Android Network Programming: Introduction

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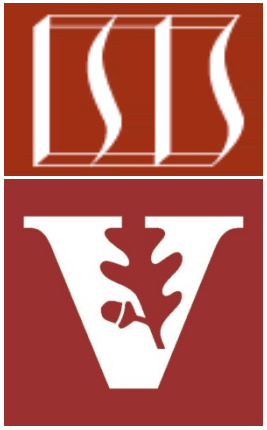

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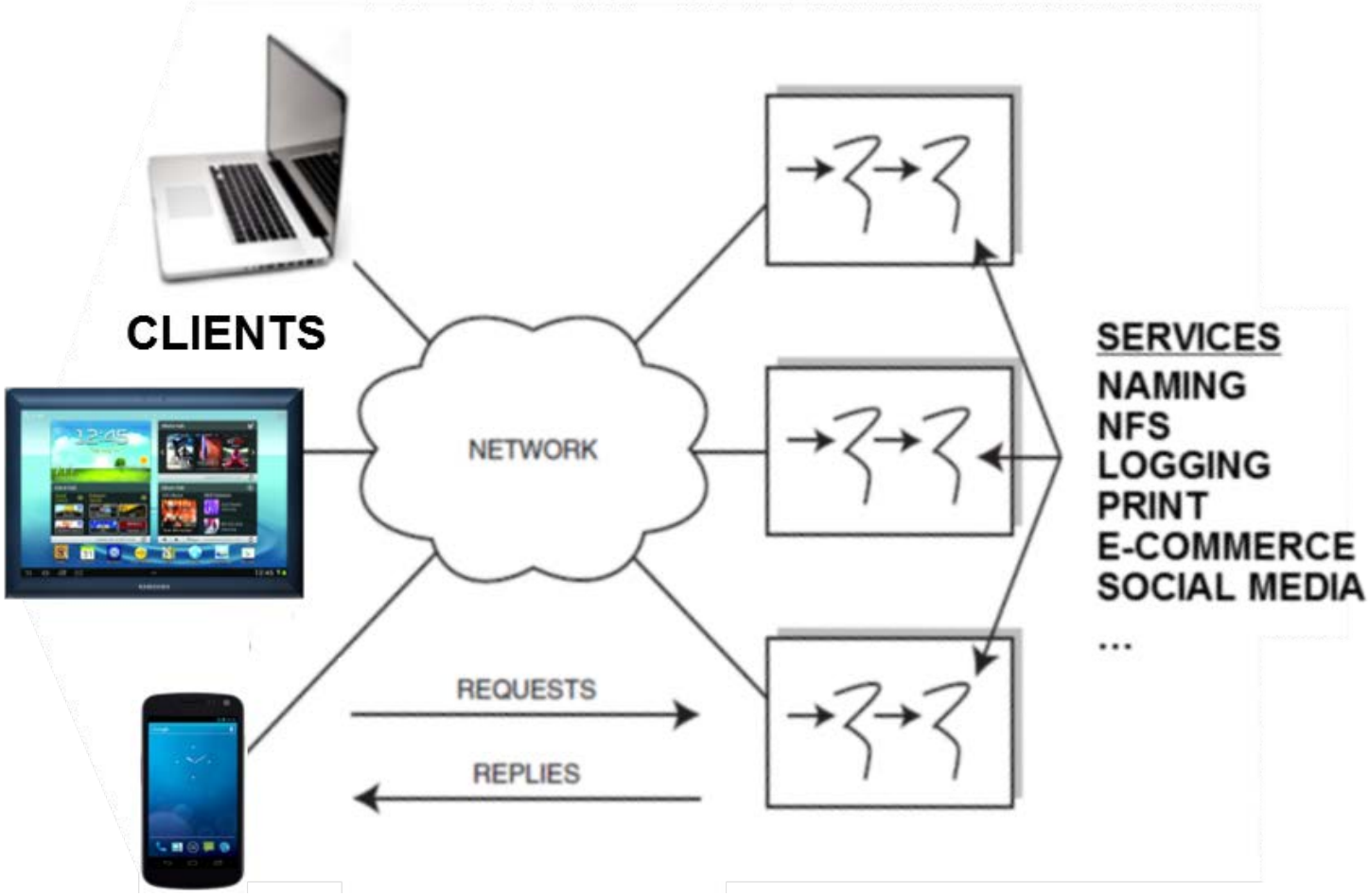
Introduction

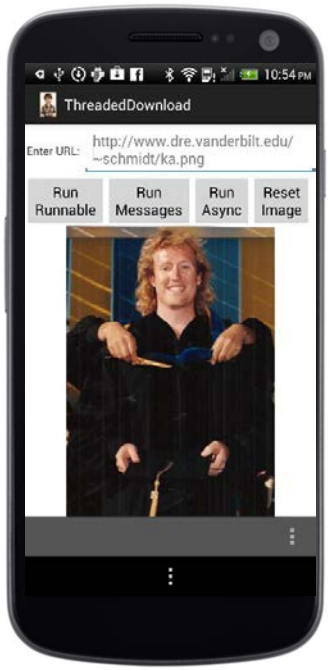
- Explore the motivations for & challenges of networked software

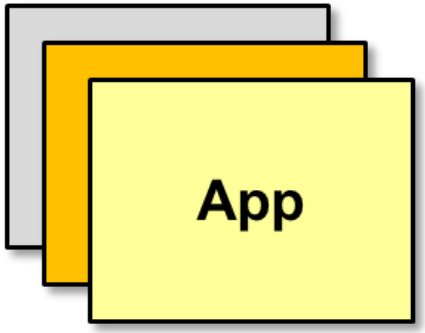


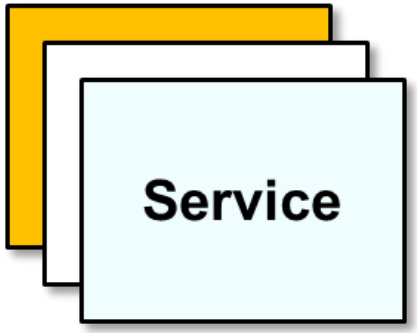
Networked software defines protocols that enable computing devices to exchange messages & perform services remotely

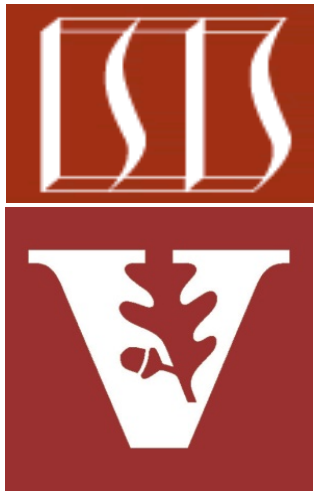
Introduction

- Explore the motivations for & challenges of networked software
- Describe the Android mechanisms available to implement apps & services that communicate across process boundaries that span mobile devices & server hosts



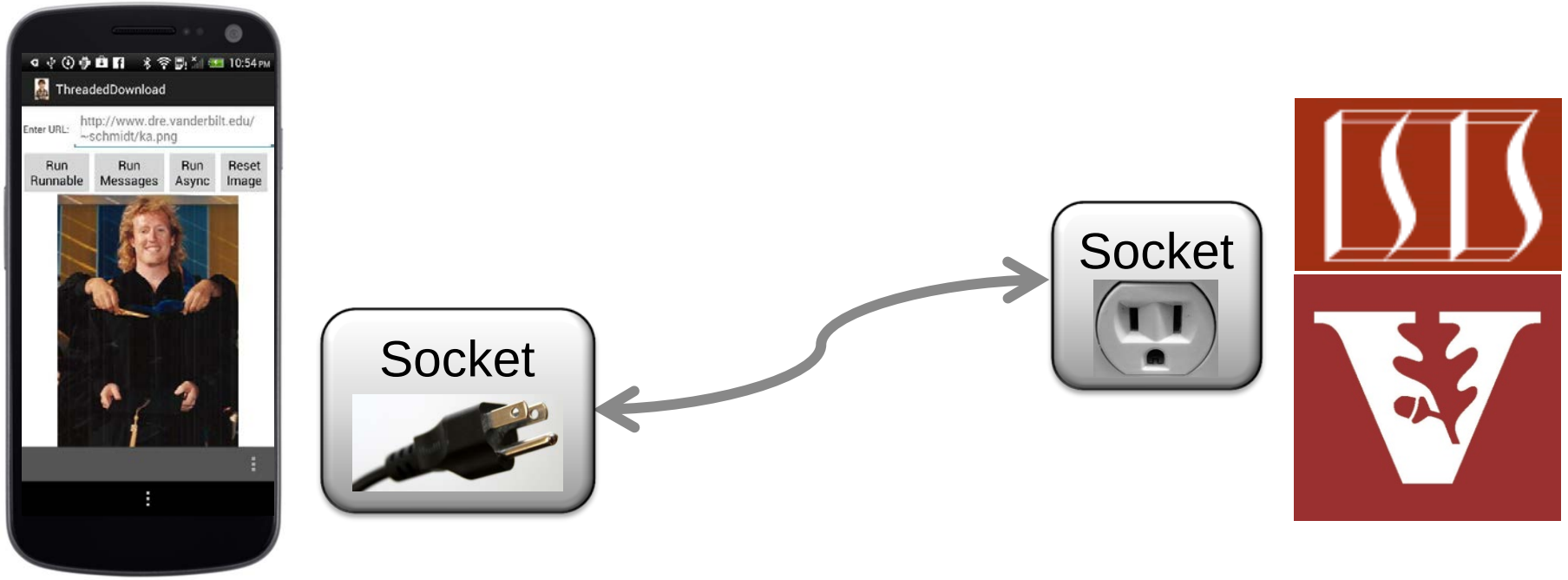






Introduction

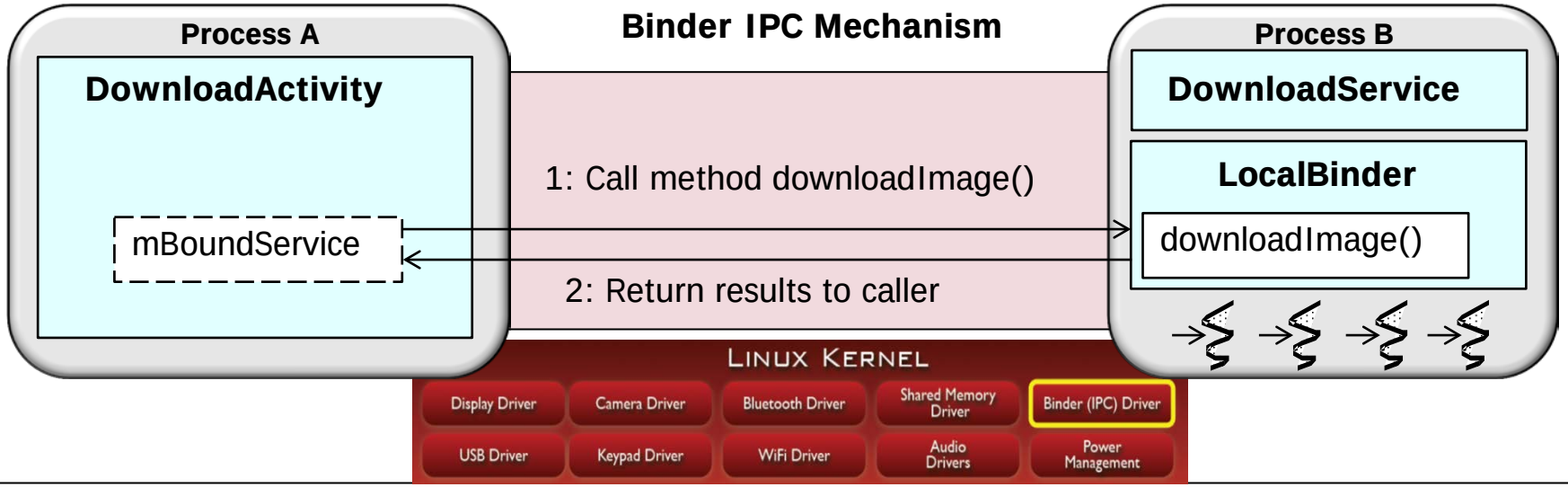
- Explore the motivations for & challenges of networked software
- Describe the Android mechanisms available to implement apps & services that communicate across process boundaries
- Many Android apps use Sockets & TCP and/or HTTP to communicate & exchange data via the Internet
  - e.g., Browser, Email, MMS/SMS, Calendar, Contacts, etc.



See developer.android.com/training/basics/network-ops/connecting.html

Introduction

- Explore the motivations for & challenges of networked software
- Describe the Android mechanisms available to implement apps & services that communicate across process boundaries
- Many Android apps use Sockets & TCP and/or HTTP to communicate & exchange data via the Internet
- Android also provides certain IPC mechanisms that are optimized for inter-process communicate within a mobile device
  - e.g., the Android Interface Definition Language (AIDL) & Binder framework



We'll cover the the Android Binder & AIDL in later modules

Android Network Programming: Part 1

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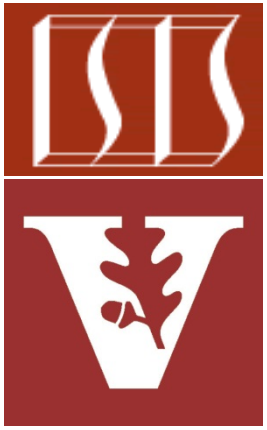

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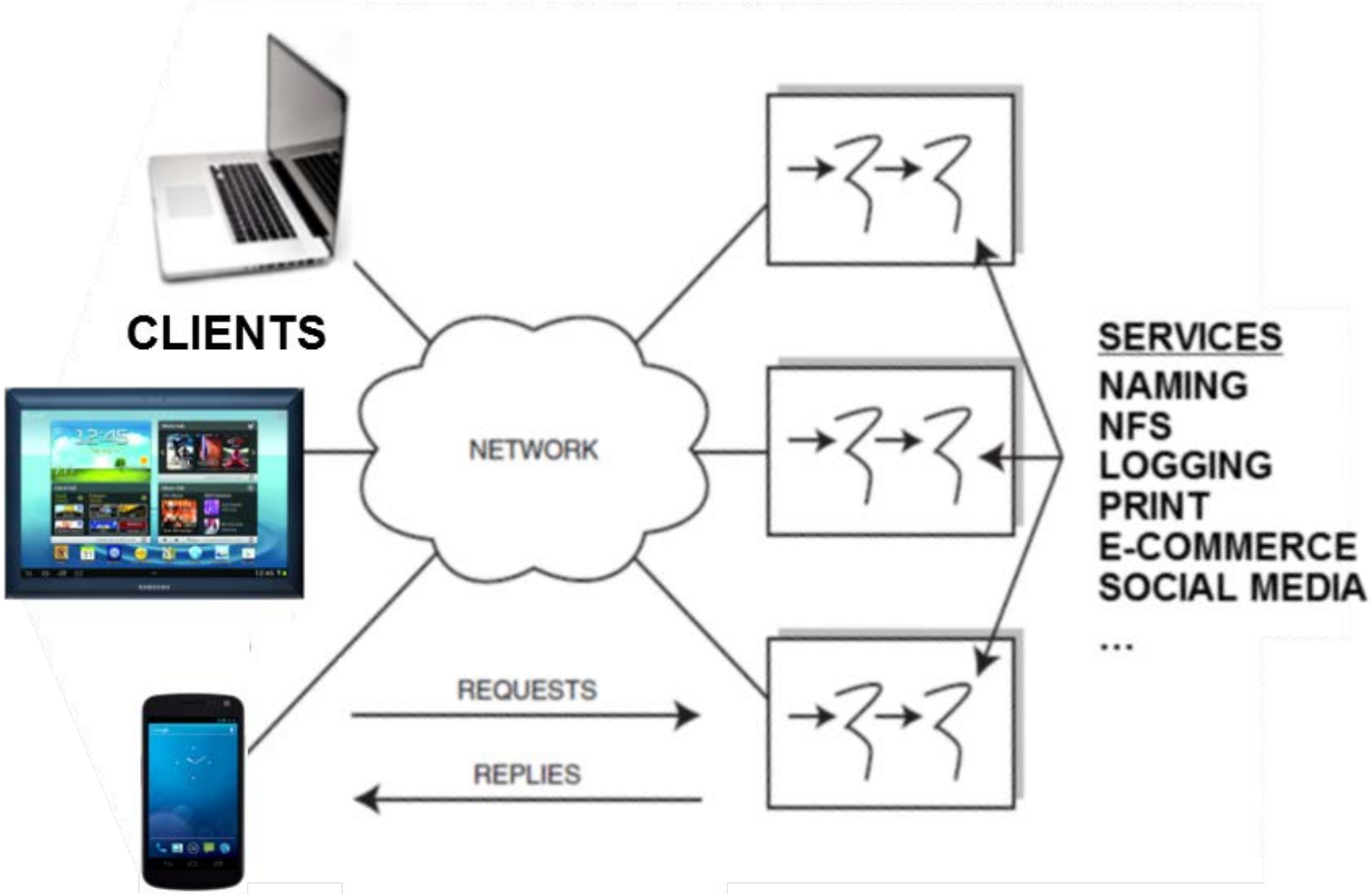
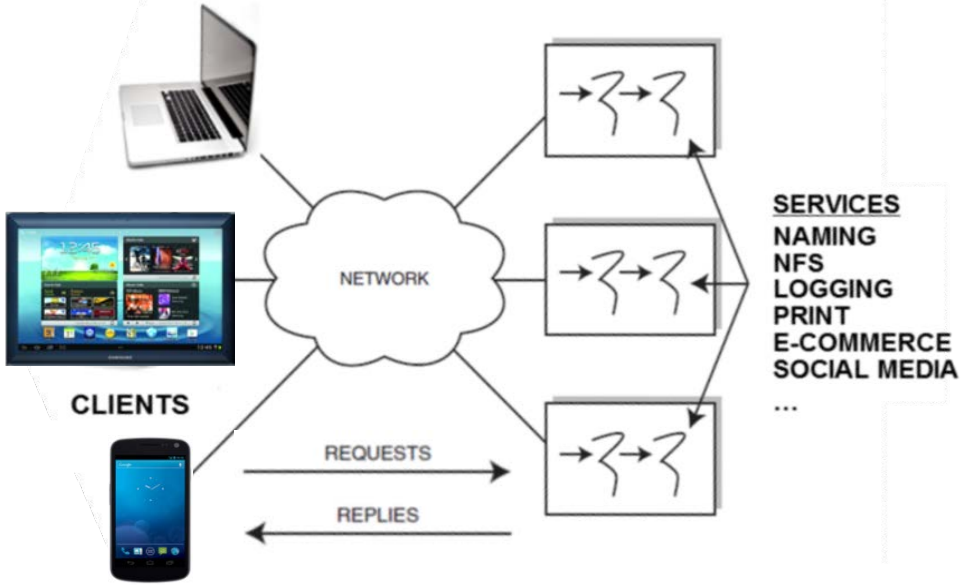
Learning Objectives in this Part of the Module

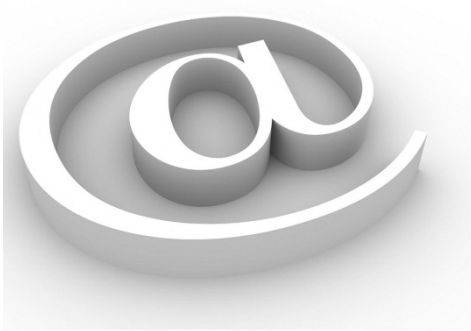
- Understand the motivations for & challenges of networked software



Motivations for Networked Software

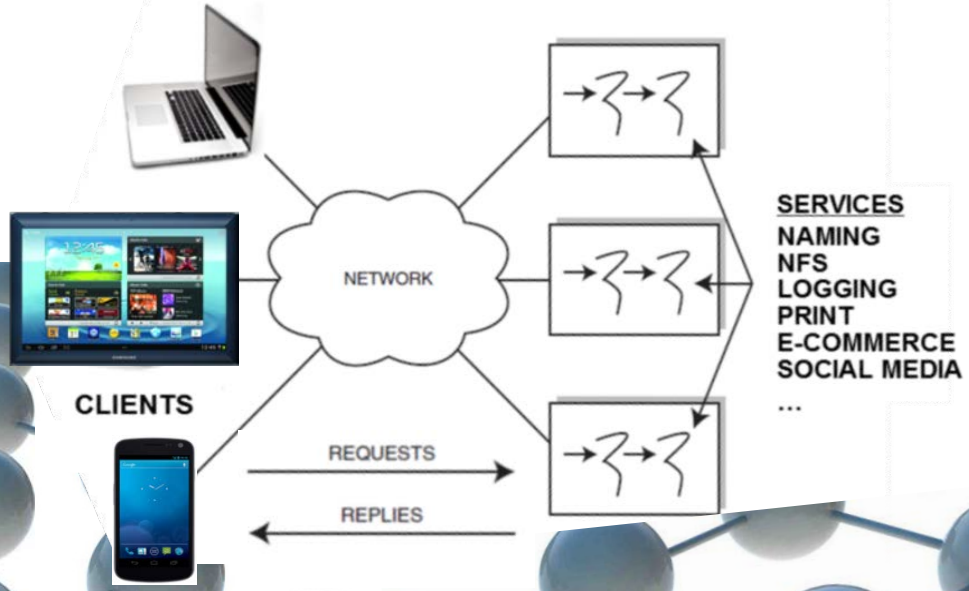
- Collaboration & commerce
  - e.g., file sharing, social media, e-commerce online transaction processing, B2B supply chain management, etc.





Motivations for Networked Software

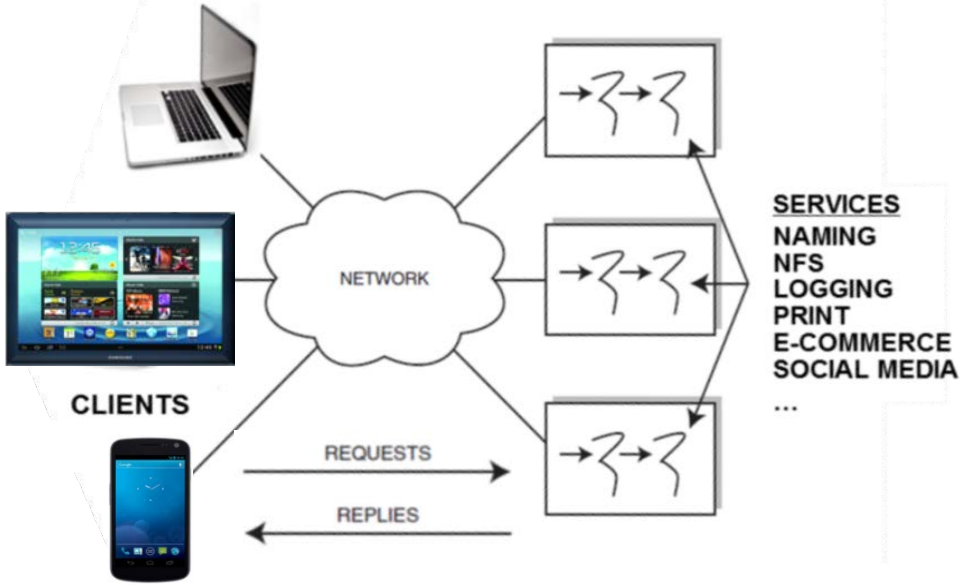
- Collaboration & commerce
- Scalability
  - e.g., utility computing in clouds



www.ge.com/stories/industrial-internet has many apt examples

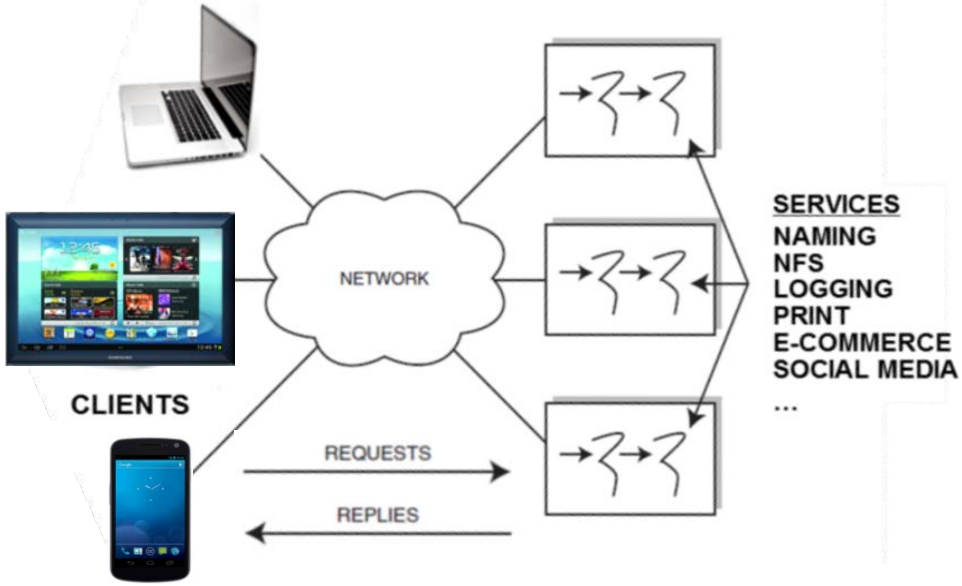
Motivations for Networked Software

- Collaboration & commerce
- Scalability
- Availability
  - e.g., minimizing single points of failure via replication



Motivations for Networked Software

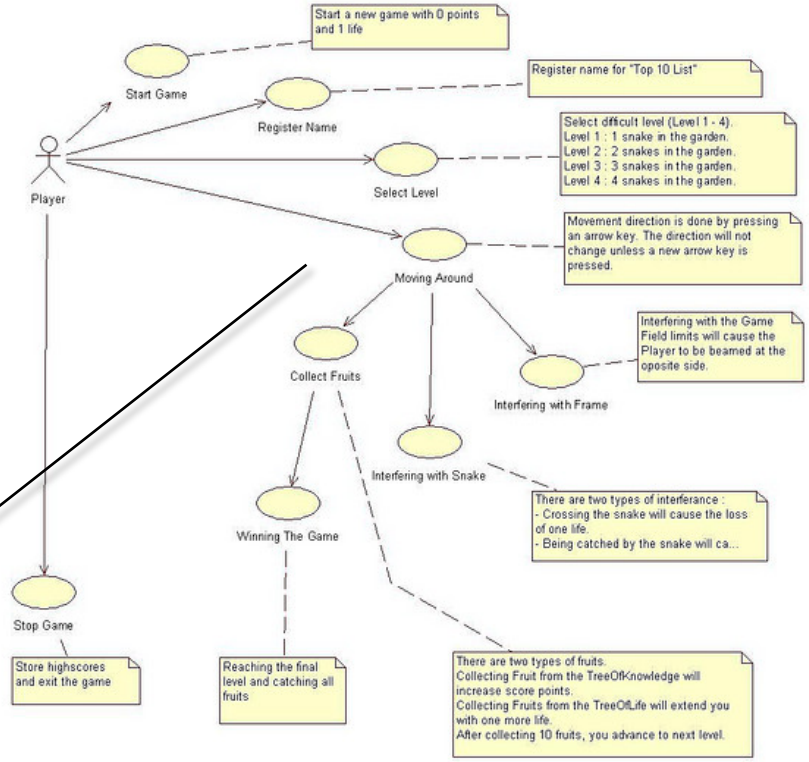
- Collaboration & commerce
- Scalability
- Availability
- Cost effectiveness
  - e.g., via shared resources

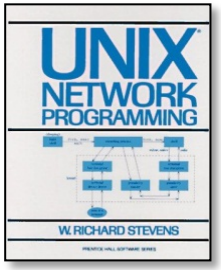


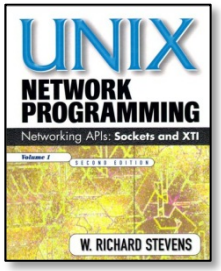
Challenges for Networked Software

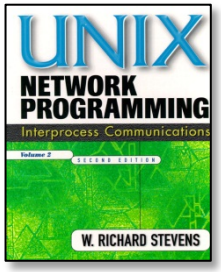
- *Accidental Complexities*
  - Algorithmic decomposition

Algorithmic decomposition is a historically popular design method that structures the software based on the actions performed by the system









www.informit.com/articles/article.aspx?p=726130&seqNum=5 has more info

Challenges for Networked Software

- *Accidental Complexities*
  - Algorithmic decomposition
  - Continuous re-discovery & re-invention of core components

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  - Continuous re-discovery & re-invention of core components
- *Inherent Complexities*
  - Latency & jitter

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- *Accidental Complexities*
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- *Inherent Complexities*
  - Latency & jitter
  - Reliability & partial failure

Error detection & handling is more complicated for networked software

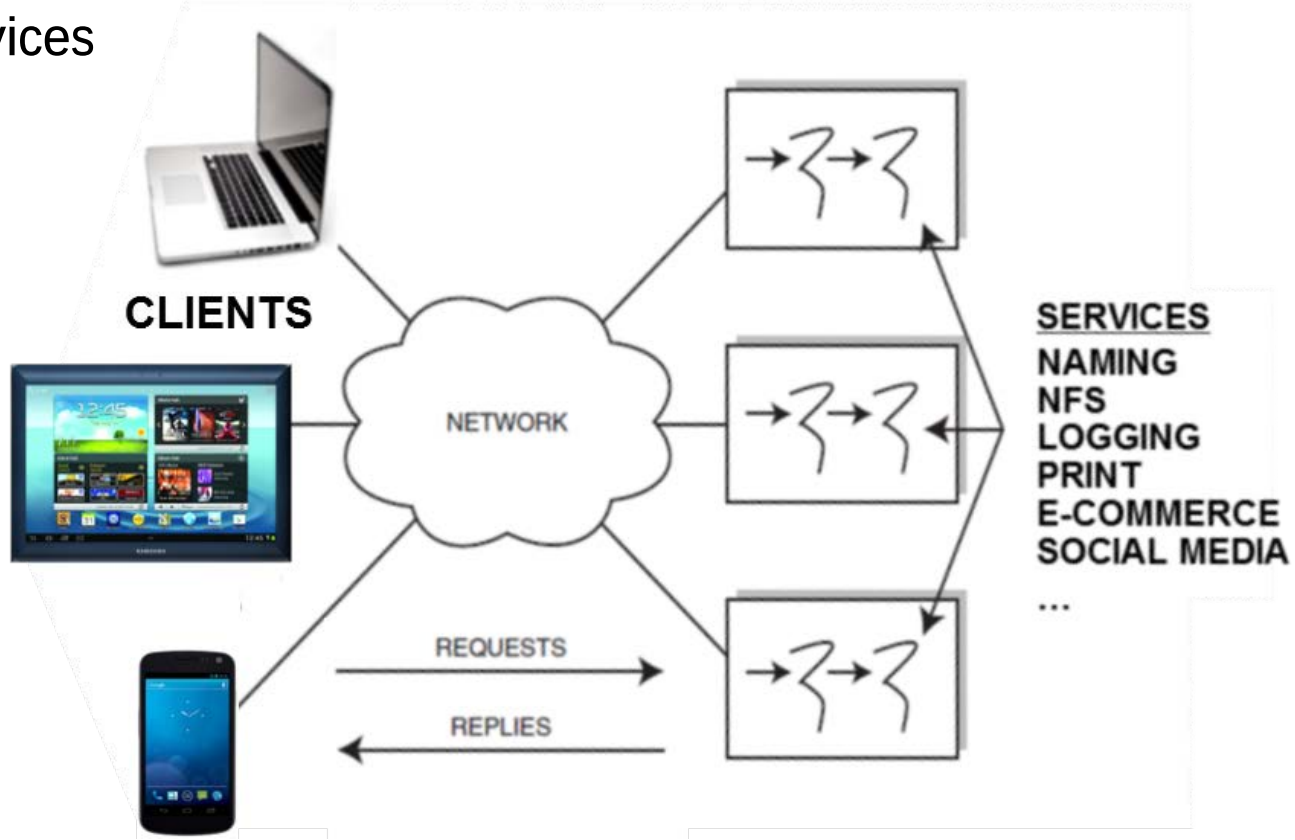
Challenges for Networked Software

- *Accidental Complexities*
  - Algorithmic decomposition
  - Continuous re-discovery & re-invention of core components
- *Inherent Complexities*
  - Latency & jitter
  - Reliability & partial failure
  - Security

See www.dre.vanderbilt.edu/~schmidt/PDF/pdcp-editorial.pdf for more info

Summary

- Networked software helps
  - Leverage advances in hardware & networking technology
  - Meet the quality & performance needs of apps & services



Summary

- Networked software helps
  - Leverage advances in hardware & networking technology
  - Meet the quality & performance needs of apps & services
- Successful networked software solutions must address key *accidental* & *inherent* complexities arising from
  - Limitations with development tools/techniques
  - Fundamental domain challenges

Summary

- Networked software helps
  - Leverage advances in hardware & networking technology
  - Meet the quality & performance needs of apps & services
- Successful networked software solutions must address key *accidental* & *inherent* complexities arising from
  - Limitations with development tools/techniques
  - Fundamental domain challenges
- As networked systems have grown in scale & functionality they must cope with a broader & more challenging set of complexities

Android Network Programming: Part 2

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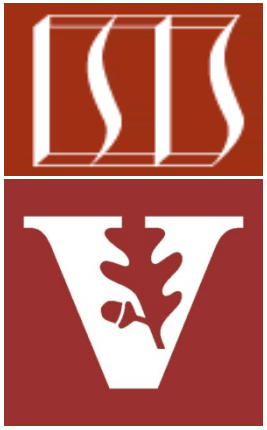

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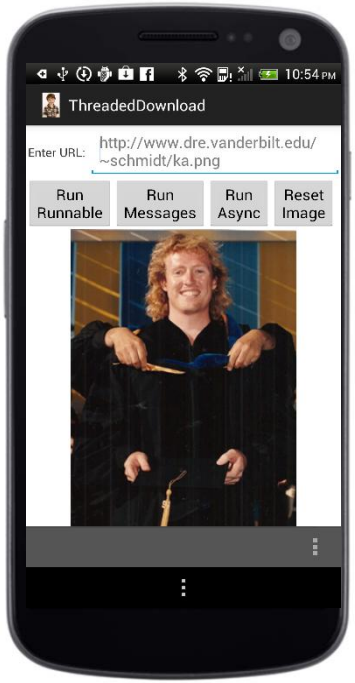
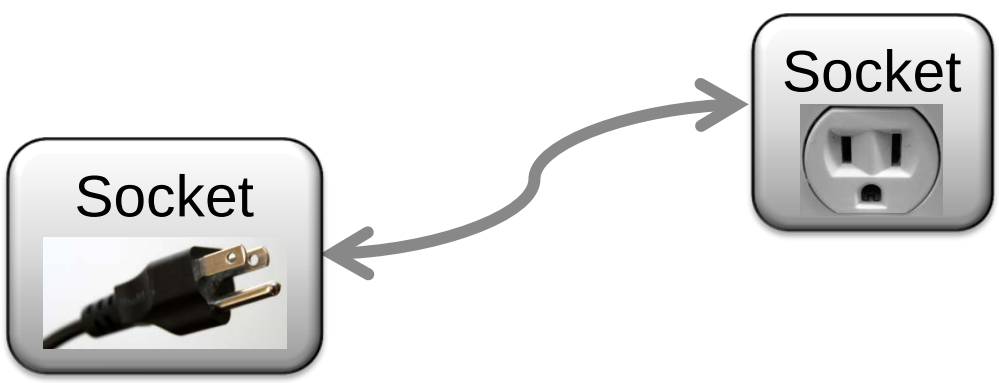
Learning Objectives in this Part of the Module

- Understand the foundational network programming mechanisms in Android





Overview of Android Network Programming

- Android includes multiple network programming classes, e.g.,
  - java.net – (Socket, URL, etc.)
  - org.apache – (HttpRequest, HttpResponse, etc.)
  - android.net – (AndroidHttpClient, URI, AudioStream, etc.)

Overview of Android Network Programming

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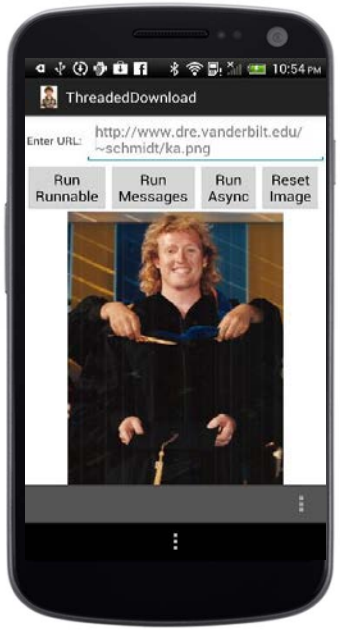
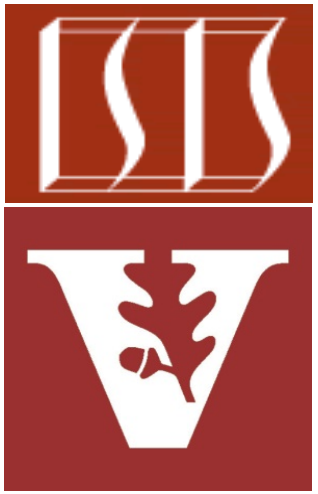
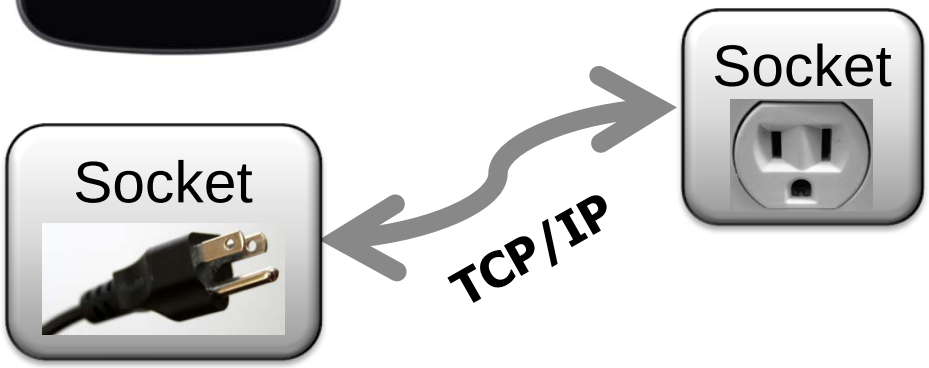
  - java.net – (Socket, URL, etc.)
  - org.apache – (HttpRequest, HttpResponse, etc.)
  - android.net – (AndroidHttpClient, URI, AudioStream, etc.)
- Under the hood, Android's HTTP libraries use the Java Sockets API
  - A socket is a software endpoint that can create a bi-directional "reliable" communication link between software processes







Sockets are a common programming interface for network communication

Overview of Android Network Programming

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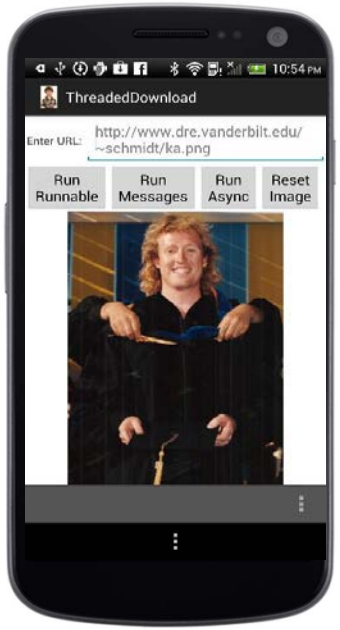
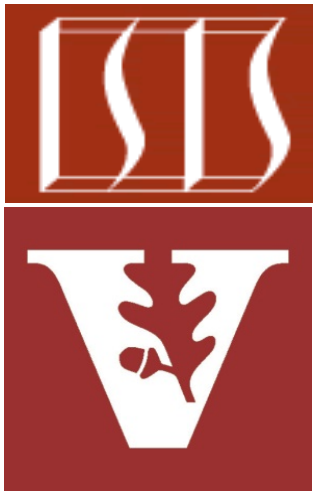
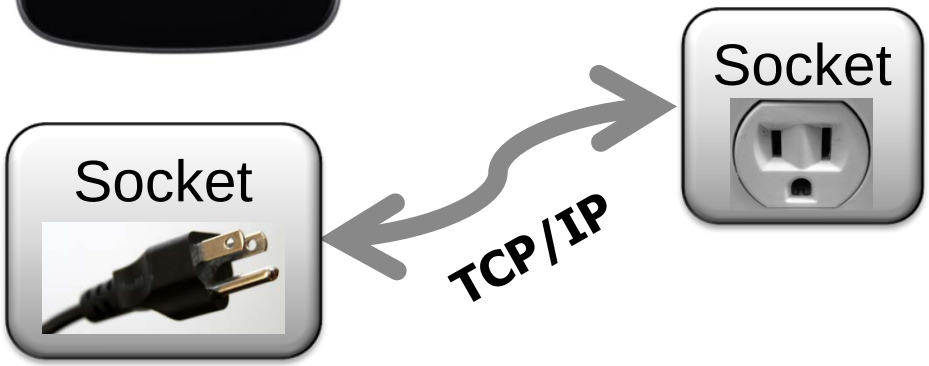
- Under the hood, Android's HTTP libraries use the Java Sockets API
- Even deeper under the hood Android's java.net implementation uses the Linux C Socket API via JNI







Overview of Java Sockets

1: Passive Role

ServerSocket
accept()
bind()
close()

Represents a server-side factory that waits for incoming client connections & creates connected Sockets

Socket

Network

developer.android.com/reference/java/net/ServerSocket.html

Overview of Java Sockets

1: Passive Role

ServerSocket
accept()
bind()
close()

Plays a portion of the Acceptor role in the Acceptor-Connector pattern

Socket

Network

Overview of Java Sockets

Provides a client-side (& server-side) TCP socket

1: Passive Role

ServerSocket
accept()
bind()
close()

2: Active Role

Socket
bind()
close()
connect()
getInputStream()
getOutputStream()

Socket

Network

Overview of Java Sockets

Clients & servers designate their addresses with an InetAddress

1: Passive Role

ServerSocket
accept()
bind()
close()

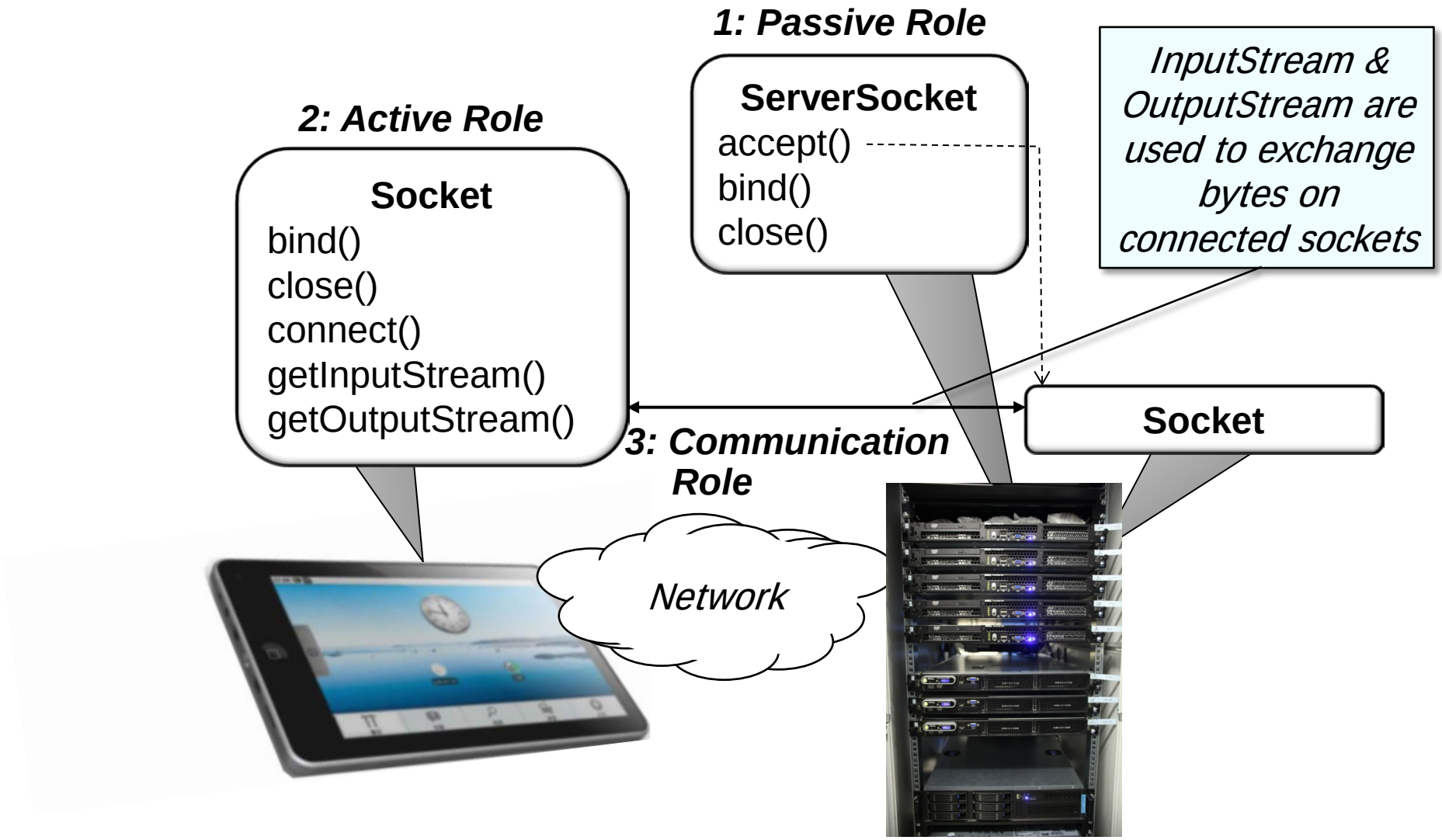
2: Active Role

Socket
bind()
close()
connect()
getInputStream()
getOutputStream()

Socket

Network

Overview of Java Sockets



InputStream in Android

- An InputStream is a stream of incoming byte data
- An InputStream can be obtained from a Socket by using the getInputStream() method
- To read from a stream, you must create a byte buffer to read in data
- Each call to read on an InputStream fills your buffer with data & returns the number of bytes read

```
InputStream in = someSocket.getInputStream();
const int BUFSIZ = 1024;
byte[] buffer = new byte[BUFSIZ];

for(int bytesRead;
    (bytesRead = in.read(buffer,0,buffer.length)) != -1;
   ) {
  // the buffer's been filled, do something with the data
}
```

developer.android.com/reference/java/io/InputStream.html has more info

InputStreamReader in Android

- An InputStreamReader turns a byte stream into a character stream
- Data read from the source input stream is converted into characters by either a default or a provided character converter
- InputStreamReader contains an 8K buffer of bytes read from the source stream & converts these into characters as needed

```
InputStream in = someSocket.getInputStream();
Reader reader = new InputStreamReader(in);
```

Read one character at a time

```
for (int data; (data = reader.read()) != -1; ){
   char theChar = (char) data;
    // … do something with the data
}

reader.close();
```

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```

```
for (int data; (data = reader.read()) != -1; ){
   char theChar = (char) data;
    // … do something with the data
}

reader.close();
```

Can also read a buffer at a time

developer.android.com/reference/java/io/InputStreamReader.html has more

BufferedReader in Android

- Wraps an existing Reader & buffers the input
- Expensive interaction with underlying reader is minimized, since most (smaller) requests can be satisfied by accessing buffer alone
- Drawback is that some extra space is required to hold the buffer & copying takes place when filling that buffer

```
BufferedReader bufferedReader =
  new BufferedReader(new InputStreamReader
                          (someSocket.getInputStream()));

for (String data;
     (data = bufferedReader.readLine()) != null; ){
    // … do something with the data
}

bufferedReader.close();
```

developer.android.com/reference/java/io/BufferedReader.html has more info

OutputStream in Android

- An OutputStream is a stream of outgoing byte data
- An OutputStream can be obtained from a Socket by using the getOutputStream() method
- You can write data to a stream by passing in a byte buffer of data
- You should use flush() if you want to ensure the data you have written is output to disk or sent to other end of socket

```
OutputStream out = someSocket.getOutputStream();
out.write("Hello Socket".getBytes());
out.flush();

byte[] buffer = new byte[1024];
// fill the buffer
out.write(buffer,0,buffer.length);
out.close();
```

developer.android.com/reference/java/io/OutputStream.html has more info

OutputStreamWriter in Android

- A class for turning a character stream into a byte stream
- Data written to the target input stream is converted into bytes by either a default or a provided character converter
- OutputStreamWriter contains an 8K buffer of bytes to be written to target stream & converts these into characters as needed

```
OutputStreamWriter out =
  new OutputStreamWriter
    (someSocket.getOutputStream());

String string1 = "Android socket IO",
       string2 = " is fun";

out.write(string1);
out.append(string2);
out.flush();
out.close();
```

developer.android.com/reference/java/io/OutputStreamWriter.html has more

PrintWriter in Android

- Wraps either an existing OutputStream or an existing Writer (including OutputStreamWriter)
- Provides convenience methods for printing common data types in a human readable format

```
PrintWriter pw =
  new PrintWriter(new
        OutputStreamWriter(someSocket.getOutputStream()),
                           // “true” indicates auto-flush
                           true);
pw.println("GET /index.html");

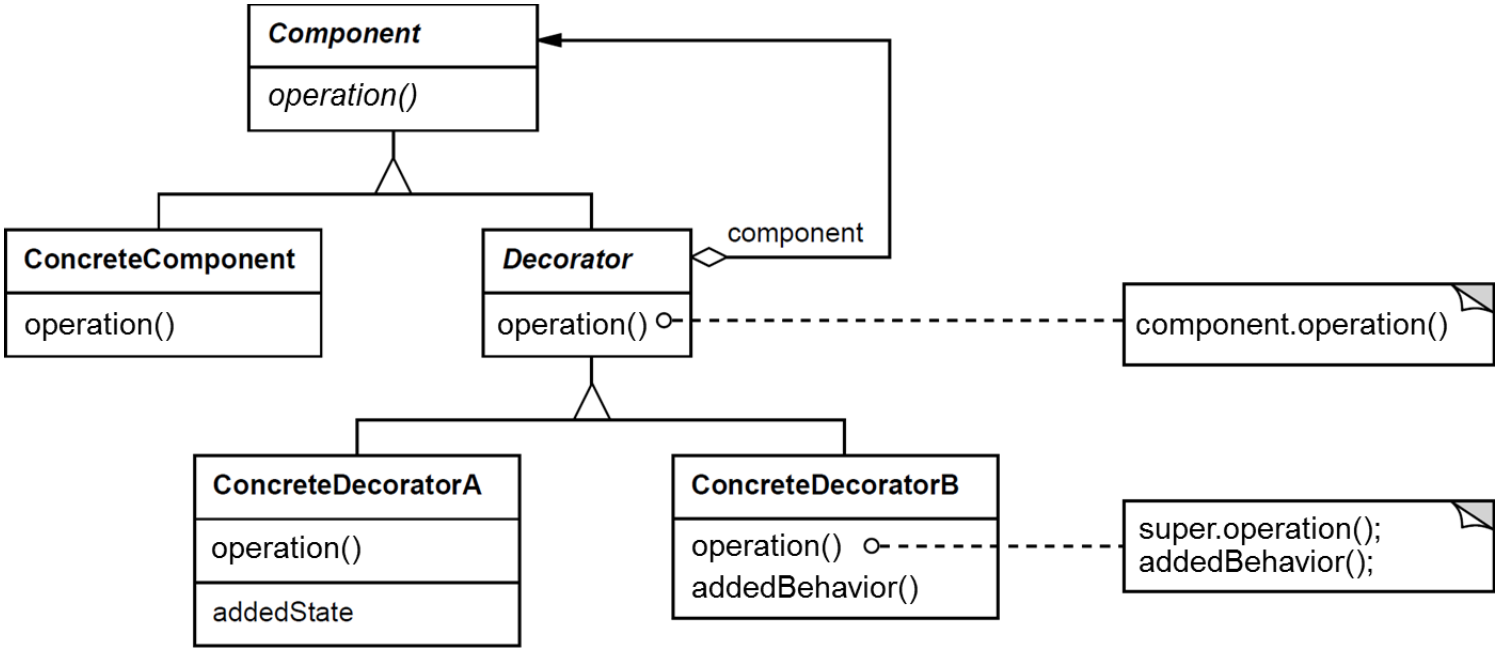
BufferedReader br = new BufferedReader(new
   InputStreamReader(socket.getInputStream()));

for (String rawData; (rawData = br.readLine()) != null; )
  data.append(rawData);
```

developer.android.com/reference/java/io/PrintWriter.html has more info

Android I/O Implements the Decorator Pattern

- The Java I/O streams classes use the *Decorator* pattern, which allows for the dynamic wrapping of objects to modify their existing responsibilities & behaviors



- Stream classes extend the base subclasses to add features to the stream classes

Programming Java Sockets in Android

```
public class NetworkingSocketsActivity extends Activity
 {
  TextView mTextView = null;

  public void onCreate(Bundle savedInstanceState) {
    ...
    // assuming server is listening on port 80
    new HttpGet().execute("www.dre.vanderbilt.edu ");
  }
```

Pass a URL to the template method of an AsyncTask

Programming Java Sockets in Android

```
private class HttpGet
              extends AsyncTask<String, Void, String> {

protected String doInBackground(String... params) {
     Socket socket = null;
     StringBuffer data = new StringBuffer();
     try {
       socket = new Socket(params[0], 80);
       PrintWriter pw =
         new PrintWriter(new
           OutputStreamWriter(socket.getOutputStream()),
                              true);
       pw.println("GET /index.html");
      ...
```

Runs in a background thread

Connect to the server

Send GET request

Programming Java Sockets in Android

```
    ...
    BufferedReader br = new BufferedReader(
              new InputStreamReader
                  (socket.getInputStream()));
    String rawData;
    while ((rawData = br.readLine()) != null) {
      data.append(rawData);
    }
  } catch ...
  // close socket
  return data.toString();
  ...
}

protected void onPostExecute(String result) {
  mTextView.setText(result);
}
```

Read data from server

Return data as a String

Display the text on the screen

Programming with URLConnection in Android

```
public class NetworkingURLActivity extends Activity {
  TextView mTextView = null;

  public void onCreate(Bundle savedInstanceState) {
     new HttpGetTask().execute
       ("http://api.geonames.org/...");
  }
  ...
```

Pass a URL to the template method of an AsyncTask

Programming with URLConnection in Android

```
private class HttpGetTask
              extends AsyncTask<String, Void, String> {

  ...
   protected String doInBackground(String... params) {
     StringBuffer serverData = new StringBuffer();
     HttpURLConnection conn = (HttpURLConnection) new
           URL(params[0]).openConnection();

     InputStream in =
       new BufferedInputStream(conn.getInputStream());
     BufferedReader br = ...;
     ...
     return serverData.toString();
   ...
```

Runs in a background thread

Connect to the server & send GET request

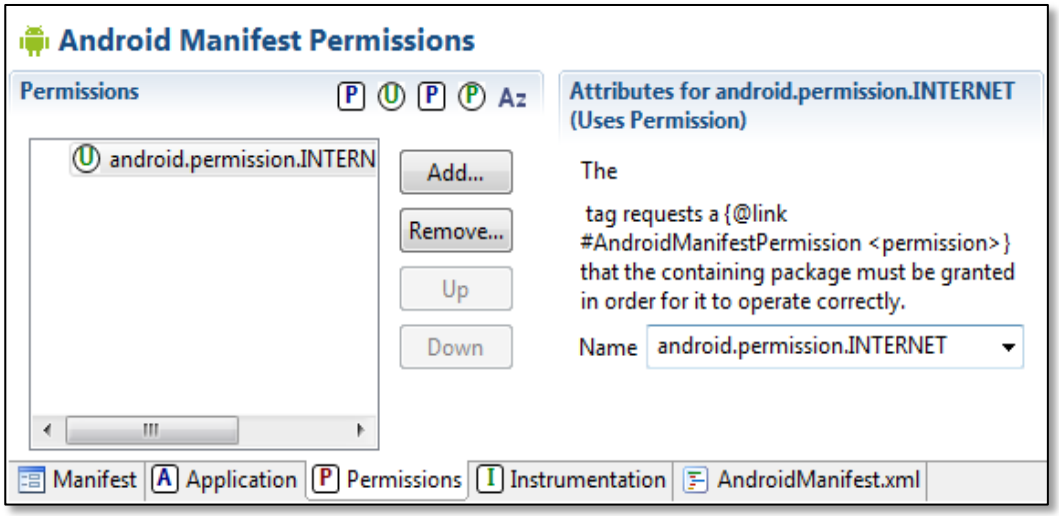
Read & process the data from the server

Return data as a String

developer.android.com/reference/java/net/URLConnection.html has more

Networking Permissions

- To allow an app to access the Internet using Eclipse, open AndroidManifest.xml, go to “Permissions” tab, add "Uses Permission" & select android.permission.INTERNET



Networking Permissions

- To allow an app to access the Internet using Eclipse, open AndroidManifest.xml, go to “Permissions” tab, add "Uses Permission" & select android.permission.INTERNET
- Alternatively, open the AndroidManifest.xml file as raw XML & add a line near the top:

```
<manifest
xmlns:android="http://schemas.android
com/apk/res/android"

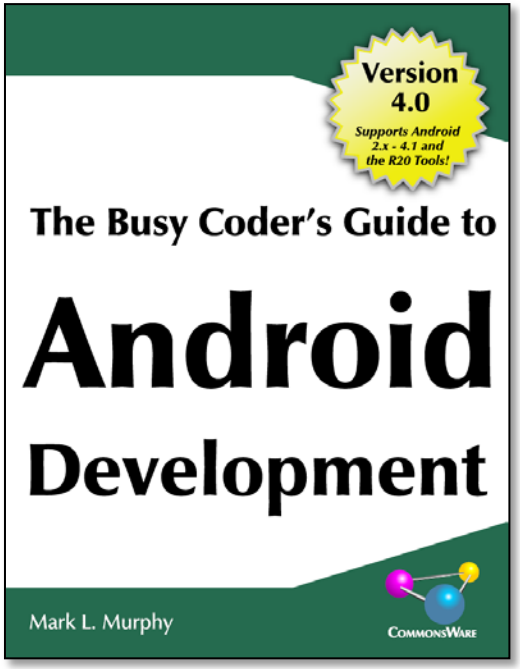
package="examples.threadeddownloads"
  android:versionCode="1"
  android:versionName="1.0" >

  <uses-permission android:name=
     "android.permission.INTERNET">
  </uses-permission>
```

If you don't do this, your application will crash with an UnknownHostException when trying to access a remote host!!

Summary

- Android provides a wide range of network programming mechanisms

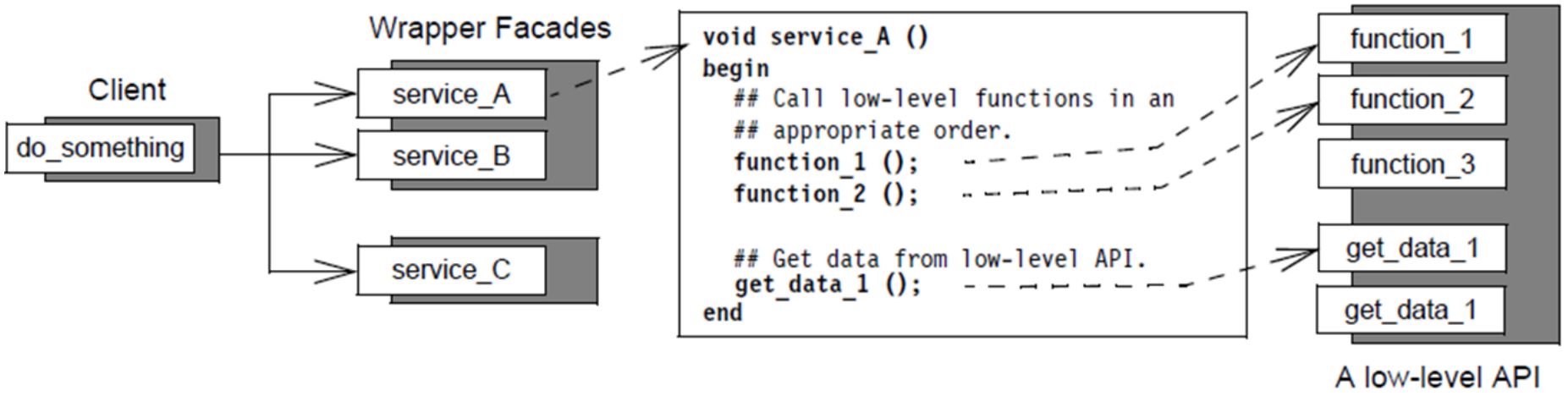


www.vogella.com/tutorials.html

There are many Android tutorials & resources available online

Summary

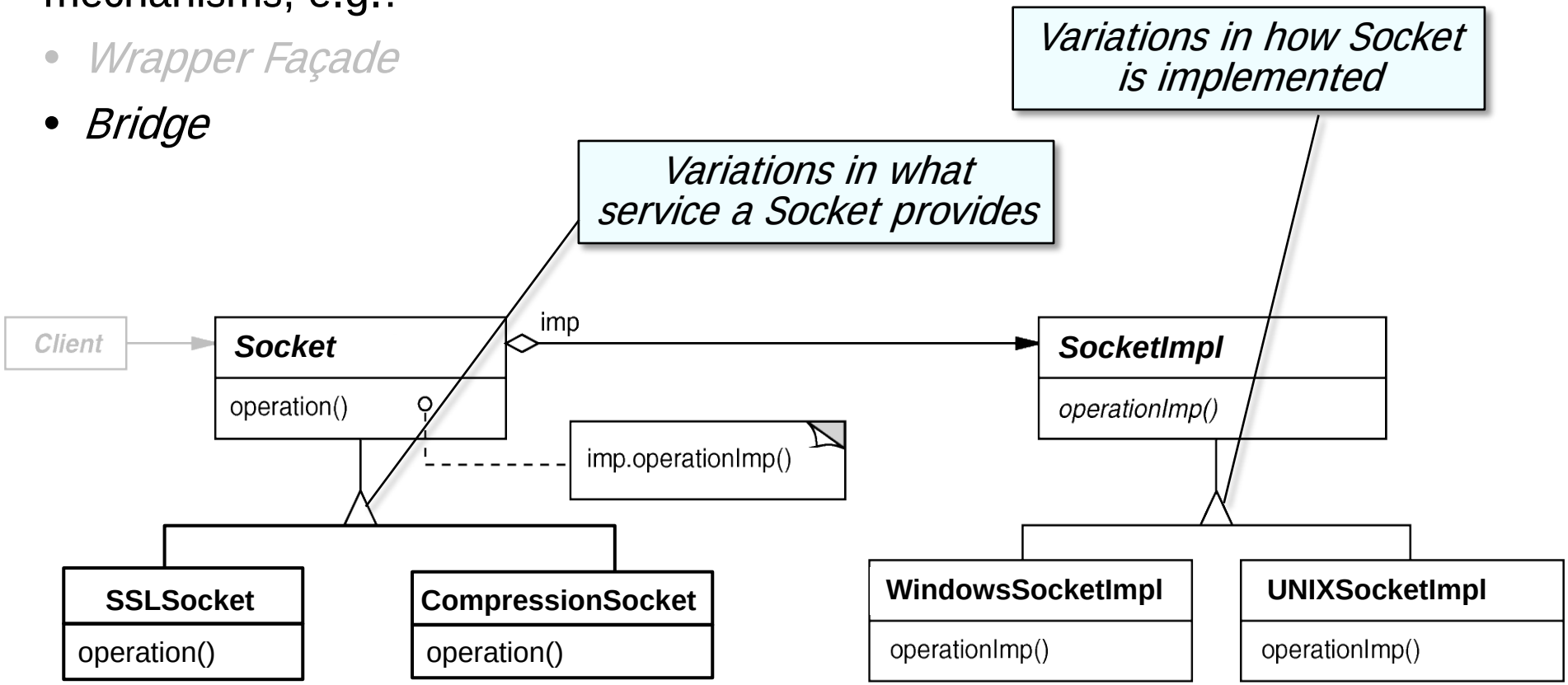
- Android provides a wide range of network programming mechanisms
- There are many patterns underlying these Android network programming mechanisms, e.g.:
  - *Wrapper Facade*



www.dre.vanderbilt.edu/~schmidt/PDF/wrapper-facade.pdf has more info

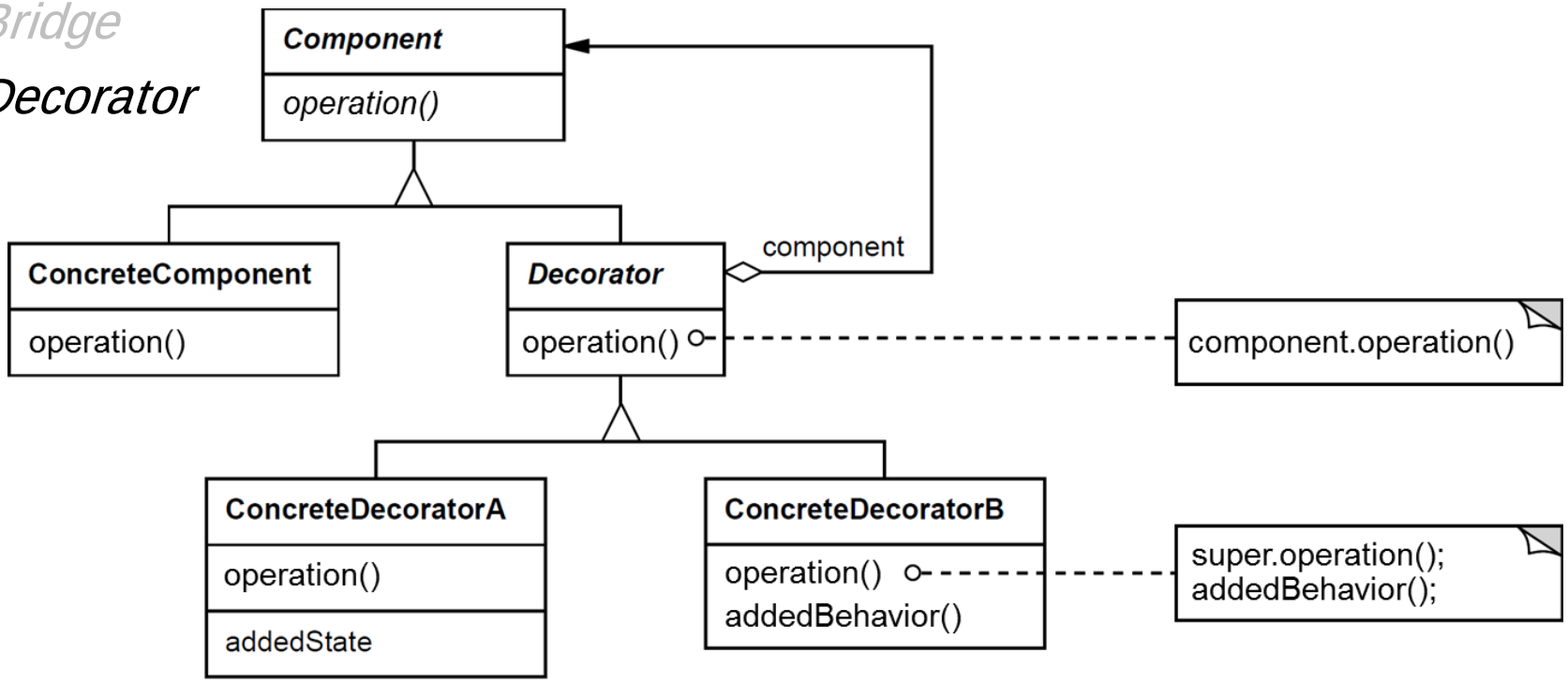
Summary

- Android provides a wide range of network programming mechanisms
- There are many patterns underlying these Android network programming mechanisms, e.g.:
  - *Wrapper Façade*
  - *Bridge*



Summary

- Android provides a wide range of network programming mechanisms
- There are many patterns underlying these Android network programming mechanisms, e.g.:
  - *Wrapper Façade*
  - *Bridge*
  - *Decorator*



en.wikipedia.org/wiki/Decorator_pattern has more info

Summary

- Android provides a wide range of network programming mechanisms
- There are many patterns underlying these Android network programming mechanisms, e.g.:
  - *Wrapper Façade*
  - *Bridge*
  - *Decorator*
  - *Acceptor-Connector*