Efficient Android Threading

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Agenda

Optimize UI thread execution

Threads on Android

Asynchronous Techniques

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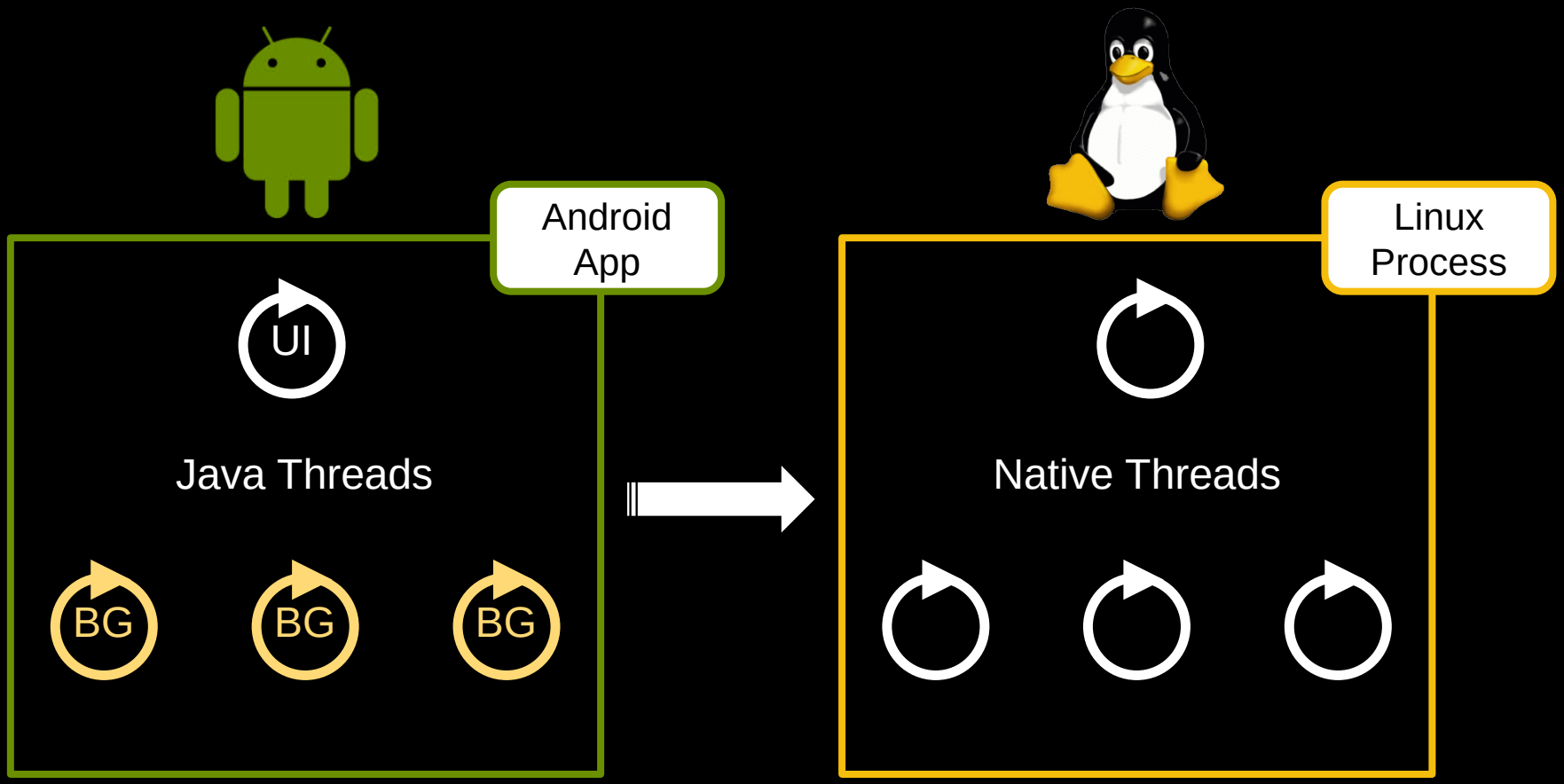
Threads on Android



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Android Scheduling

Process level:

1. Foreground
2. Visible
3. Service
4. Background

Android Scheduling

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App A

App B

Foreground Thread Group

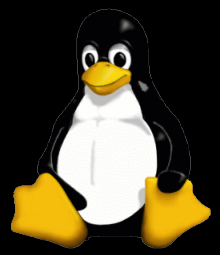
App A

> 90%

Background Thread Group

App B

< 10%



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Android Scheduling

Process level:

1. Foreground
2. Visible
3. Service
4. Background

App A

App B

Foreground Thread Group

App A

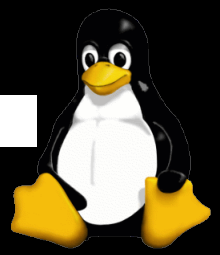
> 90%

```
Process.setThreadPriority(Process.THREAD_PRIORITY_BACKGROUND);
```

Background Thread Group

App B

< 10%



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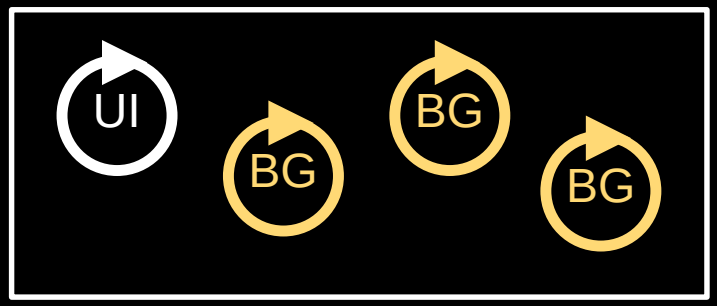
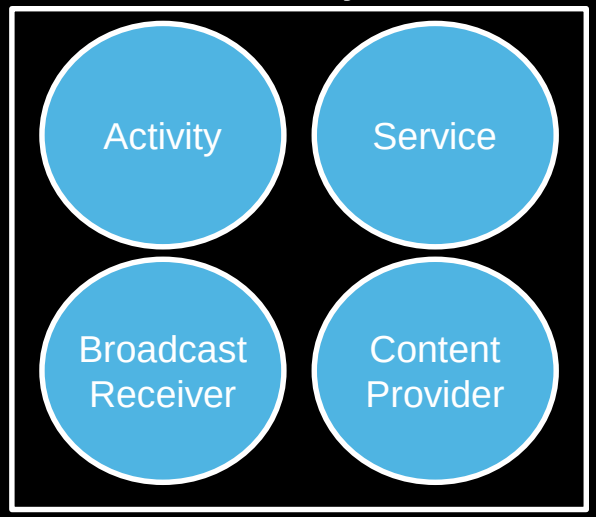
Lifecycles

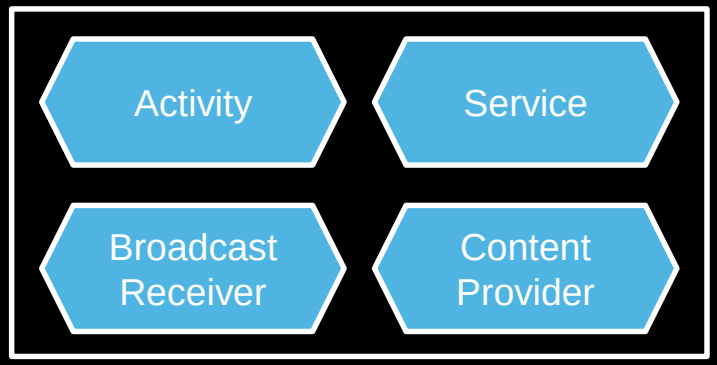
Threads



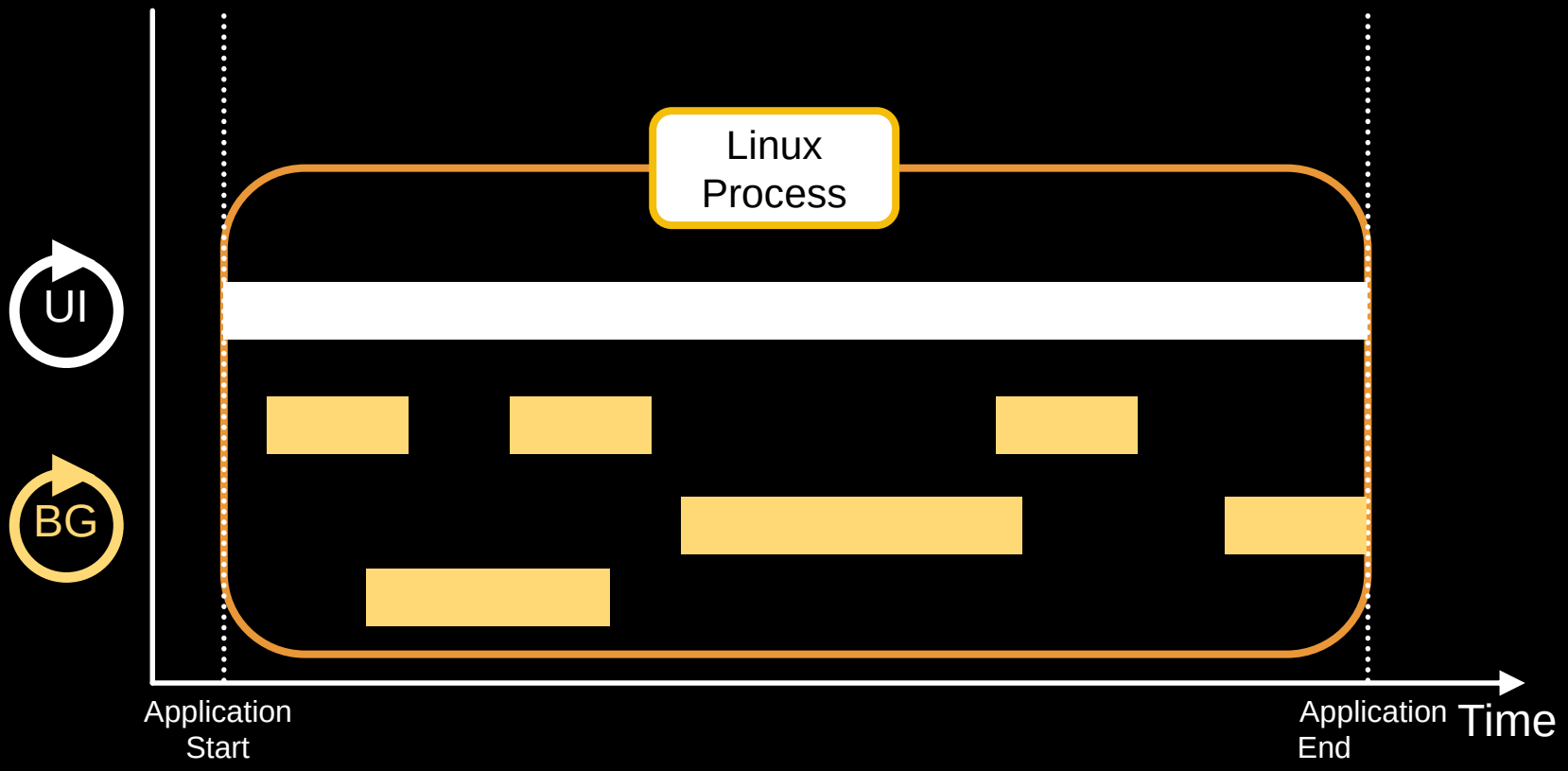
Java Objects



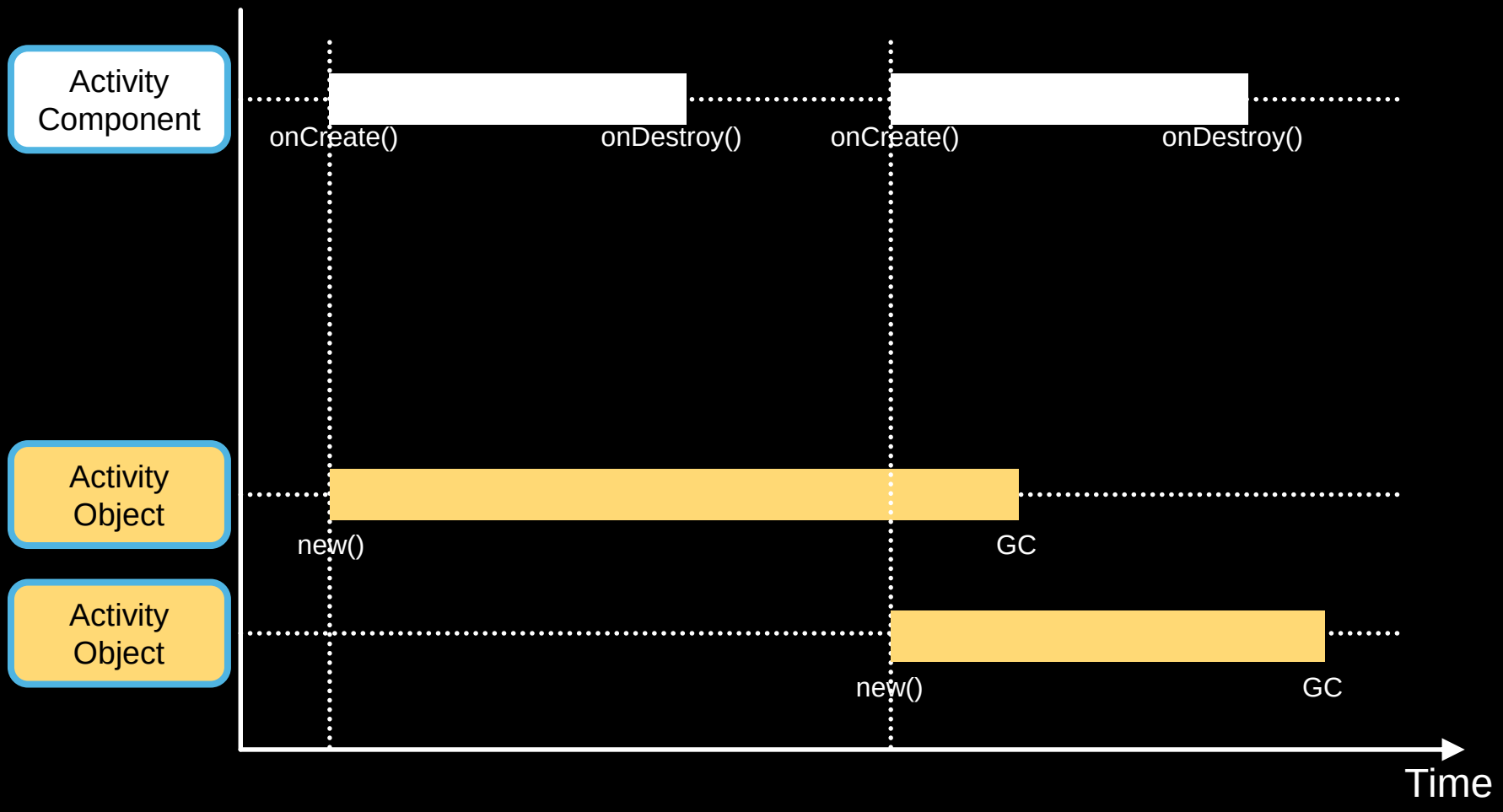
Android Components



Native Thread Lifecycle



Example: Activity Lifecycle



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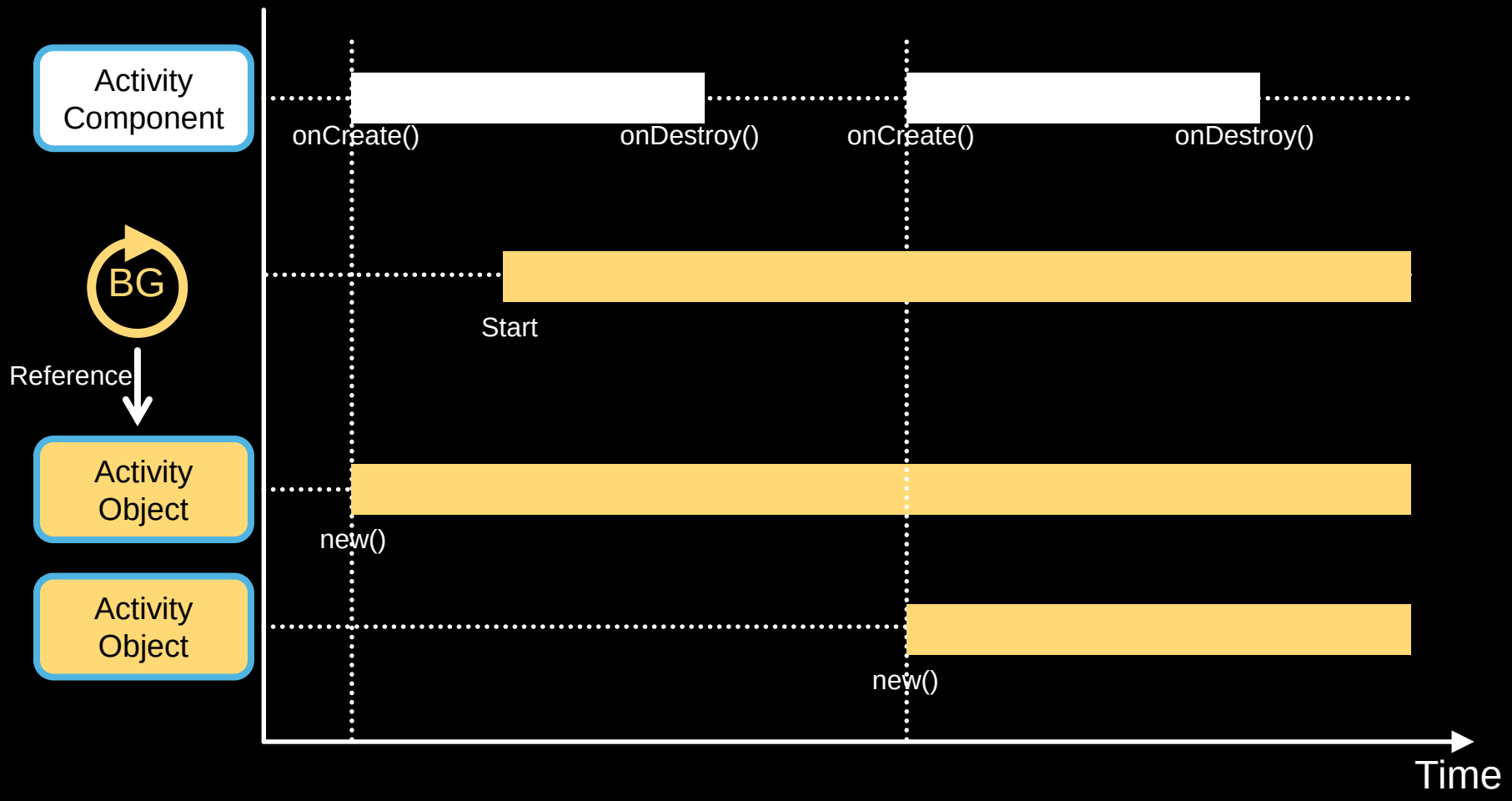
Example: Activity Lifecycle



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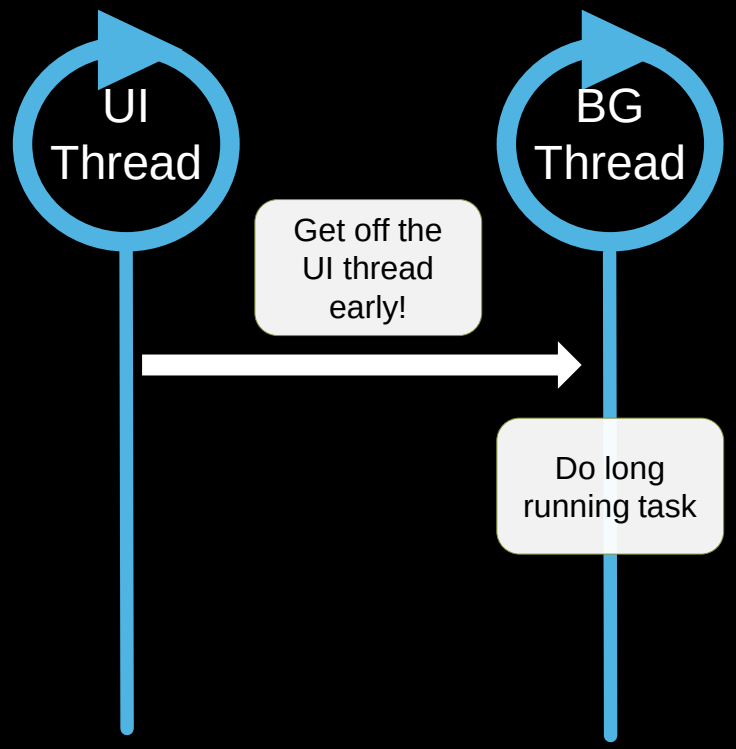
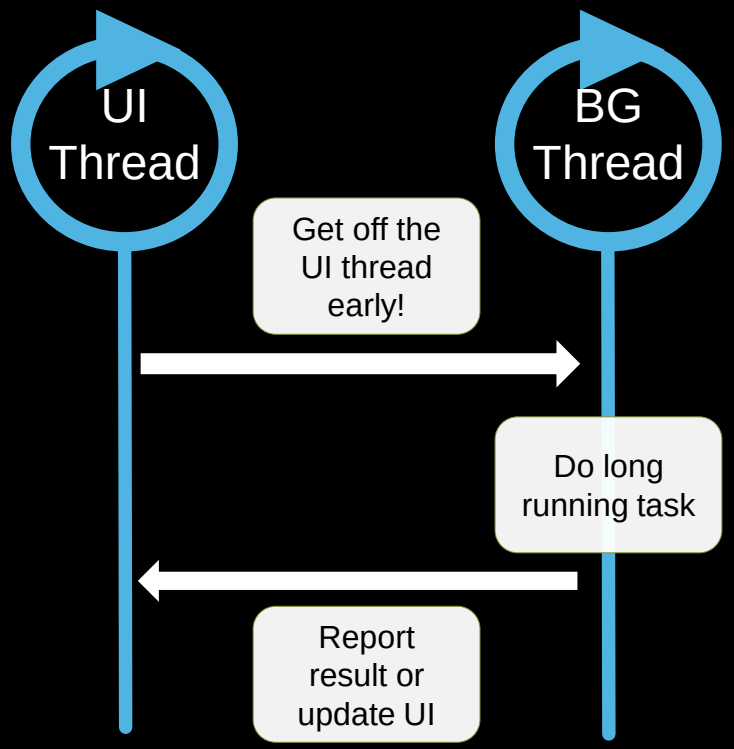
Background Threads

- A thread is a GC root
- Implement cancellation policy for your background threads!

Use Cases





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Goal

What technique shall I use for my background thread execution?

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Asynchronous Techniques

- Thread
- Executor
- HandlerThread
- AsyncTask
- Service
- IntentService
- AsyncQueryHandler
- Loader

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Thread

- Plain old Java Thread

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Creation and Start

Anonymous Inner Class

```
new Thread(new Runnable() {
        public void run() {
                // Do long task
        }
}).start();
```

External Class

```
Thread t = new MyThread();
t.start();
```

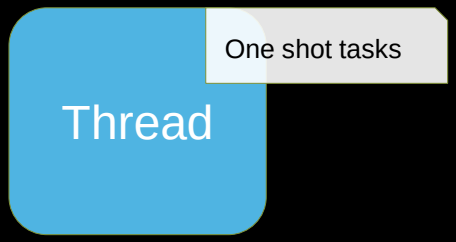
Implicit reference to outer class

Pitfalls

- Non-retained threads
- Missing cancellation policy
- Starting over and over again

Good Use Cases

- One-shot tasks
  - Post messages to the UI thread at end.



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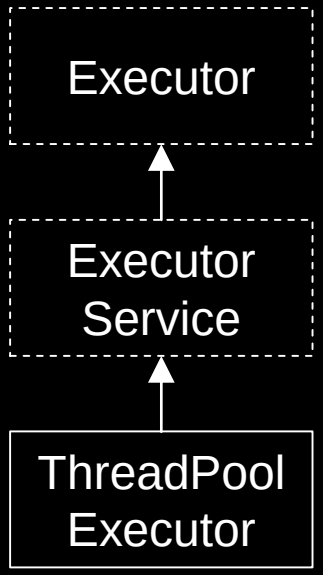
Executor

- Powerful task execution framework.

```
public interface Executor {

        public void execute(Runnable r);

}
```



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ExecutorService

Task submission:

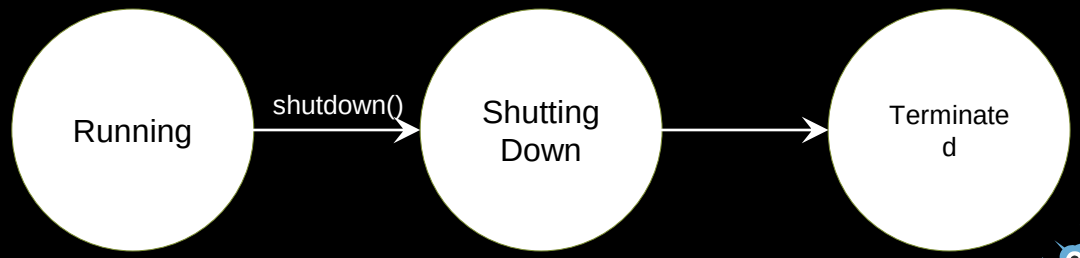
```
executorService.submit(MyTask);
executorService.invokeAll(Collection<Tasks>);
executorService.invokeAny(Collection<Tasks>);
```

Lifecycle management:

```
executorService.shutdown();
executorService.shutdownNow();
```

Lifecycle observation:

```
executorService.isShutdown();
executorService.isTerminated();
executorService.awaitTermination();
```



Task / Execution Environment

Task:
Independent unit of work executed anywhere

Runnable
run()

Callable
call()

Task manager/observer:

Future
isDone()
isCancelled()
cancel()

```
Future future = executorService.submit(Callable);
```

Execution Environment:
Technique used to execute the task

Executor
execute(Runnable)

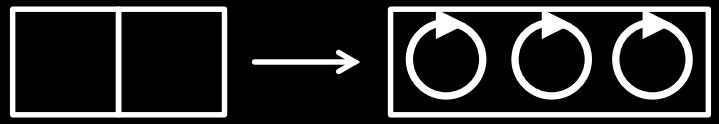
Thread Pools

- Executor managing a pool of threads and a work queue.
- Reduces overhead of thread creation

Thread Pools

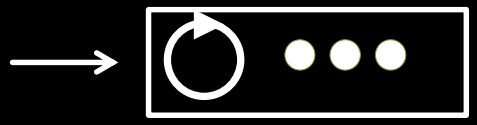
Fixed Thread Pool

```
Executors.newFixedThreadPool(3)
```



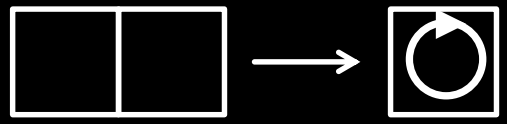
Cached Thread Pool

```
Executors.newCachedThreadPool()
```



Single Thread Pool

```
Executors.newSingleThreadExecutor()
```



Custom Thread Pool

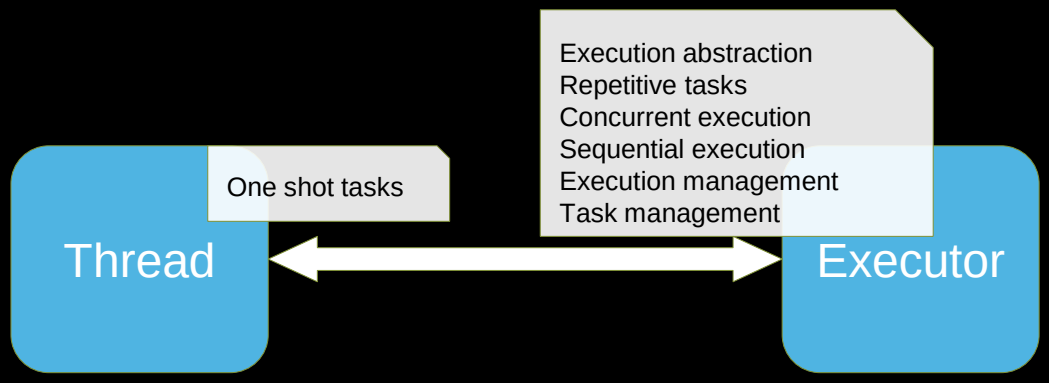
```
new ThreadPoolExecutor(corePoolSize, maximumPoolSize, aliveTime, unit, workQueue)
```

Pitfalls

- Lost thread safety when switching from sequential to concurrent execution

Good Use Cases

- Execute tasks concurrently
  - Multiple Http requests
  - Concurrent image processing
  - Use cases gaining performance from concurrent execution.
- Lifecycle management and observation of task execution.
- Maximum platform utilization


Execution abstraction
Repetitive tasks
Concurrent execution
Sequential execution
Execution management
Task management
One shot tasks
Thread
Executor

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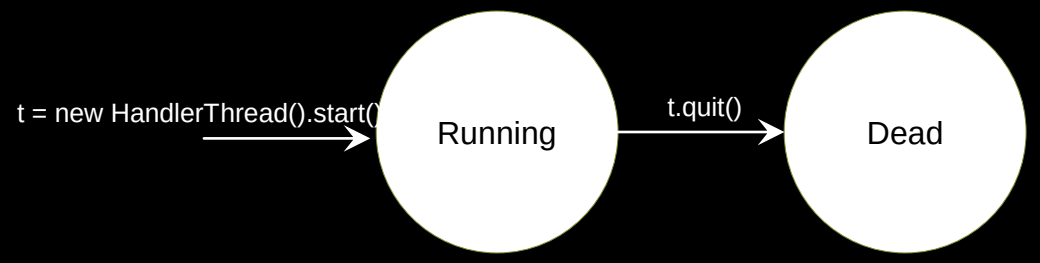
HandlerThread

- Inherits from Thread and encapsulates a Looper-object.
- Thread with a message queue and processing loop.
- Handles both Message and Runnable.



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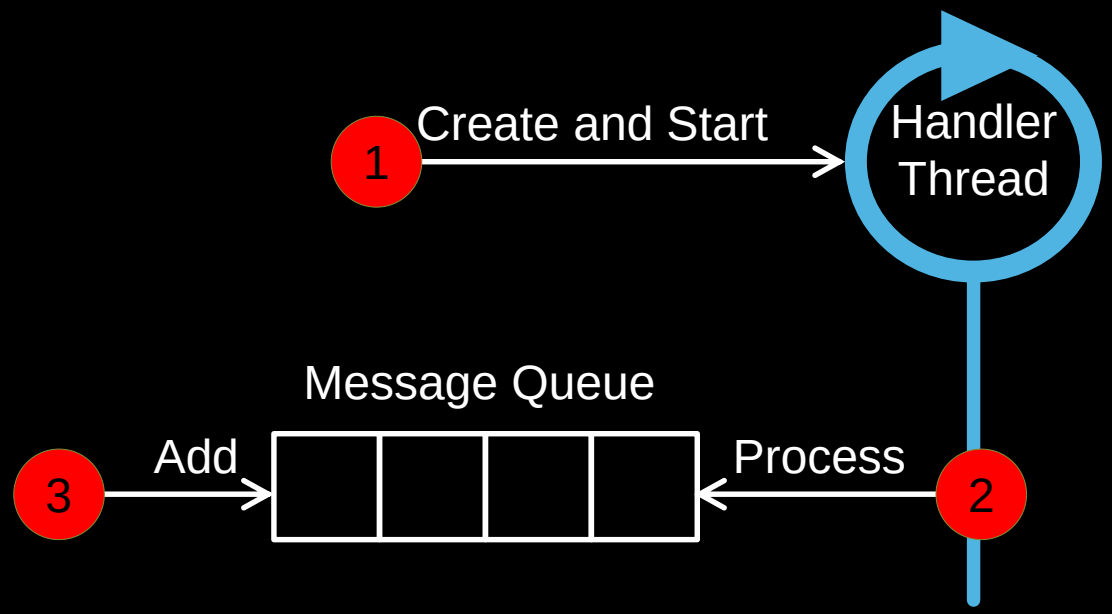
How it works



1

```
t = new HandlerThread("BgThread");
t.start();
```

3

```
h.sendEmptyMessage(42);
```

2

```
Handler h = new Handler(t.getLooper()) {
        @Override
        public void handleMessage(Message msg) {
                //Process message
        }
};
```

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Handler

Runnable/Message submission:

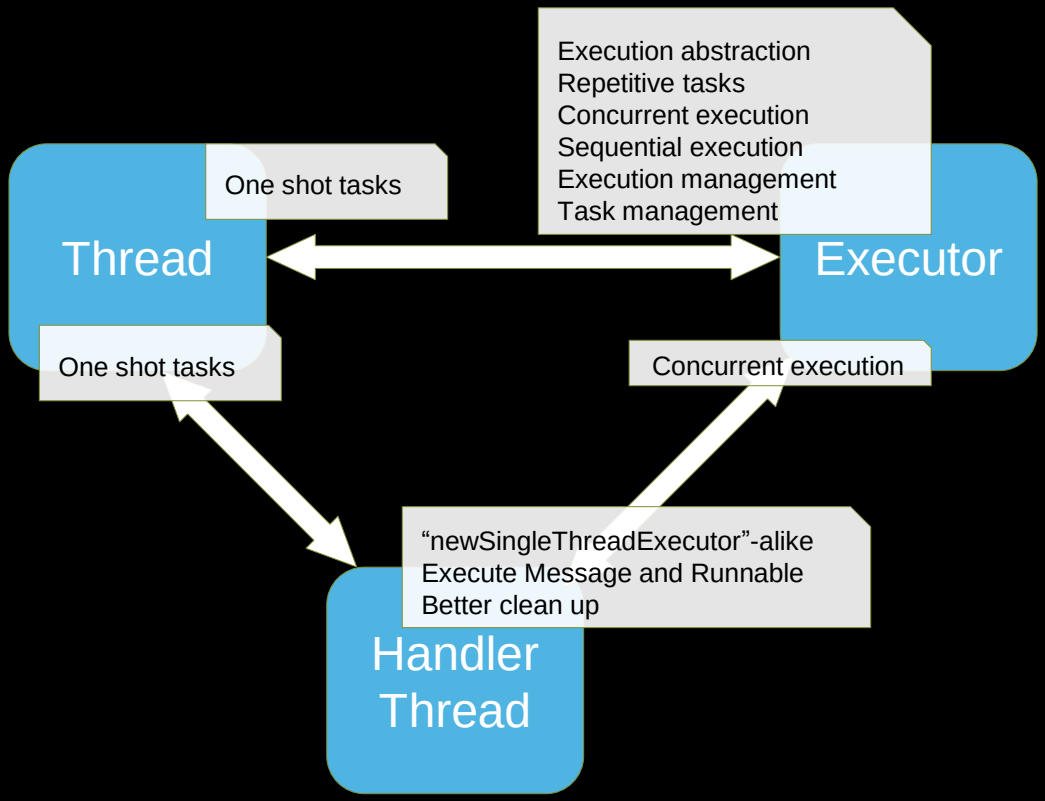
```
post(Runnable);
postDelayed(Runnable);
postAtTime(Runnable)
postAtFrontOfQueue(Runnable);
sendMessage(Message);
sendMessageDelayed(Message);
sendMessageAtTime(Message);
sendMessageAtFrontOfQueue(Message);
```

Runnable/Message removal:

```
removeCallbacks(Runnable);
removeMessages(Message)
```

Good Use Cases

- Keep a thread alive
- Sequential execution of messages
  - Avoid concurrent execution on multiple button clicks
  - State machine
  - Detailed control of message processing.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One shot tasks
Concurrent execution
“newSingleThreadExecutor”-alike
Execute Message and Runnable
Better clean up
Handler Thread

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AsyncTask

- Wraps Handler/Looper thread communication.
- Utilizes the Executor framework.
- Callbacks for UI operations and Background operation.

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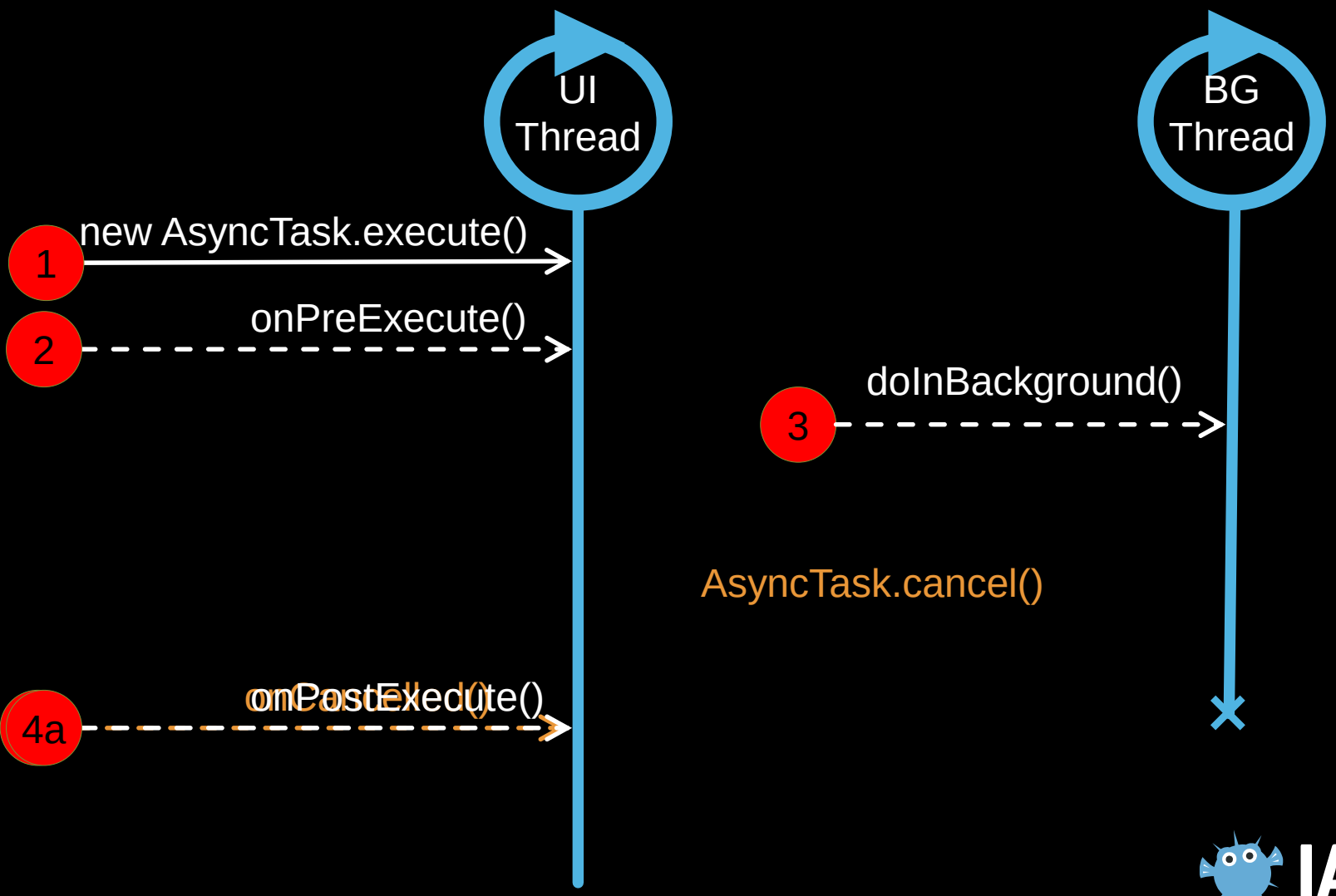
How it works



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How it works

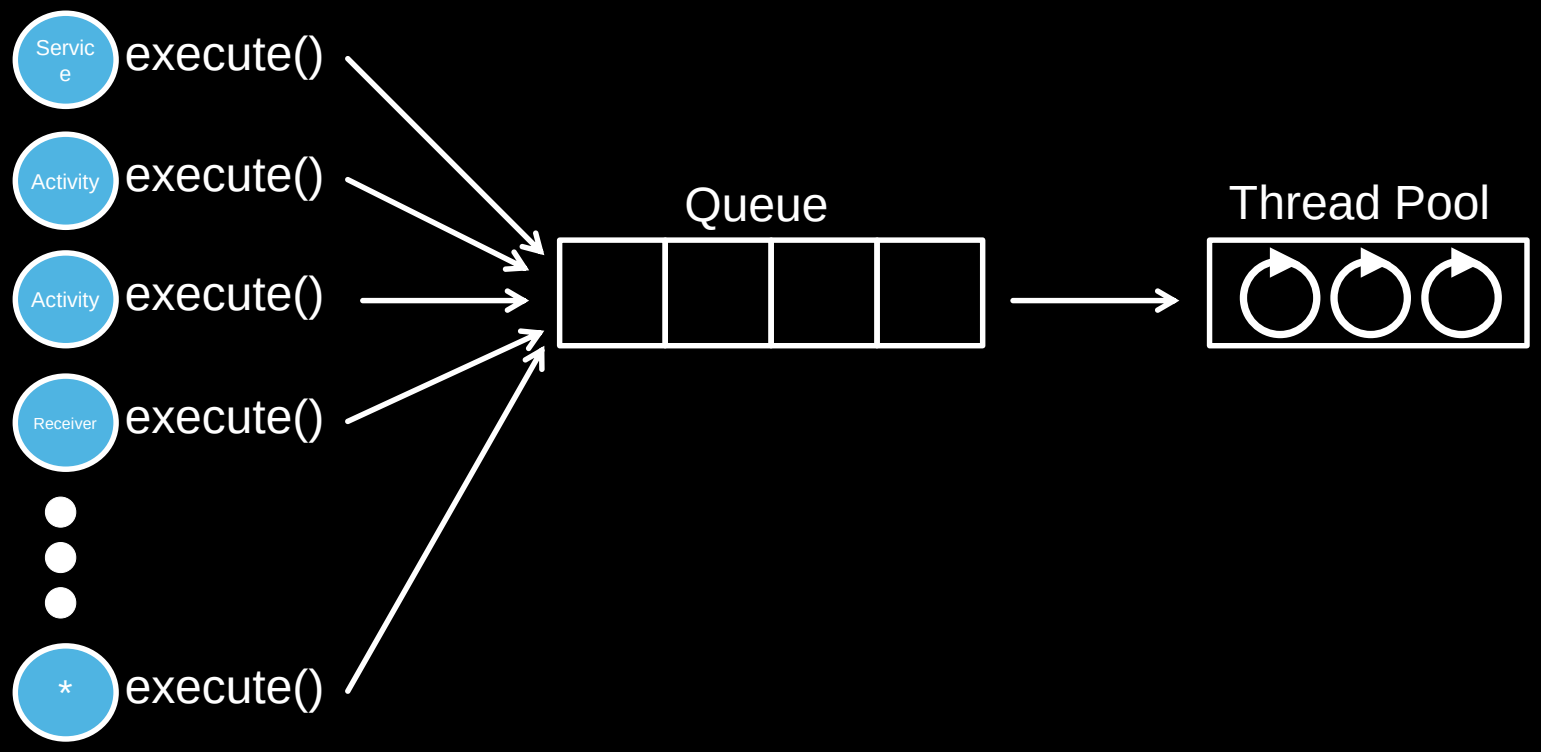
```
public class MyActivity extends Activity {

        public void onButtonClicked(View v) {
                new MyAsyncTask().execute("SomeInputString");
        }
}
```

```
public class MyAsyncTask extends AsyncTask<String, Void, Integer> {

        @Override
        protected void onPreExecute() {
        }

        @Override
        protected Integer doInBackground(String... params) {
                return null;
        }

        @Override
        protected void onCancelled(Integer result) {
        }

        @Override
        protected void onPostExecute(Integer result) {
        }
}
```

Pitfalls

- Application Global Behavior
- execute()
- Cancellation
- Creation and Start

Application Global Behavior



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execute()

Execution behavior has changed over time

< Donut: execute() → [ ][ ][ ][ ] → [ ]

< Honeycomb: execute() → [ ][ ][ ][ ] → [ ][ ][ ]

>= Honeycomb:

execute() → [ ][ ][ ][ ] → [ ]

executeOnExecutor(Executor) → [ ][ ][ ][ ] → [ ][ ][ ]

execute()

"So, if I call AsyncTask.execute on Honeycomb and later my tasks will run sequentially, right?"

"Right?!?"

"Eh, it depends…"

```
<uses-sdk  android:targetSdkVersion="12" />
```

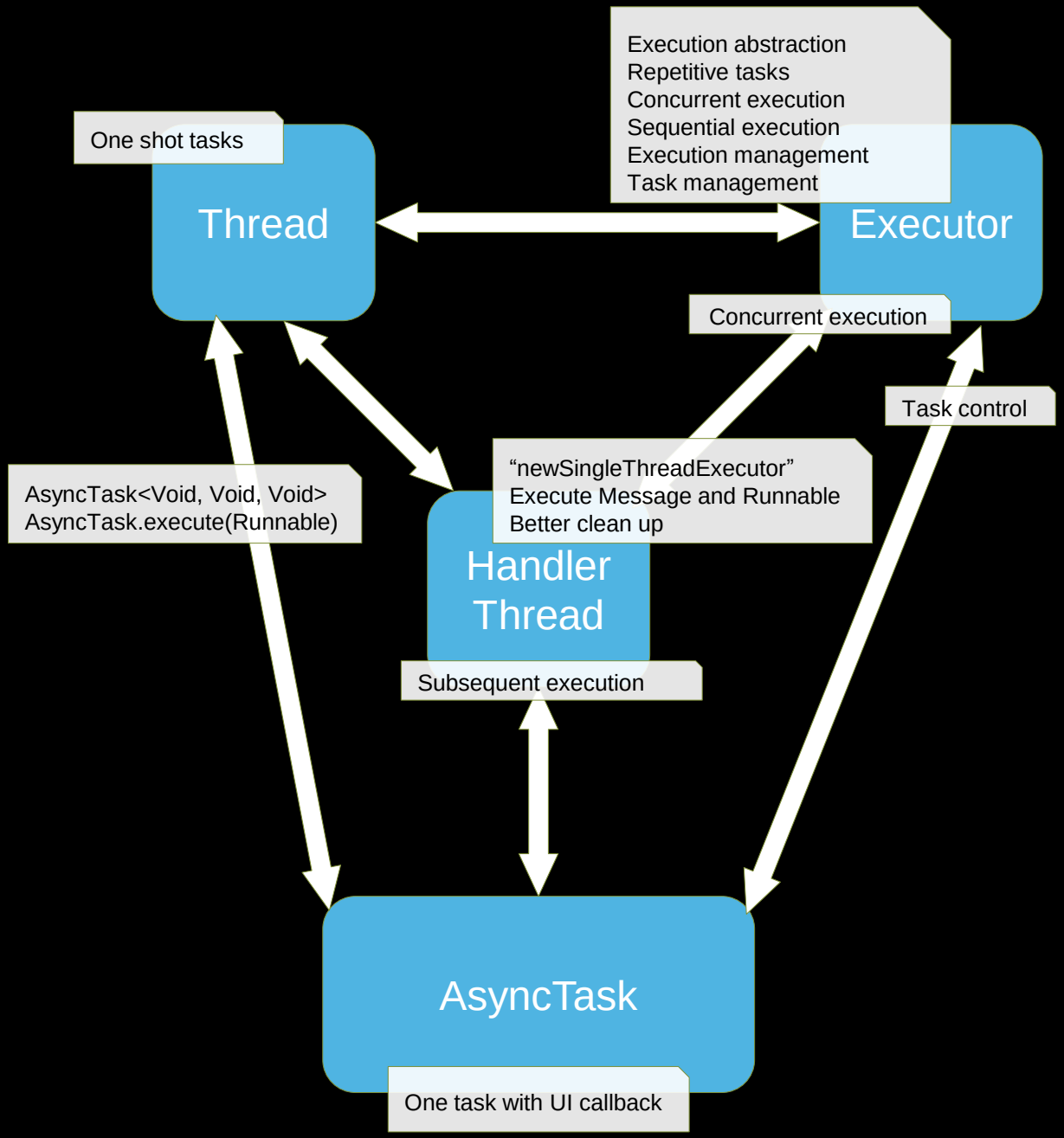
```
<uses-sdk  android:targetSdkVersion="13" />
```

Cancellation

- Cancel AsyncTask when component finishes lifecycle.
  - Avoid UI updates on unavailable component.
- cancel(true) == cancel(false) + interrupt()
- Implement cancellation policy.

Creation and Start

- at = new AsyncTask()
  - The first creation decides callback thread
    - onPostExecute()
    - onPublishProgress()
    - onCancelled()
- at.execute()
  - Callback thread of onPreExecute()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AsyncTask.execute(Runnable)
"newSingleThreadExecutor"
Execute Message and Runnable
Better clean up
Handler Thread
Subsequent execution
AsyncTask
One task with UI callback

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Service

- Background execution on the UI thread
- Decouple background threads with other lifecycles, typically the Activity lifecycle.

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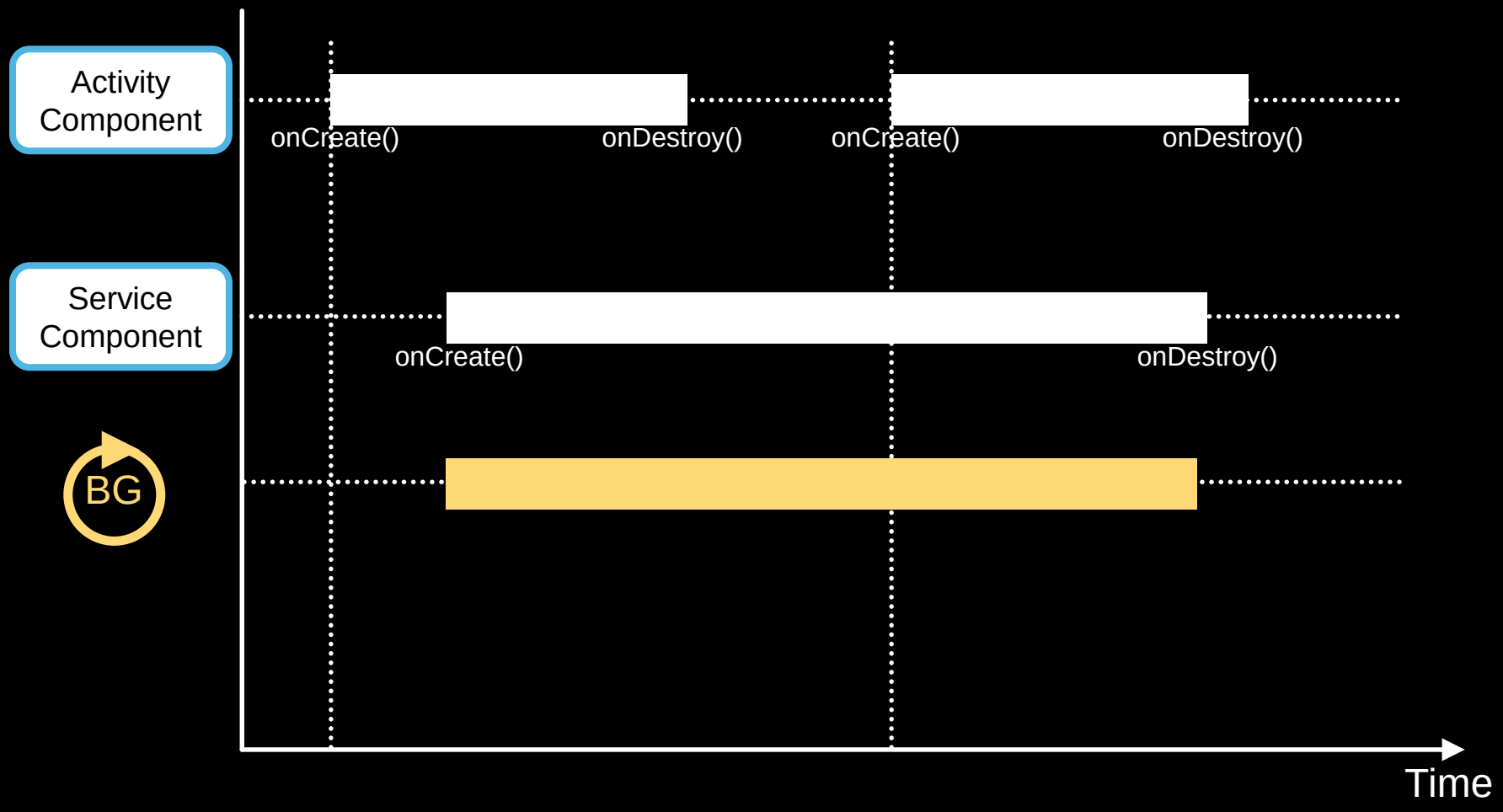
Example: Lifecycle Decoupling



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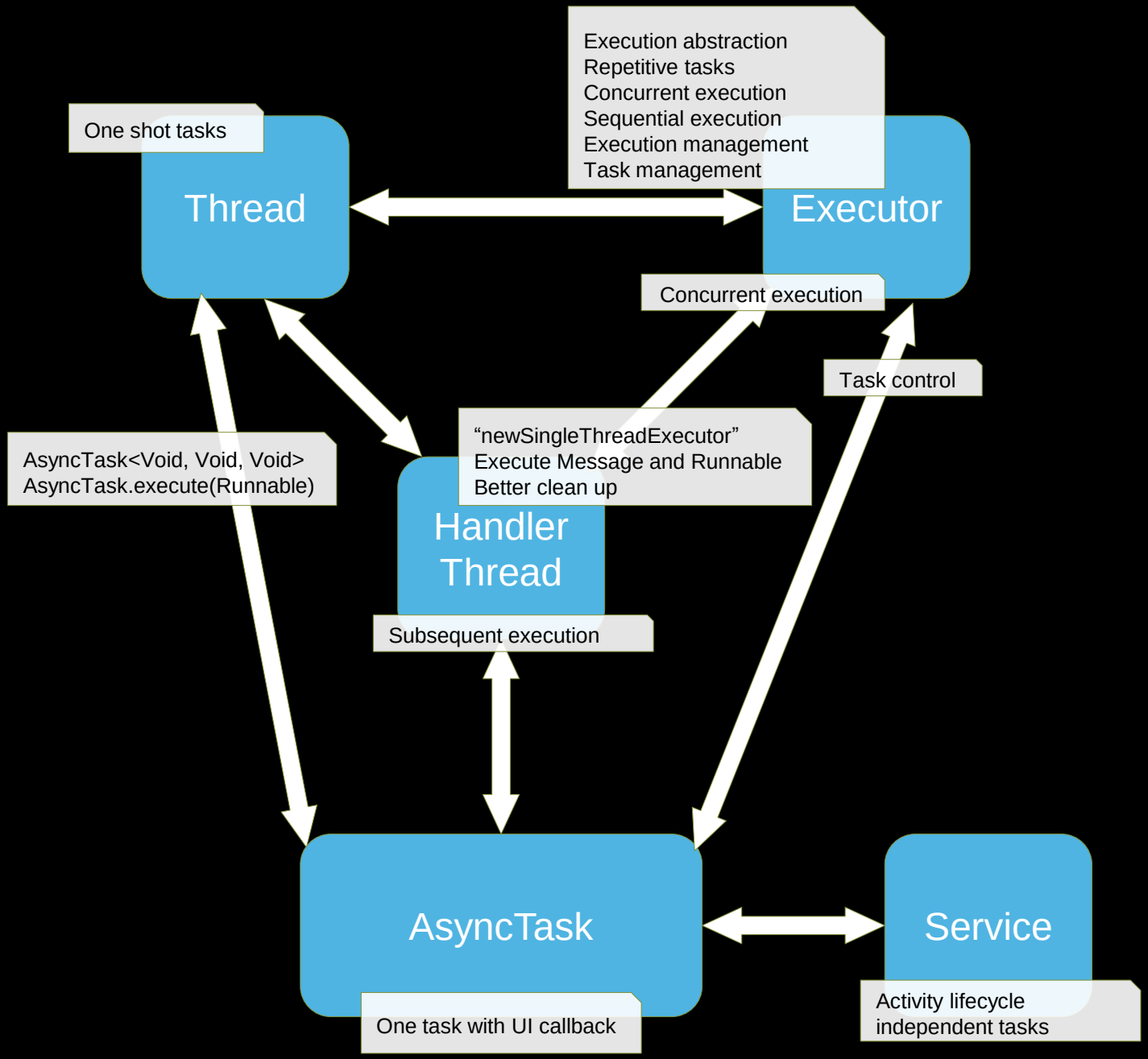
Good Use Cases

- Tasks executed independently of user interaction.
- Tasks executing over several Activity lifecycles or configuration changes.

Pitfalls

- Hidden AsyncTask.execute() with serial execution.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Subsequent execution
AsyncTask
Service
One task with UI callback
Activity lifecycle
independent tasks

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IntentService

- Service with a worker thread.
- On demand intents.

```
public class MyIntentService extends IntentService {

        @Override
        protected void onHandleIntent(Intent intent) {
        }

}
```

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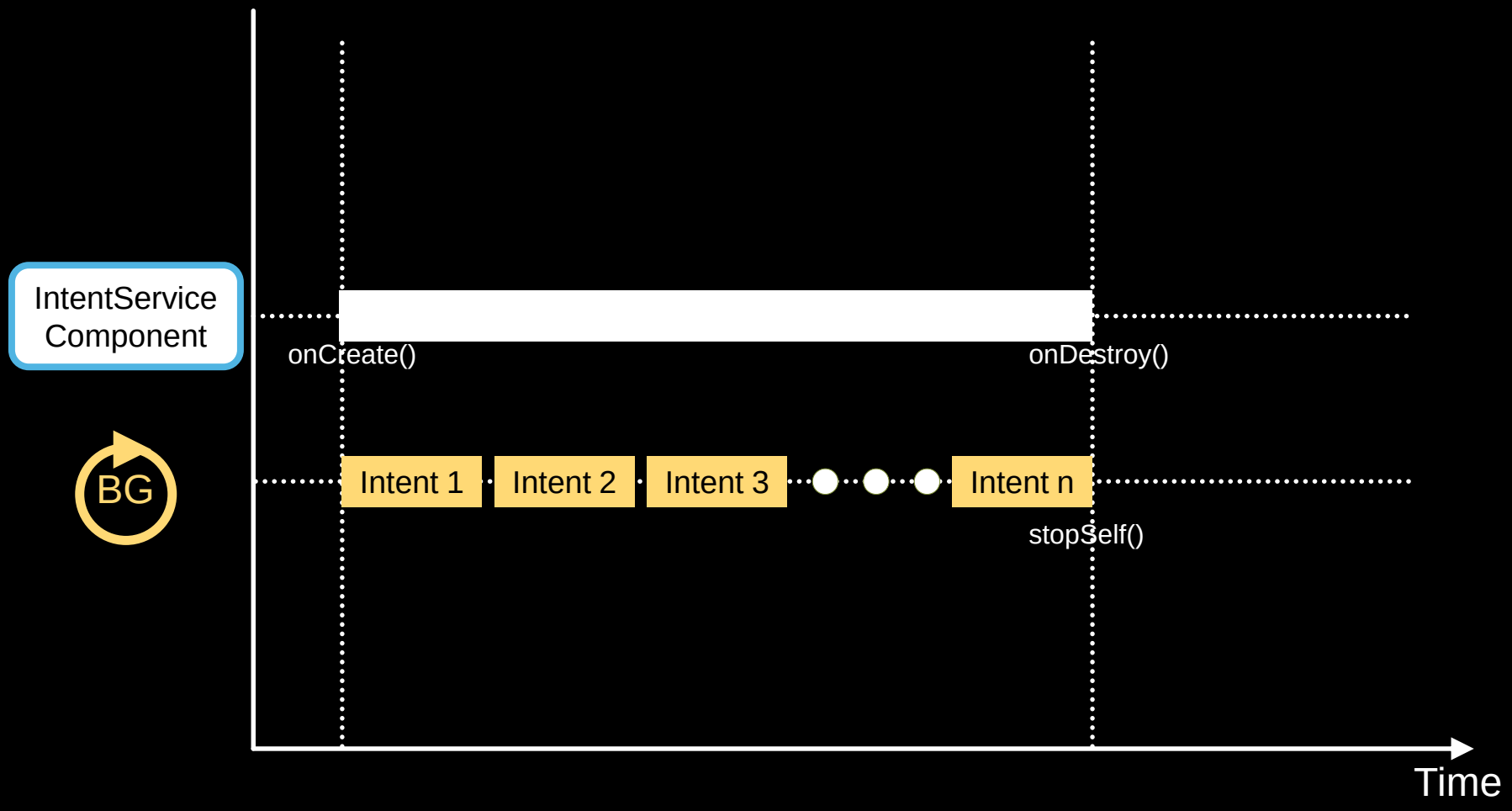
Lifecycle



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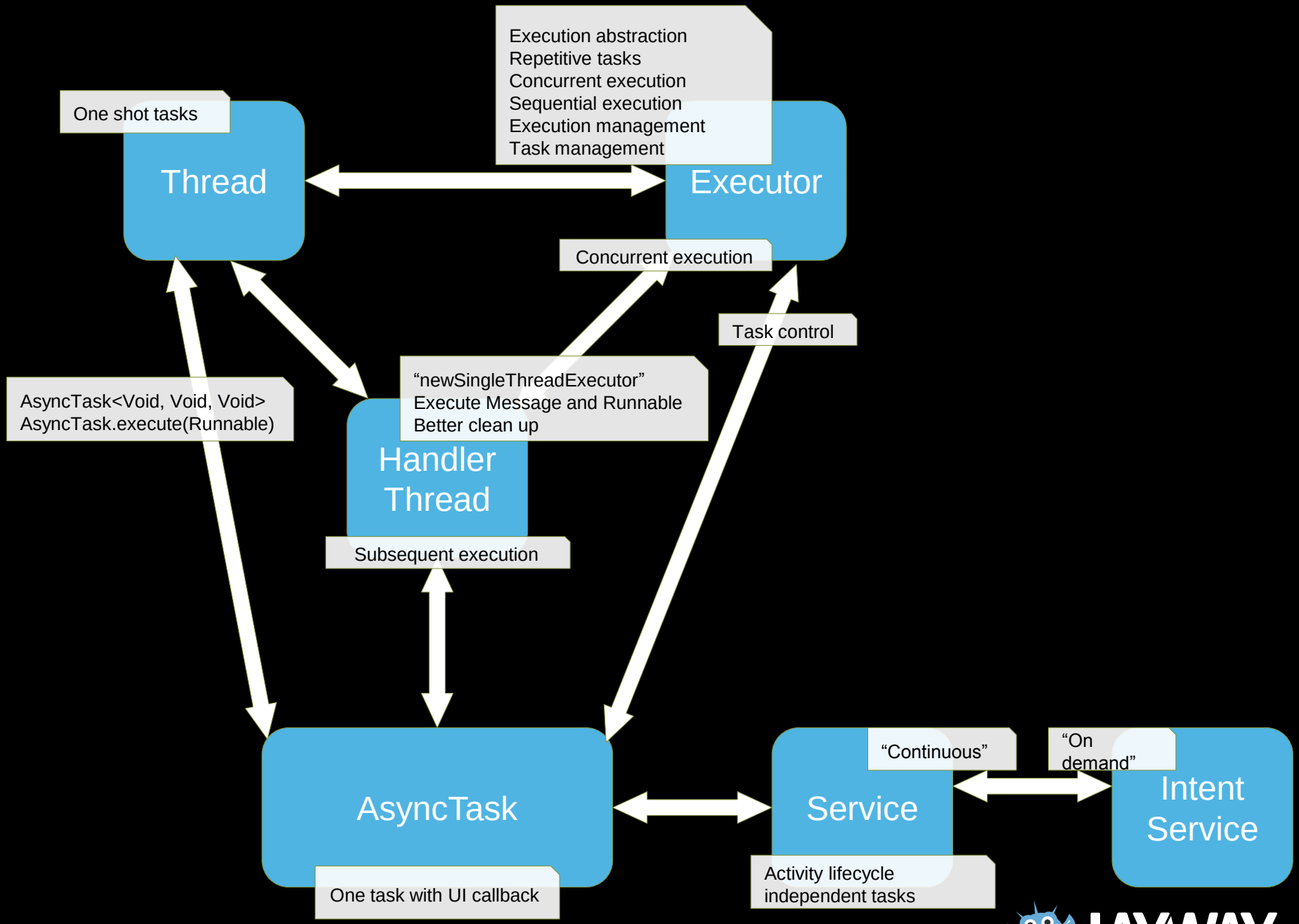
Good Use Cases

- Serially executed tasks decoupled from other component lifecycles.
- Off-load UI thread from BroadcastReceiver.
- REST client (ResultReceiver as callback)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AsyncTask
One task with UI callback
"Continuous"
"On demand"
Service
Intent Service
Activity lifecycle independent tasks

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AsyncQueryHandler

- API Level 1
- Asynchronous operations on a ContentResolver
  - Query
  - Insert
  - Delete
  - Update
- Wraps a HandlerThread

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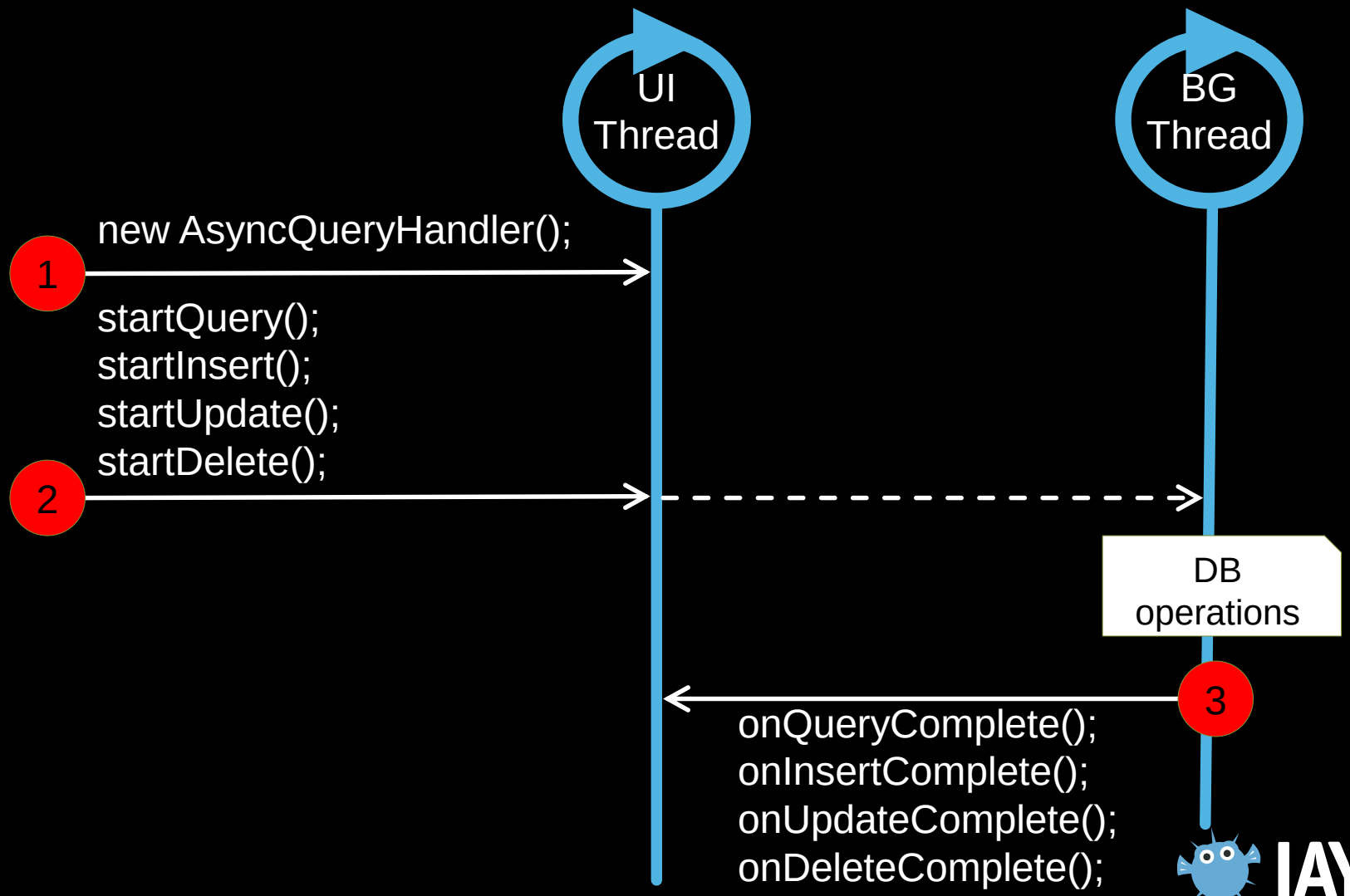
How it works



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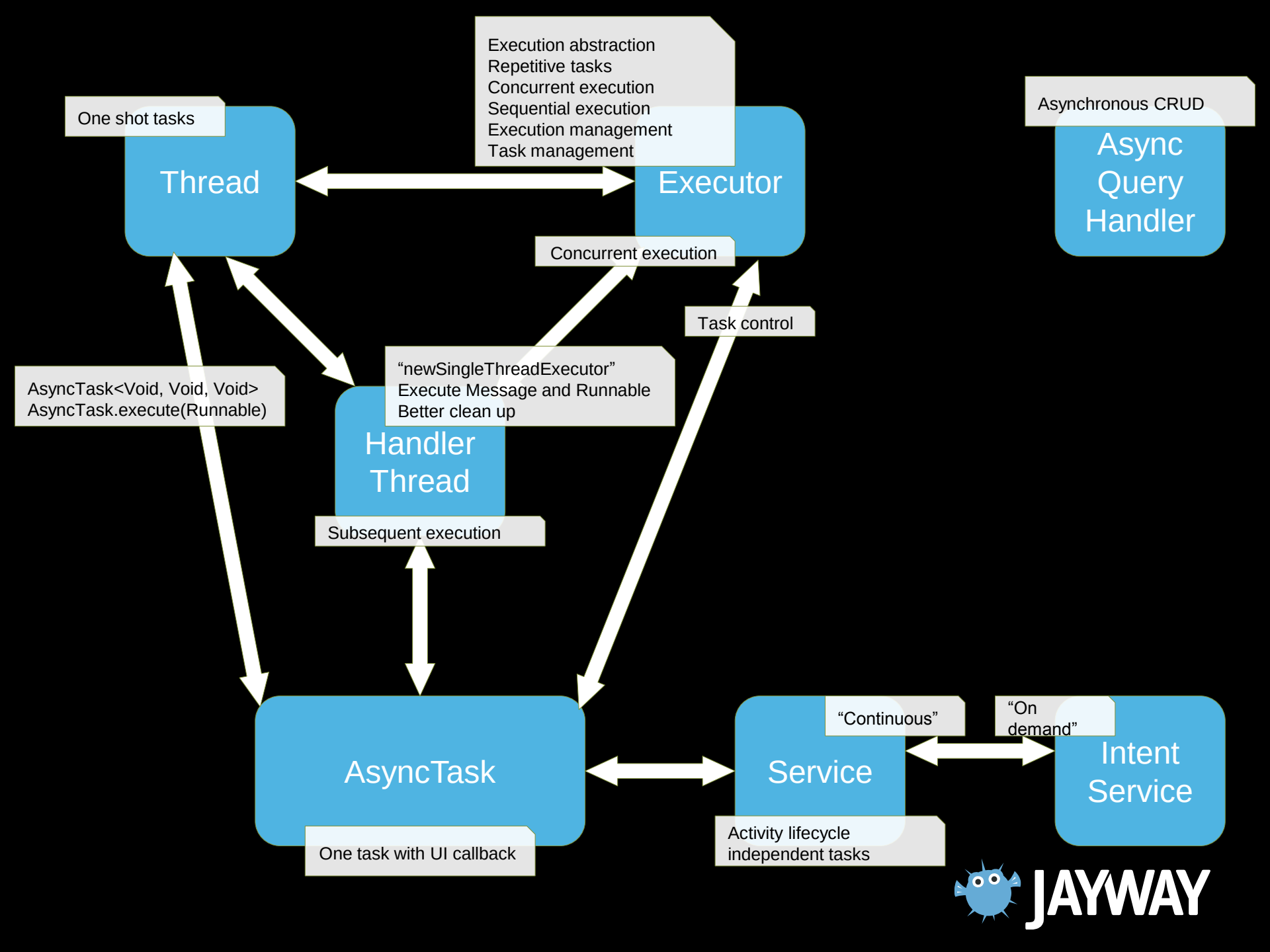
Cons

- No cursor management
- No content observation
- No data retention on configuration changes
- Background thread can’t be forced to quit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Loader

- API added in Honeycomb
- Available in compatibility package
- Load data in a background thread
- Observes data changes
- Retained on configuration changes
- Connected to the Activity and Fragment lifecycles

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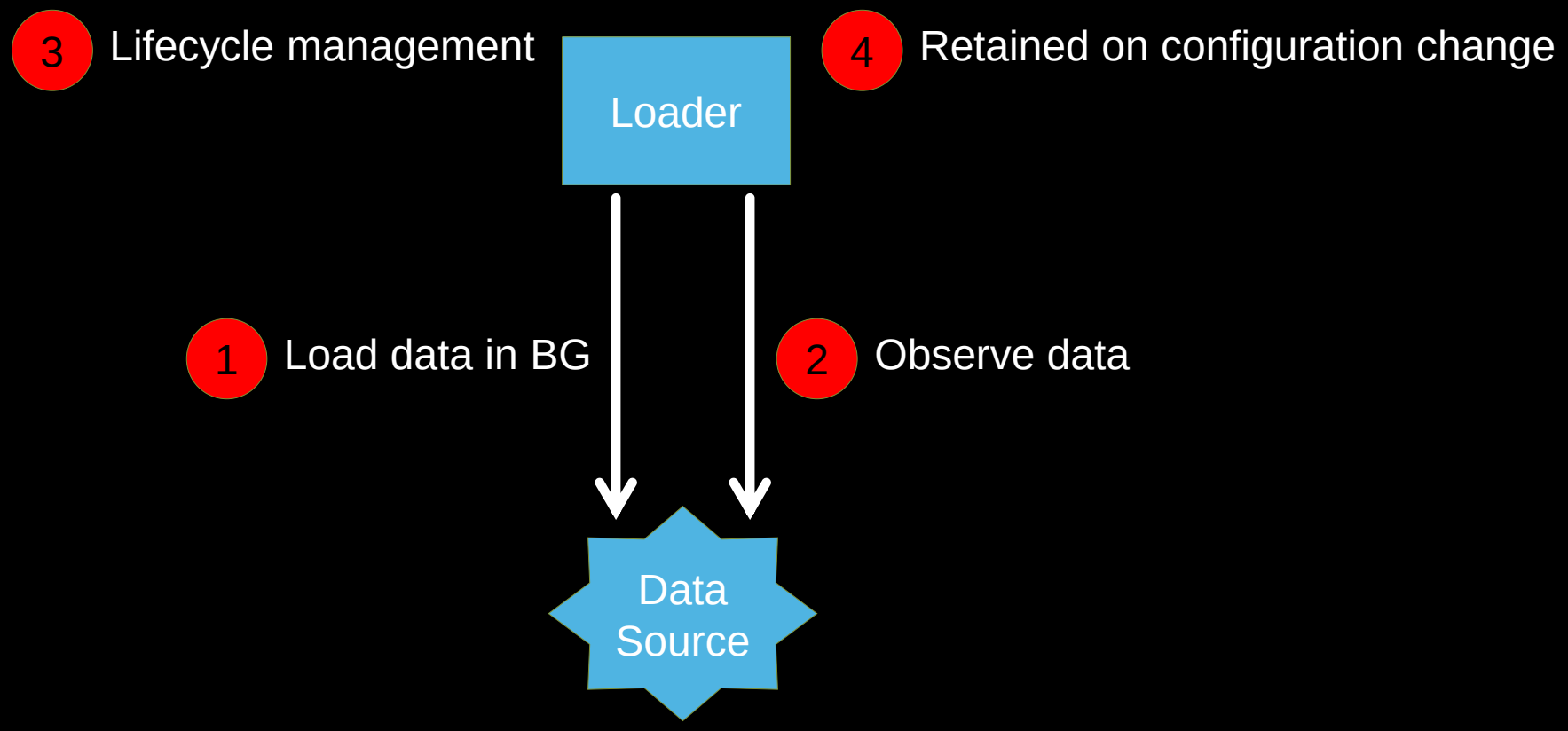
Basics



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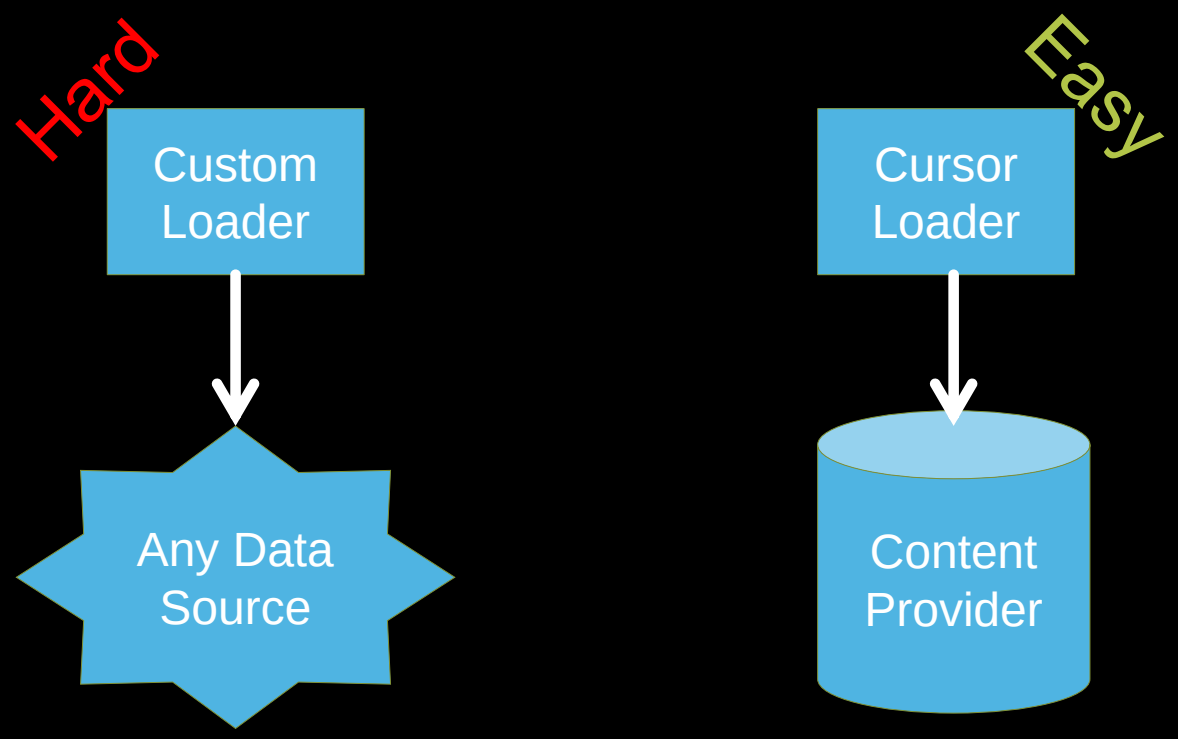
Data Sources



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How It Works

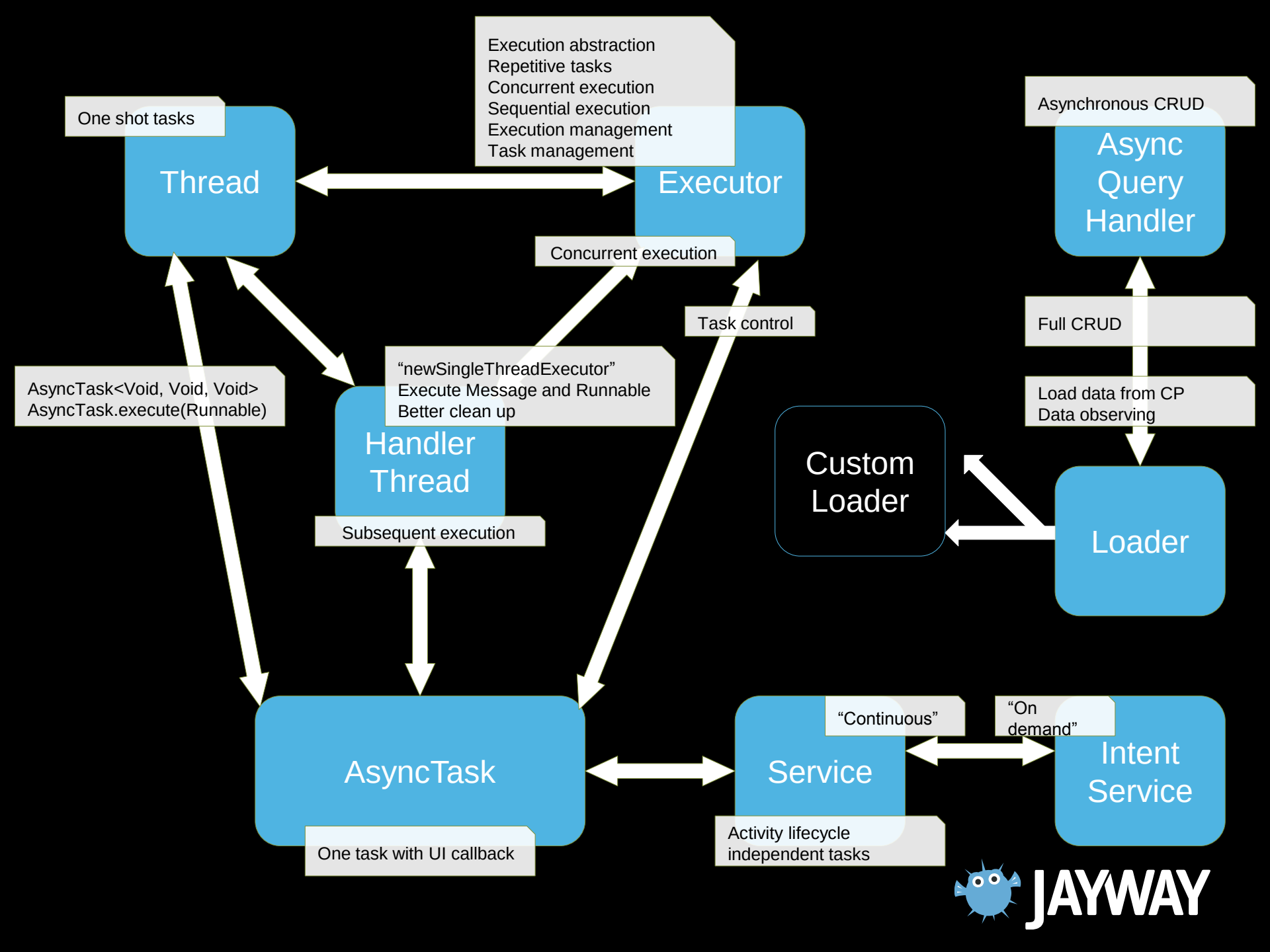
```
public class AndroidLoaderActivity extends ListActivity implements LoaderCallbacks<Cursor>{

        SimpleCursorAdapter mAdapter;

        public void onCreate(Bundle savedInstanceState) {
                getLoaderManager().initLoader(0, null, this);
        }

        @Override
        public Loader<Cursor> onCreateLoader(int id, Bundle args) {
                return new CursorLoader(..., CONTENT_URI, ...);
        }

        @Override
        public void onLoadFinished(Loader<Cursor> loader, Cursor c) {
                mAdapter.swapCursor(c);
        }

        @Override
        public void onLoaderReset(Loader<Cursor> arg0) {
                mAdapter.swapCursor(null);
        }
}
```

Pitfalls

- Data loading will stop when Activity/Fragment is destroyed
  - Http requests not finished

Good Use Cases

- Loading data from Content Providers.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Data observing
Custom Loader
Loader
Subsequent execution
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Service
Intent Service
Activity lifecycle
independent tasks
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Thank you for listening!

Questions?

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