a) A discussion on why you think the clone mechanism is required by the Java language.

b) A discussion and illustration by providing an example on how the clone mechanism is implemented in Java.

c) An explanation about the different options available to developers for implementing cloning when cloning inheritance hierarchies.

d) Some advantages and disadvantages of the clone mechanism.

e) Suggested alternatives to the Java clone mechanism.

Cloning is used in Java if you want to create a copy of an object that you want to modify without affecting the original one. Performing actions on a cloned object should not change the object passed by the caller.

One of the approaches to doing cloning in Java is by using the clone() function. This method is found in the base class Object. However, its access modifier is protected and must be overridden with a child class’s public clone method to be usable. An ArrayList is an example of a Java class that overrides the base class’s protected clone method. Due to this, the clone method can be called from ArrayLists. It should be noted though that the return type of the clone method is an Object and so the returned object must be casted to the intended type:

ArrayList v = **new** ArrayList();

ArrayList v2 = (ArrayList) v.clone();

However, not all Java classes override the clone method of the base class. For example, when the clone() method is called from an Integer type object, an error will be encountered.

Besides overriding the Base class’s protected clone method, super.clone() must also be called inside a class’s public clone method. Since all classes inherit from the Base class, the protected clone method is accessible inside a class and needs to be called to do the actual cloning. The Base’s clone determines the size of an object, reserves the memory needed, and then copies the details from the original to the clone.

Lastly, to do a successful basic clone, the Cloneable interface must be implemented by a class. When the contents of the Cloneable interface is checked though, it is empty and does not contain any methods that are required to be implemented unlike regular interfaces. In a sense, it is just implemented to mark an object as being Cloneable when for example the instance of keyword is used on it. It is useful in letting programmers know if the object they are working on is possible to clone. Also, an object that does not implement the Cloneable interface will return a CloneNotSupportedException when super.clone() is called. The Base class’s clone first checks if the class calling it is Cloneable before doing the cloning. A simple implementation of cloning can be seen below:

**class** ObjectToClone **implements** Cloneable

{

**public** Object clone()

{

Object o = **null**;

**try**

{

o = **super**.clone();

}

**catch** (CloneNotSupportedException e)

{

System.***err***.println("ObjectToClone cannot perform clone");

}

**return** o;

}

}

However, just calling super.clone() is usually not enough if a class has Objects which contain Objects. In this case, a shallow copy is only generated and modifying the Objects inside a clone’s Object fields will still modify the original’s own objects. This can be seen in the following code example. Modifying obj2’s String Array still affects obj1’s.

**class** ObjectToClone **implements** Cloneable

{

**public** String[] value = {"old"};

**public** Object clone()

{

Object o = **null**;

**try**

{

o = **super**.clone();

}

**catch** (CloneNotSupportedException e)

{

System.***err***.println("ObjectToClone cannot perform clone");

}

**return** o;

}

}

**public** **class** ShallowCopyExample

{

**public** **static** **void** main(String[] args)

{

ObjectToClone obj1 = **new** ObjectToClone();

ObjectToClone obj2 = (ObjectToClone)obj1.clone();

obj2.value[0] = "new";

System.***out***.println("obj1.value = " + obj1.value[0] + "\nobj2.value = " + obj2.value[0]);

}

}

To perform a successful clone for the example above, a deep copy must be done. Besides calling super.clone(), the objects inside the class must also be cloned so that their references will be decoupled from the original. Implementing a deep copy on the code results in the following:

**class** ObjectToClone **implements** Cloneable

{

**public** String[] value = {"old"};

**public** Object clone(ObjectToClone o)

{

o = **null**;

**try**

{

o = (ObjectToClone)**super**.clone();

}

**catch** (CloneNotSupportedException e)

{

System.***err***.println("ObjectToClone cannot perform clone");

}

o.value = o.value.clone();

**return** o;

}

}

**public** **class** ShallowCopyExample

{

**public** **static** **void** main(String[] args)

{

ObjectToClone obj1 = **new** ObjectToClone();

ObjectToClone obj2 = (ObjectToClone)obj1.clone(obj1);

obj2.value[0] = "new";

System.***out***.println("obj1.value = " + obj1.value[0] + "\nobj2.value = " + obj2.value[0]);

}

}

successful clone for the example above, a deep copy must be done. Besides calling super.clone(), the objects inside the class must also be cloned so that their references will be decoupled from the original. Implementing