Android Services & Local IPC: The Activator Pattern (Part 2)

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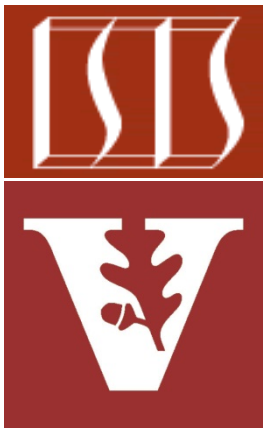

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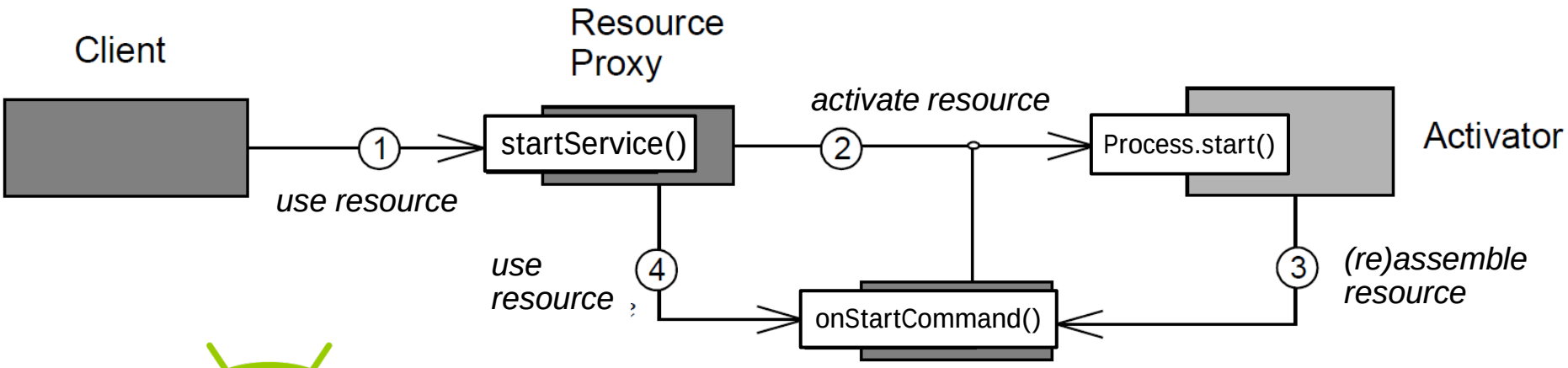
Learning Objectives in this Part of the Module

- Understand how the *Activator* pattern is applied in Android



Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
  - Encapsulate each distinct unit of app functionality into a self-contained service

```
public abstract class Service
       extends ContextWrapper
       implements
          ComponentCallbacks2
{
  public abstract IBinder
    onBind(Intent intent);

  ...
}
```

frameworks/base/core/java/android/app/Service.java has the source code

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
  - Encapsulate each distinct unit of app functionality into a self-contained service
  - Examples of service identifier representations include URLs, IORs, TCP/IP port numbers & host addresses, Android Intents, etc.

Intent Element	Purpose
Name	Optional name for a component
Action	A string naming the action to perform or the action that took place & is being reported
Data	URI of data to be acted on & the MIME type of that data
Category	String giving additional info about the action to execute

frameworks/base/core/java/android/content/Intent.java has the source code

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
  - Determine overhead of activating & deactivating services on-demand vs. keeping them alive for the duration of the system vs. security implications, etc.

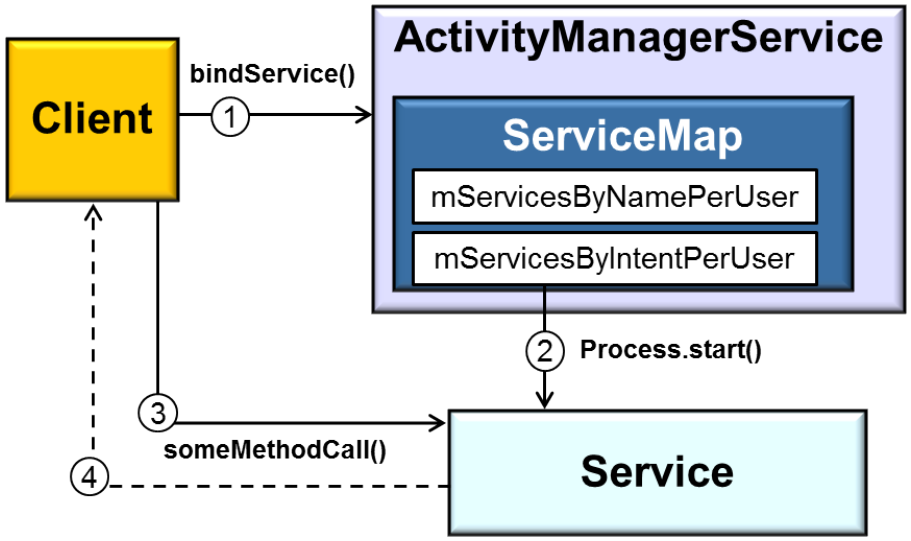
Android Service	Purpose
Media Playback Service	Provides "background" audio playback capabilities
Exchange Email Service	Send/receive email messages to an Exchange server
SMS & MMS Services	Manage messaging operations, such as sending data, text, & PDU messages
Alert Service	Handle calendar event reminders

packages/apps has source code for many Bound & Started Services

Activator POSA4 Design Pattern

Implementation

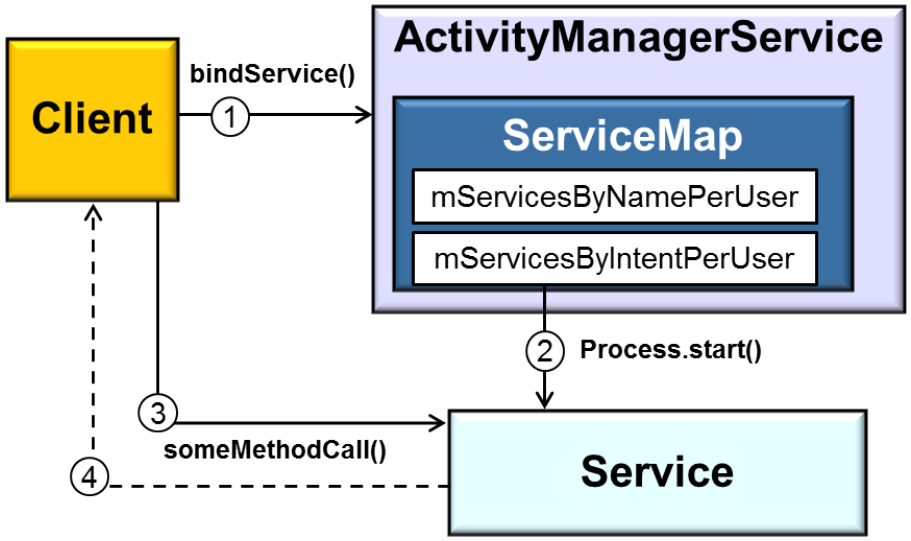
- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
  - Define service execution context representation
    - e.g., an OS process/thread or middleware container



Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
  - Define service execution context representation
  - Define service registration strategy
    - e.g., static text file or dynamic object registration



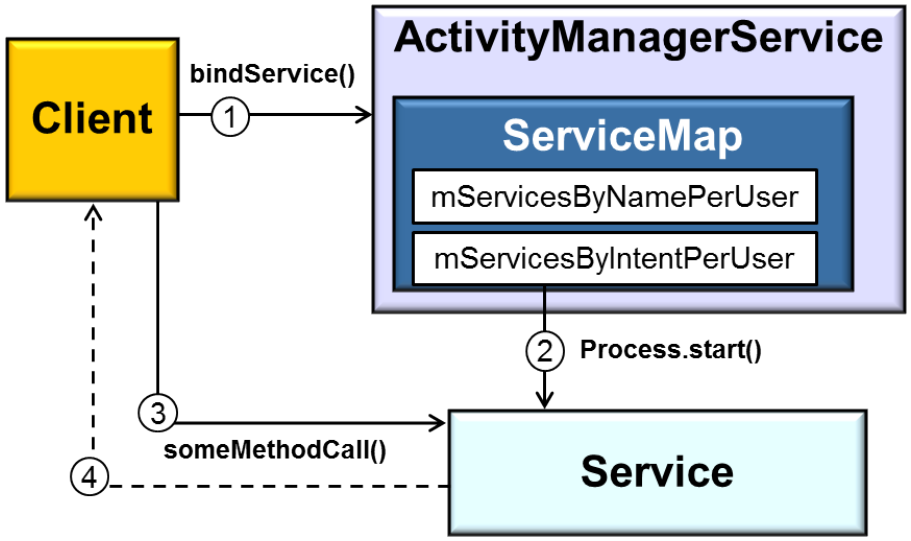

```
<service android:name=
"com.android.music.MediaPlaybackService"
   android:exported="false"/>
```

frameworks/base/services/java/com/android/server/am/ActivityManagerService.java

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
  - Define service execution context representation
  - Define service registration strategy
  - Define service initialization strategy
    - e.g., stateful vs. stateless services



Android Services are responsible for managing their own persistent state

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
  - Define service execution context representation
  - Define service registration strategy
  - Define service initialization strategy
  - Define service deactivation strategy
    - e.g., service-triggered, client-triggered, or activator-triggered deactivation

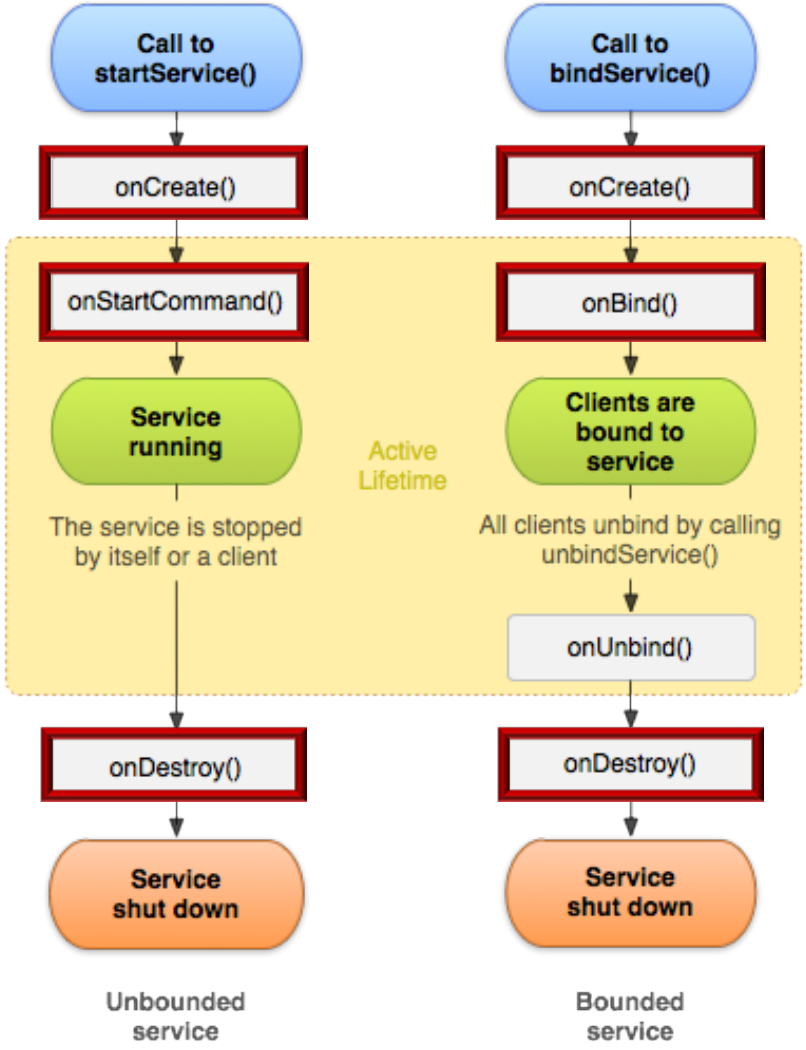
Started Service	Bound Service
• Service runs indefinitely & must stop itself by calling stopSelf() • A component can also stop the service by calling stopService() • When Service is stopped, Android destroys it	• Multiple clients can bind to same Service • When all of them unbind, the system destroys the Service • The Service does not need to stop itself an

developer.android.com/guide/components/services.html#Lifecycle has more

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
- Define interoperation between services & service execution context
  - Typically implemented via some type of lifecycle callback hook methods

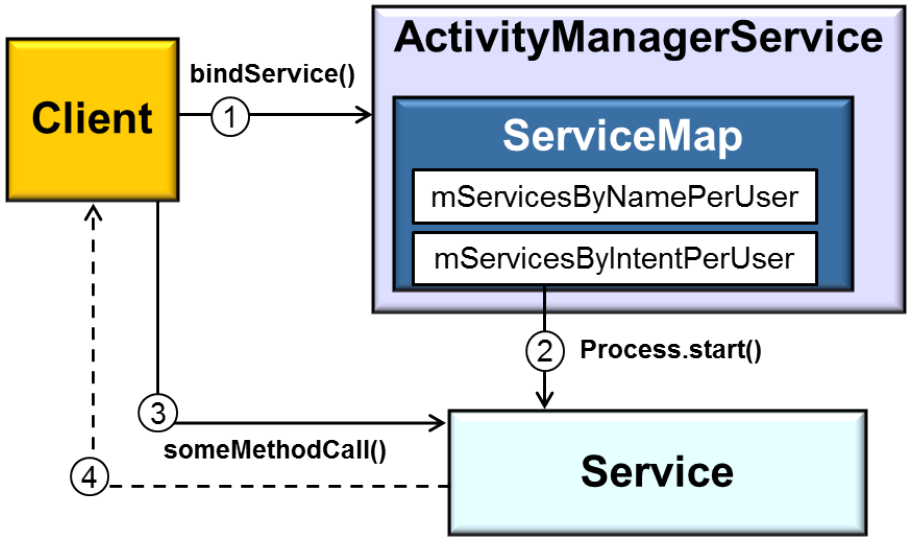


developer.android.com/guide/components/services.html#LifecycleCallbacks

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
- Define interoperation between services & service execution context
- Implement the activator
  - Determine the association between activators & services
    - e.g., singleton (shared) vs. exclusive vs. distributed activator

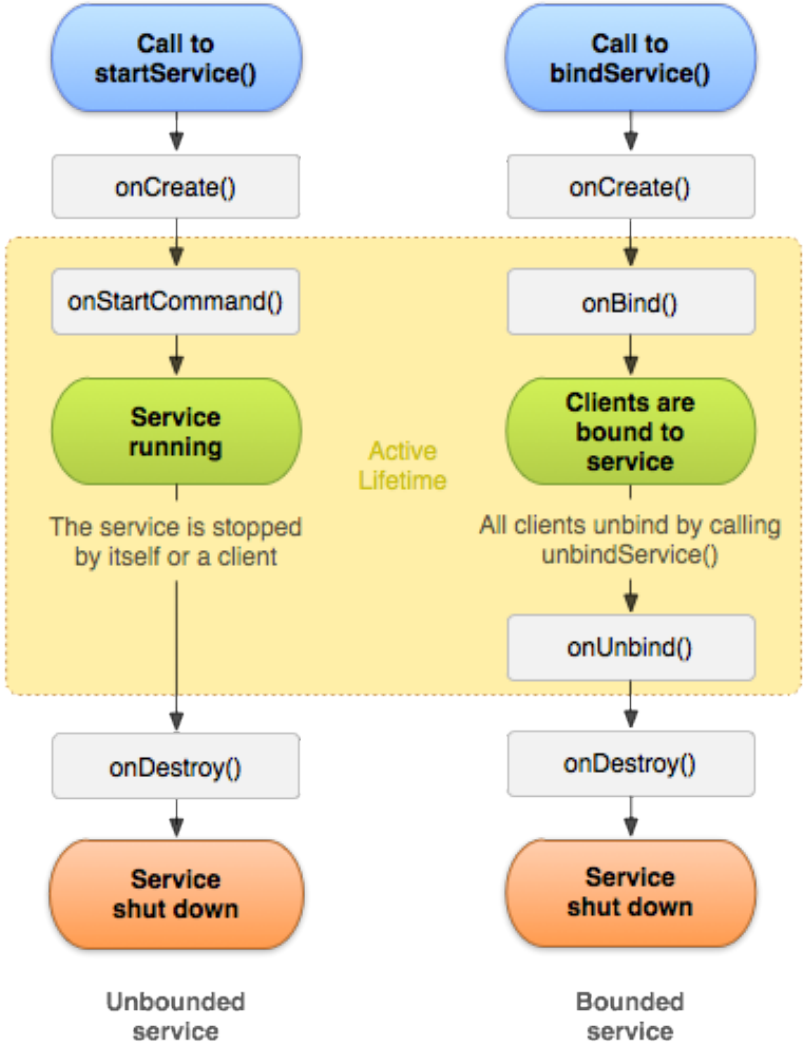


The Android Activity Manager Service is a singleton activator

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
- Define interoperation between services & service execution context
- Implement the activator
  - Determine the association between activators & services
  - Determine the degree of transparency
    - e.g., explicit vs. transparent activator

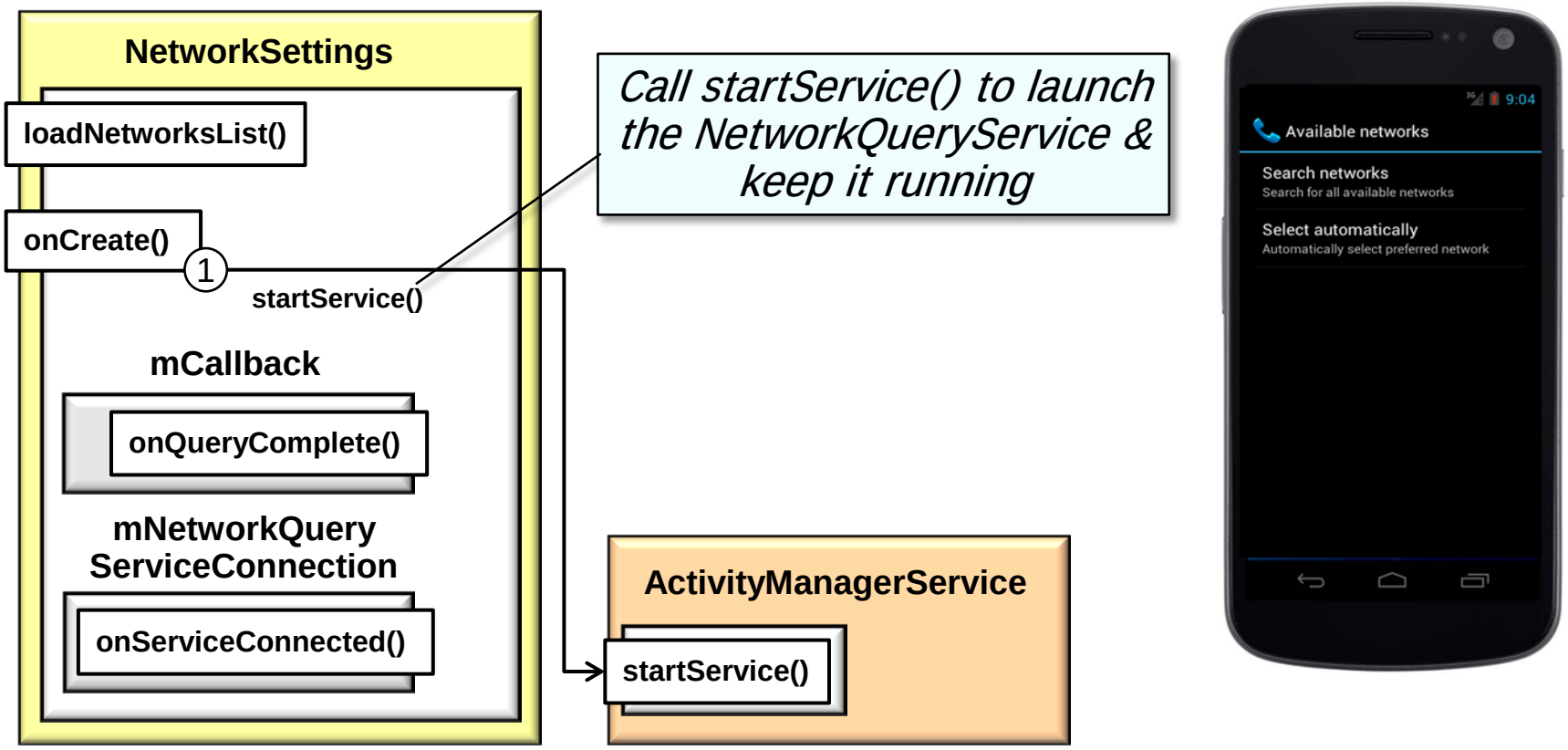


Android Started & Bound Services use an explicit activator model

Activator POSA4 Design Pattern

Applying the Activator pattern in Android

- The NetworkSettings Activity uses the *Activator* pattern to launch the NetworkQueryService to assist in querying the network for service availability



packages/apps/Phone/src/com/android/phone/NetworkSetting.java has source code

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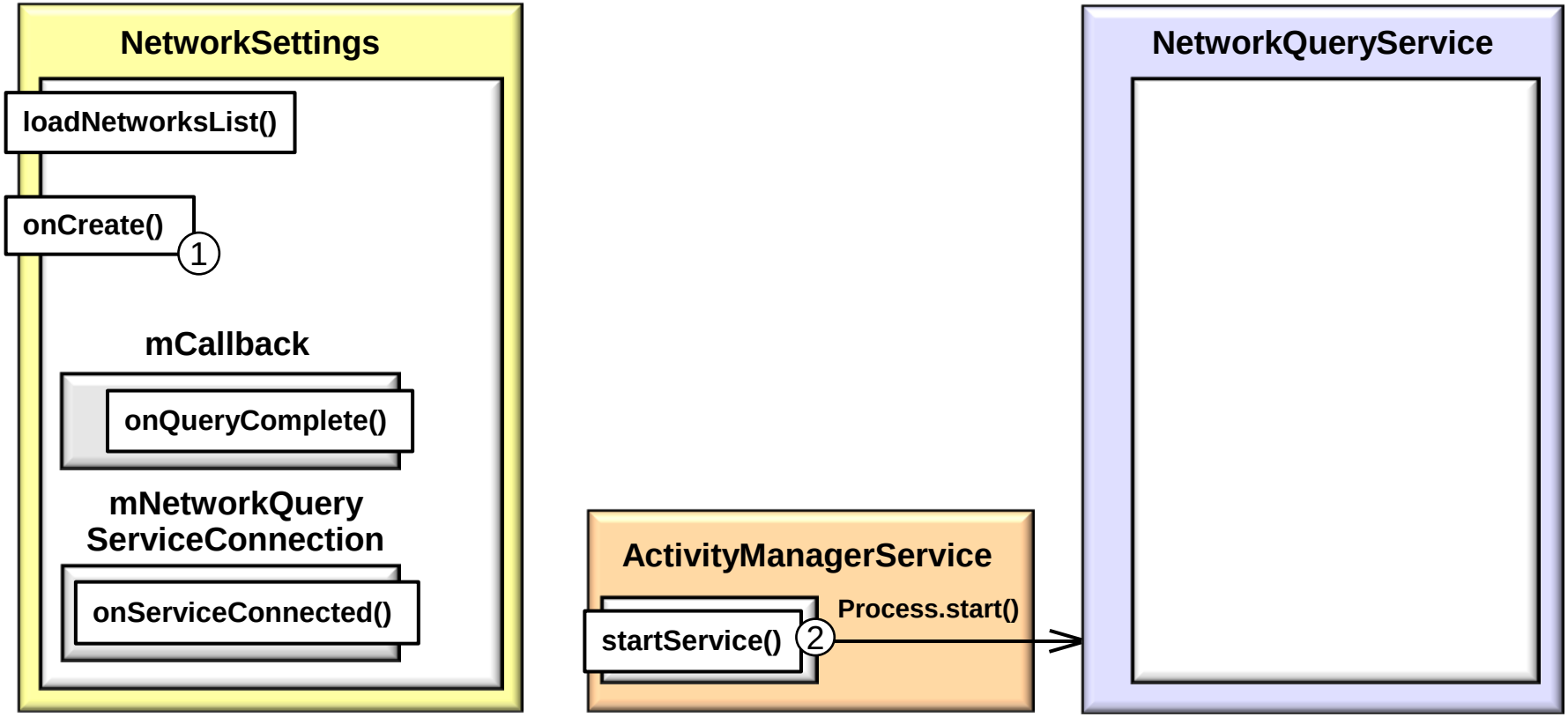

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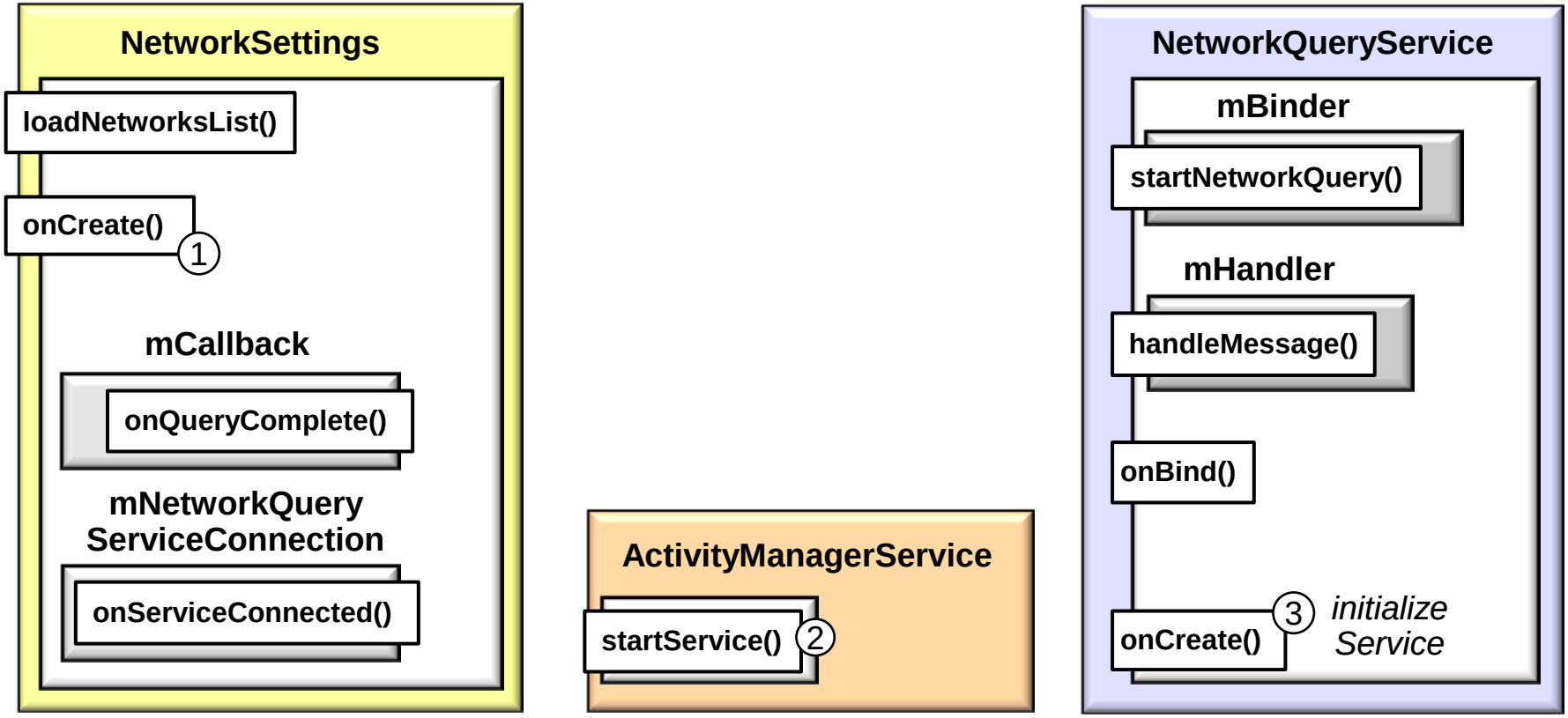

packages/apps/Phone/src/com/android/phone/NetworkQueryService.java has source

Activator POSA4 Design Pattern

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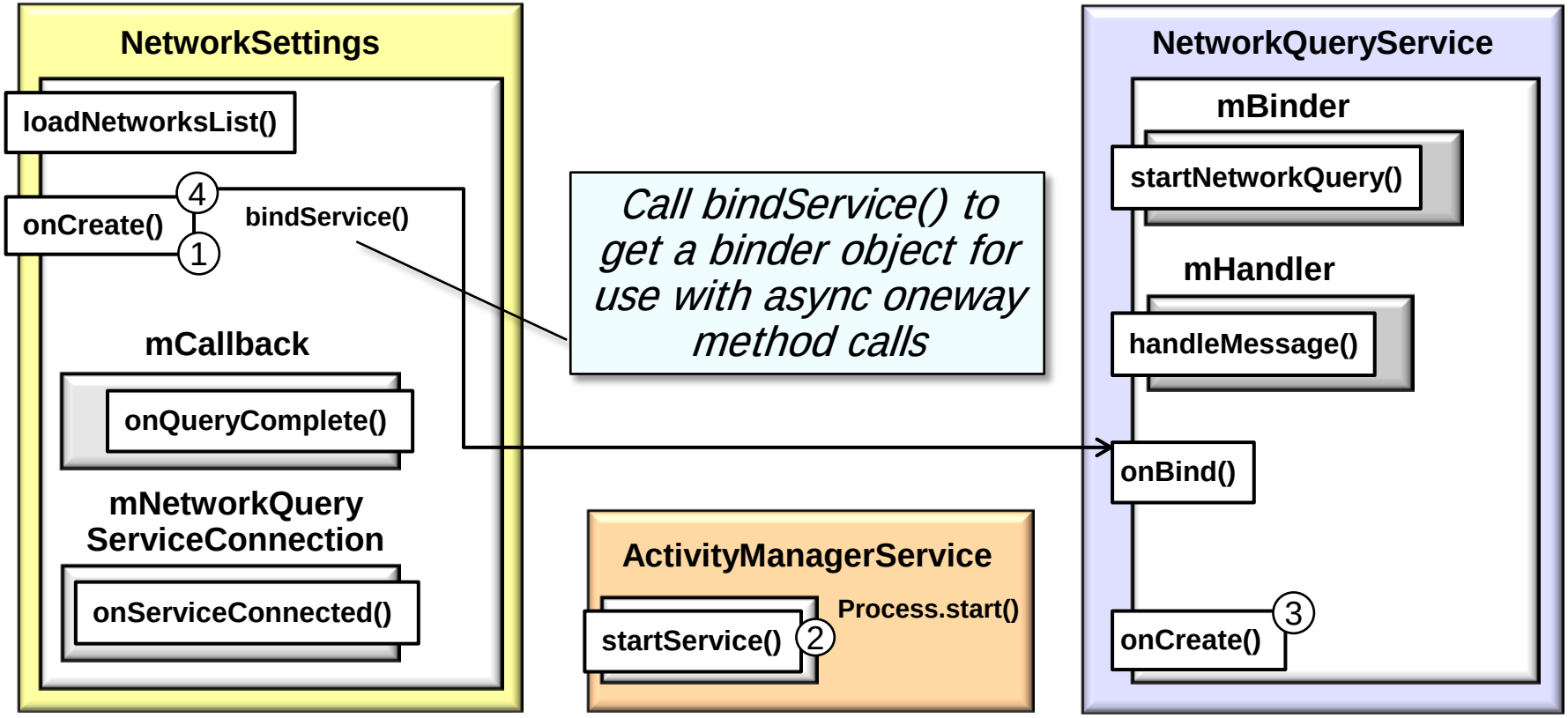

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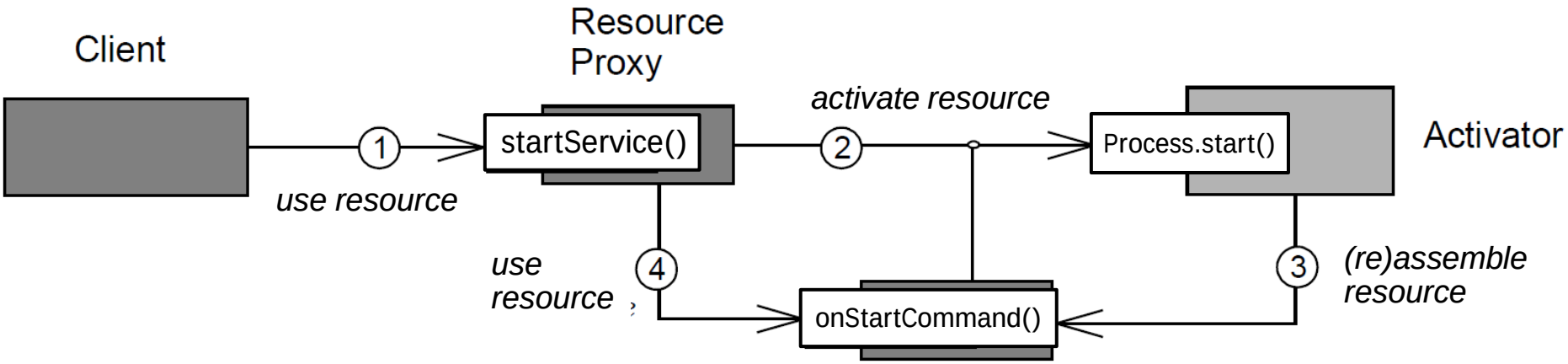
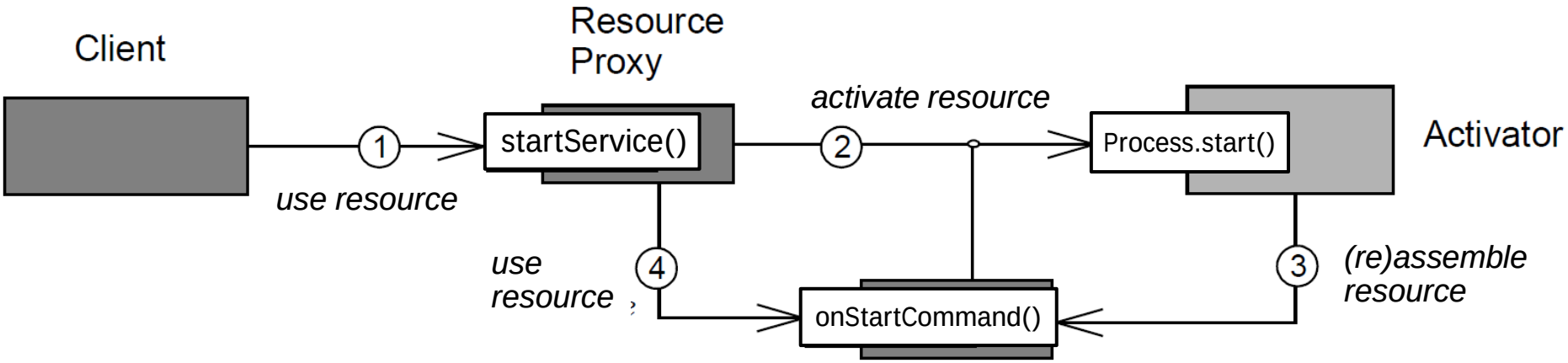
Summary



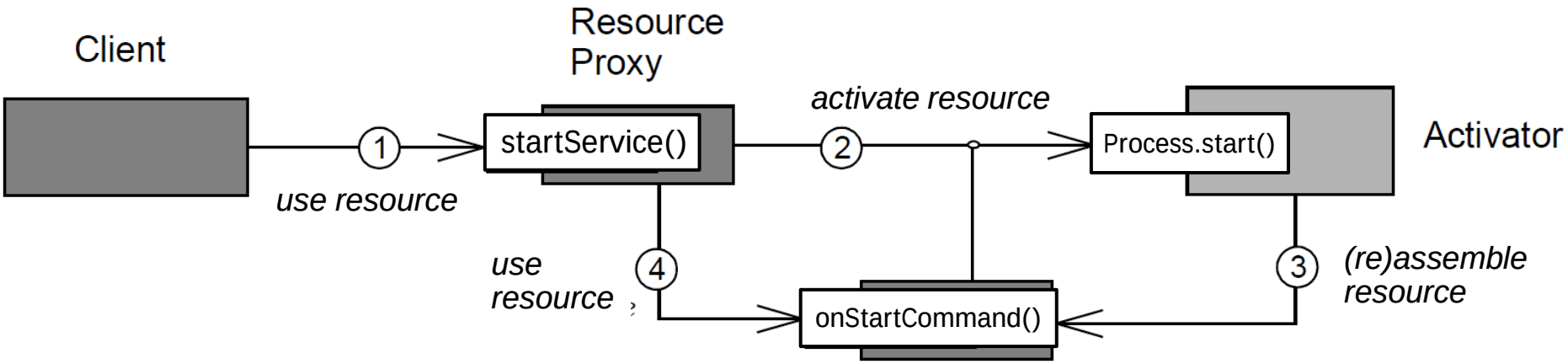
- The Android Started & Bound Services implement the *Activator* pattern

Summary



- The Android Started & Bound Services implement the *Activator* pattern
- These Services can process requests in background processes or threads
  - Processes can be configured depending on directives in the AndroidManifest.xml file

Summary



- The Android Started & Bound Services implement the *Activator* pattern
- These Services can process requests in background processes or threads
  - Processes can be configured depending on directives in the AndroidManifest.xml file
  - Threads can be programmed using the Android Intent Service framework, as discussed next

Android Services & Local IPC: The Activator Pattern (Part 1)

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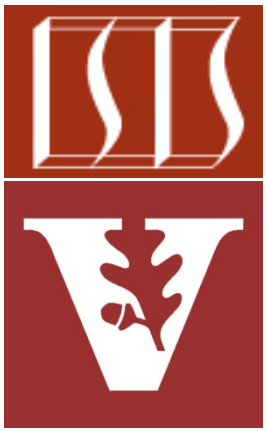

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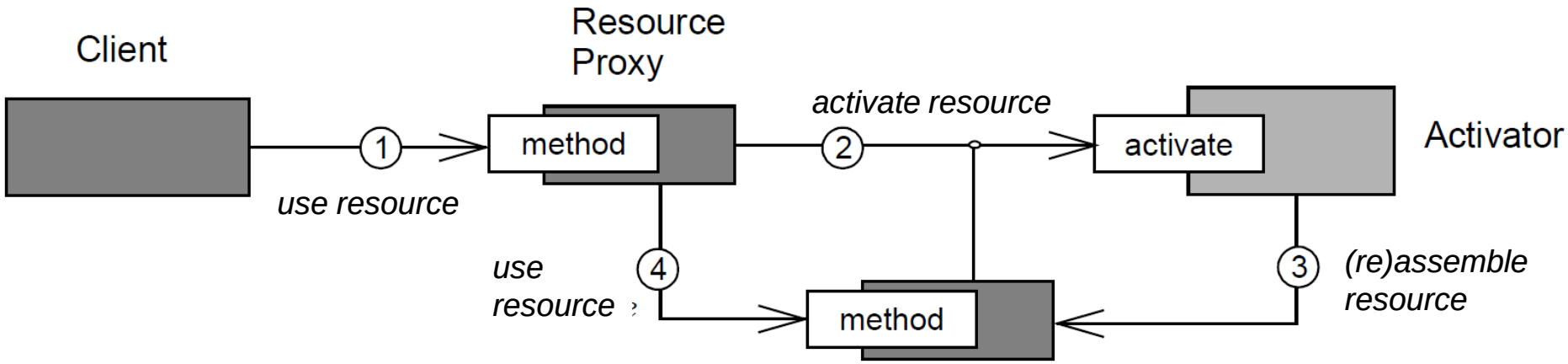
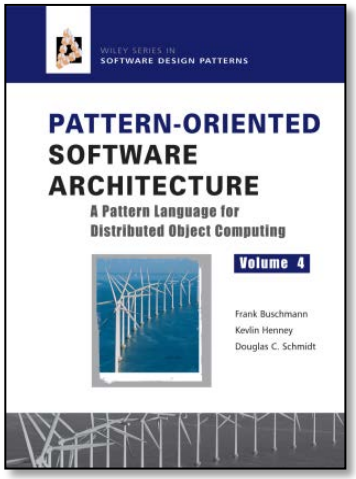


Efficiently and Transparently Automating Scalable On-demand Activation and Deactivation of Services with the Activator Pattern

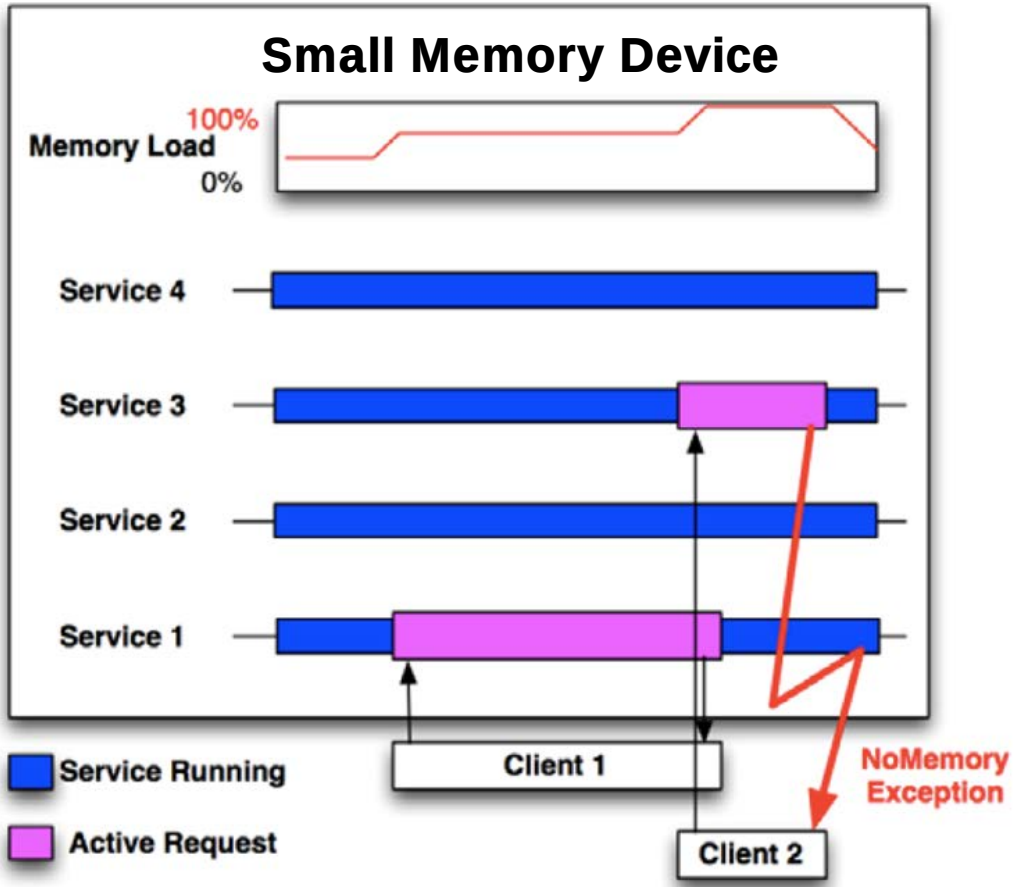


www.dre.vanderbilt.edu/~schmidt/PDF/Activator.pdf

Challenge: Minimizing Resource Utilization

Context

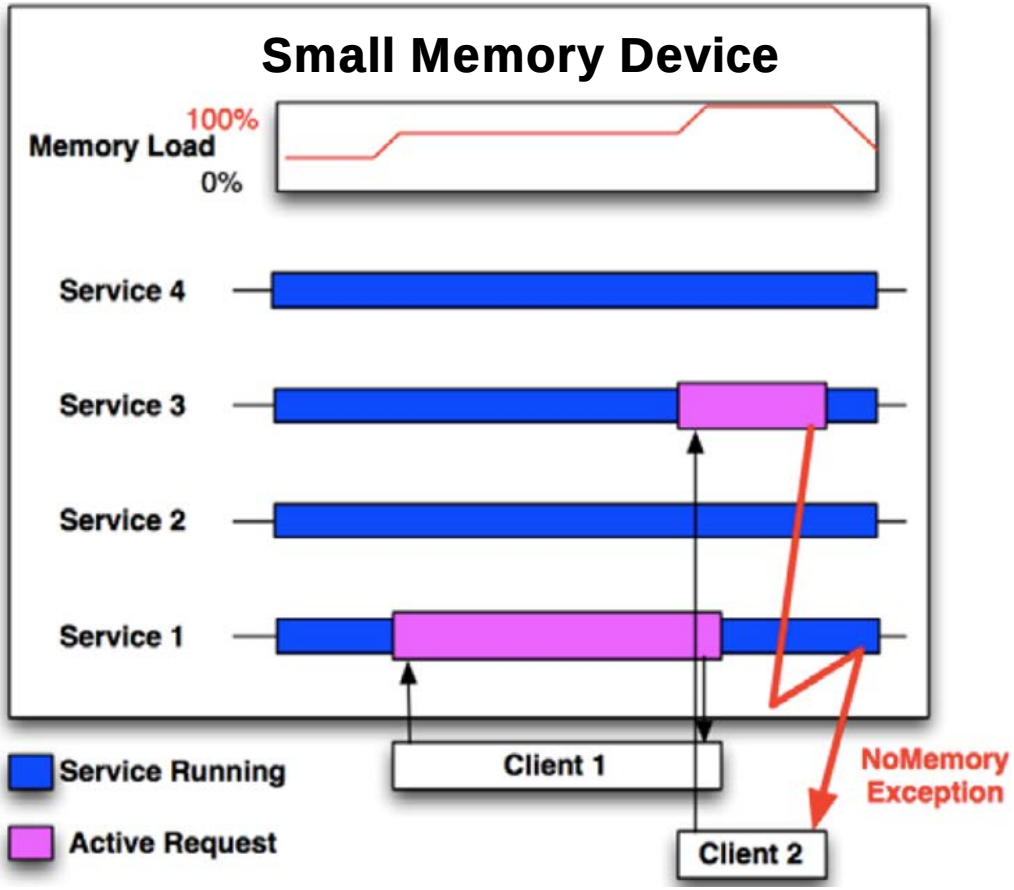
- Resource constrained & highly dynamic environments
  - Random-access memory (RAM) is a valuable resource in any software environment



Challenge: Minimizing Resource Utilization

Context

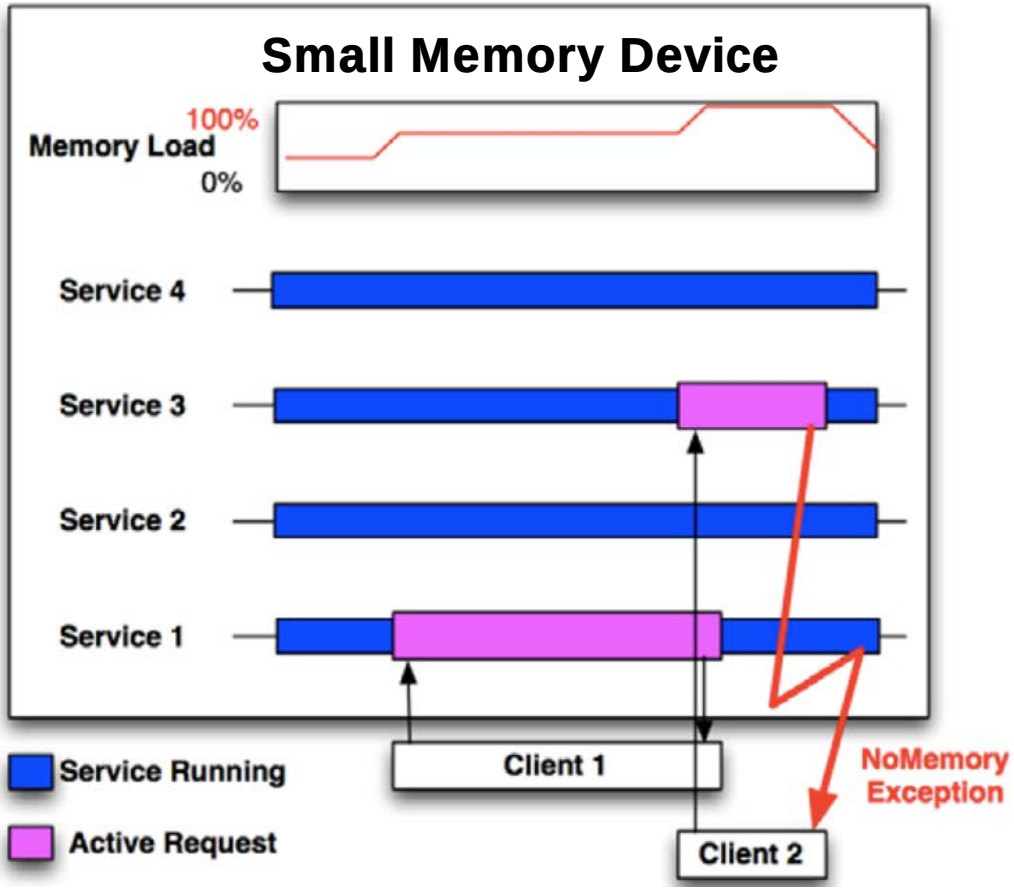
- Resource constrained & highly dynamic environments
  - Random-access memory (RAM) is a valuable resource in any software environment
  - It's even more valuable on a mobile OS like Android where physical memory is often constrained



Challenge: Processing a Long-Running Action

Problem

- It's not feasible to have all App Service implementations running all the time since this ties up end-system resources unnecessarily

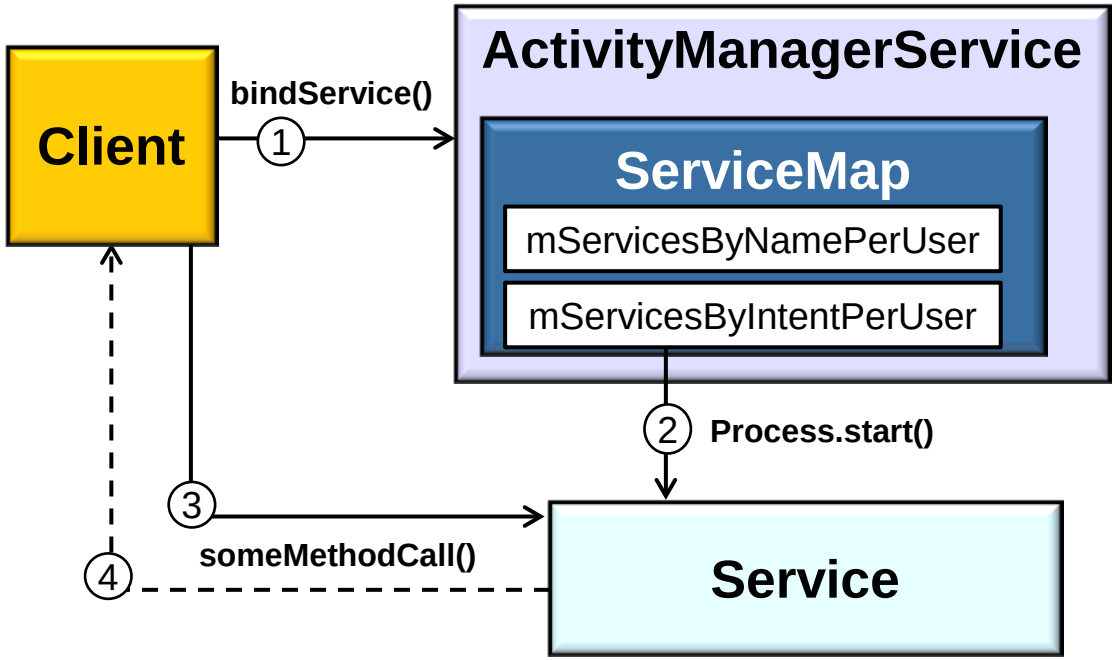


developer.android.com/training/articles/memory.html has more info

Challenge: Processing a Long-Running Action

Solution

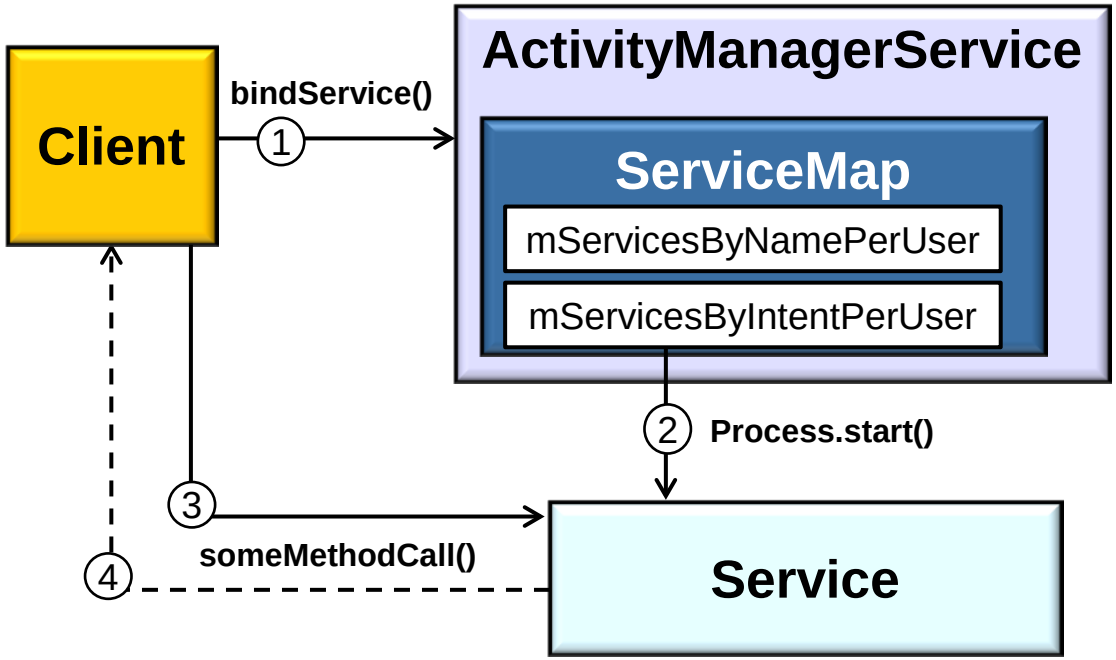
- Apply the *Activator* pattern to activate & deactivate Android Services automatically
  - If your app needs a Service to perform work in the background, don't keep it running unless it's actively performing a job



Challenge: Processing a Long-Running Action

Solution

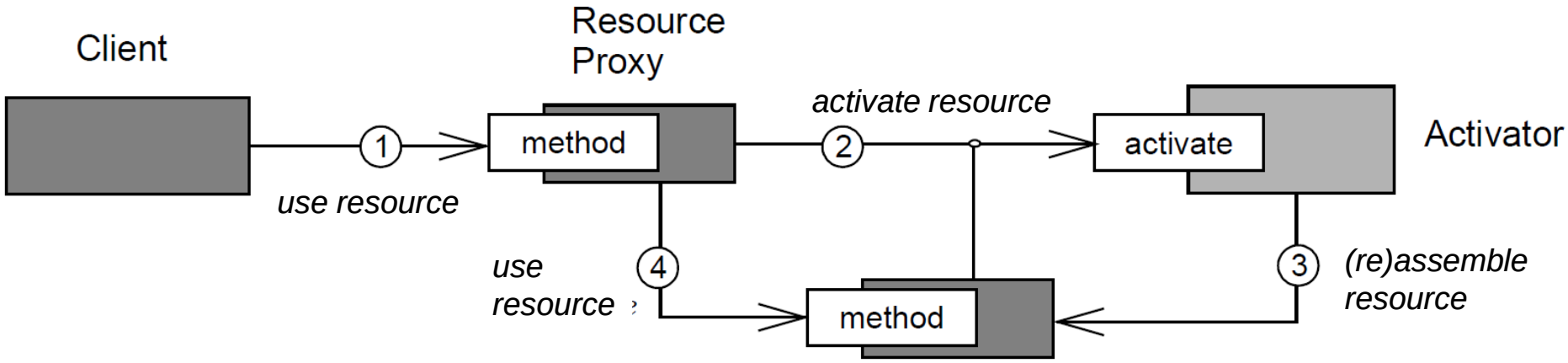
- Apply the *Activator* pattern to activate & deactivate Android Services automatically
  - If your app needs a Service to perform work in the background, don't keep it running unless it's actively performing a job
  - Be careful to never leak your Service by failing to stop it when its work is done



Activator POSA4 Design Pattern

Intent

- *Activator* automates scalable on-demand activation & deactivation of service execution contexts to run services accessed by many clients without consuming excessive resources

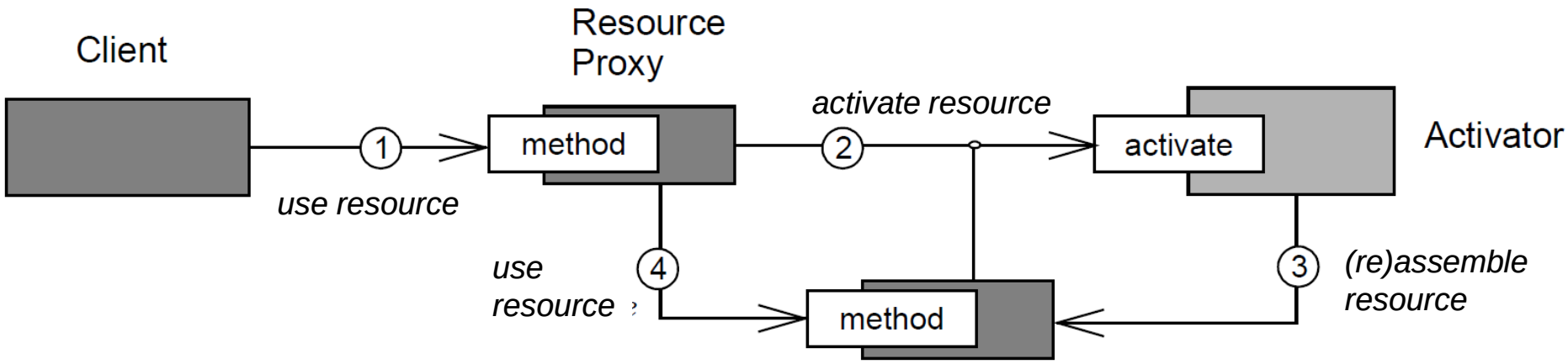


www.dre.vanderbilt.edu/~schmidt/PDF/Activator.pdf has more info

Activator POSA4 Design Pattern

Applicability

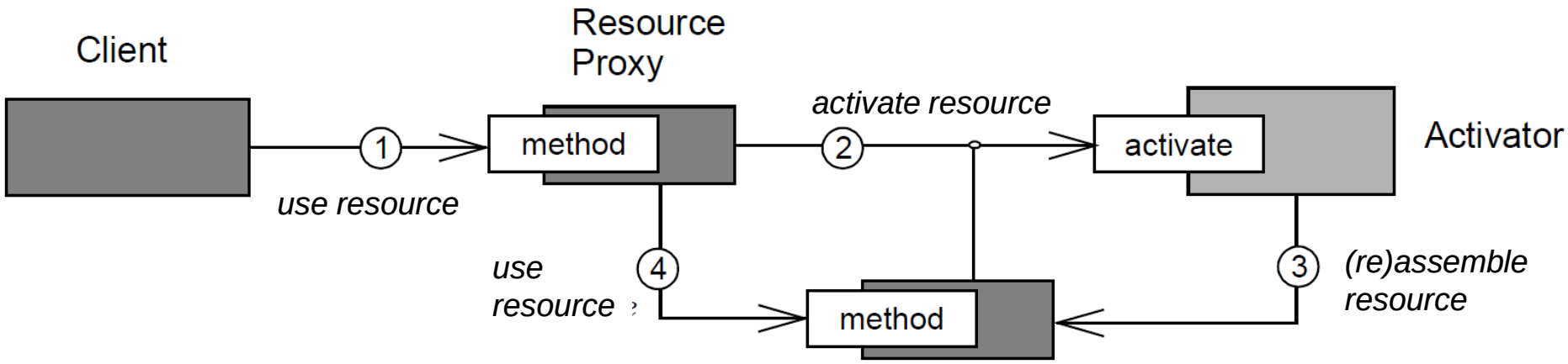
- When services in a system should only consume resources when they are accessed actively by clients



Activator POSA4 Design Pattern

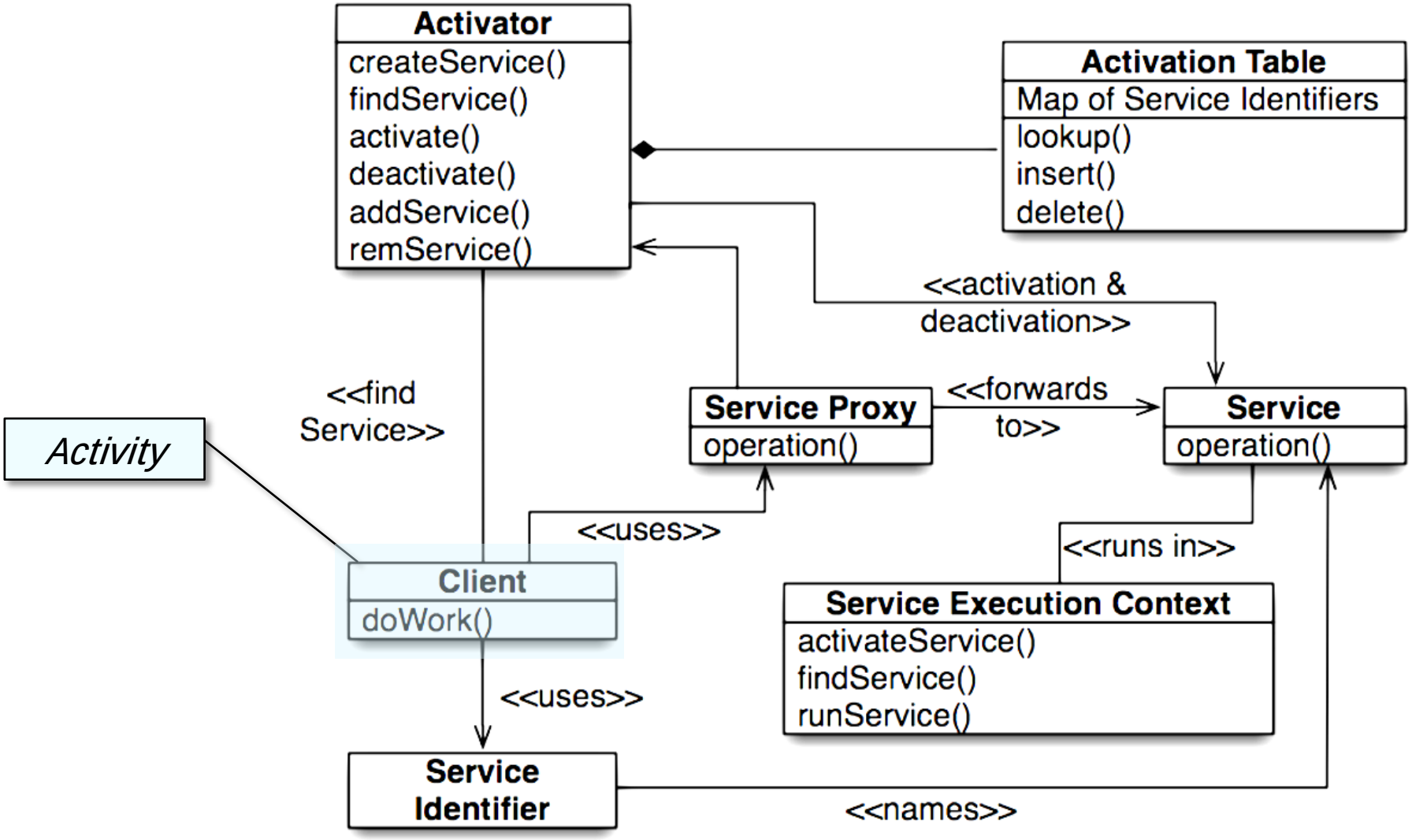
Applicability

- When services in a system should only consume resources when they are accessed actively by clients
- When clients should be shielded from where services are located, how they are deployed onto hosts or processes, & how their lifecycle is managed



Activator POSA4 Design Pattern

Structure & Participants



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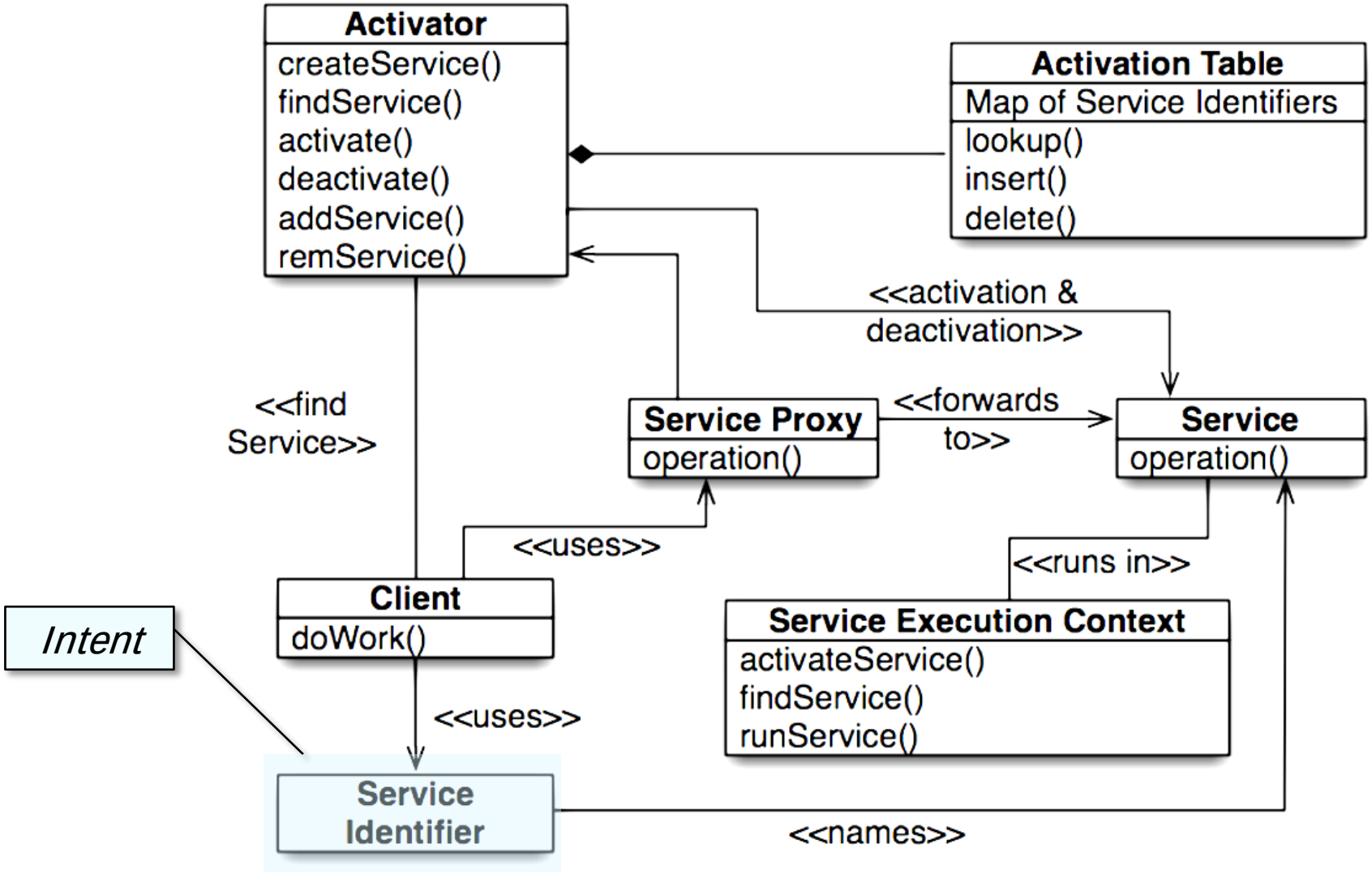

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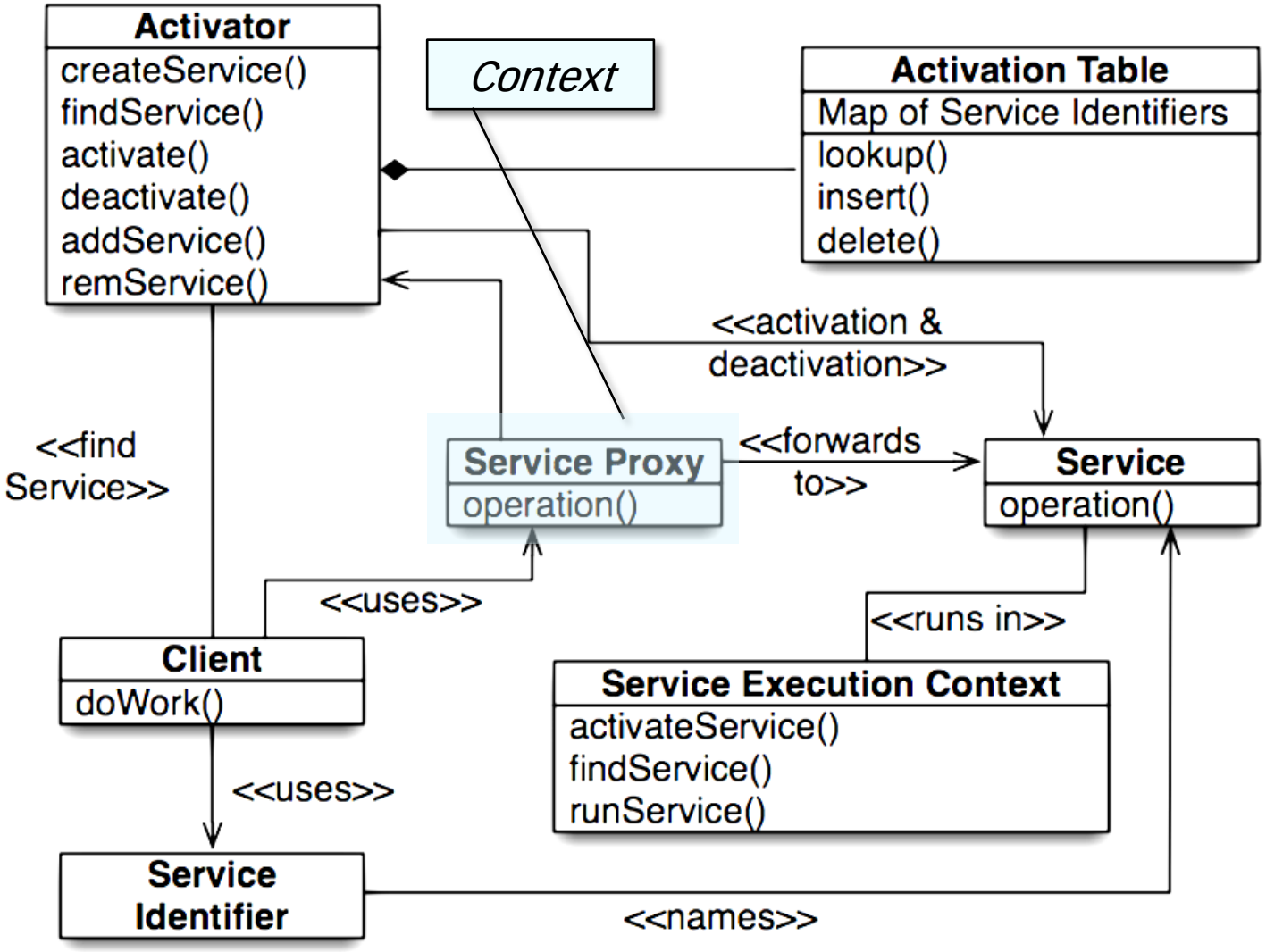

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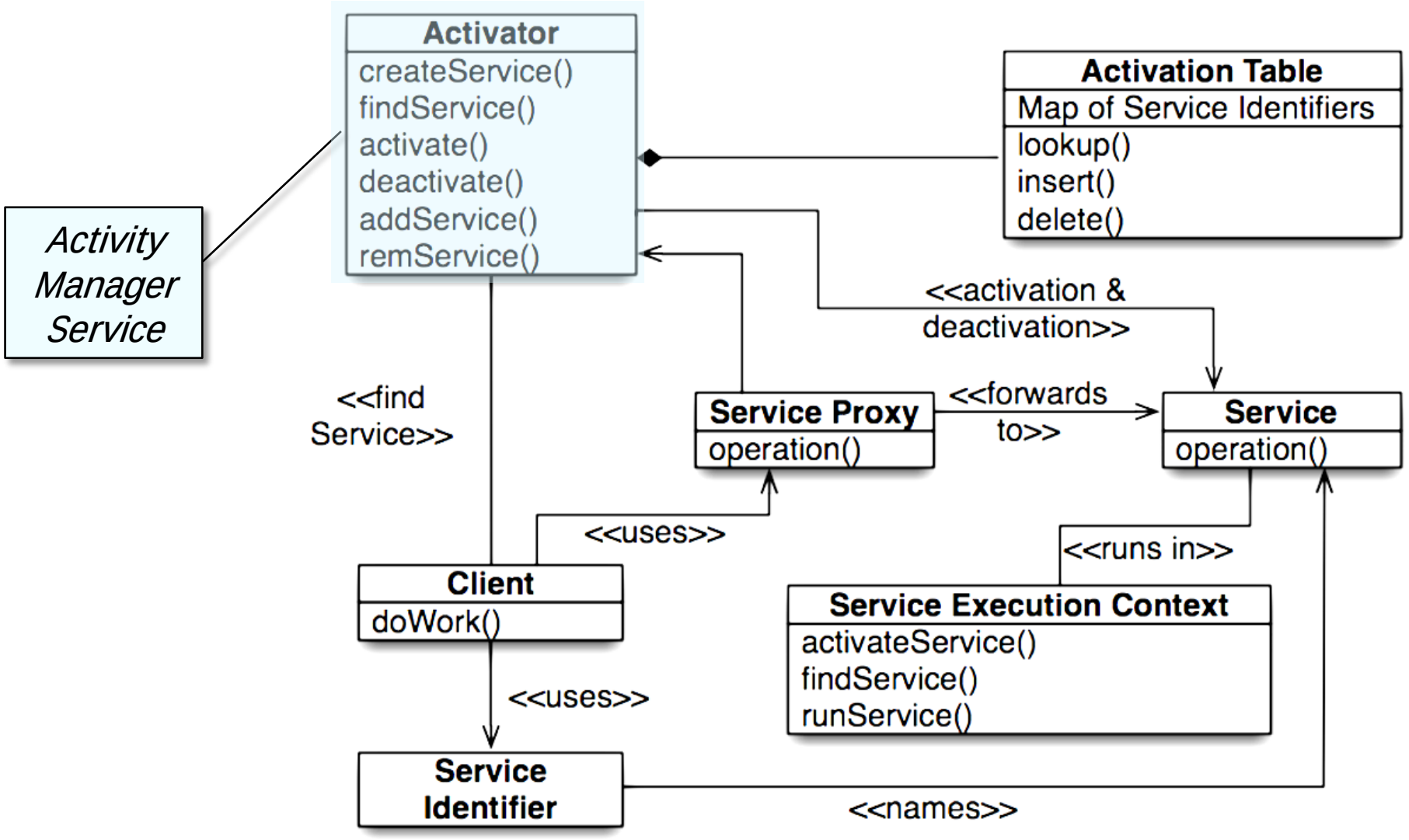

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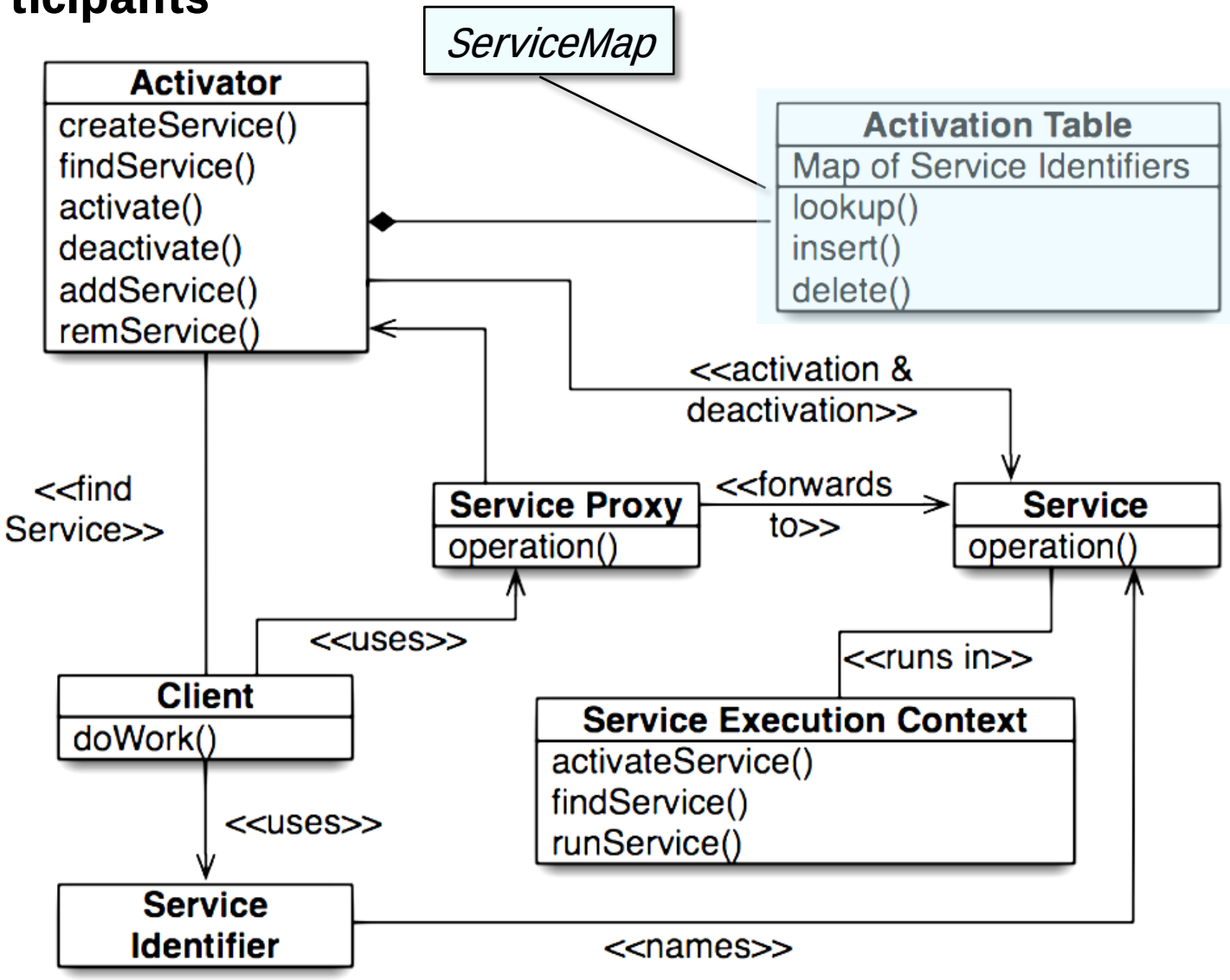

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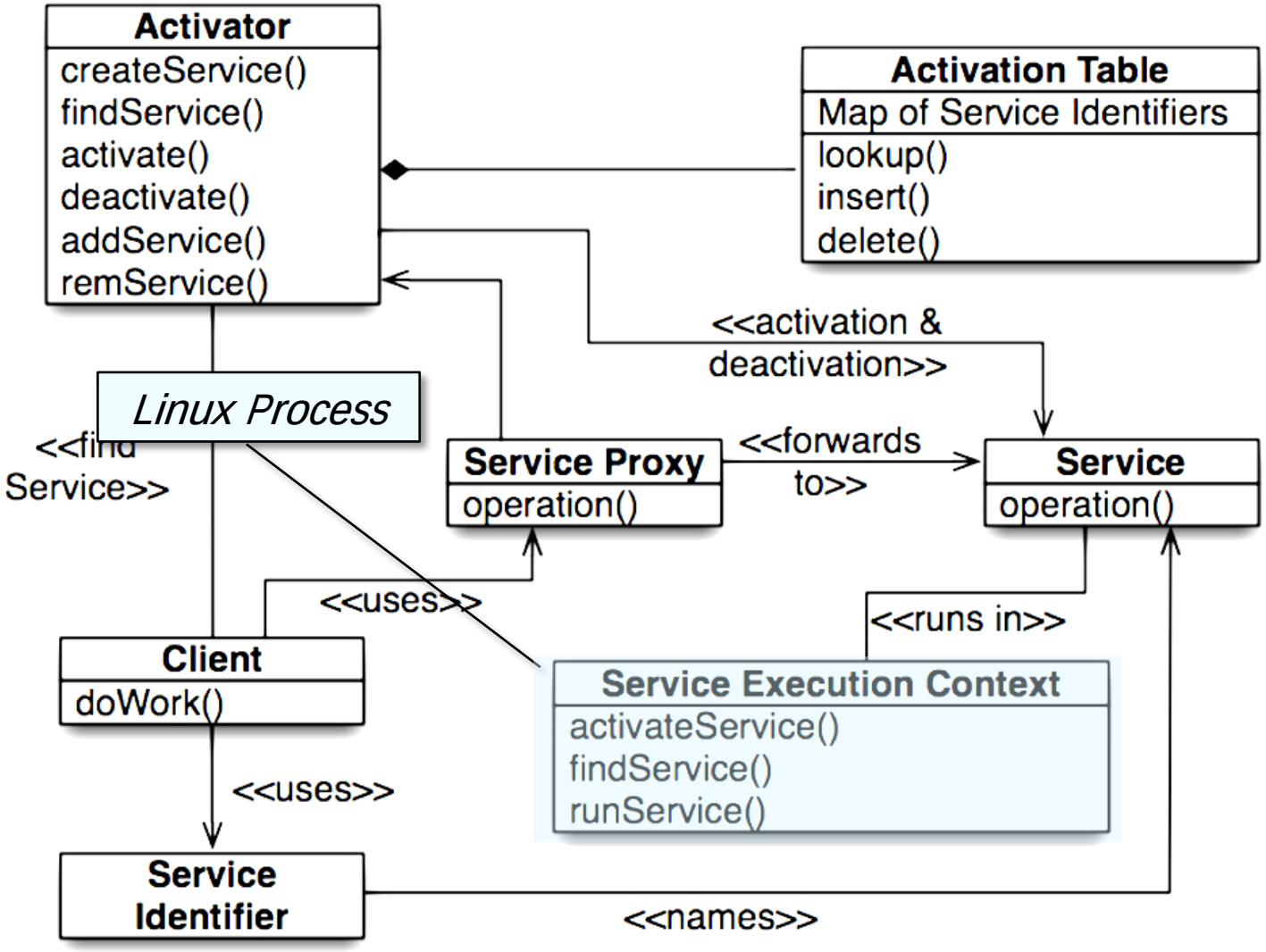

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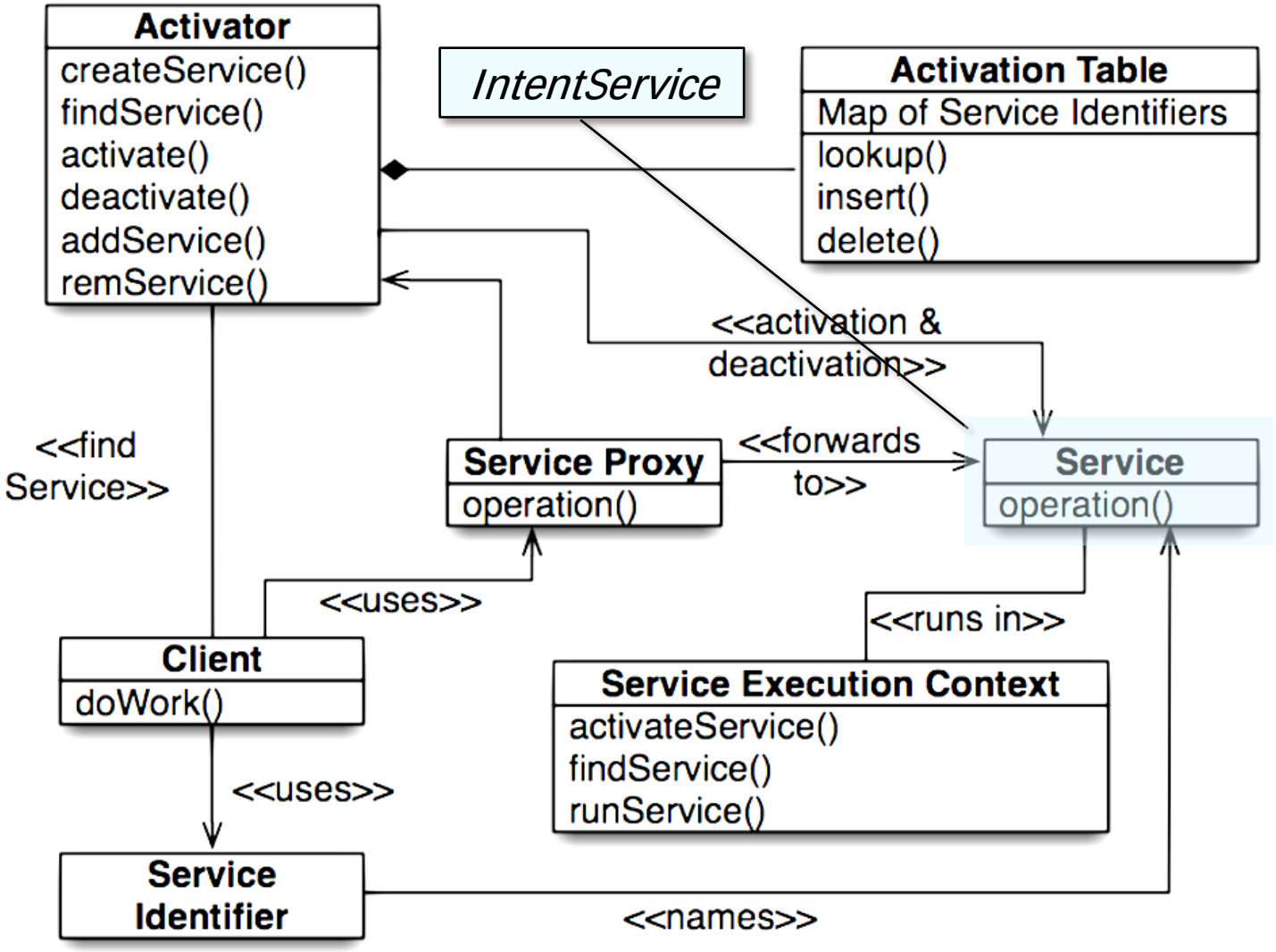
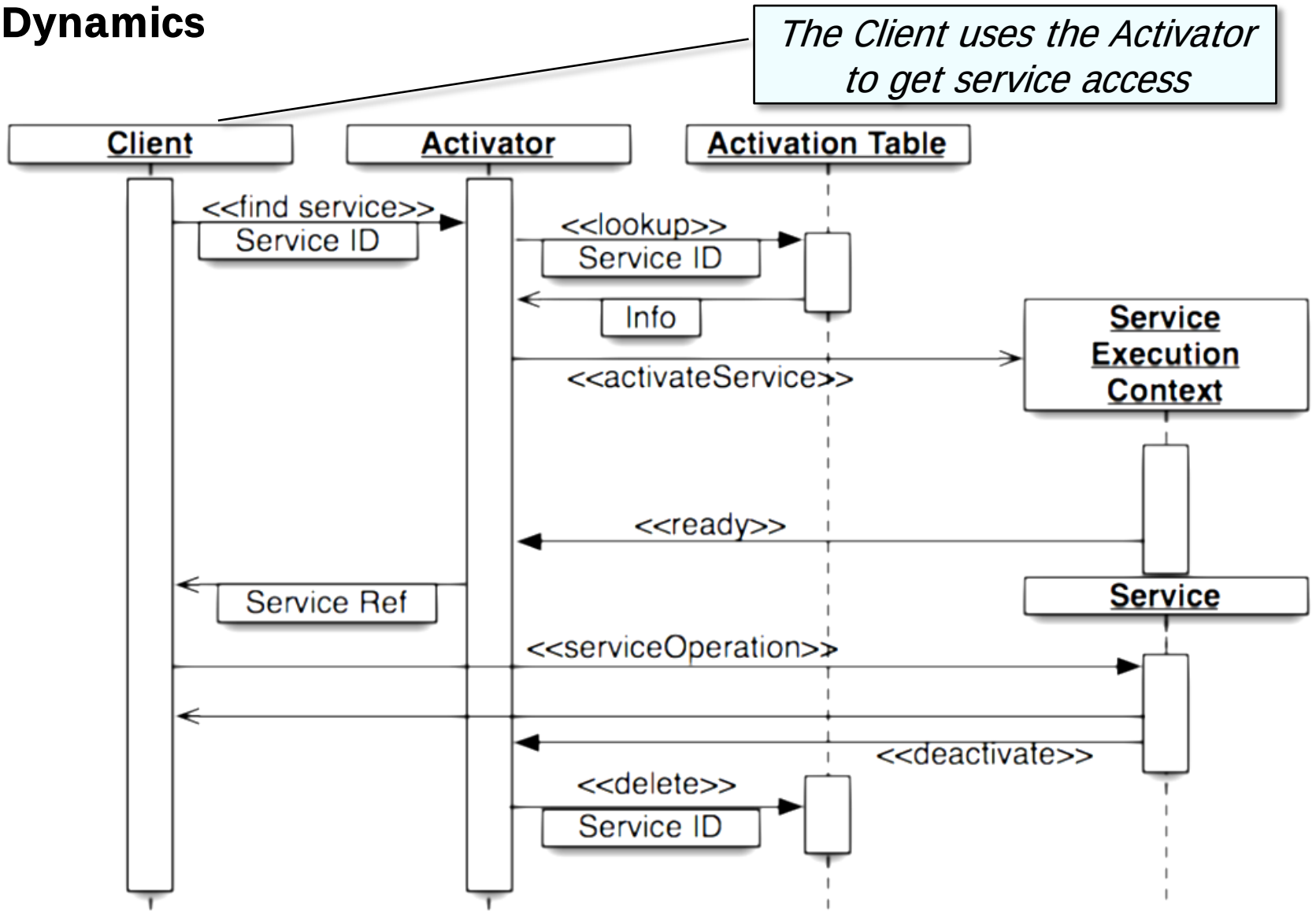


Activator POSA4 Design Pattern

Dynamics



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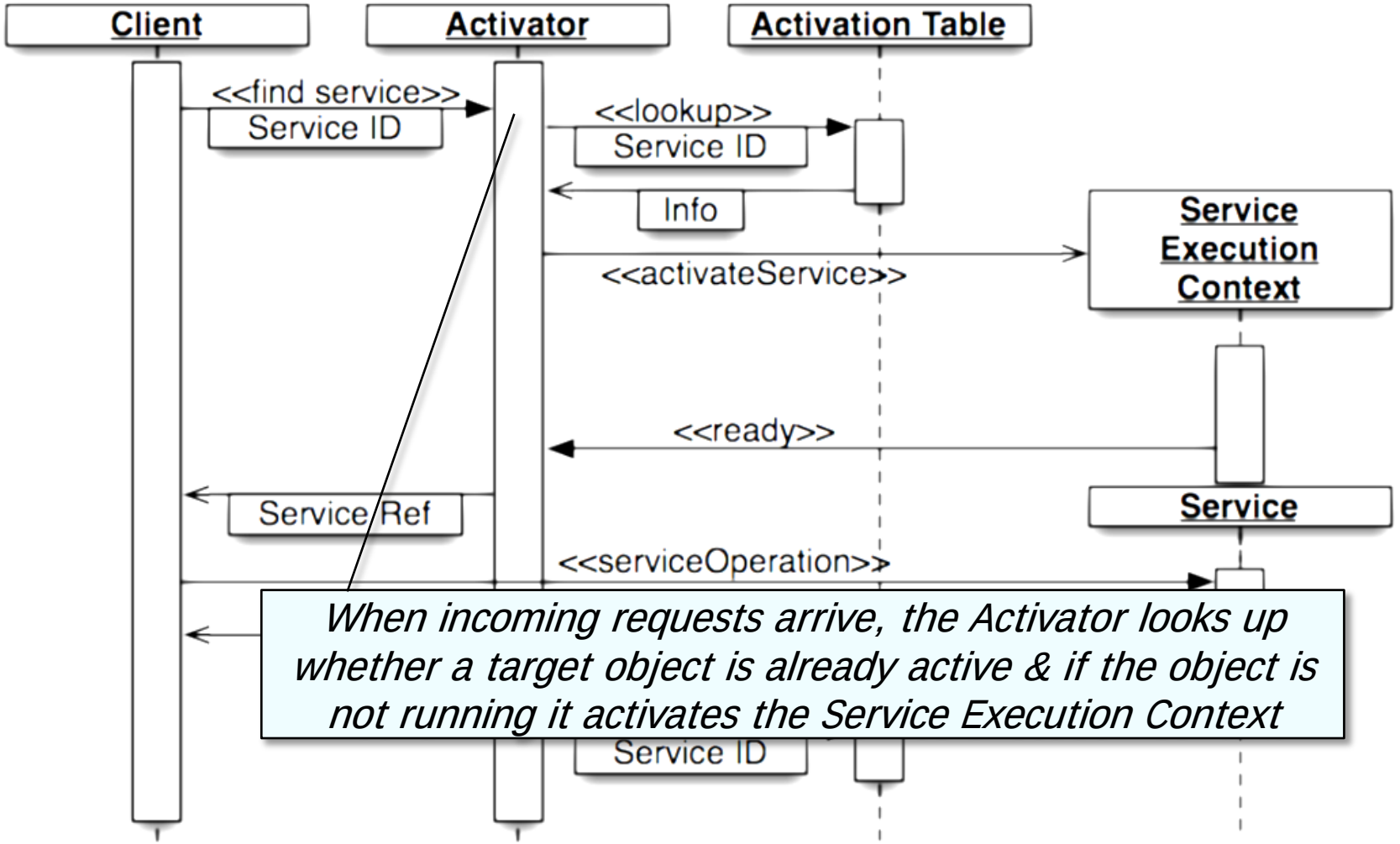
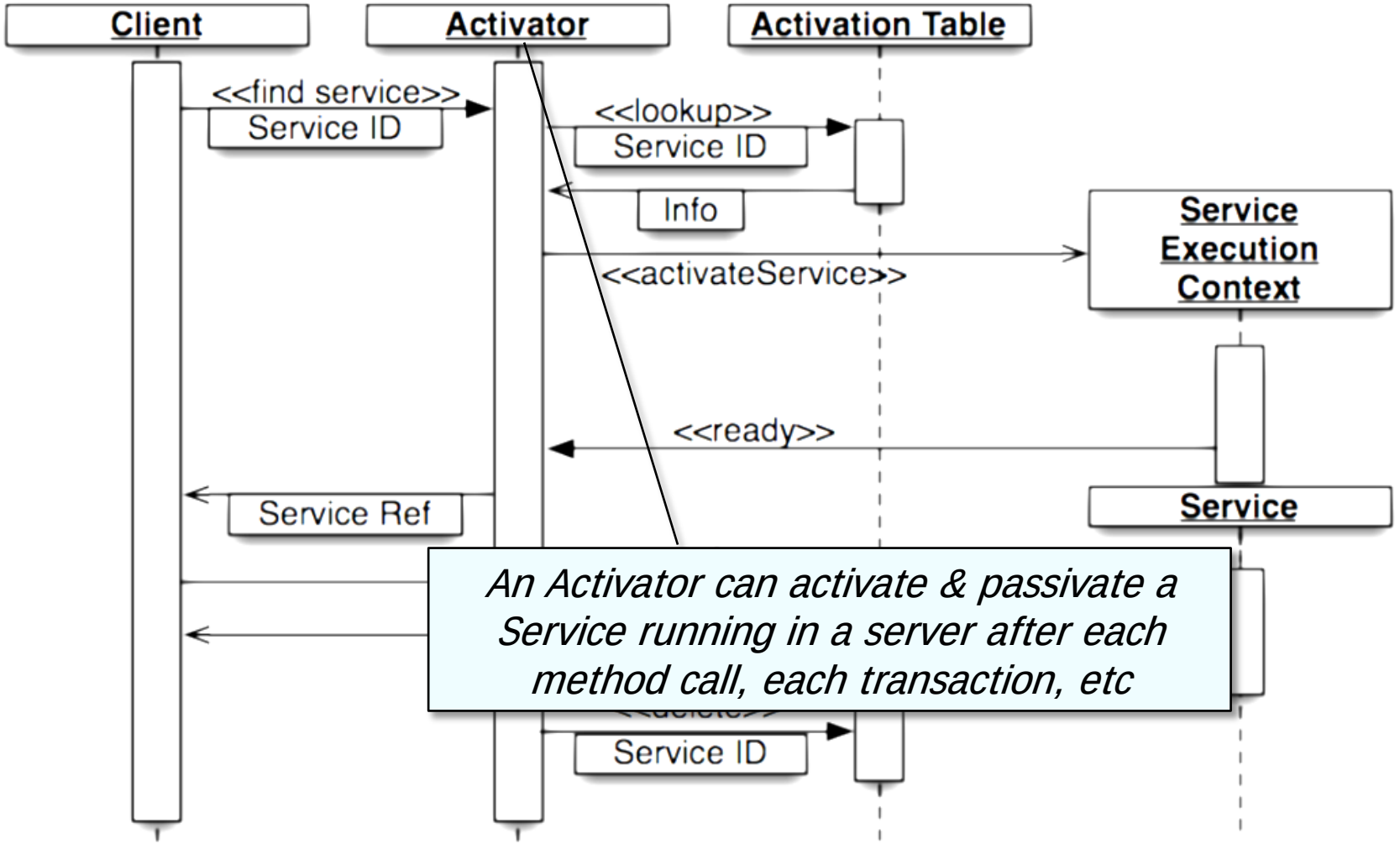


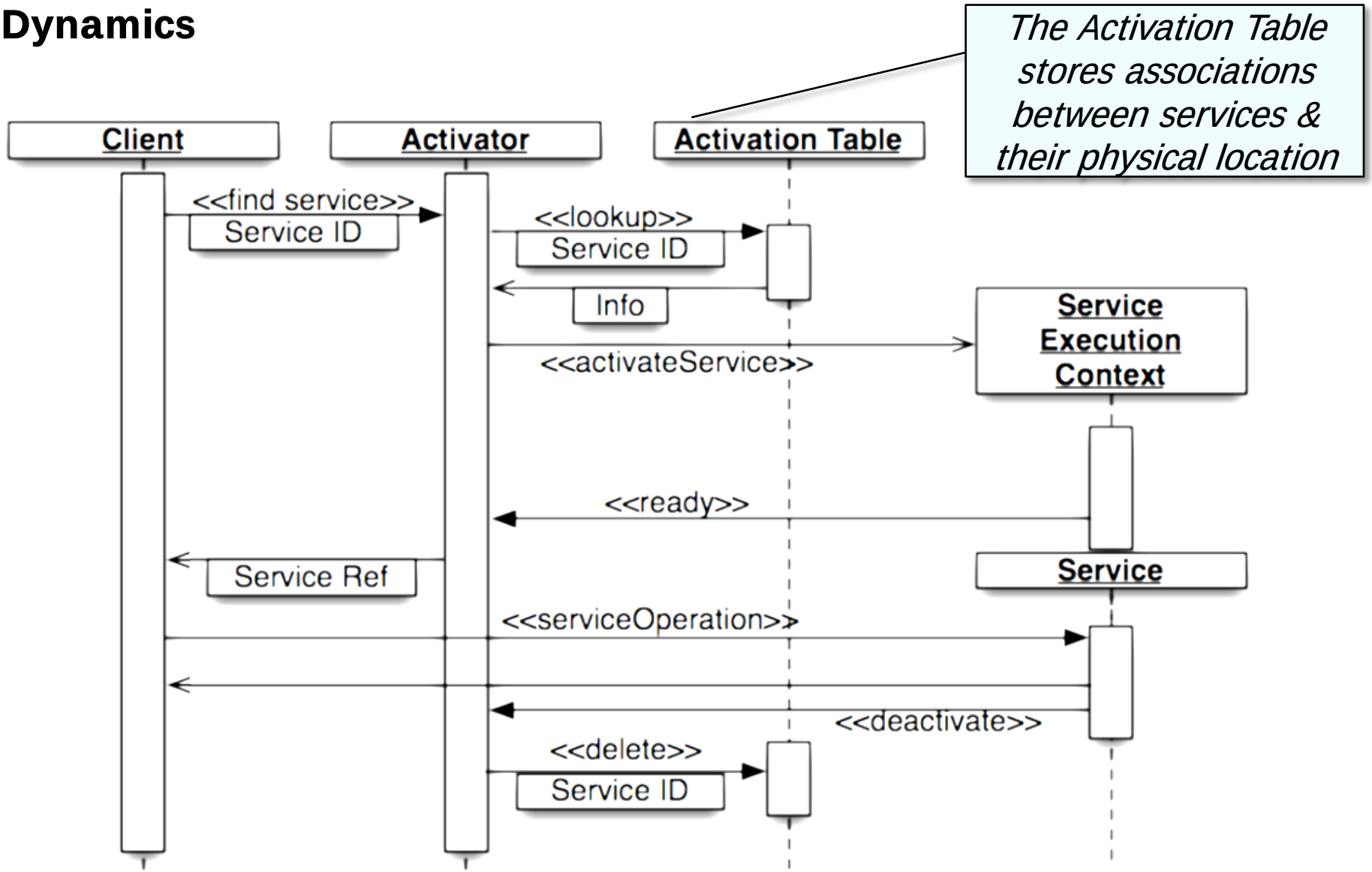
Activator POSA4 Design Pattern

Dynamics



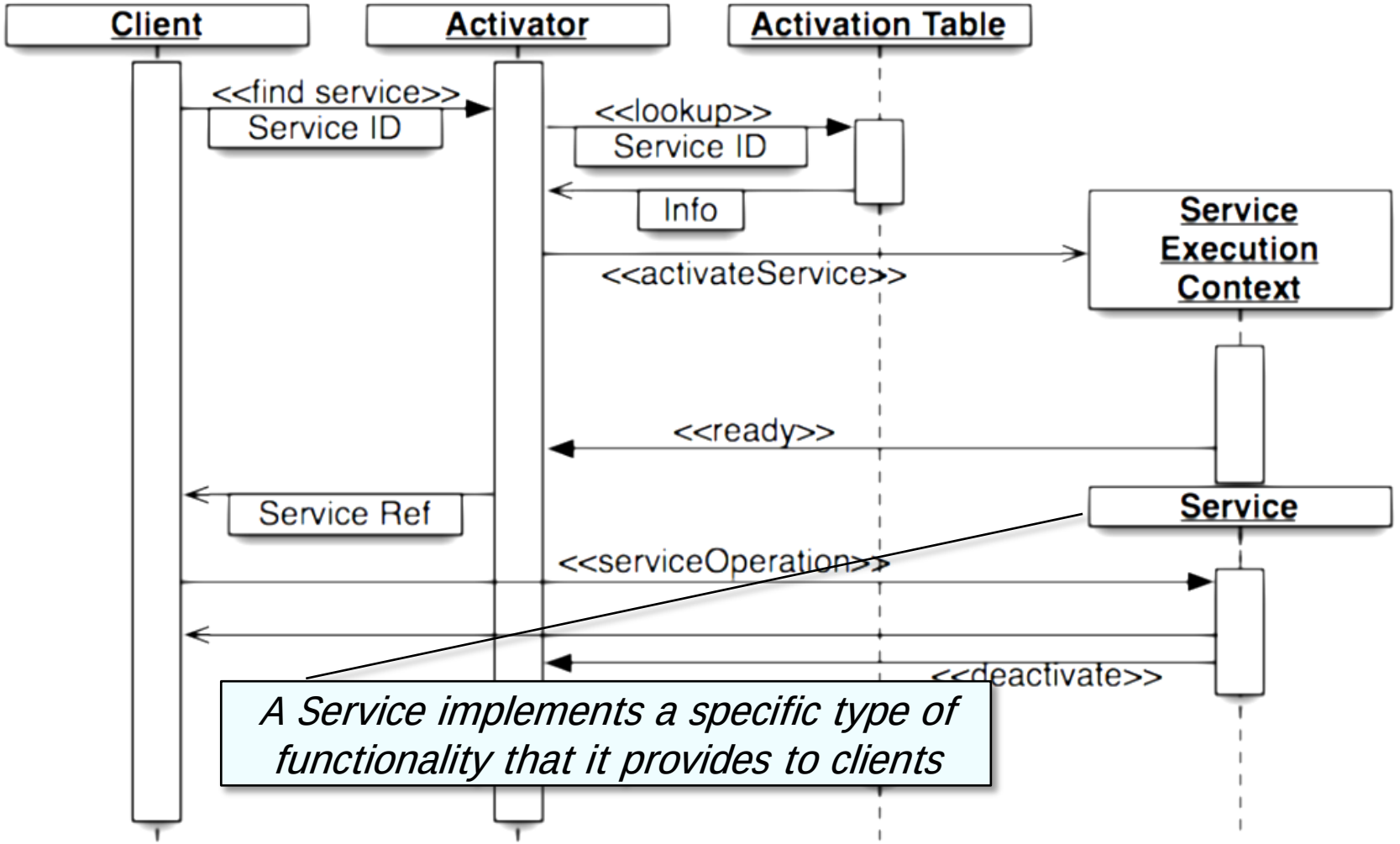
Activator POSA4 Design Pattern

Dynamics



Activator POSA4 Design Pattern

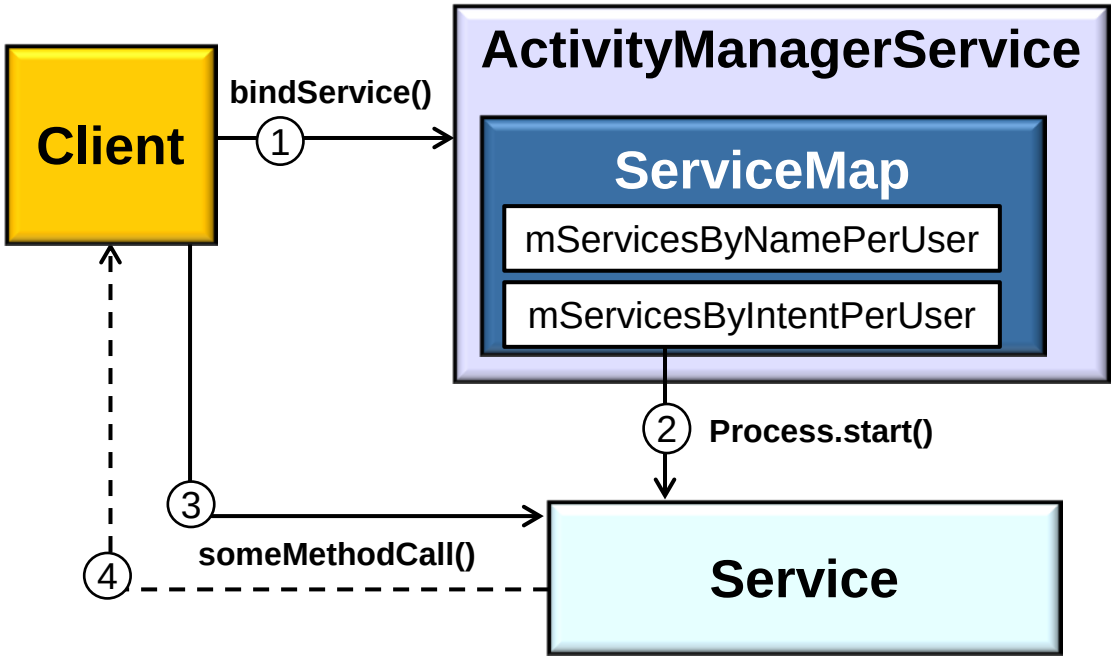
Dynamics



Activator POSA4 Design Pattern

Consequences

+ More effective resource utilization
  - Servers can be spawned "on-demand," thereby minimizing resource utilization until clients actually require them

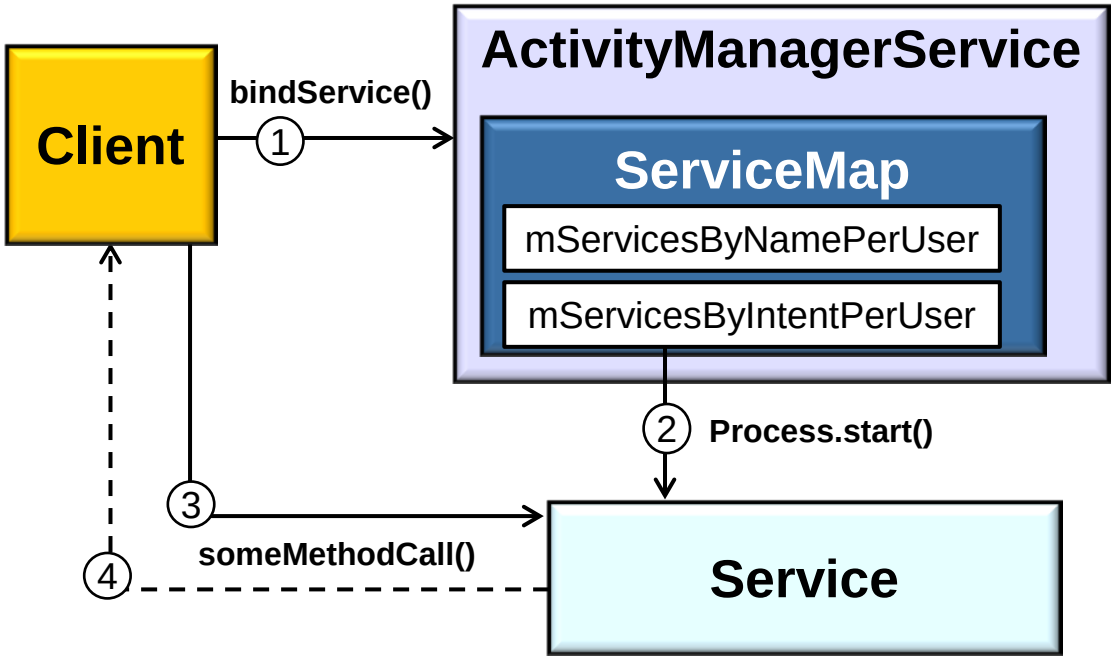


Activator POSA4 Design Pattern

Consequences

+ More effective resource utilization

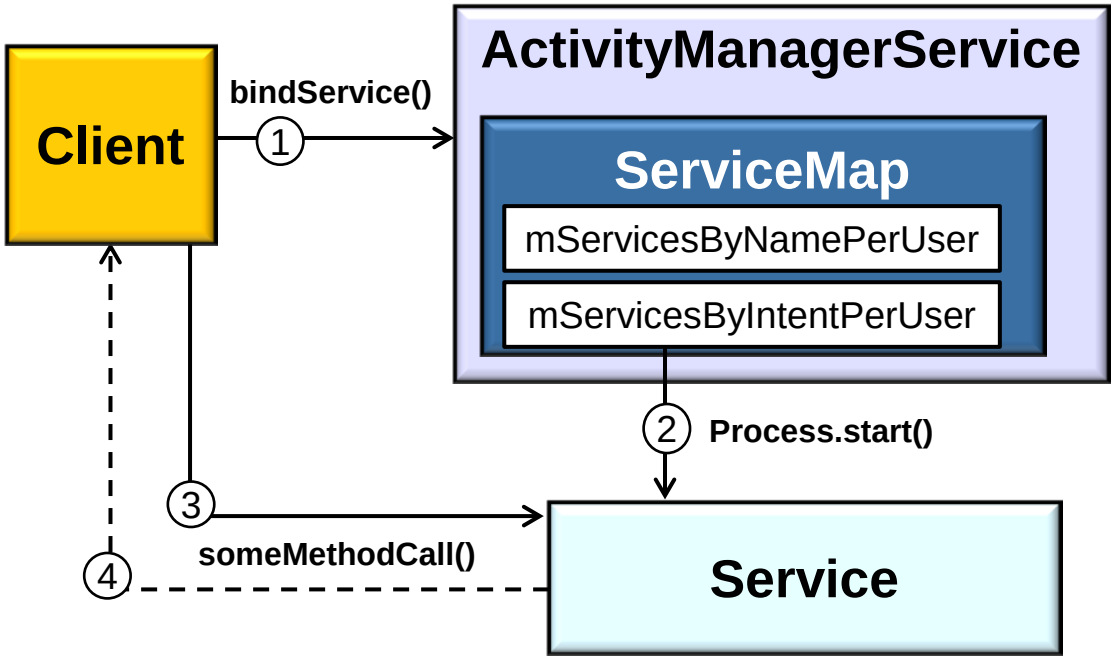
+ Coarse-grained concurrency
  - By spawning server processes to run on multi-core/CPU computers



Activator POSA4 Design Pattern

Consequences

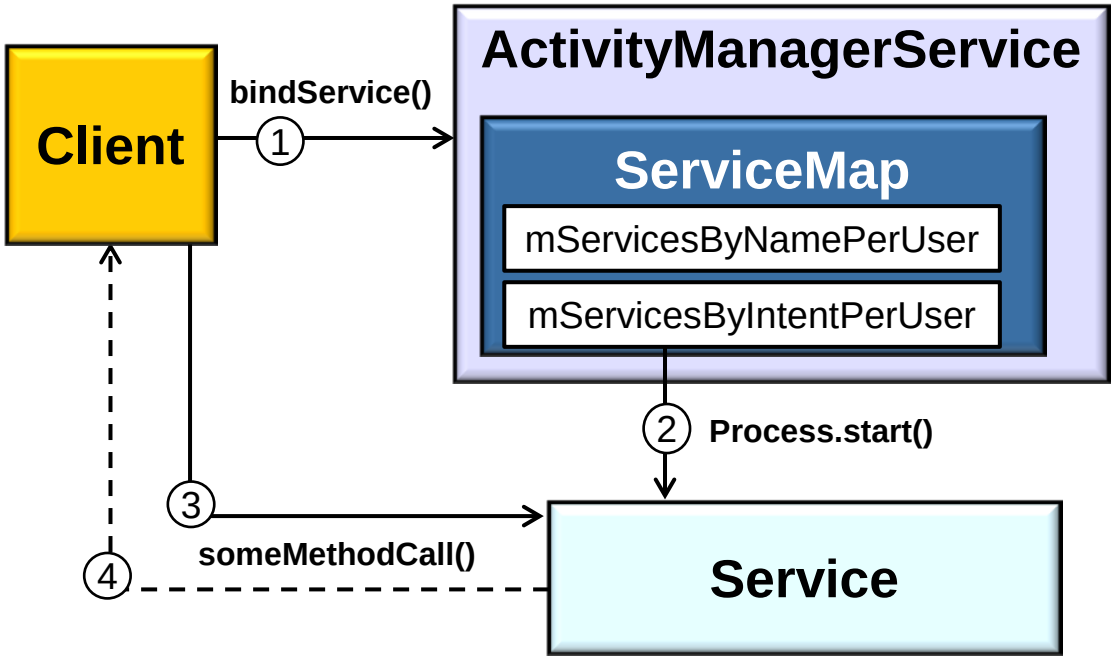
+ More effective resource utilization
+ Coarse-grained concurrency
+ Modularity, testability, & reusability
  - Application modularity & reusability is improved by decoupling server implementations from the manner in which the servers are activated



Activator POSA4 Design Pattern

Consequences

– Lack of determinism & ordering dependencies
  - Hard to determine or analyze the behavior of an app until its components are activated at runtime



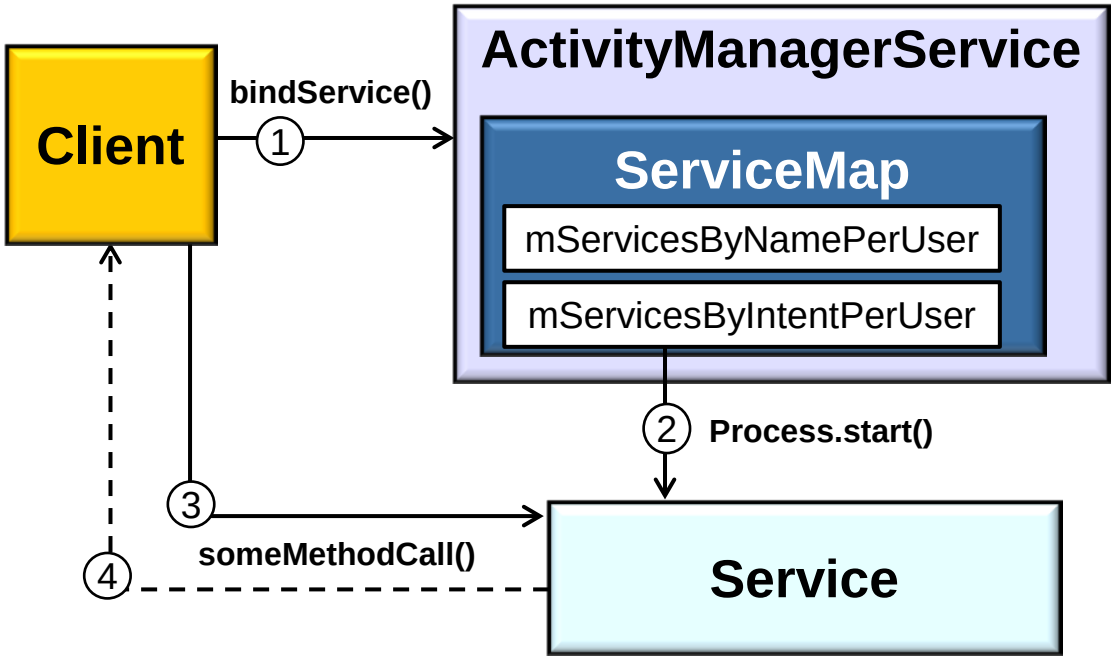
Activator POSA4 Design Pattern

Consequences

– Lack of determinism & ordering dependencies

– Reduced security & reliability

- An application that uses *Activator* may be less secure or reliable than an equivalent statically-configured application



Activator POSA4 Design Pattern

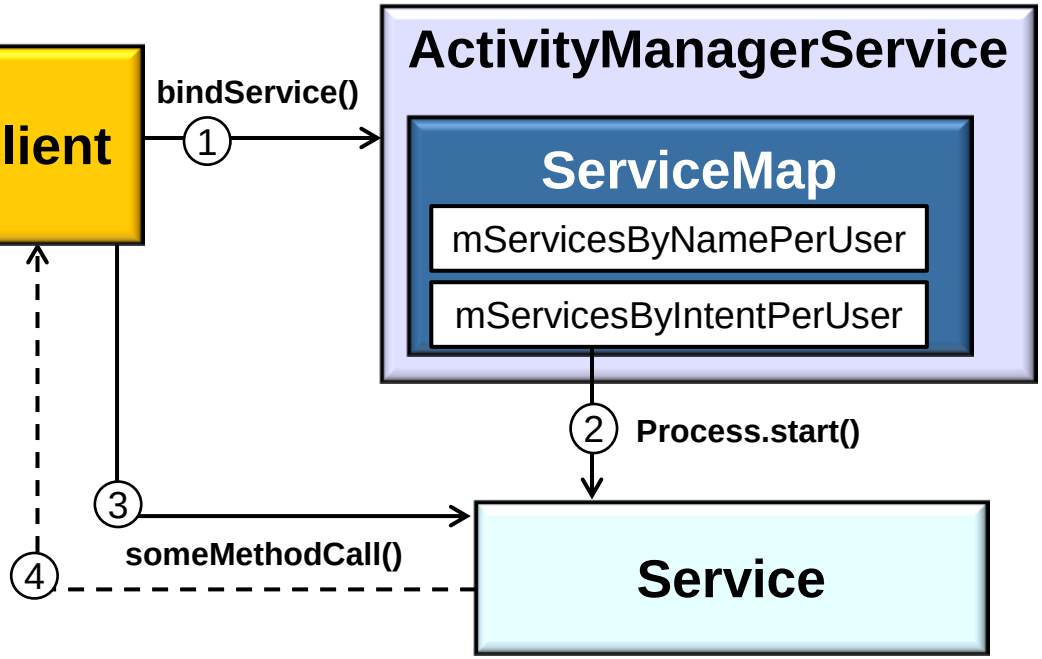
Consequences

– Lack of determinism & ordering dependencies

– Reduced security & reliability

– Increased run-time overhead & infrastructure complexity

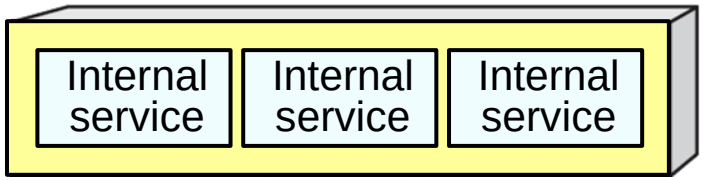
- By adding levels of abstraction & indirection when activating & executing components



Activator POSA4 Design Pattern

Known Uses

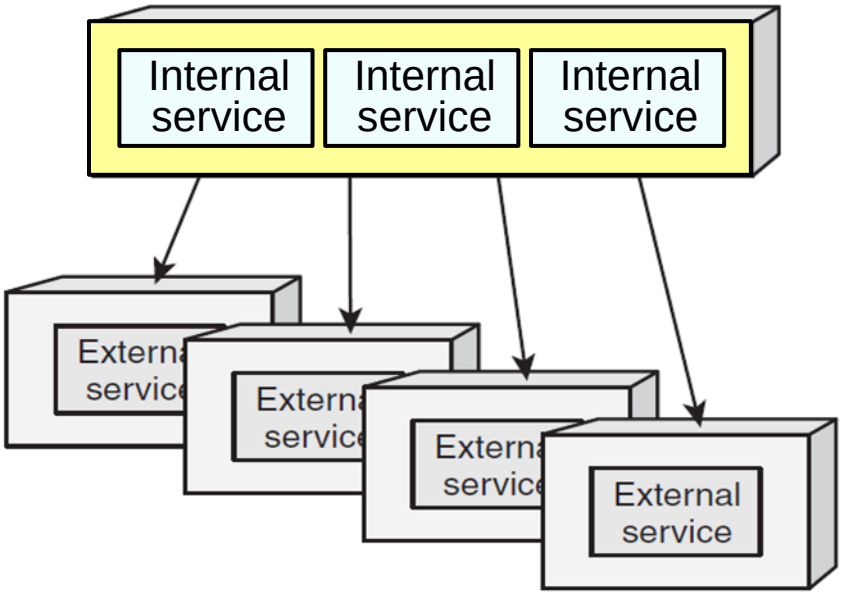
- UNIX Inetd “super server”
  - Internal services are fixed at static link time
    - e.g., **`ECHO`** & **`DAYTIME`**



Activator POSA4 Design Pattern

Known Uses

- UNIX Inetd “super server”
  - Internal services are fixed at static link time
  - External services can be dynamically reconfigured
    - e.g., **FTP**, **TELNET**, & **HTTP**



See en.wikipedia.org/wiki/Inetd for more on Inetd

Activator POSA4 Design Pattern

Known Uses

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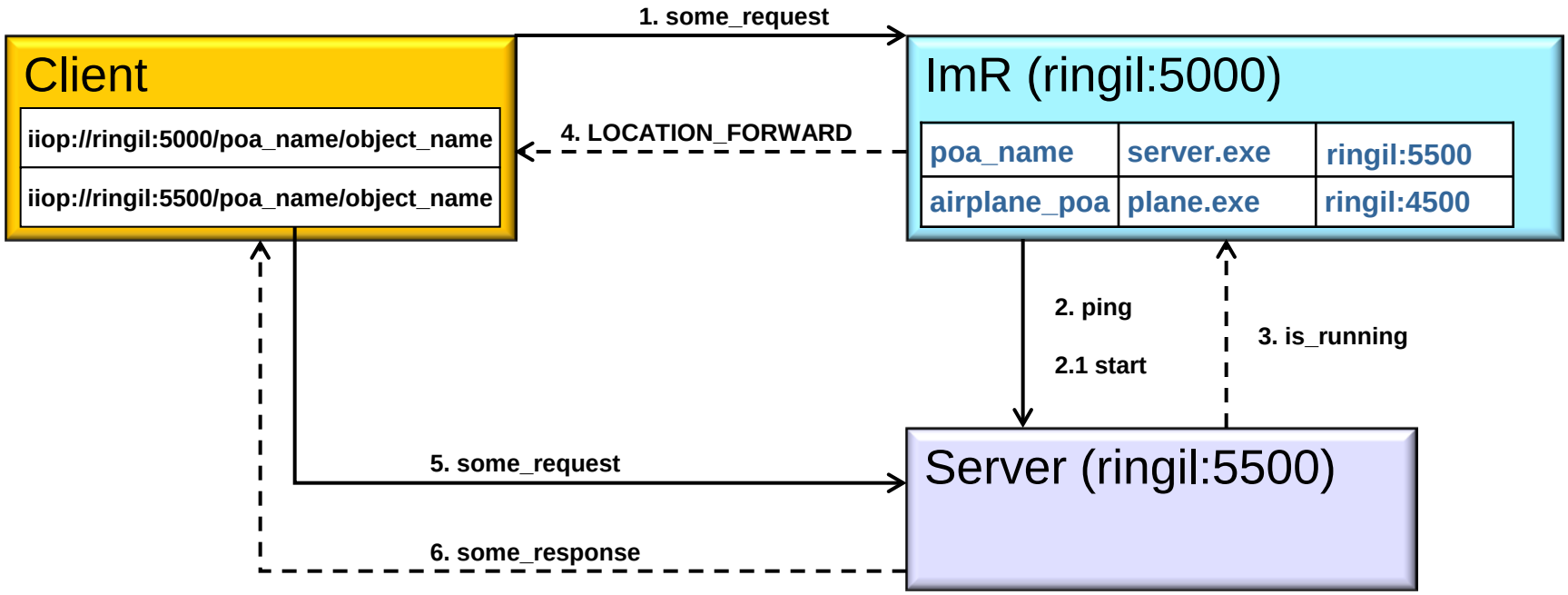
- CORBA Implementation Repository



Activator POSA4 Design Pattern

Known Uses

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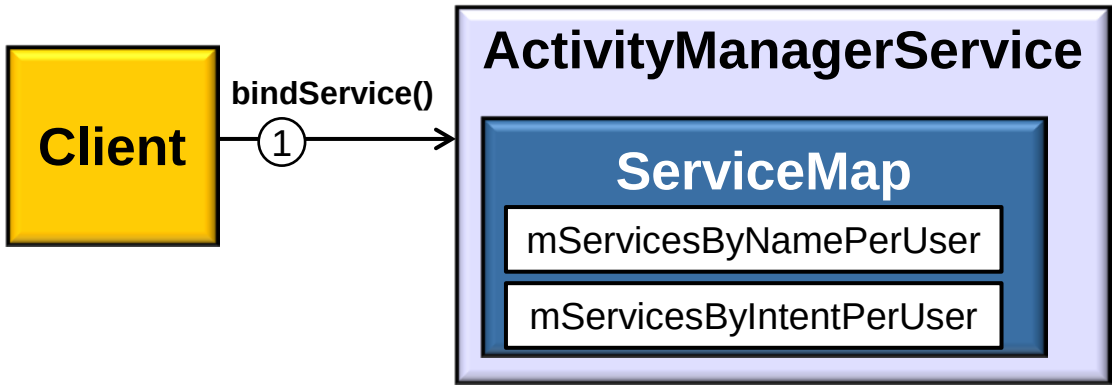
- CORBA Implementation Repository
- Android ActivityManagerService



Activator POSA4 Design Pattern

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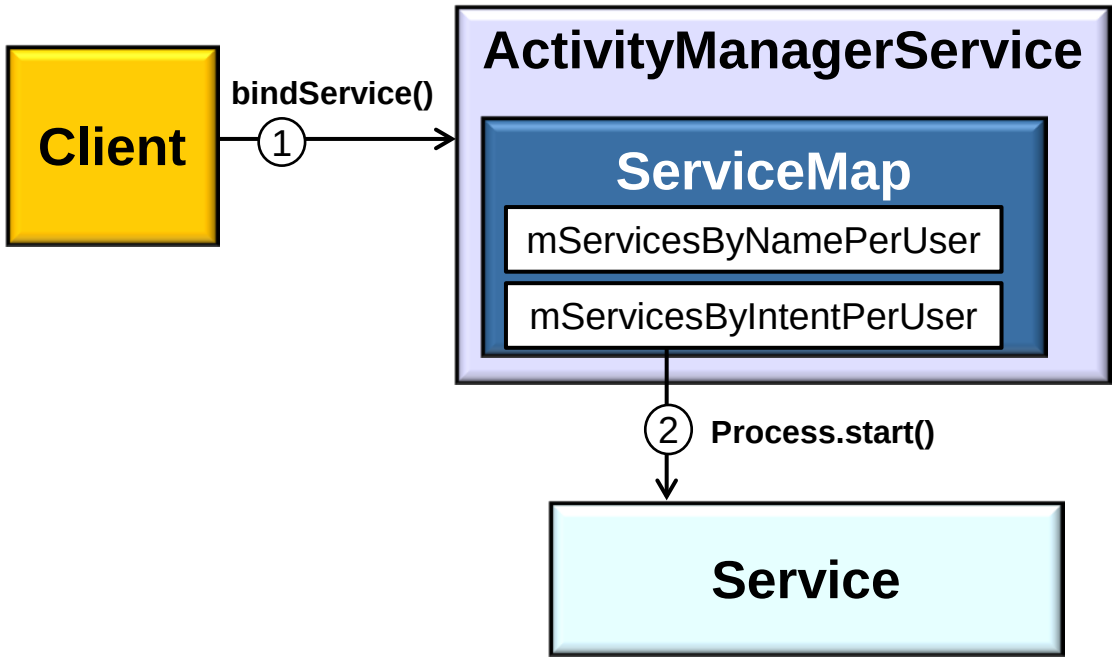

Activator POSA4 Design Pattern

Known Uses

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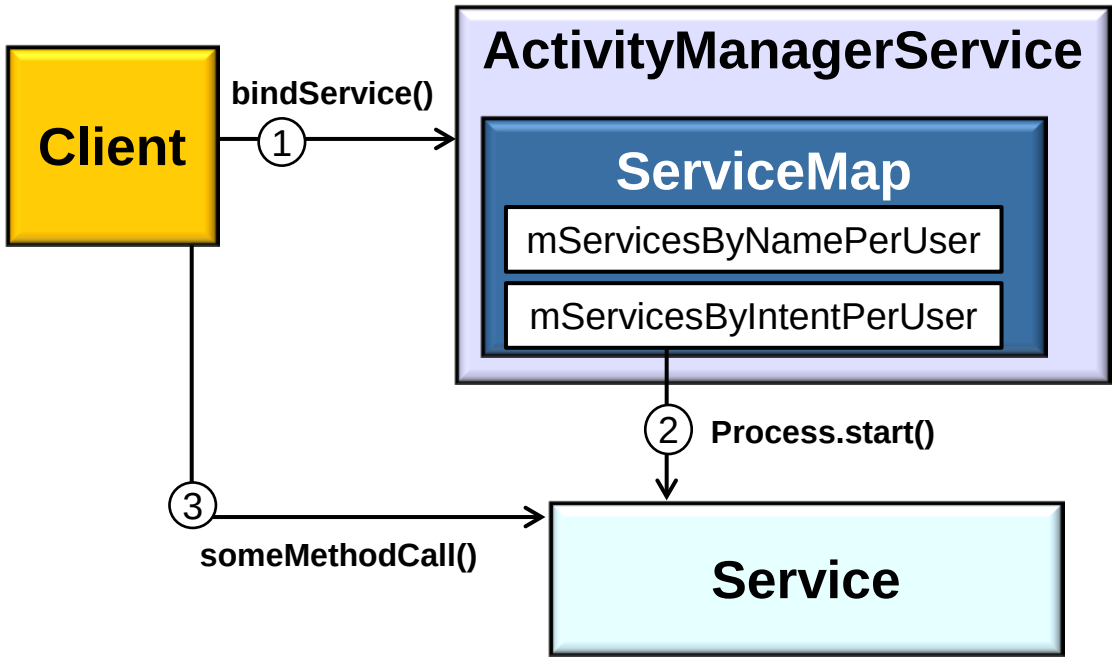

Activator POSA4 Design Pattern

Known Uses

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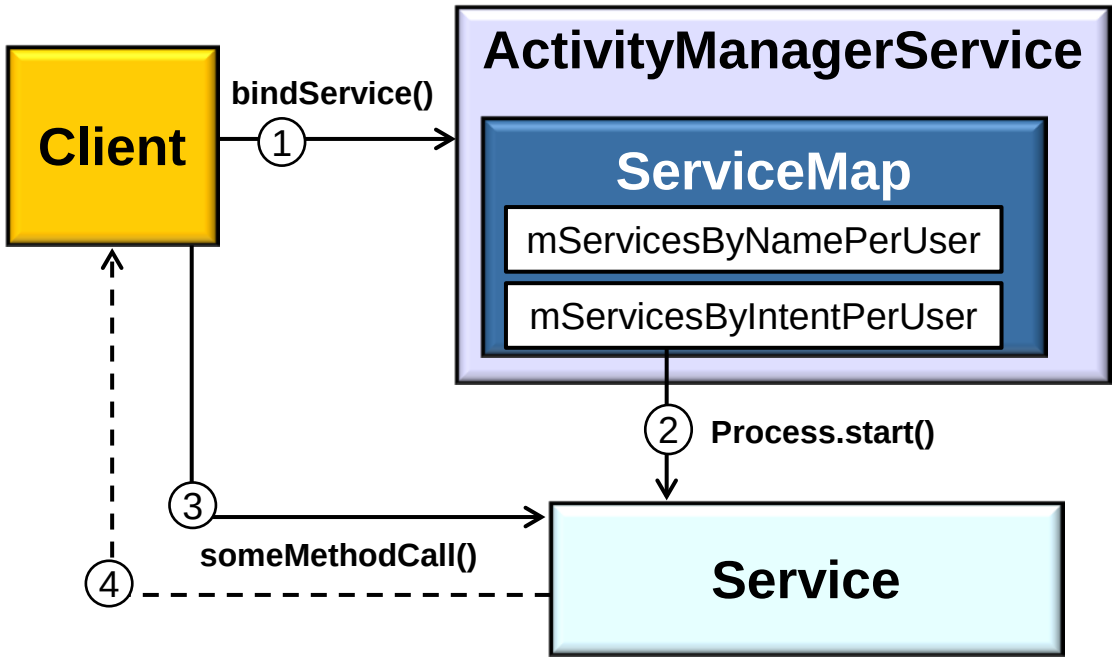
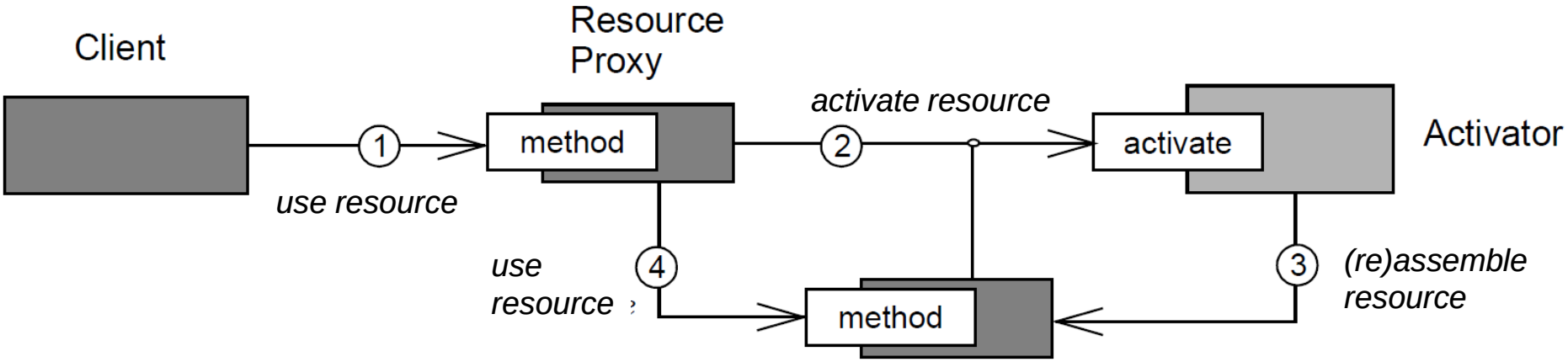
- CORBA Implementation Repository
- Android ActivityManagerService

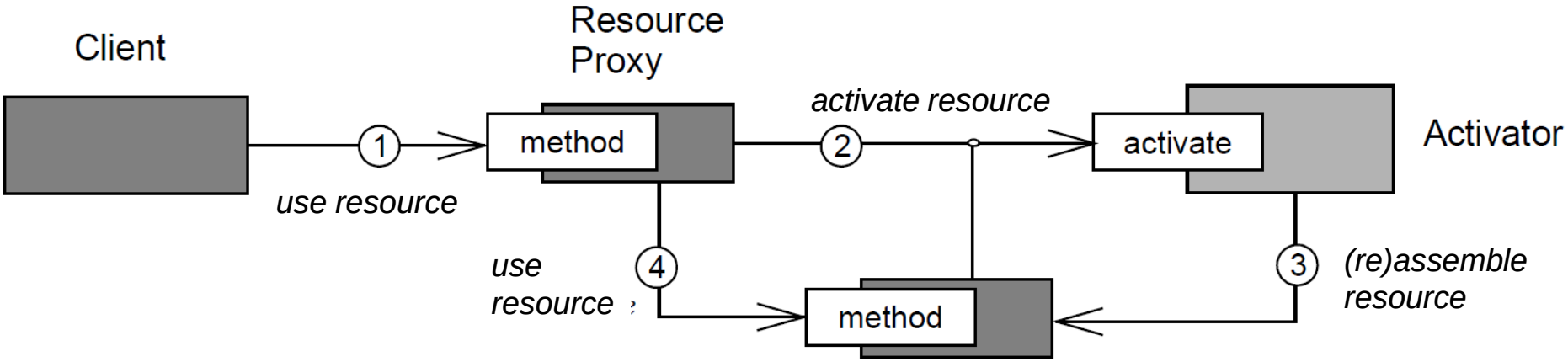


Summary



- *Activator* frees clients from the responsibility of (re)activating the resources they use
  - It appears to them as if all resources were always (virtually) available

Summary

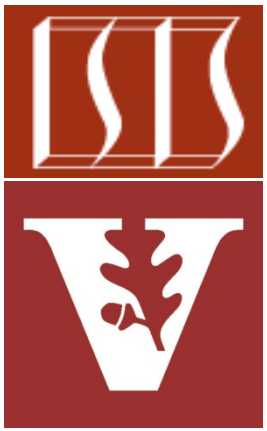


- *Activator* frees clients from the responsibility of (re)activating the resources they use
- *Activator* also ensures that (re)activating a resource incurs minimal overhead because it maintains information about how to optimize this process
  - e.g., an activator could reload the resource's persistent state & reacquire the needed computing resources in parallel, thereby speeding resource initialization

www.dre.vanderbilt.edu/~schmidt/PDF/Activator.pdf has more info

Android Services & Local IPC: The Activator Pattern (Part 2)

Douglas C. Schmidt
d.schmidt@vanderbilt.edu
www.dre.vanderbilt.edu/~schmidt



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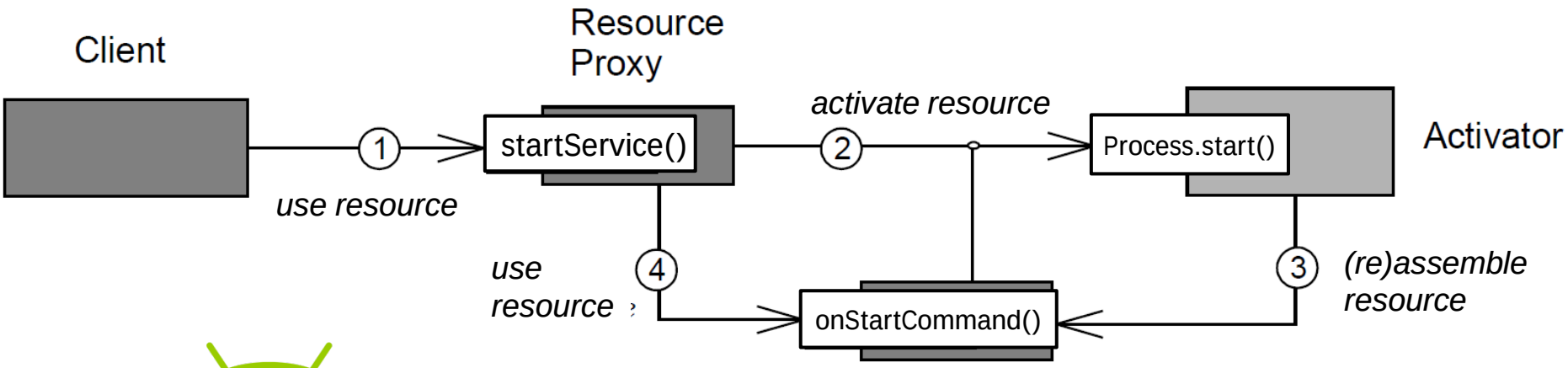
Learning Objectives in this Part of the Module

- Understand how the *Activator* pattern is applied in Android



Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
  - Encapsulate each distinct unit of app functionality into a self-contained service

```
public abstract class Service
       extends ContextWrapper
       implements
          ComponentCallbacks2
{
  public abstract IBinder
    onBind(Intent intent);

  ...
}
```

frameworks/base/core/java/android/app/Service.java has the source code

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
  - Encapsulate each distinct unit of app functionality into a self-contained service
  - Examples of service identifier representations include URLs, IORs, TCP/IP port numbers & host addresses, Android Intents, etc.

Intent Element	Purpose
Name	Optional name for a component
Action	A string naming the action to perform or the action that took place & is being reported
Data	URI of data to be acted on & the MIME type of that data
Category	String giving additional info about the action to execute

frameworks/base/core/java/android/content/Intent.java has the source code

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
  - Determine overhead of activating & deactivating services on-demand vs. keeping them alive for the duration of the system vs. security implications, etc.

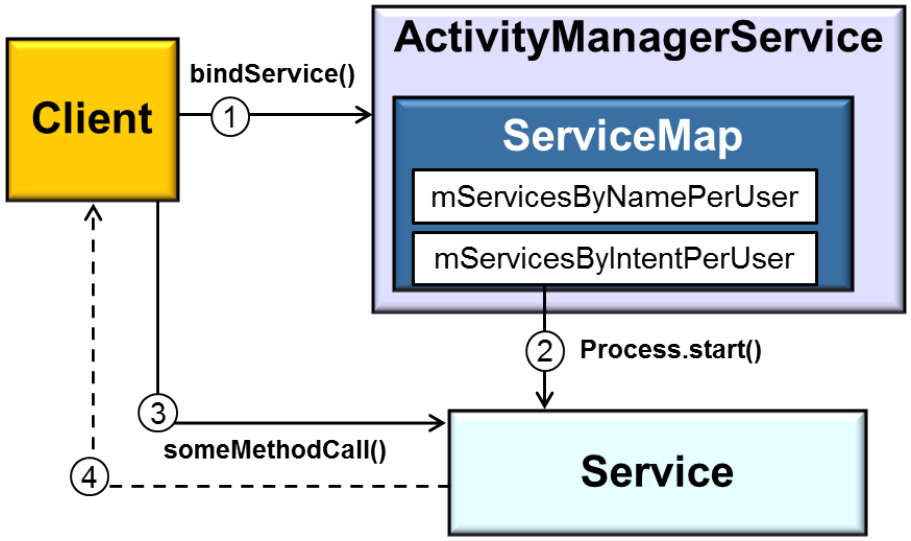
Android Service	Purpose
Media Playback Service	Provides "background" audio playback capabilities
Exchange Email Service	Send/receive email messages to an Exchange server
SMS & MMS Services	Manage messaging operations, such as sending data, text, & PDU messages
Alert Service	Handle calendar event reminders

packages/apps has source code for many Bound & Started Services

Activator POSA4 Design Pattern

Implementation

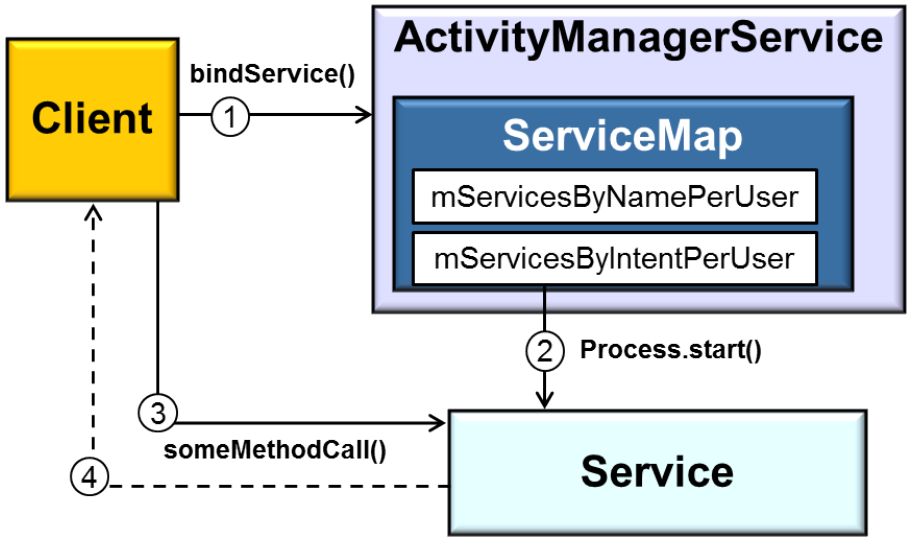
- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
  - Define service execution context representation
    - e.g., an OS process/thread or middleware container



Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
  - Define service execution context representation
  - Define service registration strategy
    - e.g., static text file or dynamic object registration



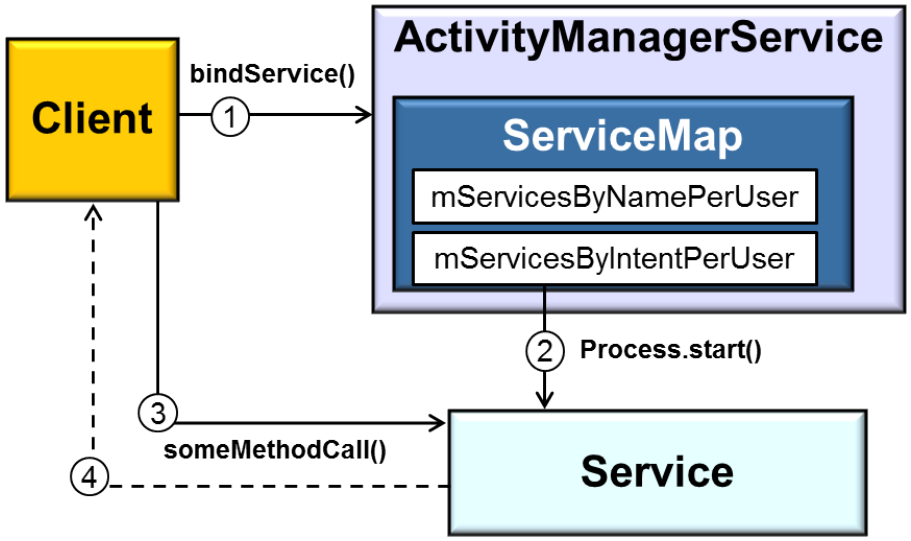

```
<service android:name=
"com.android.music.MediaPlaybackService"
   android:exported="false"/>
```

frameworks/base/services/java/com/android/server/am/ActivityManagerService.java

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
  - Define service execution context representation
  - Define service registration strategy
  - Define service initialization strategy
    - e.g., stateful vs. stateless services



Android Services are responsible for managing their own persistent state

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
  - Define service execution context representation
  - Define service registration strategy
  - Define service initialization strategy
  - Define service deactivation strategy
    - e.g., service-triggered, client-triggered, or activator-triggered deactivation

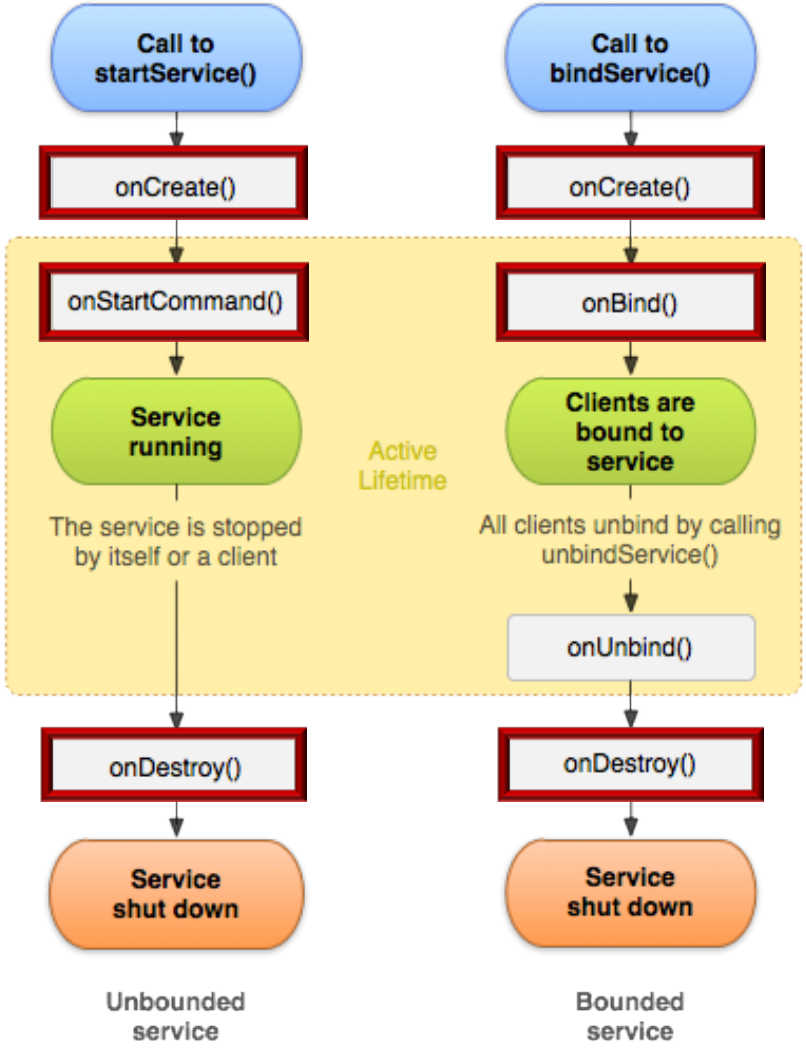
Started Service	Bound Service
• Service runs indefinitely & must stop itself by calling stopSelf() • A component can also stop the service by calling stopService() • When Service is stopped, Android destroys it	• Multiple clients can bind to same Service • When all of them unbind, the system destroys the Service • The Service does not need to stop itself an

developer.android.com/guide/components/services.html#Lifecycle has more

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
- Define interoperation between services & service execution context
  - Typically implemented via some type of lifecycle callback hook methods

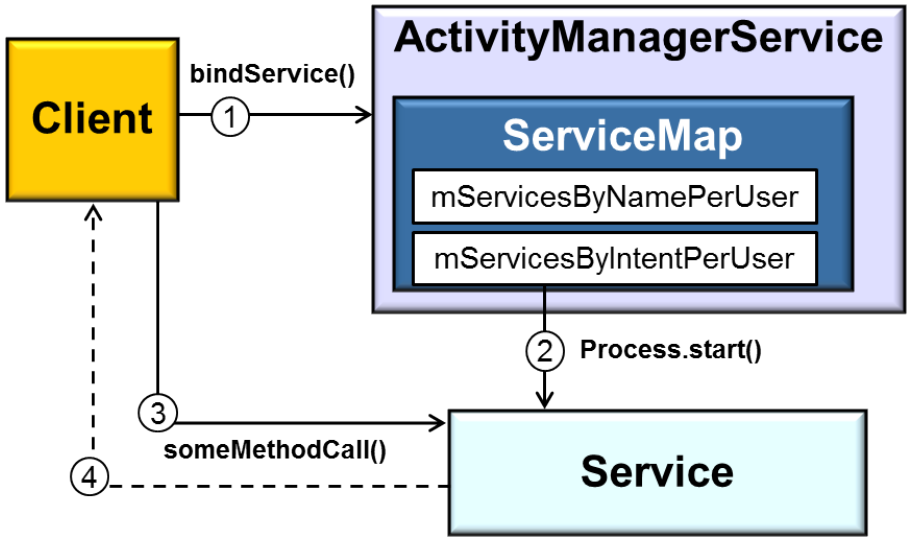


developer.android.com/guide/components/services.html#LifecycleCallbacks

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
- Define interoperation between services & service execution context
- Implement the activator
  - Determine the association between activators & services
    - e.g., singleton (shared) vs. exclusive vs. distributed activator

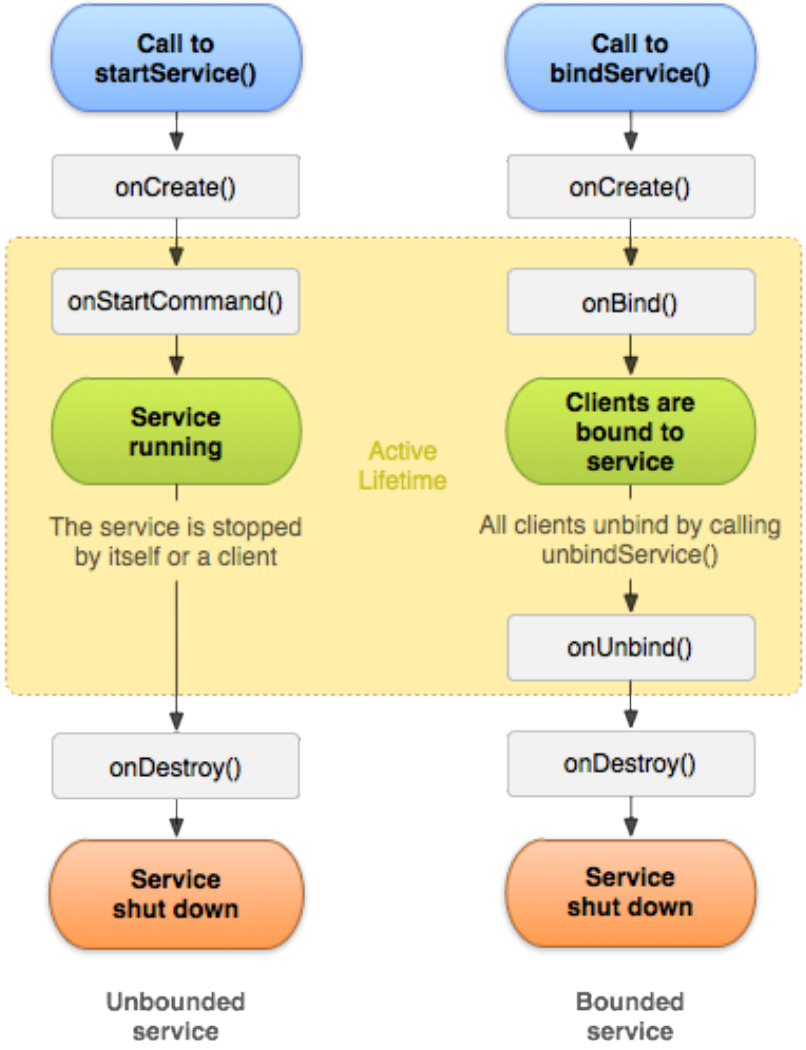


The Android Activity Manager Service is a singleton activator

Activator POSA4 Design Pattern

Implementation

- Define services & service identifiers
- Identify services to activate & deactivate on demand
- Develop service activation & deactivation strategy
- Define interoperation between services & service execution context
- Implement the activator
  - Determine the association between activators & services
  - Determine the degree of transparency
    - e.g., explicit vs. transparent activator

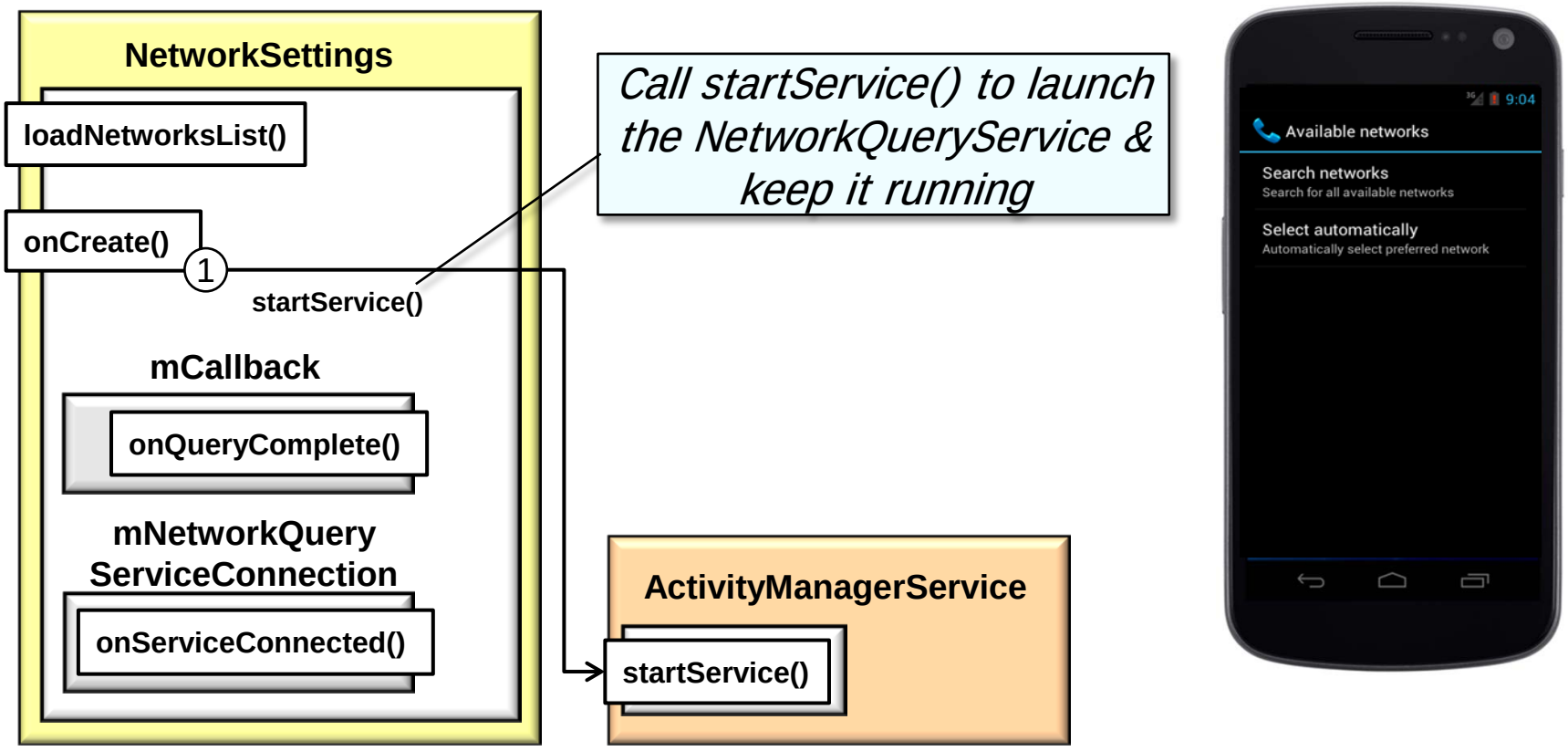


Android Started & Bound Services use an explicit activator model

Activator POSA4 Design Pattern

Applying the Activator pattern in Android

- The NetworkSettings Activity uses the *Activator* pattern to launch the NetworkQueryService to assist in querying the network for service availability



packages/apps/Phone/src/com/android/phone/NetworkSetting.java has source code

Activator POSA4 Design Pattern

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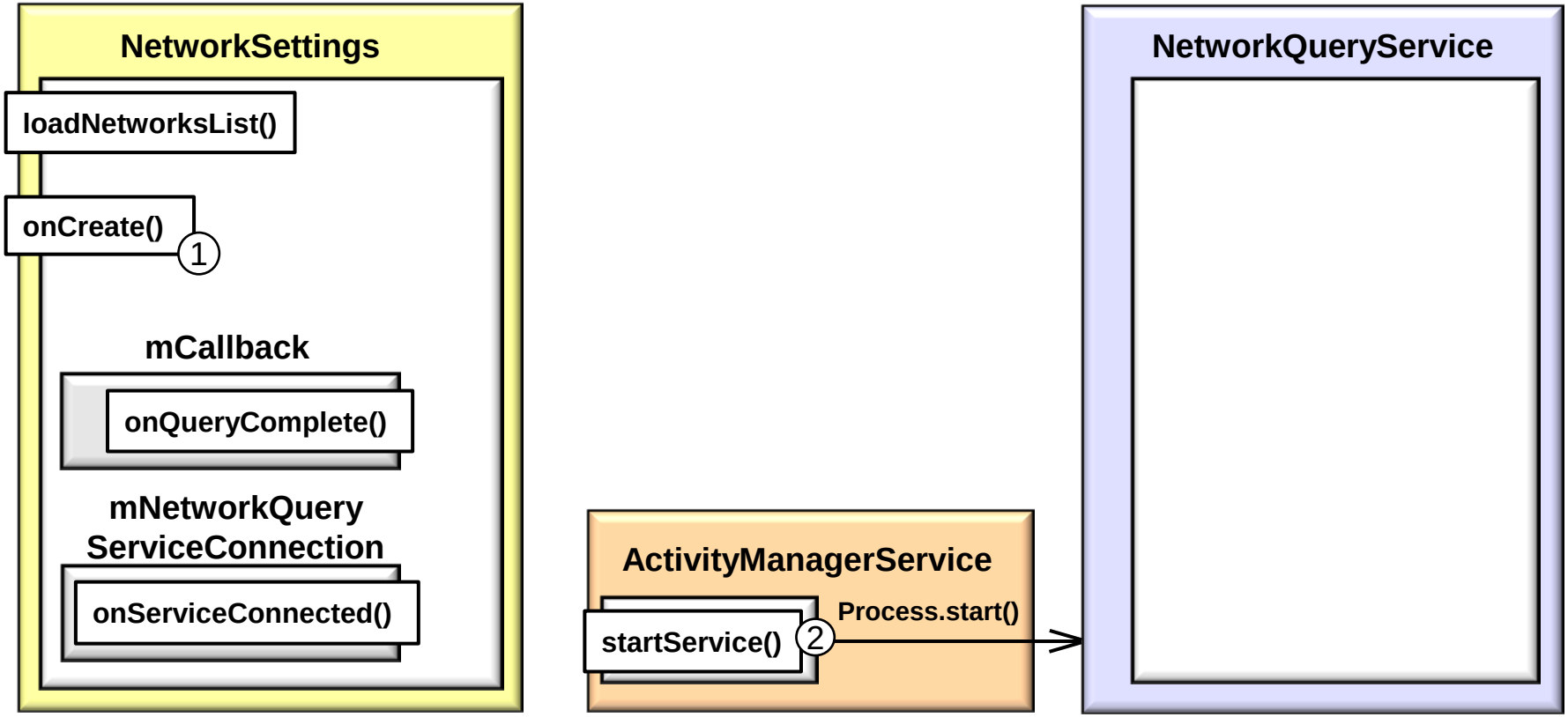

frameworks/base/services/java/com/android/server/am/ActivityManagerService.java

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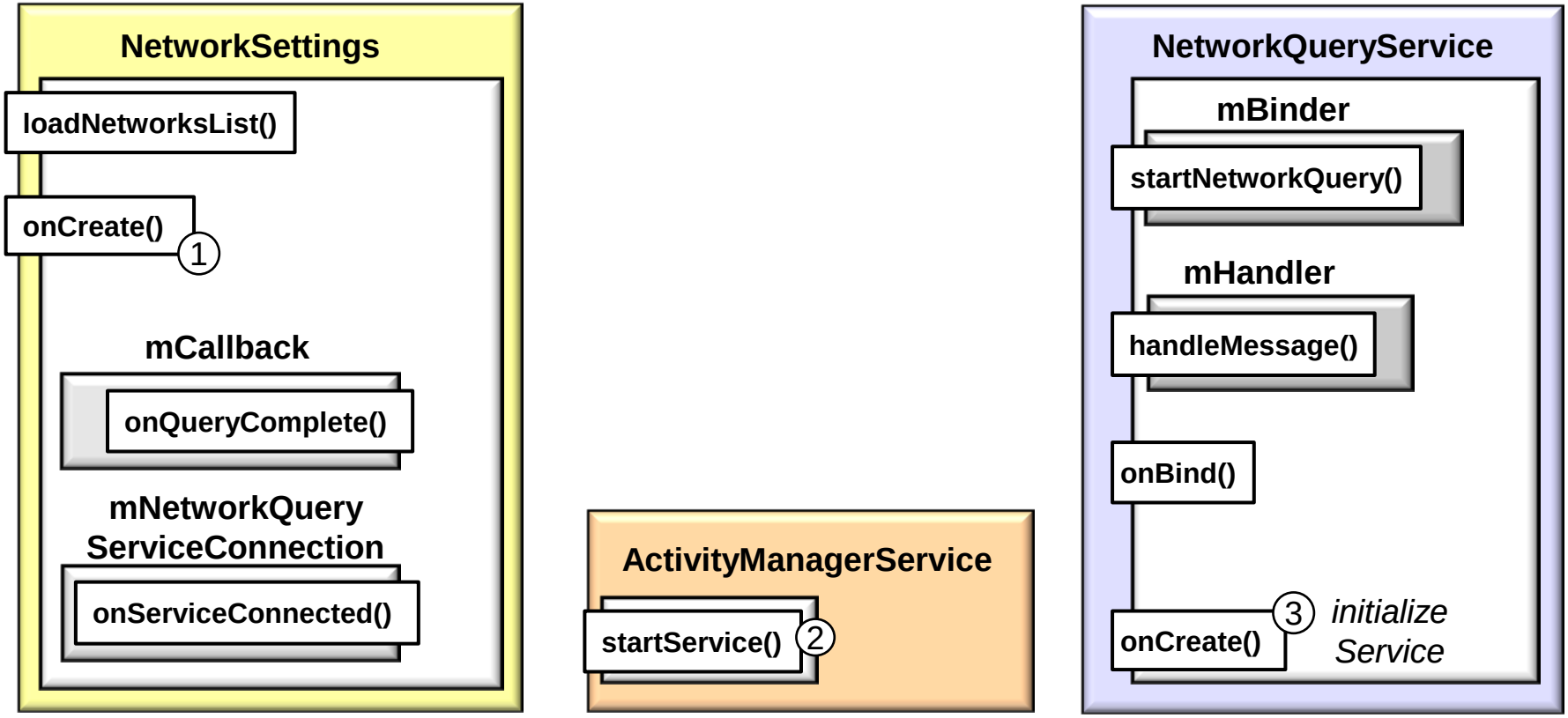
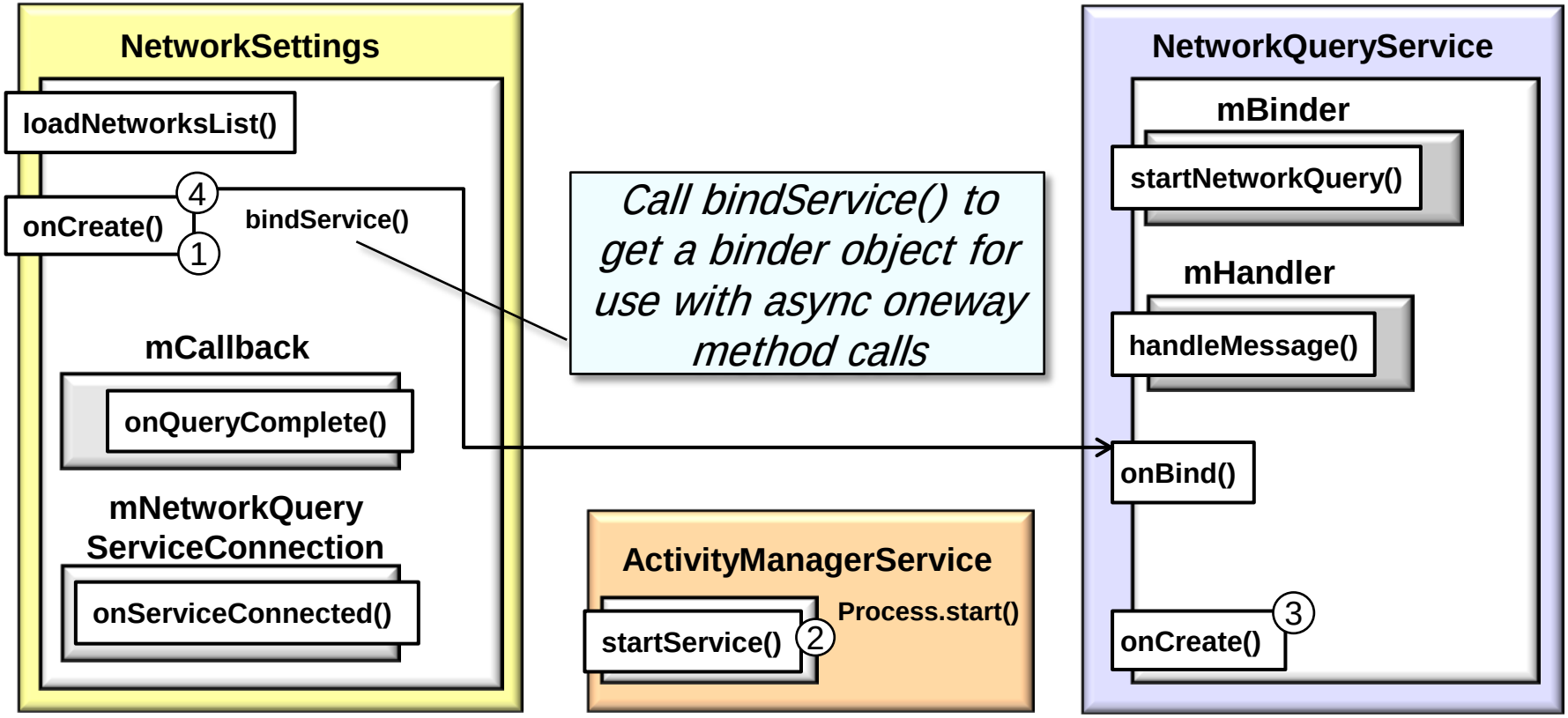


packages/apps/Phone/src/com/android/phone/NetworkQueryService.java has source

Activator POSA4 Design Pattern

Applying the Activator pattern in Android

- The NetworkSettings Activity uses the *Activator* pattern to launch the NetworkQueryService to assist in querying the network for service availability



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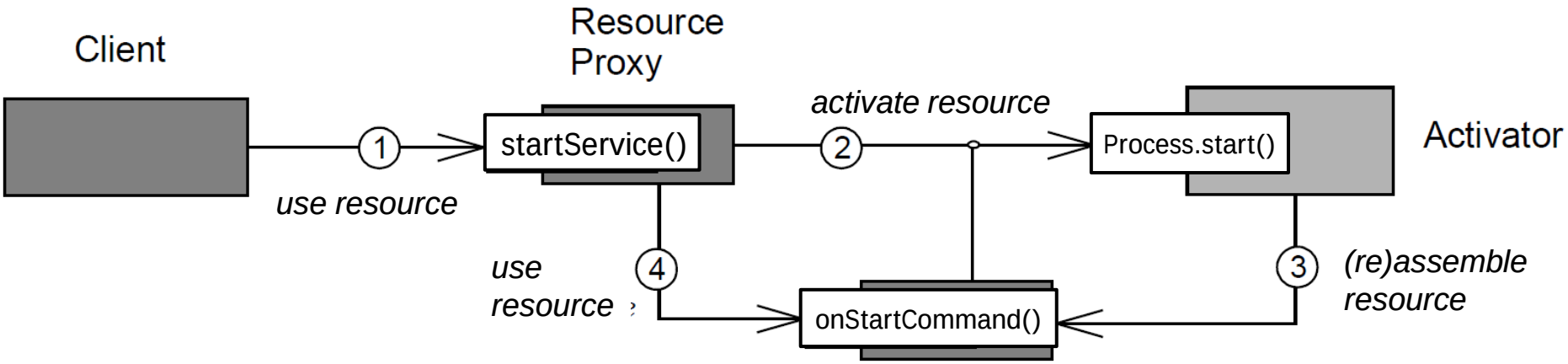
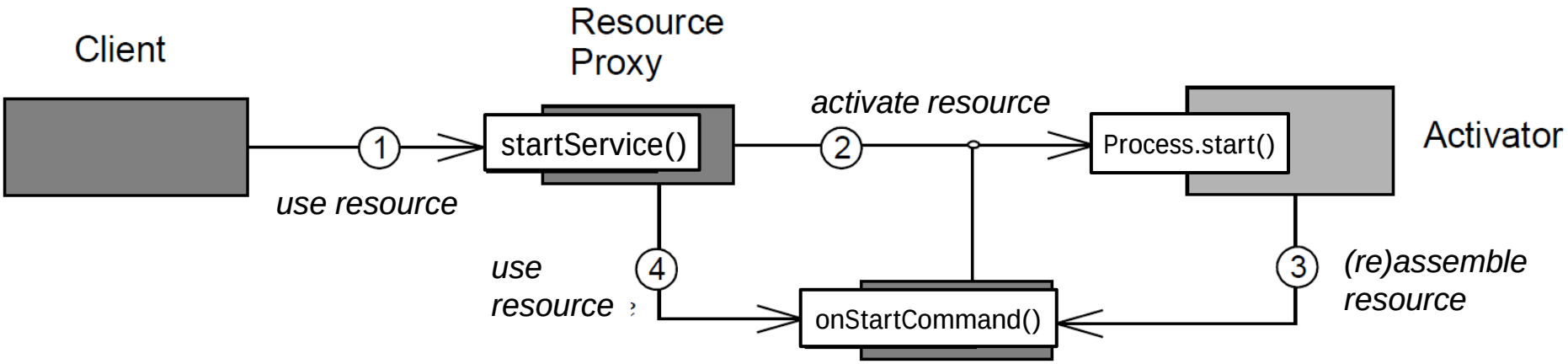
Summary



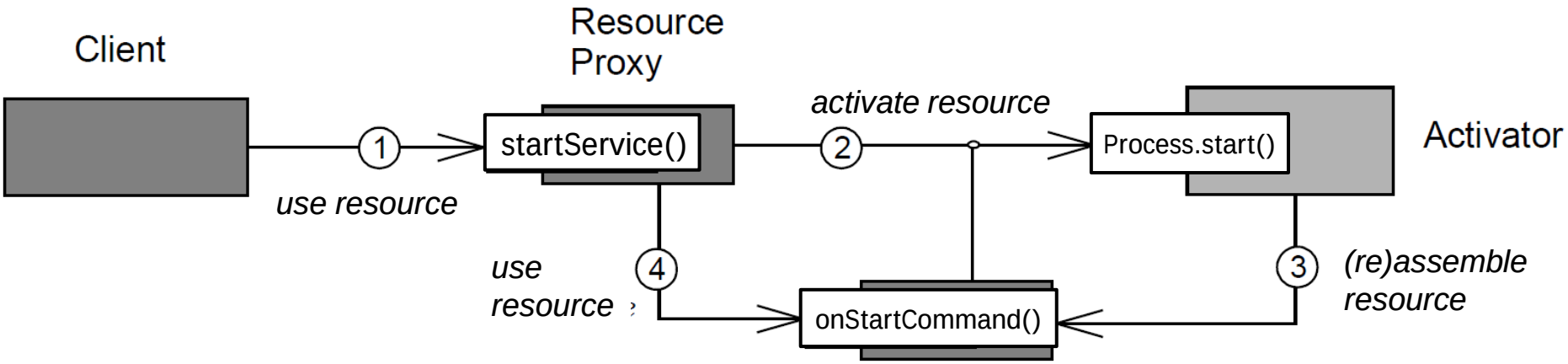
- The Android Started & Bound Services implement the *Activator* pattern

Summary



- The Android Started & Bound Services implement the *Activator* pattern
- These Services can process requests in background processes or threads
  - Processes can be configured depending on directives in the AndroidManifest.xml file

Summary



- The Android Started & Bound Services implement the *Activator* pattern
- These Services can process requests in background processes or threads
  - Processes can be configured depending on directives in the AndroidManifest.xml file
  - Threads can be programmed using the Android Intent Service framework, as discussed next