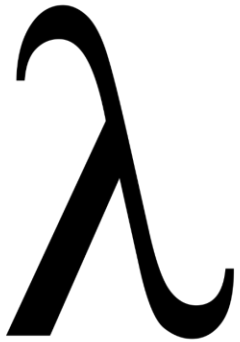
Dart

Functional Programming



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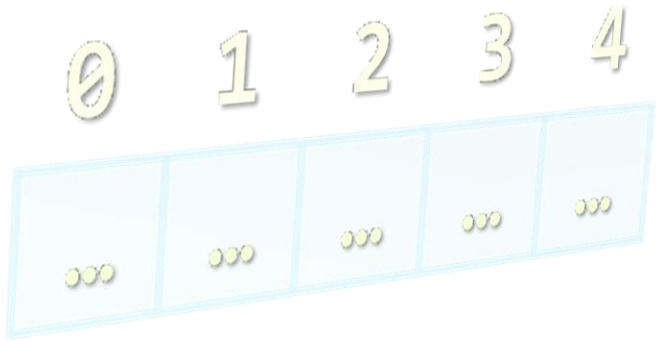


List

- Dart has a List**<T>** type to declare list

```dart
List<String> colors = ["Red", "Green", "Blue"];
var names = ["Ali", "Ahmed", "Sara"];

const nums = [2, 3, 4];
var nullNums = List<int?>.filled(10, null);

colors.forEach((color) => print(color));
names.forEach((name) => print(name));
nums.forEach((num) => print(num));
nullNums.forEach((num) => print(num));
```

List Methods

```
const nums = [2, 3, 4];

nums.add(8);
nums.insert(0, 1);
nums.removeAt(2);
nums.remove(4);
nums.removeLast();
nums.removeRange(0, 2);
nums.removeWhere((num) => num > 3);
nums.removeRange(0, nums.length);
nums.addAll([1, 2, 3]);
nums.addAll([4, 5, 6]);
```

List destructuring

- List destructuring allows you to unpack or extract values from a list and assign them to variables in a clean and concise way

```
var fruits = ["Apple", "Banana", "Cherry", "Mango", "Orange"];

// Destructuring the list
// ... is used to unpack the remaining elements
var [firstFruit, secondFruit, thirdFruit, ...others] = fruits;

print("First fruit: $firstFruit");   // Output: First fruit: Apple
print("Second fruit: $secondFruit"); // Output: Second fruit: Banana
print("Third fruit: $thirdFruit");   // Output: Third fruit: Cherry
print("Others: $others");            // Output: Others: [Mango, Orange]
```

Spread operator (...)

- Spread operator (...) allows you to include all elements of one list inside another list
  - It "spreads" the elements of a list into a new list
  - The null-aware spread operator (...?) is used when the list you're spreading might be null

```
List<String> fruits = ["Apple", "Banana"];
List<String> vegetables = ["Carrot", "Broccoli"];

List<String> food = fruits + vegetables;
print(food); // Output: [Apple, Banana, Carrot, Broccoli]

food = [...fruits, ...vegetables];
print(food); // Output: [Apple, Banana, Carrot, Broccoli]
```

Set

- *Set is same as List but does not allow duplicates*

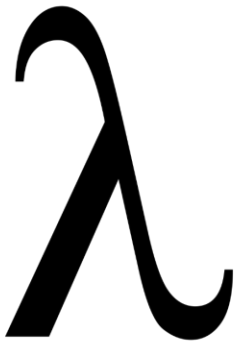
```
final Set<String> colors = {"red", "blue", "yellow"};
colors.add("pink");  // Adding a new element
 // Won't be added again because sets don't allow duplicates
colors.add("blue");
print(colors); // Output: {red, blue, yellow, pink}
```

Map

- Stores keys and associated values

```
Map<int, String> languages = {
  1: "Python",
  2: "Kotlin",
  3: "Dart",
};

languages.forEach((key, value) {
  print("$key => $value");
});
```

Lambda



Imperative vs. Declarative

Imperative Programming

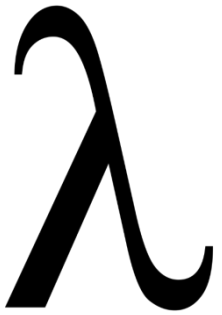
- You tell the computer **how** to perform a task

Declarative Programming

- You tell the computer **what you want**, and you let the compiler (or runtime) figure out the best way to do it. This makes the code simpler and more concise
- Also known as **Functional Programming**
- Data immutability: reducing the chance of unexpected mutations and making code more predictable (doing **.map** on list produces a new list and does NOT change the original list)
- `Declarative programming using Lambdas helps us to achieve KISS`

KEEP IT SHORT & SIMPLE

What is a Lambda?



- Lambda is an **anonymous function** that you can store in a variable, pass them as parameter, or return from other function. It has:
  - Parameters
  - A body
- It **don't have a name** (anonymous method)
- It **can be passed as a parameter** to other function:
  - As *code* to be executed by the receiving function
- Concise syntax:

```
(Parameters) => Body
```

Passing Lambda as a Parameter

- Lambda expression can be passed as a parameter to methods such as ***forEach***, ***where*** and ***map*** methods :

```
var numbers = [1, 2, 3, 4, 5, 6, 7, 8, 9];
numbers.forEach((e) => print(e));
```

forEach - Calls a Lambda on Each Element of the list

- Left side of `=>` operator is a parameter variable
- Right side is the code to operate on the parameter and compute a result
- When using a lambda with a `List` the compiler can determine the parameter type

Lambda usage

- Allows working with collections in a **functional style**

```
bool isEven(int n) => n % 2 == 0;
void main() {
  // Range (1 to 10 inclusive)
  List<int> nums = List.generate(10, (i) => i + 1);
  // Version 1
  bool hasEvenNumber = nums.any((n) => n.isEven);
  // Verion 2
  hasEvenNumber = nums.any(isEven);

  // Version 3 - most compact
  hasEvenNumber = nums.any((n) => n % 2 == 0);
  print("Has even number: $hasEvenNumber");

  // Version 1
  List<int> evens = nums.where(isEven).toList();

  // Version 2
  evens = nums.where((n) => n % 2 == 0).toList();

  print("Even numbers: $evens");
}
```

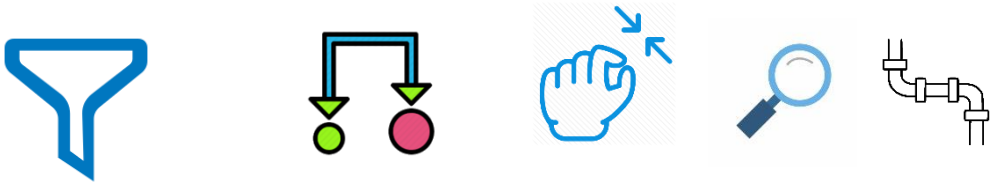
Lambda usage

e.g. What's the average age of employees working in Doha?

```
List<Employee> employees = [
  Employee(name: "Sara Faleh", city: "Doha", age: 30),
  Employee(name: "Mariam Saleh", city: "Istanbul", age: 22),
  Employee(name: "Ali Al-Ali", city: "Doha", age: 24),
];

// Filtering employees in "Doha", mapping their ages,
// and calculating the average
double avgAge = employees
    .where((employee) => employee.city == "Doha")
    .map((employee) => employee.age)
    .reduce((a, b) => a + b) /
    employees.where((employee) => employee.city == "Doha").length;

print("Average age of employees in Doha: $avgAge");
```

Common operations on collections

Filter, Map, Reduce, and others



Common operations on collections

`.map` 

- Applies a function to each list element

`.where(condition)` 

- Returns a new list with the elements that satisfy the condition

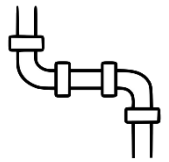
`.firstWhere(condition)` 

- Returns the first list element that satisfy the condition

`.reduce` 

- Applies an accumulator function to each element of the list to reduce them to a single value

Operations Pipeline

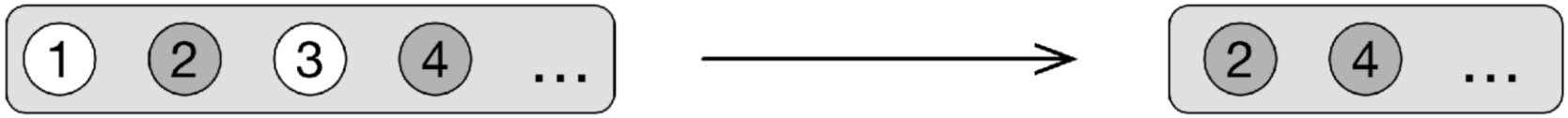


- **A pipeline of operations:** a sequence of operations where the output of each operation becomes the input into the next
  - e.g., .where -> .map -> .toList
- Operations are either **Intermediate** or **Terminal**
- **Intermediate operations** produce a new list as output (e.g., map, filter, …)
- **Terminal operations** are the final operation in the pipeline (e.g., find, reduce, toList …)
  - Once a terminal operation is invoked then no further operations can be performed

Filter using .where

Keep elements that satisfy a condition

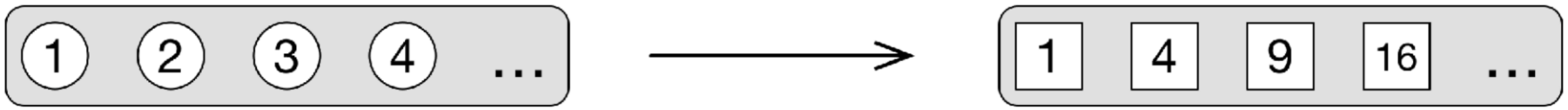
```
nums.where((n) => n % 2 == 0)
```



Map

Transform elements by applying a Lambda to each element

```
nums.map((n) => n * n)
```



Reduce

Apply an accumulator function to each element of the list to reduce them to a single value

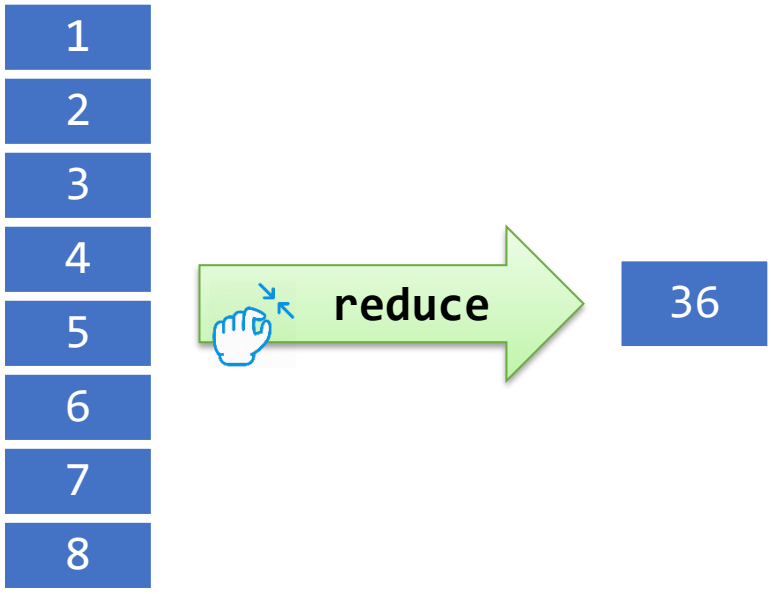
```
// Imperative
var sum = 0;
for (var n in list)
    sum = sum + n;
```

```
//Declarative
var sum = nums.reduce( (acc, n) => acc + n );
```

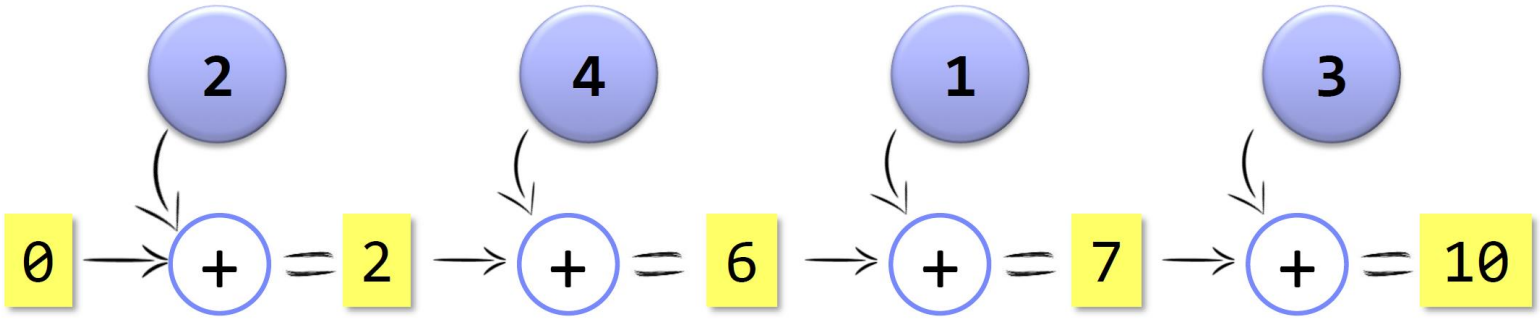
Accumulation Variable

Accumulation Lambda

Collapse the multiple elements of a list into a single element



Reduce



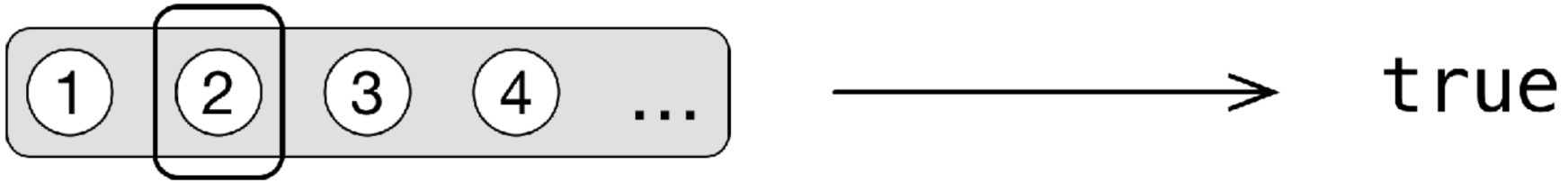

```
.reduce { (acc, n) => acc + n }
```

Reduce is **terminal** operation that yields a single value

any and every

- **any** returns true if it finds an element that satisfies the lambda condition
- **every** returns false if it finds an element that fails the lambda condition

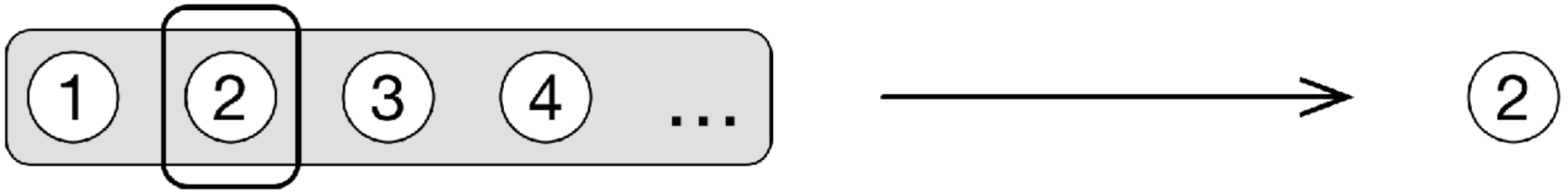
```
var hasEvenNumber = nums.any((n) => n % 2 == 0);
```



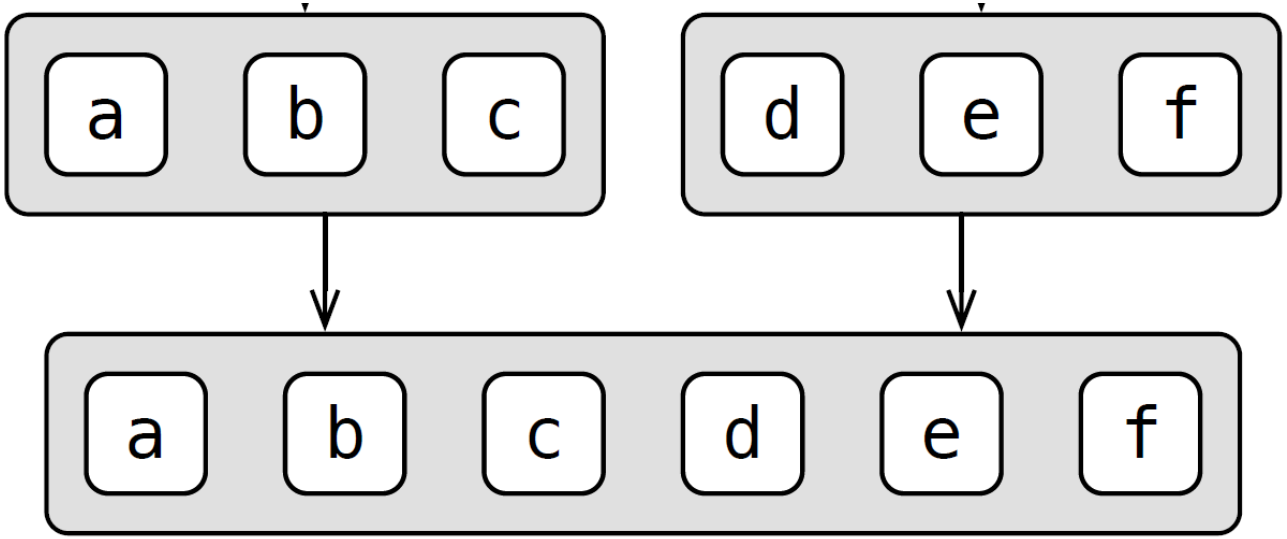
firstWhere

Return first element satisfying a condition

```
var firstEven = nums.firstWhere((n) => n % 2 == 0);
```



Expand



flatten

```
List<List<String>> listOfList = [
  ["a", "b", "c"],
  ["d", "e", "f"]
];

// Flattening the list of lists
List<String> singleList = listOfList.expand((list) => list).toList();

// Printing the result
print(singleList); // Output: [a, b, c, d, e, f]
```

expand

Do a map and flatten the results into 1 list

Each book has a list of authors. **expand** combines them to produce a single list of **all** authors

```
List<Book> books = [
  Book("Head First Dart", ["Dawn Griffiths", "David Griffiths"]),
  Book("Dart in Action", ["Dmitry Jemerov", "Svetlana Isakova"]),
];

// Flattening the list of authors
var authors = books.expand((book) => book.authors);
print(authors);
```

Sort a List using Lambda

Sort strings by length (shortest to longest)

```
  List<String> names = ["Farid", "Saleh", "Ali", "Sarah", "Samira",
"Farida"];

  var sorted = List.of(names)..sort((a, b) =>
                              a.length.compareTo(b.length));

  // Without the cascade operator, you would have to
  // do this in two steps:
  // sorted = List.of(names);
  // sorted.sort((a, b) => a.length.compareTo(b.length));

  print(names);

  print(">Sorted by length:");
  print(sorted);
```

Records

```
var (latitude, longitude) =
  (25.276987, 51.520008);
```

Records

- A Record is a data structure that allows you to group **multiple values together** without needing to create a class
  - Records are comma-delimited field lists enclosed in parentheses
  - Records can contain both named and positional fields, like argument lists in a function
  - Useful when you need to return or pass around multiple values from a function or when you want to combine values into a logical unit without a class
  - Type Safety: Dart records are strongly typed, meaning the fields have specific types that must be followed
  - Immutability: Records are immutable; once created, you cannot change the values in them

Why use Records?

- Convenient for returning multiple values:
  - Records are simpler than creating custom classes
  - No need for classes: You don't need to define a separate class for temporary or simple structures
- Type Safety: You have clear type constraints, reducing errors
- Readable code: Named fields improve readability and allow for clearer intent without the need for complex structures
- Efficient: Records are lightweight and immutable

Record Example

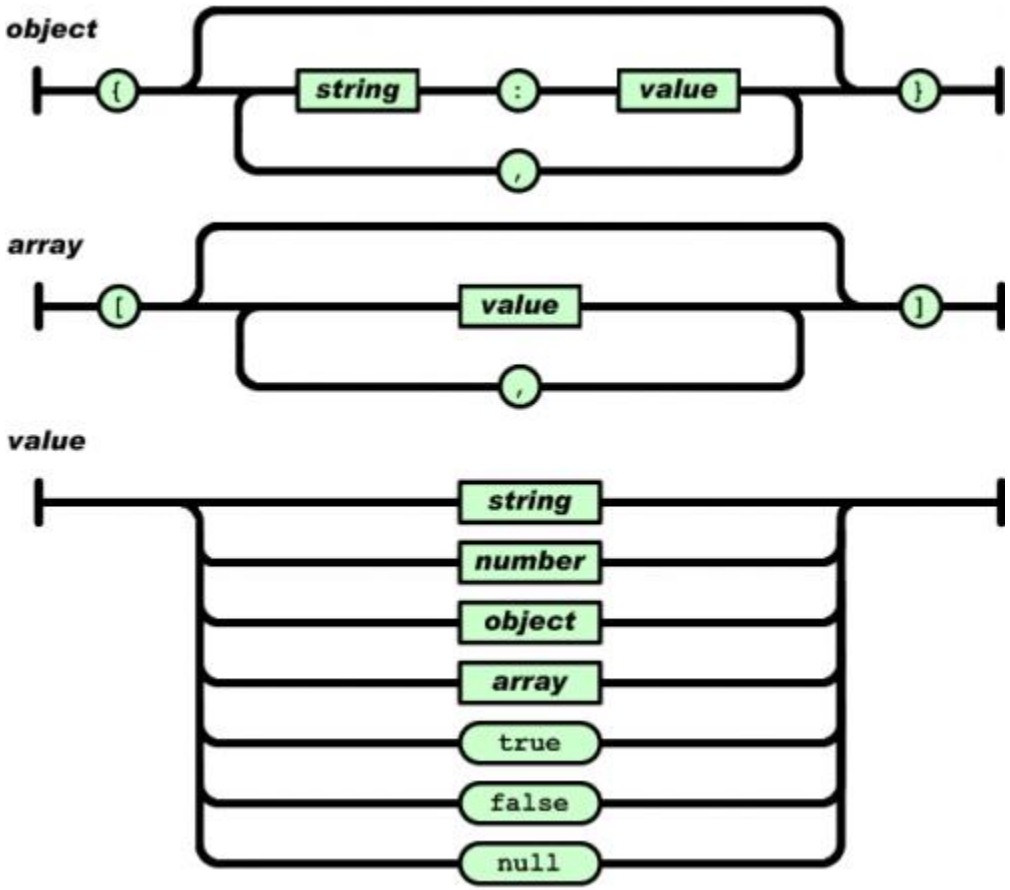
```
// Function returning coordinates as a record
(double, double) getCoordinates() {
  double latitude = 25.276987;
  double longitude = 51.520008;
  return (latitude, longitude);  // Return a record with two
positional fields
}

void main() {
  var coordinates = getCoordinates();

  print("Latitude: ${coordinates.$1}");
  print("Latitude: ${coordinates.$2}");

  // Extract the latitude and longitude from the record
  var (latitude, longitude) = getCoordinates();
  print("Latitude: $latitude");
  print("Longitude: $longitude");
}
```

Record with named fields

- Makes the code more readable and self-explanatory: Named fields make it clear what each value represents

```
// Function returning coordinates as a record with named fields
({double lat, double long}) getCoordinates() {
  double latitude = 25.276987;
  double longitude = 51.520008;
  // Return a record with named fields
  return (lat: latitude, long: longitude);
}

void main() {
  var coordinates = getCoordinates();

  // Extract the latitude and longitude from the record
  print("Latitude: ${coordinates.lat}");
  print("Longitude: ${coordinates.long}");
}
```


{;}
JSON


object
{
string
:
value
}
,
array
[
value
]
,
value
string
number
object
array
true
false
null

Back

JSON Data Format

- **JSON** (JavaScript Object Notation) is a very popular lightweight data format to transform an object to a **text** form to ease storing and transporting data
  - Encoding (aka serialization) turning a data structure into a string
  - Decoding (aka deserialization) is the opposite process -> turning a string into a data structure

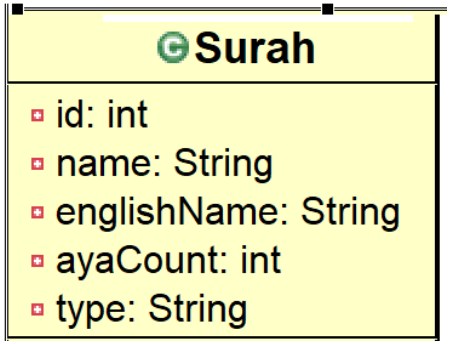
Serializing JSON manually using dart:convert

- Flutter has a built-in dart:convert library that includes a straightforward JSON encoder and decoder

```
import 'dart:convert';

void main() {
 var jsonString = '''
    {
      "name": "John Smith",
      "email": "john@dart.dev"
    }''';

  // Parse the JSON string into a Map
  final user = jsonDecode(jsonString) as Map<String, dynamic>;

  print('Hello, ${user['name']}!');
  print('We sent the verification link to ${user['email']}.');

  final userJsonString = jsonEncode(user);
  print(userJsonString);
}
```

Serializing JSON inside model classes

- Add two methods to the class:
  - A Surah.**fromJson()** constructor, for constructing a new Surah instance from a map structure
  - A **toJson()** method, which converts a Surah instance into a map




```
// Convert a Surah object to a JSON map
Map<String, dynamic> toJson() => {
  'number': number,
  'arabicName': arabicName,
  'englishName': englishName,
  'verseCount': verseCount,
  'type': type,
};

// Convert a JSON map to a Surah object
Surah.fromJson(Map<String, dynamic> json) :
  number = json['number'],
  arabicName = json['arabicName'],
  englishName = json['englishName'],
  verseCount = json['verseCount'],
  type = json['type'];
```

Serializing JSON using a code generation library

- Package json_serializable can be used to auto-generate the implementation of **fromJson** and **toJson**
  - Simply annotate the class with **@JsonSerializable()**

```
/// An annotation for the code generator to know that this class needs the
/// JSON serialization logic to be generated.
@JsonSerializable()
class User {
  String name;
  String email;
  User(this.name, this.email);

  /// A necessary factory constructor for creating a new User instance
  /// from a map. Pass the map to the generated `_$UserFromJson()` constructor.
  /// The constructor is named after the source class, in this case, User.
  factory User.fromJson(Map<String, dynamic> json) => _$UserFromJson(json);

  /// `toJson` implementation simply calls the private, generated
  /// helper method `_$UserToJson`.
  Map<String, dynamic> toJson() => _$UserToJson(this);
}
```

json_serializable dependencies

- To utilize json_serializable package, ensure that you include the required dependencies in **pubspec.yaml**

```
dev_dependencies:
  build_runner: ^2.4.9
  json_annotation: ^4.9.0
  json_serializable: ^6.8.0
```

- Run the build_runner to generate the .g.dart files:

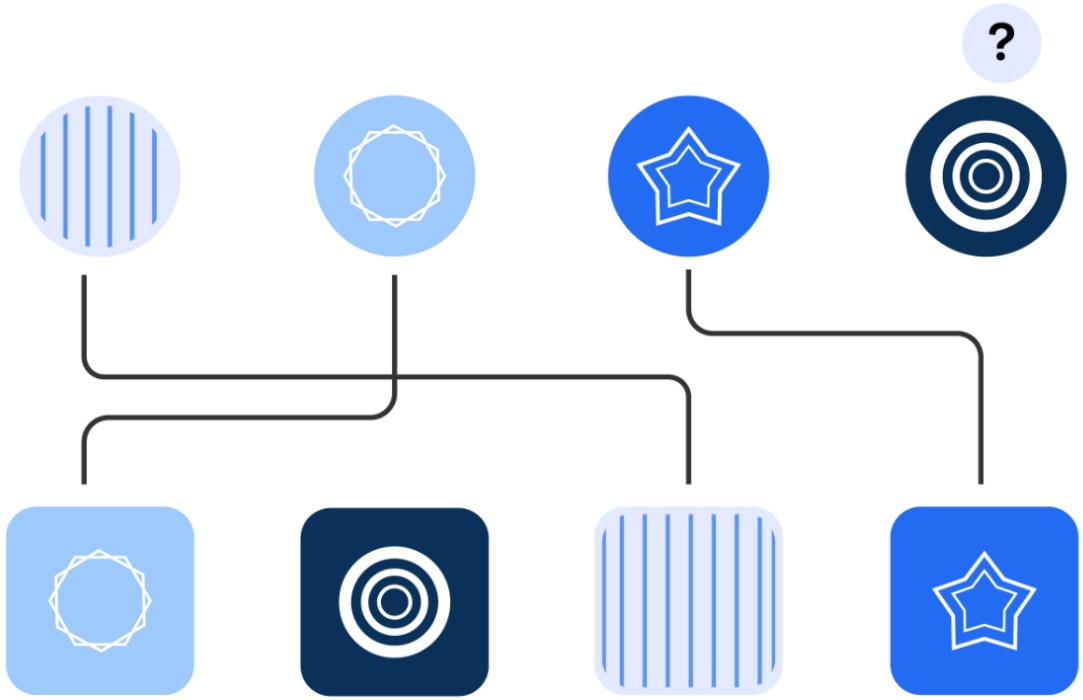
```
dart run build_runner build --delete-conflicting-outputs
```

Read JSON file

- Read a JSON file and convert its content to objects

```
final filePath = "data/surahs.json"
// Read the content of the file at the given path as a string
final fileContent = File(filePath).readAsStringSync();

// Parse the JSON content into a list of dynamic objects
final List<dynamic> jsonList = jsonDecode(fileContent);

// Convert each dynamic object into a Surah instance using fromJson
final surahs = jsonList.map((json) => Surah.fromJson(json)).toList();
```

Pattern Matching



What are patterns?

- A pattern defines a specific **shape** that the app data may match
  - Can be used to check whether a piece of data has the pattern/form you expect => this is called **pattern matching**
  - If it does, then optionally use the pattern to **extract** portions of the data into new variables => this is called **destructuring** (i.e., break a value into its **constituent parts**)
- Use patterns to break down a complex data structure (e.g., object, record, list) directly within control flow statements like switch, if-case, and loops to match specific types, values, or structures
  - They simplify type checking, data validation and extraction of values
  - Patterns are pretty challenging to master => need practice!

Key Benefits of Patterns

Patterns provide a **more intuitive, concise and simpler** way for matching and deconstructing data structures to extract specific parts from it. Resulting in:

- **Cleaner code**: reduces the need for manual type checks and value extraction
- **Expressive control flow**: by combining pattern matching with switch, if, and for loops, you can build expressive and flexible control flows to handle different cases based on the type or structure of data
- **Simplified way to match or extract specific parts of a complex data structure** including lists, maps, objects and records

Usage scenarios

- **Switch statements** for matching and deconstructing a complex data (list, map, object, record)
- **If-case statements** for conditional pattern matching
- **For loops** to destructure elements while iterating over collections
- **Destructuring a complex data (list, map, object, record)** to extract specific fields easily

Pattern Types (more info at this link)

Pattern Type	Description	Example
const	Matches a value against a constant (like a number, string, or boolean)	`null, true, false, 10, 'abc'`
relational	Test how a value compares to constants or ranges of values	`var letter = switch (grade) { >= 90 => 'A', >= 85 && < 90 => 'B+', ... }`
list	Matches and destructures elements from a list	`[first, second] = [1, 2]`
map	Matches and destructures specific key-value pairs from a map	`{'name': var uName, 'age': var uAge}) = {'name': 'Lily', 'age': 13};`
object	Matches and destructures an object by matching its type and named properties	`var user = User('Alice'); if (user case User(name: var userName)) {}`
record	Destructures **ALL** values from a record into individual variables	`(a, b) = (1, 2)`

wildcard	- Used as last match in switch
	- Ignores a value when destructuring
		`switch { … _ => {} }`
		`var list = [1, 2, 3];`
		`var [_, second, _]) = list;`

Constant patterns

- Use constant patterns to match a value against a constant (such as a specific number, string, or enum value)
  - Allows you to check if a variable holds a specific constant value and execute logic based on that match

```
String handleUserRole(UserRole role) {
  // Use a switch expression and constant patterns to return a
       message based on the role
  return switch (role) {
    UserRole.admin => 'Welcome, Admin! You have full access.',
    UserRole.user => 'Welcome, User! You have limited access.',
    UserRole.guest => 'Welcome, Guest! You can only view public content.',
  };
}
```

Relational patterns

- Use relational patterns to test how a value compares to constants or ranges of values
  - E.g., instead of writing complex if-else blocks, you can use relational patterns to test if a value is less than, greater than, or within a certain range, which makes the code more concise and readable.

```
String getLetterGrade(double grade) {
  // Use a switch expression with relational patterns to map
  // the grade to a letter grade
  return switch (grade) {
    >= 90          => 'A',
    >= 85 && < 90  => 'B+',
    >= 80 && < 85  => 'B',
    >= 75 && < 80  => 'C+',
    >= 70 && < 75  => 'C',
    >= 65 && < 70  => 'D+',
    >= 60 && < 65  => 'D',
    < 60           => 'F',
    _              => 'Invalid grade'
  };
}
```

According to QU grading policy

Patterns can be combined using logical operators like and (&&), or (||) Just like combining expressions

Object Patterns – Type Matching

- Use object pattern to **match the variable type** and allow easier type-specific handling without writing complex if-else chains
  - E.g., differentiate between different user roles and handle them appropriately

```
String getUserScreen(User user) {
  // Using a switch expression to determine the screen based on the user type
  return switch (user) {
    Admin admin                 => AdminDashboard(admin),
    VerifiedUser verifiedUser => UserHome(verifiedUser),
    Guest guest                 => WelcomeScreen()
  };
}
```

Object Patterns – Match & Extract

- Use object pattern to simultaneously **match** the object to its type and **deconstruct** it (i.e. extract values from it) in a single operation
  - Allows for easier type-specific handling **+** at the same time exact values for the object

```
  var circle = Circle(5);
  var rectangle = Rectangle(4, 6);

// Use the object pattern to match the object to its type and then against the class
properties to extract values from the object in the same expression using the : operator
  var Rectangle(:width, length:length) = rectangle;
  print('Width: $width, Height: $length');

var area = switch (shape) {
     // match the object to its type and extract values from the object in the same expression
      Rectangle(width: var w, length: var l) => w * l,
      Circle(radius: var r) => math.pi * r * r,
      _ => throw UnimplementedError(),
    };
```

Deconstructing Records

- Use record pattern to destructure a record to access their values in a concise way
  - Record patterns require that the **pattern match the entire record**

```
// A record with latitude and longitude named fields
var point = (latitude: 10.553, longitude: 21.562);

// Deconstructing the record to extract latitude and longitude
var (:latitude, :longitude) = point;
print('lat: $latitude, long: $longitude');
// or also assign them to lat and long variables respectively
var (latitude: lat, longitude: long) = point;
print('lat: $lat, long: $long');
```

Deconstructing Lists

- List patterns allow you to match specific elements in a list and extract them

```
List<({String name, int score})> participants = [
  (name: 'Mr Perfect', score: 9),
  (name: 'Mujtahid', score: 8),
  (name: 'Mujtahida', score: 10),
  (name: 'Kasul', score: 3),
  (name: 'Gamer', score: 5),
  (name: 'Movie Lover', score: 6),
];

participants.sort((p1, p2) => p2.score.compareTo(p1.score));

/*
  The list pattern [first, second, third, ...rest, last]
  is used to destructuring the list to extract the top 3 winners
  and the last participant. Others are assigned to the rest variable
*/
var [first, second, third, ...rest, last] = participants;
```

Patterns in if-case statement

- You can use patterns inside an if –case statement for more complex matching logic, making conditional checks easier and more expressive

```
if (variable case PATTERN) {
  // code
}
```

```
double getArea(Shape shape) {
  /* Using pattern matching to calculate area based on shape type
    In if-case statement object pattern can be used to match
    the object to its type and extract relevant values in the
    same expression using the : operator  */
  if (shape case Circle(:var radius)) {
    return math.pi * radius * radius;
  } else if (shape case Rectangle(:var width, length:var length)) {
    return width * length;
  } else {
    throw Exception('Unknown shape');
  }
}
```

All do the same thing, but switch expression is the best!

```
// Switch expression
bool isPrimary = switch (color) {
 Color.red || Color.yellow || Color.blue => true,
 _ => false
};

// Switch statement
switch (color) {
  case Color.red || Color.yellow || Color.blue:
    isPrimary = true;
  default:
    isPrimary = false;
}

// IF-case
if (color case Color.red || Color.yellow || Color.blue) {
  isPrimary = true;
} else {
  isPrimary = false;
}
```

Patterns with for Loops

- Patterns can be applied in for loops to destructure and process each element in a collection

```
var students = [('Ali', 85), ('Fatima', 90), ('Ahmed', 78)];
/*
Each record in the list of students is destructured in the for loop,
allowing you to directly access name and score without needing to access
each record's individual fields manually */

for (var (name, score) in students) {
  print('Student: $name, Score: $score');
}
```

If-case with constant pattern in collection literals

- If-case with constant pattern in collection literals
  - e.g., if the userRole is admin include Dashboard as a menu item they can access

```
var userRole = UserRole.admin;
var navMenuItems = [
  'Home',
  if (userRole case UserRole.admin) 'Dashboard',
  'Profile',
  'Settings'
];
```

Validating incoming JSON

- JSON data typically comes from an external source over the network. You need to **validate** it first to confirm its structure before destructuring it
  - Can apply patterns to validate and extract data from JSON objects in a clean and readable way

```
// Without patterns, validation is verbose:
if (json is Map<String, Object?> &&
    json.length == 1 &&
    json.containsKey('user')) {
  var user = json['user'];
  if (user is List<Object> &&
      user.length == 2 &&
      user[0] is String &&
      user[1] is int) {
    var name = user[0] as String;
    var age = user[1] as int;
    print('User $name is $age years old.');
  }
}
```

A pattern in an if-case statement can achieve the same JSON validation and destructuring in a **more declarative**, and **concise** way

```
//With Pattern: less verbose method of validating
  if (json case {'user': [String name, int age]}) {
    print('User $name is $age years old.');
  }
```

Pattern Matching Exhaustive Checking

- Exhaustive checking ensures that when you use a switch statement with patterns, all possible cases are covered
  - This guarantees that no case is left unhandled, making your code more reliable
  - E.g., ensuring that all possible payment types are handled in the switch expression

```
String processPayment(PaymentMethod paymentMethod) {
  return switch(paymentMethod) {
    CreditCard(:var cardNumber) => 'Payment with card number: $cardNumber',
    PayPal(:var email) => 'PayPal payment with email: $email',
    BankTransfer(:var bankAccount) => 'Bank transfer to account: $bankAccount',
  };
}
```

- Dart compiler knows that PaymentMethod has exactly three possible types: CreditCard, PayPal, and BankTransfer because PaymentMethod is a sealed class
- This allows the switch expression to be exhaustive
(sealed class can only be extended by classes defined in the same library)

```
sealed class PaymentMethod {}
class CreditCard extends PaymentMethod {
  final String cardNumber;
  CreditCard(this.cardNumber);
}
class PayPal extends PaymentMethod {
  final String email;
  PayPal(this.email);
}
class BankTransfer extends PaymentMethod {
  final String bankAccount;
  BankTransfer(this.bankAccount);
}
```

Summary

- To start thinking in the functional style ***avoid loops*** and instead use Lambdas
  - Widely used for list processing and GUI building to handle events
- A list can be processed in a pipeline
  - Typical pipeline operations are filter, map and reduce
- JSON is a very popular lightweight data format to **transform an object to a text form** to ease storing and transporting data
- Patterns are used for **pattern matching** and **destructuring** to extract portions of the data into new variables
  - They simplify type checking, data validation and extraction of values

Resources

- Drat Collections
  - https://dart.dev/language/collections
- JSON serialization
  - https://docs.flutter.dev/data-and-backend/serialization/json
  - https://codewithandrea.com/articles/parse-json-dart/
  - JSON serialization package https://pub.dev/packages/json_serializable
- Records
  - https://dart.dev/language/records
- Patterns
  - https://dart.dev/language/patterns & YouTube video
  - More pattern examples