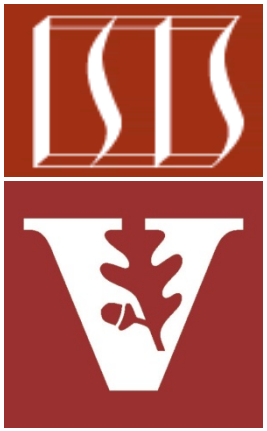
Overview of Frameworks: Introduction



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

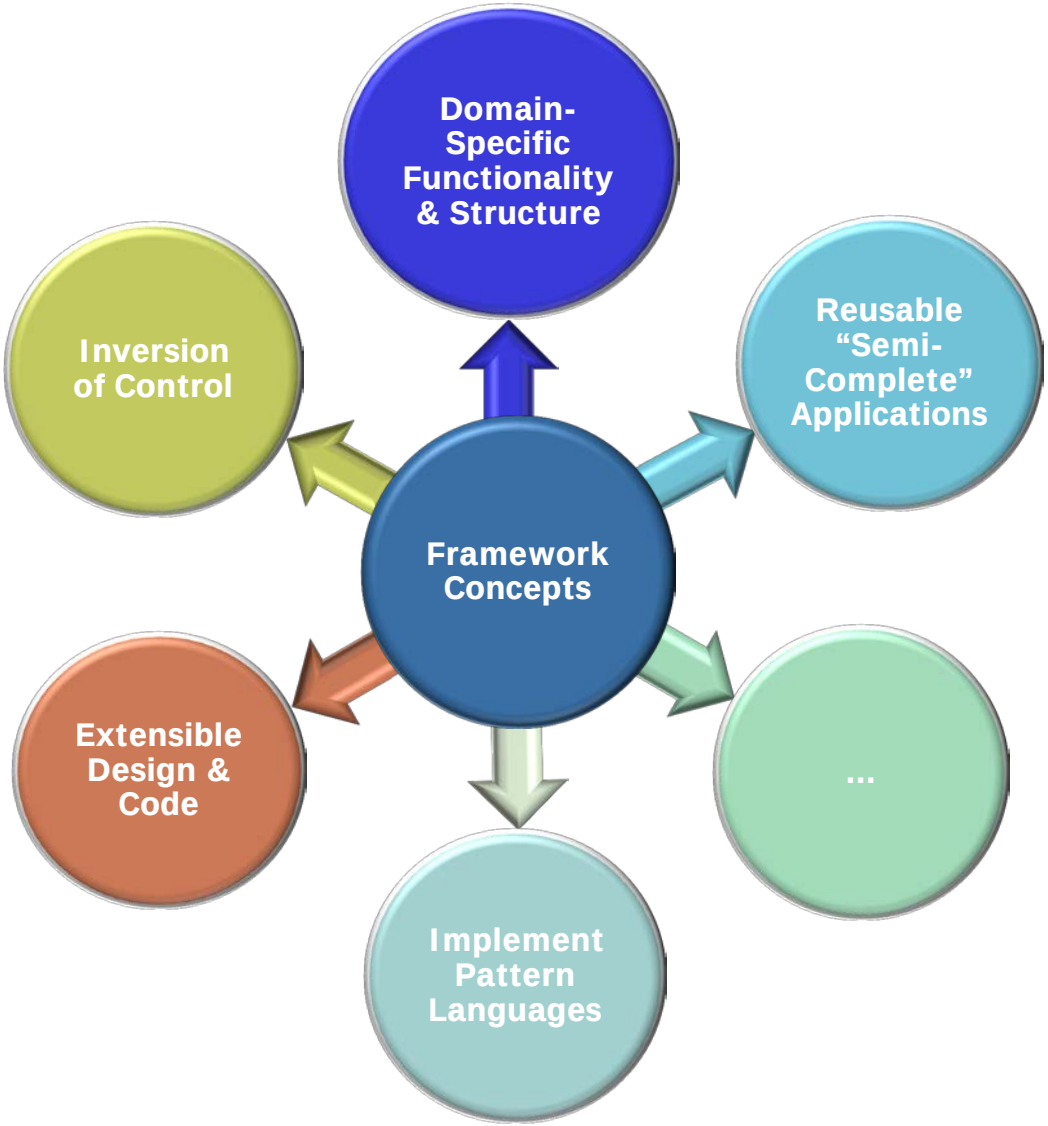
Institute for Software
Integrated Systems
Vanderbilt University
Nashville, Tennessee, USA

CS 282 Principles of Operating Systems II

Systems Programming for Android

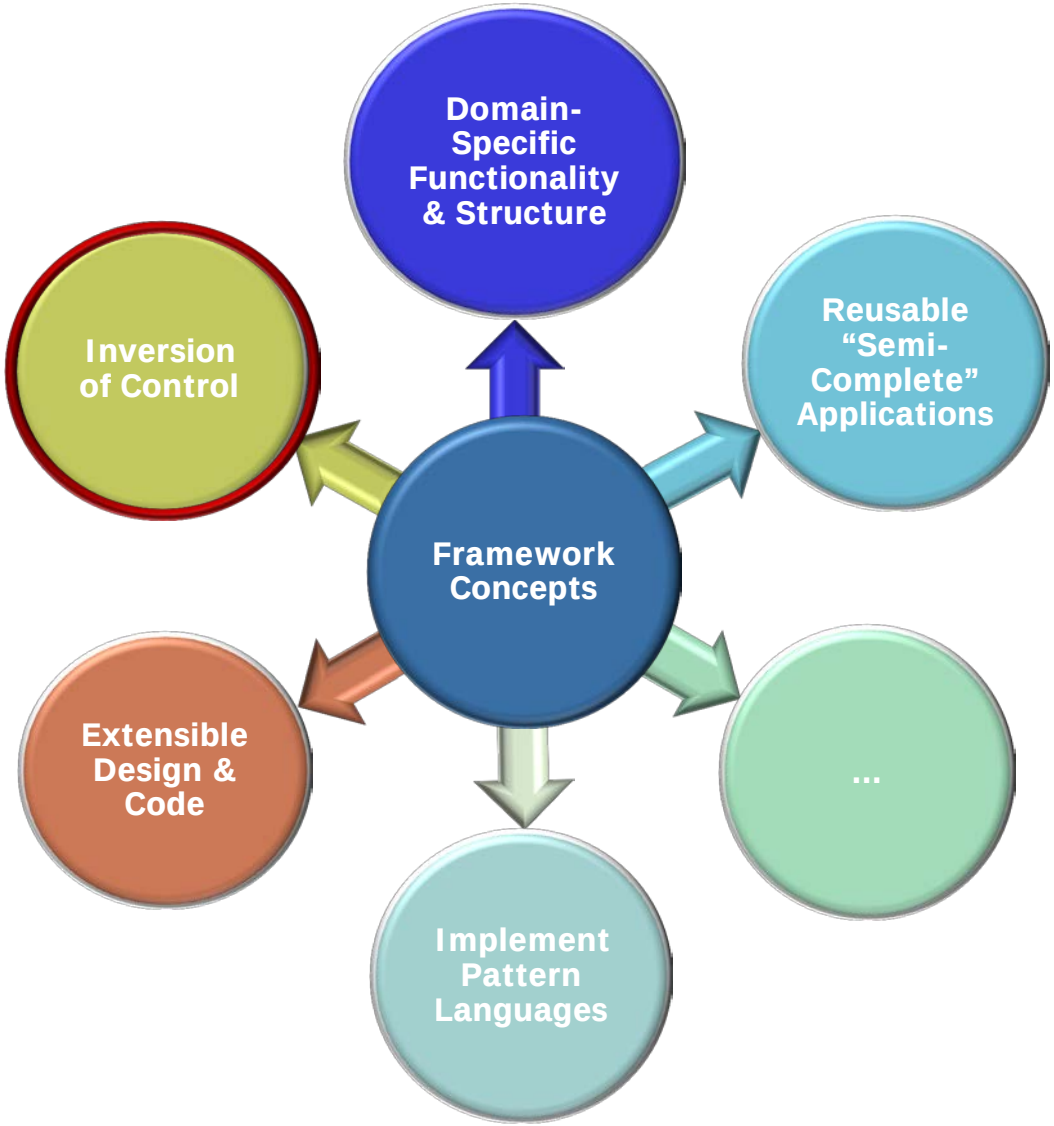
Module Introduction

- Summarize key framework concepts



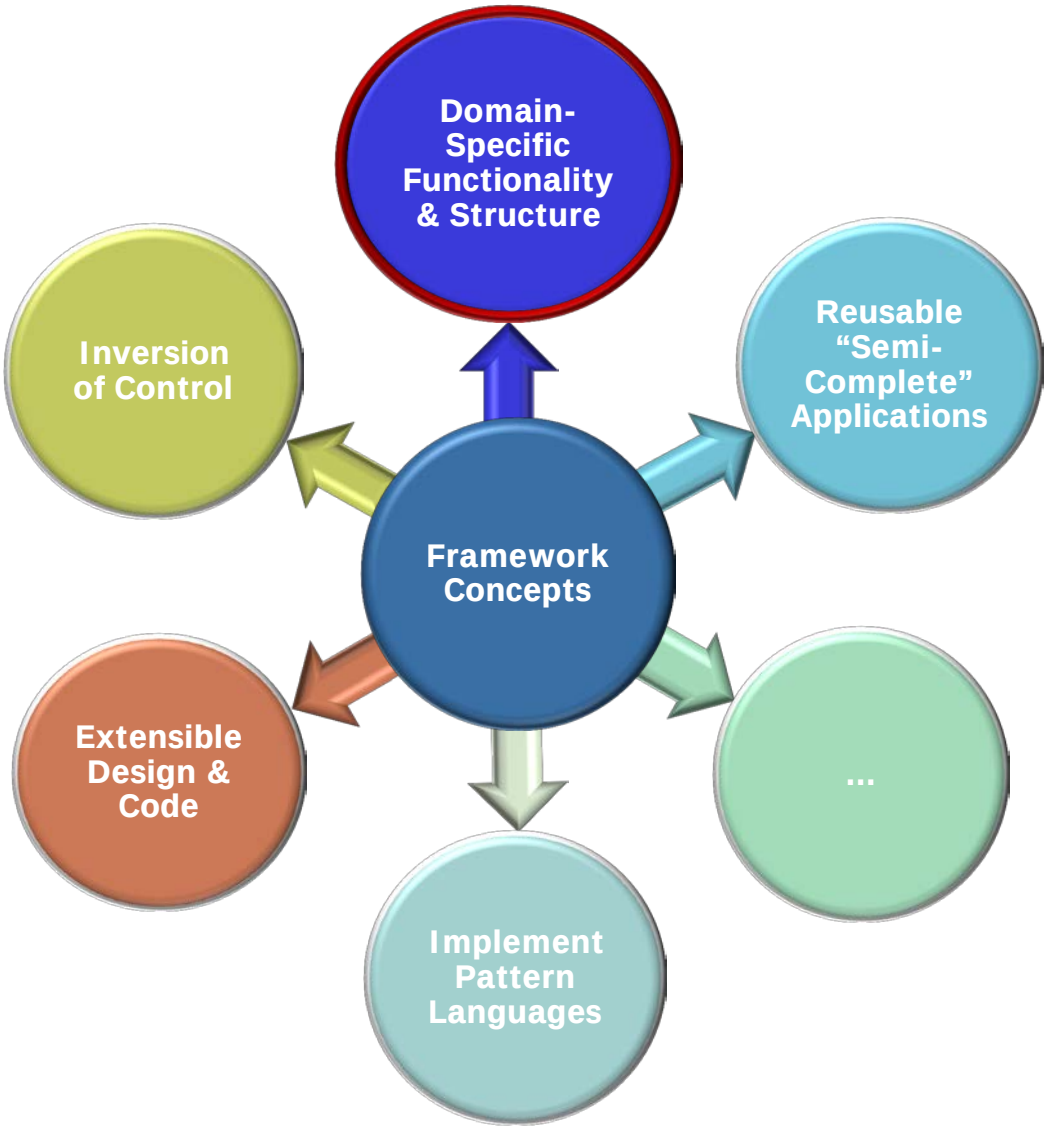
Module Introduction

- Summarize key framework concepts



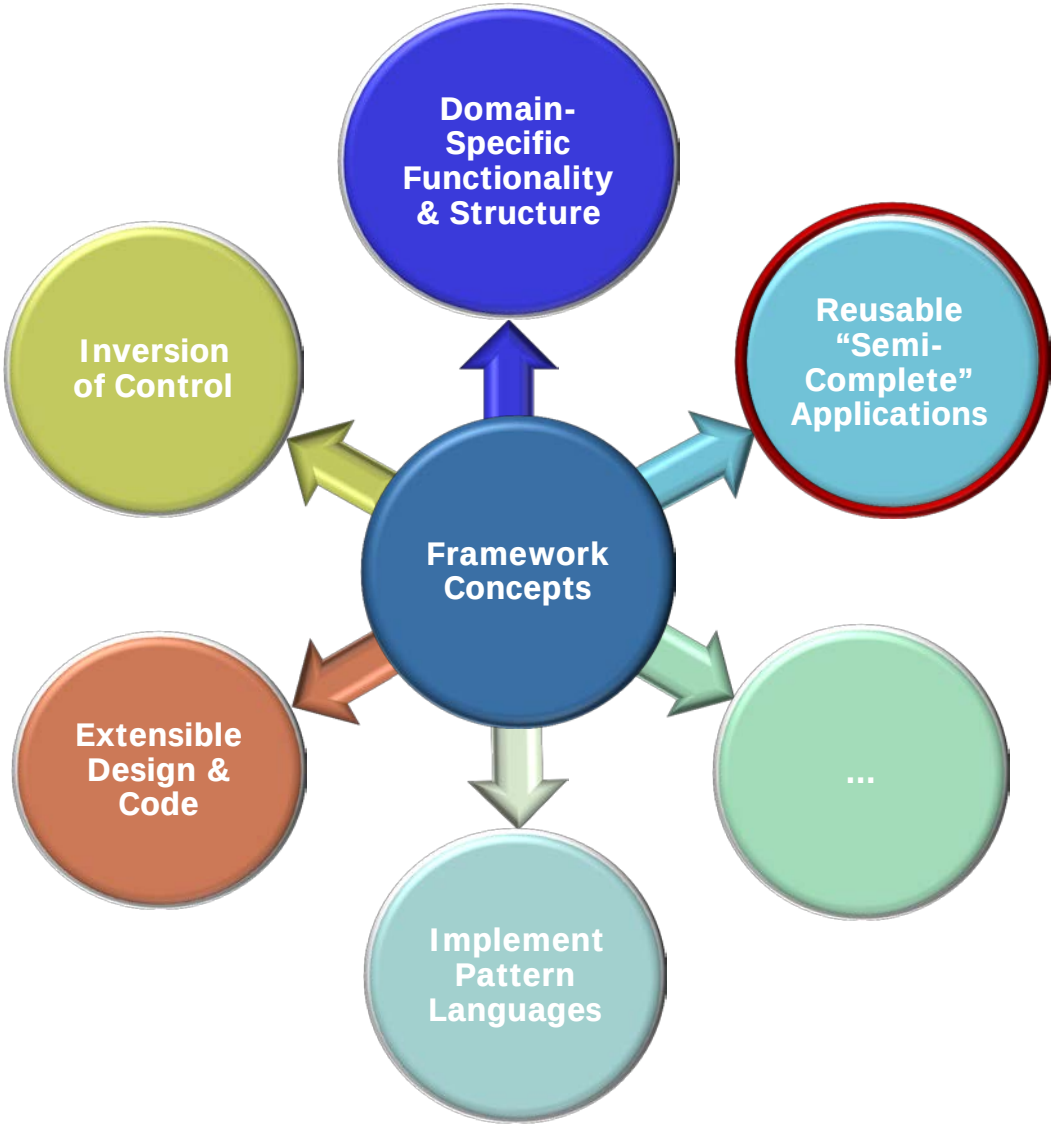
Module Introduction

- Summarize key framework concepts



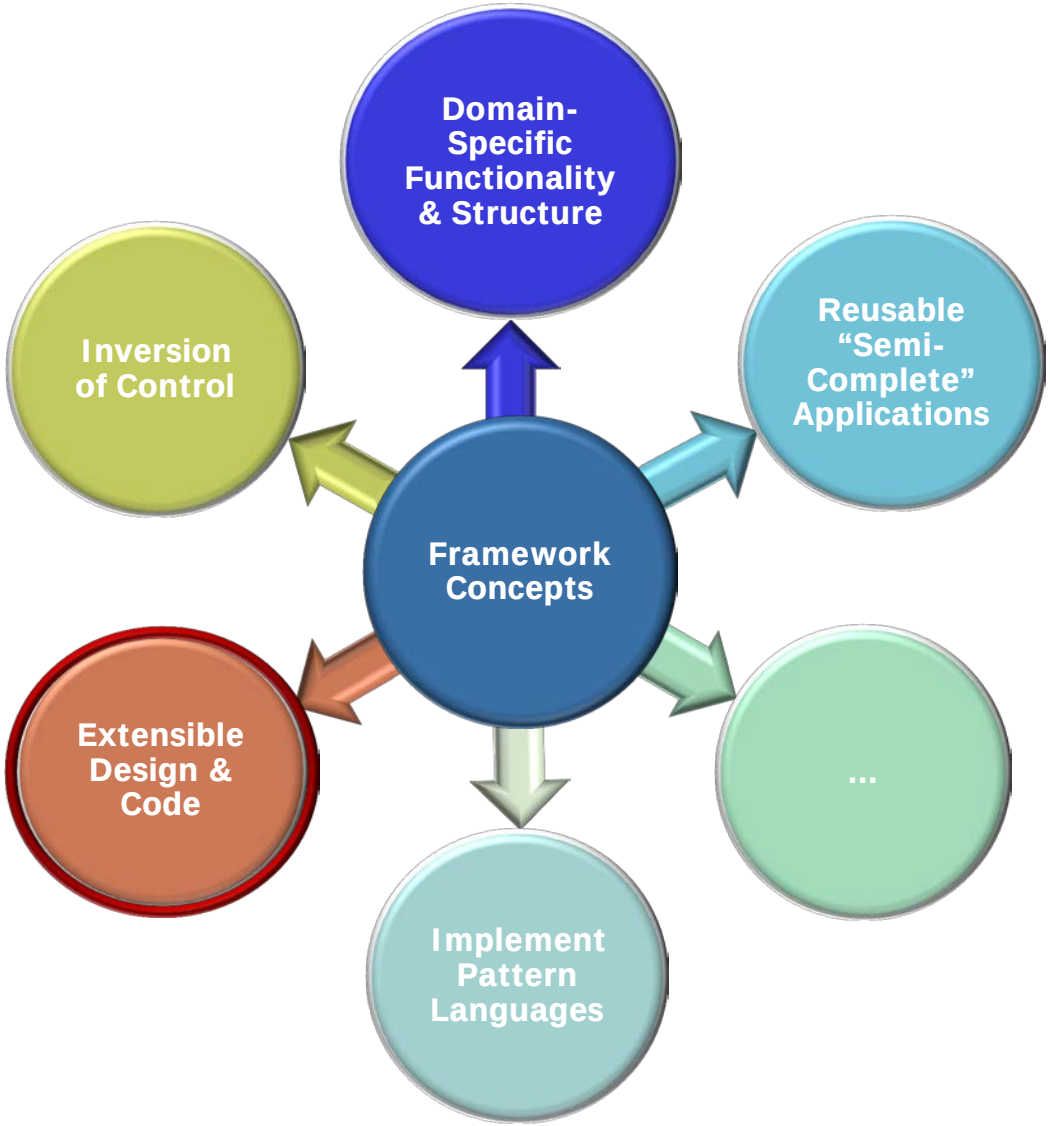
Module Introduction

- Summarize key framework concepts



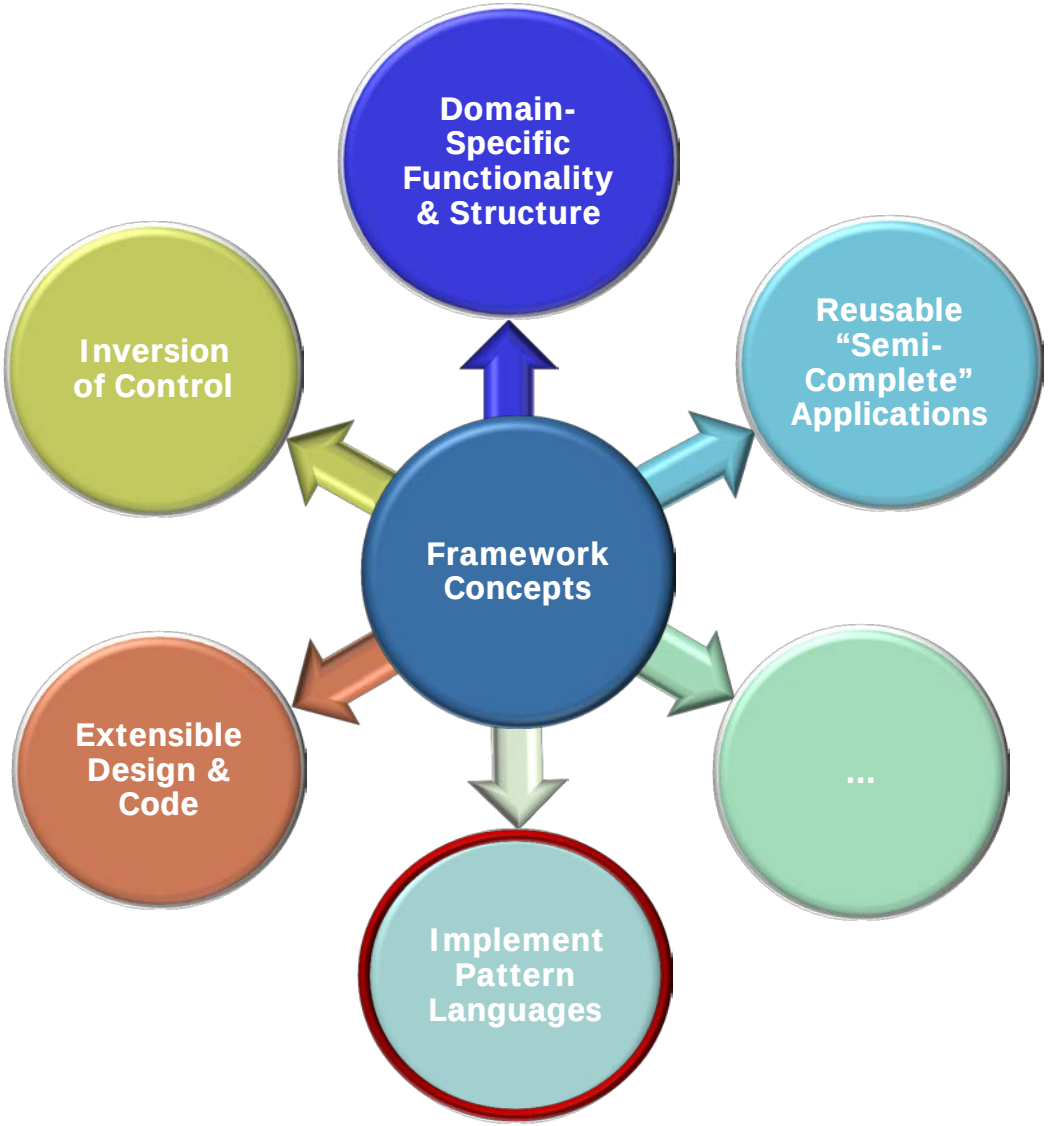
Module Introduction

- Summarize key framework concepts



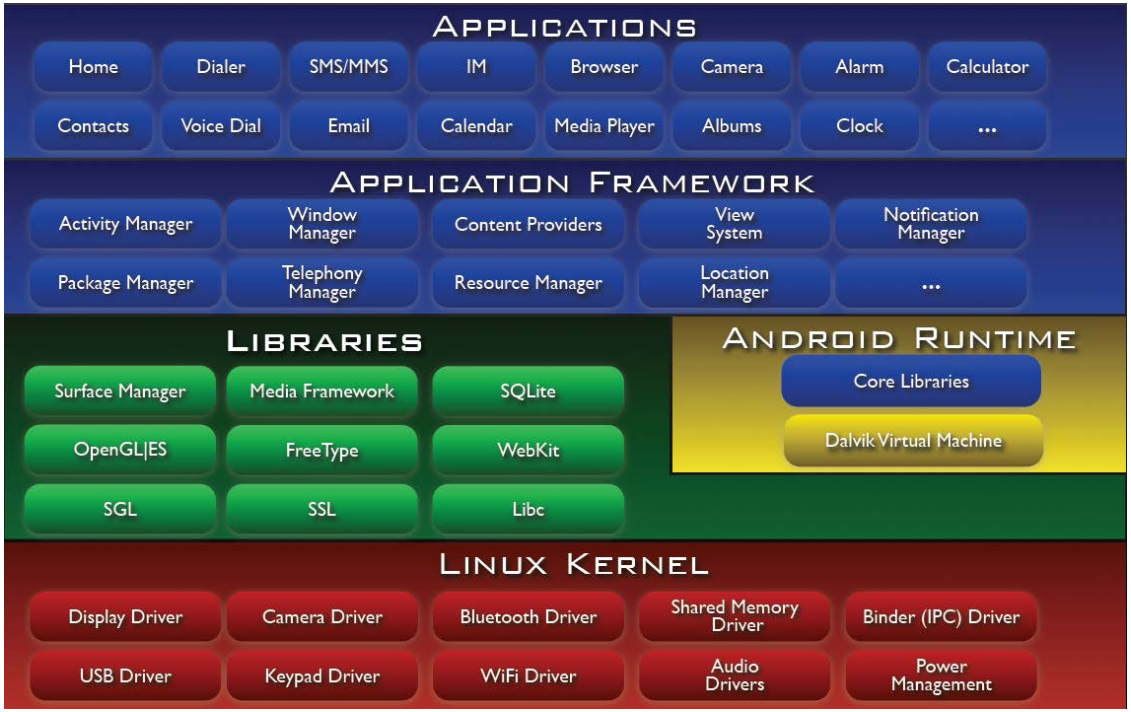
Module Introduction

- Summarize key framework concepts



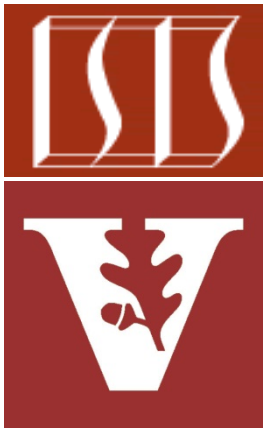
Module Introduction

- Summarize key framework concepts
- Give examples of frameworks related to Android
  - developer.android.com



Android frameworks are available in open-source form

Overview of Frameworks: Part 1



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

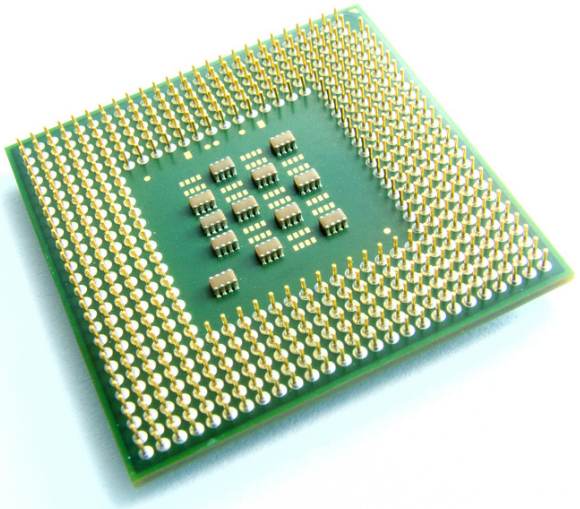
Institute for Software
Integrated Systems
Vanderbilt University
Nashville, Tennessee, USA

CS 282 Principles of Operating Systems II

Systems Programming for Android

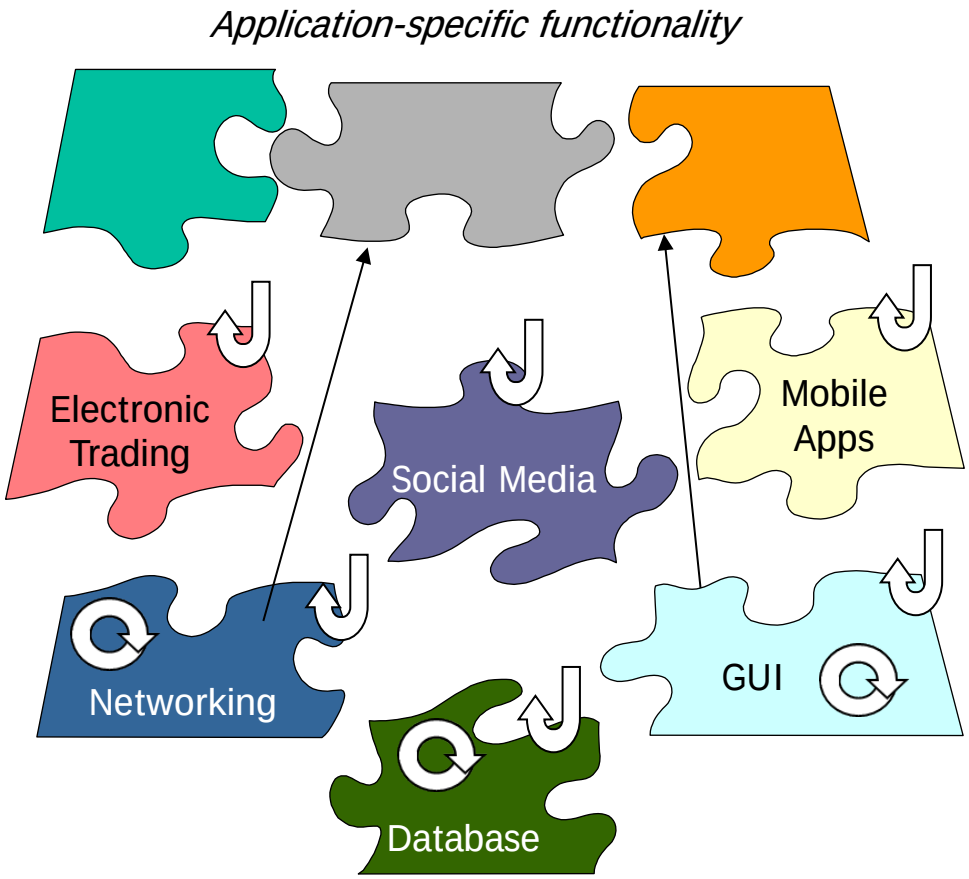
Learning Objectives of this Module

- Understand why hardware has historically improved more consistently than software



Learning Objectives of this Module

- Understand why hardware has historically improved more consistently than software
- Recognize key characteristics of frameworks that help improve software productivity & quality

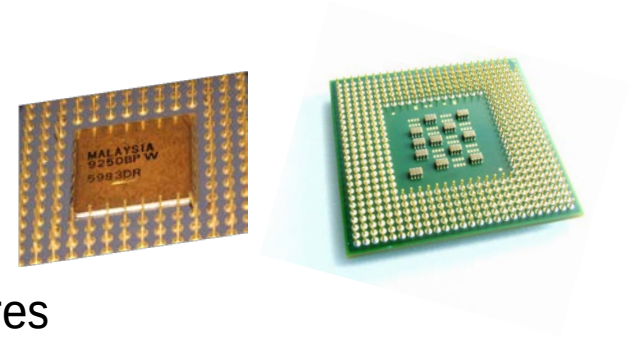


We'll give pithy examples of frameworks from Android to reify key concepts

Hardware == Better, Faster, Cheaper

- Processor & network performance has increased by many orders of magnitude in past decades

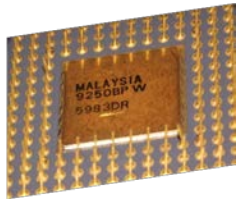
Single-core 10 Megahertz to 3+ Gigahertz multi-cores

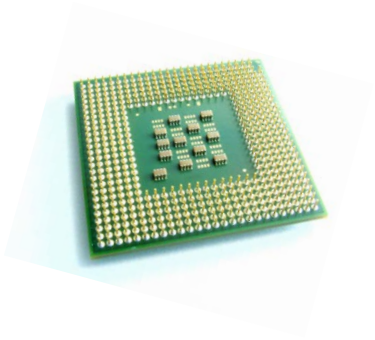


1,200 bits/sec to 10+ Gigabits/sec

Hardware == Better, Faster, Cheaper

- Processor & network performance has increased by many orders of magnitude in past decades

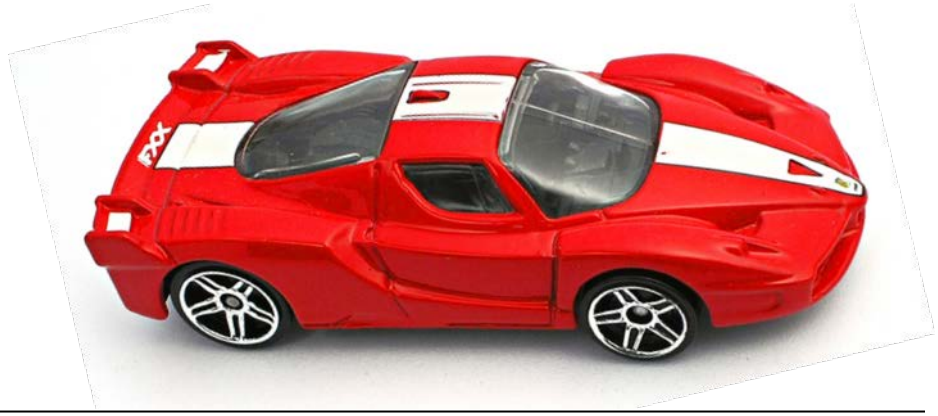




Single-core 10 Megahertz to 3+ Gigahertz multi-cores

1,200 bits/sec to 10+ Gigabits/sec

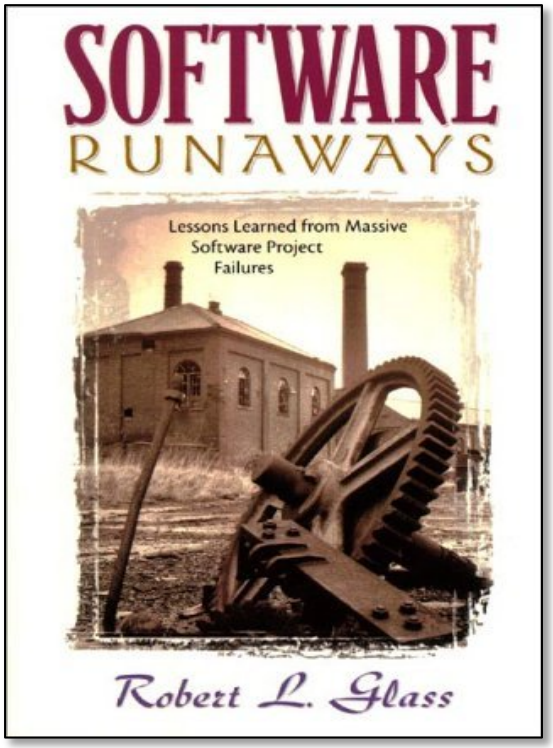
- Extrapolating these trends another decade or so yields high-performance commoditized hardware infrastructure
  - Processors with 100's→1,000's of cores
  - ~100 Gigabits/sec LANs
  - ~100 Megabits/sec wireless
  - ~10 Terabits/sec Internet backbone

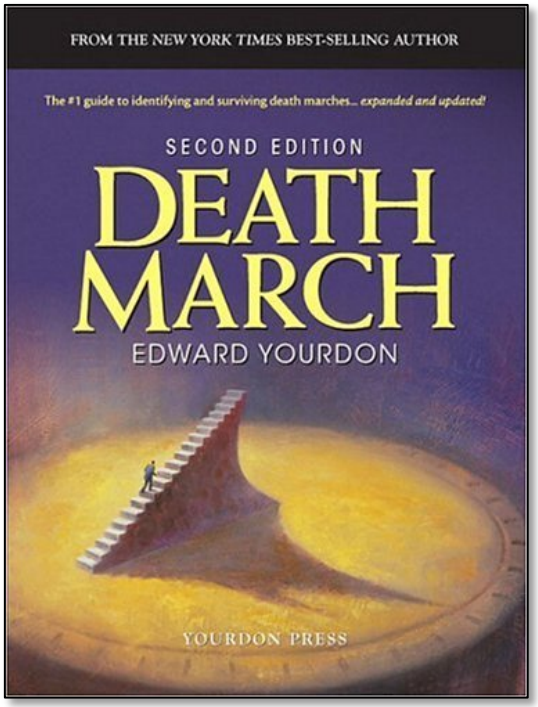


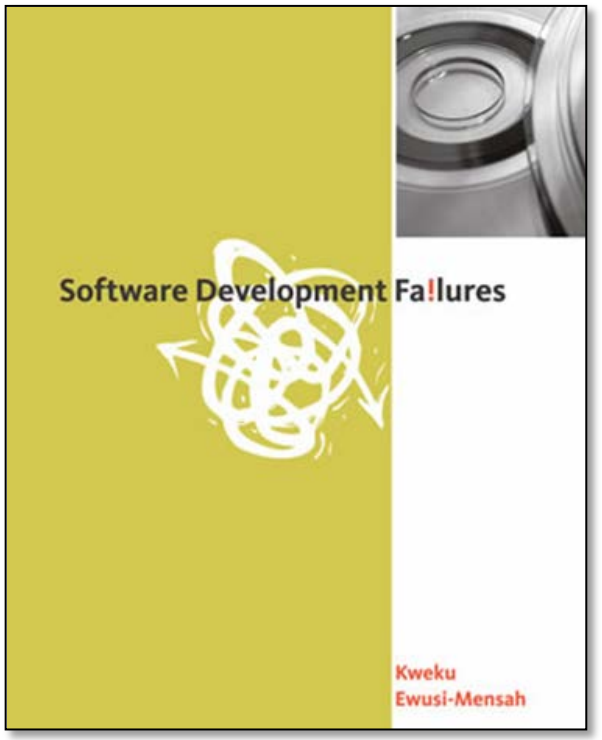
www.dre.vanderbilt.edu/~schmidt/dedicate.html has more on commoditization

Software == Buggier, Slower, & More Expensive?

- Unfortunately, software quality & productivity hasn't improved as rapidly or predictably as hardware







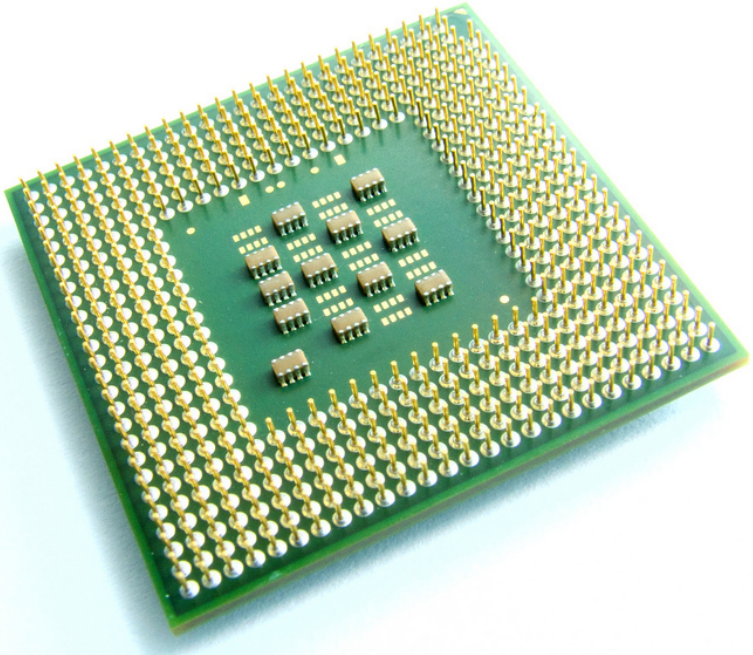
Software == Buggier, Slower, & More Expensive?

- Unfortunately, software quality & productivity hasn't improved as rapidly or predictably as hardware
- This is particularly problematic for mission-critical concurrent & networked software-reliant systems

See www.dre.vanderbilt.edu/~schmidt/comm-lessons.html for more info

Why Hardware Improves Consistently

Advances in hardware & networks stem largely from maturation of *standardized* & *reusable* interfaces, protocols, & modeling tools



x86 chipsets

TCP/IP switches

Why Software Fails to Improve as Consistently

In general, software has not been as standardized or reusable as hardware

Historically software developers have manually rediscovered & reinvented "point solutions" that are expensive to develop, integrate, validate, & sustain

Why Software Fails to Improve as Consistently

In general, software has not been as standardized or reusable as hardware




Customized Form Factors




Proprietary & Stovepiped Application & Infrastructure Software

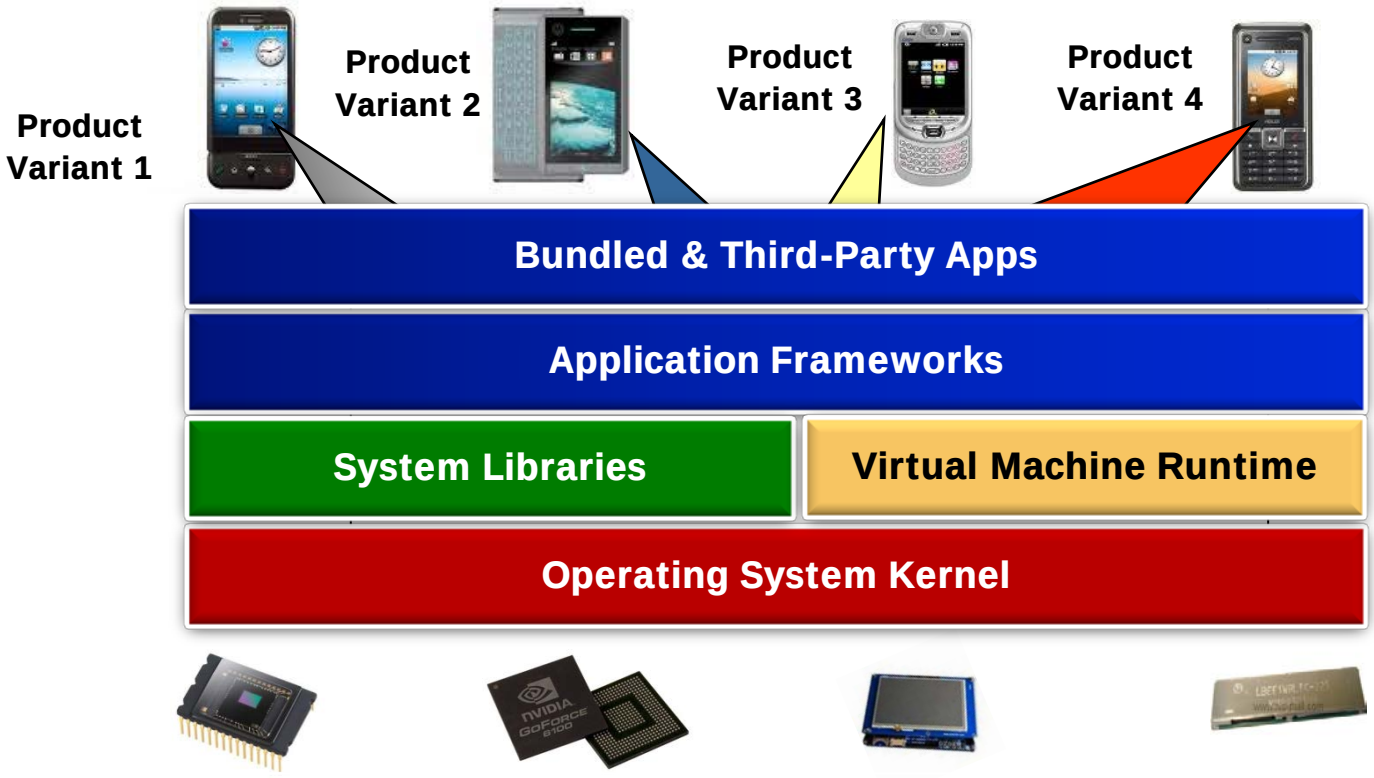


Standard/COTS Hardware & Networks

Consequence: Small changes in software/hardware have a big (negative) impact on system quality & sustainability

A Solution: Software Frameworks

A framework is an integrated set of software components that collaborate to provide a reusable architecture for a family of related applications

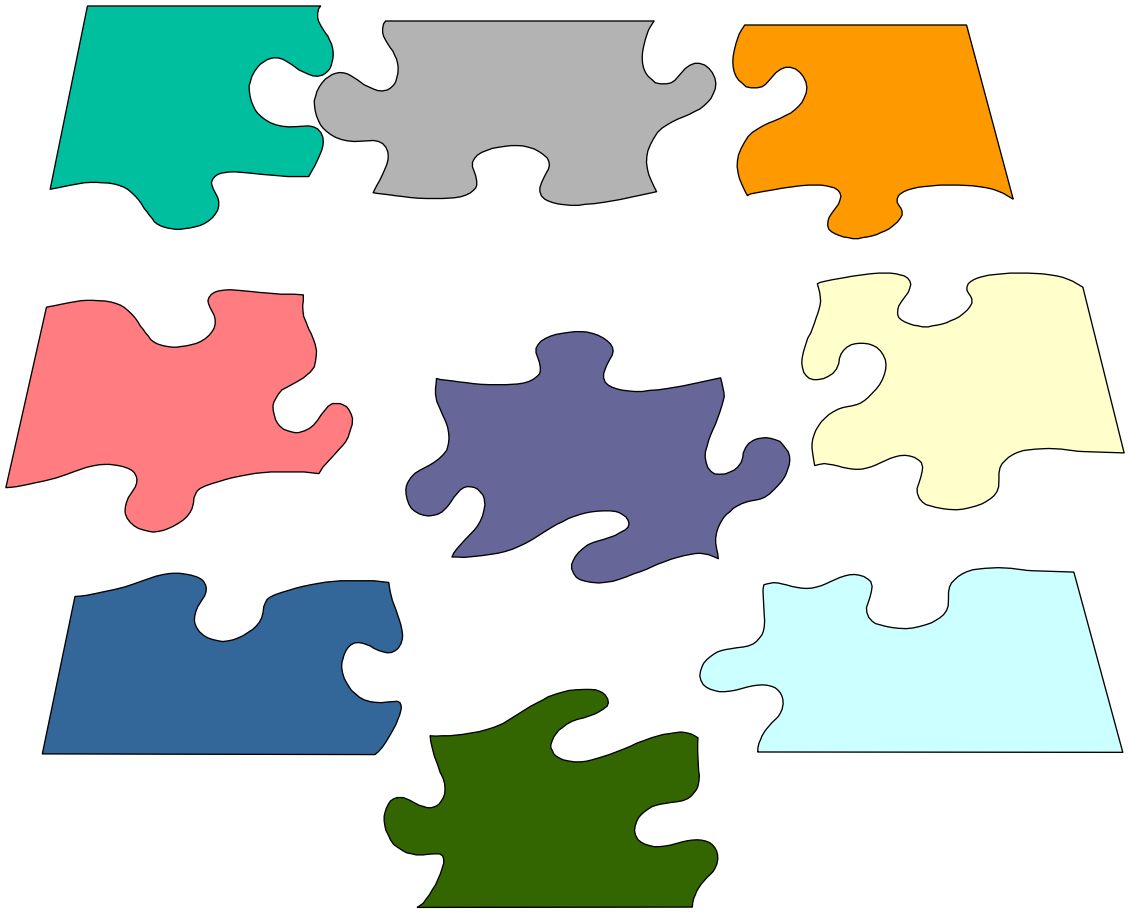


- Frameworks promote "systematic reuse" by factoring out many general-purpose & domain-specific services from traditional application responsibility

www.dre.vanderbilt.edu/~schmidt/reuse-lessons.html has info on systematic reuse

Key Characteristics of Frameworks

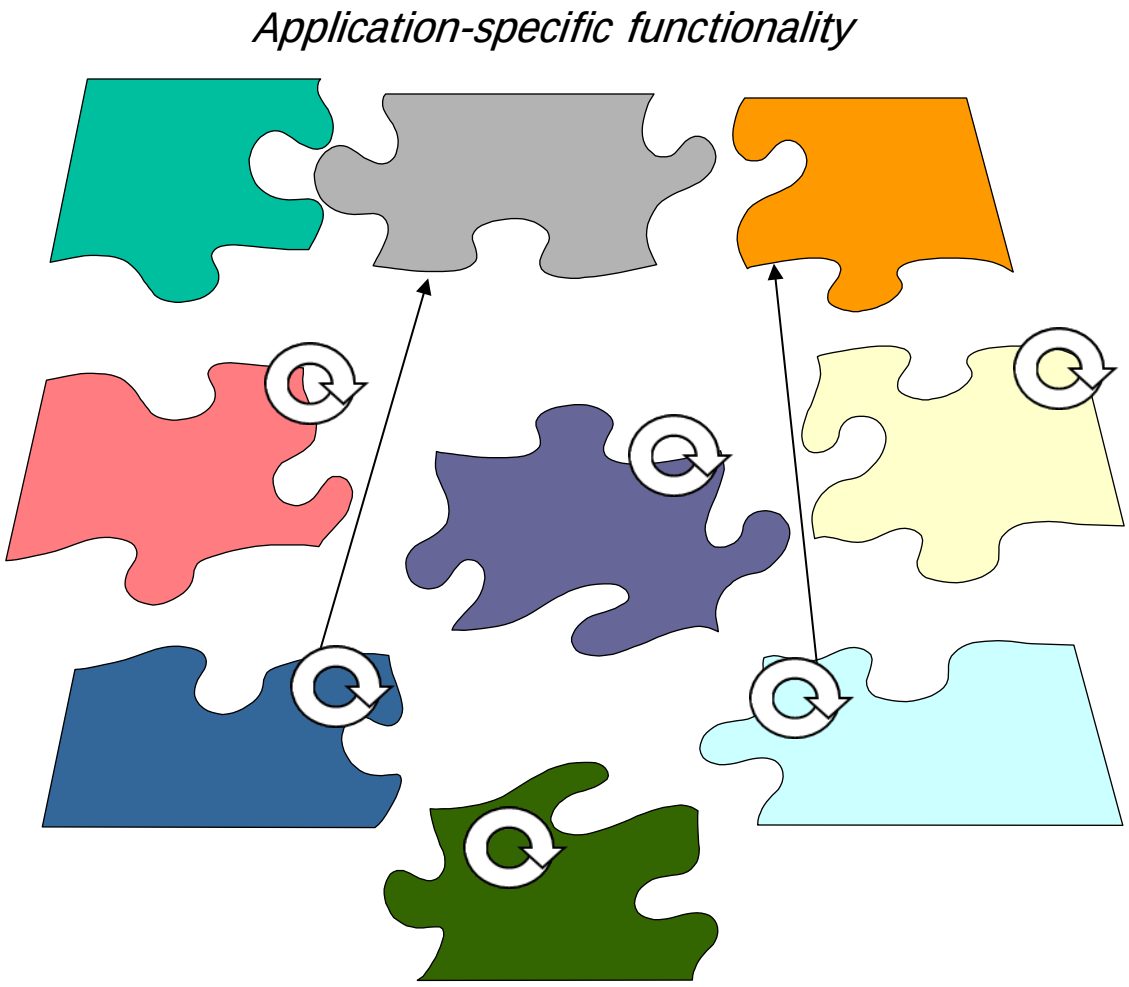
Software frameworks exhibit several key characteristics that differentiate them from other forms of systematic reuse



www.dre.vanderbilt.edu/~schmidt/CACM-frameworks.html has more info

Key Characteristics of Frameworks

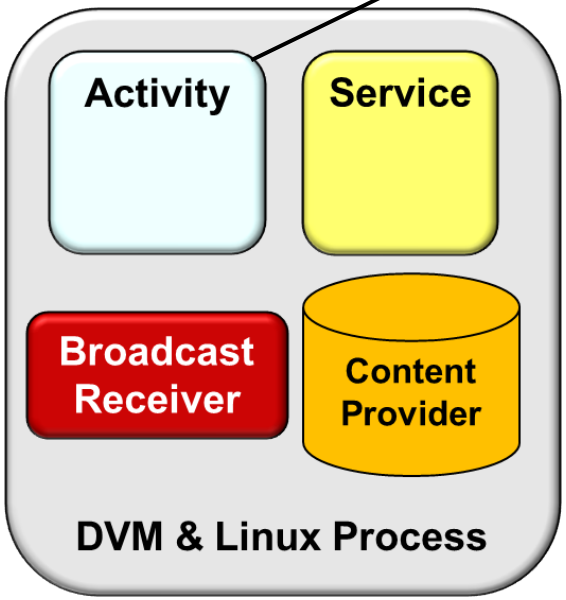
- They exhibit “inversion of control” via callbacks
  - AKA, “Hollywood Principle”

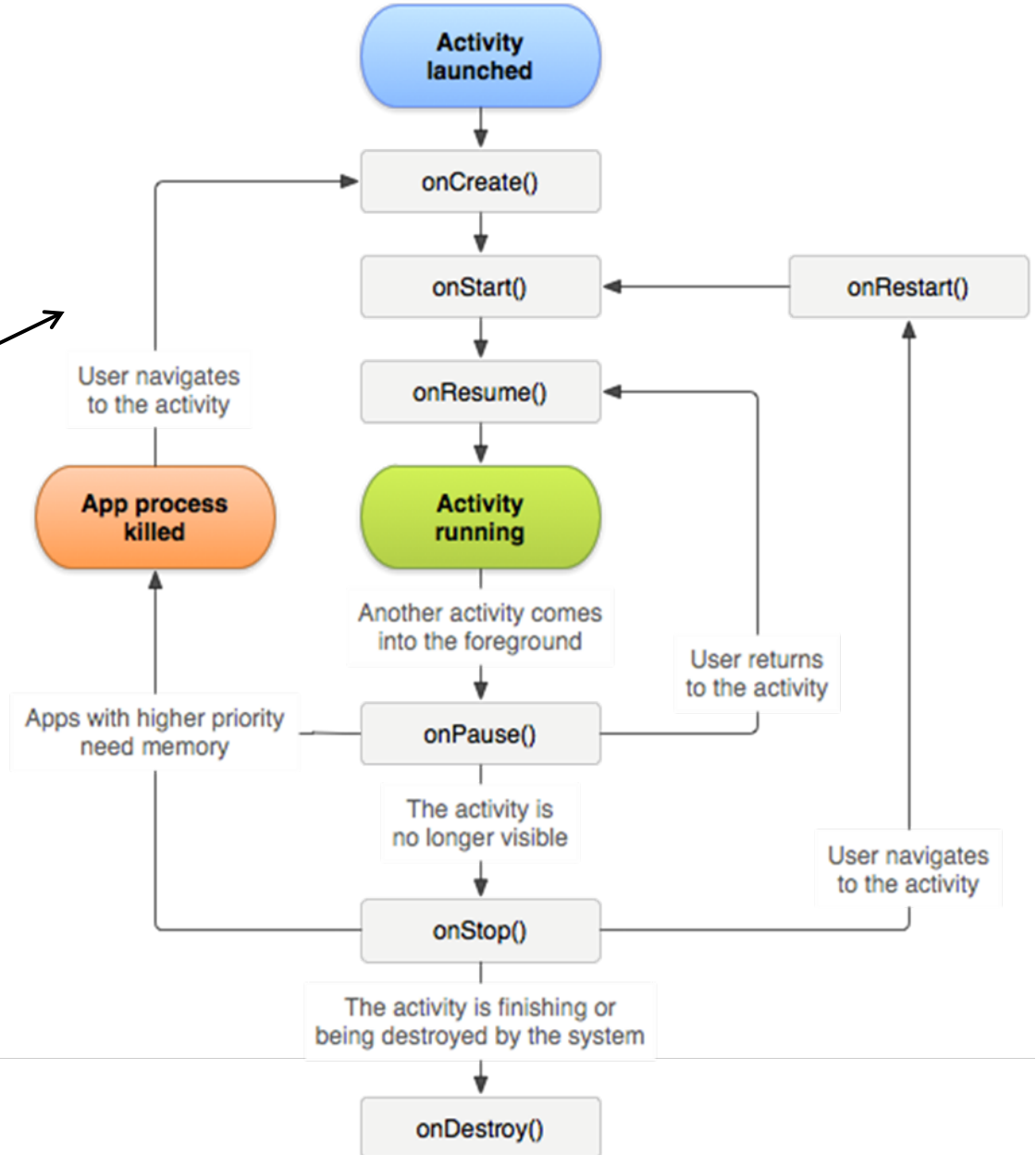


See www.dre.vanderbilt.edu/~schmidt/Coursera/articles/hollywood-principle.txt

Key Characteristics of Frameworks

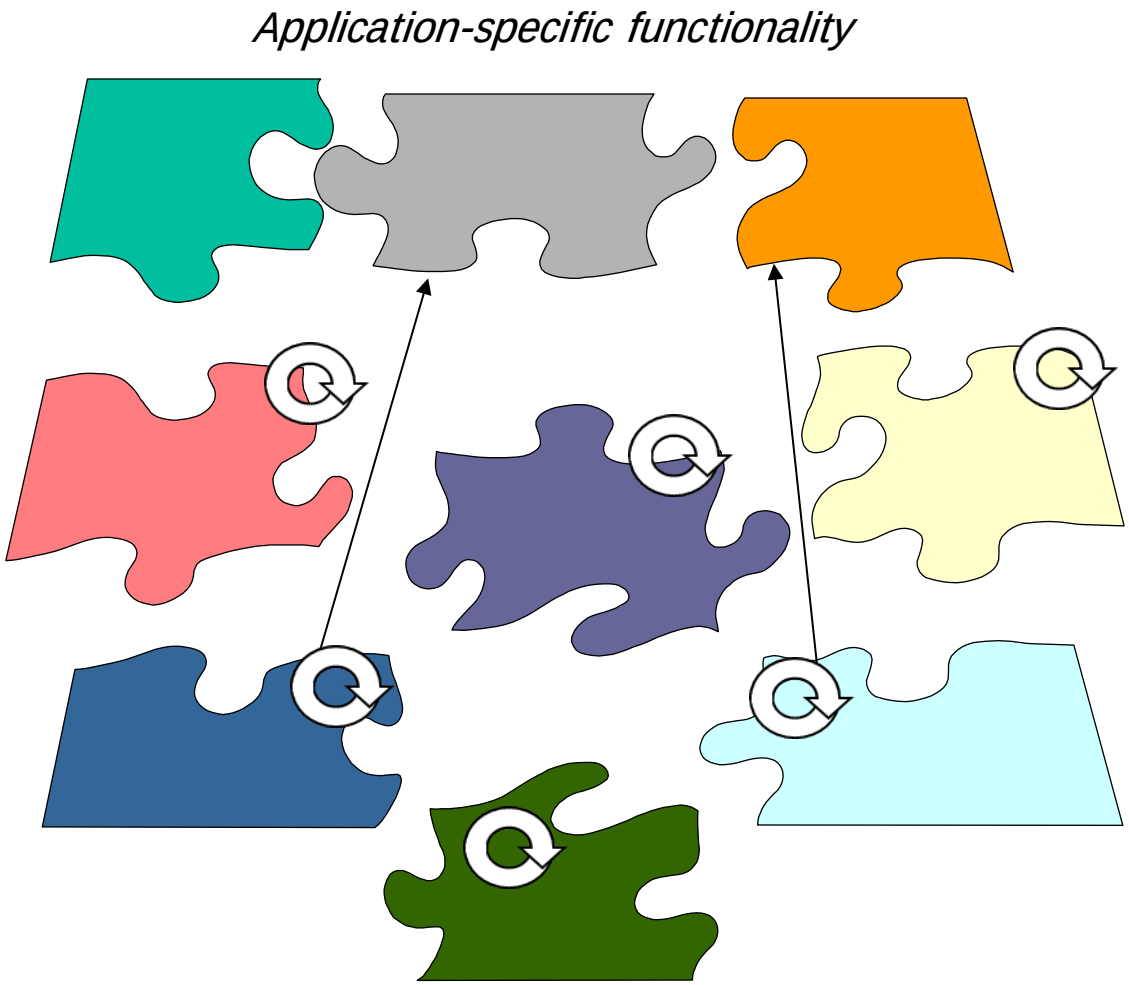
- They exhibit "inversion of control" via callbacks
  - AKA, "Hollywood Principle"





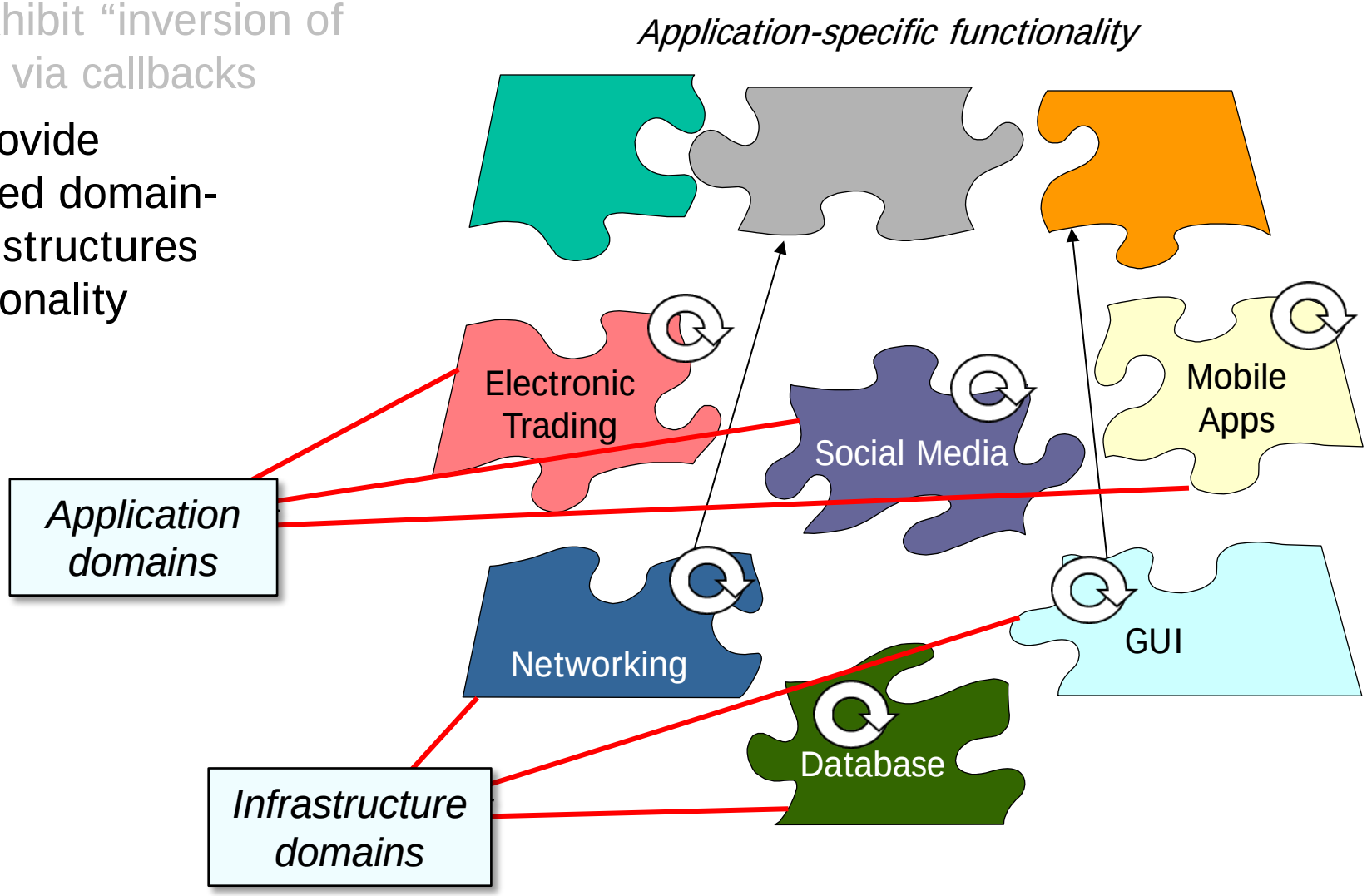
Key Characteristics of Frameworks

- They exhibit "inversion of control" via callbacks
- They provide integrated domain-specific structures & functionality



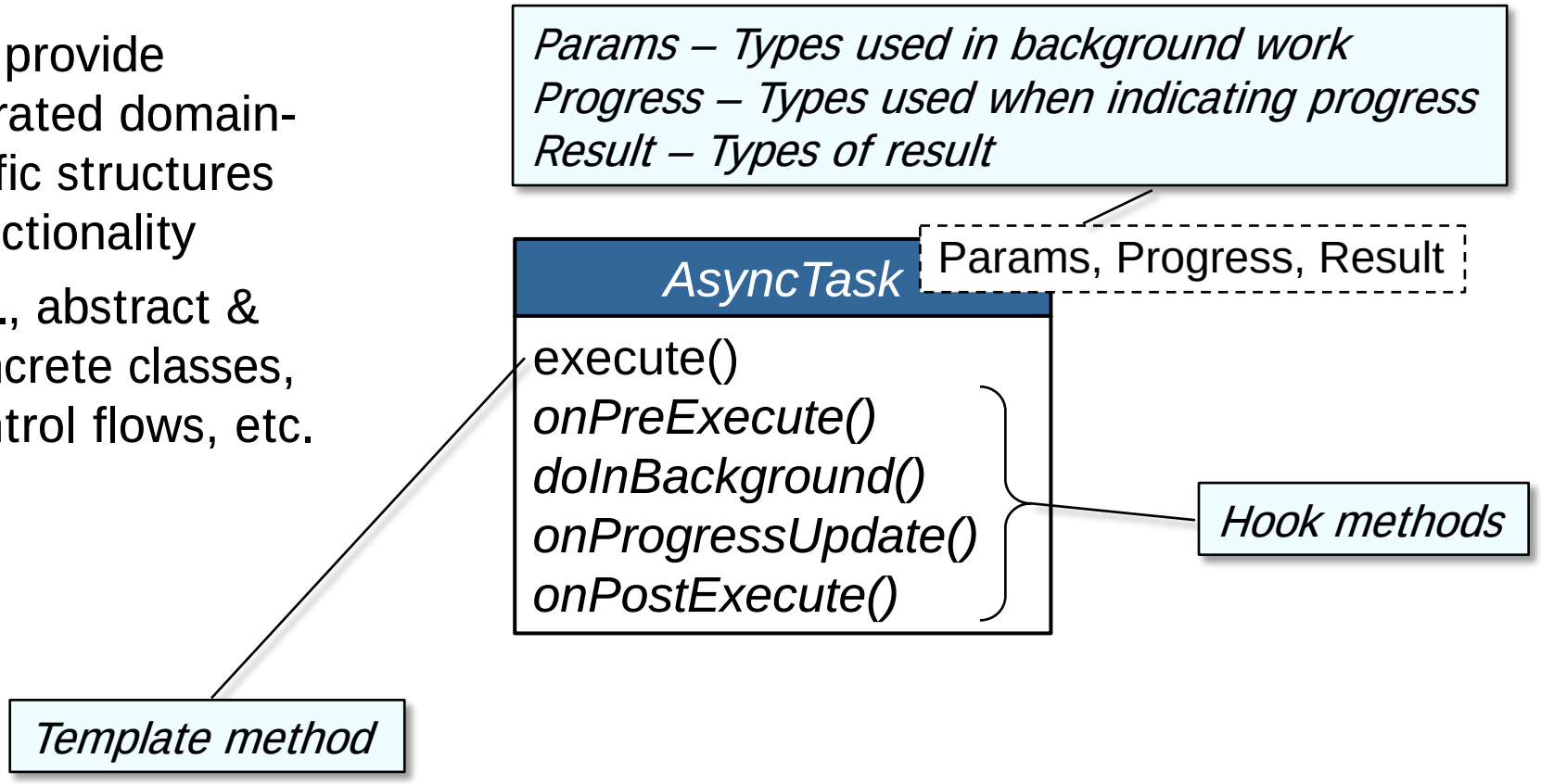
Key Characteristics of Frameworks

- They exhibit "inversion of control" via callbacks
- They provide integrated domain-specific structures & functionality



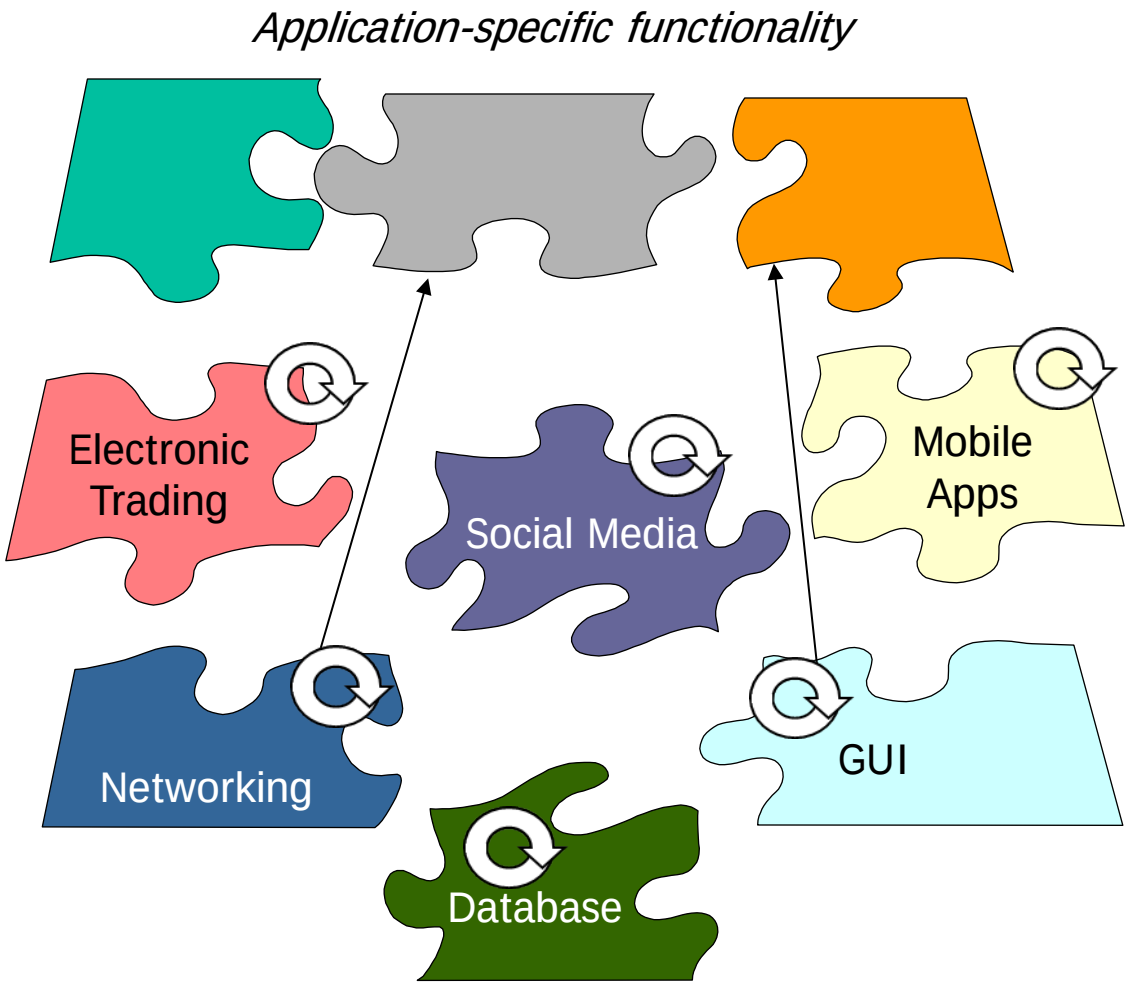
Key Characteristics of Frameworks

- They exhibit "inversion of control" via callbacks
- They provide integrated domain-specific structures & functionality
  - e.g., abstract & concrete classes, control flows, etc.



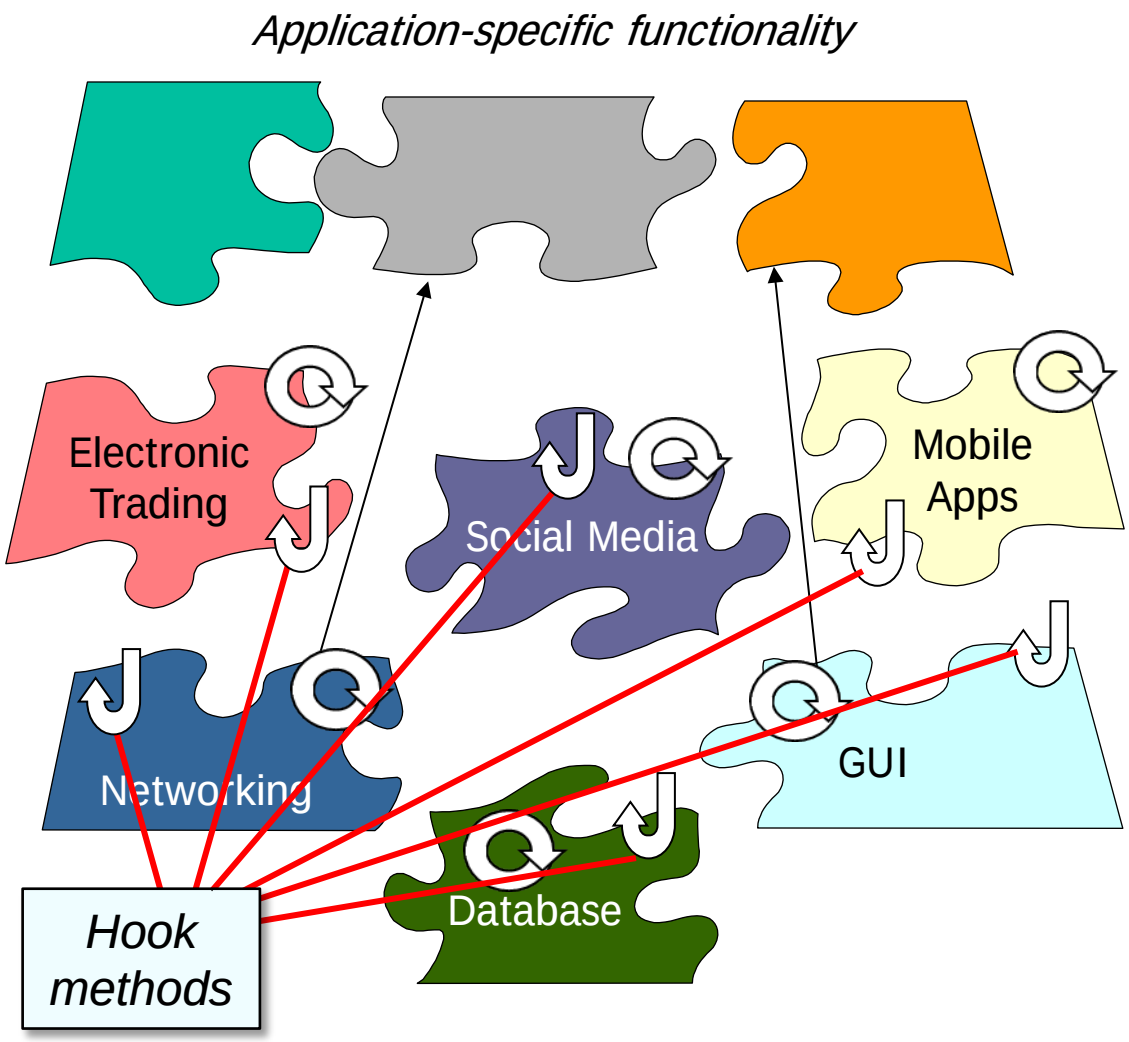
Key Characteristics of Frameworks

- They exhibit "inversion of control" via callbacks
- They provide integrated domain-specific structures & functionality
  - e.g., abstract & concrete classes, control flows, etc.
- They are "semi-complete" applications



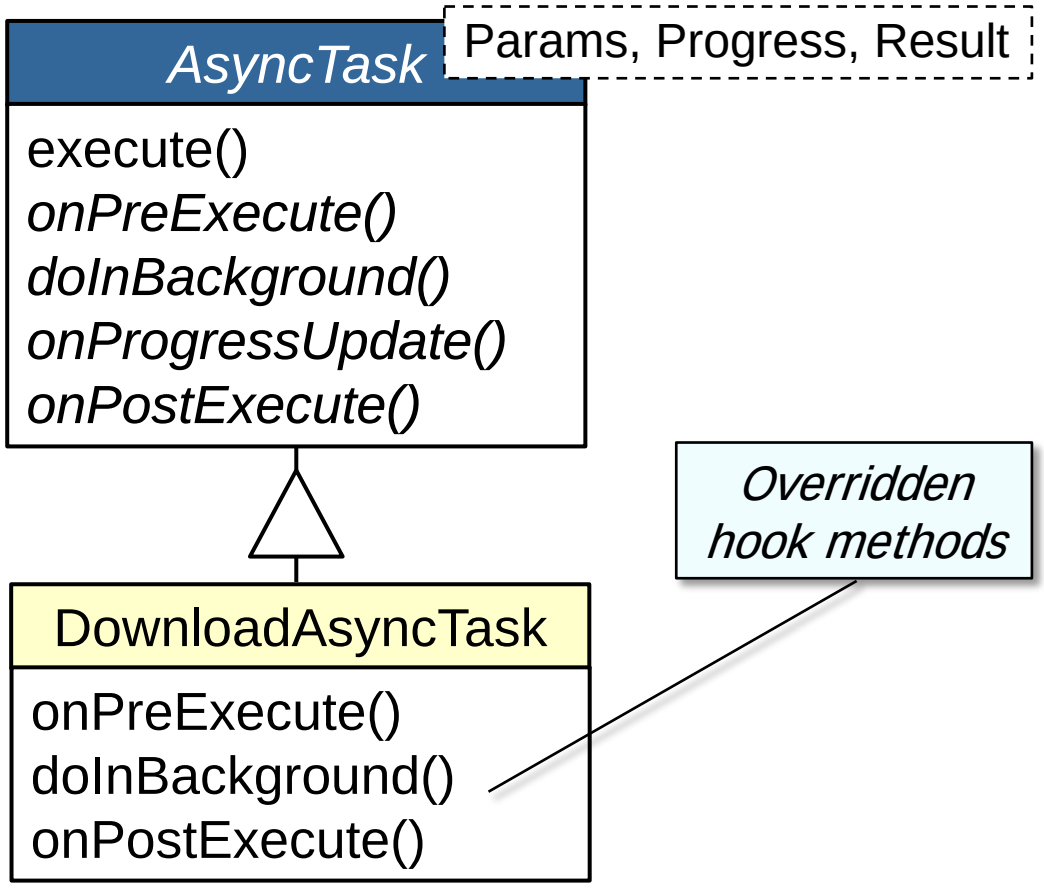
Key Characteristics of Frameworks

- They exhibit "inversion of control" via callbacks
- They provide integrated domain-specific structures & functionality
  - e.g., abstract & concrete classes, control flows, etc.
- They are "semi-complete" applications



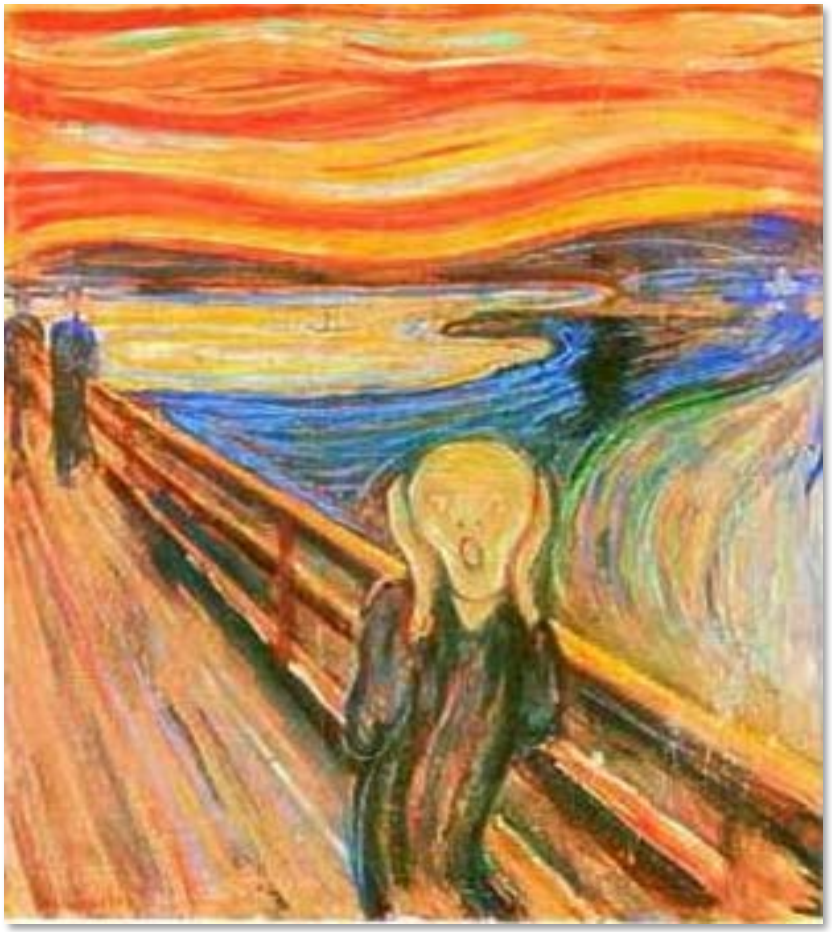
Key Characteristics of Frameworks

- They exhibit "inversion of control" via callbacks
- They provide integrated domain-specific structures & functionality
  - e.g., abstract & concrete classes, control flows, etc.
- They are "semi-complete" applications
  - Completing a framework involves instantiating objects & subclassing & overriding "hook methods"



Summary

- The quality of software (& the productivity of software developers) has historically lagged hardware (& hardware developers)



Inherent & Accidental Complexities

Summary

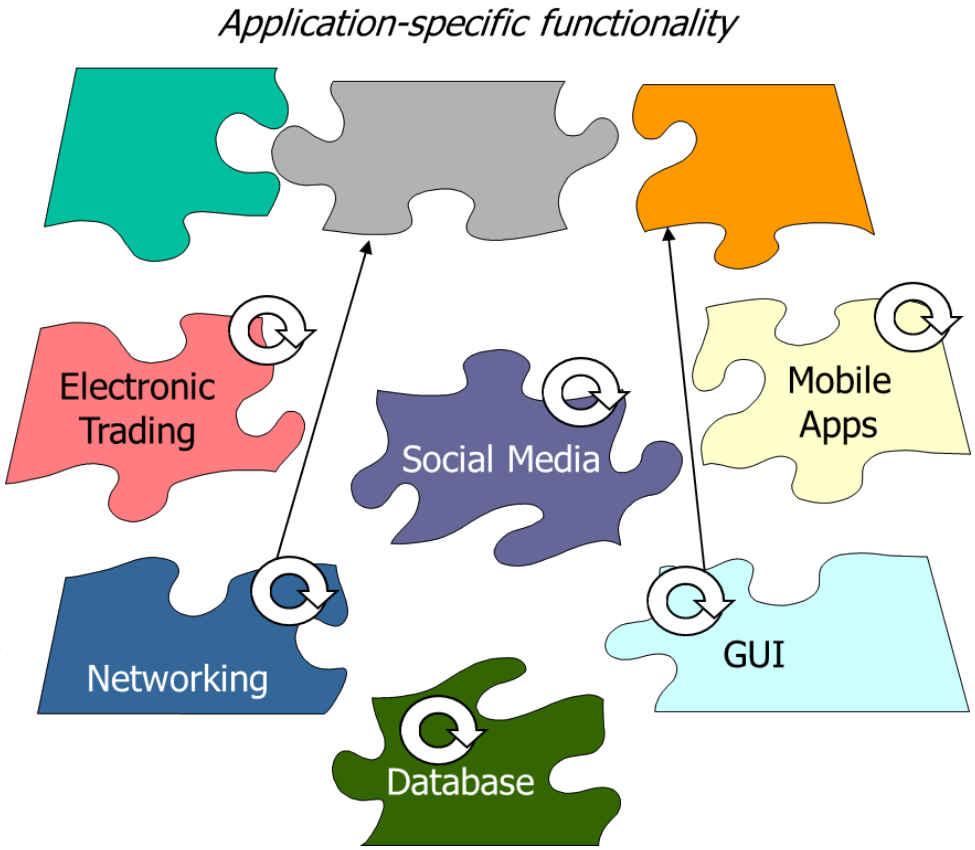
- The quality of software (& the productivity of software developers) has historically lagged hardware (& hardware developers)
  - Particularly for mission-critical concurrent & networked software

Summary

- The quality of software (& the productivity of software developers) has historically lagged hardware (& hardware developers)
  - Particularly for mission-critical concurrent & networked software
- Much cost, effort, & defects stem from continuous rediscovery & reinvention of core concepts & components across software industry

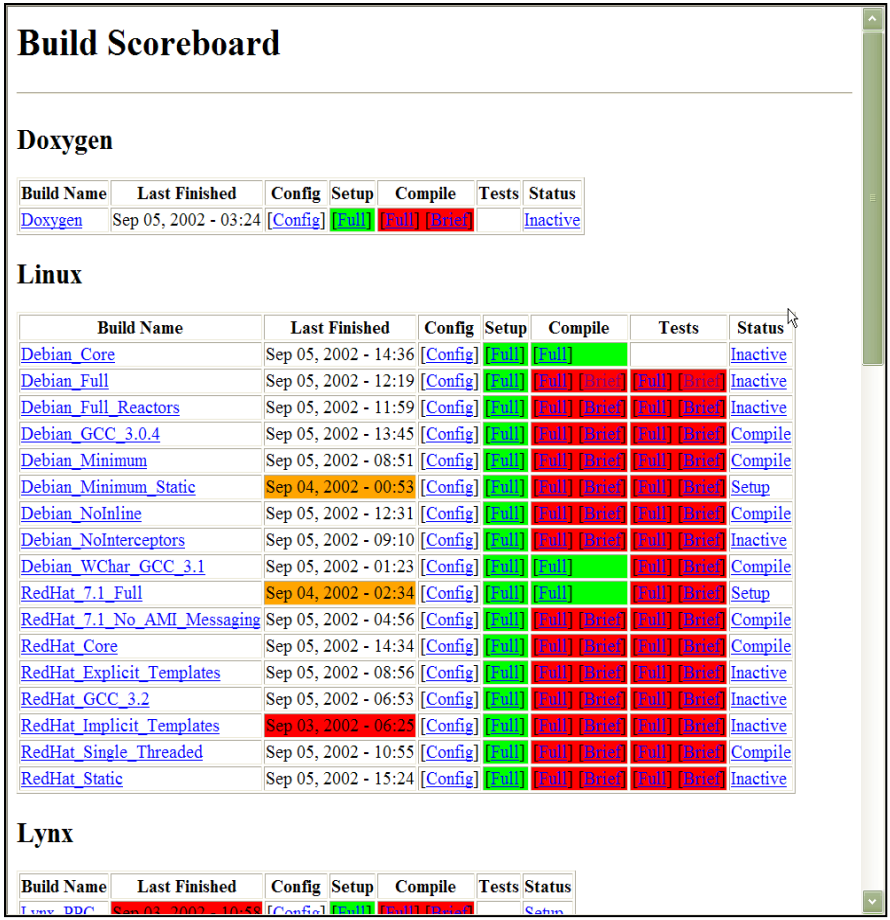
Summary

- The quality of software (& the productivity of software developers) has historically lagged hardware (& hardware developers)
  - Particularly for mission-critical concurrent & networked software
- Much cost, effort, & defects stem from continuous rediscovery & reinvention of core concepts & components across software industry
- Frameworks improve productivity & quality of software development by
  - Reifying proven software designs & implementations in selected domains



Summary

- The quality of software (& the productivity of software developers) has historically lagged hardware (& hardware developers)
  - Particularly for mission-critical concurrent & networked software
- Much cost, effort, & defects stem from continuous rediscovery & reinvention of core concepts & components across software industry
- Frameworks improve productivity & quality of software development by
  - Reifying proven software designs & implementations in selected domains
  - Amortizing quality assurance efforts & artifacts



Build Scoreboard

Doxygen

Build Name	Last Finished	Config	Setup	Compile	Tests	Status
Doxygen	Sep 05, 2002 - 03:24	[Config]	[Full]	[Full] [Brief]		Inactive

Linux

Build Name	Last Finished	Config	Setup	Compile	Tests	Status
Debian_Core	Sep 05, 2002 - 14:36	[Config]	[Full]	[Full]		Inactive
Debian_Full	Sep 05, 2002 - 12:19	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Inactive
Debian_Full_Reactors	Sep 05, 2002 - 11:59	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Inactive
Debian_GCC_3.0.4	Sep 05, 2002 - 13:45	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Compile
Debian_Minimum	Sep 05, 2002 - 08:51	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Compile
Debian_Minimum_Static	Sep 04, 2002 - 00:53	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Setup
Debian_NoInline	Sep 05, 2002 - 12:31	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Compile
Debian_NoInterceptors	Sep 05, 2002 - 09:10	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Inactive
Debian_WChar_GCC_3.1	Sep 05, 2002 - 01:23	[Config]	[Full]	[Full]	[Full] [Brief]	Compile
RedHat_7.1_Full	Sep 04, 2002 - 02:34	[Config]	[Full]	[Full]	[Full] [Brief]	Setup
RedHat_7.1_No_AMI_Messaging	Sep 05, 2002 - 04:56	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Compile
RedHat_Core	Sep 05, 2002 - 14:34	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Compile
RedHat_Explicit_Templates	Sep 05, 2002 - 08:56	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Inactive
RedHat_GCC_3.2	Sep 05, 2002 - 06:53	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Inactive
RedHat_Implicit_Templates	Sep 03, 2002 - 06:25	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Inactive
RedHat_Single_Threaded	Sep 05, 2002 - 10:55	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Compile
RedHat_Static	Sep 05, 2002 - 15:24	[Config]	[Full]	[Full] [Brief]	[Full] [Brief]	Inactive

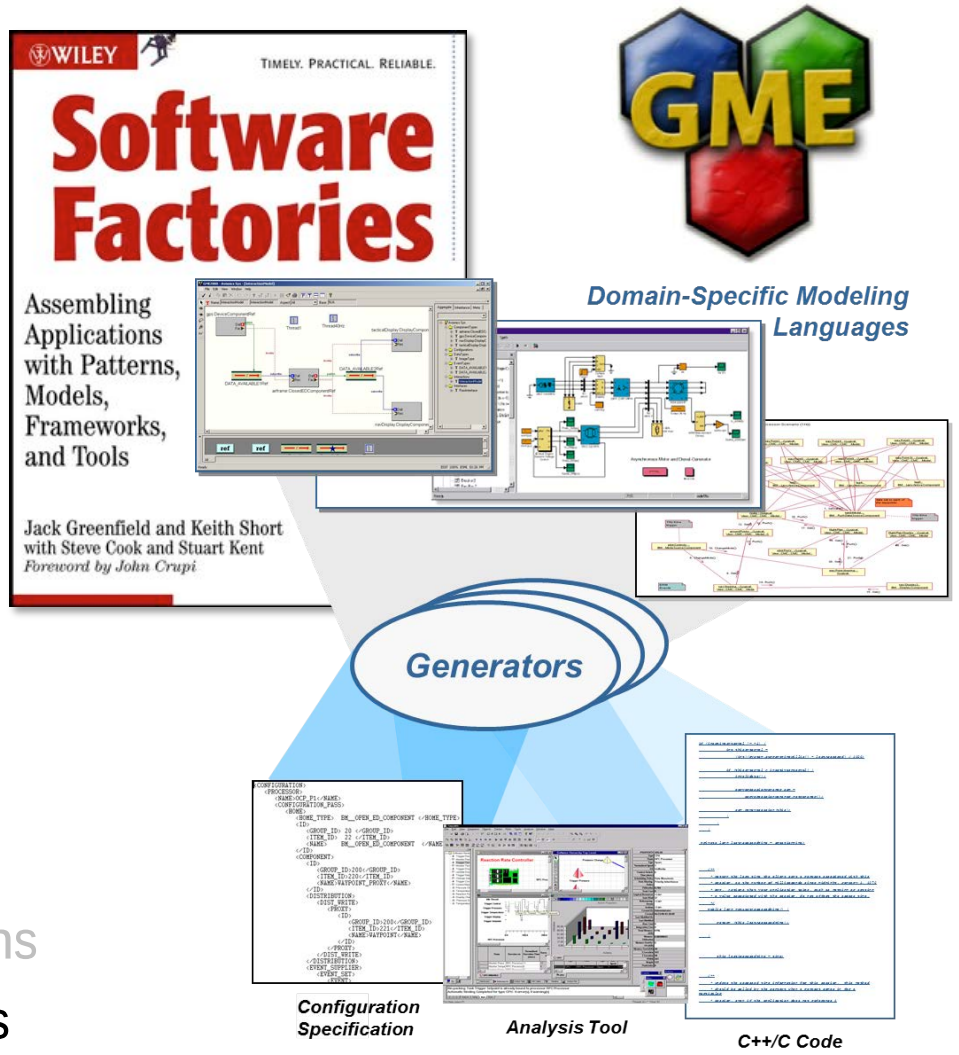
Lynx

Build Name	Last Finished	Config	Setup	Compile	Tests	Status

www.dre.vanderbilt.edu/scoreboard

Summary

- The quality of software (& the productivity of software developers) has historically lagged hardware (& hardware developers)
  - Particularly for mission-critical concurrent & networked software
- Much cost, effort, & defects stem from continuous rediscovery & reinvention of core concepts & components across software industry
- Frameworks improve productivity & quality of software development by
  - Reifying proven software designs & implementations in selected domains
  - Amortizing quality assurance efforts & artifacts

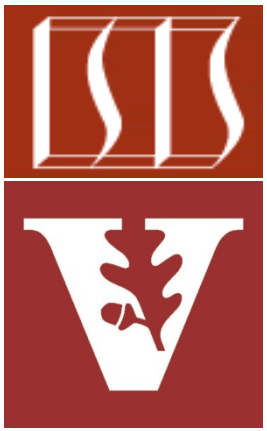


w3.isis.vanderbilt.edu/projects/gme

We have a long way to go to match hardware engineers use of modeling tools

Overview of Frameworks: Part 2

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



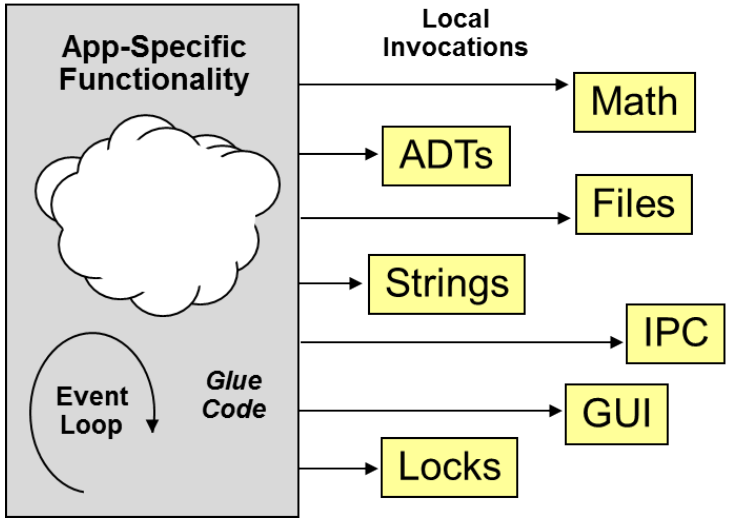
Professor of Computer Science

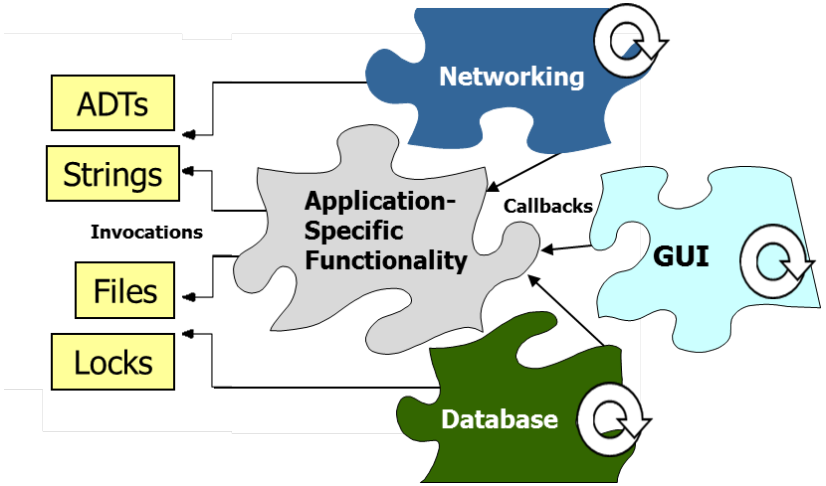
Institute for Software
Integrated Systems

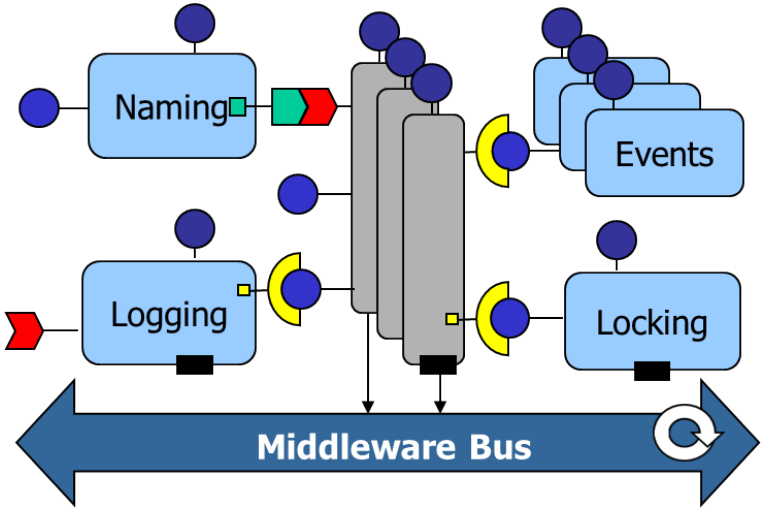
Vanderbilt University
Nashville, Tennessee, USA

Learning Objectives of this Module

- Understand how frameworks compare with other systematic reuse techniques

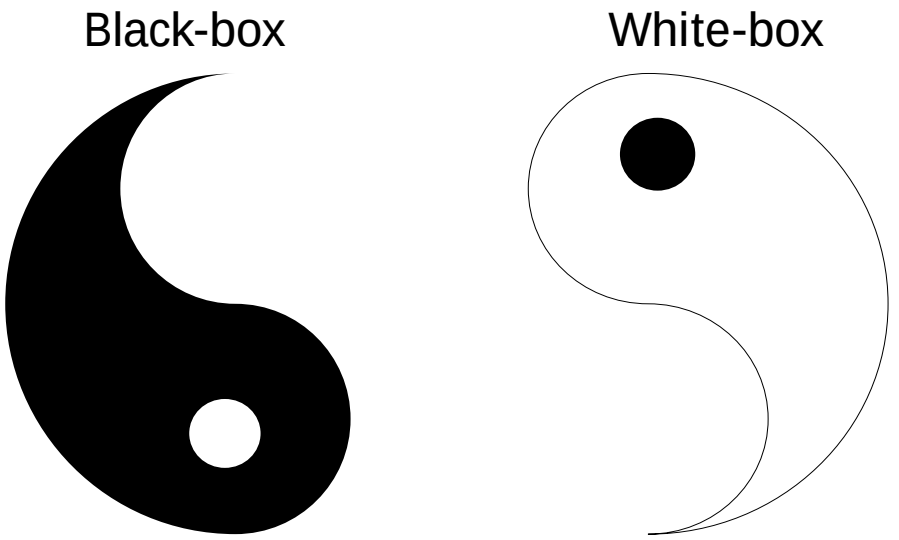






Learning Objectives of this Module

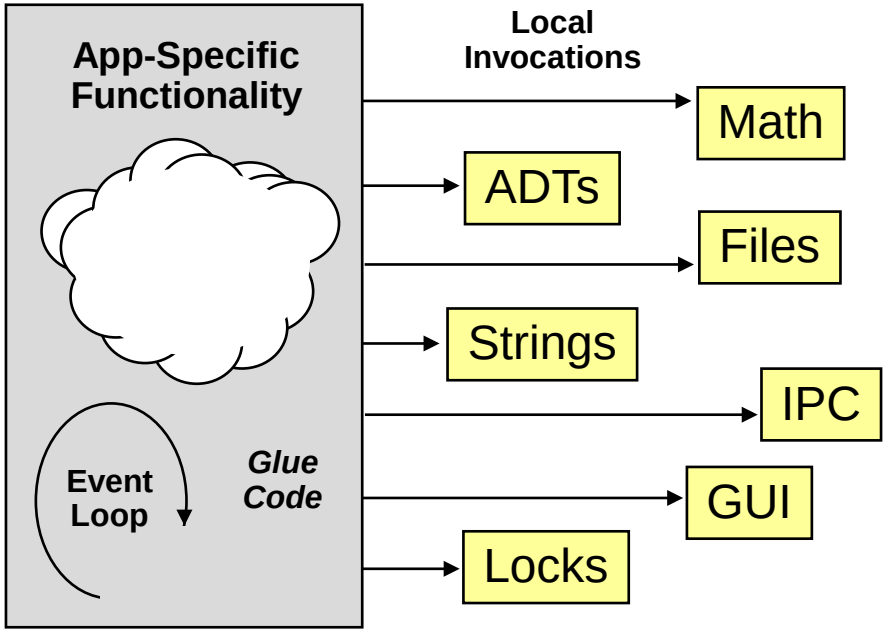
- Understand how frameworks compare with other systematic reuse techniques
- Recognize the different categories of frameworks



Again, we give pithy examples of frameworks from Android to reify key points

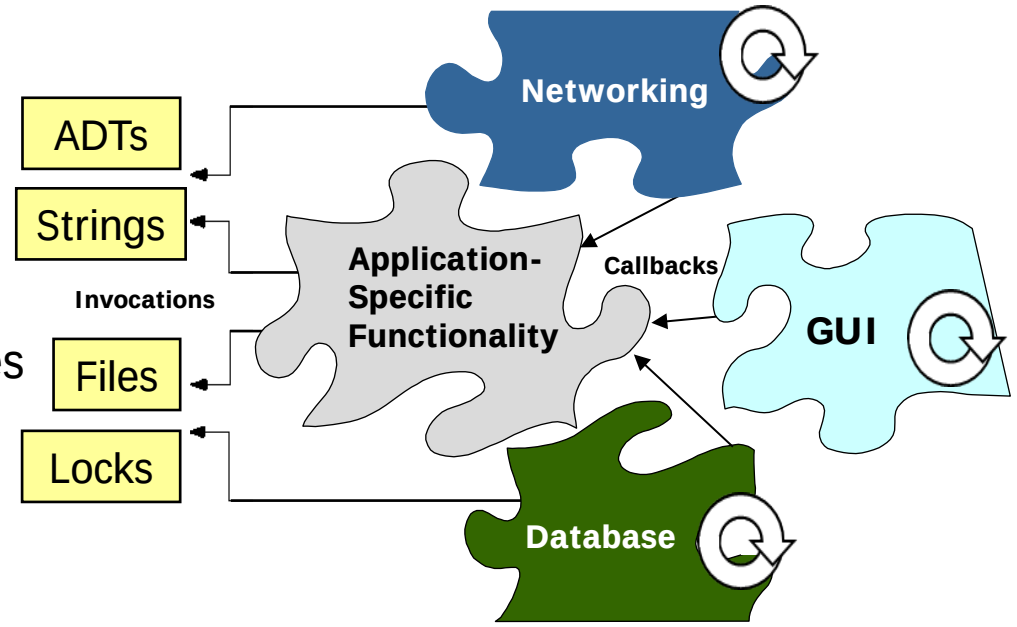
Comparing Systematic Reuse Techniques

- **Class Library Architecture**
  - Class is a reusable implementation unit in an OO language
  - Classes are typically passive



Comparing Systematic Reuse Techniques

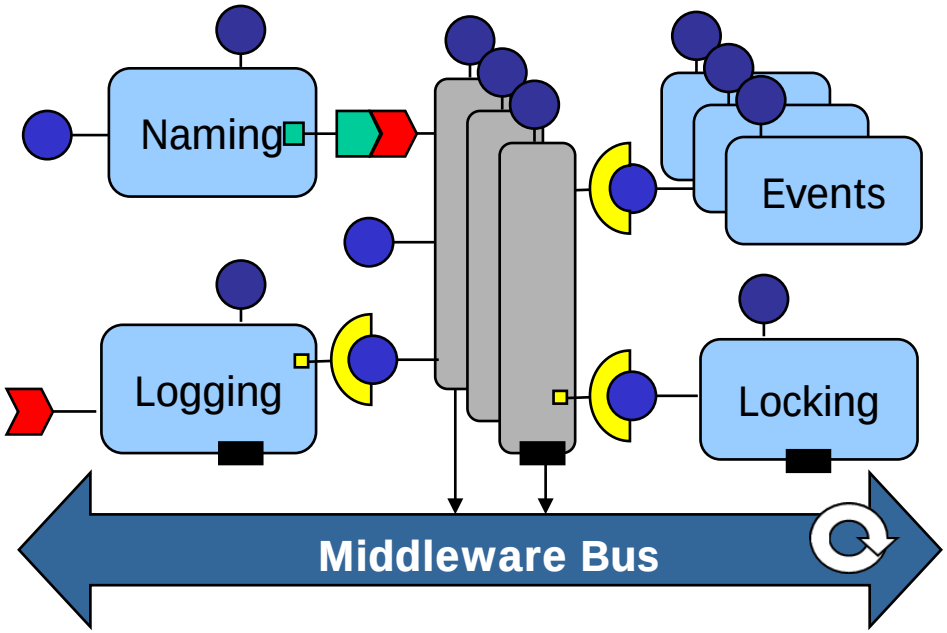
- **Class Library Architecture**
  - Class is a reusable implementation unit in an OO language
  - Classes are typically passive
- **Framework Architecture**
  - Framework is integrated set of classes that collaborate to form a reusable architecture for a family of apps
  - Frameworks own the event loop(s)



See st-www.cs.illinois.edu/users/johnson/frameworks.html

Comparing Systematic Reuse Techniques

- **Class Library Architecture**
  - Class is a reusable implementation unit in an OO language
  - Classes are typically passive
- **Framework Architecture**
  - Framework is integrated set of classes that collaborate to form a reusable architecture for a family of apps
  - Frameworks reify pattern languages
- **Component-based & Service-Oriented Architecture**
  - Component is an encapsulation unit with one or more interfaces that provide clients with access to services
  - Components can be deployed & configured via meta-data contained in assemblies



See www.dre.vanderbilt.edu/~schmidt/report-doc.html for more info

Comparing Systematic Reuse Techniques

- **Class Library Architecture**
  - Class is a reusable implementation unit in an OO language
  - Classes are typically passive
- **Framework Architecture**
  - Framework is integrated set of classes that collaborate to form a reusable architecture for a family of apps
  - Frameworks reify pattern languages
- **Component-based & Service-Oriented Architecture**
  - Component is an encapsulation unit with one or more interfaces that provide clients with access to services
  - Components can be deployed & configured via meta-data contained in assemblies

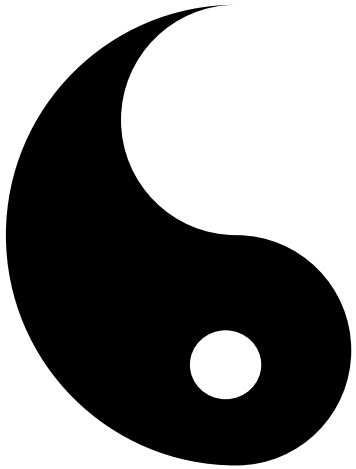
Frameworks are generally more flexible/powerful than other systematic reuse techniques, but also more complicated to develop & use

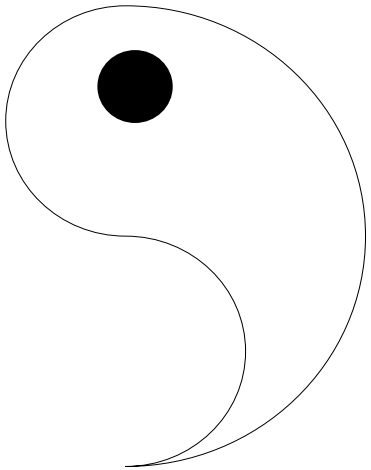
Categories of Frameworks

- **Black-box frameworks** only require understanding external interfaces of objects
  - Framework elements typically reused by parameterizing & assembling objects

Categories of Frameworks

- **Black-box frameworks** only require understanding external interfaces of objects
  - Framework elements typically reused by parameterizing & assembling objects
- **White-box frameworks** require understanding the framework implementation to some degree
  - Framework elements typically reused by subclassing & overridding



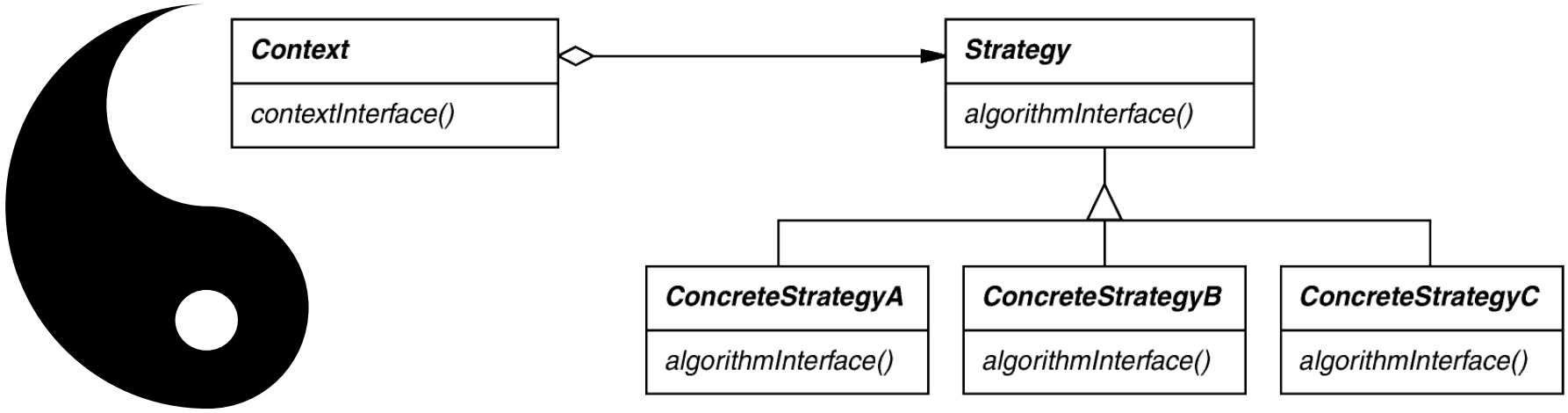


www.laputan.org/drc/drc.html has more on black-box & white-box frameworks

Categories of Frameworks

- **Black-box frameworks** only require understanding external interfaces of objects
  - Framework elements typically reused by parameterizing & assembling objects
- **White-box frameworks** require understanding the framework implementation to some degree
  - Framework elements typically reused by subclassing & overridding

- Each category of OO framework uses different sets of patterns



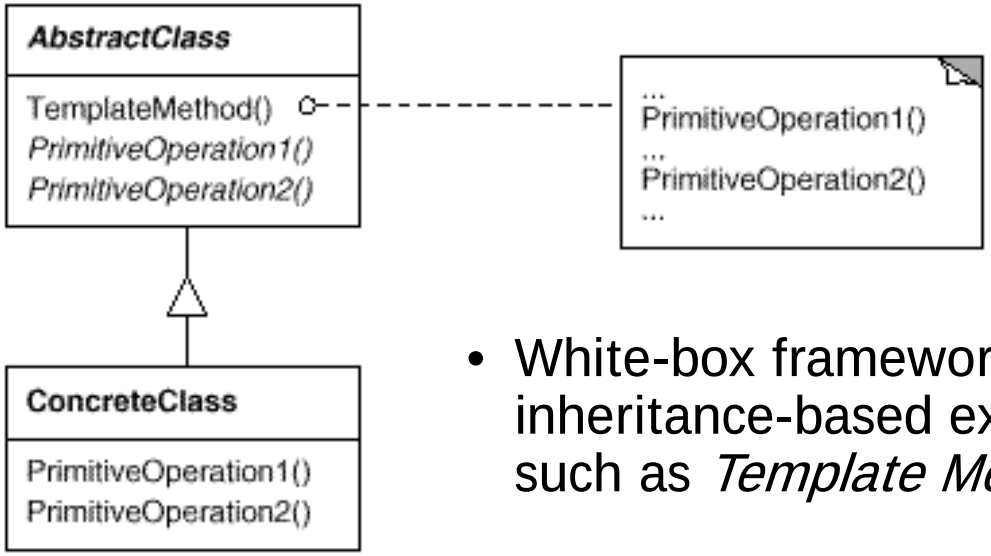
  - Black-box frameworks reply heavily on object composition patterns, such as *Strategy* & *Decorator*

en.wikipedia.org/wiki/Strategy_pattern has more on the *Strategy* pattern

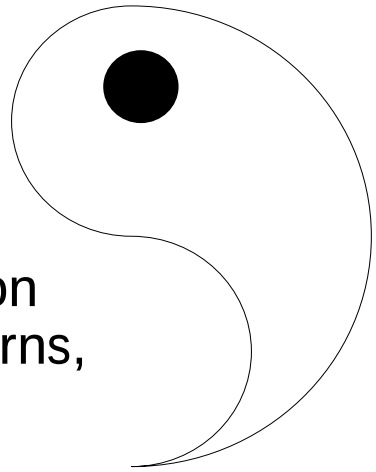
Categories of Frameworks

- **Black-box frameworks** only require understanding external interfaces of objects
  - Framework elements typically reused by parameterizing & assembling objects
- **White-box frameworks** require understanding the framework implementation to some degree
  - Framework elements typically reused by subclassing & overridding

- Each category of OO framework uses different sets of patterns



- White-box frameworks rely heavily on inheritance-based extensibility patterns, such as *Template Method* & *State*

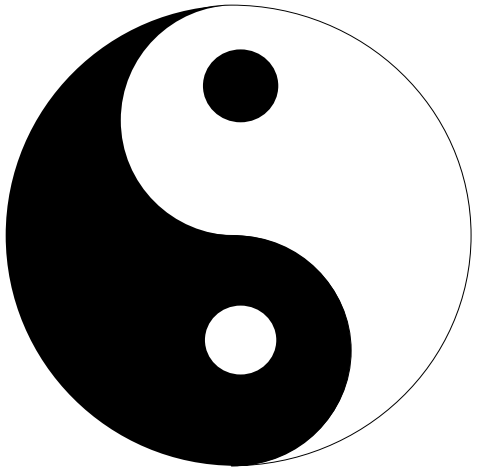


en.wikipedia.org/wiki/Template_method has more on *Template Method* pattern

Categories of Frameworks

- **Black-box frameworks** only require understanding external interfaces of objects
  - Framework elements typically reused by parameterizing & assembling objects
- **White-box frameworks** require understanding the framework implementation to some degree
  - Framework elements typically reused by subclassing & overridding

- Each category of OO framework uses different sets of patterns
- Many frameworks fall in between white-box & black-box categories



Categories of Frameworks

- **Black-box frameworks** only require understanding external interfaces of objects
  - Framework elements typically reused by parameterizing & assembling objects
- **White-box frameworks** require understanding the framework implementation to some degree
  - Framework elements typically reused by subclassing & overridding

- Each category of OO framework uses different sets of patterns
- Many frameworks fall in between white-box & black-box categories
- In general
  - White-box frameworks are easier to develop, but harder to use

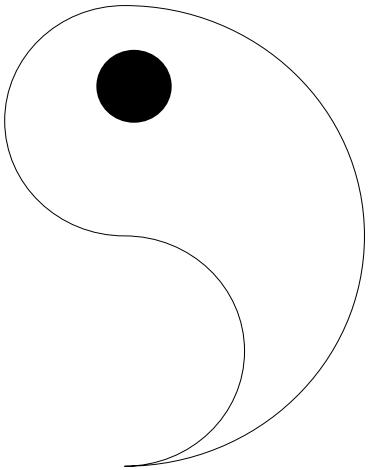
Categories of Frameworks

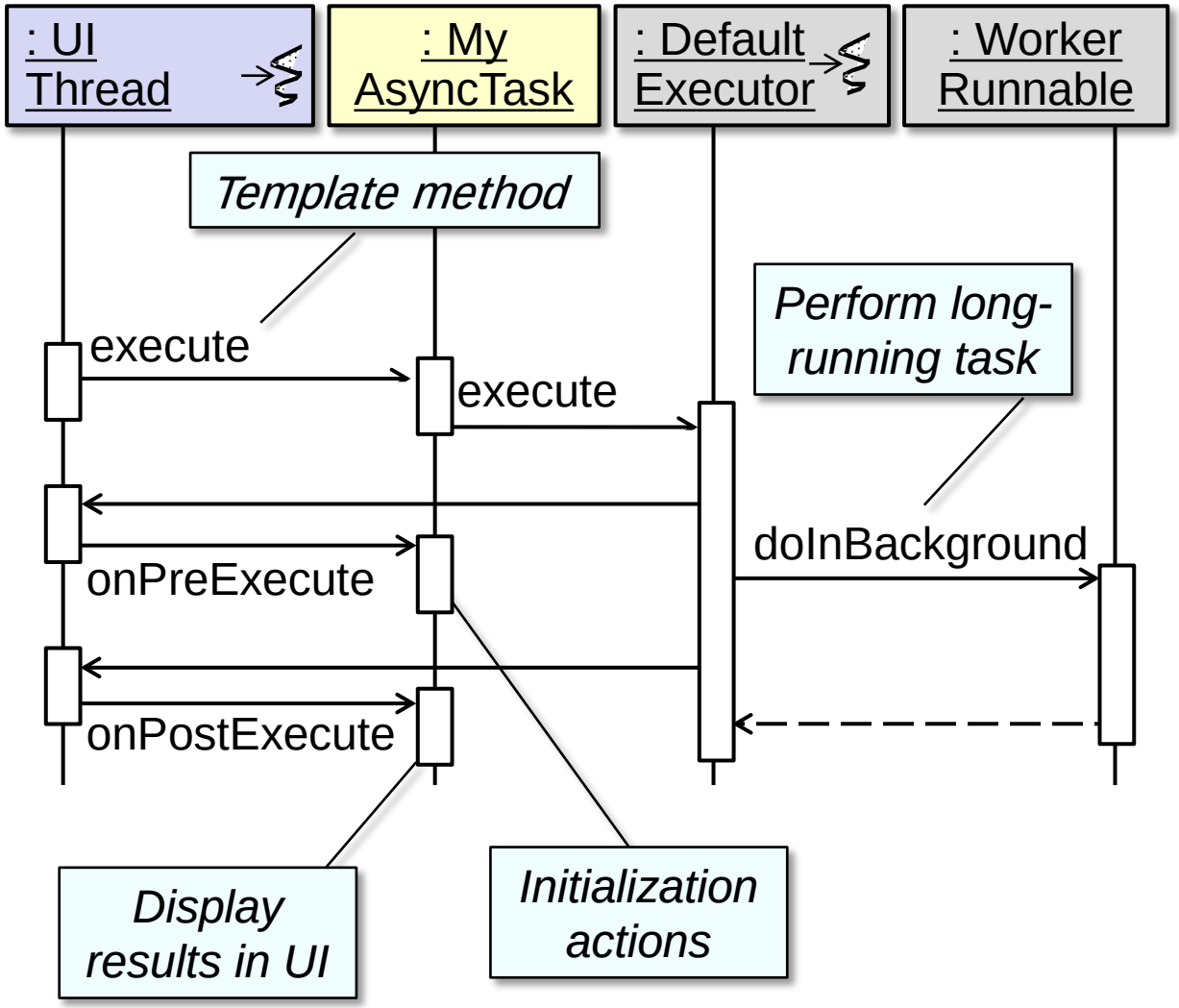
- **Black-box frameworks** only require understanding external interfaces of objects
  - Framework elements typically reused by parameterizing & assembling objects
- **White-box frameworks** require understanding the framework implementation to some degree
  - Framework elements typically reused by subclassing & overridding

- Each category of OO framework uses different sets of patterns
- Many frameworks fall in between white-box & black-box categories
- In general
  - White-box frameworks are easier to develop, but harder to use
  - Black-box frameworks are harder to develop, but easier to use

White-box Framework: Android AsyncTask

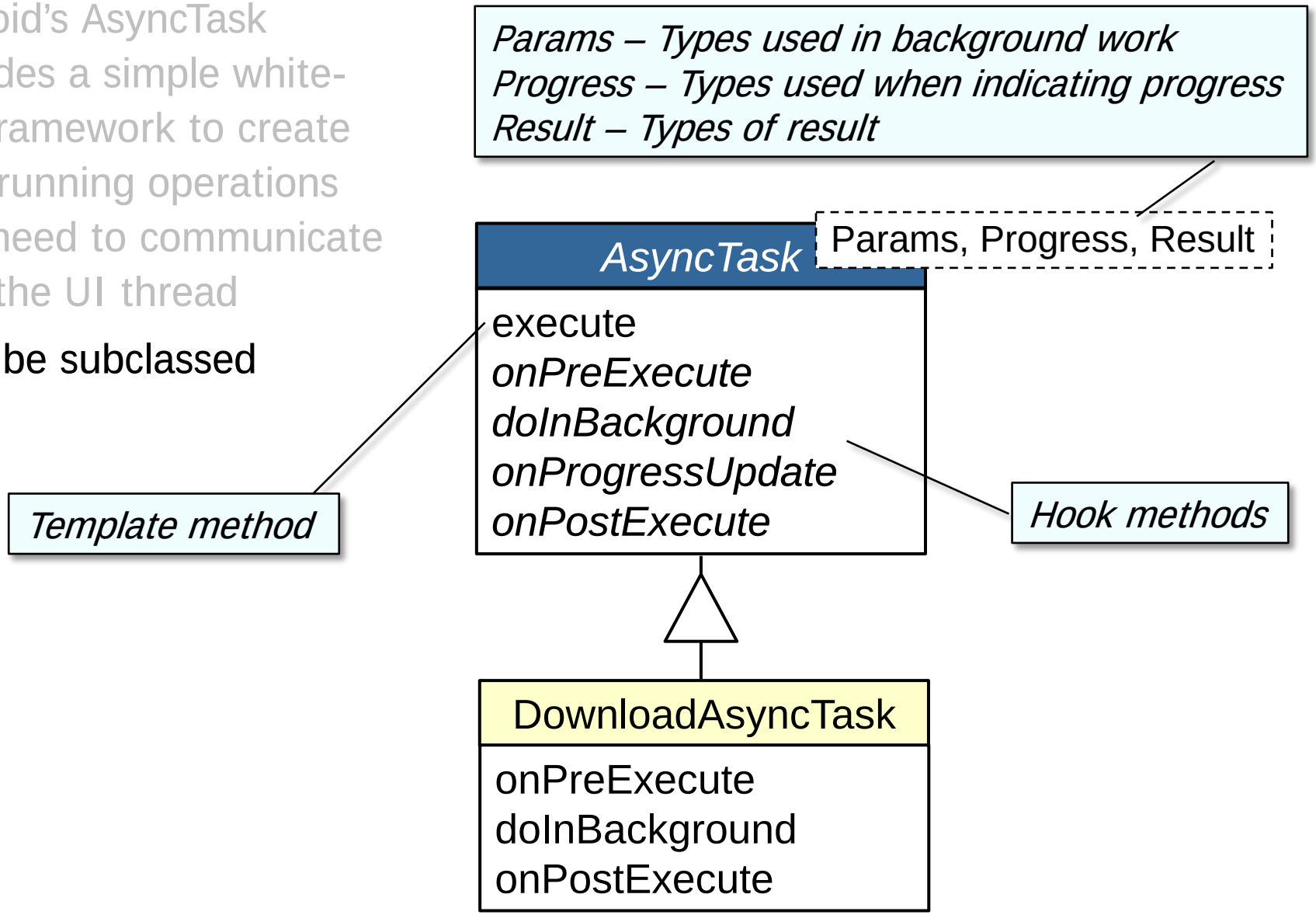
- Android's AsyncTask provides a simple white-box framework to create long-running operations that need to communicate with the UI thread





White-box Framework: Android AsyncTask

- Android's AsyncTask provides a simple white-box framework to create long-running operations that need to communicate with the UI thread
- Must be subclassed



White-box Framework: Android AsyncTask

- Android's AsyncTask provides a simple white-box framework to create long-running operations that need to communicate with the UI thread
- Must be subclassed
  - Hook methods can be overridden

```
class DownloadAsyncTask
      extends AsyncTask<String, Integer, Bitmap> {

  protected void onPreExecute() {
    dialog.display();
  }

  protected Bitmap doInBackground(String... url) {
    return downloadImage(url[0]);
  }

  protected void onPostExecute(Bitmap bitmap) {
    performPostDownloadOperations(bitmap);
    dialog.dismiss();
  }
}
```

Perform on UI thread

Perform on UI thread

Download in background thread

Perform on UI thread

White-box Framework: Android AsyncTask

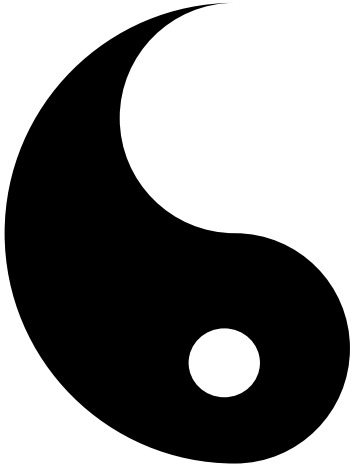
- Android's AsyncTask provides a simple white-box framework to create long-running operations that need to communicate with the UI thread
- Must be subclassed
  - Hook methods can be overridden
- Instance must be created on the UI thread & can only be executed once

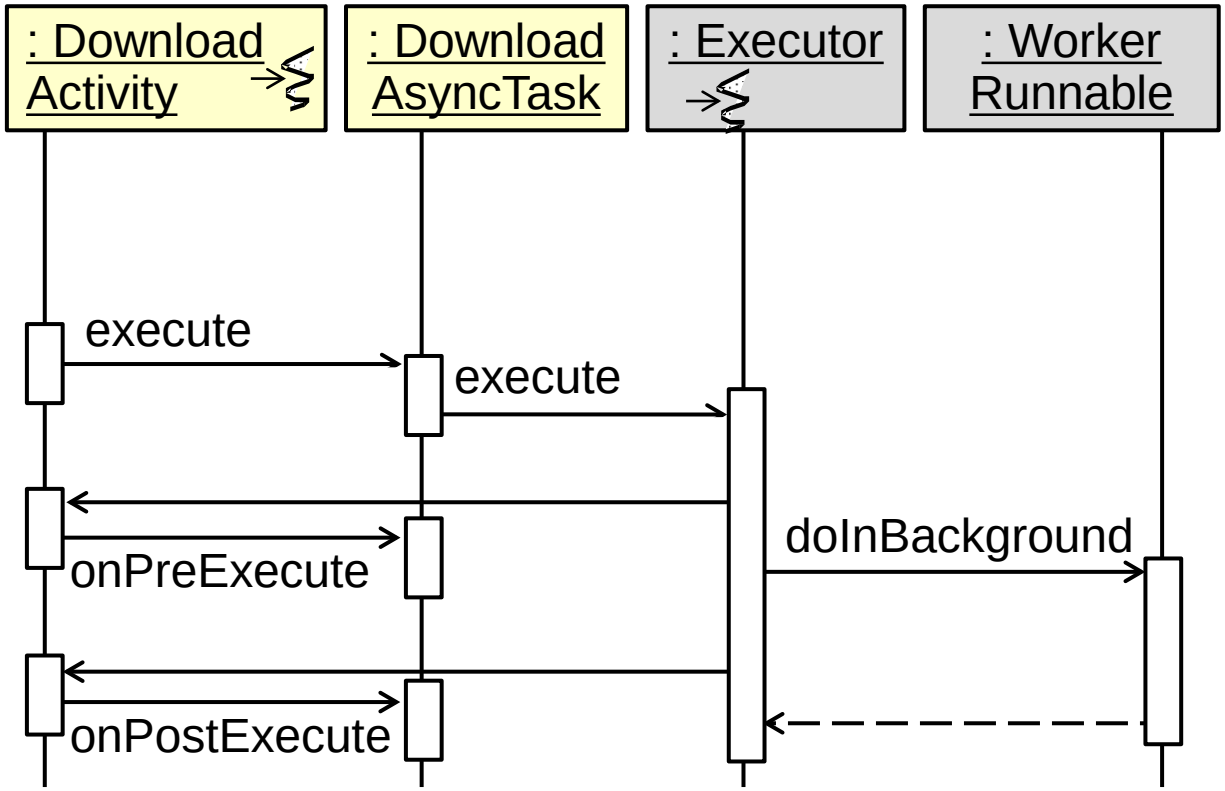
```
public class ThreadedDownloadActivity
             extends Activity {
…
  public void runAsyncTask(View view) {
    final String url =
           urlEditText.getText().toString();

    new DownloadAsyncTask().execute(url);
  }
…
}
```

UI thread calls template method to trigger image download in a new AsyncTask

Black-box Framework: Android AsyncTask

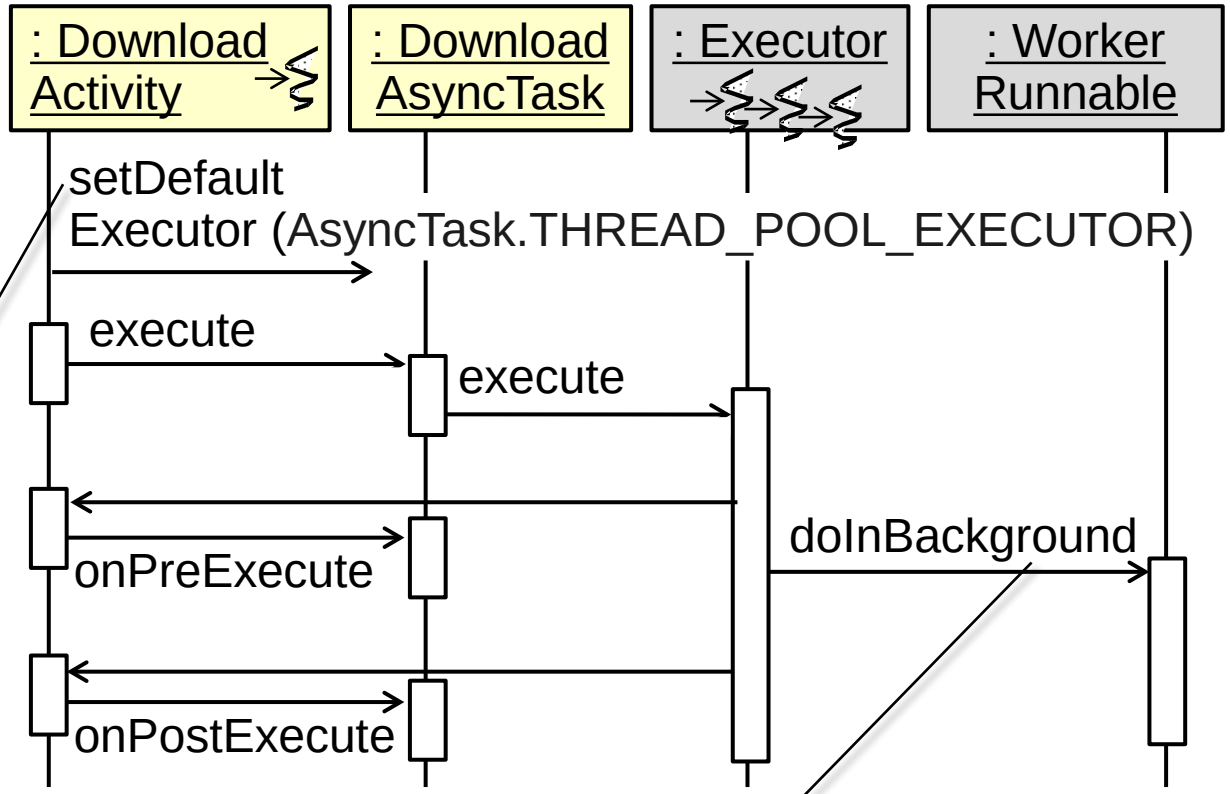
- Android's AsyncTask provides a simple black-box framework for controlling the # & behavior of thread(s) running in background





Black-box Framework: Android AsyncTask

- Android's AsyncTask provides a simple black-box framework for controlling the # & behavior of thread(s) running in background
- Client can select the desired Executor

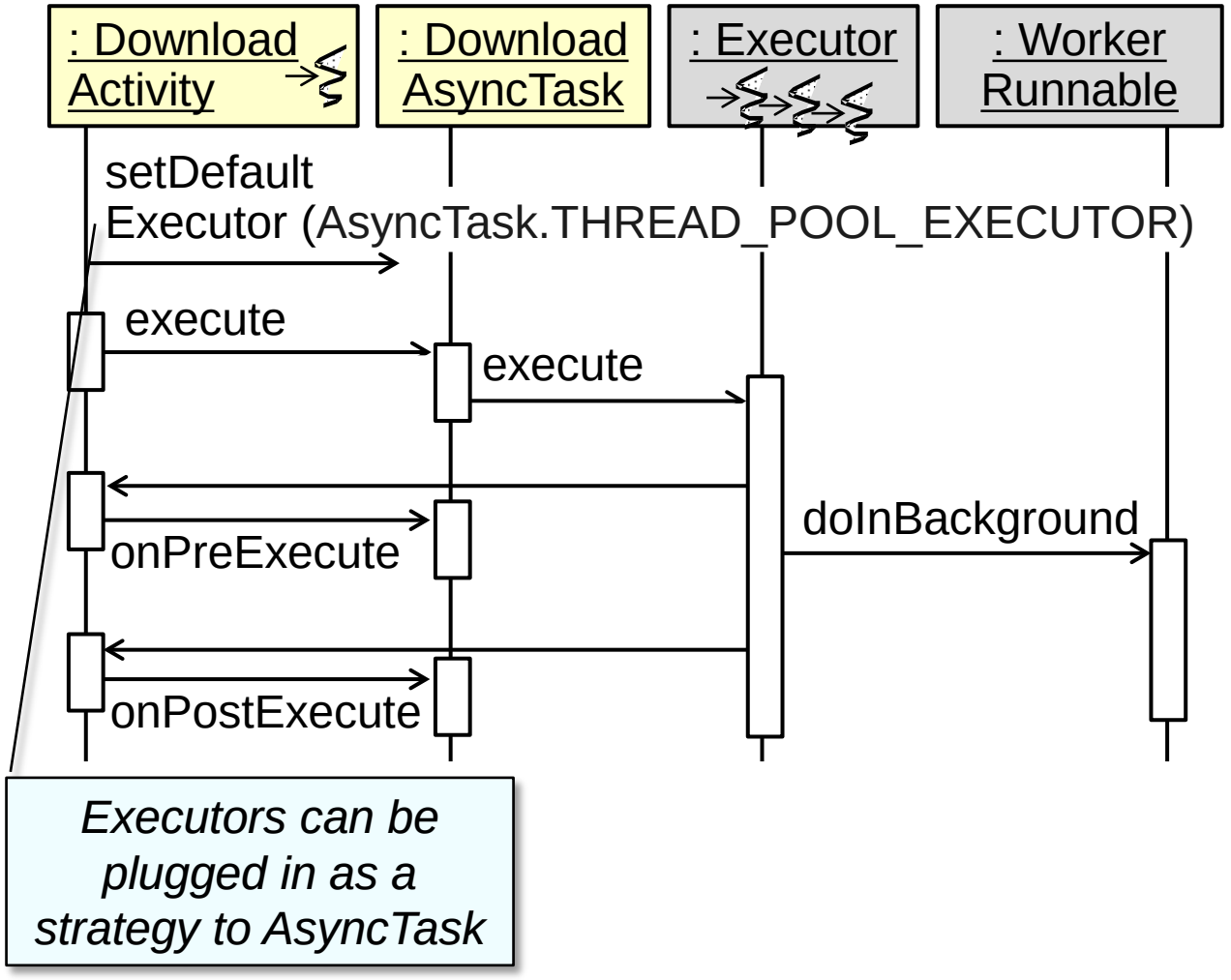


SERIAL_EXECUTOR, THREAD_POOL_EXECUTOR, or custom Executor

Allows multiple long-running tasks to run in parallel in multiple threads

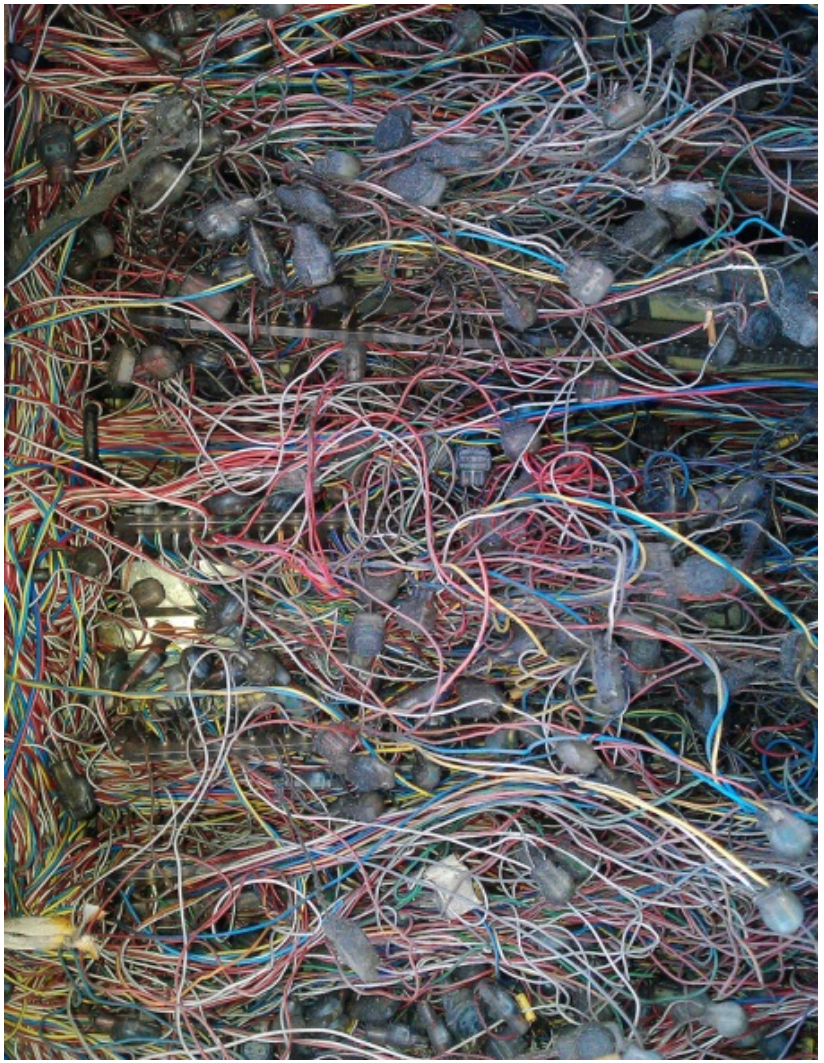
Black-box Framework: Android AsyncTask

- Android's AsyncTask provides a simple black-box framework for controlling the # & behavior of thread(s) running in background
- Client can select the desired Executor
- Executor treated as a "black-box"
  - i.e., only requires understanding of external interfaces



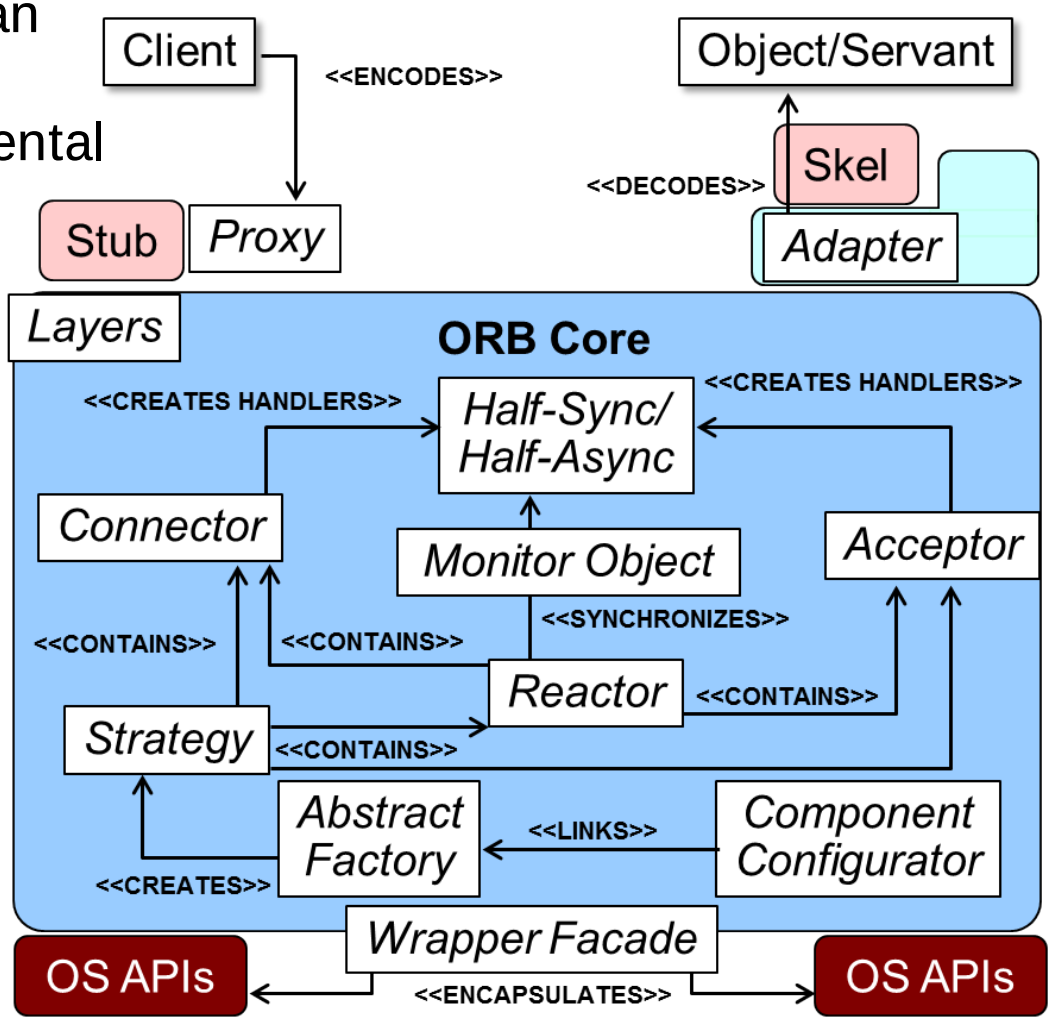
Summary

- Frameworks are powerful—but can be hard to develop & use by app developers due to inherent/accidental complexities of various domains



Summary

- Frameworks are powerful—but can be hard to develop & use by app developers due to inherent/accidental complexities of various domains
  - Patterns (especially pattern languages) help to alleviate many framework complexities



www.dre.vanderbilt.edu/~schmidt/PDF/ORB-patterns.pdf has more info

Summary

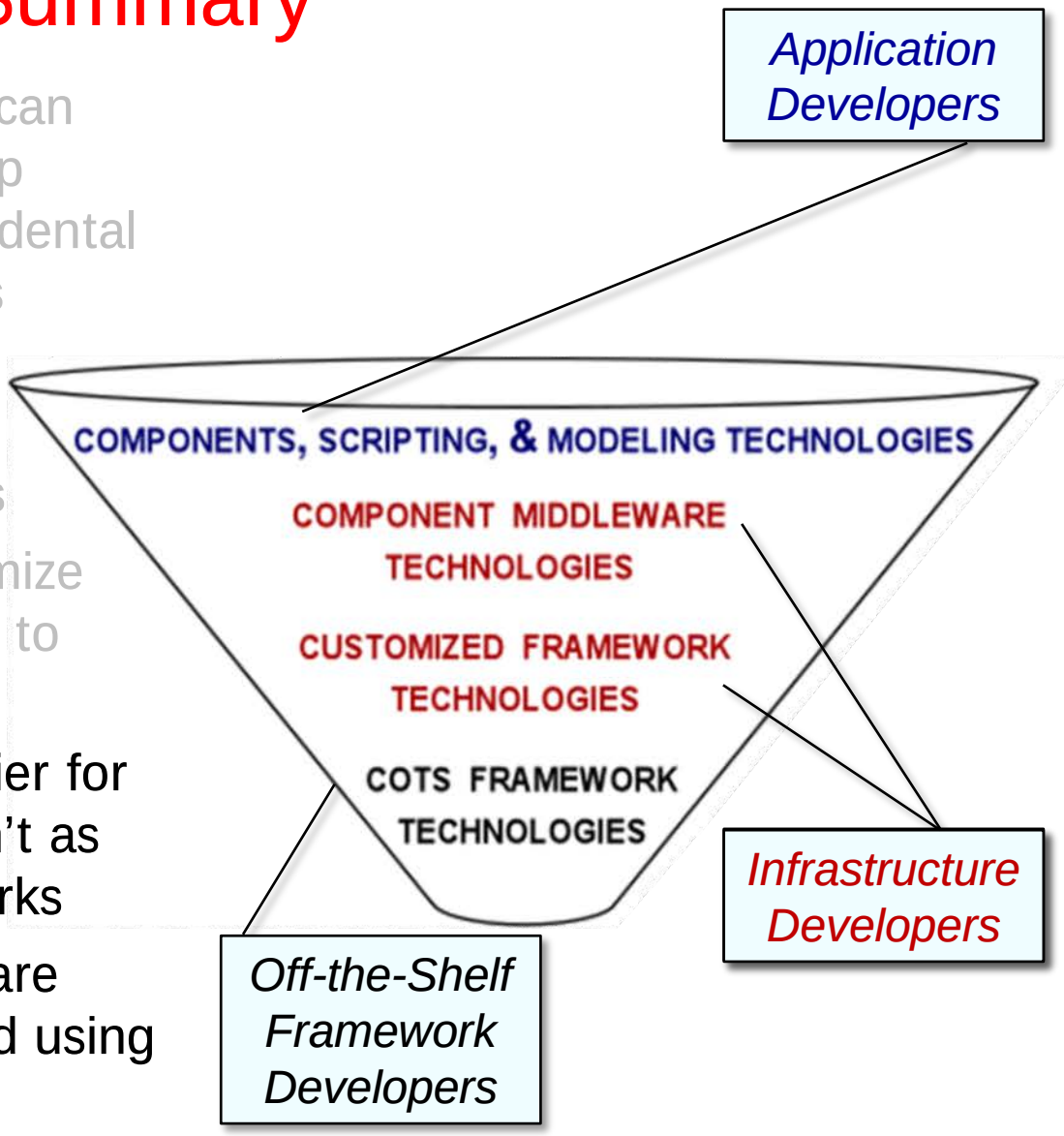
- Frameworks are powerful—but can be hard to develop & use by app developers due to inherent/accidental complexities of various domains
  - Patterns (especially pattern languages) help to alleviate many framework complexities
- It's often better to use & customize "off-the-shelf" frameworks than to develop frameworks in-house

Summary

- Frameworks are powerful—but can be hard to develop & use by app developers due to inherent/accidental complexities of various domains
  - Patterns (especially pattern languages) help to alleviate many framework complexities
- It's often better to use & customize "off-the-shelf" frameworks than to develop frameworks in-house
- Components & services are easier for app developers to use, but aren't as powerful or flexible as frameworks

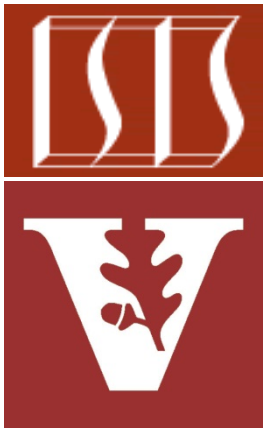
Summary

- Frameworks are powerful—but can be hard to develop & use by app developers due to inherent/accidental complexities of various domains
  - Patterns (especially pattern languages) help to alleviate many framework complexities
- It's often better to use & customize "off-the-shelf" frameworks than to develop frameworks in-house
- Components & services are easier for app developers to use, but aren't as powerful or flexible as frameworks
  - Successful software projects are therefore often best organized using the "funnel" model



www.dre.vanderbilt.edu/~schmidt/PDF/Queue-04.pdf has more on frameworks

Overview of Frameworks: Part 3



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

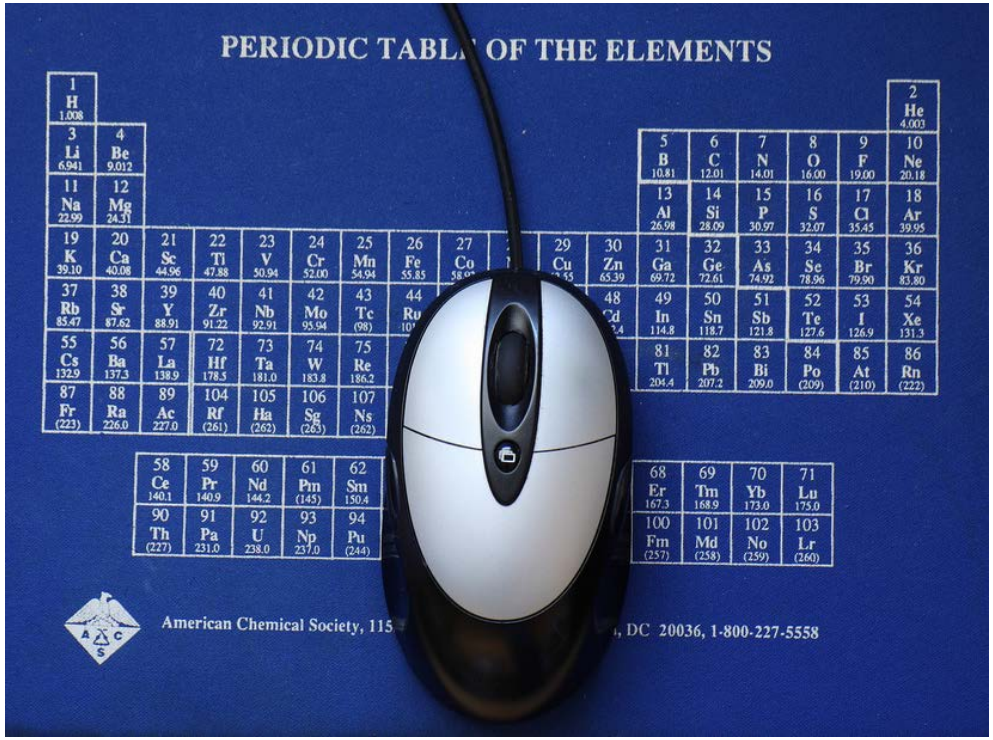
Institute for Software
Integrated Systems
Vanderbilt University
Nashville, Tennessee, USA

CS 282 Principles of Operating Systems II

Systems Programming for Android

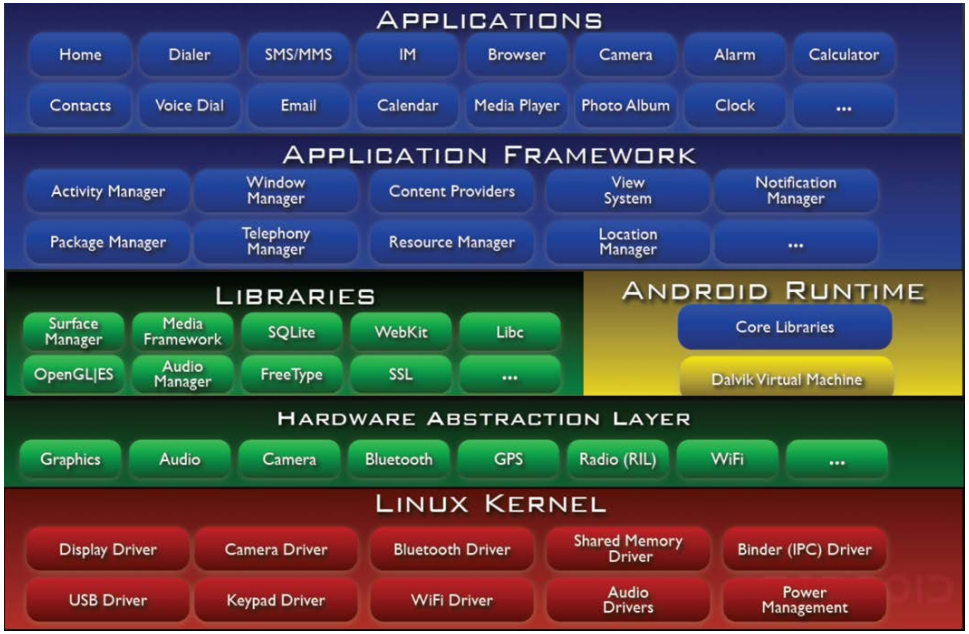
Learning Objectives of this Module

- Present *Scope, Commonality, & Variability* (SCV) analysis as a method for developing & applying software product-lines & frameworks



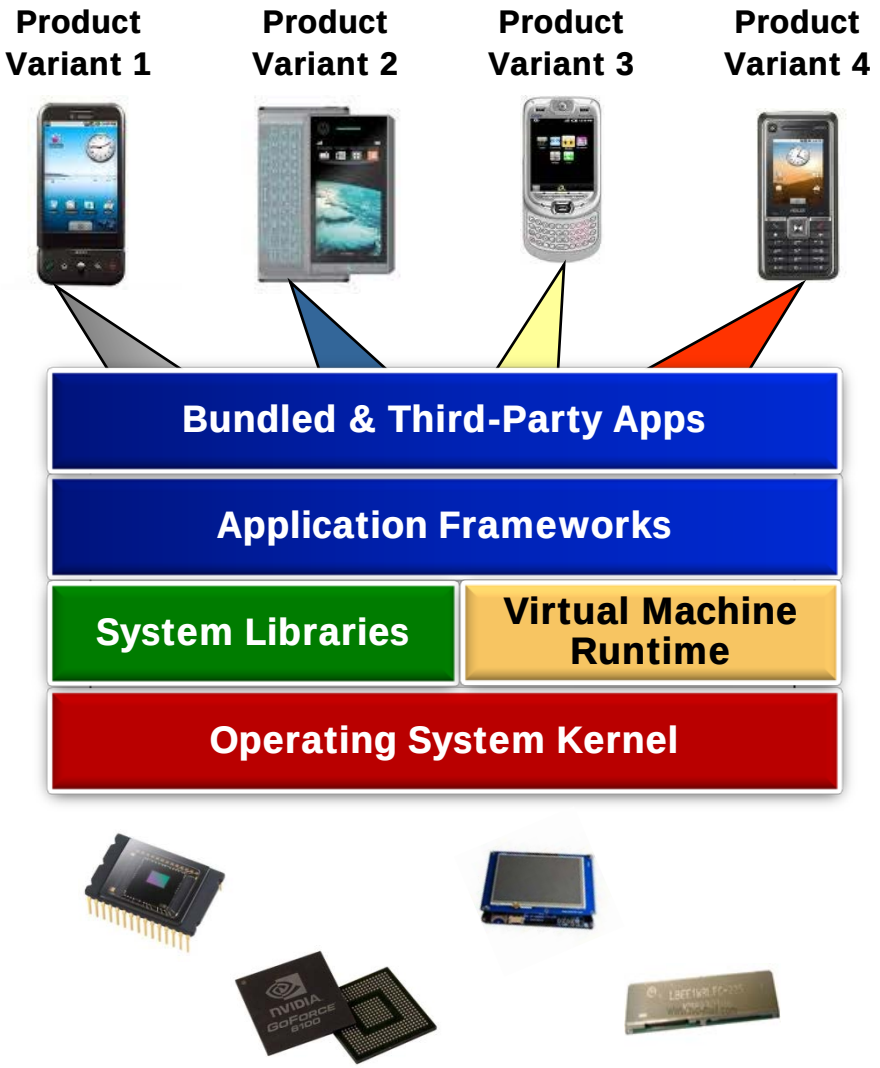
Learning Objectives of this Module

- Present *Scope, Commonality, & Variability* (SCV) analysis as a method for developing & applying software product-lines & frameworks
- Illustrate the application of SCV to Android



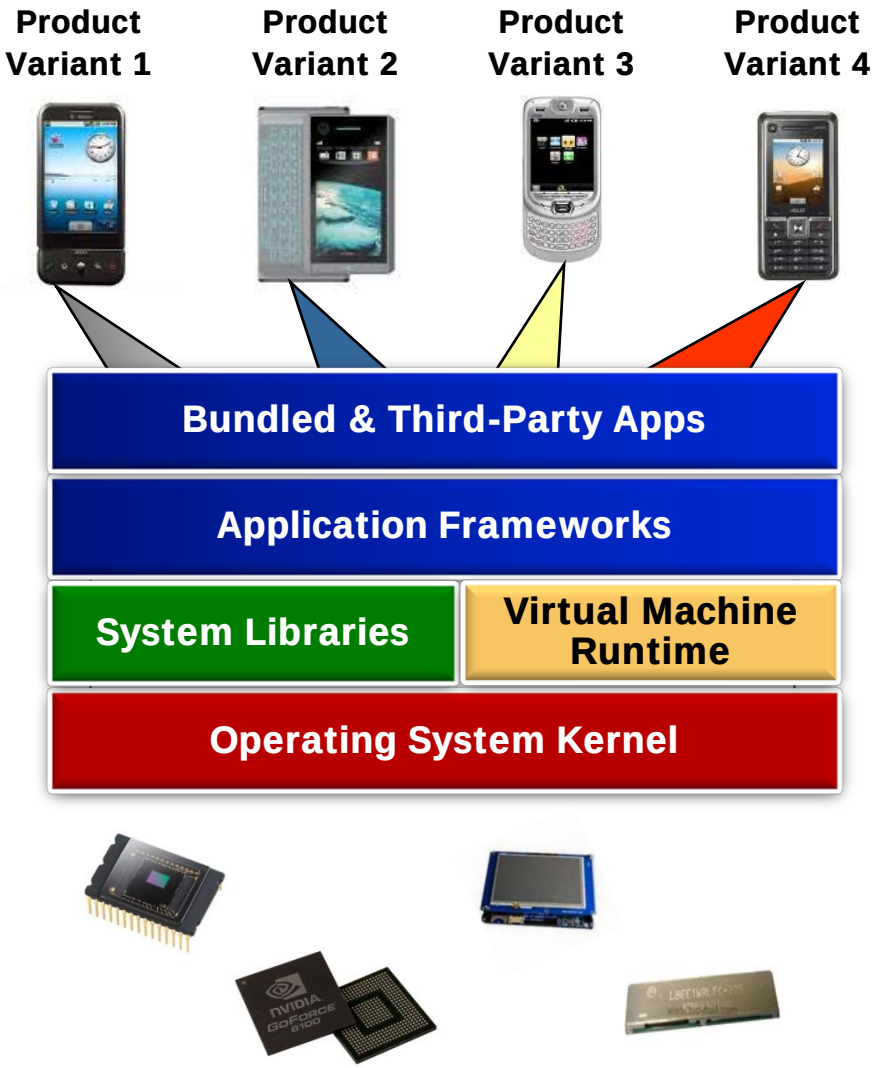
Overview of Software Product-Lines

- A *software product line* (SPL) is a form of systematic software reuse
  - An SPL a set of software-intensive systems
  - These systems share a common, managed set of features satisfying the specific needs of a particular market segment or mission
  - They are developed from a common set of core assets in a prescribed way



Overview of Software Product-Lines

- A *software product line* (SPL) is a form of systematic software reuse
  - An SPL a set of software-intensive systems
  - These systems share a common, managed set of features satisfying the specific needs of a particular market segment or mission
  - They are developed from a common set of core assets in a prescribed way
- Frameworks can help define & improve core SPL assets by factoring out many reusable general-purpose & domain-specific services from application responsibility



See www.sei.cmu.edu/productlines for more info on software product-lines

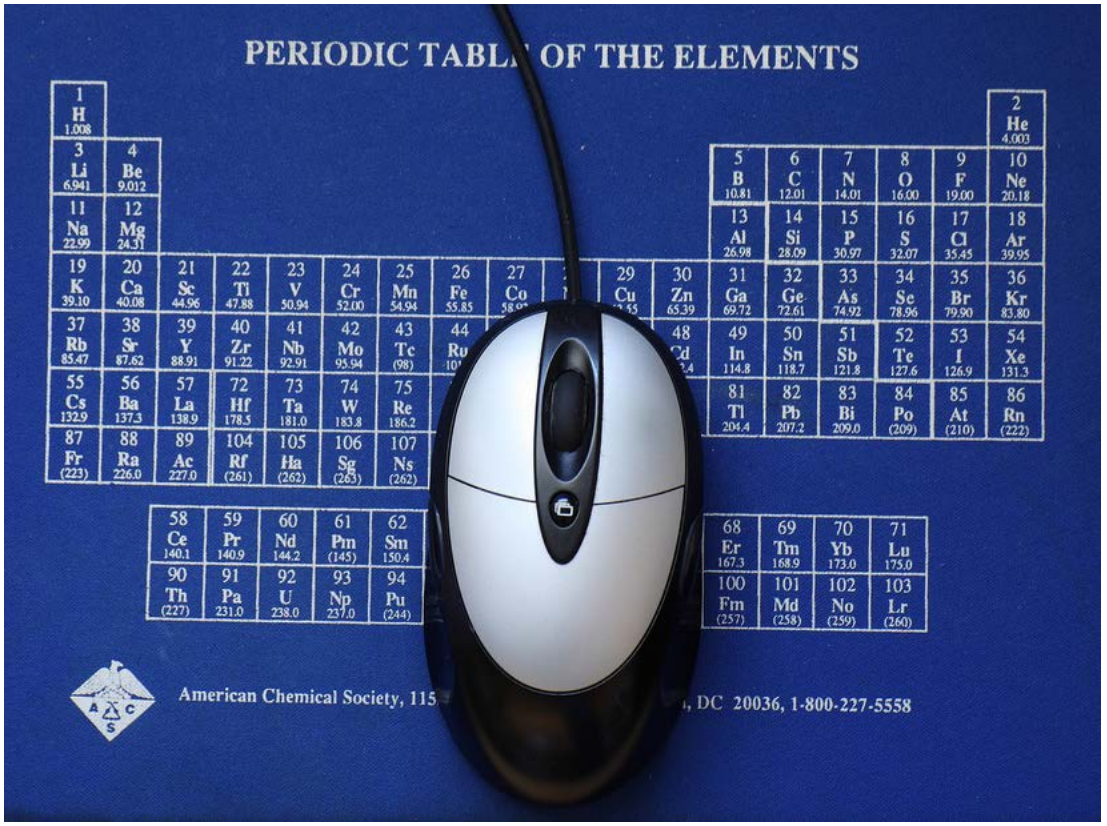
Scope, Commonality, & Variability Analysis

- Key software product-line & framework structure & behavior can be captured systematically via *Scope*, *Commonality*, & *Variability* (SCV) analysis

Scope, Commonality, & Variability Analysis

- Key software product-line & framework structure & behavior can be captured systematically via *Scope*, *Commonality*, & *Variability* (SCV) analysis

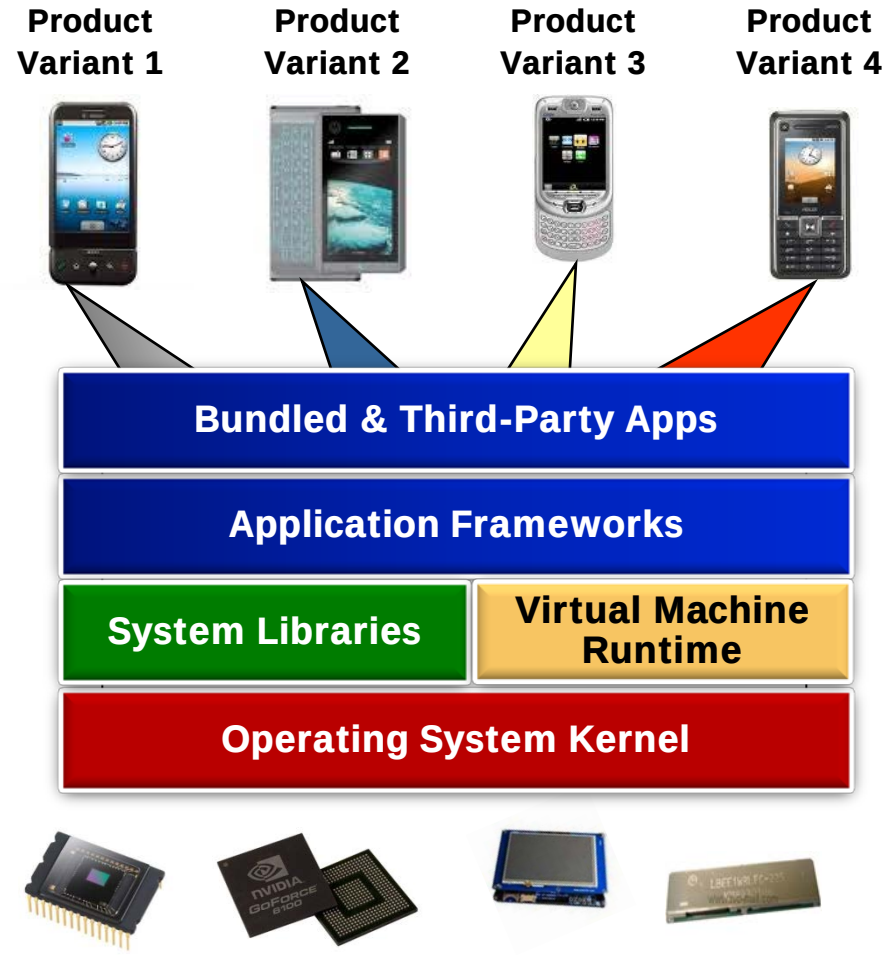
- This process can be applied to identify commonalities & variabilities in a domain



www.cs.iastate.edu/~cs309/references/CoplienHoffmanWeiss_CommonalityVariability.pdf

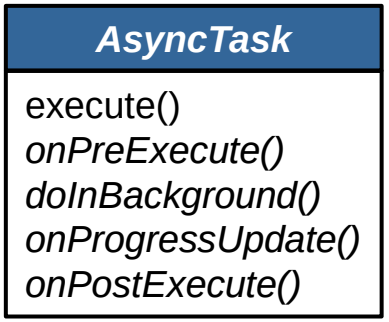
Scope, Commonality, & Variability Analysis

- Key software product-line & framework structure & behavior can be captured systematically via *Scope*, *Commonality*, & *Variability* (SCV) analysis
- This process can be applied to identify commonalities & variabilities in a domain
  - Often used to guide the development & application of software product-lines & frameworks



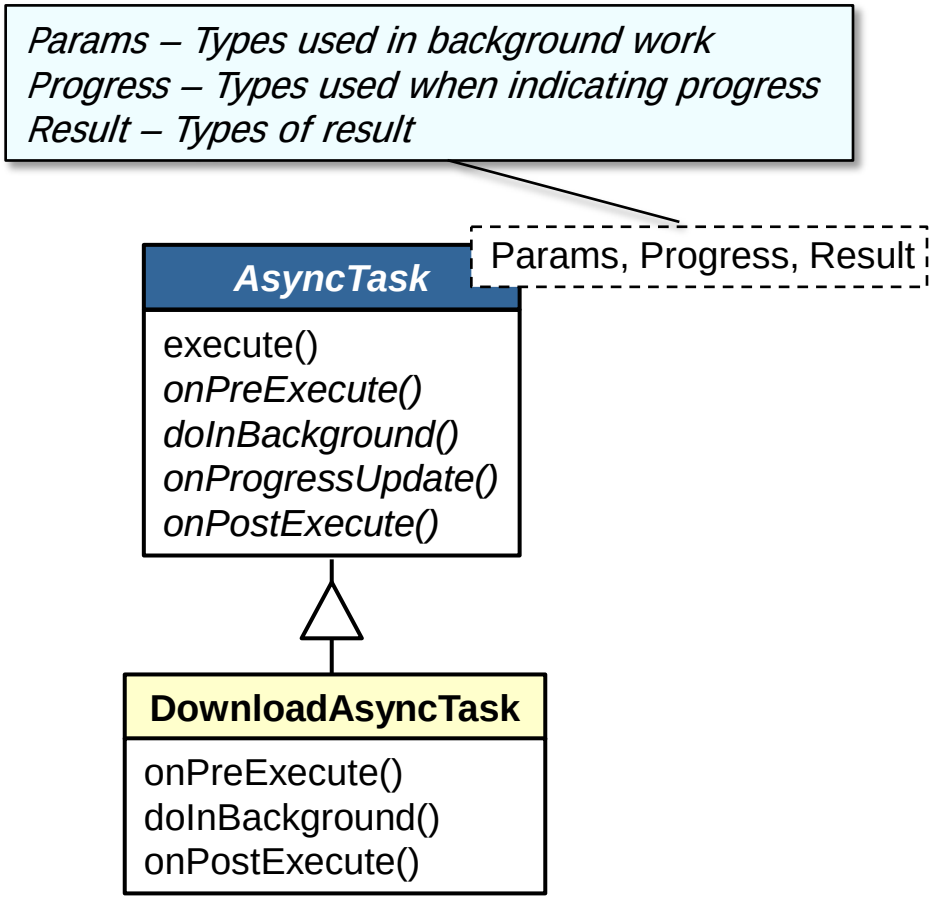
Scope, Commonality, & Variability Analysis

- Key software product-line & framework structure & behavior can be captured systematically via *Scope*, *Commonality*, & *Variability* (SCV) analysis
- This process can be applied to identify commonalities & variabilities in a domain
- General method
  - Identify common portions of a domain & define stable interfaces (fairly easy)



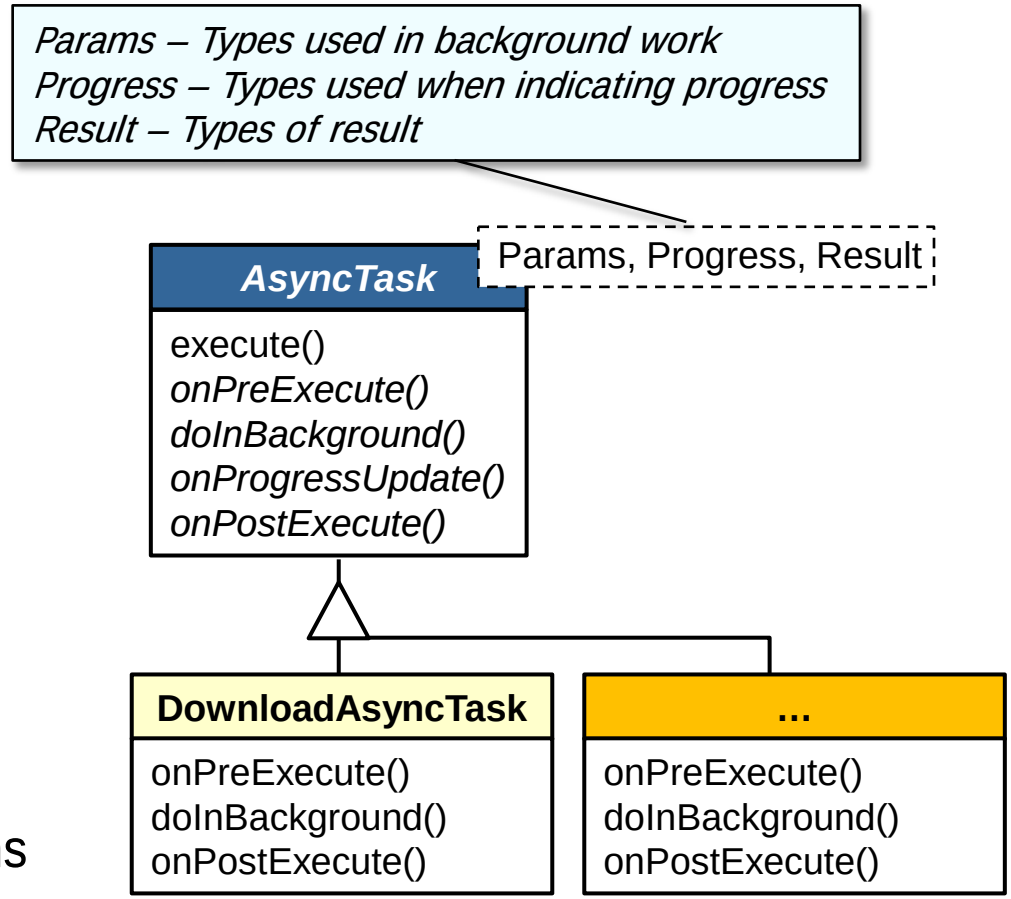
Scope, Commonality, & Variability Analysis

- Key software product-line & framework structure & behavior can be captured systematically via *Scope*, *Commonality*, & *Variability* (SCV) analysis
- This process can be applied to identify commonalities & variabilities in a domain
- General method
  - Identify common portions of a domain & define stable interfaces (fairly easy)
  - Identify variable portions of a domain & define stable interfaces (harder)



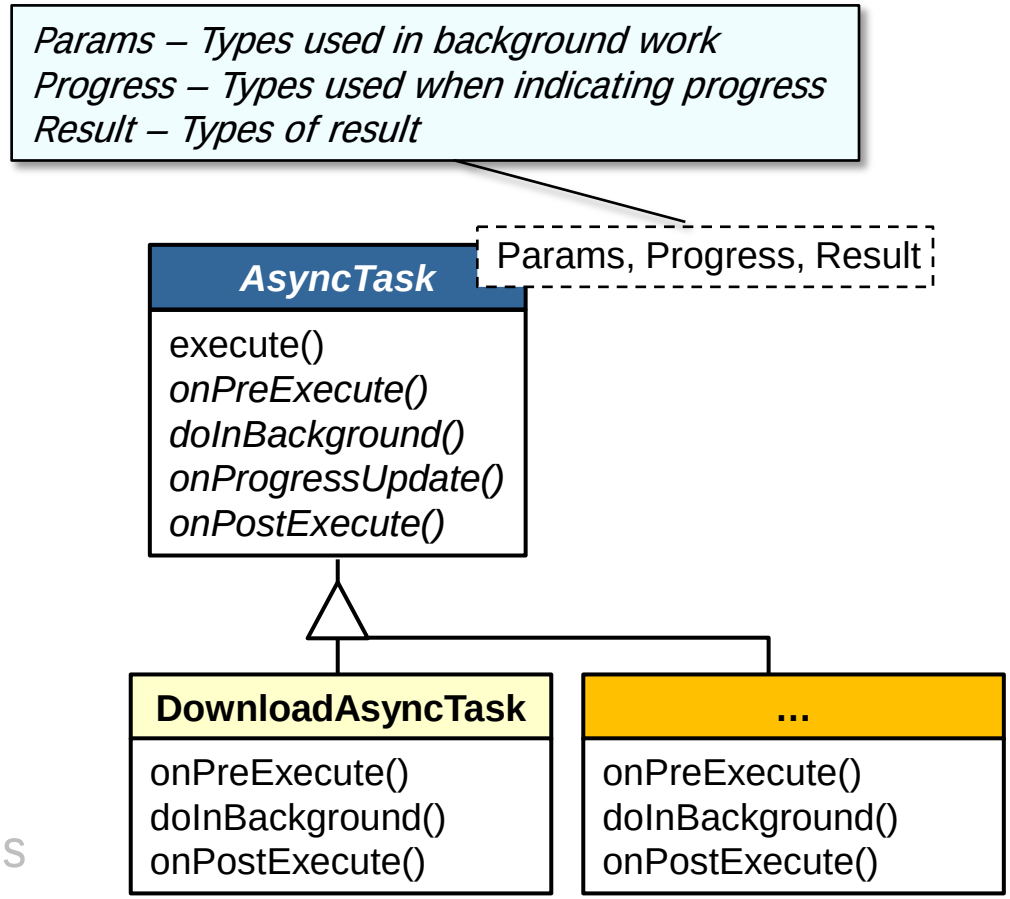
Scope, Commonality, & Variability Analysis

- Key software product-line & framework structure & behavior can be captured systematically via *Scope*, *Commonality*, & *Variability* (SCV) analysis
- This process can be applied to identify commonalities & variabilities in a domain
- General method
  - Identify common portions of a domain & define stable interfaces (fairly easy)
  - Identify variable portions of a domain & define stable interfaces (harder)
  - Create different implementations of the variable portions as plug-ins



Scope, Commonality, & Variability Analysis

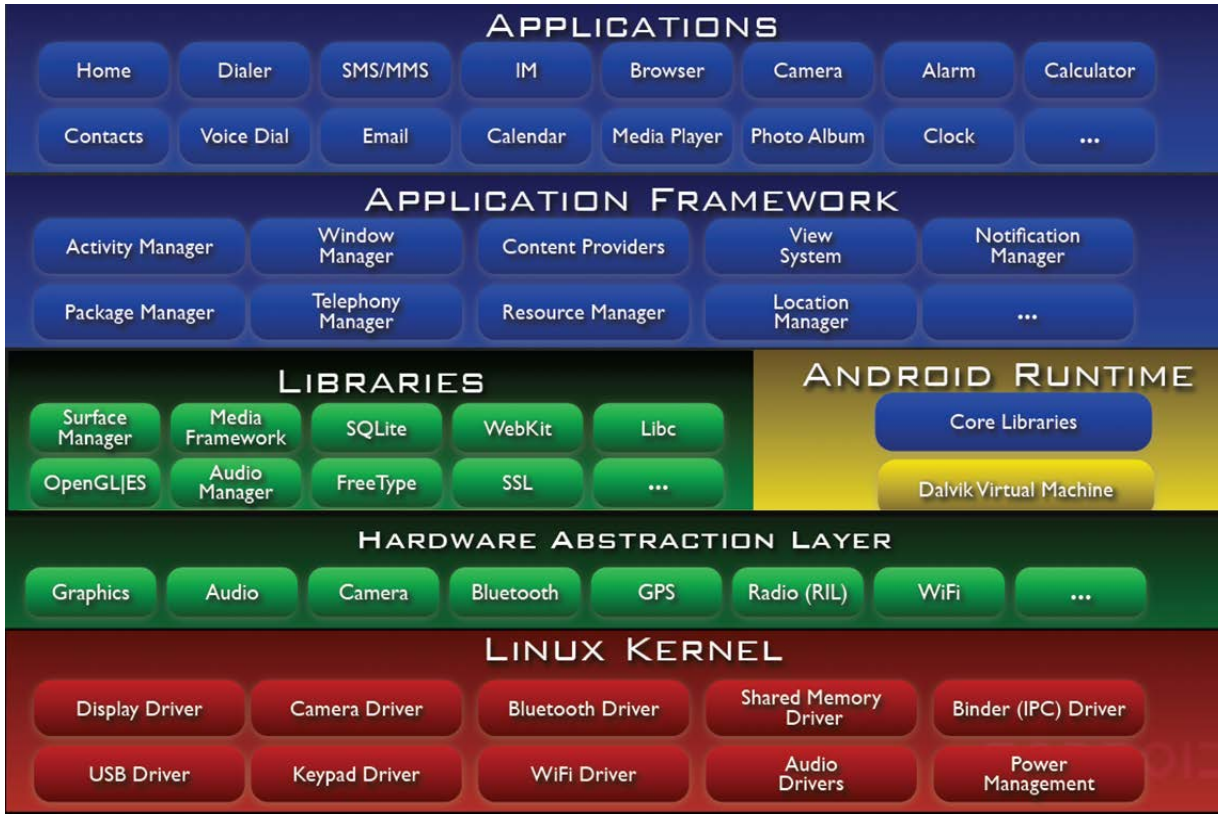
- Key software product-line & framework structure & behavior can be captured systematically via *Scope*, *Commonality*, & *Variability* (SCV) analysis
- This process can be applied to identify commonalities & variabilities in a domain
- General method
  - Identify common portions of a domain & define stable interfaces (fairly easy)
  - Identify variable portions of a domain & define stable interfaces (harder)
  - Create different implementations of the variable portions as plug-ins



en.wikipedia.org/wiki/SOLID_(object-oriented_design) has more info

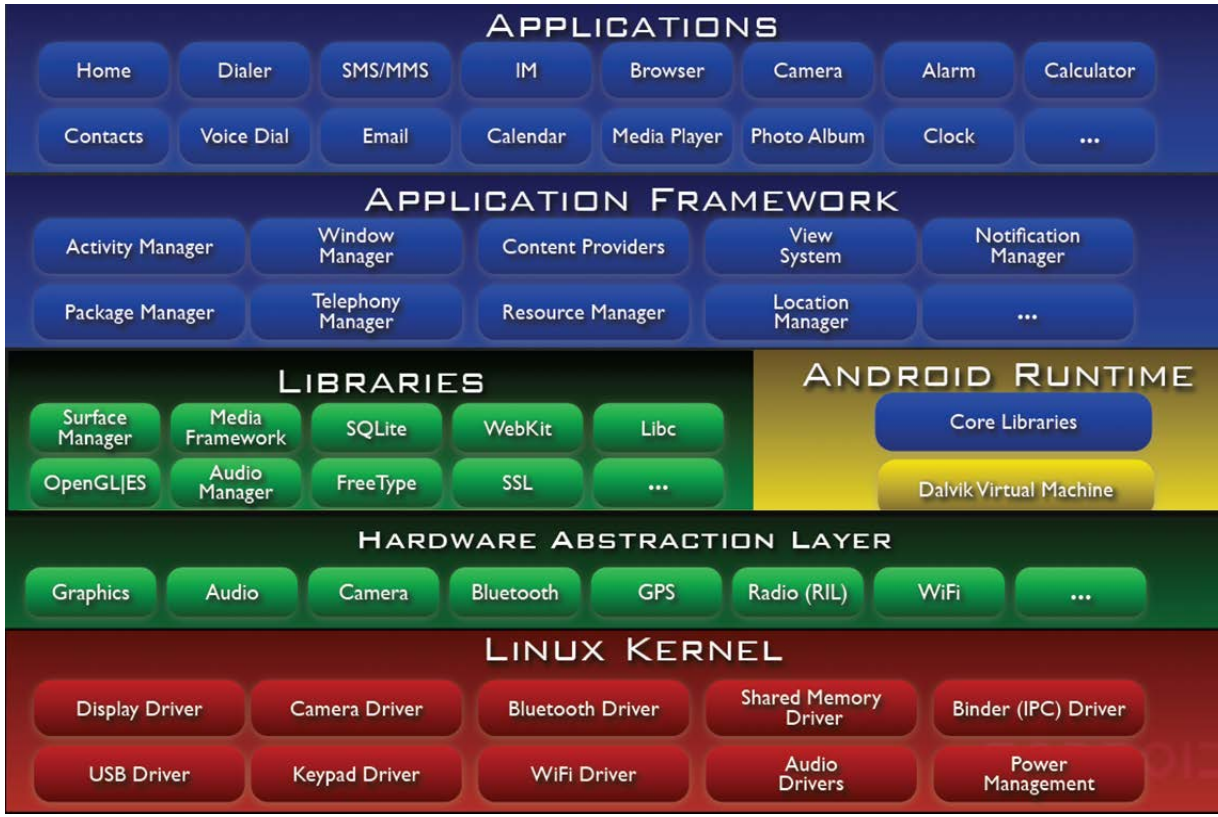
Applying SCV to Android

- **Scope** defines the domain & context of Android & its various frameworks & components
- e.g.,
  - Resource-constrained mobile devices
    - e.g., limited power, memory, processors, network, & price points



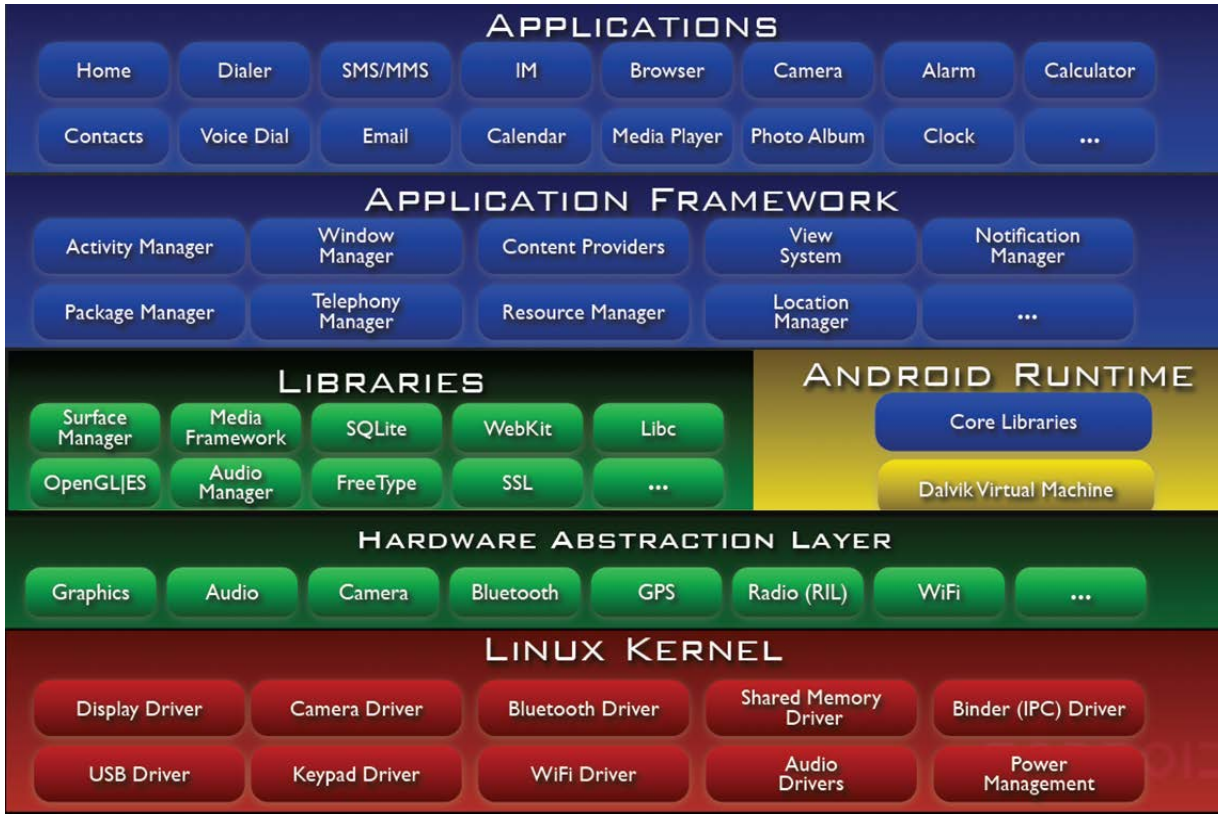
Applying SCV to Android

- **Scope** defines the domain & context of Android & its various frameworks & components
- e.g.,
  - Resource-constrained mobile devices
    - e.g., limited power, memory, processors, network, & price points
  - Touch-based user interfaces



Applying SCV to Android

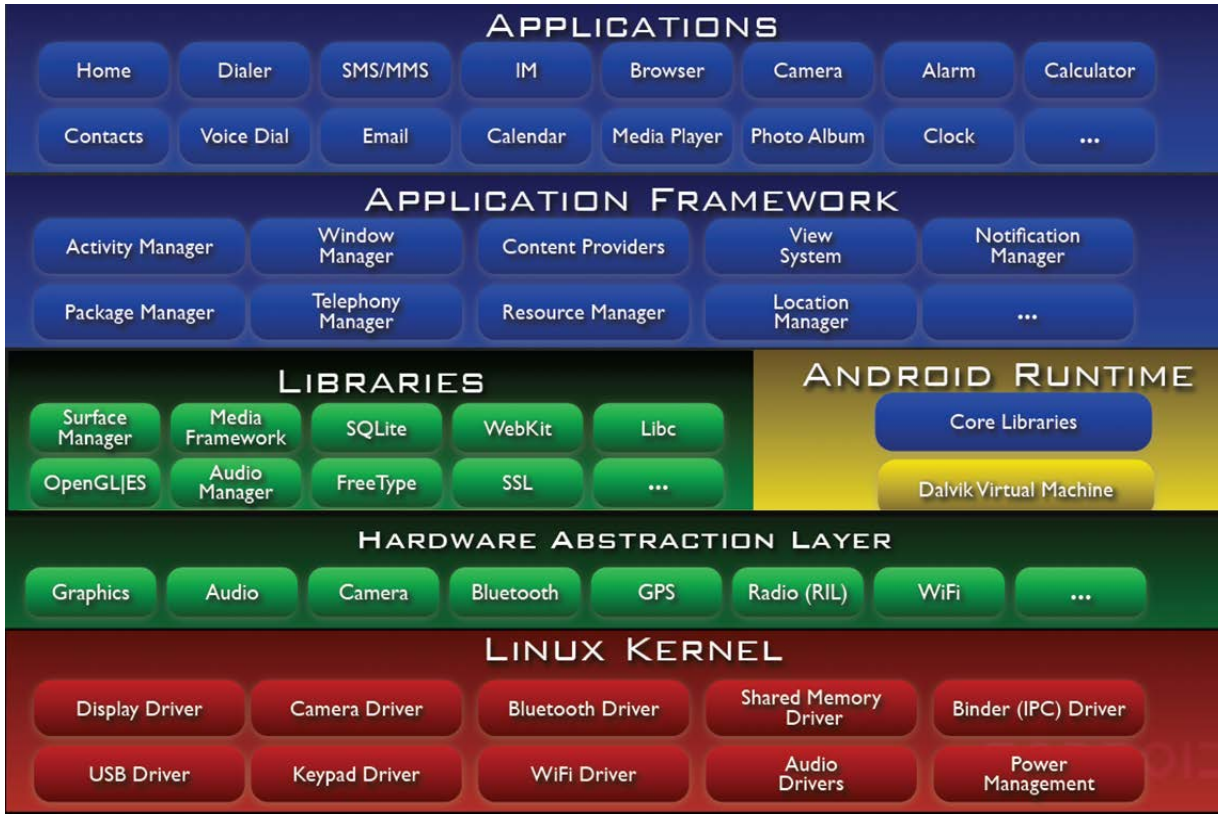
- **Scope** defines the domain & context of Android & its various frameworks & components
- e.g.,
  - Resource-constrained mobile devices
    - e.g., limited power, memory, processors, network, & price points
  - Touch-based user interfaces



- (Largely) open-source, vendor- & hardware-agnostic ecosystem

Applying SCV to Android

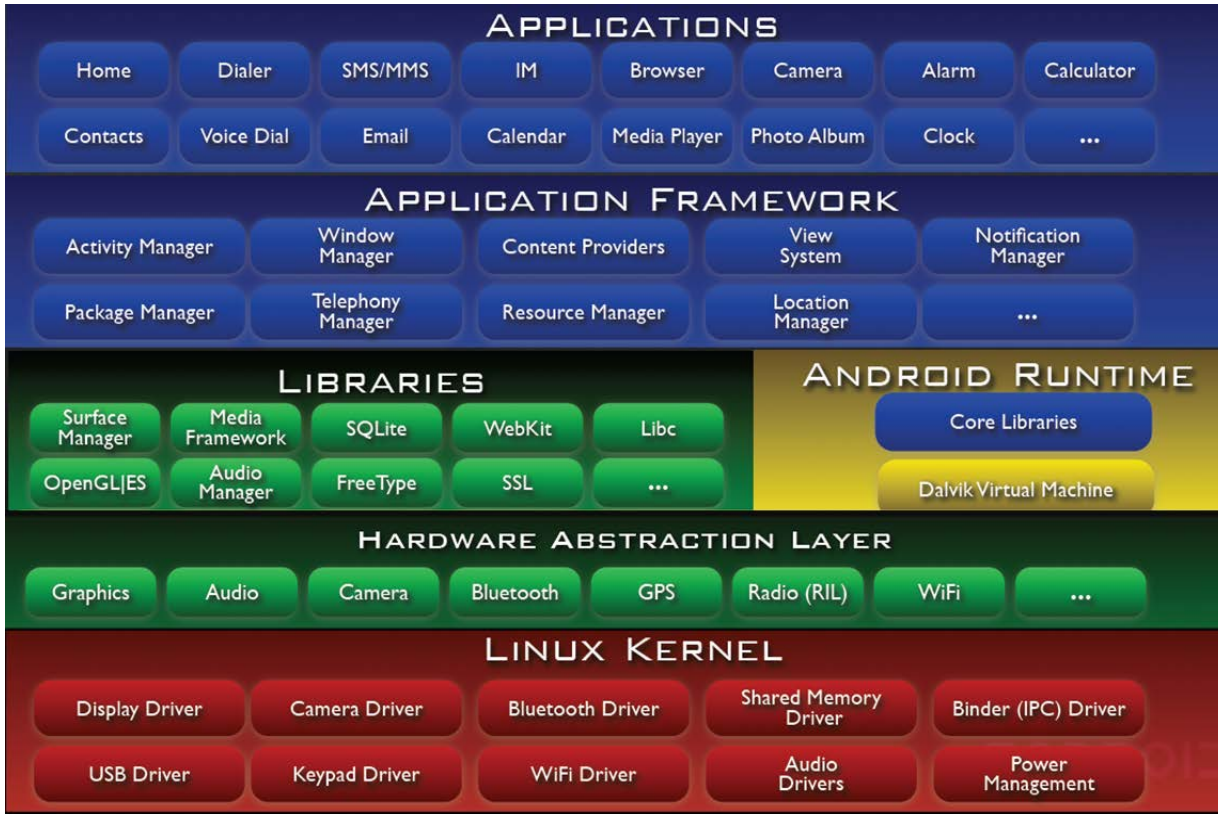
- **Scope** defines the domain & context of Android & its various frameworks & components
- e.g.,
  - Resource-constrained mobile devices
    - e.g., limited power, memory, processors, network, & price points
  - Touch-based user interfaces
  - (Largely) open-source, vendor- & hardware-agnostic ecosystem
  - Focus on installed-base of Java app developers



See developer.android.com for more info on Android

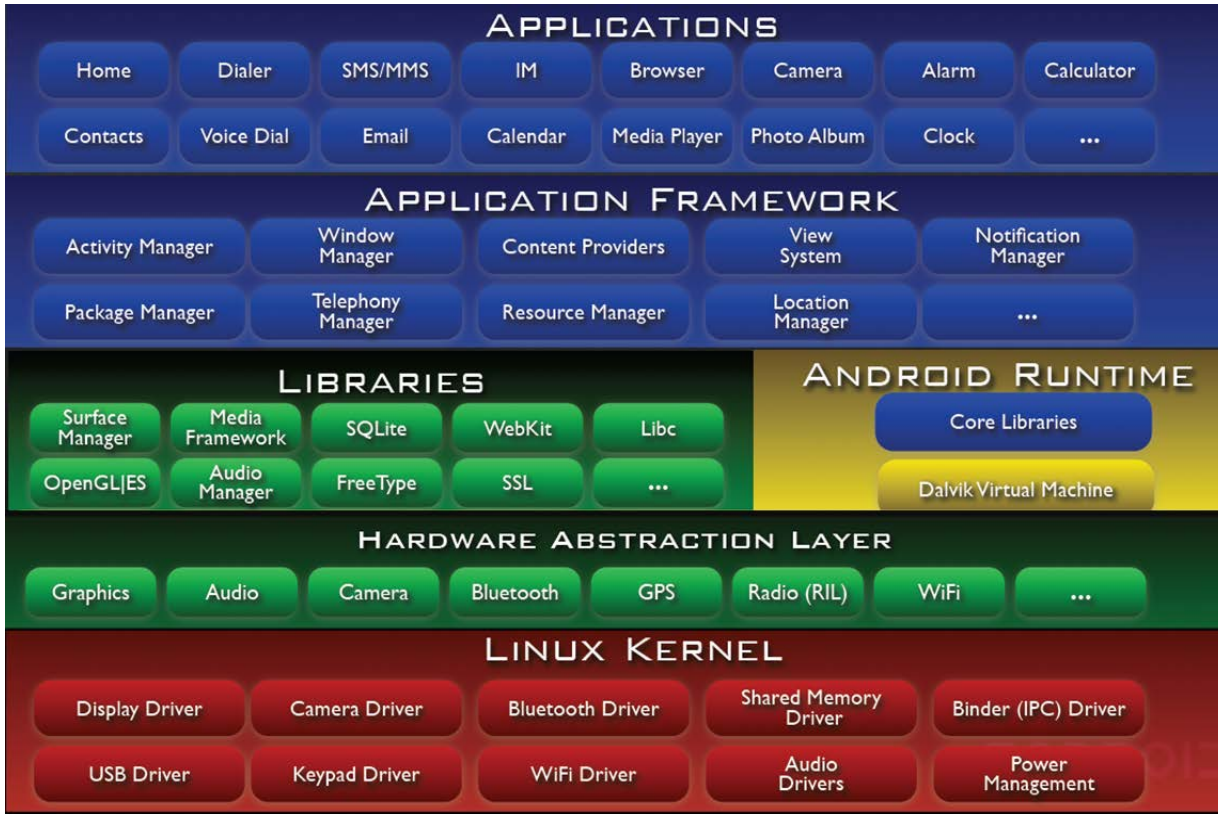
Applying SCV to Android

- **Commonalities** describe the attributes common across all instances of Android
  - *Common framework components*
    - e.g., Activities, Services, Content Providers, & Broadcast Receivers



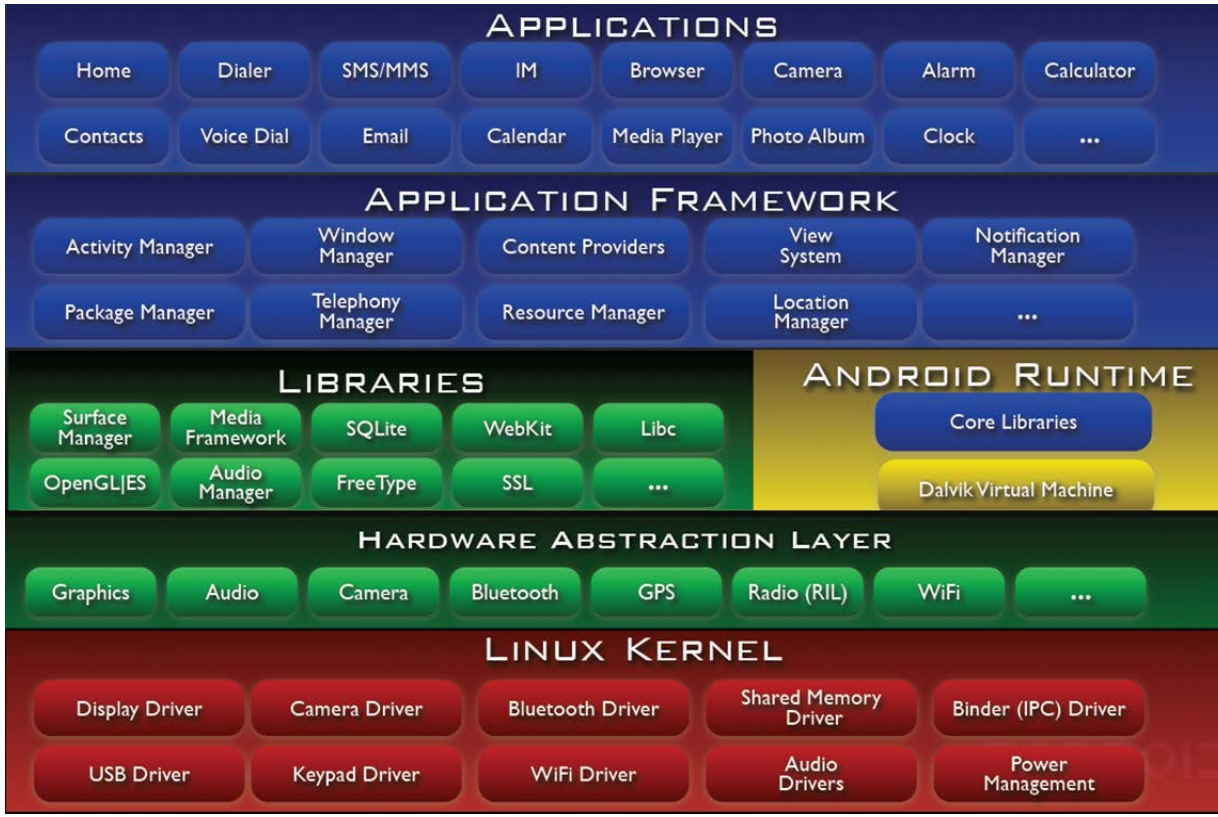
Applying SCV to Android

- **Commonalities** describe the attributes common across all instances of Android
  - *Common framework components*
    - e.g., Activities, Services, Content Providers, & Broadcast Receivers
  - *Common application frameworks*
    - e.g., Activity Manager, Package Manager, Telephony Manager, Location Manager, Notification Manager, etc.



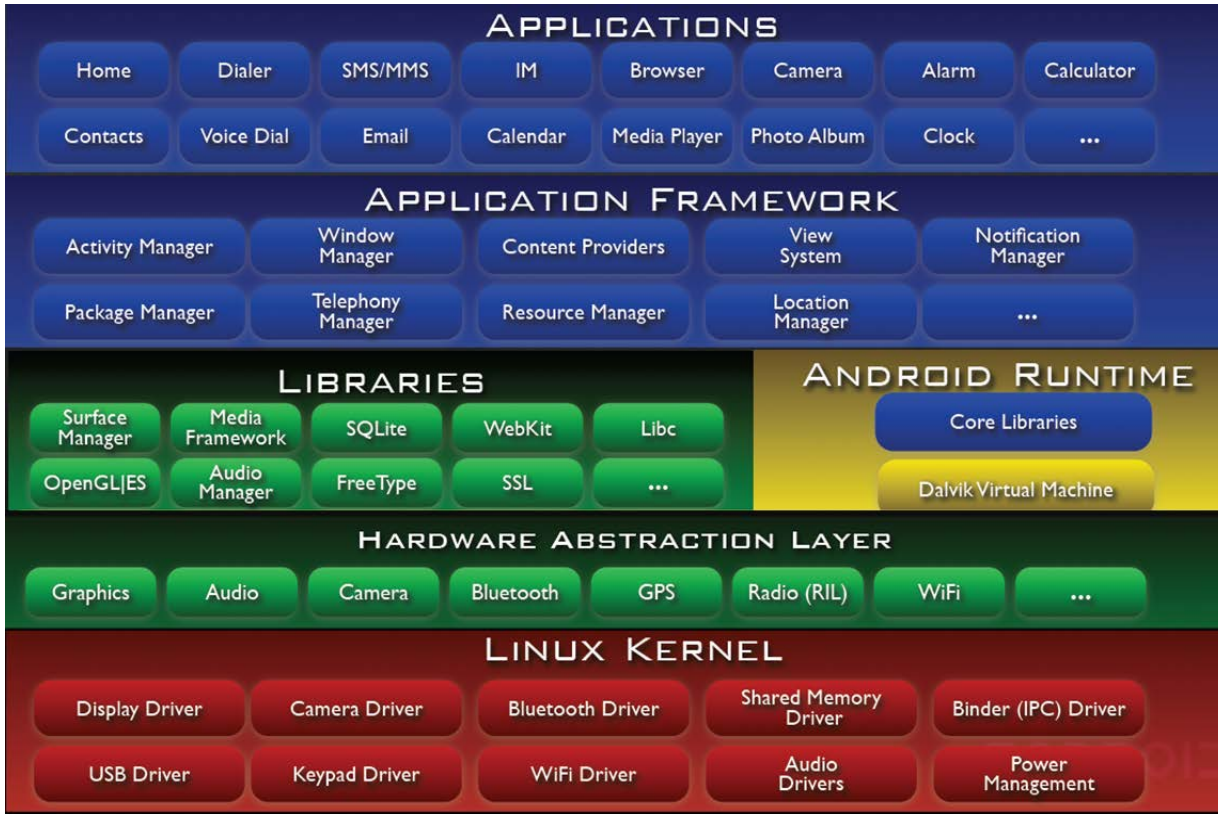
Applying SCV to Android

- **Commonalities** describe the attributes common across all instances of Android
  - *Common framework components*
    - e.g., Activities, Services, Content Providers, & Broadcast Receivers
  - *Common application frameworks*
    - e.g., Activity Manager, Package Manager, Telephony Manager, Location Manager, Notification Manager, etc.
  - *Common infrastructure*
    - e.g., Intent framework, Binder, Webkit, Hardware Abstraction Layer, OS device driver frameworks etc.



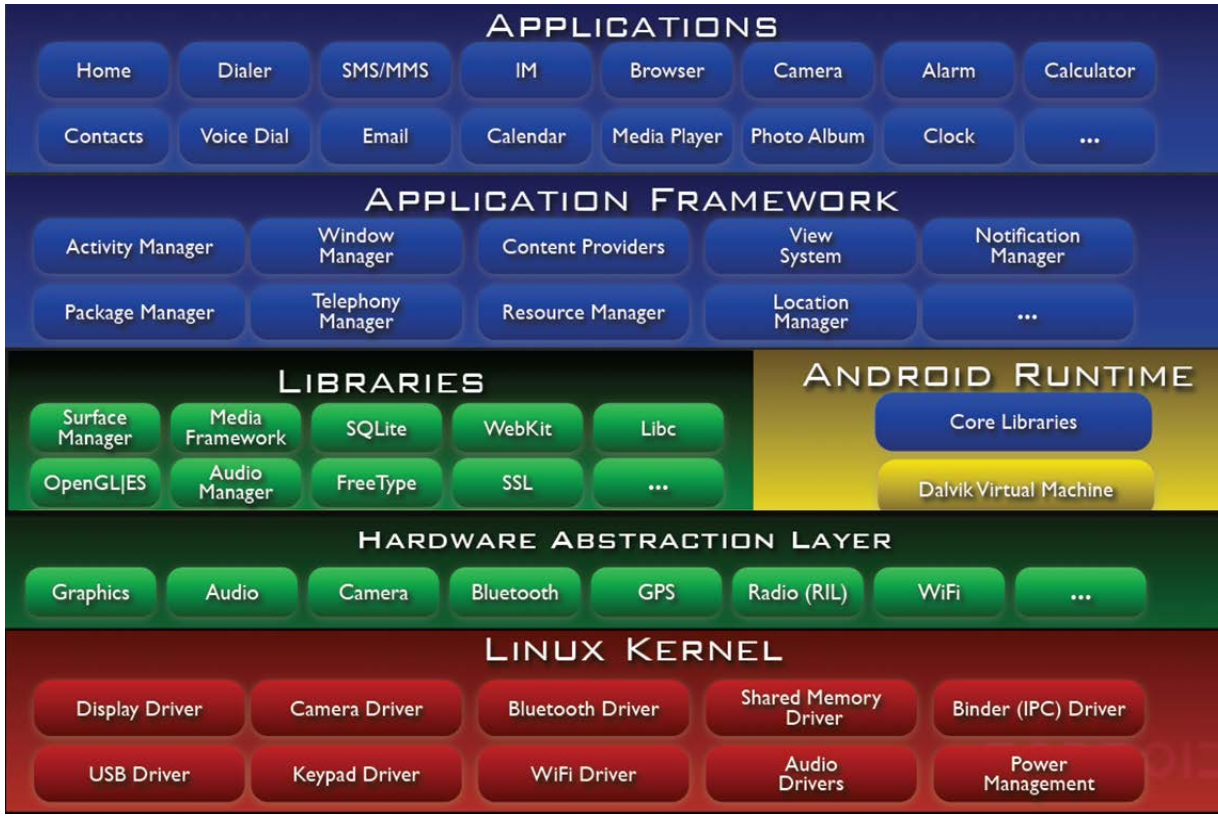
Applying SCV to Android

- **Variabilities** describe the attributes unique to different instantiations of Android
  - *Product-dependent components*
    - e.g., different "look & feel" variants of vendor-specific user interfaces, sensor & device properties, etc.



Applying SCV to Android

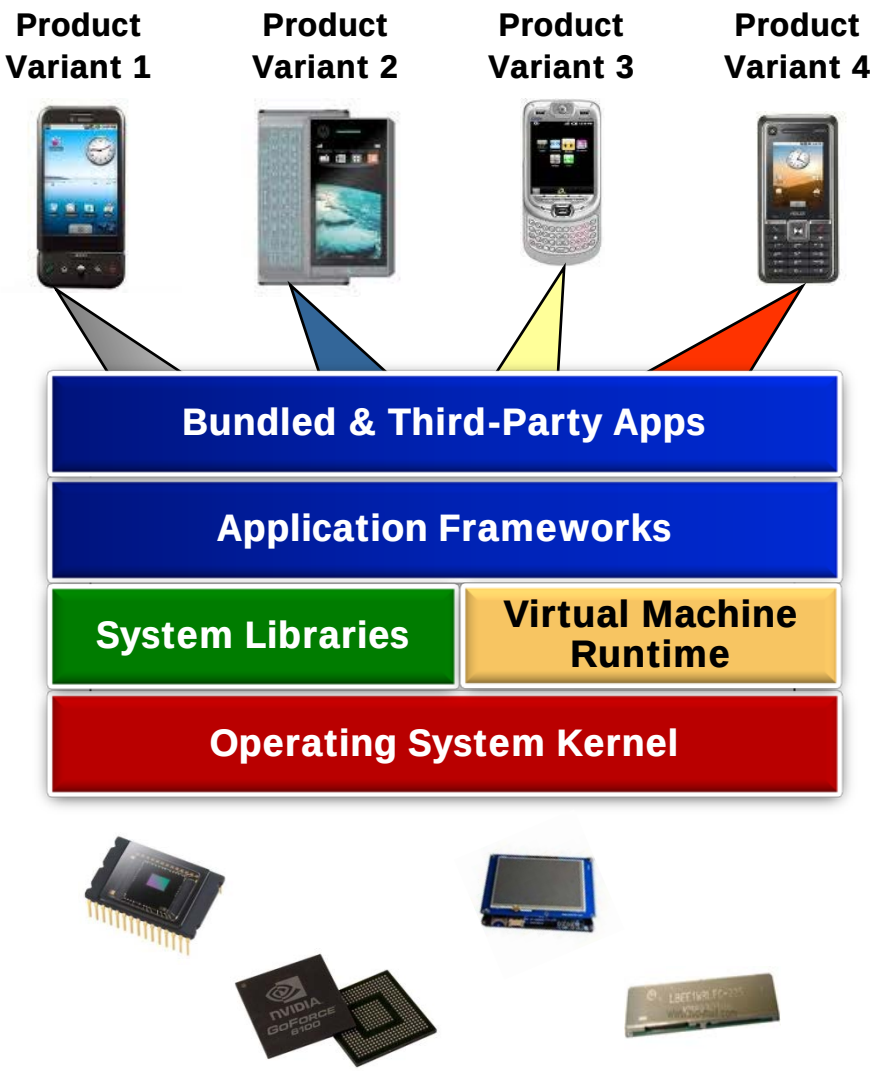
- **Variabilities** describe the attributes unique to different instantiations of Android
  - *Product-dependent components*
    - e.g., different "look & feel" variants of vendor-specific user interfaces, sensor & device properties, etc.
  - *Product-dependent component assemblies*
    - e.g., different bundled apps, CDMA vs. GSM & different hardware, OS, & network/bus configurations, etc.



SCV can also be applied recursively for all the Android frameworks & layers

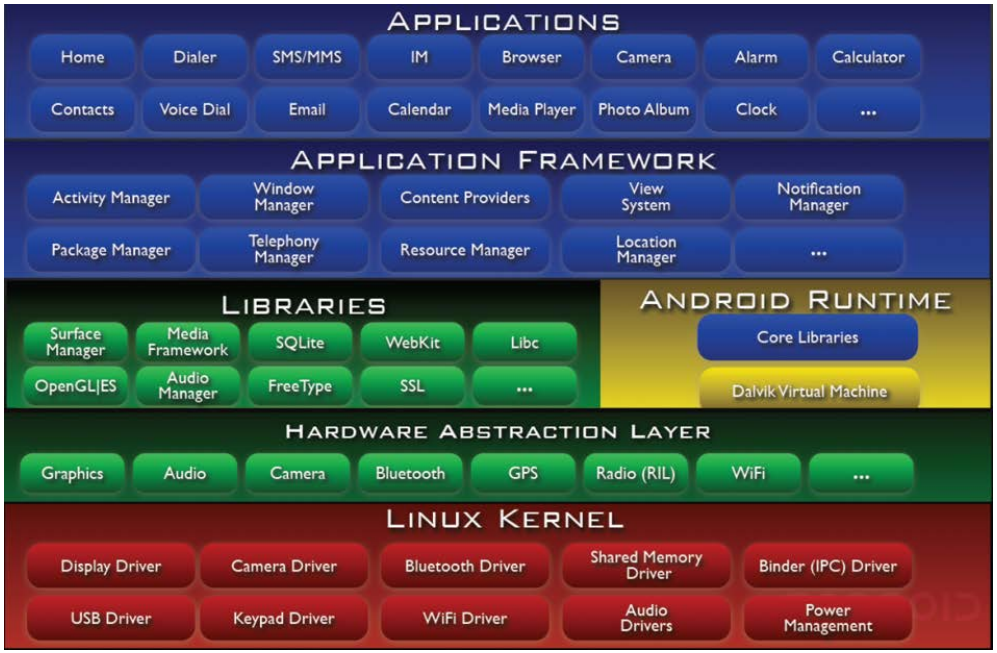
Summary

- *Scope, Commonality, & Variability* (SCV) analysis is an advanced systematic reuse technique
  - It helps developers alleviate problems associated with maintaining many versions of the same product that have large amounts of similar software created to satisfy new & diverse requirements



Summary

- *Scope, Commonality, & Variability* (SCV) analysis is an advanced systematic reuse technique
  - It helps developers alleviate problems associated with maintaining many versions of the same product that have large amounts of similar software created to satisfy new & diverse requirements



- The frameworks in Android form software product-lines that enable systematic software reuse across a wide range of apps & infrastructure platforms