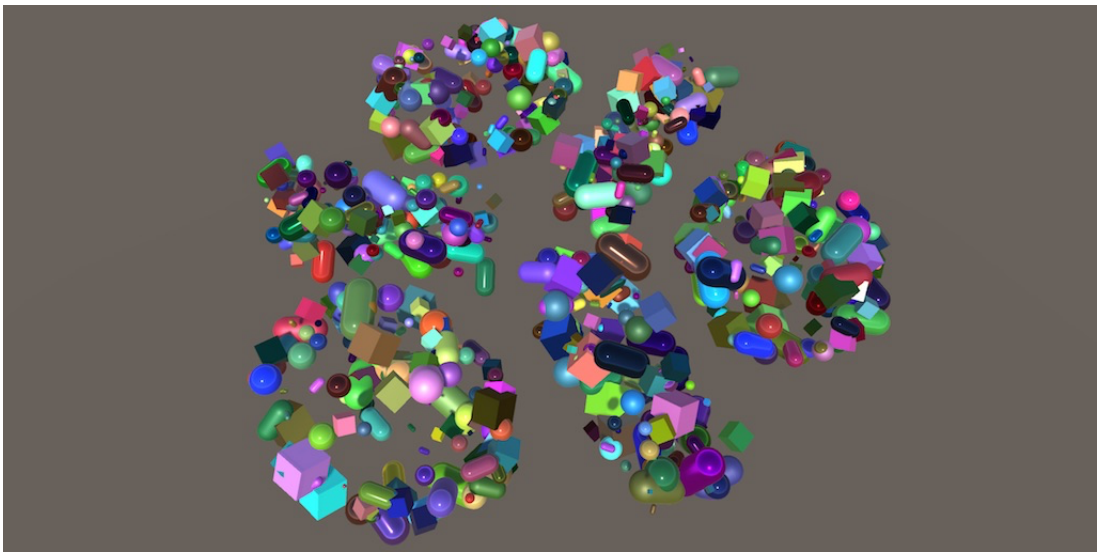
Spawn Zones Level Variety

Create a spawn zone and transform it.
Use gizmos to visualize spawn zones.
Support a different spawn zone per scene.
Connect objects from different scenes.
Create multiple spawn zone types.

This is the fifth tutorial in a series about Object Management. It's about making objects spawn in more varied patterns, configurable per level.

This tutorial is made with Unity 2017.4.4f1.



Create big shapes by spawning little shapes.

1 Spawn Points

Our simple game is about spawning random shapes. The material and color of each shape are randomly chosen, and so are its position, rotation, and scale. Although the spawn points are randomized, they are constrained to a spherical region with a radius of five units, centered on the world origin. Once enough objects have been spawned, they will form a recognizable sphere. This is the spawn zone that we have hard-coded into our game.

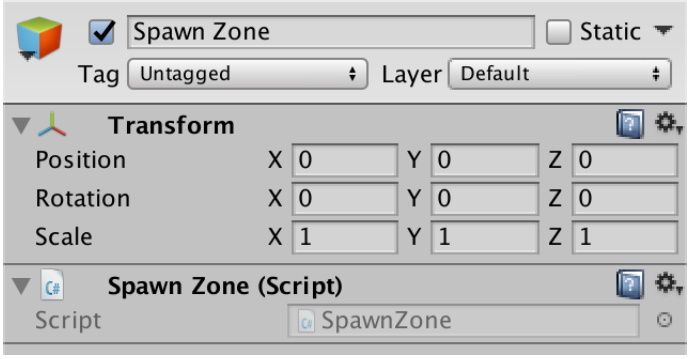
We do not have to restrict ourselves to a single spawn zone. We could make it possible for shapes to spawn in different configurations. To do so, we have to replace our fixed code with a configurable spawn zone.

1.1 Spawn Zone Component

Create a new `SpawnZone` component type. Its only purpose it to provide spawn points, so give it a `Vector3 SpawnPoint` property. This provides a way to get points—not to set them—so it only needs a `get` block. That makes it a getter-only or readonly property. We'll begin by still returning a random point inside a sphere with a radius of five units.

```
using UnityEngine;

public class SpawnZone : MonoBehaviour {

	public Vector3 SpawnPoint {
		get {
			return Random.insideUnitSphere * 5f;
		}
	}
}
```

Add a *Spawn Zone* game object to the main scene and attach the new component to it. We now have a spawn zone in the game, but nothing's using it yet.



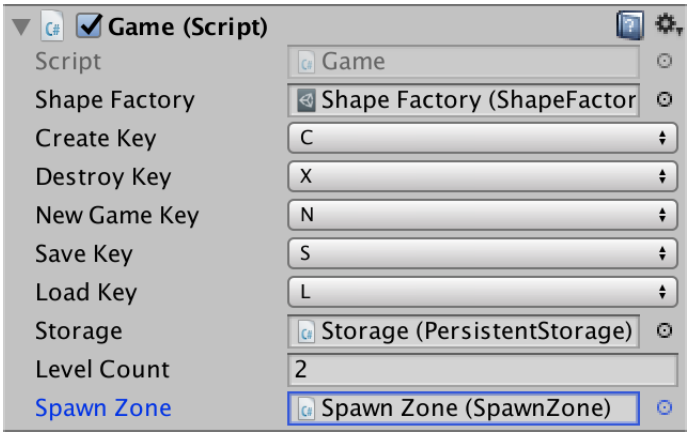
Spawn zone object.

1.2 Using the Zone

The next step is to have `Game` retrieve its spawn points from the separate spawn zone. Add a public field for that and use it in `CreateShape` to get a spawn point.

```
	public SpawnZone spawnZone;

	…

	void CreateShape () {
		Shape instance = shapeFactory.GetRandom();
		Transform t = instance.transform;
		//t.localPosition = Random.insideUnitSphere * 5f;
		t.localPosition = spawnZone.SpawnPoint;
		…
	}
```

Connect the spawn zone via the inspector. Although the game still behaves the same, it now relies on the *Spawn Zone* object.



Spawn zone reference.

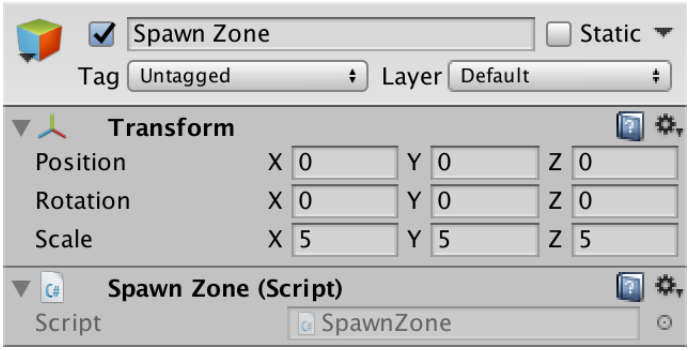
1.3 Transforming the Zone

Because the spawn zone is part of a game object, we can move it around. To have that influence the spawn points, add the object's position to the random point. By using the `position` property of the `Transform` component instead of `localPosition`, it's possible to make the spawn zone a child of another object. That way the spawn zone could be attached to something else, which might be moving.

```
	public Vector3 SpawnPoint {
		get {
			return Random.insideUnitSphere * 5f + transform.position;
		}
	}
```

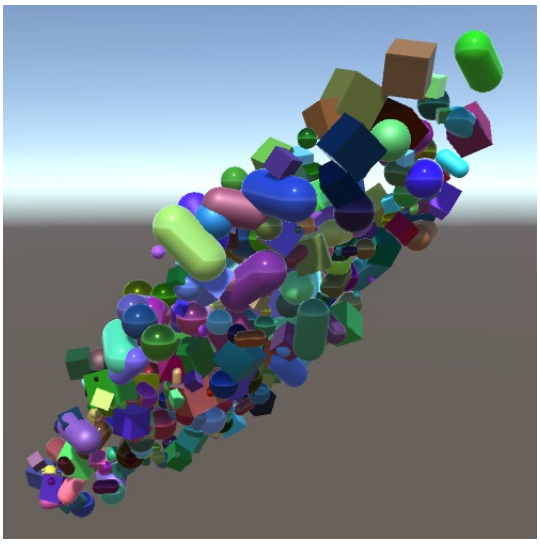
We can go a step further and apply the entire transformation of the game object hierarchy to the spawn point. Then we can also rotate and scale the zone. To do this, invoke the `TransformPoint` method of the zone's `Transform` component, with the random point as an argument. We can now do away with the multiplication by five, instead controlling the zone's radius by setting its object's scale.

```
		//return Random.insideUnitSphere * 5f + transform.position;
		return transform.TransformPoint(Random.insideUnitSphere);
```



Spawn zone scaled to five units.

This also makes it possible to deform the sphere, by using a nonuniform scale.



Spawn zone with 45° Z rotation and scale (10, 2, 5).

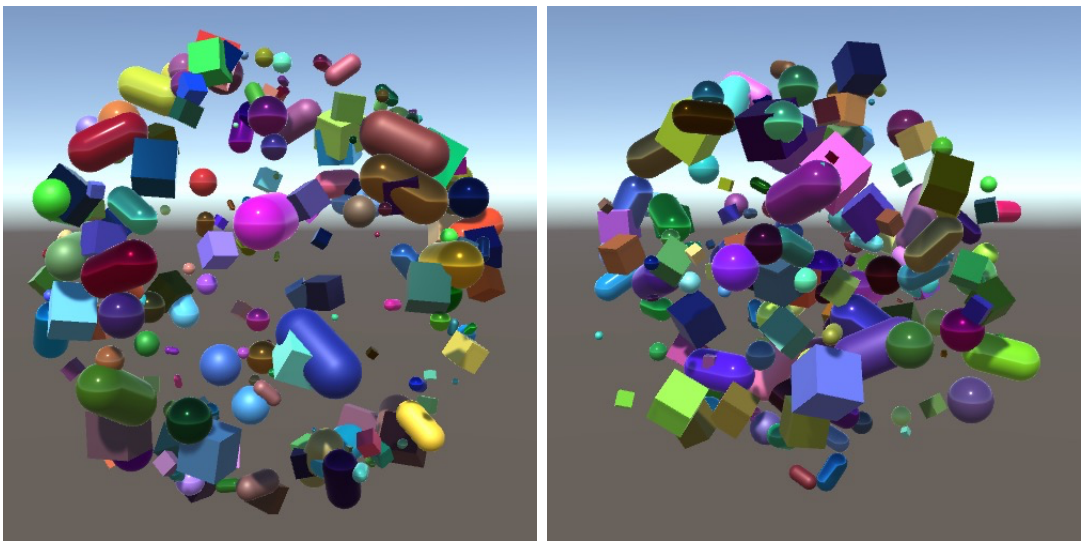
1.4 Surface Only

We don't have to pick a spawn point inside the sphere's radius. It is also possible to get a point on the sphere's surface, by using `Random.onUnitSphere` instead of `Random.insideUnitSphere`. Let's make that an option, by adding a `surfaceOnly` toggle field to the zone.

```
	[SerializeField]
	bool surfaceOnly;

	public Vector3 SpawnPoint {
		get {
			return transform.TransformPoint(
				surfaceOnly ? Random.onUnitSphere : Random.insideUnitSphere
			);
		}
	}
```

Spawning only on the zone's surface.

Spawning only on the surface makes the shape of the sphere more obvious.



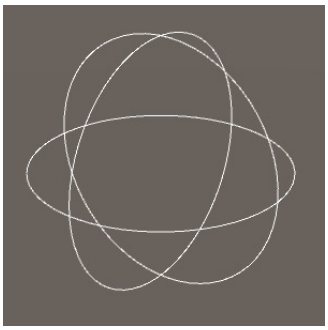
Surface-only vs. volume.

1.5 Zone Visualization

Now that it is possible to adjust the spawn zone, it would be helpful if we could see its shape, without having to spawn lots of points. We can draw a visual aid in the scene view, by adding a `void OnDrawGizmos` method to `SpawnZone`. This is a special Unity method that gets invoked each time the scene window is drawn.

Inside `OnDrawGizmos`, invoke `Gizmos.DrawWireSphere` to draw a wire representation of a sphere, which renders three circles. We have to supply it with a position and radius, for which we'll use the zero vector and 1, describing the unit sphere.

```
	void OnDrawGizmos () {
		Gizmos.DrawWireSphere(Vector3.zero, 1f);
	}
```



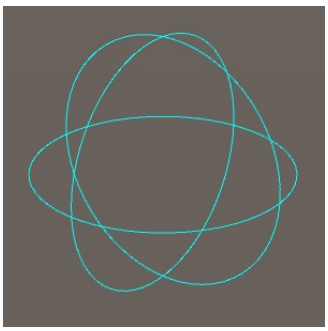
Gizmo wire sphere.

Can we also see the gizmos in the game window?

Yes, there is a *Gizmos* option for that on the right side of the game window's toolbar. This applies to the editor only, the gizmos are not included in builds.

The default gizmo color is white, but you can use a different color by changing the `Gizmos.color` property. This helps to differentiate it from other gizmos. Let's use cyan for our spawn zone gizmo.

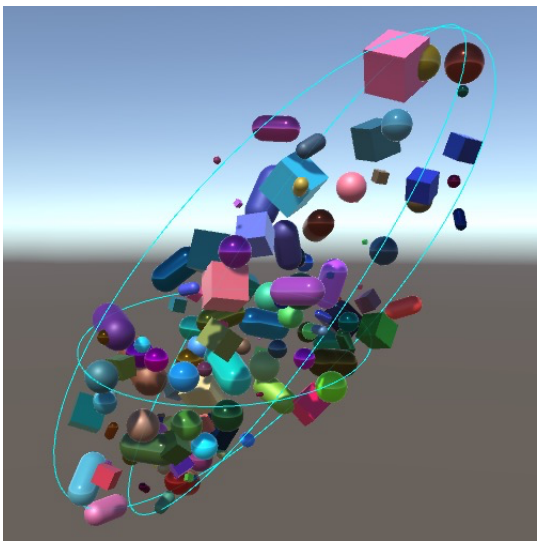
```
	void OnDrawGizmos () {
		Gizmos.color = Color.cyan;
		Gizmos.DrawWireSphere(Vector3.zero, 1f);
	}
```



Colored gizmo.

Currently, our wire sphere is drawn at the origin with a radius of one, regardless of the zone's transformation. The gizmos are drawn in world space by default. To change this, we have to indicate which transformation matrix should be used instead, via the `Gizmos.matrix` property. We can get the required matrix via the `localToWorldMatrix` property of our zone's `Transform` component.

```
	void OnDrawGizmos () {
		Gizmos.color = Color.cyan;
		Gizmos.matrix = transform.localToWorldMatrix;
		Gizmos.DrawWireSphere(Vector3.zero, 1f);
	}
```



Transformed gizmo, with spawned shapes.

Do we have to reset the gizmo color and matrix?

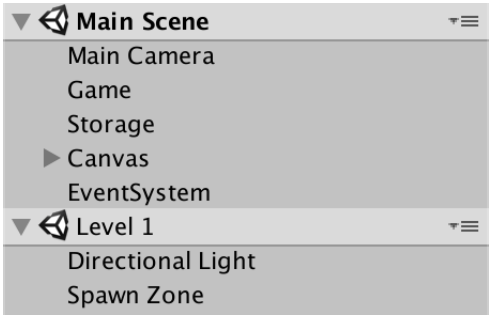
No, they are reset automatically.

2 A Zone per Level

Now that we can configure spawn zones, the next step is to make it possible for each level to have its own spawn zone.

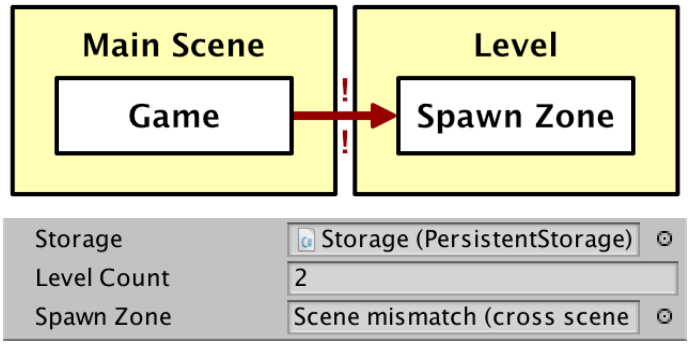
2.1 Migrating to a Different Scene

We can move objects between open scenes via dragging in the hierarchy window. Do this with the *Spawn Zone* object, moving it from *Main Scene* to *Level 1*.



Level 1 with a spawn zone.

The zone is now part of the level, but Unity warns us that it detected a cross-scene reference. Unfortunately, direct references between objects in different scenes cannot be saved, because the scenes might not be open at the same time. Currently, the spawn zone reference of *Game* indicates a scene mismatch, and after a save or play it will be cleared.



Scene mismatch.

Game needs a reference to a spawn zone, but because we now store it in a different scene we cannot save such a reference. The simplest change would then be to replace the `spawnZone` field with a public property. Let's explicitly name it `SpawnZoneOfLevel`, to indicate that it isn't part of the main scene, but of a level scene.

```
	//public SpawnZone spawnZone;
	public SpawnZone SpawnZoneOfLevel { get; set; }

	…

	void CreateShape () {
		Shape instance = shapeFactory.GetRandom();
		Transform t = instance.transform;
		t.localPosition = SpawnZoneOfLevel.SpawnPoint;
		…
	}
```

2.2 Finding the Game

Someone needs to set the `SpawnZoneOfLevel` property. This can only be done after a level has been loaded. Indeed, it has to be done each time a level has been loaded, because each must have its own spawn zone. The question is who is responsible for this.

Although `Game` controls the loading of levels, it doesn't have direct access to the level contents. It would need to retrieve the root objects of the level scene and then search for the correct object. Alternatively, we can make it the responsibility of the level to set the `SpawnZoneOfLevel` property after it has been loaded. Let's do that.

In order to set `SpawnZoneOfLevel`, the level must first somehow get a reference to the *Game* object in the main scene. There is only a single `Game` instance, so we can store a reference to it in a static `Instance` property of the `Game` class. Everyone is allowed to get this reference, but only `Game` is allows to set it. This is an example of the singleton design pattern.

```
	public static Game Instance { get; private set; }
```

When our game instance awakens, it should assign itself to the `Instance` property. An object can get a reference to itself via the `this` keyword.

```
	void Awake () {
		Instance = this;
	}
```

Shouldn't we enforce only one singleton instance ever exists?

In general, that might be a good idea. But in our specific case we only have a single `Game` component instance in the main scene, which is loaded exactly once and never unloaded. If this were not the case then we'd have either made a mistake while editing scenes, or loaded the main scene more than once.

While this works when entering play mode and in builds, the static property doesn't persist between compilation while in play mode in the editor, because it isn't part of Unity's game state. To recover from recompilation, we can set the property in `OnEnable` instead. That method gets invoked by Unity each time the component gets enabled, which also happens after each recompile.

```
	//void Awake () {
	void OnEnable () {
		Instance = this;
	}
```

When does `OnEnable` get invoked exactly?

It gets invoked each time a disabled component is enabled. In case of a recompilation while in play mode, all active components are disabled first, then the game state is saved, compilation happens, the game state is restored, and previously active components are enabled again. Yes, there is also an `OnDisable` method, and indeed it gets invoked right before a recompilation.

Also, `OnEnable` gets invoked immediately after a component's `Awake` method, unless the component was saved in a disabled state. We'll make use of this fact later.

Note that `OnEnable` also gets invoked after a level change, because we're temporarily disabling `Game` when loading a level. This isn't a problem, because we end up replacing the old reference with the same reference.

As we now depend on other code to access `Game`, it is a good idea to properly hide its configuration fields. Instead of using public fields, use serialized private fields instead, like we already do for the factory and spawn zone.

```
	//public ShapeFactory shapeFactory;
	[SerializeField] ShapeFactory shapeFactory;
	…
```

I've only shown the change for `shapeFactory`, but do the same for the key configuration fields, storage, and level count. Usually attributes are placed above whatever they apply to, but because there are a lot of fields I've put them on the same line in this case.

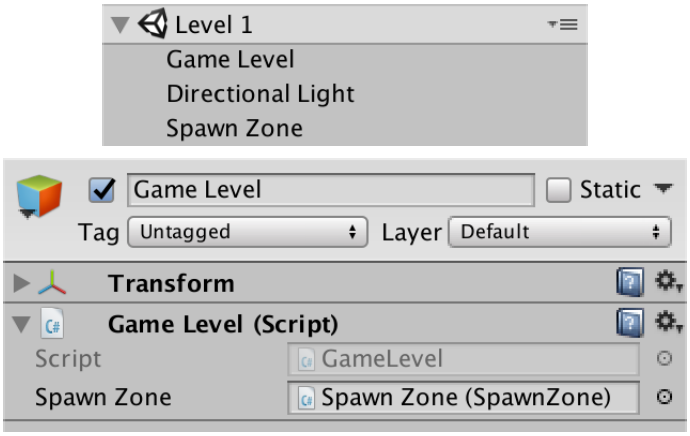
2.3 Game Level

To have a level connect the spawn zone, we need to add code to do this. While we could add this functionality to `SpawnZone`, that class should ideally be dedicated to spawn zones and not be responsible for anything else. It shouldn't need to know about the rest of the game. So we'll create a new `GameLevel` component type to set things up. It needs to know which spawn zone to use, so give it a configuration field for that. Then when it becomes active, have it grab the globally available `Game.Instance` property. It can use that to set the `SpawnZoneOfLevel` property of *Game*.

We'll make the connection in `Start`, so it happens after the level has been loaded. Also, when entering play mode in the editor the currently active scene is loaded first. By waiting until `Start`, we guarantee that `Game.OnEnable` has already executed and set `Game.Instance`, even if *Main Scene* wasn't the active scene.

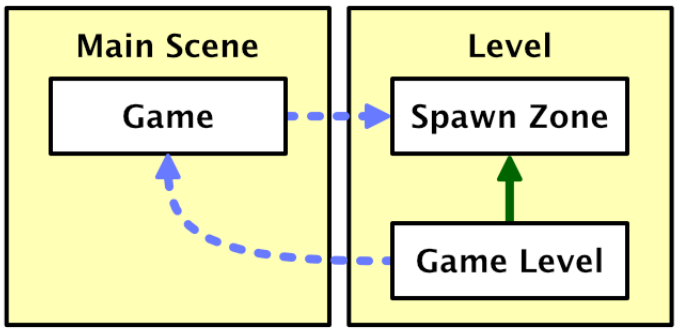
```
using UnityEngine;

public class GameLevel : MonoBehaviour {

	[SerializeField]
	SpawnZone spawnZone;

	void Start () {
		Game.Instance.SpawnZoneOfLevel = spawnZone;
	}
}
```

Add a game object with this component to the level scene and connect it to the spawn zone.



Game level object.

This means that the *Game Level* object holds a saved reference to the *Spawn Zone* object, which is allowed because both exist in the same scene. When the game is playing, *Game Level* will grab a temporary reference to *Game* via `Game.Instance`, which it uses to give *Game* a temporary reference to *Spawn Zone*. So `GameLevel` hooks things up and is aware of both `Game` and `SpawnZone`. In turn, `Game` is only aware of `SpawnZone`. Finally, `SpawnZone` doesn't know about the other two at all.



Object references, dashed lines only while playing.

Is this the best way to design the dependencies?

There isn't a universal best way to design it. In our case, we adapted the existing `spawnZone` reference of **`Game`** and made it a property, introducing the **`GameLevel`** object to connect things. We also could've gone in the other direction and made **`GameLevel`** available via a static property, which **`Game`** would use to reach the spawn zone. Or give **`Game`** a **`GameLevel`** property instead of a **`SpawnZone`** one, through which is could access the spawn zone indirectly.

The current approach works fine because the only purpose of **`GameLevel`** is to connect the spawn zone to the game. If **`GameLevel`** gains more responsibilities or connections, we'll likely have to adjust our design. Such code changes are part of the development process, so I also include them my tutorials.

Also give *Level 2* its own *Spawn Zone* and *Game Level* object. The game will work as before, but now you can adjust the spawn zones per level.

3 Zone Types

Because spawn zones have their own class, it is now possible to extend it and create other zone types. For example, besides a sphere zone we could also add support for a cube zone.

3.1 Absctract Spawn Zone

No matter the specific spawn zone type, their common functionality is that of providing spawn points. The `SpawnZone` class defines this basis. Remove all code specific to the sphere zone, leaving only the default definition of the `SpawnPoint` property.

```
public class SpawnZone : MonoBehaviour {

	//[SerializeField]
	//bool surfaceOnly;

	public Vector3 SpawnPoint { get; }
	//	get {
	//		return transform.TransformPoint(
	//			surfaceOnly ? Random.onUnitSphere : Random.insideUnitSphere
	//		);
	//	}
	//}

	//void OnDrawGizmos () {
	//	…
	//}
}
```

This defines the abstract functionality of a spawn zone. To make that explicit, mark the class with the `abstract` keyword, and the property as well.

```
public abstract class SpawnZone : MonoBehaviour {

	public abstract Vector3 SpawnPoint { get; }
}
```

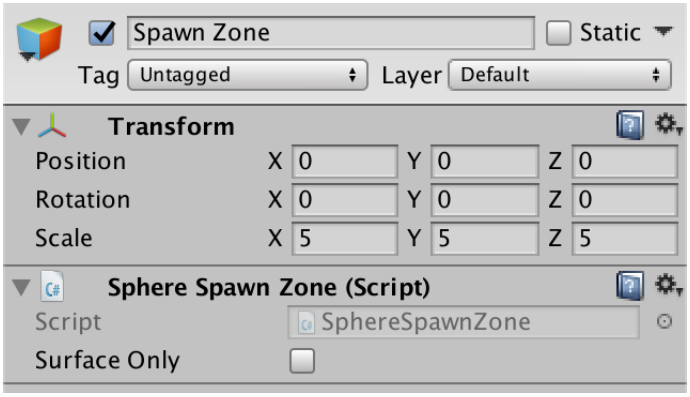
`SpawnZone` is now an abstract type, a class of which no instance can be created. As a consequence, Unity will complain that our spawn zone components have become invalid. We'll have to replace them with specific subclasses.

3.2 Sphere Zone

First, we'll recreate our spherical spawn zone component, but now as a new `SphereSpawnZone` type that extends `SpawnZone`. The only other difference with the old code is that we have to indicate that it overrides the abstract `SpawnPoint` property with a concrete implementation. This must be made explicit by adding the `override` keyword to it.

```
using UnityEngine;

public class SphereSpawnZone : SpawnZone {

	[SerializeField]
	bool surfaceOnly;

	public override Vector3 SpawnPoint {
		get {
			return transform.TransformPoint(
				surfaceOnly ? Random.onUnitSphere : Random.insideUnitSphere
			);
		}
	}

	void OnDrawGizmos () {
		Gizmos.color = Color.cyan;
		Gizmos.matrix = transform.localToWorldMatrix;
		Gizmos.DrawWireSphere(Vector3.zero, 1f);
	}
}
```

Adjust the *Spawn Zone* object of the *Level 1* scene so it uses this component. Also restore the reference of *Game Level*, which got lost when `SpawnZone` became an invalid component. *Level 2* needs to be fixed as well.



Sphere zone.

3.3 Cube Zone

Next, also create a cube spawn zone type, named `CubeSpawnZone`. Start with the minimal functionality of a spawn zone, with is just a `SpawnPoint` property that returns the zero vector.

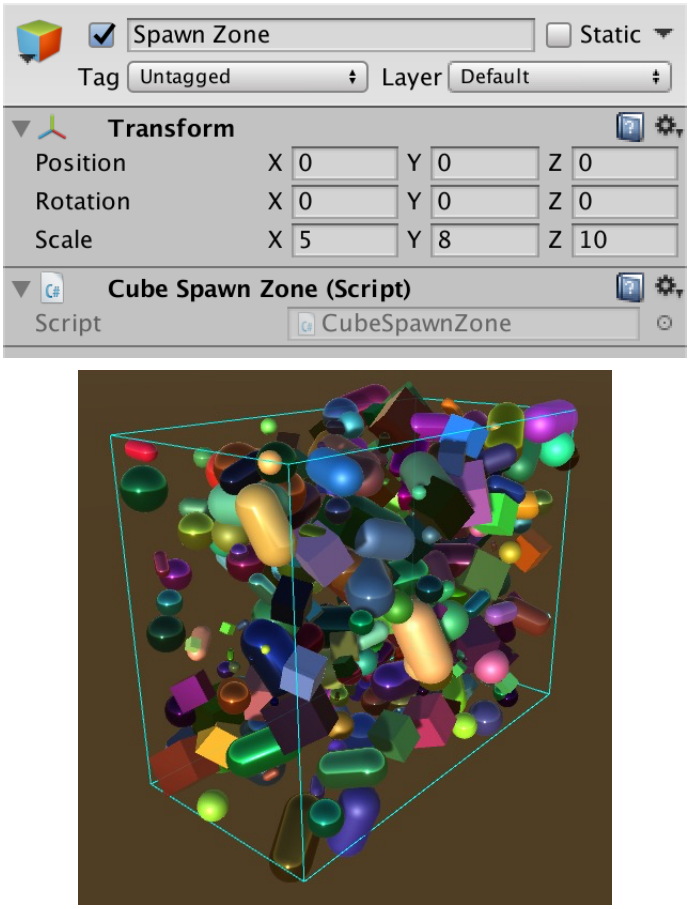
```
using UnityEngine;

public class CubeSpawnZone : SpawnZone {

	public override Vector3 SpawnPoint {
		get {
			return Vector3.zero;
		}
	}
}
```

There is no convenient `Random.insideUnitCube` property, so we have to construct the random point ourselves. A unit cube is centered on the origin and has an edge length of one unit. So its volume extends by half a unit in both directions in each dimension. To get a random point inside this space, we can invoke `Random.Range(-0.5f, 0.5f)` for each of the three vector coordinates separately, then transform the resulting point.

```
	public override Vector3 SpawnPoint {
		get {
			Vector3 p;
			p.x = Random.Range(-0.5f, 0.5f);
			p.y = Random.Range(-0.5f, 0.5f);
			p.z = Random.Range(-0.5f, 0.5f);
			return transform.TransformPoint(p);
		}
	}
```

There is a `Gizmos.DrawWireCube` method, so we can use that to display a gizmo for our cube zone. Its first parameter is the cube's center, while the second is its edge length.

```
	void OnDrawGizmos () {
		Gizmos.color = Color.cyan;
		Gizmos.matrix = transform.localToWorldMatrix;
		Gizmos.DrawWireCube(Vector3.zero, Vector3.one);
	}
```



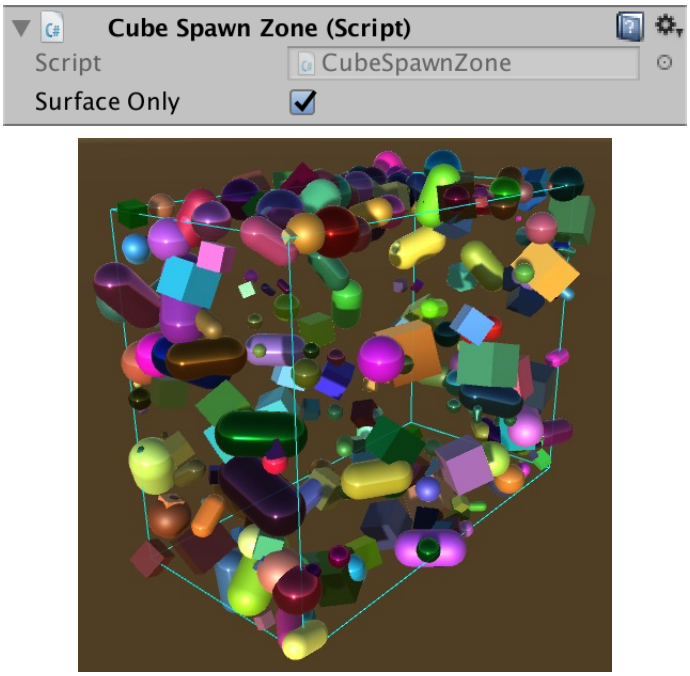
Scaled cube zone, in level 2.

Let's also add a surface-only option for our cube zone. When enabled, we have to adjust the spawn point so it ends up on one of the faces of the cube. We can do that by beginning with a random point inside the cube and then moving it along one axis until it aligns with a face. The index of the axis can be chosen randomly.

```
	[SerializeField]
	bool surfaceOnly;

	public override Vector3 SpawnPoint {
		get {
			Vector3 p;
			p.x = Random.Range(-0.5f, 0.5f);
			p.y = Random.Range(-0.5f, 0.5f);
			p.z = Random.Range(-0.5f, 0.5f);
			if (surfaceOnly) {
				int axis = Random.Range(0, 3);
			}
			return transform.TransformPoint(p);
		}
	}
```

It is possible to access a `Vector3` value with this index as if it were an array, getting or setting its corresponding coordinate. This way, we can align that component with either the positive or negative face along the axis. We can use the original coordinate to decide which side to pick. If it's negative, we'll move it to the negative face, otherwise to the positive face. That shifts the point to the nearest of the two faces.

```
			int axis = Random.Range(0, 3);
			p[axis] = p[axis] < 0f ? -0.5f : 0.5f;
```



Cube surface only.

3.4 Composite Zone

Finally, let's create a composite spawn zone type, which is defined by a collection of other spawn zones. That makes it possible to create more complex zones, consisting of multiple separate and possibly overlapping regions.

Add a `CompositeSpawnZone` class, have it extend `SpawnZone`, and give it a `spawnZones` array field.

```
using UnityEngine;

public class CompositeSpawnZone : SpawnZone {

	[SerializeField]
	SpawnZone[] spawnZones;
}
```

Its `SpawnPoint` property picks a random index from the zones array, then uses that zone's property to get the spawn point.

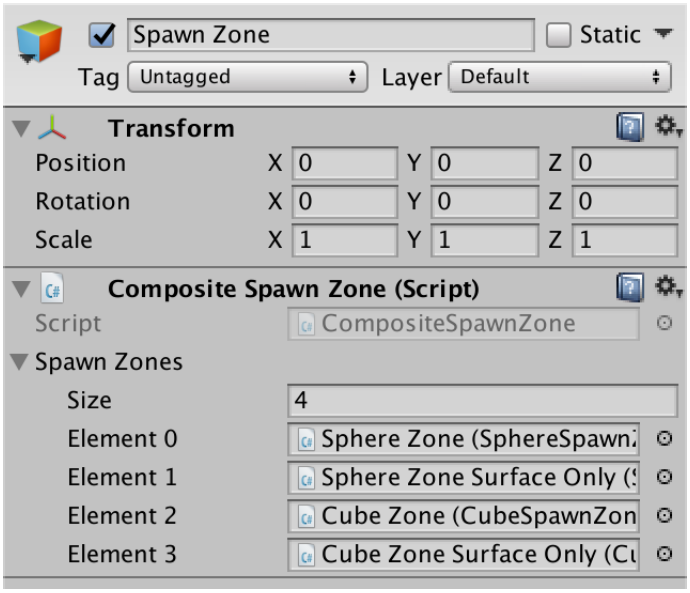
```
	public override Vector3 SpawnPoint {
		get {
			int index = Random.Range(0, spawnZones.Length);
			return spawnZones[index].SpawnPoint;
		}
	}
```

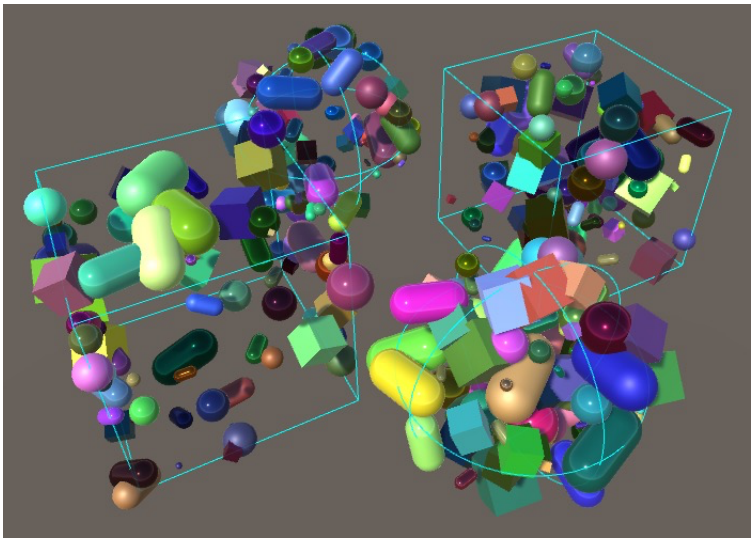
Shouldn't we check whether the array is empty?

You could do that. You could also check whether the array even exists, because it will be `null` if the component got created while in play mode. But the idea is that we design spawn zones in edit mode, making sure that they're correct before entering play mode or making a build. So we don't need to worry about what to do when a composite spawn zone is empty. Leaving one empty would be a mistake, and Unity will log an error when trying to retrieve a nonexistent array index.

Create a *Level 3* scene to try out our new composite spawn zone. Make sure that it also has a *Game Level* object that gets a reference to the spawn zone, bake its lighting, and include it in the build settings.

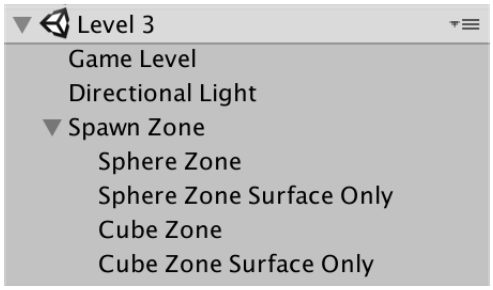
To make the composite zone work, we'll have to create some more zones of different types. For example, create two sphere zones and two cube zones, a solid and a surface-only version of each, so you can see them all at the same time. Drag these four zones onto the *Spawn Zones* array field of the composite zone. A quick way to do this is to lock the inspector while the composite zone is selected, by clicking on the lock icon at the top right of the inspector window. Then select the four other zones and drag the whole selection onto the array. After that, unlock the inspector.





Composite zone, showing all supported types.

The zones that are part of the composite zone can be anywhere in the same scene. They don't have to be children of the composite zone object, but if they are then transforming the composite zone will affect them all.



Composite zone as parent of the other zones.

It is even possible to add multiple spawn zone components to the same game object, but then you cannot transform them individually.

Besides sphere, cube, and composite zones, you could create many more spawn zone types. I've included the most straightforward ones in this tutorial. Also, there are convenient gizmos for cubes and spheres only. You'll have to be more creative to show gizmos for other shapes.

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