositories weak reference

Broadcast receivers
Intent filters

IntentFilter

- Intent contains
  - Component name
    - Explicit intent
  - Action
    - Generic action to perform (send email, open web page, ….)
  - Data
    - Uri object that references MIME type of the data
  - Category
    - String with additional information about the kind of component that should handle the intent
  - Extras
    - Key-value pairs with additional data
  - Flags
    - Metadata, for example how the activity is launched

IntentFilter

- Tells the system, which implicit intent is component able to respond
- Based on
  - Intent action
  - Intent category
  - Intent data

```
<intent-filter>
    <action android:name="android.intent.action.SEND"/>
    <category android:name="android.intent.category.DEFAULT"/>
    <data android:mimeType="text/plain"/>
</intent-filter>
```

IntentFilter

- If there is more component which are able respond to the intent, system let user to decide which component/application want to use

BroadcastReceiver

- Responds to broadcasts
- Broadcasts are system wide messages
  - Use package name prefix
- Registration
  - Static - AndroidManifest.xml
  - Dynamic - in the code at runtime
- By default runs on main thread in default process

BroadcastReceiver

- Broadcast source
  - System
    - Incoming SMS
    - Incoming call
    - Screen turned off
    - Low battery
    - Removed SD card
  - Our app
- Normal vs ordered broadcasts
- Implicit vs explicit broadcasts

Normal broadcast

- Asynchronous delivery (multiple receivers can receive intent at the same time)
- Cannot be aborted due to async behaviour
- More efficient

```
Context.sendBroadcast(intent)
```

Ordered broadcasts

- Delivered to one receiver at a time
- Receiver can abort broadcast, it won’t be passed to another receiver
- Order of receiver is controlled by the priority of the matching intent filter

Implicit vs explicit broadcast

- Implicit
  - System-wide messages
  - `ACTION_TIMEZONE_CHANGED`
  - `ACTION_BOOT_COMPLETED`
  - `ACTION_TIME_CHANGED`
- Explicit
  - Target by class name

BroadcastReceiver - Registration

- If contains intent filter any app can call the receiver
- Receivers are not enabled until first run of app
- Who can send the broadcast can be limited by permissions

```
<receiver android:enabled=["true" | "false"]
          android:exported=["true" | "false"]
          android:icon="drawable resource"
          android:label="string resource"
          android:name="string"
          android:permission="string"
          android:process="string" >
    . . .
</receiver>
```

BroadcastReceiver - runtime registration

- Without specifying permission any app can send broadcast to you

Register - Activity.onResume()

```
val intentFilter = IntentFilter()
intentFilter.addCategory("ACTION_CUSTOM")
registerReceiver(receiver, intentFilter)
```

Unregister - Activity.onPause

```
unregisterReceiver(receiver)
```

BroadcastReceiver.kt

- onReceive must finish in 10 seconds, otherwise ANR
- For longer tasks run service

```
class ExampleReceiver: BroadcastReceiver() {

    override fun onReceive(context: Context, intent: Intent) {

    }
}
```

BroadcastReceiver - security

- It is possible to limit who can send broadcast by permissions
- It is possible to protect receiver when it is registered statically and dynamically
- Possible to set permission when sending broadcast

Broadcast receivers limitations

- Android Nougat API-24
  - Not possible to register for connectivity changes in manifest
- Android Oreo API-26
  - Not possible to register receiver for implicit broadcast in manifest
- https://developer.android.com/guide/components/broadcast-exceptions
  - ACTION_BOOT_COMPLETED
  - ACTION_LOCALE_CHANGED
  - ACTION_LOCALE_CHANGED
  - SMS_RECEIVED_ACTION
  - ...

Local broadcasts

```
val lbManager =
     LocalBroadcastManager.getInstance(this@SplashScreenActivity)
lbManager.registerReceiver(receiver, intentFilter)
lbManager.unregisterReceiver(receiver)
lbManager.sendBroadcast(intent)
lbManager.sendBroadcastSync(intent)
```

Scheduling, delayed start

Timer
Handler
AlarmManager
JobScheduler
GCMNetworkManager
WorkManager

Timer and TimerTask

- `Timer` allows to run `TimerTask` in defined time or repeatedly
- Creates new thread where it runs
  - One thread per timer
- For updating UI needs to call `runOnUIThread()`
- Not recommended to use -> Use `Handler` instead
- Timer can schedule multiple TimerTask
- TimerTask is not reusable

Timer and TimerTask

```
val delay = 10000L
val period = 10000L
val timer = Timer()

val myTimerTask = object: TimerTask() {

    override fun run() {
        doSomeStuff()
    }
}

timer.schedule(myTimerTask, delay) // run task after delay
```

Handler

- Possible to run on background or UI thread
- Possible for scheduling or delaying start of some “task”
- In case of device sleep handler doesn’t run
- Messages
  - `sendMessageAtTime(Message msg, long uptimeMillis)`
  - `sendMessageDelayed(Message msg, long delayMillis)`
- Runnable
  - `postAtTime(Runnable r, long uptimeMillis)`
  - `postDelayed(Runnable r, long delayMillis)`
- Good for task with high frequency (more than one in few minutes)
- Tight with application component

Hander - repeating

```
private fun handlerRepeat() {
    val runnable = object: Runnable {
        override fun run() {
            updateUI()
            handler.postDelayed(this, 5000L)
        }
    }
  handler.postDelayed(runnable, 5000L)
}
```

Alarm manager

- Perform time-based operations outside the application lifecycle
- Fire intents at specified time
- In conjunction with broadcast receivers start services
- Operate outside of your application, trigger events or actions even app is not running or device is asleep
- Minimize app resource requirements
- Action is specified by `PendingIntent`
- Many API changes
  - Added some new method
  - Some method changed behaviour from exact -> inexact
  - READ the documentation carefully

Alarm manager - tips

- For synchronization consider to use WorkManager
- For repeating sync add some spread when it is syncing
  - Imagine 1M+ of devices trying to download something from your server at the same time
- Use `setInexactRepeating` if it is possible to group alarms from multiple apps => Reduces battery drain
- Alarms are cancelled on reboot, reschedule alarms when device boots

Alarm manager - alarm type

- `ELAPSED_REALTIME`
- `ELAPSED_REALTIME_WAKEUP`
- `RTC`
- `RTC_WAKEUP`

- Clock types
  - Elapsed - time since system boot
    - Use when there is no dependency on timezone
  - Real time clock - time since epoch
    - Use when you need to consider timezone/locale
- Wake up
  - wakeup - ensure alarm will fire at the scheduled time
  - non wakeup - alarm are fired when device awakes

AlarmManager - important changes

- API < 19 (KITKAT) - `set*` methods behave like exact time
- API > 19
  - All old methods are inexact now
  - New API for setting exact alarm
    - setExact
  - Added new API for specify windows, when it should be delivered
    - setWindow
- API 21
  - Added methods `setAlarmClock` and `getNextAlarmClock`
  - system can show information about alarm
- API 23
  - Added methods `setExactAndAllowWhileIdle` and `setAndAllowWhileIdle`
- API 24
  - Added direct callback versions of `set` and `setExact` and `setWindow`

AlarmManager - usage

```
val alarmManager = getSystemService(Context.ALARM_SERVICE) as AlarmManager

val intent = Intent("AlarmAction")
val pendingIntent = PendingIntent.getBroadcast(applicationContext, ALARM_REQUEST_CODE,
                                               intent,
                                               PendingIntent.FLAG_UPDATE_CURRENT)
alarmManager.set(AlarmManager.RTC,
                 System.currentTimeMillis() + TimeUnit.HOURS.toMillis(1L),
                 pendingIntent)
```

- AlarmType
- Time
  - Depending on the alarm type it is timestamp or time since device boots
- PendingIntent
  - PendingIntent which specify action which should happen

Alarm manager - sleeping device

- Alarm manager can wake devices, when it asleep BUT
- pending intent is able to start activity/service or send broadcast
- BUT it is not guaranteed by system to start service/activity before device fall asleep again
- only `BroadcastReceiver.onReceive` is guaranteed to keep device awake
  - If you start activity/service in receiver, there is no guarantee that activity/service will start before the wake lock is released

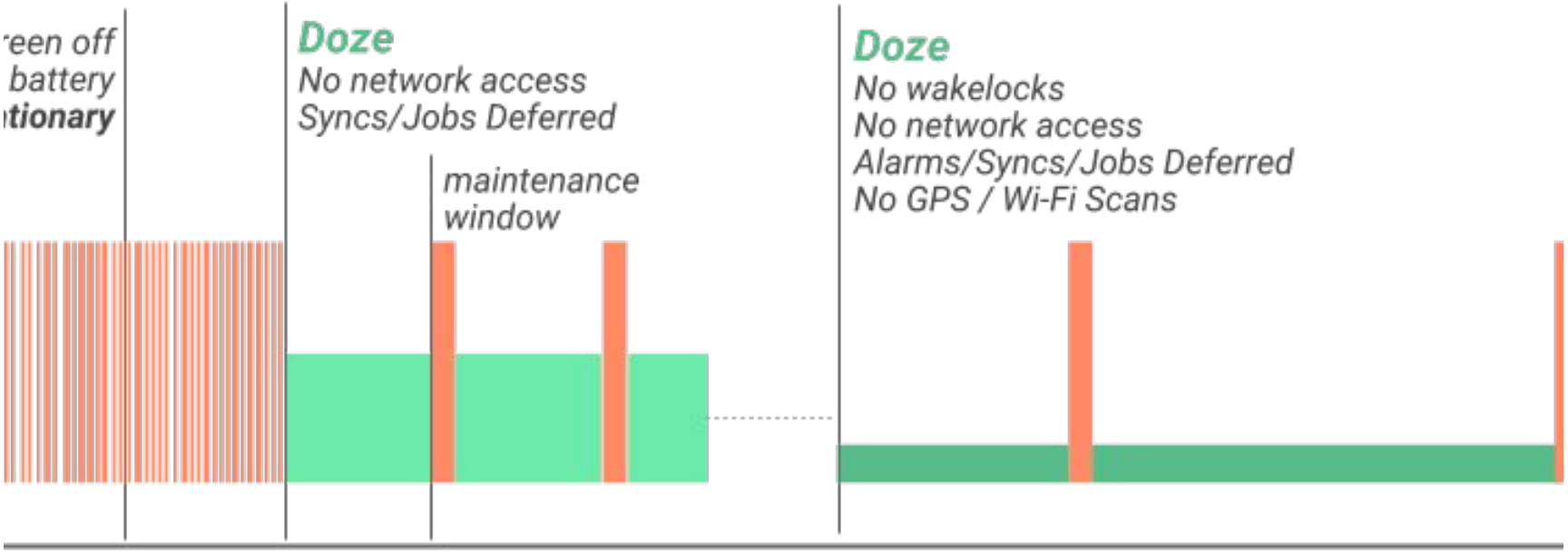
Wake locks

- Prevent device from sleep
- Requires permission `android.permission.WAKE_LOCK`
- Multiple levels
  - `PARTIAL_WAKE_LOCK`
    - CPU is running, screen and keyboard backlight allowed to go off
  - `FULL_WAKE_LOCK`
    - Screen and keyboard on full brightness
    - Released when user press power button
  - `SCREEN_DIM_WAKE_LOCK`
    - Screen is on, but can be dimmed, keyboard backlight allowed to go off
    - Released when user press power button
  - `SCREEN_BRIGHT_WAKE_LOCK`
    - Screen on full brightness, keyboard backlight allowed to go off
    - Released when user press power button

Alarm manager - sleeping device, solution

- Acquire your wake lock during `BroadcastReciver.onReceive` and before starting service
- Start service
- When service finish its job release the wake lock
  - It is really important to release wake lock, it disables turning off CPU

Doze mode



Doze mode

- Since API 21 (Lollipop)
- Restrict app access to network and cpu intensive services
- Defers jobs, sync and alarms

Doze mode

- Network access is suspended.
- The system ignores wake locks.
- Standard AlarmManager alarms (including `setExact()` and `setWindow()`) are deferred to the next maintenance window.
  - If you need to set alarms that fire while in Doze, use `setAndAllowWhileIdle()` or `setExactAndAllowWhileIdle()`.
  - Alarms set with `setAlarmClock()` continue to fire normally — the system exits Doze shortly before those alarms fire.
- The system does not perform Wi-Fi scans.
- The system does not allow sync adapters to run.
- The system does not allow JobScheduler to run.

Job Scheduler

- Not for exact time schedule
- Possible to specify connectivity, charging, idle conditions
- System batch “jobs”
- Since API 21
- Battery efficient
- Job parameters defined in `JobInfo`
  - Backoff policy
  - Periodic
  - Delay triggers
  - Deadline
  - Persistency
  - Network type
  - Charging
  - Idle

Job Scheduler

```
val jobScheduler =
getSystemService(Context.JOB_SCHEDULER_SERVICE) as JobScheduler
val componentName = ComponentName(this, MyJob::class.java)

jobScheduler.schedule(JobInfo.Builder(1, componentName)
        .setBackoffCriteria(TimeUnit.MINUTES.toMillis(5L),
JobInfo.BACKOFF_POLICY_EXPONENTIAL)
        .setPersisted(true)
        .setRequiredNetworkType(JobInfo.NETWORK_TYPE_UNMETERED)
        .setRequiresCharging(true)
        .build())
```

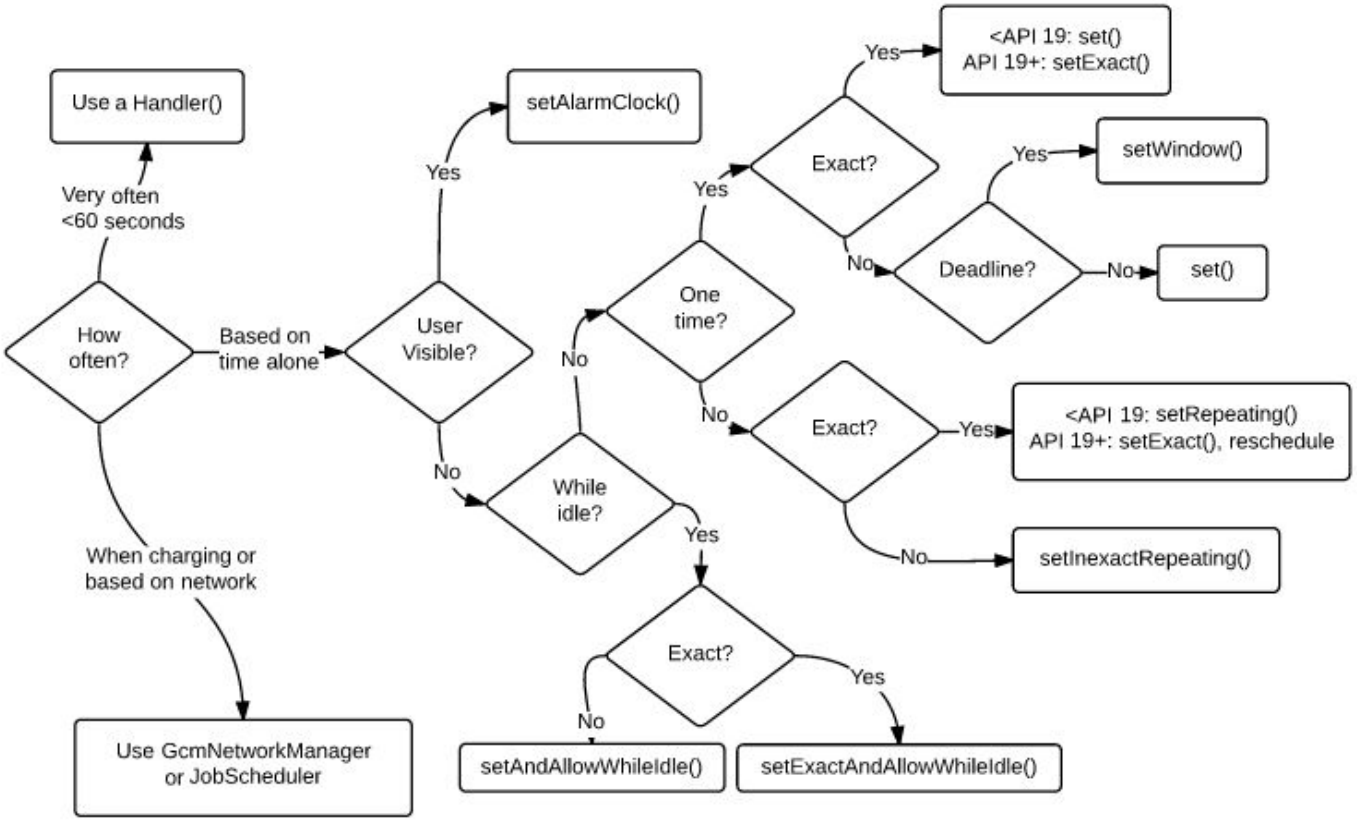
JobScheduler

```
class MyJob: JobService() {
    override fun onStopJob(params: JobParameters?): Boolean {
        // Do the job
        jobFinished(params, false)

        return false // no more work to do with this job service
    }

    override fun onStartJob(params: JobParameters?): Boolean {
        // do some stuff

        jobFinished(params, false)
        return false // no more work to do with this job service
    }
}
```

Firebase JobDispatcher

- Part of firebase
- Similar functionality and API as JobScheduler
- Uses JobScheduler on API > 21

How to decide what to use



OR

Android-job & workmanager library

http://evernote.github.io/android-job/

Replaced by

https://developer.android.com/topic/libraries/architecture/workmanager/

WorkManager

- Backward compatible up to API 14
- Use JobScheduler on devices with API23+
- Combination of BroadcastReceiver + AlarmManager API14-22
- Work constraints
  - Network
  - Charging status
- One-off or periodic
- Monitor and manage scheduled tasks
- Chain tasks
- Ensure execution even if app or device restarts
- Adheres to doze mode

Work requests

```
// Create a Constraints object that defines when the task should run
val constraints = Constraints.Builder()
        .setRequiresDeviceIdle(true)
        .setRequiresCharging(true)
        .build()

// ...then create a OneTimeWorkRequest that uses those constraints
val compressionWork = OneTimeWorkRequestBuilder<CompressWorker>()
        .setConstraints(constraints)
        .build()
```

https://developer.android.com/topic/libraries/architecture/workmanager/how-to/define-work

Workers

```
class UploadWorker(appContext: Context, workerParams: WorkerParameters)
    : Worker(appContext, workerParams) {

    override fun doWork(): Result {

            // Get the input
            val imageUriInput = getInputData().getString(Constants.KEY_IMAGE_URI)
            // Do the work
            val response = uploadFile(imageUriInput)

            // Create the output of the work
            val outputData = workDataOf(Constants.KEY_IMAGE_URL to response.imageUrl)

            // Return the output
            return Result.success(outputData)

    }
}
```

avast

Adapter views

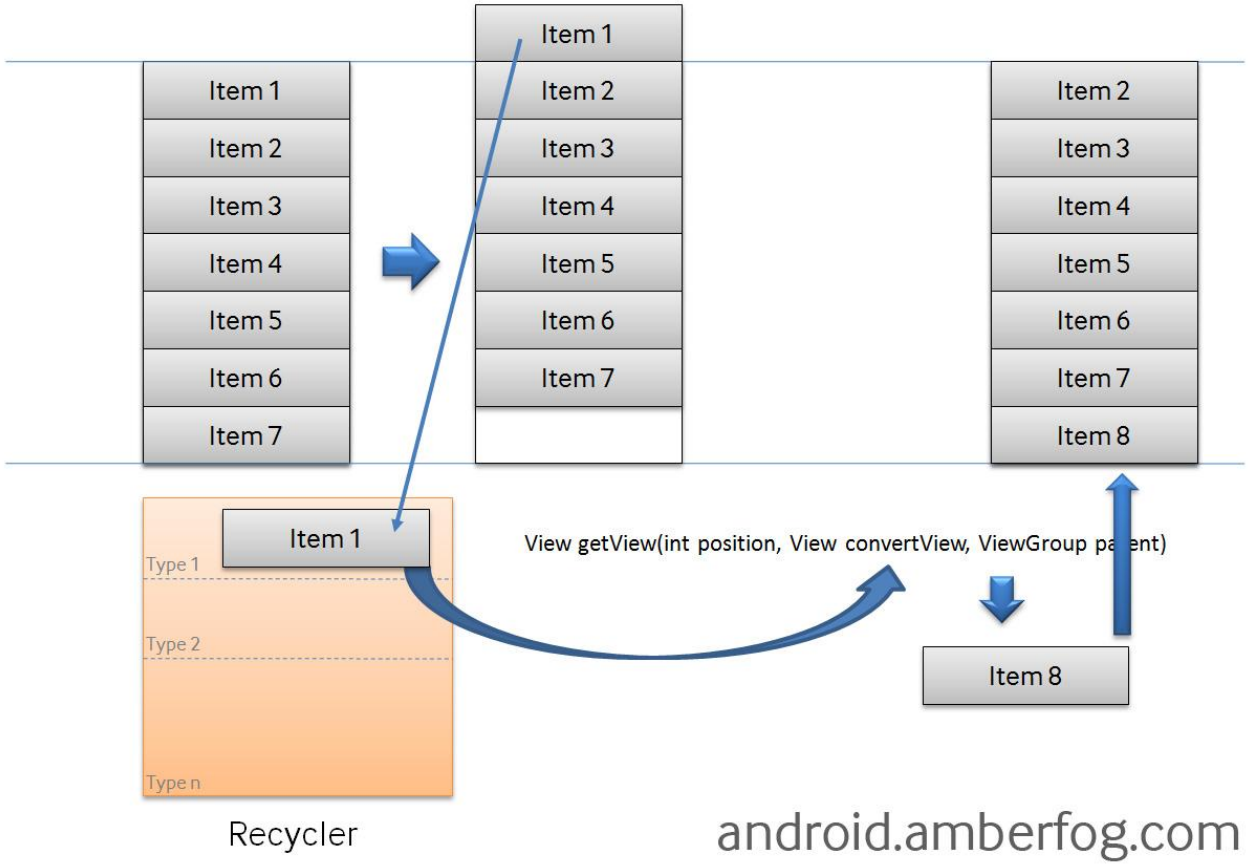
Adapter views

- Views hold multiple items
- Horizontal scrolling
  - ListView
  - GridView
  - Spinner

Adapter

- Bridge between data and view
- Responsible for creating view for every item
- For inserting items into ListView, Spinner
- BaseAdapter
  - Common base implementation of adapter
  - `int getCount()`
  - `Object getItem(int position)`
  - `getItemId(int position)`
  - `View getView(int position, View convertView, ViewGroup parent)`
- Subclasses
  - ArrayAdapter<T>
  - CursorAdapter, SimpleCursorAdapter

View recycling



ViewHolder pattern

- Remember views
- findViewById is expensive operation
  - Traversing view for complex item
  - Impact on scroll smoothness

RecyclerView

- AndroidX library
- Uses holder pattern, simplify recycling

Recycler view - Layout managers

- Measuring and positioning items in list
  - LinearLayoutManager
  - GridLayoutManager
  - StaggeredGridLayoutManager

Recycler view - ViewHolders

- View caching

RecyclerView

- RecyclerView.Adapter<ViewHolderType>
  - `onCreateViewHolder(parent: ViewGroup, viewType: Int): ViewHolderType`
  - `getItemCount(): Int`
  - `onBindViewHolder(viewHolder: RepositoryViewHolder, position: Int)`

Demo time

- Spinner to sort data
- Recycler view bind view holder
- Recycler view fill data

Thank you
Q&A

Feedback is appreciated

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Please use [mff-android] in subject