# [Developer Guide](https://docs.angularjs.org/guide)

## Section 1

# Conceptual Overview

This section briefly touches on all of the important parts of AngularJS using a simple example. For a more in-depth explanation, see the [tutorial](https://docs.angularjs.org/tutorial/).

| **Concept** | **Description** |
| --- | --- |
| [Template](https://docs.angularjs.org/guide/concepts#template) | HTML with additional markup |
| [Directives](https://docs.angularjs.org/guide/concepts#directive) | extend HTML with custom attributes and elements |
| [Model](https://docs.angularjs.org/guide/concepts#model) | the data shown to the user in the view and with which the user interacts |
| [Scope](https://docs.angularjs.org/guide/concepts#scope) | context where the model is stored so that controllers, directives and expressions can access it |
| [Expressions](https://docs.angularjs.org/guide/concepts#expression) | access variables and functions from the scope |
| [Compiler](https://docs.angularjs.org/guide/concepts#compiler) | parses the template and instantiates directives and expressions |
| [Filter](https://docs.angularjs.org/guide/concepts#filter) | formats the value of an expression for display to the user |
| [View](https://docs.angularjs.org/guide/concepts#view) | what the user sees (the DOM) |
| [Data Binding](https://docs.angularjs.org/guide/concepts#databinding) | sync data between the model and the view |
| [Controller](https://docs.angularjs.org/guide/concepts#controller) | the business logic behind views |
| [Dependency Injection](https://docs.angularjs.org/guide/concepts#di) | Creates and wires objects and functions |
| [Injector](https://docs.angularjs.org/guide/concepts#injector) | dependency injection container |
| [Module](https://docs.angularjs.org/guide/concepts#module) | a container for the different parts of an app including controllers, services, filters, directives which configures the Injector |
| [Service](https://docs.angularjs.org/guide/concepts#service) | reusable business logic independent of views |

## A first example: Data binding

In the following example we will build a form to calculate the costs of an invoice in different currencies.

Let's start with input fields for quantity and cost whose values are multiplied to produce the total of the invoice:

Code: test\_1.html

Try out the Live Preview above, and then let's walk through the example and describe what's going on.



This looks like normal HTML, with some new markup. In Angular, a file like this is called a "[template](https://docs.angularjs.org/guide/templates)". When Angular starts your application, it parses and processes this new markup from the template using the so-called"[compiler](https://docs.angularjs.org/guide/compiler)". The loaded, transformed and rendered DOM is then called the "view".

The first kind of new markup are the so-called "[directives](https://docs.angularjs.org/guide/directive)". They apply special behavior to attributes or elements in the HTML. In the example above we use the [ng-app](https://docs.angularjs.org/api/ng/directive/ngApp) attribute, which is linked to a directive that automatically initializes our application. Angular also defines a directive for the [input](https://docs.angularjs.org/api/ng/directive/input)element that adds extra behavior to the element. The [ng-model](https://docs.angularjs.org/api/ng/directive/ngModel) directive stores/updates the value of the input field into/from a variable.

**Custom directives to access the DOM**: In Angular, the only place where an application should access the DOM is within directives. This is important because artifacts that access the DOM are hard to test. If you need to access the DOM directly you should write a custom directive for this. The[directives guide](https://docs.angularjs.org/guide/directive) explains how to do this.

The second kind of new markup are the double curly braces {{ expression | filter }}: When the compiler encounters this markup, it will replace it with the evaluated value of the markup. An "[expression](https://docs.angularjs.org/guide/expression)" in a template is a JavaScript-like code snippet that allows to read and write variables. Note that those variables are not global variables. Just like variables in a JavaScript function live in a scope, Angular provides a "[scope](https://docs.angularjs.org/guide/scope)" for the variables accessible to expressions. The values that are stored in variables on the scope are referred to as the "model" in the rest of the documentation. Applied to the example above, the markup directs Angular to "take the data we got from the input widgets and multiply them together".

The example above also contains a "[filter](https://docs.angularjs.org/guide/filter)". A filter formats the value of an expression for display to the user. In the example above, the filter [currency](https://docs.angularjs.org/api/ng/filter/currency) formats a number into an output that looks like money.

The important thing in the example is that Angular provides *live* bindings: Whenever the input values change, the value of the expressions are automatically recalculated and the DOM is updated with their values. The concept behind this is "[two-way data binding](https://docs.angularjs.org/guide/databinding)".

## Adding UI logic: Controllers

Let's add some more logic to the example that allows us to enter and calculate the costs in different currencies and also pay the invoice.

Code: test\_2.html, test\_2.js

What changed?

First, there is a new JavaScript file that contains a so-called "[controller](https://docs.angularjs.org/guide/controller)". More exactly, the file contains a constructor function that creates the actual controller instance. The purpose of controllers is to expose variables and functionality to expressions and directives.

Besides the new file that contains the controller code we also added an [ng-controller](https://docs.angularjs.org/api/ng/directive/ngController) directive to the HTML. This directive tells Angular that the new InvoiceController is responsible for the element with the directive and all of the element's children. The syntax InvoiceController as invoice tells Angular to instantiate the controller and save it in the variable invoice in the current scope.

We also changed all expressions in the page to read and write variables within that controller instance by prefixing them with invoice. . The possible currencies are defined in the controller and added to the template using [ng-repeat](https://docs.angularjs.org/api/ng/directive/ngRepeat). As the controller contains a total function we are also able to bind the result of that function to the DOM using {{ invoice.total(...) }}.

Again, this binding is live, i.e. the DOM will be automatically updated whenever the result of the function changes. The button to pay the invoice uses the directive [ngClick](https://docs.angularjs.org/api/ng/directive/ngClick). This will evaluate the corresponding expression whenever the button is clicked.

In the new JavaScript file we are also creating a [module](https://docs.angularjs.org/guide/concepts#module) at which we register the controller. We will talk about modules in the next section.

The following graphic shows how everything works together after we introduced the controller:



## View independent business logic: Services

Right now, the InvoiceController contains all logic of our example. When the application grows it is a good practice to move view independent logic from the controller into a so called "[service](https://docs.angularjs.org/guide/services)", so it can be reused by other parts of the application as well. Later on, we could also change that service to load the exchange rates from the web, e.g. by calling the Yahoo Finance API, without changing the controller.

Let's refactor our example and move the currency conversion into a service in another file:

Code: test\_3.html, test\_3.js, test\_3\_finance2.js

What changed? We moved theconvertCurrency function and the definition of the existing currencies into the new file finance2.js. But how does the controller get a hold of the now separated function?

This is where "[Dependency Injection](https://docs.angularjs.org/guide/di)" comes into play. Dependency Injection (DI) is a software design pattern that deals with how objects and functions get created and how they get a hold of their dependencies. Everything within Angular (directives, filters, controllers, services, ...) is created and wired using dependency injection. Within Angular, the DI container is called the "[injector](https://docs.angularjs.org/guide/di)".

To use DI, there needs to be a place where all the things that should work together are registered. In Angular, this is the purpose of the so-called "[modules](https://docs.angularjs.org/guide/module)". When Angular starts, it will use the configuration of the module with the name defined by the ng-app directive, including the configuration of all modules that this module depends on.

In the example above: The template contains the directive ng-app="invoice2". This tells Angular to use the invoice2 module as the main module for the application. The code snippetangular.module('invoice2', ['finance2']) specifies that the invoice2 module depends on thefinance2 module. By this, Angular uses the InvoiceController as well as the currencyConverterservice.

Now that Angular knows of all the parts of the application, it needs to create them. In the previous section we saw that controllers are created using a factory function. For services there are multiple ways to define their factory (see the [service guide](https://docs.angularjs.org/guide/services)). In the example above, we are using a function that returns thecurrencyConverter function as the factory for the service.

Back to the initial question: How does the InvoiceController get a reference to the currencyConverterfunction? In Angular, this is done by simply defining arguments on the constructor function. With this, the injector is able to create the objects in the right order and pass the previously created objects into the factories of the objects that depend on them. In our example, the InvoiceController has an argument named currencyConverter. By this, Angular knows about the dependency between the controller and the service and calls the controller with the service instance as argument.

The last thing that changed in the example between the previous section and this section is that we now pass an array to the module.controller function, instead of a plain function. The array first contains the names of the service dependencies that the controller needs. The last entry in the array is the controller constructor function. Angular uses this array syntax to define the dependencies so that the DI also works after minifying the code, which will most probably rename the argument name of the controller constructor function to something shorter like a.

## Accessing the backend

Let's finish our example by fetching the exchange rates from the Yahoo Finance API. The following example shows how this is done with Angular:

Code: test\_4.html, test\_4.js, test\_4\_finance2.js

## Section 2

# Data Binding

Data-binding in Angular apps is the automatic synchronization of data between the model and view components. The way that Angular implements data-binding lets you treat the model as the single-source-of-truth in your application. The view is a projection of the model at all times. When the model changes, the view reflects the change, and vice versa.

## Data Binding in Classical Template Systems

  
Most templating systems bind data in only one direction: they merge template and model components together into a view. After the merge occurs, changes to the model or related sections of the view are NOT automatically reflected in the view. Worse, any changes that the user makes to the view are not reflected in the model. This means that the developer has to write code that constantly syncs the view with the model and the model with the view.

## Data Binding in Angular Templates

  
Angular templates work differently. First the template (which is the uncompiled HTML along with any additional markup or directives) is compiled on the browser. The compilation step produces a live view. Any changes to the view are immediately reflected in the model, and any changes in the model are propagated to the view. The model is the single-source-of-truth for the application state, greatly simplifying the programming model for the developer. You can think of the view as simply an instant projection of your model.

Because the view is just a projection of the model, the controller is completely separated from the view and unaware of it. This makes testing a snap because it is easy to test your controller in isolation without the view and the related DOM/browser dependency.

## Section 3

# Controllers

# Understanding Controllers

In Angular, a Controller is a JavaScript **constructor function** that is used to augment the [Angular Scope](https://docs.angularjs.org/guide/scope).

When a Controller is attached to the DOM via the [ng-controller](https://docs.angularjs.org/api/ng/directive/ngController) directive, Angular will instantiate a new Controller object, using the specified Controller's **constructor function**. A new **child scope** will be available as an injectable parameter to the Controller's constructor function as $scope.

Use controllers to:

* Set up the initial state of the $scope object.
* Add behavior to the $scope object.

Do not use controllers to:

* Manipulate DOM — Controllers should contain only business logic. Putting any presentation logic into Controllers significantly affects its testability. Angular has [databinding](https://docs.angularjs.org/guide/databinding) for most cases and[directives](https://docs.angularjs.org/guide/directive) to encapsulate manual DOM manipulation.
* Format input — Use [angular form controls](https://docs.angularjs.org/guide/forms) instead.
* Filter output — Use [angular filters](https://docs.angularjs.org/guide/filter) instead.
* Share code or state across controllers — Use [angular services](https://docs.angularjs.org/guide/services) instead.
* Manage the life-cycle of other components (for example, to create service instances).

# Setting up the initial state of a *$scope* object

Typically, when you create an application you need to set up the initial state for the Angular $scope. You set up the initial state of a scope by attaching properties to the $scope object. The properties contain the**view model** (the model that will be presented by the view). All the $scope properties will be available to the template at the point in the DOM where the Controller is registered.

The following example demonstrates creating a GreetingController, which attaches a greetingproperty containing the string 'Hola!' to the $scope:

var myApp = angular.module('myApp',[]);

myApp.controller('GreetingController', ['$scope', function($scope) {

$scope.greeting = 'Hola!';

}]);

We create an [Angular Module](https://docs.angularjs.org/guide/module), myApp, for our application. Then we add the controller's constructor function to the module using the .controller() method. This keeps the controller's constructor function out of the global scope.

We have used an **inline injection annotation** to explicitly specify the dependency of the Controller on the $scope service provided by Angular. See the guide on [Dependency Injection](https://docs.angularjs.org/guide/di) for more information.

We attach our controller to the DOM using the ng-controller directive. The greeting property can now be data-bound to the template:

<div ng-controller="GreetingController">

{{ greeting }}

</div>

# Adding Behavior to a Scope Object

In order to react to events or execute computation in the view we must provide behavior to the scope. We add behavior to the scope by attaching methods to the $scope object. These methods are then available to be called from the template/view.

The following example uses a Controller to add a method to the scope, which doubles a number:

var myApp = angular.module('myApp',[]);

myApp.controller('DoubleController', ['$scope', function($scope) {

$scope.double = function(value) { return value \* 2; };

}]);

Once the Controller has been attached to the DOM, the double method can be invoked in an Angular expression in the template:

<div ng-controller="DoubleController">

Two times <input ng-model="num"> equals {{ double(num) }}

</div>

As discussed in the [Concepts](https://docs.angularjs.org/guide/concepts) section of this guide, any objects (or primitives) assigned to the scope become model properties. Any methods assigned to the scope are available in the template/view, and can be invoked via angular expressions and ng event handler directives (e.g. [ngClick](https://docs.angularjs.org/api/ng/directive/ngClick)).

# Using Controllers Correctly

In general, a Controller shouldn't try to do too much. It should contain only the business logic needed for a single view.

The most common way to keep Controllers slim is by encapsulating work that doesn't belong to controllers into services and then using these services in Controllers via dependency injection. This is discussed in the [Dependency Injection](https://docs.angularjs.org/guide/di) [Services](https://docs.angularjs.org/guide/services) sections of this guide.

# Associating Controllers with Angular Scope Objects

You can associate Controllers with scope objects implicitly via the [ngController directive](https://docs.angularjs.org/api/ng/directive/ngController) or [$route service](https://docs.angularjs.org/api/ngRoute/service/$route).

## Simple Spicy Controller Example

To illustrate further how Controller components work in Angular, let's create a little app with the following components:

* A [template](https://docs.angularjs.org/guide/templates) with two buttons and a simple message
* A model consisting of a string named spice
* A Controller with two functions that set the value of spice

The message in our template contains a binding to the spice model, which by default is set to the string "very". Depending on which button is clicked, the spice model is set to chili or jalapeño, and the message is automatically updated by data-binding.

Code: test\_5.html, test\_5.js

Things to notice in the example above:

* The ng-controller directive is used to (implicitly) create a scope for our template, and the scope is augmented (managed) by the SpicyController Controller.
* SpicyController is just a plain JavaScript function. As an (optional) naming convention the name starts with capital letter and ends with "Controller".
* Assigning a property to $scope creates or updates the model.
* Controller methods can be created through direct assignment to scope (see the chiliSpicymethod)
* The Controller methods and properties are available in the template (for the <div> element and its children).

## Spicy Arguments Example

Controller methods can also take arguments, as demonstrated in the following variation of the previous example.

Code: test\_6.html, test\_6.js

Notice that the SpicyController Controller now defines just one method called spicy, which takes one argument called spice. The template then refers to this Controller method and passes in a string constant 'chili' in the binding for the first button and a model property customSpice (bound to an input box) in the second button.

## Scope Inheritance Example

It is common to attach Controllers at different levels of the DOM hierarchy. Since the [ng-controller](https://docs.angularjs.org/api/ng/directive/ngController) directive creates a new child scope, we get a hierarchy of scopes that inherit from each other. The $scope that each Controller receives will have access to properties and methods defined by Controllers higher up the hierarchy. See [Understanding Scopes](https://github.com/angular/angular.js/wiki/Understanding-Scopes) for more information about scope inheritance.

Code: test\_7.html, test\_7.js

Notice how we nested three ng-controller directives in our template. This will result in four scopes being created for our view:

* The root scope
* The MainController scope, which contains timeOfDay and name properties
* The ChildController scope, which inherits the timeOfDay property but overrides (hides) thename property from the previous
* The GrandChildController scope, which overrides (hides) both the timeOfDay property defined inMainController and the name property defined in ChildController

Inheritance works with methods in the same way as it does with properties. So in our previous examples, all of the properties could be replaced with methods that return string values.

## Section 4

# Services

Angular services are substitutable objects that are wired together using [dependency injection (DI)](https://docs.angularjs.org/guide/di). You can use services to organize and share code across your app.

Angular services are:

* Lazily instantiated – Angular only instantiates a service when an application component depends on it.
* Singletons – Each component dependent on a service gets a reference to the single instance generated by the service factory.

Angular offers several useful services (like [$http](https://docs.angularjs.org/api/ng/service/$http)), but for most applications you'll also want to [create your own](https://docs.angularjs.org/guide/services#creating-services).

**Note:** Like other core Angular identifiers, built-in services always start with $ (e.g. $http).

## Using a Service

To use an Angular service, you add it as a dependency for the component (controller, service, filter or directive) that depends on the service. Angular's [dependency injection](https://docs.angularjs.org/guide/di) subsystem takes care of the rest.

Code: test\_8.html, test\_8.js

## Creating Services

Application developers are free to define their own services by registering the service's name and **service factory function**, with an Angular module.

The **service factory function** generates the single object or function that represents the service to the rest of the application. The object or function returned by the service is injected into any component (controller, service, filter or directive) that specifies a dependency on the service.

### Registering Services

Services are registered to modules via the [Module API](https://docs.angularjs.org/api/ng/type/angular.Module). Typically you use the [Module#factory](https://docs.angularjs.org/api/ng/function/angular.module) API to register a service:

var myModule = angular.module('myModule', []);

myModule.factory('serviceId', function() {

var shinyNewServiceInstance;

// factory function body that constructs shinyNewServiceInstance

return shinyNewServiceInstance;

});

Note that you are not registering a **service instance**, but rather a **factory function** that will create this instance when called.

### Dependencies

Services can have their own dependencies. Just like declaring dependencies in a controller, you declare dependencies by specifying them in the service's factory function signature.

For more on dependencies, see the [dependency injection](https://docs.angularjs.org/guide/di) docs.

The example module below has two services, each with various dependencies:

var batchModule = angular.module('batchModule', []);

batchModule.factory('batchLog', ['$interval', '$log', function($interval, $log) {

var messageQueue = [];

function log() {

if (messageQueue.length) {

$log.log('batchLog messages: ', messageQueue);

messageQueue = [];

}

}

$interval(log, 50000);

return function(message) {

messageQueue.push(message);

}

}]);

batchModule.factory('routeTemplateMonitor', ['$route', 'batchLog', '$rootScope',

function($route, batchLog, $rootScope) {

$rootScope.$on('$routeChangeSuccess', function() {

batchLog($route.current ? $route.current.template : null);

});

}]);

In the example, note that:

* The batchLog service depends on the built-in [$interval](https://docs.angularjs.org/api/ng/service/$interval) and [$log](https://docs.angularjs.org/api/ng/service/$log) services.
* The routeTemplateMonitor service depends on the built-in [$route](https://docs.angularjs.org/api/ngRoute/service/$route) service and our custombatchLog service.
* Both services use the array notation to declare their dependencies.
* The order of identifiers in the array is the same as the order of argument names in the factory function.

### Registering a Service with *$provide*

You can also register services via the [$provide](https://docs.angularjs.org/api/auto/service/$provide) service inside of a module's config function:

angular.module('myModule', []).config(['$provide', function($provide) {

$provide.factory('serviceId', function() {

var shinyNewServiceInstance;

// factory function body that constructs shinyNewServiceInstance

return shinyNewServiceInstance;

});

}]);

This technique is often used in unit tests to mock out a service's dependencies.

## Section 5

# Scopes

# What are Scopes?

[scope](https://docs.angularjs.org/api/ng/type/$rootScope.Scope) is an object that refers to the application model. It is an execution context for [expressions](https://docs.angularjs.org/guide/expression). Scopes are arranged in hierarchical structure which mimic the DOM structure of the application. Scopes can watch[expressions](https://docs.angularjs.org/guide/expression) and propagate events.

## Scope characteristics

* Scopes provide APIs ([$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch)) to observe model mutations.
* Scopes provide APIs ([$apply](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$apply)) to propagate any model changes through the system into the view from outside of the "Angular realm" (controllers, services, Angular event handlers).
* Scopes can be nested to limit access to the properties of application components while providing access to shared model properties. Nested scopes are either "child scopes" or "isolate scopes". A "child scope" (prototypically) inherits properties from its parent scope. An "isolate scope" does not. See [isolated scopes](https://docs.angularjs.org/guide/directive#isolating-the-scope-of-a-directive)for more information.
* Scopes provide context against which [expressions](https://docs.angularjs.org/guide/expression) are evaluated. For example {{username}} expression is meaningless, unless it is evaluated against a specific scope which defines the username property.

## Scope as Data-Model

Scope is the glue between application controller and the view. During the template [linking](https://docs.angularjs.org/guide/compiler) phase the[directives](https://docs.angularjs.org/api/ng/provider/$compileProvider#directive) set up [$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) expressions on the scope. The $watch allows the directives to be notified of property changes, which allows the directive to render the updated value to the DOM.

Both controllers and directives have reference to the scope, but not to each other. This arrangement isolates the controller from the directive as well as from the DOM. This is an important point since it makes the controllers view agnostic, which greatly improves the testing story of the applications.

Code: test\_9.html, test\_9.js

In the above example notice that the MyController assigns World to the username property of the scope. The scope then notifies the input of the assignment, which then renders the input with username pre-filled. This demonstrates how a controller can write data into the scope.

Similarly the controller can assign behavior to scope as seen by the sayHello method, which is invoked when the user clicks on the 'greet' button. The sayHello method can read the username property and create a greeting property. This demonstrates that the properties on scope update automatically when they are bound to HTML input widgets.

Logically the rendering of {{greeting}} involves:

* retrieval of the scope associated with DOM node where {{greeting}} is defined in template. In this example this is the same scope as the scope which was passed into MyController. (We will discuss scope hierarchies later.)
* Evaluate the greeting [expression](https://docs.angularjs.org/guide/expression) against the scope retrieved above, and assign the result to the text of the enclosing DOM element.

You can think of the scope and its properties as the data which is used to render the view. The scope is the single source-of-truth for all things view related.

From a testability point of view, the separation of the controller and the view is desirable, because it allows us to test the behavior without being distracted by the rendering details.

it('should say hello', function() {

var scopeMock = {};

var cntl = new MyController(scopeMock);

// Assert that username is pre-filled

expect(scopeMock.username).toEqual('World');

// Assert that we read new username and greet

scopeMock.username = 'angular';

scopeMock.sayHello();

expect(scopeMock.greeting).toEqual('Hello angular!');

});

## Scope Hierarchies

Each Angular application has exactly one [root scope](https://docs.angularjs.org/api/ng/service/$rootScope), but may have several child scopes.

The application can have multiple scopes, because some [directives](https://docs.angularjs.org/guide/directive) create new child scopes (refer to directive documentation to see which directives create new scopes). When new scopes are created, they are added as children of their parent scope. This creates a tree structure which parallels the DOM where they're attached.

When Angular evaluates {{name}}, it first looks at the scope associated with the given element for thename property. If no such property is found, it searches the parent scope and so on until the root scope is reached. In JavaScript this behavior is known as prototypical inheritance, and child scopes prototypically inherit from their parents.

This example illustrates scopes in application, and prototypical inheritance of properties. The example is followed by a diagram depicting the scope boundaries.

Code: test\_10.html, test\_10.js, test\_10\_style.css

Notice that Angular automatically places ng-scope class on elements where scopes are attached. The<style> definition in this example highlights in red the new scope locations. The child scopes are necessary because the repeater evaluates {{name}} expression, but depending on which scope the expression is evaluated it produces different result. Similarly the evaluation of {{department}}prototypically inherits from root scope, as it is the only place where the department property is defined.

## Retrieving Scopes from the DOM.

Scopes are attached to the DOM as $scope data property, and can be retrieved for debugging purposes. (It is unlikely that one would need to retrieve scopes in this way inside the application.) The location where the root scope is attached to the DOM is defined by the location of [ng-app](https://docs.angularjs.org/api/ng/directive/ngApp) directive. Typically ng-app is placed on the <html> element, but it can be placed on other elements as well, if, for example, only a portion of the view needs to be controlled by Angular.

To examine the scope in the debugger:

1. Right click on the element of interest in your browser and select 'inspect element'. You should see the browser debugger with the element you clicked on highlighted.
2. The debugger allows you to access the currently selected element in the console as $0 variable.
3. To retrieve the associated scope in console execute: angular.element($0).scope() or just type $scope

## Scope Events Propagation

Scopes can propagate events in similar fashion to DOM events. The event can be [broadcasted](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$broadcast) to the scope children or [emitted](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$emit) to scope parents.

Code: test\_11.html, test\_11.js

## Scope Life Cycle

The normal flow of a browser receiving an event is that it executes a corresponding JavaScript callback. Once the callback completes the browser re-renders the DOM and returns to waiting for more events.

When the browser calls into JavaScript the code executes outside the Angular execution context, which means that Angular is unaware of model modifications. To properly process model modifications the execution has to enter the Angular execution context using the [$apply](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$apply) method. Only model modifications which execute inside the $apply method will be properly accounted for by Angular. For example if a directive listens on DOM events, such as [ng-click](https://docs.angularjs.org/api/ng/directive/ngClick) it must evaluate the expression inside the $applymethod.

After evaluating the expression, the $apply method performs a [$digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest). In the $digest phase the scope examines all of the $watch expressions and compares them with the previous value. This dirty checking is done asynchronously. This means that assignment such as $scope.username="angular" will not immediately cause a $watch to be notified, instead the $watch notification is delayed until the $digestphase. This delay is desirable, since it coalesces multiple model updates into one $watch notification as well as it guarantees that during the $watch notification no other $watches are running. If a $watchchanges the value of the model, it will force additional $digest cycle.

1. **Creation**

The [root scope](https://docs.angularjs.org/api/ng/service/$rootScope) is created during the application bootstrap by the [$injector](https://docs.angularjs.org/api/auto/service/$injector). During template linking, some directives create new child scopes.

1. **Watcher registration**

During template linking directives register [watches](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) on the scope. These watches will be used to propagate model values to the DOM.

1. **Model mutation**

For mutations to be properly observed, you should make them only within the [scope.$apply()](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$apply). (Angular APIs do this implicitly, so no extra $apply call is needed when doing synchronous work in controllers, or asynchronous work with [$http](https://docs.angularjs.org/api/ng/service/$http), [$timeout](https://docs.angularjs.org/api/ng/service/$timeout) or [$interval](https://docs.angularjs.org/api/ng/service/$interval) services.

1. **Mutation observation**

At the end of $apply, Angular performs a [$digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest) cycle on the root scope, which then propagates throughout all child scopes. During the $digest cycle, all $watched expressions or functions are checked for model mutation and if a mutation is detected, the $watch listener is called.

1. **Scope destruction**

When child scopes are no longer needed, it is the responsibility of the child scope creator to destroy them via [scope.$destroy()](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$destroy) API. This will stop propagation of $digest calls into the child scope and allow for memory used by the child scope models to be reclaimed by the garbage collector.

### Scopes and Directives

During the compilation phase, the [compiler](https://docs.angularjs.org/guide/compiler) matches [directives](https://docs.angularjs.org/api/ng/provider/$compileProvider#directive) against the DOM template. The directives usually fall into one of two categories:

* Observing [directives](https://docs.angularjs.org/api/ng/provider/$compileProvider#directive), such as double-curly expressions {{expression}}, register listeners using the [$watch()](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) method. This type of directive needs to be notified whenever the expression changes so that it can update the view.
* Listener directives, such as [ng-click](https://docs.angularjs.org/api/ng/directive/ngClick), register a listener with the DOM. When the DOM listener fires, the directive executes the associated expression and updates the view using the [$apply()](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$apply) method.

When an external event (such as a user action, timer or XHR) is received, the associated [expression](https://docs.angularjs.org/guide/expression) must be applied to the scope through the [$apply()](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$apply) method so that all listeners are updated correctly.

### Directives that Create Scopes

In most cases, [directives](https://docs.angularjs.org/api/ng/provider/$compileProvider#directive) and scopes interact but do not create new instances of scope. However, some directives, such as [ng-controller](https://docs.angularjs.org/api/ng/directive/ngController) and [ng-repeat](https://docs.angularjs.org/api/ng/directive/ngRepeat), create new child scopes and attach the child scope to the corresponding DOM element. You can retrieve a scope for any DOM element by using anangular.element(aDomElement).scope() method call. See the [directives guide](https://docs.angularjs.org/guide/directive#isolating-the-scope-of-a-directive) for more information about isolate scopes.

### Controllers and Scopes

Scopes and controllers interact with each other in the following situations:

* Controllers use scopes to expose controller methods to templates (see [ng-controller](https://docs.angularjs.org/api/ng/directive/ngController)).
* Controllers define methods (behavior) that can mutate the model (properties on the scope).
* Controllers may register [watches](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) on the model. These watches execute immediately after the controller behavior executes.

See the [ng-controller](https://docs.angularjs.org/api/ng/directive/ngController) for more information.

### Scope *$watch* Performance Considerations

Dirty checking the scope for property changes is a common operation in Angular and for this reason the dirty checking function must be efficient. Care should be taken that the dirty checking function does not do any DOM access, as DOM access is orders of magnitude slower than property access on JavaScript object.

### Scope *$watch* Depths



Dirty checking can be done with three strategies: By reference, by collection contents, and by value. The strategies differ in the kinds of changes they detect, and in their performance characteristics.

* Watching by reference ([scope.$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) (watchExpression, listener)) detects a change when the whole value returned by the watch expression switches to a new value. If the value is an array or an object, changes inside it are not detected. This is the most efficient strategy.
* Watching collection contents ([scope.$watchCollection](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watchCollection) (watchExpression, listener)) detects changes that occur inside an array or an object: When items are added, removed, or reordered. The detection is shallow - it does not reach into nested collections. Watching collection contents is more expensive than watching by reference, because copies of the collection contents need to be maintained. However, the strategy attempts to minimize the amount of copying required.
* Watching by value ([scope.$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) (watchExpression, listener, true)) detects any change in an arbitrarily nested data structure. It is the most powerful change detection strategy, but also the most expensive. A full traversal of the nested data structure is needed on each digest, and a full copy of it needs to be held in memory.

## Integration with the browser event loop



The diagram and the example below describe how Angular interacts with the browser's event loop.

1. The browser's event-loop waits for an event to arrive. An event is a user interaction, timer event, or network event (response from a server).
2. The event's callback gets executed. This enters the JavaScript context. The callback can modify the DOM structure.
3. Once the callback executes, the browser leaves the JavaScript context and re-renders the view based on DOM changes.

Angular modifies the normal JavaScript flow by providing its own event processing loop. This splits the JavaScript into classical and Angular execution context. Only operations which are applied in the Angular execution context will benefit from Angular data-binding, exception handling, property watching, etc... You can also use $apply() to enter the Angular execution context from JavaScript. Keep in mind that in most places (controllers, services) $apply has already been called for you by the directive which is handling the event. An explicit call to $apply is needed only when implementing custom event callbacks, or when working with third-party library callbacks.

1. Enter the Angular execution context by calling [scope](https://docs.angularjs.org/guide/scope).[$apply](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$apply)(stimulusFn), where stimulusFn is the work you wish to do in the Angular execution context.
2. Angular executes the stimulusFn(), which typically modifies application state.
3. Angular enters the [$digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest) loop. The loop is made up of two smaller loops which process[$evalAsync](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$evalAsync) queue and the [$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) list. The [$digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest) loop keeps iterating until the model stabilizes, which means that the [$evalAsync](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$evalAsync) queue is empty and the [$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) list does not detect any changes.
4. The [$evalAsync](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$evalAsync) queue is used to schedule work which needs to occur outside of current stack frame, but before the browser's view render. This is usually done with setTimeout(0), but thesetTimeout(0) approach suffers from slowness and may cause view flickering since the browser renders the view after each event.
5. The [$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) list is a set of expressions which may have changed since last iteration. If a change is detected then the $watch function is called which typically updates the DOM with the new value.
6. Once the Angular [$digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest) loop finishes the execution leaves the Angular and JavaScript context. This is followed by the browser re-rendering the DOM to reflect any changes.

Here is the explanation of how the Hello world example achieves the data-binding effect when the user enters text into the text field.

1. During the compilation phase:
   1. the [ng-model](https://docs.angularjs.org/api/ng/directive/ngModel) and [input](https://docs.angularjs.org/api/ng/directive/input) [directive](https://docs.angularjs.org/guide/directive) set up a keydown listener on the <input> control.
   2. the [interpolation](https://docs.angularjs.org/api/ng/service/$interpolate) sets up a [$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) to be notified of name changes.
2. During the runtime phase:
   1. Pressing an 'X' key causes the browser to emit a keydown event on the input control.
   2. The [input](https://docs.angularjs.org/api/ng/directive/input) directive captures the change to the input's value and calls[$apply](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$apply)("name = 'X';") to update the application model inside the Angular execution context.
   3. Angular applies the name = 'X'; to the model.
   4. The [$digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest) loop begins
   5. The [$watch](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) list detects a change on the name property and notifies the [interpolation](https://docs.angularjs.org/api/ng/service/$interpolate), which in turn updates the DOM.
   6. Angular exits the execution context, which in turn exits the keydown event and with it the JavaScript execution context.
   7. The browser re-renders the view with update text.

## Section 6

# Dependency Injection

Dependency Injection (DI) is a software design pattern that deals with how components get hold of their dependencies.

The AngularJS injector subsystem is in charge of creating components, resolving their dependencies, and providing them to other components as requested.

## Using Dependency Injection

DI is pervasive throughout AngularJS. You can use it when defining components or when providing run and config blocks for a module.

* Components such as services, directives, filters, and animations are defined by an injectable factory method or constructor function. These components can be injected with "service" and "value" components as dependencies.
* Controllers are defined by a constructor function, which can be injected with any of the "service" and "value" components as dependencies, but they can also be provided with special dependencies. See [Controllers](https://docs.angularjs.org/guide/di#controllers) below for a list of these special dependencies.
* The run method accepts a function, which can be injected with "service", "value" and "constant" components as dependencies. Note that you cannot inject "providers" into run blocks.
* The config method accepts a function, which can be injected with "provider" and "constant" components as dependencies. Note that you cannot inject "service" or "value" components into configuration.

See [Modules](https://docs.angularjs.org/guide/module#module-loading-dependencies) for more details about run and config blocks.

### Factory Methods

The way you define a directive, service, or filter is with a factory function. The factory methods are registered with modules. The recommended way of declaring factories is:

angular.module('myModule', [])

.factory('serviceId', ['depService', function(depService) {

// ...

}])

.directive('directiveName', ['depService', function(depService) {

// ...

}])

.filter('filterName', ['depService', function(depService) {

// ...

}]);

### Module Methods

We can specify functions to run at configuration and run time for a module by calling the config and run methods. These functions are injectable with dependencies just like the factory functions above.

angular.module('myModule', [])

.config(['depProvider', function(depProvider) {

// ...

}])

.run(['depService', function(depService) {

// ...

}]);

### Controllers

Controllers are "classes" or "constructor functions" that are responsible for providing the application behavior that supports the declarative markup in the template. The recommended way of declaring Controllers is using the array notation:

someModule.controller('MyController', ['$scope', 'dep1', 'dep2', function($scope, dep1, dep2) {

...

$scope.aMethod = function() {

...

}

...

}]);

Unlike services, there can be many instances of the same type of controller in an application.

Moreover, additional dependencies are made available to Controllers:

* [$scope](https://docs.angularjs.org/guide/scope): Controllers are associated with an element in the DOM and so are provided with access to the [scope](https://docs.angularjs.org/guide/scope). Other components (like services) only have access to the [$rootScope](https://docs.angularjs.org/api/ng/service/$rootScope) service.
* [resolves](https://docs.angularjs.org/api/ngRoute/provider/$routeProvider#when): If a controller is instantiated as part of a route, then any values that are resolved as part of the route are made available for injection into the controller.

## Dependency Annotation

AngularJS invokes certain functions (like service factories and controllers) via the injector. You need to annotate these functions so that the injector knows what services to inject into the function. There are three ways of annotating your code with service name information:

* Using the inline array annotation (preferred)
* Using the $inject property annotation
* Implicitly from the function parameter names (has caveats)

### Inline Array Annotation

This is the preferred way to annotate application components. This is how the examples in the documentation are written.

For example:

someModule.controller('MyController', ['$scope', 'greeter', function($scope, greeter) {

// ...

}]);

Here we pass an array whose elements consist of a list of strings (the names of the dependencies) followed by the function itself.

When using this type of annotation, take care to keep the annotation array in sync with the parameters in the function declaration.

### $inject Property Annotation

To allow the minifiers to rename the function parameters and still be able to inject the right services, the function needs to be annotated with the $inject property. The $inject property is an array of service names to inject.

var MyController = function($scope, greeter) {

// ...

}

MyController.$inject = ['$scope', 'greeter'];

someModule.controller('MyController', MyController);

In this scenario the ordering of the values in the $inject array must match the ordering of the parameters in MyController.

Just like with the array annotation, you'll need to take care to keep the $inject in sync with the parameters in the function declaration.

### Implicit Annotation

**Careful:** If you plan to [minify](http://en.wikipedia.org/wiki/Minification_(programming)) your code, your service names will get renamed and break your app.

The simplest way to get hold of the dependencies is to assume that the function parameter names are the names of the dependencies.

someModule.controller('MyController', function($scope, greeter) {

// ...

});

Given a function, the injector can infer the names of the services to inject by examining the function declaration and extracting the parameter names. In the above example, $scope and greeter are two services which need to be injected into the function.

One advantage of this approach is that there's no array of names to keep in sync with the function parameters. You can also freely reorder dependencies.

However this method will not work with JavaScript minifiers/obfuscators because of how they rename parameters.

Tools like [ng-annotate](https://github.com/olov/ng-annotate) let you use implicit dependency annotations in your app and automatically add inline array annotations prior to minifying. If you decide to take this approach, you probably want to use ng-strict-di.

Because of these caveats, we recommend avoiding this style of annotation.

## Using Strict Dependency Injection

You can add an ng-strict-di directive on the same element as ng-app to opt into strict DI mode:

<!doctype html>

<html ng-app="myApp" ng-strict-di>

<body>

I can add: {{ 1 + 2 }}.

<script src="angular.js"></script>

</body>

</html>

Strict mode throws an error whenever a service tries to use implicit annotations.

Consider this module, which includes a willBreak service that uses implicit DI:

angular.module('myApp', [])

.factory('willBreak', function($rootScope) {

// $rootScope is implicitly injected

})

.run(['willBreak', function(willBreak) {

// AngularJS will throw when this runs

}]);

When the willBreak service is instantiated, AngularJS will throw an error because of strict mode. This is useful when using a tool like [ng-annotate](https://github.com/olov/ng-annotate) to ensure that all of your application components have annotations.

If you're using manual bootstrapping, you can also use strict DI by providing strictDi: true in the optional config argument:

angular.bootstrap(document, ['myApp'], {

strictDi: true

});

## Why Dependency Injection?

This section motivates and explains AngularJS's use of DI. For how to use DI, see above.

For in-depth discussion about DI, see [Dependency Injection](http://en.wikipedia.org/wiki/Dependency_injection) at Wikipedia, [Inversion of Control](http://martinfowler.com/articles/injection.html) by Martin Fowler, or read about DI in your favorite software design pattern book.

There are only three ways a component (object or function) can get a hold of its dependencies:

1. The component can create the dependency, typically using the new operator.
2. The component can look up the dependency, by referring to a global variable.
3. The component can have the dependency passed to it where it is needed.

The first two options of creating or looking up dependencies are not optimal because they hard code the dependency to the component. This makes it difficult, if not impossible, to modify the dependencies. This is especially problematic in tests, where it is often desirable to provide mock dependencies for test isolation.

The third option is the most viable, since it removes the responsibility of locating the dependency from the component. The dependency is simply handed to the component.

function SomeClass(greeter) {

this.greeter = greeter;

}

SomeClass.prototype.doSomething = function(name) {

this.greeter.greet(name);

}

In the above example SomeClass is not concerned with creating or locating the greeter dependency, it is simply handed the greeterwhen it is instantiated.

This is desirable, but it puts the responsibility of getting hold of the dependency on the code that constructs SomeClass.



To manage the responsibility of dependency creation, each AngularJS application has an [injector](https://docs.angularjs.org/api/ng/function/angular.injector). The injector is a [service locator](http://en.wikipedia.org/wiki/Service_locator_pattern) that is responsible for construction and lookup of dependencies.

Here is an example of using the injector service:

// Provide the wiring information in a module

var myModule = angular.module('myModule', []);

Teach the injector how to build a greeter service. Notice that greeter is dependent on the $window service. The greeter service is an object that contains a greet method.

myModule.factory('greeter', function($window) {

return {

greet: function(text) {

$window.alert(text);

}

};

});

Create a new injector that can provide components defined in our myModule module and request our greeter service from the injector. (This is usually done automatically by AngularJS bootstrap).

var injector = angular.injector(['ng', 'myModule']);

var greeter = injector.get('greeter');

Asking for dependencies solves the issue of hard coding, but it also means that the injector needs to be passed throughout the application. Passing the injector breaks the [Law of Demeter](http://en.wikipedia.org/wiki/Law_of_Demeter). To remedy this, we use a declarative notation in our HTML templates, to hand the responsibility of creating components over to the injector, as in this example:

<div ng-controller="MyController">

<button ng-click="sayHello()">Hello</button>

</div>

function MyController($scope, greeter) {

$scope.sayHello = function() {

greeter.greet('Hello World');

};

}

When AngularJS compiles the HTML, it processes the ng-controller directive, which in turn asks the injector to create an instance of the controller and its dependencies.

injector.instantiate(MyController);

This is all done behind the scenes. Notice that by having the ng-controller ask the injector to instantiate the class, it can satisfy all of the dependencies of MyController without the controller ever knowing about the injector.

This is the best outcome. The application code simply declares the dependencies it needs, without having to deal with the injector. This setup does not break the Law of Demeter.

## Section 7

# Templates

In AngularJS, templates are written with HTML that contains AngularJS-specific elements and attributes. AngularJS combines the template with information from the model and controller to render the dynamic view that a user sees in the browser.

These are the types of AngularJS elements and attributes you can use:

* [Directive](https://docs.angularjs.org/guide/directive) — An attribute or element that augments an existing DOM element or represents a reusable DOM component.
* [Markup](https://docs.angularjs.org/api/ng/service/$interpolate) — The double curly brace notation {{ }} to bind expressions to elements is built-in AngularJS markup.
* [Filter](https://docs.angularjs.org/guide/filter) — Formats data for display.
* [Form controls](https://docs.angularjs.org/guide/forms) — Validates user input.

The following code snippet shows a template with [directives](https://docs.angularjs.org/guide/directive) and curly-brace [expression](https://docs.angularjs.org/guide/expression) bindings:

<html ng-app>

<!-- Body tag augmented with ngController directive -->

<body ng-controller="MyController">

<input ng-model="foo" value="bar">

<!-- Button tag with ngClick directive, and

string expression 'buttonText'

wrapped in "{{ }}" markup -->

<button ng-click="changeFoo()">{{buttonText}}</button>

<script src="angular.js"></script>

</body>

</html>

In a simple app, the template consists of HTML, CSS, and AngularJS directives contained in just one HTML file (usually index.html).

In a more complex app, you can display multiple views within one main page using "partials" – segments of template located in separate HTML files. You can use the [ngView](https://docs.angularjs.org/api/ngRoute/directive/ngView) directive to load partials based on configuration passed to the [$route](https://docs.angularjs.org/api/ngRoute/service/$route) service. The [AngularJS tutorial](https://docs.angularjs.org/tutorial/) shows this technique in steps seven and eight.

## Section 8

# Expressions

AngularJS expressions are JavaScript-like code snippets that are mainly placed in interpolation bindings such as <span title="{{ attrBinding }}">{{ textBinding }}</span>, but also used directly in directive attributes such as ng-click="functionExpression()".

For example, these are valid expressions in AngularJS:

* 1+2
* a+b
* user.name
* items[index]

AngularJS Expressions vs. JavaScript Expressions

AngularJS expressions are like JavaScript expressions with the following differences:

* **Context:** JavaScript expressions are evaluated against the global window. In AngularJS, expressions are evaluated against a [scope](https://docs.angularjs.org/api/ng/type/$rootScope.Scope) object.
* **Forgiving:** In JavaScript, trying to evaluate undefined properties generates ReferenceError or TypeError. In AngularJS, expression evaluation is forgiving to undefined and null.
* **Filters:** You can use [filters](https://docs.angularjs.org/guide/filter) within expressions to format data before displaying it.
* **No Control Flow Statements:** You cannot use the following in an AngularJS expression: conditionals, loops, or exceptions.
* **No Function Declarations:** You cannot declare functions in an AngularJS expression, even inside ng-init directive.
* **No RegExp Creation With Literal Notation:** You cannot create regular expressions in an AngularJS expression. An exception to this rule is [ng-pattern](https://docs.angularjs.org/api/ng/directive/ngPattern) which accepts valid RegExp.
* **No Object Creation With New Operator:** You cannot use new operator in an AngularJS expression.
* **No Bitwise, Comma, And Void Operators:** You cannot use [Bitwise](https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Operators/Bitwise_Operators), , or void operators in an AngularJS expression.

If you want to run more complex JavaScript code, you should make it a controller method and call the method from your view. If you want to eval() an AngularJS expression yourself, use the [$eval()](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$eval)method.

Example

Code: test\_12.html

You can try evaluating different expressions here:

Code: test\_13.html, test\_13.js

Context

AngularJS does not use JavaScript's eval() to evaluate expressions. Instead AngularJS's [$parse](https://docs.angularjs.org/api/ng/service/$parse) service processes these expressions.

AngularJS expressions do not have direct access to global variables like window, document or location. This restriction is intentional. It prevents accidental access to the global state – a common source of subtle bugs.

Instead use services like $window and $location in functions on controllers, which are then called from expressions. Such services provide mockable access to globals.

It is possible to access the context object using the identifier this and the locals object using the identifier $locals.

Code: test\_14.html, test\_14.js

Forgiving

Expression evaluation is forgiving to undefined and null. In JavaScript, evaluating a.b.c throws an exception if a is not an object. While this makes sense for a general purpose language, the expression evaluations are primarily used for data binding, which often look like this:

{{a.b.c}}

It makes more sense to show nothing than to throw an exception if a is undefined (perhaps we are waiting for the server response, and it will become defined soon). If expression evaluation wasn't forgiving we'd have to write bindings that clutter the code, for example: {{((a||{}).b||{}).c}}

Similarly, invoking a function a.b.c() on undefined or null simply returns undefined.

No Control Flow Statements

Apart from the ternary operator (a ? b : c), you cannot write a control flow statement in an expression. The reason behind this is core to the AngularJS philosophy that application logic should be in controllers, not the views. If you need a real conditional, loop, or to throw from a view expression, delegate to a JavaScript method instead.

No function declarations or RegExp creation with literal notation

You can't declare functions or create regular expressions from within AngularJS expressions. This is to avoid complex model transformation logic inside templates. Such logic is better placed in a controller or in a dedicated filter where it can be tested properly.

$event

Directives like [ngClick](https://docs.angularjs.org/api/ng/directive/ngClick) and [ngFocus](https://docs.angularjs.org/api/ng/directive/ngFocus) expose a $event object within the scope of that expression. The object is an instance of a [jQuery Event Object](http://api.jquery.com/category/events/event-object/) when jQuery is present or a similar jqLite object.

Code: test\_15.html, test\_15.js

Note in the example above how we can pass in $event to clickMe, but how it does not show up in {{$event}}. This is because $event is outside the scope of that binding.

One-time binding

An expression that starts with :: is considered a one-time expression. One-time expressions will stop recalculating once they are stable, which happens after the first digest if the expression result is a non-undefined value (see value stabilization algorithm below).

Code: test\_16.html, test\_16.js

Reasons for using one-time binding

The main purpose of one-time binding expression is to provide a way to create a binding that gets deregistered and frees up resources once the binding is stabilized. Reducing the number of expressions being watched makes the digest loop faster and allows more information to be displayed at the same time.

Value stabilization algorithm

One-time binding expressions will retain the value of the expression at the end of the digest cycle as long as that value is not undefined. If the value of the expression is set within the digest loop and later, within the same digest loop, it is set to undefined, then the expression is not fulfilled and will remain watched.

1. Given an expression that starts with ::, when a digest loop is entered and expression is dirty-checked, store the value as V
2. If V is not undefined, mark the result of the expression as stable and schedule a task to deregister the watch for this expression when we exit the digest loop
3. Process the digest loop as normal
4. When digest loop is done and all the values have settled, process the queue of watch deregistration tasks. For each watch to be deregistered, check if it still evaluates to a value that is not undefined. If that's the case, deregister the watch. Otherwise, keep dirty-checking the watch in the future digest loops by following the same algorithm starting from step 1

Special case for object literals

Unlike simple values, object-literals are watched until every key is defined. See <http://www.bennadel.com/blog/2760-one-time-data-bindings-for-object-literal-expressions-in-angularjs-1-3.htm>

How to benefit from one-time binding

If the expression will not change once set, it is a candidate for one-time binding. Here are three example cases.

When interpolating text or attributes:

<div name="attr: {{::color}}">text: {{::name | uppercase}}</div>

When using a directive with bidirectional binding and parameters that will not change:

someModule.directive('someDirective', function() {

return {

scope: {

name: '=',

color: '@'

},

template: '{{name}}: {{color}}'

};

});

<div some-directive name="::myName" color="My color is {{::myColor}}"></div>

When using a directive that takes an expression:

<ul>

<li ng-repeat="item in ::items | orderBy:'name'">{{item.name}};</li>

</ul>

## Section 9

# Interpolation

Interpolation markup with embedded [expressions](https://docs.angularjs.org/guide/expression) is used by AngularJS to provide data-binding to text nodes and attribute values.

An example of interpolation is shown below:

<a ng-href="img/{{username}}.jpg">Hello {{username}}!</a>

How text and attribute bindings work

During the compilation process the [compiler](https://docs.angularjs.org/api/ng/service/$compile) uses the [$interpolate](https://docs.angularjs.org/api/ng/service/$interpolate) service to see if text nodes and element attributes contain interpolation markup with embedded expressions.

If that is the case, the compiler adds an interpolateDirective to the node and registers [watches](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) on the computed interpolation function, which will update the corresponding text nodes or attribute values as part of the normal [digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest) cycle.

Note that the interpolateDirective has a priority of 100 and sets up the watch in the preLink function.

How the string representation is computed

If the interpolated value is not a String, it is computed as follows:

* undefined and null are converted to ''
* if the value is an object that is not a Number, Date or Array, $interpolate looks for a custom toString() function on the object, and uses that. Custom means that myObject.toString !== Object.prototype.toString.
* if the above doesn't apply, JSON.stringify is used.

Binding to boolean attributes

Attributes such as disabled are called boolean attributes, because their presence means true and their absence means false. We cannot use normal attribute bindings with them, because the HTML specification does not require browsers to preserve the values of boolean attributes. This means that if we put an AngularJS interpolation expression into such an attribute then the binding information would be lost, because the browser ignores the attribute value.

In the following example, the interpolation information would be ignored and the browser would simply interpret the attribute as present, meaning that the button would always be disabled.

Disabled: <input type="checkbox" ng-model="isDisabled" />

<button disabled="{{isDisabled}}">Disabled</button>

For this reason, AngularJS provides special ng-prefixed directives for the following boolean attributes: [disabled](https://docs.angularjs.org/api/ng/directive/ngDisabled), [required](https://docs.angularjs.org/api/ng/directive/ngRequired), [selected](https://docs.angularjs.org/api/ng/directive/ngSelected), [checked](https://docs.angularjs.org/api/ng/directive/ngChecked), [readOnly](https://docs.angularjs.org/api/ng/directive/ngReadonly) , and [open](https://docs.angularjs.org/api/ng/directive/ngOpen).

These directives take an expression inside the attribute, and set the corresponding boolean attribute to true when the expression evaluates to truthy.

Disabled: <input type="checkbox" ng-model="isDisabled" />

<button ng-disabled="isDisabled">Disabled</button>

ngAttr for binding to arbitrary attributes

Web browsers are sometimes picky about what values they consider valid for attributes.

For example, considering this template:

<svg>

<circle cx="{{cx}}"></circle>

</svg>

We would expect AngularJS to be able to bind to this, but when we check the console we see something like Error: Invalid value for attribute cx="{{cx}}". Because of the SVG DOM API's restrictions, you cannot simply write cx="{{cx}}".

With ng-attr-cx you can work around this problem.

If an attribute with a binding is prefixed with the ngAttr prefix (denormalized as ng-attr-) then during the binding it will be applied to the corresponding unprefixed attribute. This allows you to bind to attributes that would otherwise be eagerly processed by browsers (e.g. an SVG element's circle[cx] attributes). When using ngAttr, the allOrNothing flag of [$interpolate](https://docs.angularjs.org/api/ng/service/$interpolate) is used, so if any expression in the interpolated string results in undefined, the attribute is removed and not added to the element.

For example, we could fix the example above by instead writing:

<svg>

<circle ng-attr-cx="{{cx}}"></circle>

</svg>

If one wants to modify a camelcased attribute (SVG elements have valid camelcased attributes), such as viewBox on the svg element, one can use underscores to denote that the attribute to bind to is naturally camelcased.

For example, to bind to viewBox, we can write:

<svg ng-attr-view\_box="{{viewBox}}">

</svg>

Other attributes may also not work as expected when they contain interpolation markup, and can be used with ngAttr instead. The following is a list of known problematic attributes:

* **size** in <select> elements (see [issue 1619](https://github.com/angular/angular.js/issues/1619))
* **placeholder** in <textarea> in Internet Explorer 10/11 (see [issue 5025](https://github.com/angular/angular.js/issues/5025))
* **type** in <button> in Internet Explorer 11 (see [issue 14117](https://github.com/angular/angular.js/issues/5025))
* **value** in <progress> in Internet Explorer = 11 (see [issue 7218](https://github.com/angular/angular.js/issues/7218))

Known Issues

Dynamically changing an interpolated value

You should avoid dynamically changing the content of an interpolated string (e.g. attribute value or text node). Your changes are likely to be overwritten, when the original string gets evaluated. This restriction applies to both directly changing the content via JavaScript or indirectly using a directive.

For example, you should not use interpolation in the value of the style attribute (e.g.style="color: {{ 'orange' }}; font-weight: {{ 'bold' }};") **and** at the same time use a directive that changes the content of that attribute, such as ngStyle.

Embedding interpolation markup inside expressions

**Note:** AngularJS directive attributes take either expressions *or* interpolation markup with embedded expressions. It is considered **bad practice** to embed interpolation markup inside an expression:

<div ng-show="form{{$index}}.$invalid"></div>

You should instead delegate the computation of complex expressions to the scope, like this:

<div ng-show="getForm($index).$invalid"></div>

function getForm(index) {

return $scope['form' + index];

}

You can also access the scope with this in your templates:

<div ng-show="this['form' + $index].$invalid"></div>

Why mixing interpolation and expressions is bad practice:

* It increases the complexity of the markup
* There is no guarantee that it works for every directive, because interpolation itself is a directive. If another directive accesses attribute data before interpolation has run, it will get the raw interpolation markup and not data.
* It impacts performance, as interpolation adds another watcher to the scope.
* Since this is not recommended usage, we do not test for this, and changes to AngularJS core may break your code.

## Section 10

# Filters

Filters format the value of an expression for display to the user. They can be used in view templates, controllers or services. AngularJS comes with a collection of [built-in filters](https://docs.angularjs.org/api/ng/filter), but it is easy to define your own as well.

The underlying API is the [$filterProvider](https://docs.angularjs.org/api/ng/provider/$filterProvider).

## Using filters in view templates

Filters can be applied to expressions in view templates using the following syntax:

{{ expression | filter }}

E.g. the markup {{ 12 | currency }} formats the number 12 as a currency using the [currency](https://docs.angularjs.org/api/ng/filter/currency) filter. The resulting value is $12.00.

Filters can be applied to the result of another filter. This is called "chaining" and uses the following syntax:

{{ expression | filter1 | filter2 | ... }}

Filters may have arguments. The syntax for this is

{{ expression | filter:argument1:argument2:... }}

E.g. the markup {{ 1234 | number:2 }} formats the number 1234 with 2 decimal points using the [number](https://docs.angularjs.org/api/ng/filter/number) filter. The resulting value is 1,234.00.

### When filters are executed

In templates, filters are only executed when their inputs have changed. This is more performant than executing a filter on each [$digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest) as is the case with [expressions](https://docs.angularjs.org/guide/expression).

There are two exceptions to this rule:

1. In general, this applies only to filters that take [primitive values](https://developer.mozilla.org/docs/Glossary/Primitive) as inputs. Filters that receive [Objects](https://developer.mozilla.org/en-US/docs/Web/JavaScript/Data_structures#Objects) as input are executed on each $digest, as it would be too costly to track if the inputs have changed.
2. Filters that are marked as $stateful are also executed on each $digest. See [Stateful filters](https://docs.angularjs.org/guide/filter#stateful-filters) for more information. Note that no AngularJS core filters are $stateful.

## Using filters in controllers, services, and directives

You can also use filters in controllers, services, and directives.

For this, inject a dependency with the name <filterName>Filter into your controller/service/directive. E.g. a filter called number is injected by using the dependency numberFilter. The injected argument is a function that takes the value to format as first argument, and filter parameters starting with the second argument.

The example below uses the filter called [filter](https://docs.angularjs.org/api/ng/filter/filter). This filter reduces arrays into sub arrays based on conditions. The filter can be applied in the view template with markup like {{ctrl.array | filter:'a'}}, which would do a fulltext search for "a". However, using a filter in a view template will reevaluate the filter on every digest, which can be costly if the array is big.

The example below therefore calls the filter directly in the controller. By this, the controller is able to call the filter only when needed (e.g. when the data is loaded from the backend or the filter expression is changed).

Code: test\_17.html, test\_17.js

## Creating custom filters

Writing your own filter is very easy: just register a new filter factory function with your module. Internally, this uses the [filterProvider](https://docs.angularjs.org/api/ng/provider/$filterProvider). This factory function should return a new filter function which takes the input value as the first argument. Any filter arguments are passed in as additional arguments to the filter function.

The filter function should be a [pure function](http://en.wikipedia.org/wiki/Pure_function), which means that it should always return the same result given the same input arguments and should not affect external state, for example, other AngularJS services. AngularJS relies on this contract and will by default execute a filter only when the inputs to the function change. [Stateful filters](https://docs.angularjs.org/guide/filter#stateful-filters) are possible, but less performant.

**Note:** Filter names must be valid AngularJS [Expressions](https://docs.angularjs.org/guide/expression) identifiers, such as uppercase or orderBy. Names with special characters, such as hyphens and dots, are not allowed. If you wish to namespace your filters, then you can use capitalization (myappSubsectionFilterx) or underscores (myapp\_subsection\_filterx).

The following sample filter reverses a text string. In addition, it conditionally makes the text upper-case.

Code: test\_18.html, test\_18.js

### Stateful filters

It is strongly discouraged to write filters that are stateful, because the execution of those can't be optimized by AngularJS, which often leads to performance issues. Many stateful filters can be converted into stateless filters just by exposing the hidden state as a model and turning it into an argument for the filter.

If you however do need to write a stateful filter, you have to mark the filter as $stateful, which means that it will be executed one or more times during the each $digest cycle.

  Code: test\_19.html, test\_19.js

## Section 11

# Forms

Controls (input, select, textarea) are ways for a user to enter data. A Form is a collection of controls for the purpose of grouping related controls together.

Form and controls provide validation services, so that the user can be notified of invalid input before submitting a form. This provides a better user experience than server-side validation alone because the user gets instant feedback on how to correct the error. Keep in mind that while client-side validation plays an important role in providing good user experience, it can easily be circumvented and thus can not be trusted. Server-side validation is still necessary for a secure application.

Simple form

The key directive in understanding two-way data-binding is [ngModel](https://docs.angularjs.org/api/ng/directive/ngModel). The ngModel directive provides the two-way data-binding by synchronizing the model to the view, as well as view to the model. In addition it provides an [API](https://docs.angularjs.org/api/ng/type/ngModel.NgModelController) for other directives to augment its behavior.

  Code: test\_20.html, test\_20.js

Note that novalidate is used to disable browser's native form validation.

The value of ngModel won't be set unless it passes validation for the input field. For example: inputs of type email must have a value in the form of user@domain.

Using CSS classes

To allow styling of form as well as controls, ngModel adds these CSS classes:

* ng-valid: the model is valid
* ng-invalid: the model is invalid
* ng-valid-[key]: for each valid key added by $setValidity
* ng-invalid-[key]: for each invalid key added by $setValidity
* ng-pristine: the control hasn't been interacted with yet
* ng-dirty: the control has been interacted with
* ng-touched: the control has been blurred
* ng-untouched: the control hasn't been blurred
* ng-pending: any $asyncValidators are unfulfilled

The following example uses the CSS to display validity of each form control. In the example both user.name and user.email are required, but are rendered with red background only after the input is blurred (loses focus). This ensures that the user is not distracted with an error until after interacting with the control, and failing to satisfy its validity.

  Code: test\_21.html, test\_21.js

Binding to form and control state

A form is an instance of [FormController](https://docs.angularjs.org/api/ng/type/form.FormController). The form instance can optionally be published into the scope using the name attribute.

Similarly, an input control that has the [ngModel](https://docs.angularjs.org/api/ng/directive/ngModel) directive holds an instance of [NgModelController](https://docs.angularjs.org/api/ng/type/ngModel.NgModelController). Such a control instance can be published as a property of the form instance using the name attribute on the input control. The name attribute specifies the name of the property on the form instance.

This implies that the internal state of both the form and the control is available for binding in the view using the standard binding primitives.

This allows us to extend the above example with these features:

* Custom error message displayed after the user interacted with a control (i.e. when $touched is set)
* Custom error message displayed upon submitting the form ($submitted is set), even if the user didn't interact with a control

 Code: test\_22.html, test\_22.js

Custom model update triggers

By default, any change to the content will trigger a model update and form validation. You can override this behavior using the [ngModelOptions](https://docs.angularjs.org/api/ng/directive/ngModelOptions) directive to bind only to specified list of events. I.e. ng-model-options="{ updateOn: 'blur' }" will update and validate only after the control loses focus. You can set several events using a space delimited list. I.e. ng-model-options="{ updateOn: 'mousedown blur' }"

If you want to keep the default behavior and just add new events that may trigger the model update and validation, add "default" as one of the specified events.

I.e. ng-model-options="{ updateOn: 'default blur' }"

The following example shows how to override immediate updates. Changes on the inputs within the form will update the model only when the control loses focus (blur event).

Code: test\_23.html, test\_23.js

Non-immediate (debounced) model updates

You can delay the model update/validation by using the debounce key with the [ngModelOptions](https://docs.angularjs.org/api/ng/directive/ngModelOptions) directive. This delay will also apply to parsers, validators and model flags like $dirty or $pristine.

I.e. ng-model-options="{ debounce: 500 }" will wait for half a second since the last content change before triggering the model update and form validation.

If custom triggers are used, custom debouncing timeouts can be set for each event using an object in debounce. This can be useful to force immediate updates on some specific circumstances (like blur events).

I.e. ng-model-options="{ updateOn: 'default blur', debounce: { default: 500, blur: 0 } }"

If those attributes are added to an element, they will be applied to all the child elements and controls that inherit from it unless they are overridden.

This example shows how to debounce model changes. Model will be updated only 250 milliseconds after last change.

Code: test\_24.html, test\_24.js

Custom Validation

AngularJS provides basic implementation for most common HTML5 [input](https://docs.angularjs.org/api/ng/directive/input) types: ([text](https://docs.angularjs.org/api/ng/input/input%5Btext%5D), [number](https://docs.angularjs.org/api/ng/input/input%5Bnumber%5D), [url](https://docs.angularjs.org/api/ng/input/input%5Burl%5D), [email](https://docs.angularjs.org/api/ng/input/input%5Bemail%5D), [date](https://docs.angularjs.org/api/ng/input/input%5Bdate%5D), [radio](https://docs.angularjs.org/api/ng/input/input%5Bradio%5D), [checkbox](https://docs.angularjs.org/api/ng/input/input%5Bcheckbox%5D)), as well as some directives for validation (required, pattern, minlength, maxlength, min, max).

With a custom directive, you can add your own validation functions to the $validators object on the [ngModelController](https://docs.angularjs.org/api/ng/type/ngModel.NgModelController). To get a hold of the controller, you require it in the directive as shown in the example below.

Each function in the $validators object receives the modelValue and the viewValue as parameters. AngularJS will then call $setValidity internally with the function's return value (true: valid, false: invalid). The validation functions are executed every time an input is changed ($setViewValue is called) or whenever the bound model changes. Validation happens after successfully running $parsers and $formatters, respectively. Failed validators are stored by key in [ngModelController.$error](https://docs.angularjs.org/api/ng/type/ngModel.NgModelController#$error).

Additionally, there is the $asyncValidators object which handles asynchronous validation, such as making an $http request to the backend. Functions added to the object must return a promise that must be resolved when valid or rejected when invalid. In-progress async validations are stored by key in [ngModelController.$pending](https://docs.angularjs.org/api/ng/type/ngModel.NgModelController#$pending).

In the following example we create two directives:

* An integer directive that validates whether the input is a valid integer. For example, 1.23 is an invalid value, since it contains a fraction. Note that we validate the viewValue (the string value of the control), and not the modelValue. This is because input[number] converts the viewValue to a number when running the $parsers.
* A username directive that asynchronously checks if a user-entered value is already taken. We mock the server request with a $qdeferred.

Code: test\_25.html, test\_25.js

Modifying built-in validators

Since AngularJS itself uses $validators, you can easily replace or remove built-in validators, should you find it necessary. The following example shows you how to overwrite the email validator in input[email] from a custom directive so that it requires a specific top-level domain, example.com to be present. Note that you can alternatively use ng-pattern to further restrict the validation.

Code: test\_26.html, test\_26.js

Implementing custom form controls (using ngModel)

AngularJS implements all of the basic HTML form controls ([input](https://docs.angularjs.org/api/ng/directive/input), [select](https://docs.angularjs.org/api/ng/directive/select), [textarea](https://docs.angularjs.org/api/ng/directive/textarea)), which should be sufficient for most cases. However, if you need more flexibility, you can write your own form control as a directive.

In order for custom control to work with ngModel and to achieve two-way data-binding it needs to:

* implement $render method, which is responsible for rendering the data after it passed the [NgModelController.$formatters](https://docs.angularjs.org/api/ng/type/ngModel.NgModelController#$formatters),
* call $setViewValue method, whenever the user interacts with the control and model needs to be updated. This is usually done inside a DOM Event listener.

See [$compileProvider.directive](https://docs.angularjs.org/guide/directive) for more info.

The following example shows how to add two-way data-binding to contentEditable elements.

Code: test\_27.html, test\_27.js

## Section 12

# Directives

This document explains when you'd want to create your own directives in your AngularJS app, and how to implement them.

What are Directives?

At a high level, directives are markers on a DOM element (such as an attribute, element name, comment or CSS class) that tell AngularJS's **HTML compiler** ([$compile](https://docs.angularjs.org/api/ng/service/$compile)) to attach a specified behavior to that DOM element (e.g. via event listeners), or even to transform the DOM element and its children.

AngularJS comes with a set of these directives built-in, like ngBind, ngModel, and ngClass. Much like you create controllers and services, you can create your own directives for AngularJS to use. When AngularJS [bootstraps](https://docs.angularjs.org/guide/bootstrap) your application, the [HTML compiler](https://docs.angularjs.org/guide/compiler) traverses the DOM matching directives against the DOM elements.

**What does it mean to "compile" an HTML template?** For AngularJS, "compilation" means attaching directives to the HTML to make it interactive. The reason we use the term "compile" is that the recursive process of attaching directives mirrors the process of compiling source code in[compiled programming languages](http://en.wikipedia.org/wiki/Compiled_languages).

Matching Directives

Before we can write a directive, we need to know how AngularJS's [HTML compiler](https://docs.angularjs.org/guide/compiler) determines when to use a given directive.

Similar to the terminology used when an [element **matches** a selector](https://developer.mozilla.org/en-US/docs/Web/API/Element.matches), we say an element **matches** a directive when the directive is part of its declaration.

In the following example, we say that the <input> element **matches** the ngModel directive

<input ng-model="foo">

The following <input> element also **matches** ngModel:

<input data-ng-model="foo">

And the following <person> element **matches** the person directive:

<person>{{name}}</person>

Normalization

AngularJS **normalizes** an element's tag and attribute name to determine which elements match which directives. We typically refer to directives by their case-sensitive [camelCase](http://en.wikipedia.org/wiki/CamelCase) **normalized** name (e.g. ngModel). However, since HTML is case-insensitive, we refer to directives in the DOM by lower-case forms, typically using [dash-delimited](https://en.wikipedia.org/wiki/Letter_case#Special_case_styles) attributes on DOM elements (e.g. ng-model).

The **normalization** process is as follows:

1. Strip x- and data- from the front of the element/attributes.
2. Convert the :, -, or \_-delimited name to camelCase.

For example, the following forms are all equivalent and match the [ngBind](https://docs.angularjs.org/api/ng/directive/ngBind) directive:

Code: test\_28.html, test\_28.js

**Best Practice:** Prefer using the dash-delimited format (e.g. ng-bind for ngBind). If you want to use an HTML validating tool, you can instead use the data-prefixed version (e.g. data-ng-bind for ngBind). The other forms shown above are accepted for legacy reasons but we advise you to avoid them.

Directive types

$compile can match directives based on element names (E), attributes (A), class names (C), and comments (M).

The built-in AngularJS directives show in their documentation page which type of matching they support.

The following demonstrates the various ways a directive (myDir in this case) that matches all 4 types can be referenced from within a template.

<my-dir></my-dir>

<span my-dir="exp"></span>

<!-- directive: my-dir exp -->

<span class="my-dir: exp;"></span>

A directive can specify which of the 4 matching types it supports in the [restrict](https://docs.angularjs.org/api/ng/service/$compile#-restrict-) property of the directive definition object. The default is EA.

**Best Practice:** Prefer using directives via tag name and attributes over comment and class names. Doing so generally makes it easier to determine what directives a given element matches.

**Best Practice:** Comment directives were commonly used in places where the DOM API limits the ability to create directives that spanned multiple elements (e.g. inside <table> elements). AngularJS 1.2 introduces [ng-repeat-start and ng-repeat-end](https://docs.angularjs.org/api/ng/directive/ngRepeat) as a better solution to this problem. Developers are encouraged to use this over custom comment directives when possible.

Creating Directives

First let's talk about the [API for registering directives](https://docs.angularjs.org/api/ng/provider/$compileProvider#directive). Much like controllers, directives are registered on modules. To register a directive, you use the module.directive API. module.directive takes the[normalized](https://docs.angularjs.org/guide/directive#matching-directives) directive name followed by a **factory function.** This factory function should return an object with the different options to tell $compile how the directive should behave when matched.

The factory function is invoked only once when the [compiler](https://docs.angularjs.org/api/ng/service/$compile) matches the directive for the first time. You can perform any initialization work here. The function is invoked using [$injector.invoke](https://docs.angularjs.org/api/auto/service/$injector#invoke) which makes it injectable just like a controller.

We'll go over a few common examples of directives, then dive deep into the different options and compilation process.

**Best Practice:** In order to avoid collisions with some future standard, it's best to prefix your own directive names. For instance, if you created a <carousel> directive, it would be problematic if HTML7 introduced the same element. A two or three letter prefix (e.g. btfCarousel) works well. Similarly, do not prefix your own directives with ng or they might conflict with directives included in a future version of AngularJS.

For the following examples, we'll use the prefix my (e.g. myCustomer).

Template-expanding directive

Let's say you have a chunk of your template that represents a customer's information. This template is repeated many times in your code. When you change it in one place, you have to change it in several others. This is a good opportunity to use a directive to simplify your template.

Let's create a directive that simply replaces its contents with a static template:

Code: test\_29.html, test\_29.js

Notice that we have bindings in this directive. After $compile compiles and links<div my-customer></div>, it will try to match directives on the element's children. This means you can compose directives of other directives. We'll see how to do that in [an example](https://docs.angularjs.org/guide/directive#creating-directives-that-communicate) below.

In the example above we in-lined the value of the template option, but this will become annoying as the size of your template grows.

**Best Practice:** Unless your template is very small, it's typically better to break it apart into its own HTML file and load it with the templateUrl option.

If you are familiar with ngInclude, templateUrl works just like it. Here's the same example using templateUrl instead:

Code: test\_30.html, test\_30.js

templateUrl can also be a function which returns the URL of an HTML template to be loaded and used for the directive. AngularJS will call the templateUrl function with two parameters: the element that the directive was called on, and an attr object associated with that element.

**Note:** You do not currently have the ability to access scope variables from the templateUrlfunction, since the template is requested before the scope is initialized.

Code: test\_31.html, test\_31.js

**Note:** When you create a directive, it is restricted to attribute and elements only by default. In order to create directives that are triggered by class name, you need to use the restrict option.

The restrict option is typically set to:

* 'A' - only matches attribute name
* 'E' - only matches element name
* 'C' - only matches class name
* 'M' - only matches comment

These restrictions can all be combined as needed:

* 'AEC' - matches either attribute or element or class name

Let's change our directive to use restrict: 'E':

Code: test\_32.html, test\_32.js

For more on the restrict property, see the [API docs](https://docs.angularjs.org/api/ng/service/$compile#directive-definition-object).

**When should I use an attribute versus an element?** Use an element when you are creating a component that is in control of the template. The common case for this is when you are creating a Domain-Specific Language for parts of your template. Use an attribute when you are decorating an existing element with new functionality.

Using an element for the myCustomer directive is clearly the right choice because you're not decorating an element with some "customer" behavior; you're defining the core behavior of the element as a customer component.

Isolating the Scope of a Directive

Our myCustomer directive above is great, but it has a fatal flaw. We can only use it once within a given scope.

In its current implementation, we'd need to create a different controller each time in order to re-use such a directive:

Code: test\_33.html, test\_33.js

This is clearly not a great solution.

What we want to be able to do is separate the scope inside a directive from the scope outside, and then map the outer scope to a directive's inner scope. We can do this by creating what we call an **isolate scope**. To do this, we can use a [directive's scope](https://docs.angularjs.org/api/ng/service/$compile#-scope-) option:

Code: test\_34.html, test\_34.js

Looking at index.html, the first <my-customer> element binds the info attribute to naomi, which we have exposed on our controller's scope. The second binds info to igor.

Let's take a closer look at the scope option:

//...

scope: {

customerInfo: '=info'

},

//...

The **scope option** is an object that contains a property for each isolate scope binding. In this case it has just one property:

* Its name (customerInfo) corresponds to the directive's **isolate scope** property, customerInfo.
* Its value (=info) tells $compile to bind to the info attribute.

**Note:** These =attr attributes in the scope option of directives are normalized just like directive names. To bind to the attribute in <div bind-to-this="thing">, you'd specify a binding of =bindToThis.

For cases where the attribute name is the same as the value you want to bind to inside the directive's scope, you can use this shorthand syntax:

...

scope: {

// same as '=customer'

customer: '='

},

...

Besides making it possible to bind different data to the scope inside a directive, using an isolated scope has another effect.

We can show this by adding another property, vojta, to our scope and trying to access it from within our directive's template:

Code: test\_35.html, test\_35.js

Notice that {{vojta.name}} and {{vojta.address}} are empty, meaning they are undefined. Although we defined vojta in the controller, it's not available within the directive.

As the name suggests, the **isolate scope** of the directive isolates everything except models that you've explicitly added to the scope: {} hash object. This is helpful when building reusable components because it prevents a component from changing your model state except for the models that you explicitly pass in.

**Note:** Normally, a scope prototypically inherits from its parent. An isolated scope does not. See the ["Directive Definition Object - scope"](https://docs.angularjs.org/api/ng/service/$compile#directive-definition-object) section for more information about isolate scopes.

**Best Practice:** Use the scope option to create isolate scopes when making components that you want to reuse throughout your app.

Creating a Directive that Manipulates the DOM

In this example we will build a directive that displays the current time. Once a second, it updates the DOM to reflect the current time.

Directives that want to modify the DOM typically use the link option to register DOM listeners as well as update the DOM. It is executed after the template has been cloned and is where directive logic will be put.

link takes a function with the following signature,function link(scope, element, attrs, controller, transcludeFn) { ... }, where:

* scope is an AngularJS scope object.
* element is the jqLite-wrapped element that this directive matches.
* attrs is a hash object with key-value pairs of normalized attribute names and their corresponding attribute values.
* controller is the directive's required controller instance(s) or its own controller (if any). The exact value depends on the directive's require property.
* transcludeFn is a transclude linking function pre-bound to the correct transclusion scope.

For more details on the link option refer to the [$compile API](https://docs.angularjs.org/api/ng/service/$compile#-link-) page.

In our link function, we want to update the displayed time once a second, or whenever a user changes the time formatting string that our directive binds to. We will use the $interval service to call a handler on a regular basis. This is easier than using $timeout but also works better with end-to-end testing, where we want to ensure that all $timeouts have completed before completing the test. We also want to remove the $interval if the directive is deleted so we don't introduce a memory leak.

Code: test\_36.html, test\_36.js

There are a couple of things to note here. Just like the module.controller API, the function argument in module.directive is dependency injected. Because of this, we can use $interval and dateFilterinside our directive's link function.

We register an event element.on('$destroy', ...). What fires this $destroy event?

There are a few special events that AngularJS emits. When a DOM node that has been compiled with AngularJS's compiler is destroyed, it emits a $destroy event. Similarly, when an AngularJS scope is destroyed, it broadcasts a $destroy event to listening scopes.

By listening to this event, you can remove event listeners that might cause memory leaks. Listeners registered to scopes and elements are automatically cleaned up when they are destroyed, but if you registered a listener on a service, or registered a listener on a DOM node that isn't being deleted, you'll have to clean it up yourself or you risk introducing a memory leak.

**Best Practice:** Directives should clean up after themselves. You can useelement.on('$destroy', ...) or scope.$on('$destroy', ...) to run a clean-up function when the directive is removed.

Creating a Directive that Wraps Other Elements

We've seen that you can pass in models to a directive using the isolate scope, but sometimes it's desirable to be able to pass in an entire template rather than a string or an object. Let's say that we want to create a "dialog box" component. The dialog box should be able to wrap any arbitrary content.

To do this, we need to use the transclude option.

Code: test\_37.html, test\_37.js

What does this transclude option do, exactly? transclude makes the contents of a directive with this option have access to the scope **outside** of the directive rather than inside.

To illustrate this, see the example below. Notice that we've added a link function in script.js that redefines name as Jeff. What do you think the {{name}} binding will resolve to now?

Code: test\_38.html, test\_38.js

Ordinarily, we would expect that {{name}} would be Jeff. However, we see in this example that the {{name}} binding is still Tobias.

The transclude option changes the way scopes are nested. It makes it so that the **contents** of a transcluded directive have whatever scope is outside the directive, rather than whatever scope is on the inside. In doing so, it gives the contents access to the outside scope.

Note that if the directive did not create its own scope, then scope in scope.name = 'Jeff' would reference the outside scope and we would see Jeff in the output.

This behavior makes sense for a directive that wraps some content, because otherwise you'd have to pass in each model you wanted to use separately. If you have to pass in each model that you want to use, then you can't really have arbitrary contents, can you?

**Best Practice:** only use transclude: true when you want to create a directive that wraps arbitrary content.

Next, we want to add buttons to this dialog box, and allow someone using the directive to bind their own behavior to it.

Code: test\_39.html, test\_39.js

We want to run the function we pass by invoking it from the directive's scope, but have it run in the context of the scope where it's registered.

We saw earlier how to use =attr in the scope option, but in the above example, we're using &attrinstead. The & binding allows a directive to trigger evaluation of an expression in the context of the original scope, at a specific time. Any legal expression is allowed, including an expression which contains a function call. Because of this, & bindings are ideal for binding callback functions to directive behaviors.

When the user clicks the x in the dialog, the directive's close function is called, thanks to ng-click.This call to close on the isolated scope actually evaluates the expression hideDialog(message) in the context of the original scope, thus running Controller's hideDialog function.

Often it's desirable to pass data from the isolate scope via an expression to the parent scope, this can be done by passing a map of local variable names and values into the expression wrapper function. For example, the hideDialog function takes a message to display when the dialog is hidden. This is specified in the directive by calling close({message: 'closing for now'}). Then the local variable message will be available within the on-close expression.

**Best Practice:** use &attr in the scope option when you want your directive to expose an API for binding to behaviors.

Creating a Directive that Adds Event Listeners

Previously, we used the link function to create a directive that manipulated its DOM elements. Building upon that example, let's make a directive that reacts to events on its elements.

For instance, what if we wanted to create a directive that lets a user drag an element?

Code: test\_40.html, test\_40.js

Creating Directives that Communicate

You can compose any directives by using them within templates.

Sometimes, you want a component that's built from a combination of directives.

Imagine you want to have a container with tabs in which the contents of the container correspond to which tab is active.

Code: test\_41.html, test\_41.js

The myPane directive has a require option with value ^^myTabs. When a directive uses this option, $compile will throw an error unless the specified controller is found. The ^^ prefix means that this directive searches for the controller on its parents. (A ^ prefix would make the directive look for the controller on its own element or its parents; without any prefix, the directive would look on its own element only.)

So where does this myTabs controller come from? Directives can specify controllers using the unsurprisingly named controller option. As you can see, the myTabs directive uses this option. Just like ngController, this option attaches a controller to the template of the directive.

If it is necessary to reference the controller or any functions bound to the controller from the template, you can use the option controllerAs to specify the name of the controller as an alias. The directive needs to define a scope for this configuration to be used. This is particularly useful in the case when the directive is used as a component.

Looking back at myPane's definition, notice the last argument in its link function: tabsCtrl. When a directive requires a controller, it receives that controller as the fourth argument of its link function. Taking advantage of this, myPane can call the addPane function of myTabs.

If multiple controllers are required, the require option of the directive can take an array argument. The corresponding parameter being sent to the link function will also be an array.

angular.module('docsTabsExample', [])

.directive('myPane', function() {

return {

require: ['^^myTabs', 'ngModel'],

restrict: 'E',

transclude: true,

scope: {

title: '@'

},

link: function(scope, element, attrs, controllers) {

var tabsCtrl = controllers[0],

modelCtrl = controllers[1];

tabsCtrl.addPane(scope);

},

templateUrl: 'my-pane.html'

};

});

Savvy readers may be wondering what the difference is between link and controller. The basic difference is that controller can expose an API, and link functions can interact with controllers using require.

**Best Practice:** use controller when you want to expose an API to other directives. Otherwise use link.

Summary

Here we've seen the main use cases for directives. Each of these samples acts as a good starting point for creating your own directives.

You might also be interested in an in-depth explanation of the compilation process that's available in the [compiler guide](https://docs.angularjs.org/guide/compiler).

The [$compile API](https://docs.angularjs.org/api/ng/service/$compile) page has a comprehensive list of directive options for reference.

controls for the purpose of grouping related controls together.

## Section 13

# Components

In AngularJS, a Component is a special kind of [directive](https://docs.angularjs.org/guide/directive) that uses a simpler configuration which is suitable for a component-based application structure.

This makes it easier to write an app in a way that's similar to using Web Components or using the new Angular's style of application architecture.

Advantages of Components:

* simpler configuration than plain directives
* promote sane defaults and best practices
* optimized for component-based architecture
* writing component directives will make it easier to upgrade to Angular

When not to use Components:

* for directives that need to perform actions in compile and pre-link functions, because they aren't available
* when you need advanced directive definition options like priority, terminal, multi-element
* when you want a directive that is triggered by an attribute or CSS class, rather than an element

## Creating and configuring a Component

Components can be registered using the .component() method of an AngularJS module (returned by [angular.module()](https://docs.angularjs.org/guide/module)). The method takes two arguments:

* The name of the Component (as string).
* The Component config object. (Note that, unlike the .directive() method, this method does **not**take a factory function.)

Code: test\_42.html, test\_42.js

It's also possible to add components via [$compileProvider](https://docs.angularjs.org/api/ng/provider/$compileProvider#component) in a module's config phase.

### Comparison between Directive definition and Component definition

|  | **Directive** | **Component** |
| --- | --- | --- |
| bindings | No | Yes (binds to controller) |
| bindToController | Yes (default: false) | No (use bindings instead) |
| compile function | Yes | No |
| controller | Yes | Yes (default function() {}) |
| controllerAs | Yes (default: false) | Yes (default: $ctrl) |
| link functions | Yes | No |
| multiElement | Yes | No |
| priority | Yes | No |
| replace | Yes (deprecated) | No |
| require | Yes | Yes |
| restrict | Yes | No (restricted to elements only) |
| scope | Yes (default: false) | No (scope is always isolate) |
| template | Yes | Yes, injectable |
| templateNamespace | Yes | No |
| templateUrl | Yes | Yes, injectable |
| terminal | Yes | No |
| transclude | Yes (default: false) | Yes (default: false) |

## Component-based application architecture

As already mentioned, the component helper makes it easier to structure your application with a component-based architecture. But what makes a component beyond the options that the component helper has?

* **Components only control their own View and Data:** Components should never modify any data or DOM that is out of their own scope. Normally, in AngularJS it is possible to modify data anywhere in the application through scope inheritance and watches. This is practical, but can also lead to problems when it is not clear which part of the application is responsible for modifying the data. That is why component directives use an isolate scope, so a whole class of scope manipulation is not possible.
* **Components have a well-defined public API - Inputs and Outputs:** However, scope isolation only goes so far, because AngularJS uses two-way binding. So if you pass an object to a component like this - bindings: {item: '='}, and modify one of its properties, the change will be reflected in the parent component. For components however, only the component that owns the data should modify it, to make it easy to reason about what data is changed, and when. For that reason, components should follow a few simple conventions:
  + Inputs should be using < and @ bindings. The < symbol denotes [one-way bindings](https://docs.angularjs.org/api/ng/service/$compile#-scope-) which are available since 1.5. The difference to = is that the bound properties in the component scope are not watched, which means if you assign a new value to the property in the component scope, it will not update the parent scope. Note however, that both parent and component scope reference the same object, so if you are changing object properties or array elements in the component, the parent will still reflect that change. The general rule should therefore be to never change an object or array property in the component scope. @ bindings can be used when the input is a string, especially when the value of the binding doesn't change.
  + bindings: {
  + hero: '<',
  + comment: '@'

}

* + Outputs are realized with & bindings, which function as callbacks to component events.
  + bindings: {
  + onDelete: '&',
  + onUpdate: '&'

}

* + Instead of manipulating Input Data, the component calls the correct Output Event with the changed data. For a deletion, that means the component doesn't delete the hero itself, but sends it back to the owner component via the correct event.
  + <!-- note that we use kebab-case for bindings in the template as usual -->
  + <editable-field on-update="$ctrl.update('location', value)"></editable-field><br>

<button ng-click="$ctrl.onDelete({hero: $ctrl.hero})">Delete</button>

* + That way, the parent component can decide what to do with the event (e.g. delete an item or update the properties)
  + ctrl.deleteHero(hero) {
  + $http.delete(...).then(function() {
  + var idx = ctrl.list.indexOf(hero);
  + if (idx >= 0) {
  + ctrl.list.splice(idx, 1);
  + }
  + });

}

* **Components have a well-defined lifecycle** Each component can implement "lifecycle hooks". These are methods that will be called at certain points in the life of the component. The following hook methods can be implemented:
  + $onInit() - Called on each controller after all the controllers on an element have been constructed and had their bindings initialized (and before the pre & post linking functions for the directives on this element). This is a good place to put initialization code for your controller.
  + $onChanges(changesObj) - Called whenever one-way bindings are updated. The changesObj is a hash whose keys are the names of the bound properties that have changed, and the values are an object of the form{ currentValue, previousValue, isFirstChange() }. Use this hook to trigger updates within a component such as cloning the bound value to prevent accidental mutation of the outer value.
  + $doCheck() - Called on each turn of the digest cycle. Provides an opportunity to detect and act on changes. Any actions that you wish to take in response to the changes that you detect must be invoked from this hook; implementing this has no effect on when $onChanges is called. For example, this hook could be useful if you wish to perform a deep equality check, or to check a Date object, changes to which would not be detected by AngularJS's change detector and thus not trigger $onChanges. This hook is invoked with no arguments; if detecting changes, you must store the previous value(s) for comparison to the current values.
  + $onDestroy() - Called on a controller when its containing scope is destroyed. Use this hook for releasing external resources, watches and event handlers.
  + $postLink() - Called after this controller's element and its children have been linked. Similar to the post-link function this hook can be used to set up DOM event handlers and do direct DOM manipulation. Note that child elements that contain templateUrl directives will not have been compiled and linked since they are waiting for their template to load asynchronously and their own compilation and linking has been suspended until that occurs. This hook can be considered analogous to the ngAfterViewInit and ngAfterContentInit hooks in Angular. Since the compilation process is rather different in AngularJS there is no direct mapping and care should be taken when upgrading.

By implementing these methods, your component can hook into its lifecycle.

* **An application is a tree of components:** Ideally, the whole application should be a tree of components that implement clearly defined inputs and outputs, and minimize two-way data binding. That way, it's easier to predict when data changes and what the state of a component is.

## Example of a component tree

The following example expands on the simple component example and incorporates the concepts we introduced above:

Instead of an ngController, we now have a heroList component that holds the data of different heroes, and creates a heroDetail for each of them.

The heroDetail component now contains new functionality:

* a delete button that calls the bound onDelete function of the heroList component
* an input to change the hero location, in the form of a reusable editableField component. Instead of manipulating the hero object itself, it sends a changeset upwards to the heroDetail, which sends it upwards to the heroList component, which updates the original data.

Code: test\_43.html, test\_43.js

## Components as route templates

Components are also useful as route templates (e.g. when using [ngRoute](https://docs.angularjs.org/api/ngRoute)). In a component-based application, every view is a component:

var myMod = angular.module('myMod', ['ngRoute']);

myMod.component('home', {

template: '<h1>Home</h1><p>Hello, {{ $ctrl.user.name }} !</p>',

controller: function() {

this.user = {name: 'world'};

}

});

myMod.config(function($routeProvider) {

$routeProvider.when('/', {

template: '<home></home>'

});

});

When using [$routeProvider](https://docs.angularjs.org/api/ngRoute/provider/$routeProvider), you can often avoid some boilerplate, by passing the resolved route dependencies directly to the component. Since 1.5, ngRoute automatically assigns the resolves to the route scope property $resolve (you can also configure the property name via resolveAs). When using components, you can take advantage of this and pass resolves directly into your component without creating an extra route controller:

var myMod = angular.module('myMod', ['ngRoute']);

myMod.component('home', {

template: '<h1>Home</h1><p>Hello, {{ $ctrl.user.name }} !</p>',

bindings: {

user: '<'

}

});

myMod.config(function($routeProvider) {

$routeProvider.when('/', {

template: '<home user="$resolve.user"></home>',

resolve: {

user: function($http) { return $http.get('...'); }

}

});

});

## Intercomponent Communication

Directives can require the controllers of other directives to enable communication between each other. This can be achieved in a component by providing an object mapping for the require property. The object keys specify the property names under which the required controllers (object values) will be bound to the requiring component's controller.

Note that the required controllers will not be available during the instantiation of the controller, but they are guaranteed to be available just before the $onInit method is executed!

Here is a tab pane example built from components:

Code: test\_44.html, test\_44.js

## Unit-testing Component Controllers

The easiest way to unit-test a component controller is by using the [$componentController](https://docs.angularjs.org/api/ngMock/service/$componentController) that is included in [ngMock](https://docs.angularjs.org/api/ngMock). The advantage of this method is that you do not have to create any DOM elements. The following example shows how to do this for the heroDetail component from above.

The examples use the [Jasmine](http://jasmine.github.io/) testing framework.

**Controller Test:**

describe('HeroDetailController', function() {

var $componentController;

beforeEach(module('heroApp'));

beforeEach(inject(function(\_$componentController\_) {

$componentController = \_$componentController\_;

}));

it('should call the `onDelete` binding, when deleting the hero', function() {

var onDeleteSpy = jasmine.createSpy('onDelete');

var bindings = {hero: {}, onDelete: onDeleteSpy};

var ctrl = $componentController('heroDetail', null, bindings);

ctrl.delete();

expect(onDeleteSpy).toHaveBeenCalledWith({hero: ctrl.hero});

});

it('should call the `onUpdate` binding, when updating a property', function() {

var onUpdateSpy = jasmine.createSpy('onUpdate');

var bindings = {hero: {}, onUpdate: onUpdateSpy};

var ctrl = $componentController('heroDetail', null, bindings);

ctrl.update('foo', 'bar');

expect(onUpdateSpy).toHaveBeenCalledWith({

hero: ctrl.hero,

prop: 'foo',

value: 'bar'

});

});

});

## Section 14

# Component Router

**Deprecation Notice:** In an effort to keep synchronized with router changes in the new Angular, this implementation of the Component Router (ngComponentRouter module) has been deprecated and will not receive further updates. We are investigating backporting the new Angular Router to AngularJS, but alternatively, use the [ngRoute](https://docs.angularjs.org/api/ngRoute) module or community developed projects (e.g. [ui-router](https://github.com/angular-ui/ui-router)).

Code: test\_45.html, test\_45.js

## Section 15

# Animations

AngularJS provides animation hooks for common directives such as [ngRepeat](https://docs.angularjs.org/api/ng/directive/ngRepeat), [ngSwitch](https://docs.angularjs.org/api/ng/directive/ngSwitch), and [ngView](https://docs.angularjs.org/api/ngRoute/directive/ngView), as well as custom directives via the $animate service. These animation hooks are set in place to trigger animations during the life cycle of various directives and when triggered, will attempt to perform a CSS Transition, CSS Keyframe Animation or a JavaScript callback Animation (depending on whether an animation is placed on the given directive). Animations can be placed using vanilla CSS by following the naming conventions set in place by AngularJS or with JavaScript code, defined as a factory.

Note that we have used non-prefixed CSS transition properties in our examples as the major browsers now support non-prefixed properties. If you intend to support older browsers or certain mobile browsers then you will need to include prefixed versions of the transition properties. Take a look at <http://caniuse.com/#feat=css-transitions> for what browsers require prefixes, and<https://github.com/postcss/autoprefixer> for a tool that can automatically generate the prefixes for you.

Animations are not available unless you include the [ngAnimate module](https://docs.angularjs.org/api/ngAnimate) as a dependency of your application.

Below is a quick example of animations being enabled for ngShow and ngHide:

Code: test\_46.html, test\_46.js

Installation

See the [API docs for ngAnimate](https://docs.angularjs.org/api/ngAnimate) for instructions on installing the module.

You may also want to setup a separate CSS file for defining CSS-based animations.

How they work

Animations in AngularJS are completely based on CSS classes. As long as you have a CSS class attached to an HTML element within your application, you can apply animations to it. Let's say for example that we have an HTML template with a repeater like so:

<div ng-repeat="item in items" class="repeated-item">

{{ item.id }}

</div>

As you can see, the repeated-item class is present on the element that will be repeated and this class will be used as a reference within our application's CSS and/or JavaScript animation code to tell AngularJS to perform an animation.

As ngRepeat does its thing, each time a new item is added into the list, ngRepeat will add anng-enter class to the element that is being added. When removed it will apply an ng-leave class and when moved around it will apply an ng-move class.

Taking a look at the following CSS code, we can see some transition and keyframe animation code set up for each of those events that occur when ngRepeat triggers them:

/\*

We are using CSS transitions for when the enter and move events

are triggered for the element that has the `repeated-item` class

\*/

.repeated-item.ng-enter, .repeated-item.ng-move {

transition: all 0.5s linear;

opacity: 0;

}

/\*

`.ng-enter-active` and `.ng-move-active` are where the transition destination

properties are set so that the animation knows what to animate

\*/

.repeated-item.ng-enter.ng-enter-active,

.repeated-item.ng-move.ng-move-active {

opacity: 1;

}

/\*

We are using CSS keyframe animations for when the `leave` event

is triggered for the element that has the `repeated-item` class

\*/

.repeated-item.ng-leave {

animation: 0.5s my\_animation;

}

@keyframes my\_animation {

from { opacity: 1; }

to { opacity: 0; }

}

The same approach to animation can be used using JavaScript code (**for simplicity, we rely on jQuery to perform animations here**):

myModule.animation('.repeated-item', function() {

return {

enter: function(element, done) {

// Initialize the element's opacity

element.css('opacity', 0);

// Animate the element's opacity

// (`element.animate()` is provided by jQuery)

element.animate({opacity: 1}, done);

// Optional `onDone`/`onCancel` callback function

// to handle any post-animation cleanup operations

return function(isCancelled) {

if (isCancelled) {

// Abort the animation if cancelled

// (`element.stop()` is provided by jQuery)

element.stop();

}

};

},

leave: function(element, done) {

// Initialize the element's opacity

element.css('opacity', 1);

// Animate the element's opacity

// (`element.animate()` is provided by jQuery)

element.animate({opacity: 0}, done);

// Optional `onDone`/`onCancel` callback function

// to handle any post-animation cleanup operations

return function(isCancelled) {

if (isCancelled) {

// Abort the animation if cancelled

// (`element.stop()` is provided by jQuery)

element.stop();

}

};

},

// We can also capture the following animation events:

move: function(element, done) {},

addClass: function(element, className, done) {},

removeClass: function(element, className, done) {}

}

});

With these generated CSS class names present on the element at the time, AngularJS automatically figures out whether to perform a CSS and/or JavaScript animation. Note that you can't have both CSS and JavaScript animations based on the same CSS class. See [here](https://docs.angularjs.org/api/ngAnimate#css-js-animations-together) for more details.

Class and ngClass animation hooks

AngularJS also pays attention to CSS class changes on elements by triggering the **add** and **remove**hooks. This means that if a CSS class is added to or removed from an element then an animation can be executed in between, before the CSS class addition or removal is finalized. (Keep in mind that AngularJS will only be able to capture class changes if an **interpolated expression** or the **ng-class** directive is used on the element.)

The example below shows how to perform animations during class changes:

Code: test\_47.html, test\_47.js

Although the CSS is a little different than what we saw before, the idea is the same.

Which directives support animations?

A handful of common AngularJS directives support and trigger animation hooks whenever any major event occurs during their life cycle. The table below explains in detail which animation events are triggered:

| **Directive** | **Supported Animations** |
| --- | --- |
| [ngRepeat](https://docs.angularjs.org/api/ng/directive/ngRepeat#animations) | enter, leave, and move |
| [ngIf](https://docs.angularjs.org/api/ng/directive/ngIf#animations) | enter and leave |
| [ngSwitch](https://docs.angularjs.org/api/ng/directive/ngSwitch#animations) | enter and leave |
| [ngInclude](https://docs.angularjs.org/api/ng/directive/ngInclude#animations) | enter and leave |
| [ngView](https://docs.angularjs.org/api/ngRoute/directive/ngView#animations) | enter and leave |
| [ngMessage / ngMessageExp](https://docs.angularjs.org/api/ngMessages#animations) | enter and leave |
| [ngClass / {{class}​}](https://docs.angularjs.org/api/ng/directive/ngClass#animations) | add and remove |
| [ngClassEven](https://docs.angularjs.org/api/ng/directive/ngClassEven#animations) | add and remove |
| [ngClassOdd](https://docs.angularjs.org/api/ng/directive/ngClassOdd#animations) | add and remove |
| [ngHide](https://docs.angularjs.org/api/ng/directive/ngHide#animations) | add and remove (the ng-hide class) |
| [ngShow](https://docs.angularjs.org/api/ng/directive/ngShow#animations) | add and remove (the ng-hide class) |
| [ngModel](https://docs.angularjs.org/api/ng/directive/ngModel#animations) | add and remove ([various classes](https://docs.angularjs.org/api/ng/directive/ngModel#css-classes)) |
| [form / ngForm](https://docs.angularjs.org/api/ng/directive/form#animations) | add and remove ([various classes](https://docs.angularjs.org/api/ng/directive/form#css-classes)) |
| [ngMessages](https://docs.angularjs.org/api/ngMessages#animations) | add and remove (the ng-active/ng-inactive classes) |

For a full breakdown of the steps involved during each animation event, refer to the [API docs](https://docs.angularjs.org/api/ng/service/$animate).

How do I use animations in my own directives?

Animations within custom directives can also be established by injecting $animate directly into your directive and making calls to it when needed.

myModule.directive('my-directive', ['$animate', function($animate) {

return function(scope, element) {

element.on('click', function() {

if (element.hasClass('clicked')) {

$animate.removeClass(element, 'clicked');

} else {

$animate.addClass(element, 'clicked');

}

});

};

}]);

Animations on app bootstrap / page load

By default, animations are disabled when the AngularJS app [bootstraps](https://docs.angularjs.org/guide/bootstrap). If you are using the [ngApp](https://docs.angularjs.org/api/ng/directive/ngApp)directive, this happens in the DOMContentLoaded event, so immediately after the page has been loaded. Animations are disabled, so that UI and content are instantly visible. Otherwise, with many animations on the page, the loading process may become too visually overwhelming, and the performance may suffer.

Internally, ngAnimate waits until all template downloads that are started right after bootstrap have finished. Then, it waits for the currently running [$digest](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$digest) and one more after that, to finish. This ensures that the whole app has been compiled fully before animations are attempted.

If you do want your animations to play when the app bootstraps, you can enable animations globally in your main module's [run](https://docs.angularjs.org/api/ng/type/angular.Module#run) function:

myModule.run(function($animate) {

$animate.enabled(true);

});

How to (selectively) enable, disable and skip animations

There are several different ways to disable animations, both globally and for specific animations. Disabling specific animations can help to speed up the render performance, for example for large ngRepeat lists that don't actually have animations. Because ngAnimate checks at runtime if animations are present, performance will take a hit even if an element has no animation.

During the config: [$animateProvider.customFilter()](https://docs.angularjs.org/api/ng/provider/$animateProvider#customFilter)

This function can be called during the [config](https://docs.angularjs.org/api/ng/type/angular.Module#config) phase of an app. It takes a filter function as the only argument, which will then be used to "filter" animations (based on the animated element, the event type, and the animation options). Only when the filter function returns true, will the animation be performed. This allows great flexibility - you can easily create complex rules, such as allowing specific events only or enabling animations on specific subtrees of the DOM, and dynamically modify them, for example disabling animations at certain points in time or under certain circumstances.

app.config(function($animateProvider) {

$animateProvider.customFilter(function(node, event, options) {

// Example: Only animate `enter` and `leave` operations.

return event === 'enter' || event === 'leave';

});

});

The customFilter approach generally gives a big speed boost compared to other strategies, because the matching is done before other animation disabling strategies are checked.

**Best Practice:** Keep the filtering function as lean as possible, because it will be called for each DOM action (e.g. insertion, removal, class change) performed by "animation-aware" directives. See [here](https://docs.angularjs.org/guide/animations#which-directives-support-animations-) for a list of built-in directives that support animations. Performing computationally expensive or time-consuming operations on each call of the filtering function can make your animations sluggish.

During the config: [$animateProvider.classNameFilter()](https://docs.angularjs.org/api/ng/provider/$animateProvider#classNameFilter)

This function too can be called during the [config](https://docs.angularjs.org/api/ng/type/angular.Module#config) phase of an app. It takes a regex as the only argument, which will then be matched against the classes of any element that is about to be animated. The regex allows a lot of flexibility - you can either allow animations for specific classes only (useful when you are working with 3rd party animations), or exclude specific classes from getting animated.

app.config(function($animateProvider) {

$animateProvider.classNameFilter(/animate-/);

});

/\* prefixed with `animate-` \*/

.animate-fade-add.animate-fade-add-active {

transition: all 1s linear;

opacity: 0;

}

The classNameFilter approach generally gives a big speed boost compared to other strategies, because the matching is done before other animation disabling strategies are checked. However, that also means it is not possible to override class name matching with the two following strategies. It's of course still possible to enable / disable animations by changing an element's class name at runtime.

At runtime: [$animate.enabled()](https://docs.angularjs.org/api/ng/service/$animate#enabled)

This function can be used to enable / disable animations in two different ways:

With a single boolean argument, it enables / disables animations globally: $animate.enabled(false)disables all animations in your app.

When the first argument is a native DOM or jqLite/jQuery element, the function enables / disables animations on this element *and all its children*: $animate.enabled(myElement, false). You can still use it to re-enable animations for a child element, even if you have disabled them on a parent element. And compared to the classNameFilter, you can change the animation status at runtime instead of during the config phase.

Note however that the $animate.enabled() state for individual elements does not overwrite disabling rules that have been set in the [classNameFilter](https://docs.angularjs.org/api/ng/provider/$animateProvider#classNameFilter).

Via CSS styles: overwriting styles in the ng-animate CSS class

Whenever an animation is started, ngAnimate applies the ng-animate class to the element for the whole duration of the animation. By applying CSS transition / animation styling to that class, you can skip an animation:

.my-class {

transition: transform 2s;

}

.my-class:hover {

transform: translateX(50px);

}

my-class.ng-animate {

transition: 0s;

}

By setting transition: 0s, ngAnimate will ignore the existing transition styles, and not try to animate them (Javascript animations will still execute, though). This can be used to prevent [issues with existing animations interfering with ngAnimate](https://docs.angularjs.org/guide/animations#preventing-collisions-with-existing-animations-and-third-party-libraries).

Preventing flicker before an animation starts

When nesting elements with structural animations, such as ngIf, into elements that have class-based animations such as ngClass, it sometimes happens that before the actual animation starts, there is a brief flicker or flash of content where the animated element is briefly visible.

To prevent this, you can apply styles to the ng-[event]-prepare class, which is added as soon as an animation is initialized, but removed before the actual animation starts (after waiting for a $digest). This class is only added for *structural* animations (enter, move, and leave).

Here's an example where you might see flickering:

<div ng-class="{red: myProp}">

<div ng-class="{blue: myProp}">

<div class="message" ng-if="myProp"></div>

</div>

</div>

It is possible that during the enter event, the .message div will be briefly visible before it starts animating. In that case, you can add styles to the CSS that make sure the element stays hidden before the animation starts:

.message.ng-enter-prepare {

opacity: 0;

}

/\* Other animation styles ... \*/

Preventing collisions with existing animations and third-party libraries

By default, any ngAnimate-enabled directives will assume that transition / animation styles on the element are part of an ngAnimate animation. This can lead to problems when the styles are actually for animations that are independent of ngAnimate.

For example, an element acts as a loading spinner. It has an infinite css animation on it, and also an [ngIf](https://docs.angularjs.org/api/ng/directive/ngIf)directive, for which no animations are defined:

.spinner {

animation: rotating 2s linear infinite;

}

@keyframes rotating {

from { transform: rotate(0deg); }

to { transform: rotate(360deg); }

}

Now, when the ngIf expression changes, ngAnimate will see the spinner animation and use it to animate the enter/leave event, which doesn't work because the animation is infinite. The element will still be added / removed after a timeout, but there will be a noticeable delay.

This might also happen because some third-party frameworks place animation duration defaults across many element or className selectors in order to make their code small and reusable.

You can prevent this unwanted behavior by adding CSS to the .ng-animate class, that is added for the whole duration of each animation. Simply overwrite the transition / animation duration. In the case of the spinner, this would be:

.spinner.ng-animate {

animation: 0s none;

transition: 0s none;

}

If you do have CSS transitions / animations defined for the animation events, make sure they have a higher priority than any styles that are not related to ngAnimate.

You can also use one of the other [strategies to disable animations](https://docs.angularjs.org/guide/animations#how-to-selectively-enable-disable-and-skip-animations).

Enable animations for elements outside of the AngularJS application DOM tree: [$animate.pin()](https://docs.angularjs.org/api/ng/service/$animate#pin)

Before animating, ngAnimate checks if the animated element is inside the application DOM tree. If not, no animation is run. Usually, this is not a problem since most apps use the html or body elements as their root.

Problems arise when the application is bootstrapped on a different element, and animations are attempted on elements that are outside the application tree, e.g. when libraries append popup or modal elements to the body tag.

You can use [$animate.pin(element, parentHost)](https://docs.angularjs.org/api/ng/service/$animate#pin) to associate an element with another element that belongs to your application. Simply call it before the element is added to the DOM / before the animation starts, with the element you want to animate, and the element which should be its assumed parent.

More about animations

For a full breakdown of each method available on $animate, see the [API documentation](https://docs.angularjs.org/api/ng/service/$animate).

To see a complete demo, see the [animation step in the phonecat tutorial](https://docs.angularjs.org/tutorial/step_14).

## Section 16

# Modules

What is a Module?

You can think of a module as a container for the different parts of your app – controllers, services, filters, directives, etc.

Why?

Most applications have a main method that instantiates and wires together the different parts of the application.

AngularJS apps don't have a main method. Instead modules declaratively specify how an application should be bootstrapped. There are several advantages to this approach:

* The declarative process is easier to understand.
* You can package code as reusable modules.
* The modules can be loaded in any order (or even in parallel) because modules delay execution.
* Unit tests only have to load relevant modules, which keeps them fast.
* End-to-end tests can use modules to override configuration.

The Basics

I'm in a hurry. How do I get a Hello World module working?

Code: test\_48.html, test\_48.js

Important things to notice:

* The [Module](https://docs.angularjs.org/api/ng/type/angular.Module) API
* The reference to myApp module in <div ng-app="myApp">. This is what bootstraps the app using your module.
* The empty array in angular.module('myApp', []). This array is the list of modules myAppdepends on.

Recommended Setup

While the example above is simple, it will not scale to large applications. Instead we recommend that you break your application to multiple modules like this:

* A module for each feature
* A module for each reusable component (especially directives and filters)
* And an application level module which depends on the above modules and contains any initialization code.

You can find a community [style guide](https://github.com/johnpapa/angular-styleguide) to help yourself when application grows.

The above is a suggestion. Tailor it to your needs.

Code: test\_49.html, test\_49.js

Module Loading

A [module](https://docs.angularjs.org/api/ng/type/angular.Module) is a collection of providers, services, directives etc., and optionally config and run blocks which get applied to the application during the bootstrap process.

The [module API](https://docs.angularjs.org/api/ng/type/angular.Module) describes all the available methods and how they can be used.

See [Using Dependency Injection](https://docs.angularjs.org/guide/di#using-dependency-injection) to find out which dependencies can be injected in each method.

Dependencies and Order of execution

Modules can list other modules as their dependencies. Depending on a module implies that the required module will be loaded before the requiring module is loaded.

In a single module the order of execution is as follows:

1. [provider](https://docs.angularjs.org/api/ng/type/angular.Module#provider) functions are executed, so they and the services they define can be made available to the [$injector](https://docs.angularjs.org/api/auto/service/$injector).
2. After that, the configuration blocks ([config](https://docs.angularjs.org/api/ng/type/angular.Module#config) functions) are executed. This means the configuration blocks of the required modules execute before the configuration blocks of any requiring module.

This continues until all module dependencies has been resolved.

Then, the [run](https://docs.angularjs.org/api/ng/type/angular.Module#run) blocks that have been collected from each module are executed in order of requirement.

Note: each module is only loaded once, even if multiple other modules require it. Note: the factory function for "values" and "services" is called lazily when the value/service is injected for the first time.

Registration in the config block

While it is recommended to register injectables directly with the [module API](https://docs.angularjs.org/api/ng/type/angular.Module), it is also possible to register services, directives etc. by injecting [$provide](https://docs.angularjs.org/api/auto/service/$provide) or the individual service providers into the config function:

angular.module('myModule', []).

value('a', 123).

factory('a', function() { return 123; }).

directive('directiveName', ...).

filter('filterName', ...);

// is same as

angular.module('myModule', []).

config(function($provide, $compileProvider, $filterProvider) {

$provide.value('a', 123);

$provide.factory('a', function() { return 123; });

$compileProvider.directive('directiveName', ...);

$filterProvider.register('filterName', ...);

});

Run Blocks

Run blocks are the closest thing in AngularJS to the main method. A run block is the code which needs to run to kickstart the application. It is executed after all of the services have been configured and the injector has been created. Run blocks typically contain code which is hard to unit-test, and for this reason should be declared in isolated modules, so that they can be ignored in the unit-tests.

Asynchronous Loading

Modules are a way of managing $injector configuration, and have nothing to do with loading of scripts into a VM. There are existing projects which deal with script loading, which may be used with AngularJS. Because modules do nothing at load time they can be loaded into the VM in any order and thus script loaders can take advantage of this property and parallelize the loading process.

Creation versus Retrieval

Beware that using angular.module('myModule', []) will create the module myModule and overwrite any existing module named myModule. Use angular.module('myModule') to retrieve an existing module.

var myModule = angular.module('myModule', []);

// add some directives and services

myModule.service('myService', ...);

myModule.directive('myDirective', ...);

// overwrites both myService and myDirective by creating a new module

var myModule = angular.module('myModule', []);

// throws an error because myOtherModule has yet to be defined

var myModule = angular.module('myOtherModule');

Unit Testing

A unit test is a way of instantiating a subset of an application to apply stimulus to it. Small, structured modules help keep unit tests concise and focused.

Each module can only be loaded once per injector. Usually an AngularJS app has only one injector and modules are only loaded once. Each test has its own injector and modules are loaded multiple times.

In all of these examples we are going to assume this module definition:

angular.module('greetMod', []).

factory('alert', function($window) {

return function(text) {

$window.alert(text);

}

}).

value('salutation', 'Hello').

factory('greet', function(alert, salutation) {

return function(name) {

alert(salutation + ' ' + name + '!');

}

});

Let's write some tests to show how to override configuration in tests.

describe('myApp', function() {

// load application module (`greetMod`) then load a special

// test module which overrides `$window` with a mock version,

// so that calling `window.alert()` will not block the test

// runner with a real alert box.

beforeEach(module('greetMod', function($provide) {

$provide.value('$window', {

alert: jasmine.createSpy('alert')

});

}));

// inject() will create the injector and inject the `greet` and

// `$window` into the tests.

it('should alert on $window', inject(function(greet, $window) {

greet('World');

expect($window.alert).toHaveBeenCalledWith('Hello World!');

}));

// this is another way of overriding configuration in the

// tests using inline `module` and `inject` methods.

it('should alert using the alert service', function() {

var alertSpy = jasmine.createSpy('alert');

module(function($provide) {

$provide.value('alert', alertSpy);

});

inject(function(greet) {

greet('World');

expect(alertSpy).toHaveBeenCalledWith('Hello World!');

});

});

});

## Section 17

# HTML Compiler

Overview

AngularJS's [HTML compiler](https://docs.angularjs.org/api/ng/service/$compile) allows the developer to teach the browser new HTML syntax. The compiler allows you to attach behavior to any HTML element or attribute and even create new HTML elements or attributes with custom behavior. AngularJS calls these behavior extensions [directives](https://docs.angularjs.org/api/ng/provider/$compileProvider#directive).

HTML has a lot of constructs for formatting the HTML for static documents in a declarative fashion. For example if something needs to be centered, there is no need to provide instructions to the browser how the window size needs to be divided in half so that the center is found, and that this center needs to be aligned with the text's center. Simply add an align="center" attribute to any element to achieve the desired behavior. Such is the power of declarative language.

However, the declarative language is also limited, as it does not allow you to teach the browser new syntax. For example, there is no easy way to get the browser to align the text at 1/3 the position instead of 1/2. What is needed is a way to teach the browser new HTML syntax.

AngularJS comes pre-bundled with common directives which are useful for building any app. We also expect that you will create directives that are specific to your app. These extensions become a Domain Specific Language for building your application.

All of this compilation takes place in the web browser; no server side or pre-compilation step is involved.

Compiler

Compiler is an AngularJS service which traverses the DOM looking for attributes. The compilation process happens in two phases.

1. **Compile:** traverse the DOM and collect all of the directives. The result is a linking function.
2. **Link:** combine the directives with a scope and produce a live view. Any changes in the scope model are reflected in the view, and any user interactions with the view are reflected in the scope model. This makes the scope model the single source of truth.

Some directives such as [ng-repeat](https://docs.angularjs.org/api/ng/directive/ngRepeat) clone DOM elements once for each item in a collection. Having a compile and link phase improves performance since the cloned template only needs to be compiled once, and then linked once for each clone instance.

Directive

A directive is a behavior which should be triggered when specific HTML constructs are encountered during the compilation process. The directives can be placed in element names, attributes, class names, as well as comments. Here are some equivalent examples of invoking the [ng-bind](https://docs.angularjs.org/api/ng/directive/ngBind) directive.

<span ng-bind="exp"></span>

<span class="ng-bind: exp;"></span>

<ng-bind></ng-bind>

<!-- directive: ng-bind exp -->

A directive is just a function which executes when the compiler encounters it in the DOM. See [directive API](https://docs.angularjs.org/api/ng/provider/$compileProvider#directive)for in-depth documentation on how to write directives.

Here is a directive which makes any element draggable. Notice the draggable attribute on the <span>element.

Code: test\_50.html, test\_50.js

The presence of the draggable attribute on any element gives the element new behavior. We extended the vocabulary of the browser in a way which is natural to anyone who is familiar with the principles of HTML.

Understanding View

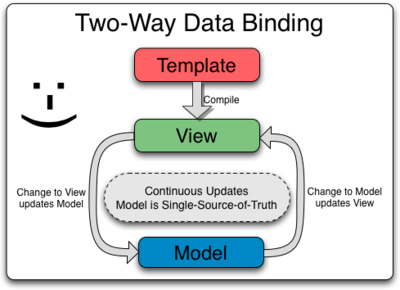
Most other templating systems consume a static string template and combine it with data, resulting in a new string. The resulting text is then innerHTMLed into an element.



This means that any changes to the data need to be re-merged with the template and then innerHTMLed into the DOM. Some of the issues with this approach are:

1. reading user input and merging it with data
2. clobbering user input by overwriting it
3. managing the whole update process
4. lack of behavior expressiveness

AngularJS is different. The AngularJS compiler consumes the DOM, not string templates. The result is a linking function, which when combined with a scope model results in a live view. The view and scope model bindings are transparent. The developer does not need to make any special calls to update the view. And because innerHTML is not used, you won't accidentally clobber user input. Furthermore, AngularJS directives can contain not just text bindings, but behavioral constructs as well.



The AngularJS approach produces a stable DOM. The DOM element instance bound to a model item instance does not change for the lifetime of the binding. This means that the code can get hold of the elements and register event handlers and know that the reference will not be destroyed by template data merge.

How directives are compiled

It's important to note that AngularJS operates on DOM nodes rather than strings. Usually, you don't notice this restriction because when a page loads, the web browser parses HTML into the DOM automatically.

HTML compilation happens in three phases:

1. [$compile](https://docs.angularjs.org/api/ng/service/$compile) traverses the DOM and matches directives.

If the compiler finds that an element matches a directive, then the directive is added to the list of directives that match the DOM element. A single element may match multiple directives.

1. Once all directives matching a DOM element have been identified, the compiler sorts the directives by their priority.

Each directive's compile functions are executed. Each compile function has a chance to modify the DOM. Each compile function returns a link function. These functions are composed into a "combined" link function, which invokes each directive's returned link function.

1. $compile links the template with the scope by calling the combined linking function from the previous step. This in turn will call the linking function of the individual directives, registering listeners on the elements and setting up [$watchs](https://docs.angularjs.org/api/ng/type/$rootScope.Scope#$watch) with the [scope](https://docs.angularjs.org/api/ng/type/$rootScope.Scope) as each directive is configured to do.

The result of this is a live binding between the scope and the DOM. So at this point, a change in a model on the compiled scope will be reflected in the DOM.

Below is the corresponding code using the $compile service. This should help give you an idea of what AngularJS does internally.

var $compile = ...; // injected into your code

var scope = ...;

var parent = ...; // DOM element where the compiled template can be appended

var html = '<div ng-bind="exp"></div>';

// Step 1: parse HTML into DOM element

var template = angular.element(html);

// Step 2: compile the template

var linkFn = $compile(template);

// Step 3: link the compiled template with the scope.

var element = linkFn(scope);

// Step 4: Append to DOM (optional)

parent.appendChild(element);

The difference between Compile and Link

At this point you may wonder why the compile process has separate compile and link phases. The short answer is that compile and link separation is needed any time a change in a model causes a change in the **structure** of the DOM.

It's rare for directives to have a **compile function**, since most directives are concerned with working with a specific DOM element instance rather than changing its overall structure.

Directives often have a **link function**. A link function allows the directive to register listeners to the specific cloned DOM element instance as well as to copy content into the DOM from the scope.

**Best Practice:** Any operation which can be shared among the instance of directives should be moved to the compile function for performance reasons.

An Example of "Compile" Versus "Link"

To understand, let's look at a real-world example with ngRepeat:

Hello {{user.name}}, you have these actions:

<ul>

<li ng-repeat="action in user.actions">

{{action.description}}

</li>

</ul>

When the above example is compiled, the compiler visits every node and looks for directives.

{{user.name}} matches the [interpolation directive](https://docs.angularjs.org/api/ng/service/$interpolate) and ng-repeat matches the [ngRepeat directive](https://docs.angularjs.org/api/ng/directive/ngRepeat).

But [ngRepeat](https://docs.angularjs.org/api/ng/directive/ngRepeat) has a dilemma.

It needs to be able to clone new <li> elements for every action in user.actions. This initially seems trivial, but it becomes more complicated when you consider that user.actions might have items added to it later. This means that it needs to save a clean copy of the <li> element for cloning purposes.

As new actions are inserted, the template <li> element needs to be cloned and inserted into ul. But cloning the <li> element is not enough. It also needs to compile the <li> so that its directives, like {{action.description}}, evaluate against the right [scope](https://docs.angularjs.org/api/ng/type/$rootScope.Scope).

A naive approach to solving this problem would be to simply insert a copy of the <li> element and then compile it. The problem with this approach is that compiling on every <li> element that we clone would duplicate a lot of the work. Specifically, we'd be traversing <li> each time before cloning it to find the directives. This would cause the compilation process to be slower, in turn making applications less responsive when inserting new nodes.

The solution is to break the compilation process into two phases:

the **compile phase** where all of the directives are identified and sorted by priority, and a **linking phase**where any work which "links" a specific instance of the [scope](https://docs.angularjs.org/api/ng/type/$rootScope.Scope) and the specific instance of an <li> is performed.

**Note:** *Link* means setting up listeners on the DOM and setting up $watch on the Scope to keep the two in sync.

[ngRepeat](https://docs.angularjs.org/api/ng/directive/ngRepeat) works by preventing the compilation process from descending into the <li> element so it can make a clone of the original and handle inserting and removing DOM nodes itself.

Instead the [ngRepeat](https://docs.angularjs.org/api/ng/directive/ngRepeat) directive compiles <li> separately. The result of the <li> element compilation is a linking function which contains all of the directives contained in the <li> element, ready to be attached to a specific clone of the <li> element.

At runtime the [ngRepeat](https://docs.angularjs.org/api/ng/directive/ngRepeat) watches the expression and as items are added to the array it clones the <li>element, creates a new [scope](https://docs.angularjs.org/api/ng/type/$rootScope.Scope) for the cloned <li> element and calls the link function on the cloned <li>.

Understanding How Scopes Work with Transcluded Directives

One of the most common use cases for directives is to create reusable components.

Below is a pseudo code showing how a simplified dialog component may work.

<div>

<button ng-click="show=true">show</button>

<dialog title="Hello {{username}}."

visible="show"

on-cancel="show = false"

on-ok="show = false; doSomething()">

Body goes here: {{username}} is {{title}}.

</dialog>

</div>

Clicking on the "show" button will open the dialog. The dialog will have a title, which is data bound to username, and it will also have a body which we would like to transclude into the dialog.

Here is an example of what the template definition for the dialog widget may look like.

<div ng-show="visible">

<h3>{{title}}</h3>

<div class="body" ng-transclude></div>

<div class="footer">

<button ng-click="onOk()">Save changes</button>

<button ng-click="onCancel()">Close</button>

</div>

</div>

This will not render properly, unless we do some scope magic.

The first issue we have to solve is that the dialog box template expects title to be defined. But we would like the template's scope property title to be the result of interpolating the <dialog> element's title attribute (i.e. "Hello {{username}}"). Furthermore, the buttons expect the onOk and onCancel functions to be present in the scope. This limits the usefulness of the widget. To solve the mapping issue we use the scope to create local variables which the template expects as follows:

scope: {

title: '@', // the title uses the data-binding from the parent scope

onOk: '&', // create a delegate onOk function

onCancel: '&', // create a delegate onCancel function

visible: '=' // set up visible to accept data-binding

}

Creating local properties on widget scope creates two problems:

1. isolation - if the user forgets to set title attribute of the dialog widget the dialog template will bind to parent scope property. This is unpredictable and undesirable.
2. transclusion - the transcluded DOM can see the widget locals, which may overwrite the properties which the transclusion needs for data-binding. In our example the title property of the widget clobbers the title property of the transclusion.

To solve the issue of lack of isolation, the directive declares a new isolated scope. An isolated scope does not prototypically inherit from the parent scope, and therefore we don't have to worry about accidentally clobbering any properties.

However isolated scope creates a new problem: if a transcluded DOM is a child of the widget isolated scope then it will not be able to bind to anything. For this reason the transcluded scope is a child of the original scope, before the widget created an isolated scope for its local variables. This makes the transcluded and widget isolated scope siblings.

This may seem to be unexpected complexity, but it gives the widget user and developer the least surprise.

Therefore the final directive definition looks something like this:

transclude: true,

scope: {

title: '@', // the title uses the data-binding from the parent scope

onOk: '&', // create a delegate onOk function

onCancel: '&', // create a delegate onCancel function

visible: '=' // set up visible to accept data-binding

},

restrict: 'E',

replace: true

Double Compilation, and how to avoid it

Double compilation occurs when an already compiled part of the DOM gets compiled again. This is an undesired effect and can lead to misbehaving directives, performance issues, and memory leaks. A common scenario where this happens is a directive that calls $compile in a directive link function on the directive element. In the following **faulty example**, a directive adds a mouseover behavior to a button with ngClick on it:

angular.module('app').directive('addMouseover', function($compile) {

return {

link: function(scope, element, attrs) {

var newEl = angular.element('<span ng-show="showHint"> My Hint</span>');

element.on('mouseenter mouseleave', function() {

scope.$apply('showHint = !showHint');

});

attrs.$set('addMouseover', null); // To stop infinite compile loop

element.append(newEl);

$compile(element)(scope); // Double compilation

}

}

})

At first glance, it looks like removing the original addMouseover attribute is all there is needed to make this example work. However, if the directive element or its children have other directives attached, they will be compiled and linked again, because the compiler doesn't keep track of which directives have been assigned to which elements.

This can cause unpredictable behavior, e.g. ngClick or other event handlers will be attached again. It can also degrade performance, as watchers for text interpolation are added twice to the scope.

Double compilation should therefore be avoided. In the above example, only the new element should be compiled:

angular.module('app').directive('addMouseover', function($compile) {

return {

link: function(scope, element, attrs) {

var newEl = angular.element('<span ng-show="showHint"> My Hint</span>');

element.on('mouseenter mouseleave', function() {

scope.$apply('showHint = !showHint');

});

element.append(newEl);

$compile(newEl)(scope); // Only compile the new element

}

}

})

Another scenario is adding a directive programmatically to a compiled element and then executing compile again. See the following **faulty example**:

<input ng-model="$ctrl.value" add-options>

angular.module('app').directive('addOptions', function($compile) {

return {

link: function(scope, element, attrs) {

attrs.$set('addOptions', null) // To stop infinite compile loop

attrs.$set('ngModelOptions', '{debounce: 1000}');

$compile(element)(scope); // Double compilation

}

}

});

In that case, it is necessary to intercept the *initial* compilation of the element:

1. Give your directive the terminal property and a higher priority than directives that should not be compiled twice. In the example, the compiler will only compile directives which have a priority of 100 or higher.
2. Inside this directive's compile function, add any other directive attributes to the template.
3. Compile the element, but restrict the maximum priority, so that any already compiled directives (including the addOptions directive) are not compiled again.
4. In the link function, link the compiled element with the element's scope.

angular.module('app').directive('addOptions', function($compile) {

return {

priority: 100, // ngModel has priority 1

terminal: true,

compile: function(templateElement, templateAttributes) {

templateAttributes.$set('ngModelOptions', '{debounce: 1000}');

// The third argument is the max priority. Only directives with priority < 100 will be compiled,

// therefore we don't need to remove the attribute

var compiled = $compile(templateElement, null, 100);

return function linkFn(scope) {

compiled(scope) // Link compiled element to scope

}

}

}

});