Advanced HL7 FHIR Shorthand

Ninja Tricks for Nerds

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Introducing Your Captain

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  - Co-creator of FHIR Shorthand w/ Mark Kramer
  - Development lead for FSH Tools (SUSHI, etc.)
  - Technical Lead for AHRQ CDS Connect

This is me doing virtual training

MITRE

SOLVING PROBLEMS FOR A SAFER WORLD®

A US non-profit operating federally-funded research and development centers, working in the public interest. We bring a conflict-free perspective and a whole of government vantage point to bring innovative ideas into existence.

Prerequisites

- HL7 FHIR Fundamentals course
  - or equivalent experience
- Introduction to FHIR Shorthand course
  - or equivalent experience

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Recommended Software

- Node.js LTS (for SUSHI and GoFSH)
- SUSHI (`npm install -g fsh-sushi`)
- GoFSH (`npm install -g gofsh`)
- Java SDK 17 (Eclipse Temurin / Oracle, for IG Publisher)
- Ruby and Jekyll (for IG Publisher)
- Visual Studio Code
- FHIR Shorthand (FSH) Extension (for VS Code)

Agenda

- Back to the Basics
- Tools of the Trade: VS Code
- Tricks for Tackling Tediosity
- Slicing (without Losing a Finger)
- ~~Finvariants~~ Invariants
- Intensional Value Sets
- IG Configuration
- GoFSH
- Review

Cookie Time

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BACK TO THE BASICS

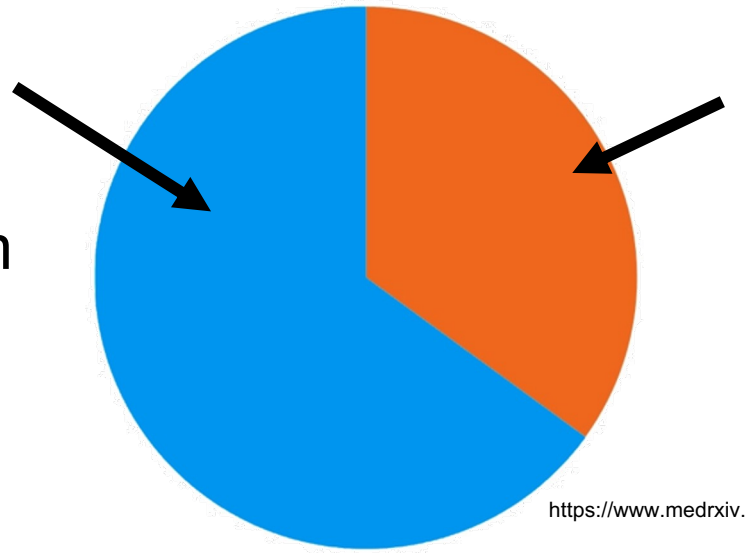
Why pun? Just for the halibut!

Why Create an Implementation Guide?

- FHIR is a framework, not a complete solution

Base FHIR:

- On-the-wire syntax
- API for read, write, search
- FHIR base resources
- Data types
- Extensibility mechanism



Implementation Guide:

- Specific problem to be solved
- Actors and workflow sequences
- Profiles of base resources
- Terminology and value sets
- Additional API operations
- & more

https://www.medrxiv.org/content/10.1101/2022.03.09.22272163v1.full

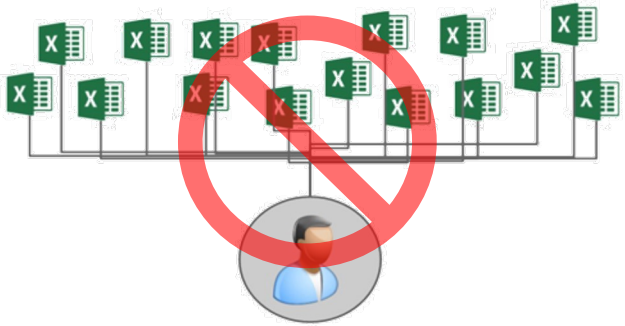
Approaches to Authoring Definitional Resources

Hand-Editing

XML

JSON

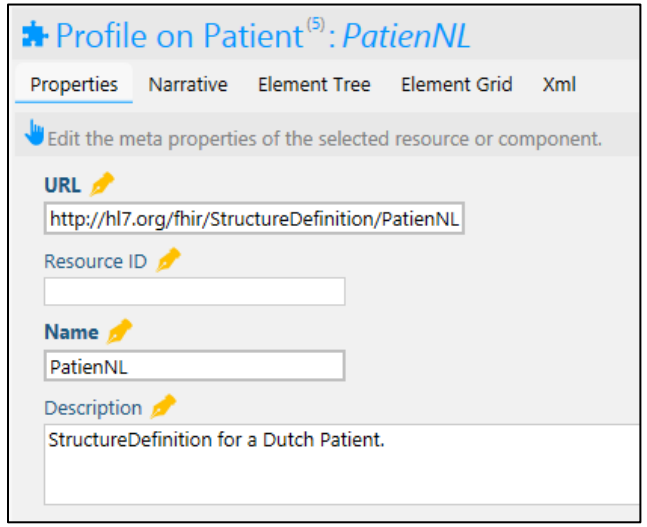
Spreadsheets



User Interfaces

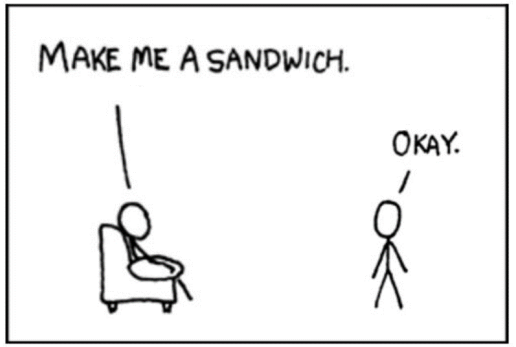
Trifolia-on-FHIR

Forge



Command-Driven

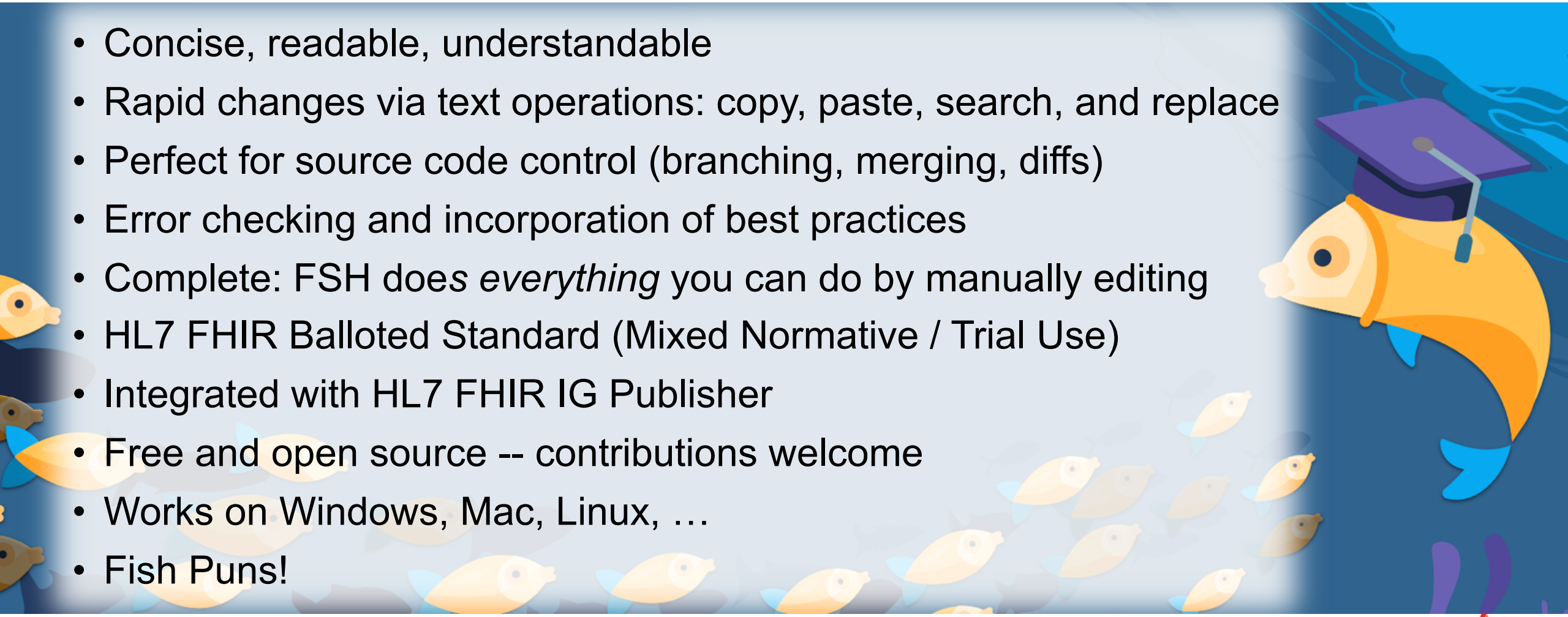
FHIR® Shorthand™



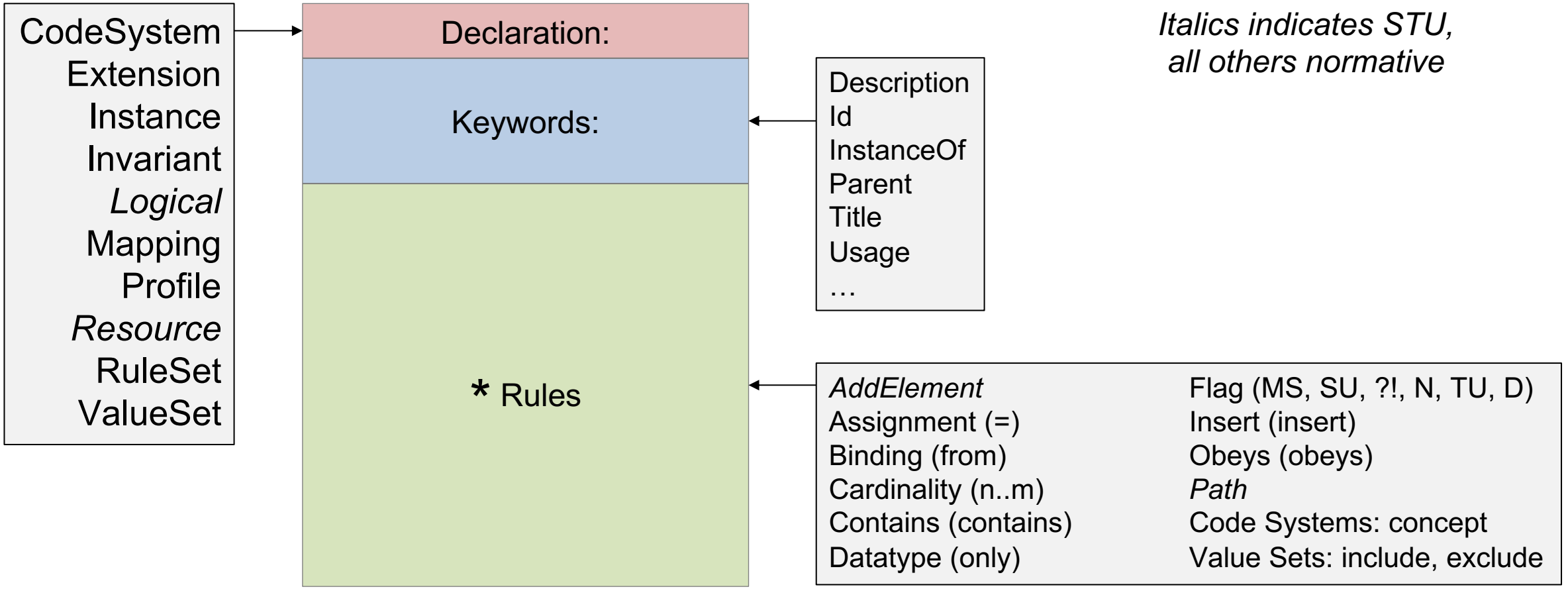

```
Profile: MyPatient
Parent: Patient
* name 1..* MS
```

Advantages of FHIR Shorthand

- Concise, readable, understandable
- Rapid changes via text operations: copy, paste, search, and replace
- Perfect for source code control (branching, merging, diffs)
- Error checking and incorporation of best practices
- Complete: FSH does *everything* you can do by manually editing
- HL7 FHIR Balloted Standard (Mixed Normative / Trial Use)
- Integrated with HL7 FHIR IG Publisher
- Free and open source -- contributions welcome
- Works on Windows, Mac, Linux, …
- Fish Puns!



Anatomy of a FSH Item



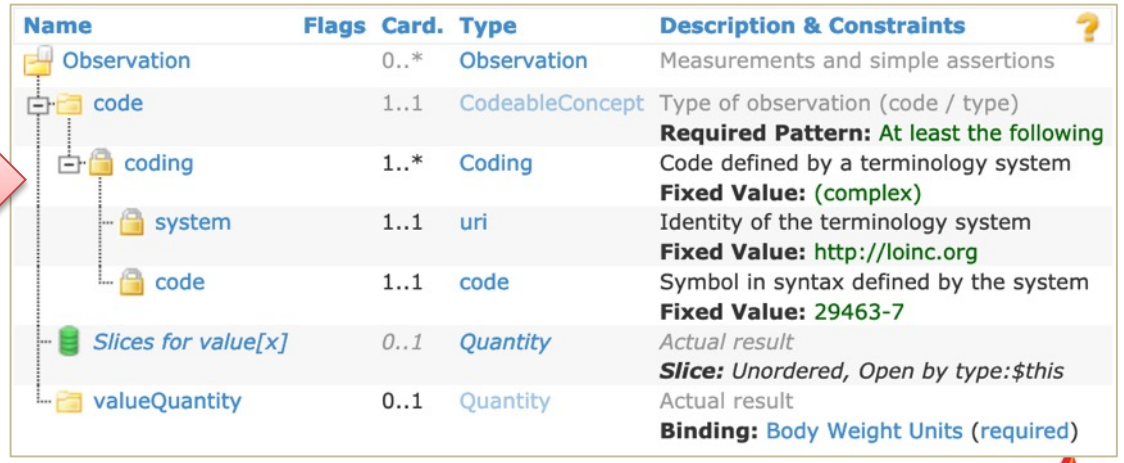
Italics indicates STU, all others normative

Defining Profiles in FHIR Shorthand

FSH Keyword	Usage	Element in StructureDefinition	Data Type	Required
Profile	Name of the profile	name	name	Yes
Parent	Base definition of the profile	baseDefinition	name/id/url	Yes
Id	Identifier of the profile	id	id	No
Title	Title of the profile	title	string	No
Description	Human-readable description	description	string	No

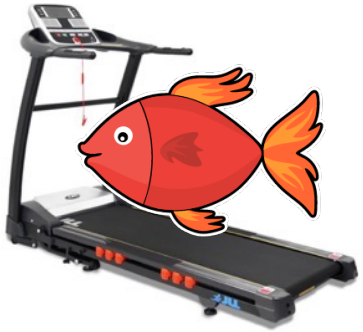
Example Profile on FHIR R4 Observation

```
Profile: BodyWeightProfile
Parent: Observation
Id: example-weight-profile
Title: "Body Weight"
Description: "An example profile for collecting weight"
* code = http://loinc.org#29463-7 // Body weight
* value[x] only Quantity
* valueQuantity from BodyWeightUnits
```



Name	Flags	Card.	Type	Description & Constraints
Observation		0..*	Observation	Measurements and simple assertions
code		1..1	CodeableConcept	Type of observation (code / type) **Required Pattern:** At least the following
coding		1..*	Coding	Code defined by a terminology system **Fixed Value:** (complex)
system		1..1	uri	Identity of the terminology system **Fixed Value:** http://loinc.org
code		1..1	code	Symbol in syntax defined by the system **Fixed Value:** 29463-7
Slices for value[x]		*0..1*	*Quantity*	*Actual result* ***Slice:*** *Unordered, Open by type:$this*
valueQuantity		0..1	Quantity	Actual result **Binding:** Body Weight Units (required)

FSH Exercise: Back to the Basics



GOAL: Create, build, and publish a simple SUSHI project

1. Open a terminal and navigate (*cd*) to a parent folder
2. Run the command: `sushi --init`
3. Navigate (cd) to your new project folder in terminal
4. Run the command: `sushi .`
5. Run *./update_publisher* (*.sh* for mac, *.bat* for windows)
6. Run *./genonce* (*.sh* for mac, *.bat* for windows)
7. Review *./output/qa.html* and *./output/index.html*

Good times to review project in VS Code

New treadmill – JLL S400 by CharmaineZoe, CC BY 2.0 via Flickr Cartoon Fish, public domain via FreeSVG.org

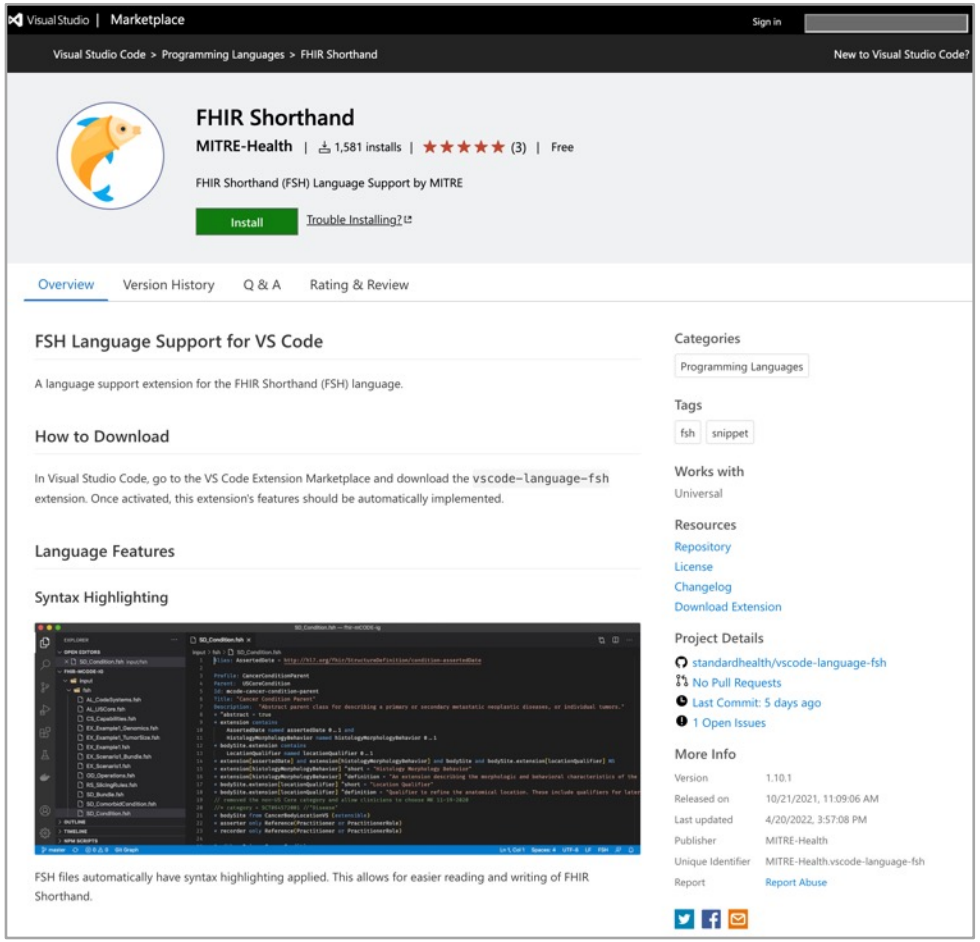
TOOLS OF THE TRADE: VS CODE

Cool and So-FSH-ticated!

Visual Studio Code + FSH Extension

To install VS Code and the FSH extension:

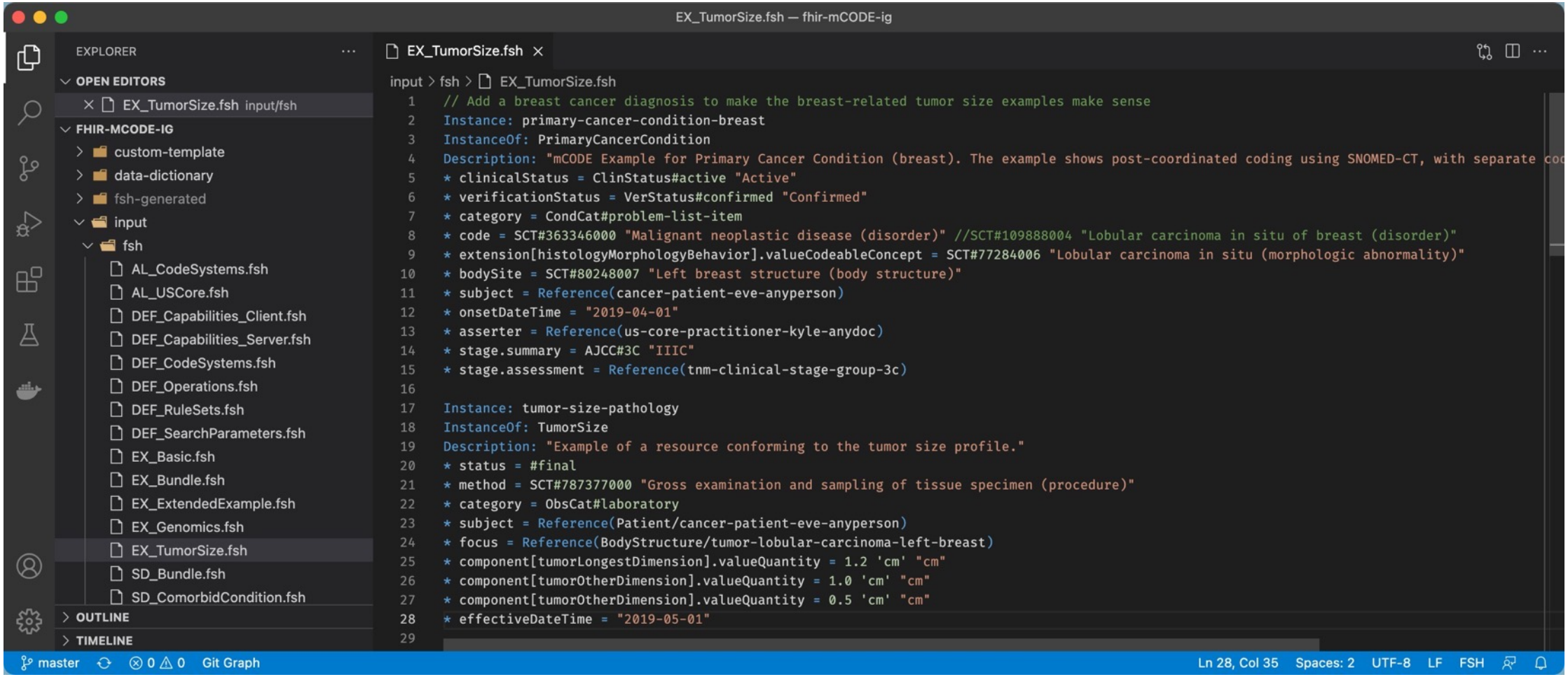
1. **VS Code**: https://code.visualstudio.com/download
2. **FSH Extension**:
   - Open a .fsh file and follow prompts, or
   - Search “FHIR Shorthand” in Marketplace, or
   - Go to: https://bit.ly/vsc-fsh



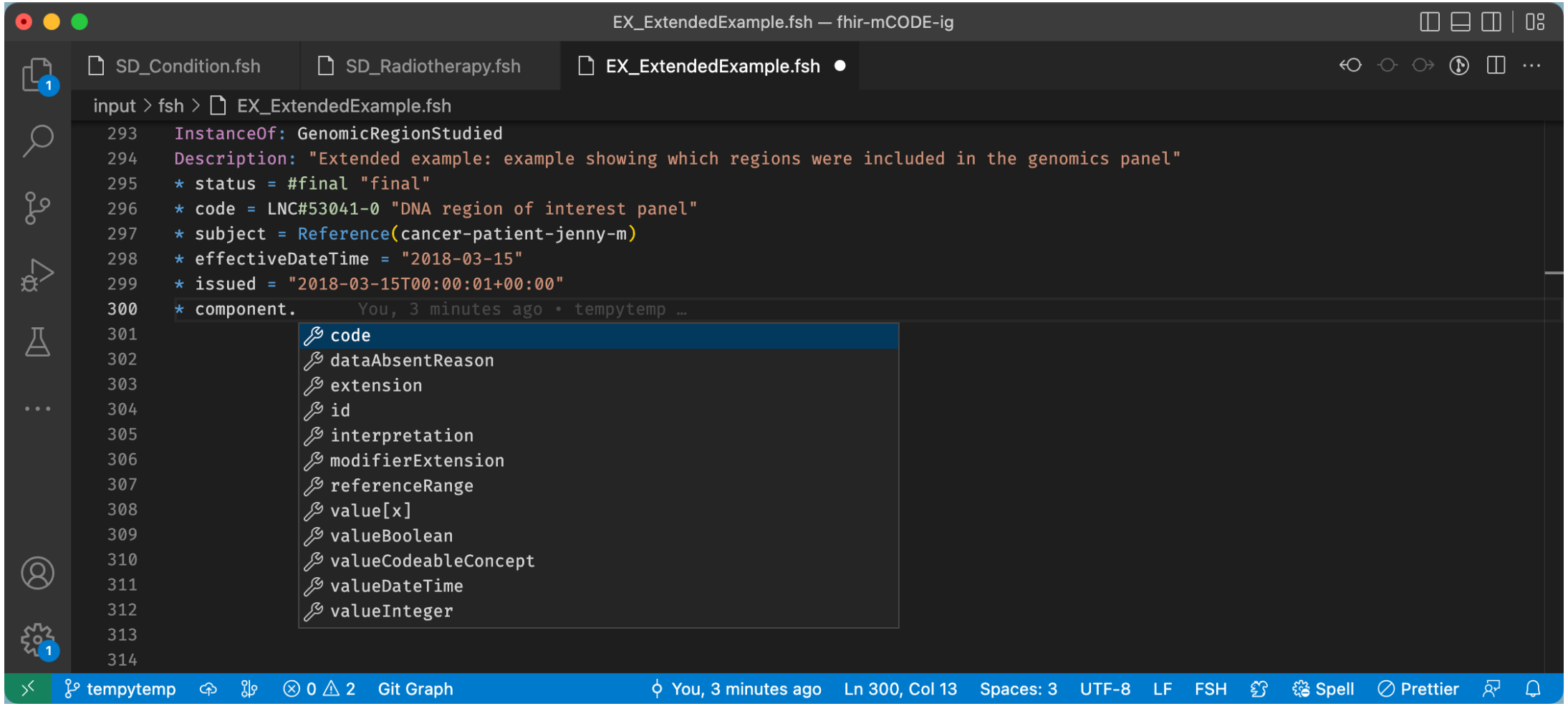
WHY?

- Syntax highlighting
- Path completion
- Snippets
- Go to definition
- Open FHIR documentation
- SUSHI build task

VS Code: FSH Syntax Highlighting



VS Code: FSH Path Completion

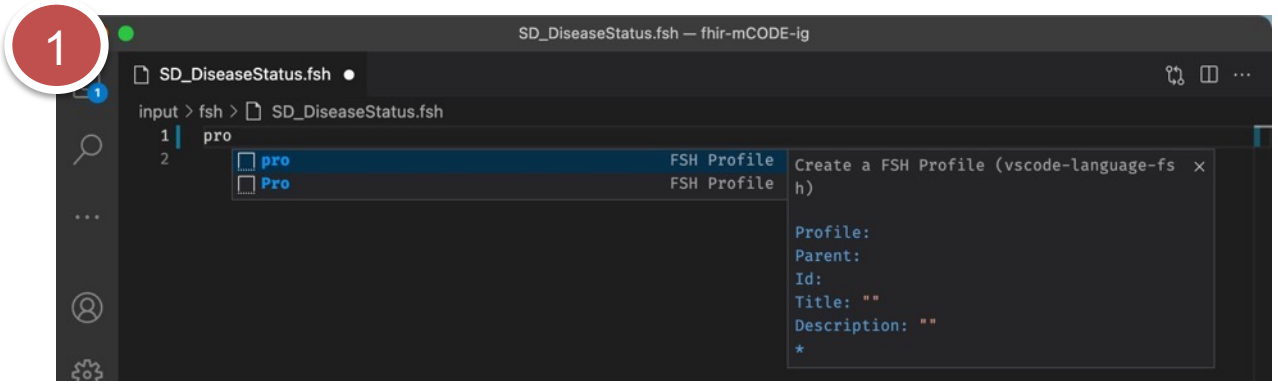


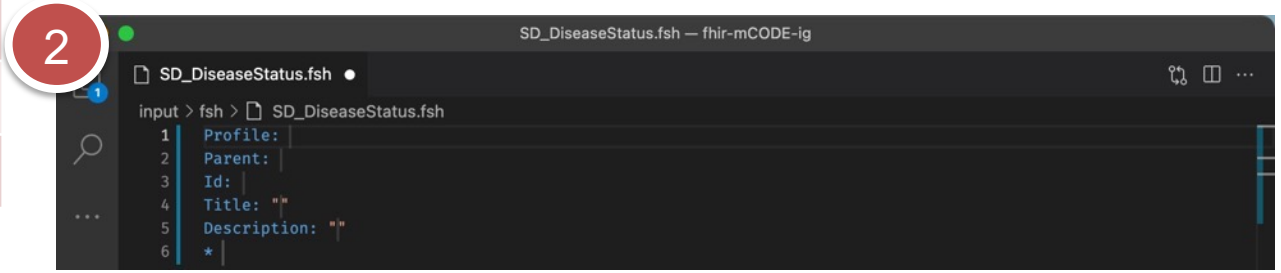
VS Code: FSH Snippets

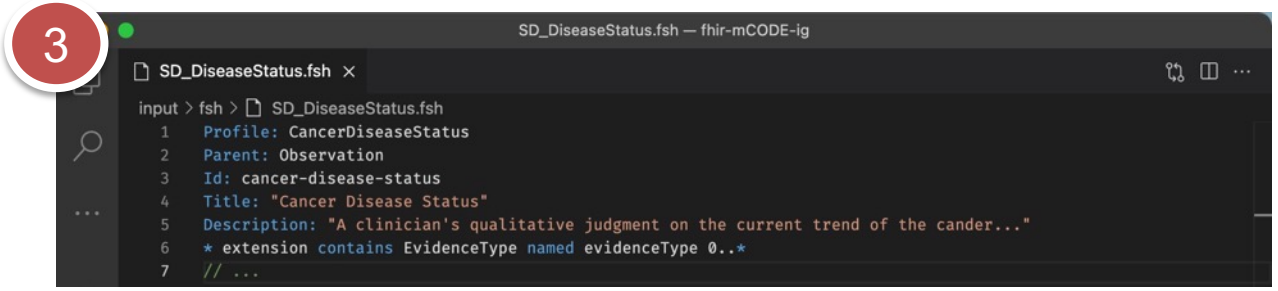
1. **Type a FSH trigger phrase**

Trigger	FSH Item
pro	Profile
ext	Extension
log	Logical
res	Resource
vs	ValueSet
cs	CodeSystem

Trigger	FSH Item
inst	Instance
inv	Invariant
map	Map
rs	RuleSet
^slicing	*(slicing rules)*





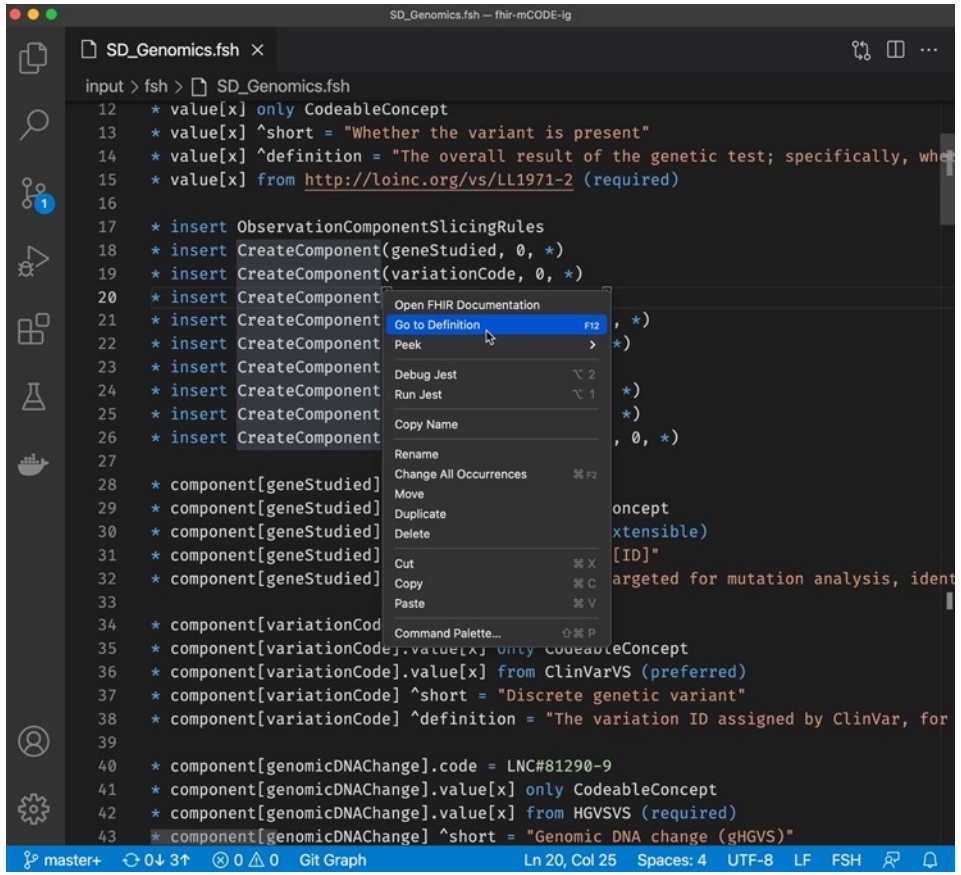


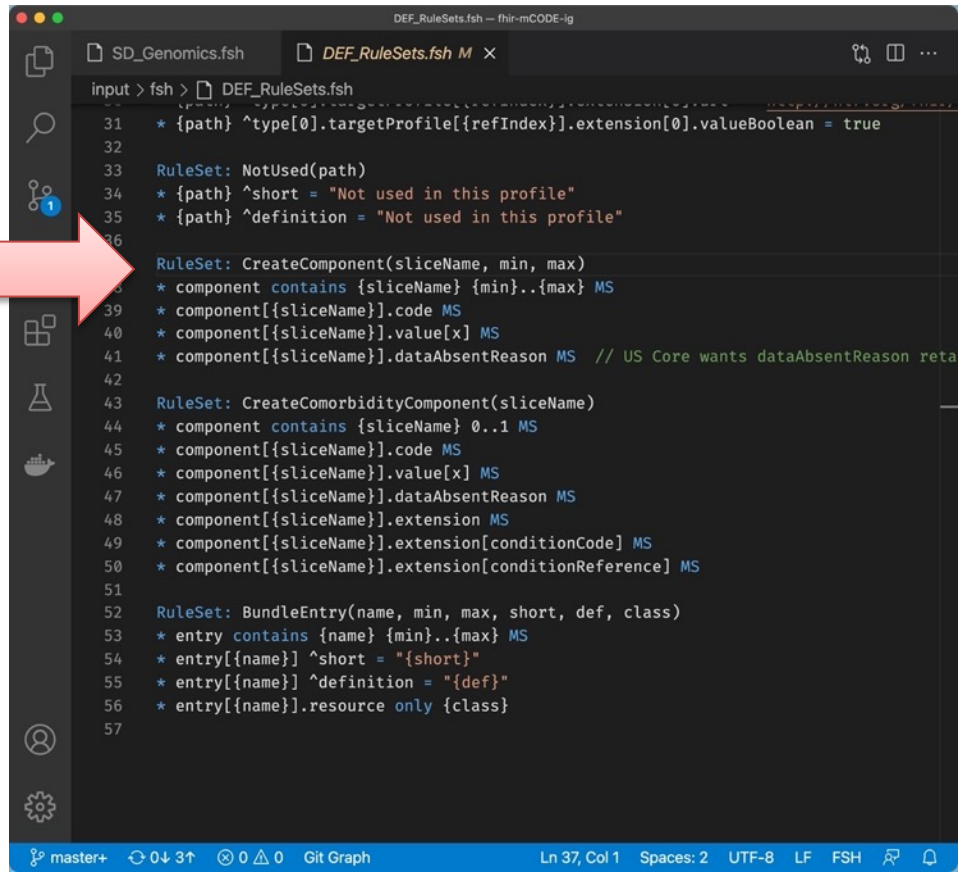
2. **Hit <ENTER> or <TAB> to start**

3. **Use <TAB> to visit placeholders**

VS Code: Go to Definition

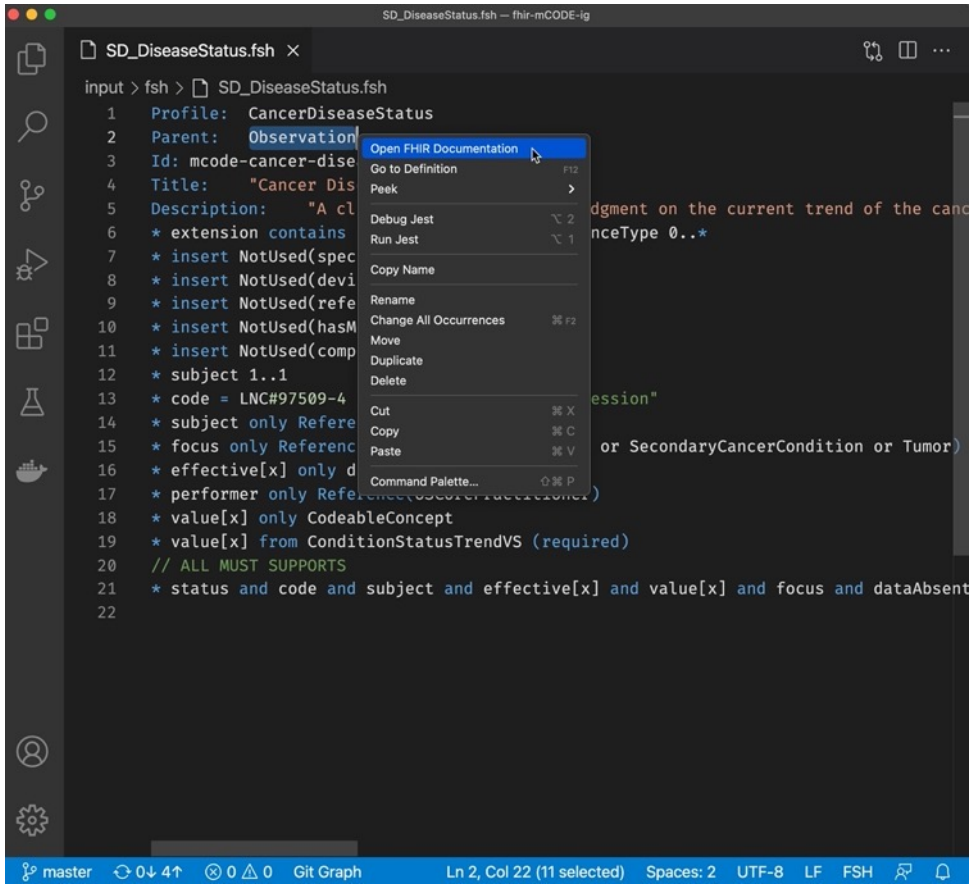
Right-click a FSH name and “Go to Definition” to see its definition

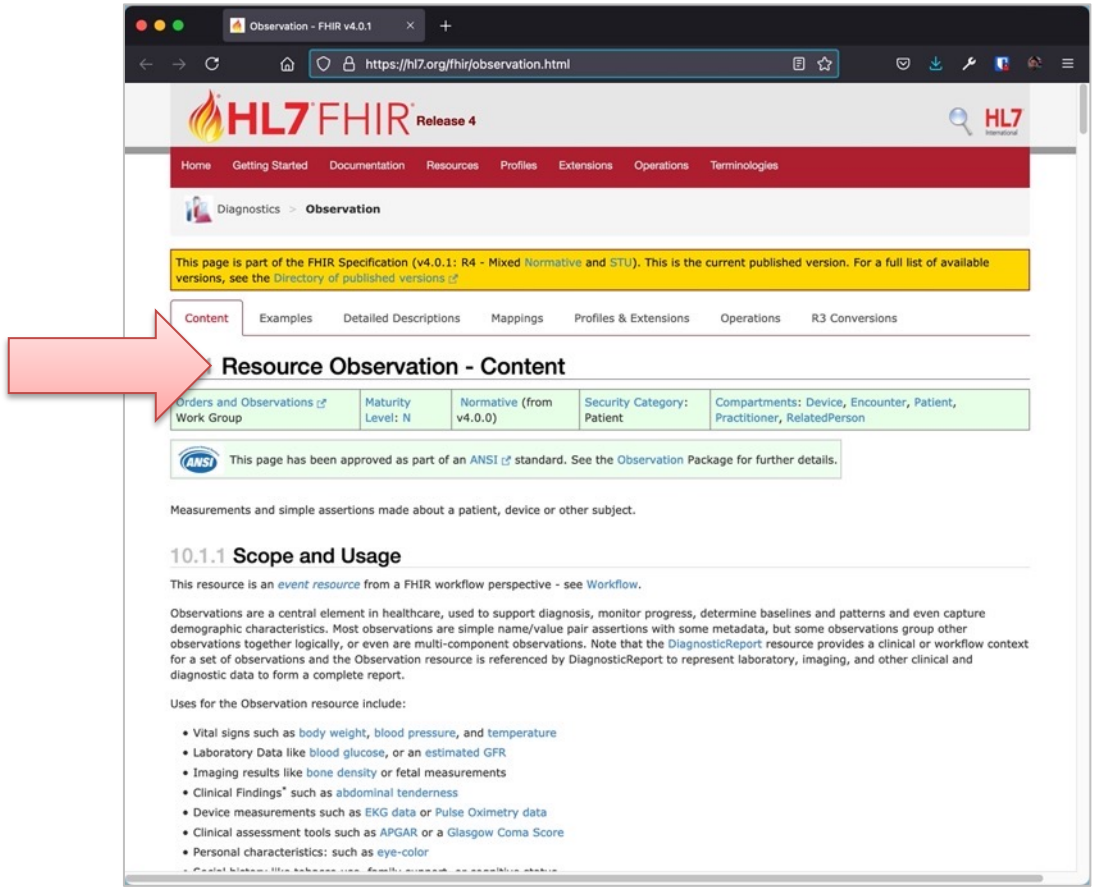




VS Code: Go to FHIR Documentation

Right-click a FHIR name and “Go to FHIR Documentation” to see its definition





VS Code: SUSHI Build Task

Click **Terminal**

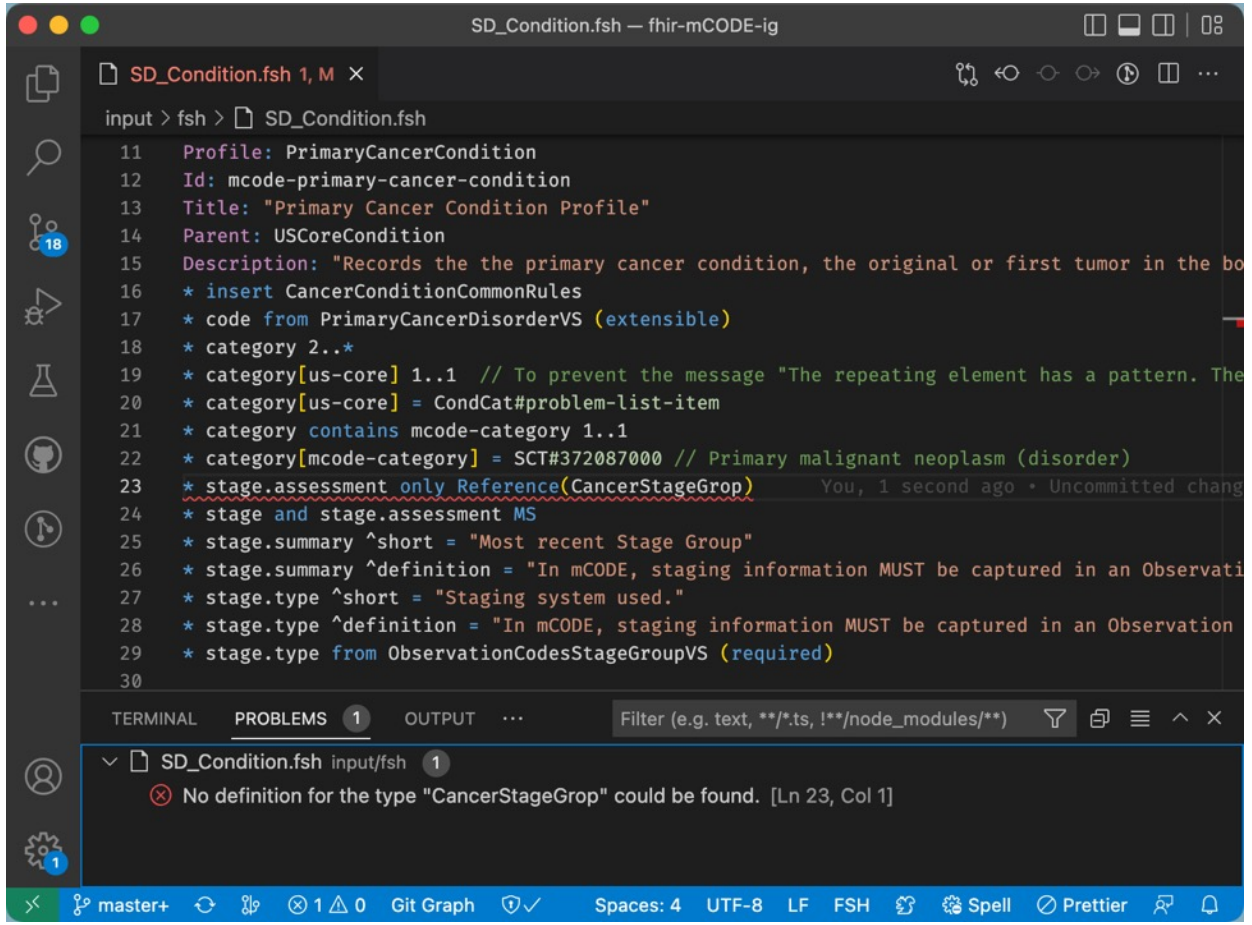
→ **Run Build Task…**

→ **fsh:sushi**

or

Windows: **<SHIFT> + <CTL> + B**

Mac: **<SHIFT> + <CMD> + B**



TRICKS FOR TACKLING TEDIOSITY*

* Yes, this is a real word.

It doesn’t get any betta than this!

Tricks for Tackling Tediosity

- Soft Indexing
- RuleSets
- Parameterized RuleSets
- Preprocessed FSH

Managing Lists w/ Explicit Indexing (FSH 1.0)

```
* item[0].linkId = "sp-101"
* item[0].text = "What is your date of birth?"
* item[0].type = #date

* item[1].linkId = "sp-102"
* item[1].text = "What is your country of birth?"
* item[1].type = #code

* item[2].linkId = "sp-103"
* item[2].text = "What country do you currently reside in?"
* item[2].type = #code

* item[3].linkId = "sp-104"
* item[3].text = "What country did you travel to?"
* item[3].type = #code

* item[4].linkId = "sp-105"
* item[4].text = "When did the travel start?"
* item[4].type = #date

* item[5].linkId = "sp-106"
* item[5].text = "When did the travel end?"
* item[5].type = #date
```

Problems with explicit indexing:

- Error prone (oops, I missed one!)
- Adding/removing items in the middle requires renumbering
- Similar blocks of code are not reusable

```
* item[ ].linkId = "sp-108"
* item[ ].text = "When state do you currently reside in?"
* item[ ].type = #code
```

Managing Lists w/ Soft Indexing (FSH 2.0)

```
* item[+].linkId = "sp-101"
* item[=].text = "What is your date of birth?"
* item[=].type = #date

* item[+].linkId = "sp-102"
* item[=].text = "What is your country of birth?"
* item[=].type = #code

* item[+].linkId = "sp-103"
* item[=].text = "What country do you currently reside in?"
* item[=].type = #code

* item[+].linkId = "sp-104"
* item[=].text = "What country did you travel to?"
* item[=].type = #code

* item[+].linkId = "sp-105"
* item[=].text = "When did the travel start?"
* item[=].type = #date

* item[+].linkId = "sp-106"
* item[=].text = "When did the travel end?"
* item[=].type = #date
```

Soft indexing approach:

- [+] → next item in array
- [=] → last referenced item in the array
- Start an empty array with [+], [0], or implicit index 0

```
* item[+].linkId = "sp-108"
* item[=].text = "When state do you currently reside in?"
* item[=].type = #code
```

Advantages of soft indexing:

- No need to count (counting is hard!)
- Easily add/remove/move items
- Copy/paste and RuleSet friendly

RuleSets

```
RuleSet: ContactAndCopyright
* ^contact[+].name = "Homer Simpson"
* ^contact[=].telecom.system = #phone
* ^contact[=].telecom.value = "939-555-0113"
* ^copyright = "© 2022 Springfield Nuclear Power Plant"
```

```
Profile: RadiationTherapyPatient
Parent: Patient
* insert ContactAndCopyright
* name 1..* MS
```

SUSHI Preprocessor

```
Profile: RadiationTherapyPatient
Parent: Patient
* ^contact[+].name = "Homer Simpson"
* ^contact[=].telecom.system = #phone
* ^contact[=].telecom.value = "939-555-0113"
* ^copyright = "© 2022 Springfield Nuclear Power Plant"
* name 1..* MS
```

RuleSets allow you to:

- Define common rules *once*
- And apply them multiple times

Use the **insert** keyword to apply rulesets in definitions where they *fit*.

But wait! There's more!

Parameterized RuleSets

```
RuleSet: Context(type, expression)
* ^context[+].type = {type}
* ^context[=].expression = {expression}
```

```
Extension: OrganizationPreferredContact
* insert Context(#element, "Organization.contact")
* value[x] only boolean
```

SUSHI Preprocessor

```
Extension: OrganizationPreferredContact
* ^context[+].type = #element
* ^context[=].expression = "Organization.contact"
* value[x] only boolean
```

Parameterized RuleSets have:

- Input parameters *(in parentheses)*
- Placeholders *(in curly braces)*

When you **insert** rulesets:

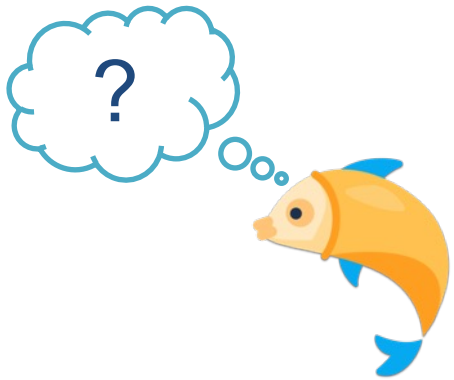
- Specify values in parentheses
- Separate values by a comma

Works like simple **find & replace**

- Escape commas & ending parentheses
- e.g., *insert RS(#foo, "a\,b\,c\,… (etc.\)")*

Example: CapabilityStatement

```
// MeasureReport requirements
* rest.resource[0].type = #MeasureReport
* rest.resource[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[0].extension[0].valueCode = #SHALL
* rest.resource[0].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureReport"
* rest.resource[0].supportedProfile[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[0].supportedProfile[0].extension[0].valueCode = #SHALL
* rest.resource[0].interaction[0].code = #create
* rest.resource[0].interaction[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[0].interaction[0].extension[0].valueCode = #SHALL
* rest.resource[0].interaction[1].code = #update
* rest.resource[0].interaction[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[0].interaction[1].extension[0].valueCode = #SHALL
// Measure requirements
* rest.resource[1].type = #Measure
* rest.resource[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].extension[0].valueCode = #SHALL
* rest.resource[1].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasure"
* rest.resource[1].supportedProfile[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].supportedProfile[0].extension[0].valueCode = #SHOULD
* rest.resource[1].supportedProfile[1] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureStratifier"
* rest.resource[1].supportedProfile[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].supportedProfile[1].extension[0].valueCode = #SHOULD
* rest.resource[1].interaction[0].code = #create
* rest.resource[1].interaction[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].interaction[0].extension[0].valueCode = #SHOULD
* rest.resource[1].interaction[1].code = #update
* rest.resource[1].interaction[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].interaction[1].extension[0].valueCode = #SHOULD
```



Example: CapabilityStatement w/ Alias & Soft Indexing

```
// MeasureReport requirements
* rest.resource[0].type = #MeasureReport
* rest.resource[=].extension[0].url = $ExpExt
* rest.resource[=].extension[=].valueCode = #SHALL
* rest.resource[=].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureReport"
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[=].valueCode = #SHALL
* rest.resource[=].interaction[0].code = #create
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHALL
* rest.resource[=].interaction[+].code = #update
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHALL
// Measure requirements
* rest.resource[+].type = #Measure
* rest.resource[=].extension[0].url = $ExpExt
* rest.resource[=].extension[=].valueCode = #SHALL
* rest.resource[=].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasure"
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[=].valueCode = #SHOULD
* rest.resource[=].supportedProfile[+] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureStratifier"
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[=].valueCode = #SHOULD
* rest.resource[=].interaction[0].code = #create
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHOULD
* rest.resource[=].interaction[+].code = #update
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHOULD
```

Example: RuleSets for Repeated FSH

```
RuleSet: SupportResource (resource, expectation)
* rest.resource[+].type = {resource}
* rest.resource[=].extension[0].url = $ExpExt
* rest.resource[=].extension[0].valueCode = {expectation}

RuleSet: SupportProfile (profile, expectation)
* rest.resource[=].supportedProfile[+] = {profile}
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[0].valueCode = {expectation}

RuleSet: SupportInteraction (interaction, expectation)
* rest.resource[=].interaction[+].code = {interaction}
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[0].valueCode = {expectation}
```

```
// MeasureReport requirements
* insert SupportResource(#MeasureReport, #SHALL)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureReport", #SHALL)
* insert SupportInteraction(#create, #SHALL)
* insert SupportInteraction(#update, #SHALL)
```

Example: CapabilityStatement w/ RuleSets


```
// MeasureReport requirements
* insert SupportResource(#MeasureReport, #SHALL)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureReport", #SHALL)
* insert SupportInteraction(#create, #SHALL)
* insert SupportInteraction(#update, #SHALL)
// Measure requirements
* insert SupportResource(#Measure, #SHALL)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasure", #SHOULD)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureStratifier", #SHOULD)
* insert SupportInteraction(#create, #SHOULD)
* insert SupportInteraction(#update, #SHOULD)
```

- Compact
- Consistent
- Easier to read
- Easier to write
- Fewer mistakes
- Happier FSH

Successfully Tackling Tediosity

Original CapabilityStatement

```
Instance: TestCapabilityStatement1
InstanceOf: CapabilityStatement
Usage: #example
* status = #active
* date = "2020-12-18"
* kind = #requirements
* fhirVersion = #4.0.1
* format[0] = #json
* rest.mode = #server
// MeasureReport requirements
* rest.resource[0].type = #MeasureReport
* rest.resource[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[0].extension[0].valueCode = #SHALL
* rest.resource[0].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureReport"
* rest.resource[0].supportedProfile[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[0].supportedProfile[0].extension[0].valueCode = #SHALL
* rest.resource[0].interaction[0].code = #create
* rest.resource[0].interaction[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[0].interaction[0].extension[0].valueCode = #SHALL
* rest.resource[0].interaction[1].code = #update
* rest.resource[0].interaction[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[0].interaction[1].extension[0].valueCode = #SHALL
// Measure requirements
* rest.resource[1].type = #Measure
* rest.resource[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].extension[0].valueCode = #SHALL
* rest.resource[1].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasure"
* rest.resource[1].supportedProfile[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].supportedProfile[0].extension[0].valueCode = #SHOULD
* rest.resource[1].supportedProfile[1] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureStratifier"
* rest.resource[1].supportedProfile[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].supportedProfile[1].extension[0].valueCode = #SHOULD
* rest.resource[1].interaction[0].code = #create
* rest.resource[1].interaction[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].interaction[0].extension[0].valueCode = #SHOULD
* rest.resource[1].interaction[1].code = #update
* rest.resource[1].interaction[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[1].interaction[1].extension[0].valueCode = #SHOULD
// Location requirements
* rest.resource[2].type = #Location
* rest.resource[2].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[2].extension[0].valueCode = #SHALL
* rest.resource[2].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/saner-resource-location"
* rest.resource[2].supportedProfile[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[2].supportedProfile[0].extension[0].valueCode = #SHOULD
* rest.resource[2].interaction[0].code = #create
* rest.resource[2].interaction[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[2].interaction[0].extension[0].valueCode = #SHOULD
* rest.resource[2].interaction[1].code = #update
* rest.resource[2].interaction[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[2].interaction[1].extension[0].valueCode = #SHOULD
// QuestionnaireResponse requirements
* rest.resource[3].type = #QuestionnaireResponse
* rest.resource[3].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[3].extension[0].valueCode = #SHALL
* rest.resource[3].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/SanerQuestionnaireResponse"
* rest.resource[3].supportedProfile[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[3].supportedProfile[0].extension[0].valueCode = #SHALL
* rest.resource[3].interaction[0].code = #create
* rest.resource[3].interaction[0].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[3].interaction[0].extension[0].valueCode = #SHALL
* rest.resource[3].interaction[1].code = #update
* rest.resource[3].interaction[1].extension[0].url = "http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation"
* rest.resource[3].interaction[1].extension[0].valueCode = #SHALL
```

+ Alias & Soft Indexing

```
Alias: $ExpExt = http://hl7.org/fhir/StructureDefinition/capabilitystatement-expectation

Instance: TestCapabilityStatement2
InstanceOf: CapabilityStatement
Usage: #example
* status = #active
* date = "2020-12-18"
* kind = #requirements
* fhirVersion = #4.0.1
* format[0] = #json
* rest.mode = #server
// MeasureReport requirements
* rest.resource[0].type = #MeasureReport
* rest.resource[=].extension[0].url = $ExpExt
* rest.resource[=].extension[=].valueCode = #SHALL
* rest.resource[=].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureReport"
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[=].valueCode = #SHALL
* rest.resource[=].interaction[0].code = #create
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHALL
* rest.resource[=].interaction[+].code = #update
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHALL
// Measure requirements
* rest.resource[+].type = #Measure
* rest.resource[=].extension[0].url = $ExpExt
* rest.resource[=].extension[=].valueCode = #SHALL
* rest.resource[=].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasure"
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[=].valueCode = #SHOULD
* rest.resource[=].supportedProfile[+] = "http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureStratifier"
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[=].valueCode = #SHOULD
* rest.resource[=].interaction[0].code = #create
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHOULD
* rest.resource[=].interaction[+].code = #update
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHOULD
// Location requirements
* rest.resource[+].type = #Location
* rest.resource[=].extension[0].url = $ExpExt
* rest.resource[=].extension[=].valueCode = #SHALL
* rest.resource[=].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/saner-resource-location"
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[=].valueCode = #SHOULD
* rest.resource[=].interaction[0].code = #create
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHOULD
* rest.resource[=].interaction[+].code = #update
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHOULD
// QuestionnaireResponse requirements
* rest.resource[+].type = #QuestionnaireResponse
* rest.resource[=].extension[0].url = $ExpExt
* rest.resource[=].extension[=].valueCode = #SHALL
* rest.resource[=].supportedProfile[0] = "http://hl7.org/fhir/us/saner/StructureDefinition/SanerQuestionnaireResponse"
* rest.resource[=].supportedProfile[=].extension[0].url = $ExpExt
* rest.resource[=].supportedProfile[=].extension[=].valueCode = #SHALL
* rest.resource[=].interaction[0].code = #create
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHALL
* rest.resource[=].interaction[+].code = #update
* rest.resource[=].interaction[=].extension[0].url = $ExpExt
* rest.resource[=].interaction[=].extension[=].valueCode = #SHALL
```

+ Parameterized RuleSets

```
Instance: TestCapabilityStatement3
InstanceOf: CapabilityStatement
* status = #active
* date = "2020-12-18"
* kind = #requirements
* fhirVersion = #4.0.1
* format[0] = #json
* rest.mode = #server
// MeasureReport requirements
* insert SupportResource(#MeasureReport, #SHALL)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureReport", #SHALL)
* insert SupportInteraction(#create, #SHALL)
* insert SupportInteraction(#update, #SHALL)
// Measure requirements
* insert SupportResource(#Measure, #SHALL)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasure", #SHOULD)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/PublicHealthMeasureStratifier", #SHOULD)
* insert SupportInteraction(#create, #SHOULD)
* insert SupportInteraction(#update, #SHOULD)
// Location requirements
* insert SupportResource(#Location, #SHALL)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/saner-resource-location", #SHOULD)
* insert SupportInteraction(#create, #SHOULD)
* insert SupportInteraction(#update, #SHOULD)
// QuestionnaireResponse requirements
* insert SupportResource(#QuestionnaireResponse, #SHALL)
* insert SupportProfile("http://hl7.org/fhir/us/saner/StructureDefinition/SanerQuestionnaireResponse", #SHALL)
* insert SupportInteraction(#create, #SHALL)
* insert SupportInteraction(#update, #SHALL)
```

Trophy available for purchase at
https://www.trophies2go.com/catch-of-the-day-trout-trophy.html

Preprocessed FSH (sushi -p)

```
> sushi -p myproject
```

FSH in /input/fsh

```
Alias: CAT = http://hl7.org/fhir/ValueSet/observation-category

Profile: ObservationProfile
Parent: Observation
* insert Metadata
* category from CAT (required)

RuleSet: Metadata
* ^version = "1.2.3"
* ^publisher = "Example publisher"

Instance: PatientInstance
InstanceOf: Patient
* name
  * given[+] = "John"
  * given[+] = "Q"
  * family = "Patient"
```

Preprocessed FSH in /_preprocessed

```
Alias: CAT = http://hl7.org/fhir/ValueSet/observation-category

// Originally defined on lines 3 - 6
Profile: ObservationProfile
Parent: Observation
Id: ObservationProfile
* ^version = "1.2.3"
* ^publisher = "Example publisher"
* category from http://hl7.org/fhir/ValueSet/observation-category (required)

// Originally defined on lines 12 - 17
Instance: PatientInstance
InstanceOf: Patient
Usage: #example
* name.given[0] = "John"
* name.given[1] = "Q"
* name.family = "Patient"
```

Resolved alias | Inserted RuleSet | Expanded paths | Explicit indices

Exercise: Tackling Tediosity

GOAL: Use RuleSets to create a FetchDocumentReference OperationDefinition

1. Review USCore FetchDocumentReference
2. Copy starter FSH code to your SUSHI project
3. Convert explicit indices to soft indices
4. Create & use a RuleSet for recurring rules

Starter FSH Code for Exercise: https://bit.ly/**fsh-docref-starter**

US Core FetchDocumentReference: https://bit.ly/**usc501-docref**

FHIR OperationDefinition: https://bit.ly/**fhir4-od**

FSH Soft Indexing: https://bit.ly/**fsh2-si**

FSH RuleSets: https://bit.ly/**fsh2-rs**

US Core FetchDocumentReference Parameters

Use	Name	Cardinality	Type	Binding	Documentation
IN	patient	1..1	id		The id of the patient resource located on the server on which this operation is executed. If there is no match, an empty Bundle is returned
IN	start	0..1	dateTime		The date range relates to care dates, not record currency dates - e.g. all records relating to care provided in a certain date range. If no start date is provided, all documents prior to the end date are in scope. If neither a start date nor an end date is provided, the most recent or current document is in scope. The client **SHOULD** provide values precise to the second + time offset.
IN	end	0..1	dateTime		The date range relates to care dates, not record currency dates - e.g. all records relating to care provided in a certain date range. If no end date is provided, all documents subsequent to the start date are in scope. If neither a start date nor an end date is provided, the most recent or current document is in scope. The client **SHOULD** provide values precise to the second + time offset.
IN	type	0..1	CodeableConcept	http://hl7.org/fhir/ValueSet/c80-doc-typecodes (Required)	The type relates to document type e.g. for the LOINC code for a C-CDA Clinical Summary of Care (CCD) is 34133-9 (Summary of episode note). If no type is provided, the CCD document, if available, SHALL be in scope and all other document types MAY be in scope
IN	on-demand	0..1	boolean		This on-demand parameter allows client to dictate whether they are requesting only 'on-demand' or both 'on-demand' and 'stable' documents (or delayed/deferred assembly) that meet the query parameters
OUT	return	1..1	Bundle		The bundle type is "searchset"containing DocumentReference resources which **SHOULD** conform to the US Core DocumentReference Profiles

New treadmill – JLL S400 by CharmaineZoe, CC BY 2.0 via Flickr Cartoon Fish, public domain via FreeSVG.org

CARETS GO WELL WITH FSH

Fin-tastic job!

Using Caret Paths to Set Elements in StructureDefinition

Syntax for setting elements in StructureDefinition:

```
* ^<element of StructureDefinition> = {value}
```

```
Profile: PatientMetadata
Parent: Patient
Id: example-patient-metadata
Title: "Patient Metadata Profile"
Description: "Demonstrates setting metadata"
* ^version = "0.0.1"
* ^status = #draft
* ^experimental = true
* ^date = 2021-09-30
* ^contact.name = "Shorty the FSH Fish"
```

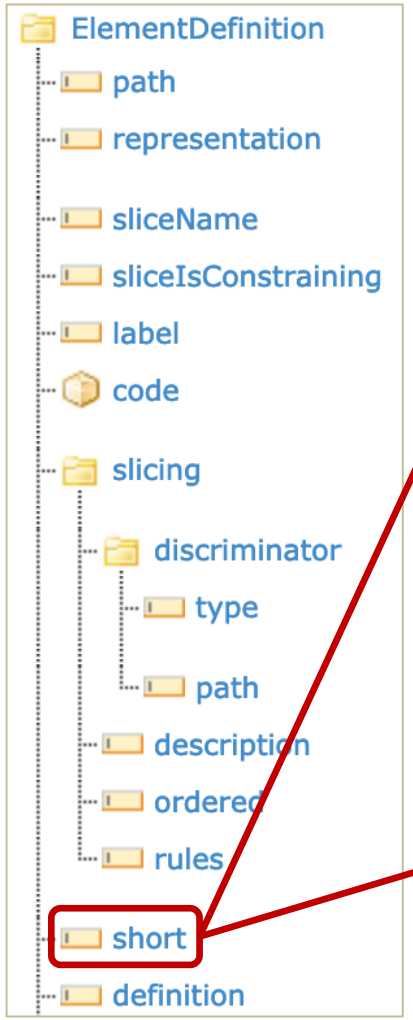
SUSHI

IG Publisher

2.16.1 Resource Profile: atient Metadata Profile

Defining URL:	http://example.org/StructureDefinition/example-patient-metadata
Version:	0.1.0
Name:	PatientMetadata
Title:	Patient Metadata Profile
Status:	Draft as of 2021-09-30
Definition:	Demonstrates setting metadata
Publisher:	Example Publisher
Source Resource:	XML / JSON / Turtle

Using Caret Paths to Set Elements in ElementDefinition



Syntax for setting elements in ElementDefinition:

```
* <element> ^<element of ElementDefinition> = {value}
```

```
Profile: PatientNameMetadata
Parent: Patient
Id: example-patient-name-metadata
* name 1..1
* name ^short = "The full legal name of the patient"
* name ^definition = "Although the patient may have multiple..."
```

SUSHI

```
"differential": {
  "element": [
    {
      "id": "Patient.name",
      "path": "Patient.name",
      "short": "The full legal name of the patient",
      "definition": "Although ient may have multiple ... ",
      "min": 1,
      "max": "1"
    }
  ]
}
```

IG Publisher

Patient	0..*	Patient	Information about an individual or animal receiving th care services
name	1..1	HumanName	The full legal name of the patient

Use special dot path to represent the "self" element

```
Profile: PatientRootElementMetadata
Parent: Patient
Id: example-patient-root-metadata
* . ^short = "A patient from the course on authoring FHIR Implementation Guides"
* . ^definition = "Patients who attend FHIR IG courses have characteristics..."
```

SUSHI

```
"differential": {
  "element": [
    {
      "id": "Patient",
      "path": "Patient",
      "short": "A patient from the course on authoring FHIR Implementation Guides",
      "definition": "Patients who attend FH courses have characteristics ... "
    }
  ]
}
```

IGP

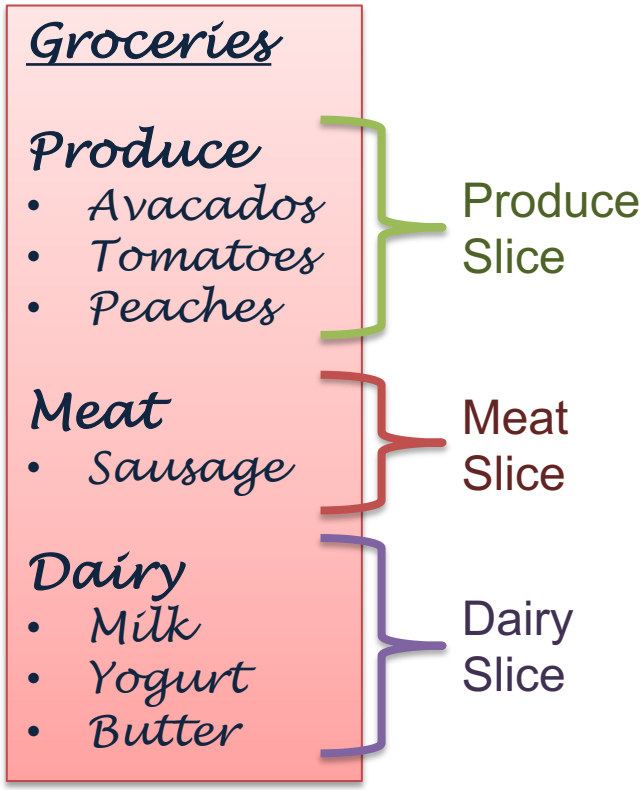
Patient	0..*	Patient	A patient from the course on authoring FHIR Implementation Guides

SLICING (WITHOUT LOSING A FINGER)

You're pirhana roll!

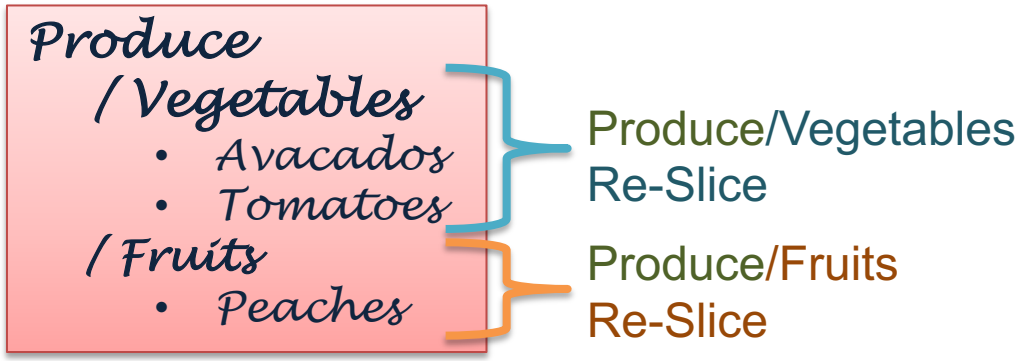
Slicing: Defining & Constraining Sub-Lists

Slicing allows you to split a list into one or more sub-lists *(slices)*



- Slices must be mutually exclusive
- Sort items into slices using discriminators
- Apply different constraints to each slice
- Optionally require slices to be in order
- Optionally allow items that don't fit in any slice

- Re-slice to support sub-sub-lists *(expert level)*



Slicing Element in ElementDefinition

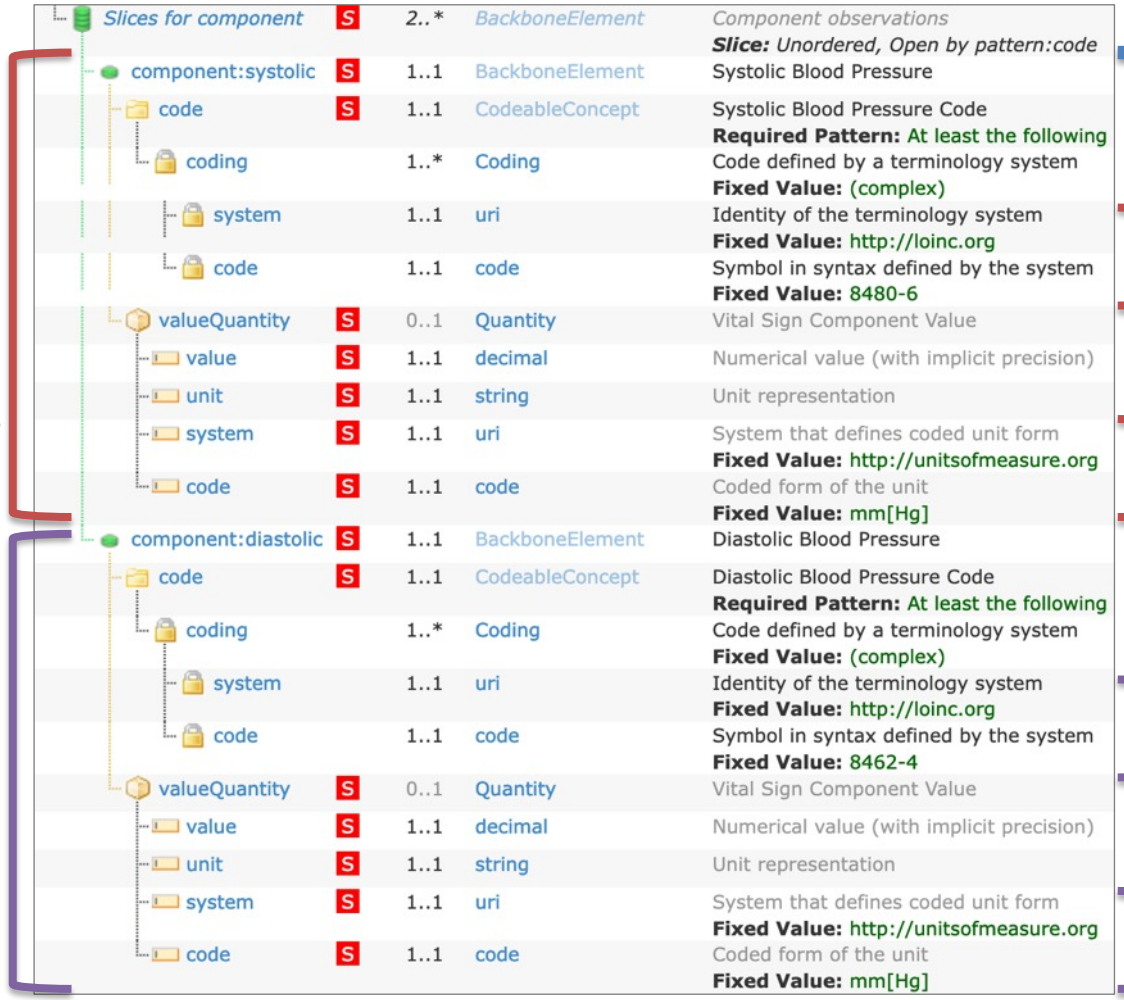
slicing	Σ I	0..1	Element	This element is sliced - slices follow *+ Rule: If there are no discriminators, there must be a definition*
discriminator	Σ	0..*	Element	Element values that are used to distinguish the slices
type	Σ	1..1	code	value | exists | pattern | type | profile DiscriminatorType (Required)
path	Σ	1..1	string	Path to element value
description	Σ I	0..1	string	Text description of how slicing works (or not)
ordered	Σ	0..1	boolean	If elements must be in same order as slices
rules	Σ	1..1	code	closed | open | openAtEnd SlicingRules (Required)

Understanding slicing.discriminator.type:

- **value:** match if the value is exactly the same as the value* in the slice
- **pattern:** match if the value fits the pattern* in the slice
- **exists:** match based on the presence or absence of the element
- **type:** match if the element has the same type as the element in the slice
- **profile:** match if the element has the same profile as the element in the slice

** or is a member of the value set*

Real World Slicing: US Core Blood Pressure



Slices for component	S	2..*	BackboneElement	Component observations **Slice:** Unordered, Open by pattern:code
component:systolic	S	1..1	BackboneElement	Systolic Blood Pressure
code	S	1..1	CodeableConcept	Systolic Blood Pressure Code **Required Pattern:** At least the following
coding		1..*	Coding	Code defined by a terminology system **Fixed Value:** (complex)
system		1..1	uri	Identity of the terminology system **Fixed Value:** http://loinc.org
code		1..1	code	Symbol in syntax defined by the system **Fixed Value:** 8480-6
valueQuantity	S	0..1	Quantity	Vital Sign Component Value
value	S	1..1	decimal	Numerical value (with implicit precision)
unit	S	1..1	string	Unit representation
system	S	1..1	uri	System that defines coded unit form **Fixed Value:** http://unitsofmeasure.org
code	S	1..1	code	Coded form of the unit **Fixed Value:** mm[Hg]
component:diastolic	S	1..1	BackboneElement	Diastolic Blood Pressure
code	S	1..1	CodeableConcept	Diastolic Blood Pressure Code **Required Pattern:** At least the following
coding		1..*	Coding	Code defined by a terminology system **Fixed Value:** (complex)
system		1..1	uri	Identity of the terminology system **Fixed Value:** http://loinc.org
code		1..1	code	Symbol in syntax defined by the system **Fixed Value:** 8462-4
valueQuantity	S	0..1	Quantity	Vital Sign Component Value
value	S	1..1	decimal	Numerical value (with implicit precision)
unit	S	1..1	string	Unit representation
system	S	1..1	uri	System that defines coded unit form **Fixed Value:** http://unitsofmeasure.org
code	S	1..1	code	Coded form of the unit **Fixed Value:** mm[Hg]

systolic slice

diastolic slice

Slice the Observation.component list by pattern on code

systolic code = LOINC 8480-6 *(discriminator)*

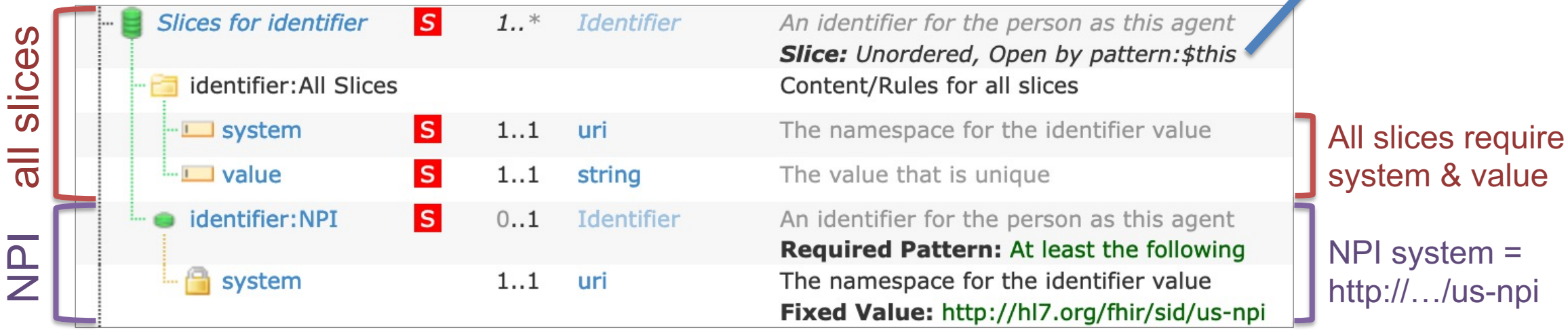
systolic units = UCUM mm[Hg]

diastolic code = LOINC 8462-4 *(discriminator)*

diastolic units = UCUM mm[Hg]

Real World Slicing: US Core Practitioner

Slice the Practitioner.identifier list
By pattern on $this (identifier)

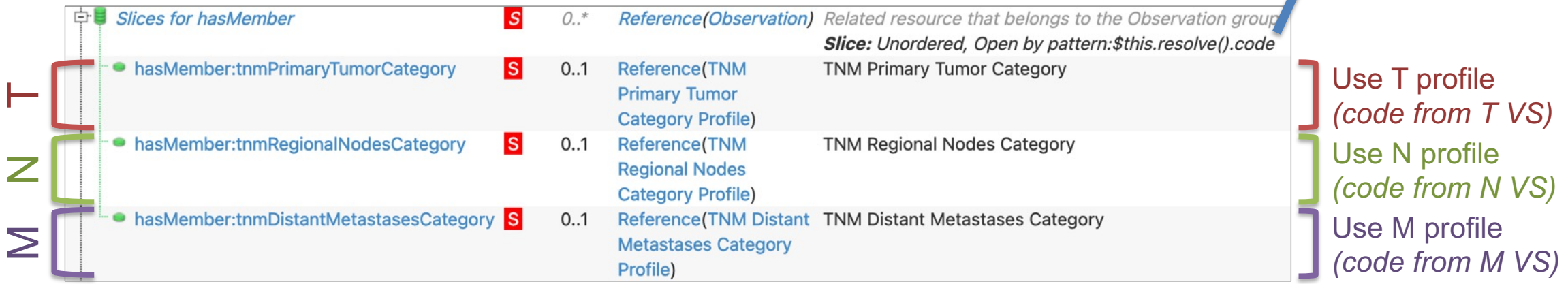


All slices require system & value

NPI system = http://…/us-npi

Real World Slicing: mCODE Cancer Stage Group

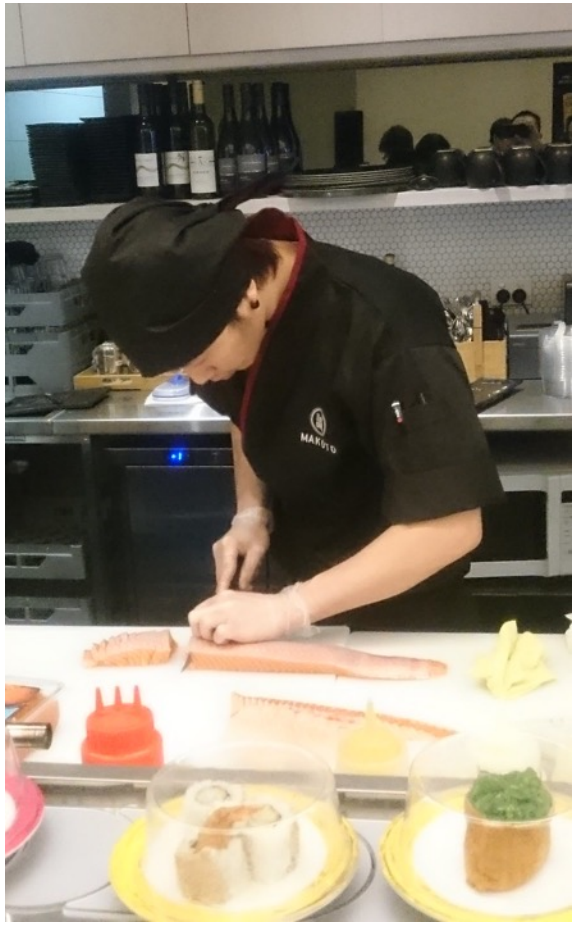
Slice the Observation.hasMember list
By pattern on $this.resolve().code



T: Primary **Tumor** Category
N: Regional **Nodes** Category
M: Distant **Metastases** Category

Slicing with FSH in Three Steps

1. Define the slicing logic
2. Identify the slices
3. Define each slice



Sushi chef slicing salmon sashimi, apprentice - Makoto, Emporium Melbourne, CC BY-NC 2.0 via Flickr

Slicing Step 1: Define the Slicing Logic

Slicing logic elements defined in ElementDefinition:

slicing	Σ I	0..1	Element	This element is sliced - slices follow *+ Rule: If there are no discriminators, there must be a definition*
discriminator	Σ	0..*	Element	Element values that are used to distinguish the slices
type	Σ	1..1	code	value | exists | pattern | type | profile DiscriminatorType (Required)
path	Σ	1..1	string	Path to element value
description	Σ I	0..1	string	Text description of how slicing works (or not)
ordered	Σ	0..1	boolean	If elements must be in same order as slices
rules	Σ	1..1	code	closed | open | openAtEnd SlicingRules (Required)

FSH example of Blood Pressure slicing logic:

```
// Step 1: Define the slicing logic
* component ^slicing.discriminator.type = #pattern  // or #value, #profile
* component ^slicing.discriminator.path = "code"    // any FHIRPath expression
* component ^slicing.rules = #open    // additional elements are ok
* component ^slicing.ordered = false  // by default, array elements in any order
* component ^slicing.description = "Slice pattern for component.code"  // optional
```

Slicing Step 2: Identify the Slices

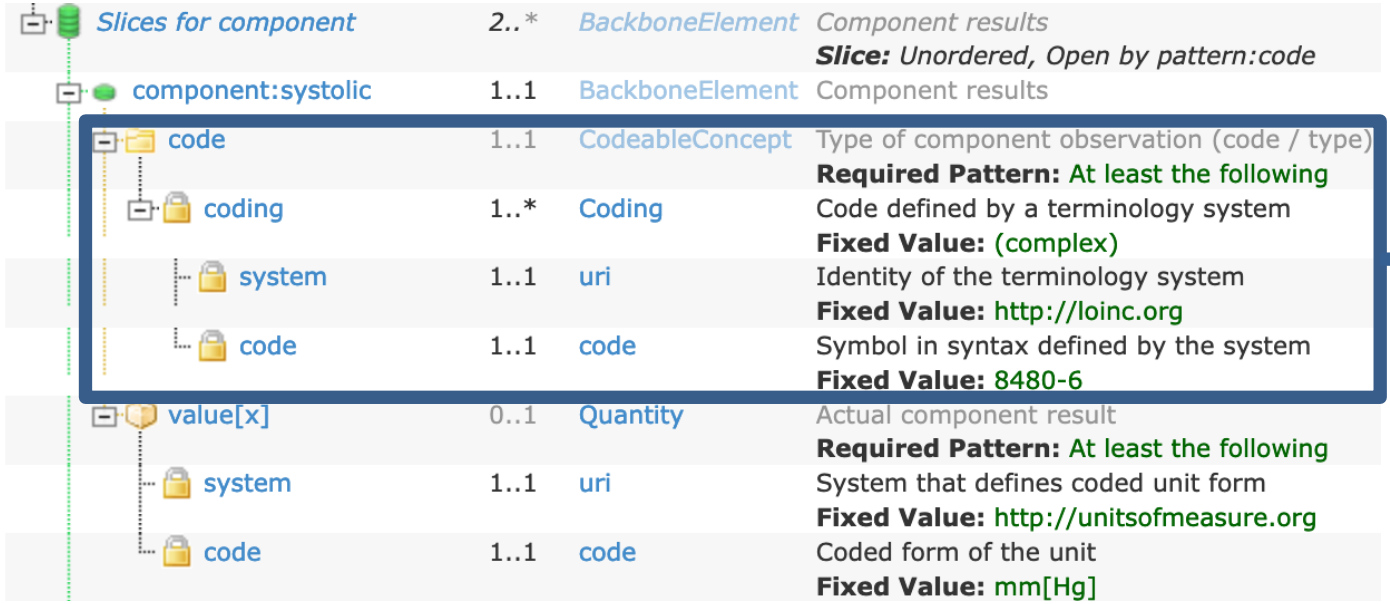
Component slices in Blood Pressure profile:

FSH example of identifying component slices in Blood Pressure profile:

```
// Step 2: Identify the slices
* component contains
    systolic 1..1 and  // each slice is identified by name, card, & optional flags
    diastolic 1..1     // using "and" to separate each slice identification
```

Slicing Step 3: Define Each Slice

Component slices in Blood Pressure profile:



Slices for component	*2..**	*BackboneElement*	*Component results* ***Slice:** Unordered, Open by pattern:code*
component:systolic	1..1	BackboneElement	Component results
code	1..1	CodeableConcept	Type of component observation (code / type) **Required Pattern:** At least the following
coding	1..*	Coding	Code defined by a terminology system **Fixed Value:** (complex)
system	1..1	uri	Identity of the terminology system **Fixed Value:** http://loinc.org
code	1..1	code	Symbol in syntax defined by the system **Fixed Value:** 8480-6
value[x]	0..1	Quantity	Actual component result **Required Pattern:** At least the following
system	1..1	uri	System that defines coded unit form **Fixed Value:** http://unitsofmeasure.org
code	1..1	code	Coded form of the unit **Fixed Value:** mm[Hg]

Discriminator element

FSH example of identifying component slices in Blood Pressure profile:

```
// Step 3: Define each slice: systolic
* component[systolic].code = $LNC#8480-6  // LNC#8480-6 distinguishes the slice
* component[systolic].value[x] only Quantity
* component[systolic].value[x] = $UCUM#mm[Hg]
```

Slicing Steps 1-3


```
Profile: BloodPressureProfile
Id: example-bp
Parent: Observation
Title: "Blood Pressure"
Description: "An example blood pressure profile"
* code = $LNC#85354-9

// Step 1: Define the slicing logic
* component ^slicing.discriminator.type = #pattern  // or #value, #profile
* component ^slicing.discriminator.path = "code"    // any FHIRPath expression
* component ^slicing.rules = #open    // additional elements are ok
* component ^slicing.ordered = false  // by default, array elements in any order
* component ^slicing.description = "Slice pattern for component.code"  // optional

// Step 2: Identify the slices
* component contains
    systolic 1..1 and  // each slice is identified by name, card, & optional flags
    diastolic 1..1     // using "and" to separate each slice identification

// Step 3: Define each slice: systolic
* component[systolic].code = $LNC#8480-6  // LNC#8480-6 distinguishes the slice
* component[systolic].value[x] only Quantity
* component[systolic].value[x] = $UCUM#mm[Hg]

// Step 3: Define each slice: diastolic
* component[diastolic].code = $LNC#8462-4 // LNC#8462-4 distinguishes the slice
* component[diastolic].value[x] only Quantity
* component[diastolic].value[x] = $UCUM#mm[Hg]
```

Exercise: Slicing

GOAL: Define and use a partial Continuity of Care Document (CCD)

1. Copy starter FSH code to your SUSHI project
2. Edit PartialCCD to slice *section* into 3 slices
3. Edit PartialCCDExample to add section data

Section	LOINC	Entry Reference
allergies	48765-2	AllergyIntolerance
medications	10160-0	MedicationRequest
problems	11450-4	Condition

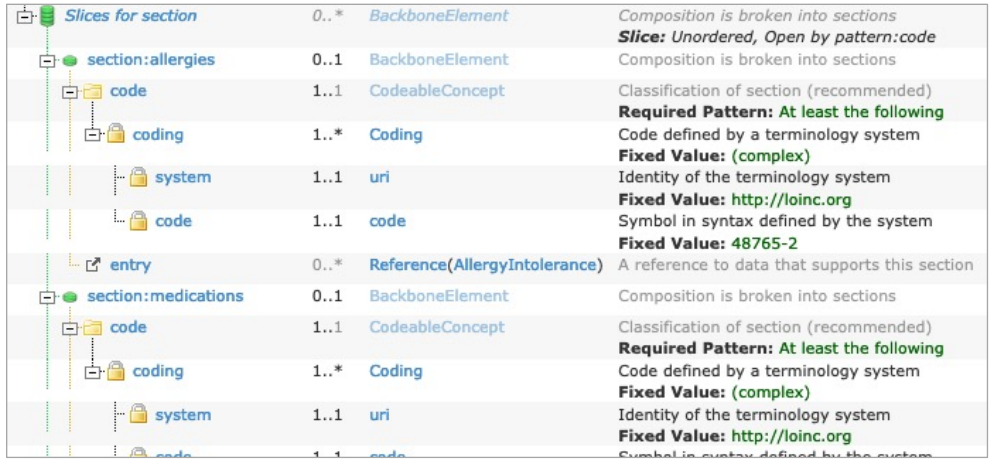
Starter FSH Code for Exercise: https://bit.ly/**fsh-ccd-starter**

FHIR Composition: https://bit.ly/**fhir4-comp**

FSH Contains Rules for Slicing: https://bit.ly/**fsh2-contains**

FSH Sliced Array Paths: https://bit.ly/**fsh2-sap**

FSH Type Rules: https://bit.ly/**fsh2-type**



New treadmill – JLL S400 by CharmaineZoe, CC BY 2.0 via Flickr Cartoon Fish, public domain via FreeSVG.org

COOKIE TIME!

Limited Edition Swedish Fish Oreo Cookies, CC BY-SA 2.0 via Flickr

~~FINVARIANTS~~ INVARIANTS

That went swimmingly!

Why Use Invariants?

Invariants use FHIRPath to define logical constraints over one or more elements

- Best used when you can't express the criteria using other constraints
- Allows for two levels of severity: *error* or *warning*

Id	Path	Details
us-core-2	Observation	If there is no component or hasMember element then either a value[x] or a data absent reason must be present : (component.empty() and hasMember.empty()) implies (dataAbsentReason.exists() or value.exists())

Top-level Invariant on Observation

FHIRPath

Id	Path	Details
pat-1	Patient.contact	SHALL at least contain a contact's details or a reference to an organization : name.exists() or telecom.exists() or address.exists() or organization.exists()

Element-level Invariant on Patient.contact

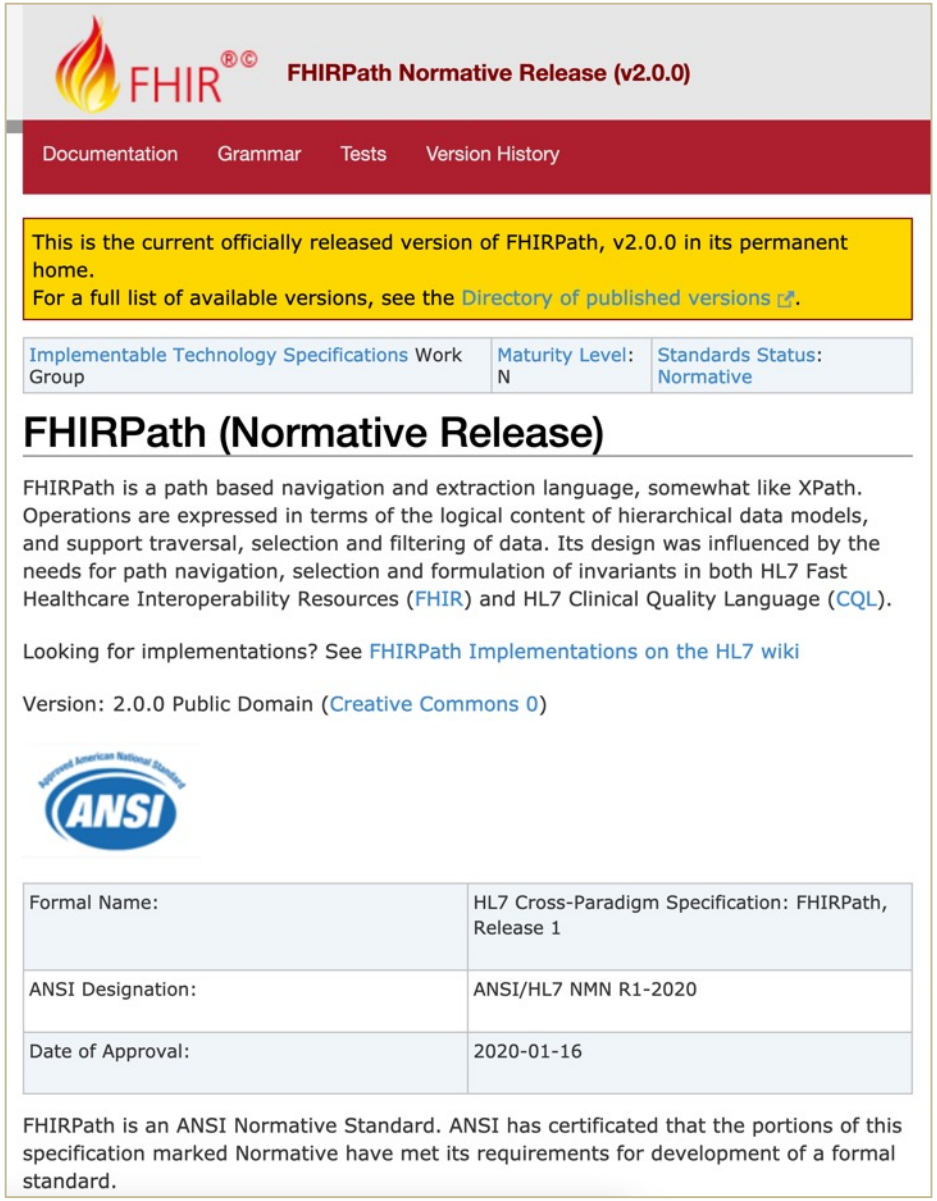
FHIRPath

FHIRPath

- Path-based navigation and extraction
- Not specific to FHIR (despite the name)
- Two specs of interest for FHIR users:
  - **FHIRPath Specification**: Core FHIRPath spec
  - **FHIR Specification**: How to use FHIRPath in FHIR

- Primary use cases for IGs:
  - Defining slice discriminators*
  - Defining invariants
  - Defining search parameters

** Limited to a restricted subset of FHIRPath ("Simple" FHIRPath)*



FHIR®© FHIRPath Normative Release (v2.0.0)

Documentation | Grammar | Tests | Version History

This is the current officially released version of FHIRPath, v2.0.0 in its permanent home.
For a full list of available versions, see the Directory of published versions.

Implementable Technology Specifications Work Group	Maturity Level: N	Standards Status: Normative

FHIRPath (Normative Release)

FHIRPath is a path based navigation and extraction language, somewhat like XPath. Operations are expressed in terms of the logical content of hierarchical data models, and support traversal, selection and filtering of data. Its design was influenced by the needs for path navigation, selection and formulation of invariants in both HL7 Fast Healthcare Interoperability Resources (FHIR) and HL7 Clinical Quality Language (CQL).

Looking for implementations? See FHIRPath Implementations on the HL7 wiki

Version: 2.0.0 Public Domain (Creative Commons 0)

ANSI

Formal Name:	HL7 Cross-Paradigm Specification: FHIRPath, Release 1
ANSI Designation:	ANSI/HL7 NMN R1-2020
Date of Approval:	2020-01-16

FHIRPath is an ANSI Normative Standard. ANSI has certificated that the portions of this specification marked Normative have met its requirements for development of a formal standard.

FHIRPath Basics: Path Navigation

- Path navigation is accomplished by concatenating element names
- Result is *always* a list (even for 0..1 / 1..1 elements)

Example results for FHIRPath expression: **Patient.name.given** (or simply **name.given**)

FHIRPath Basics: Common Expressions

Choose a specific choice type using “as”

```
Observation.value as Quantity
```

Check existence using “.exists()”

```
Observation.component.exists()
```

Query a list using “.where(…)”

```
Patient.telecom.where(use = 'mobile')
```

Specify causal relationships using “implies”

```
MedicationAdministration.status = 'not-done'
  implies MedicationAdministration.statusReason.exists()
```

Keywords:

$index	milliseconds
$this	minute
$total	minutes
and	mod
as	month
contains	months
day	or
days	second
div	seconds
false	true
hour	week
hours	weeks
implies	xor
in	year
is	years
millisecond	

FHIR-Specific FHIRPath: Common Expressions

Select extensions using “extension(…)”

```
Patient.extension('http://hl7.org/fhir/StructureDefinition/patient-birthPlace')
```

Resolve references using “resolve()”

```
Encounter.reasonReference.resolve().exists($this is FHIR.Condition)
```

Check profile conformance using “conformsTo(…)”

```
Pracitioner.conformsTo('http://hl7.org/fhir/us/core/StructureDefinition/us-core-practitioner')
```

Check value set membership using “memberOf(…)”

```
Procedure.reasonCode.memberOf('http://hl7.org/fhir/us/mcode/ValueSet/mcode-cancer-disorder-vs')
```

Defining Invariants in FHIR Shorthand

FSH Keyword	Usage	Element in ElementDefinition	Data Type	Required
Invariant	Identifier	constraint.key	id	Yes
Severity	#error or #warning	constraint.severity	code	Yes
Description	Human description of constraint	constraint.human	string	Yes
Expression	FHIRPath expression of constraint	constraint.expression	FHIRPath string	No
XPath	XPath expression of constraint	constraint.xpath	Xpath string	No

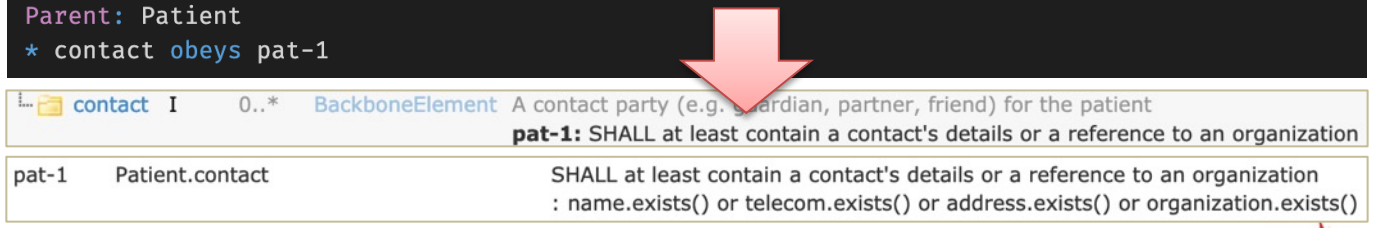
Syntax for Applying Invariants (obeys):

```
* obeys {Invariant}
* obeys {Invariant} and {Invariant2} and ...
* <element> obeys {Invariant}
* <element> obeys {Invariant} and {Invariant2}
  and ...
```

Example using FHIR R4 Patient.contact

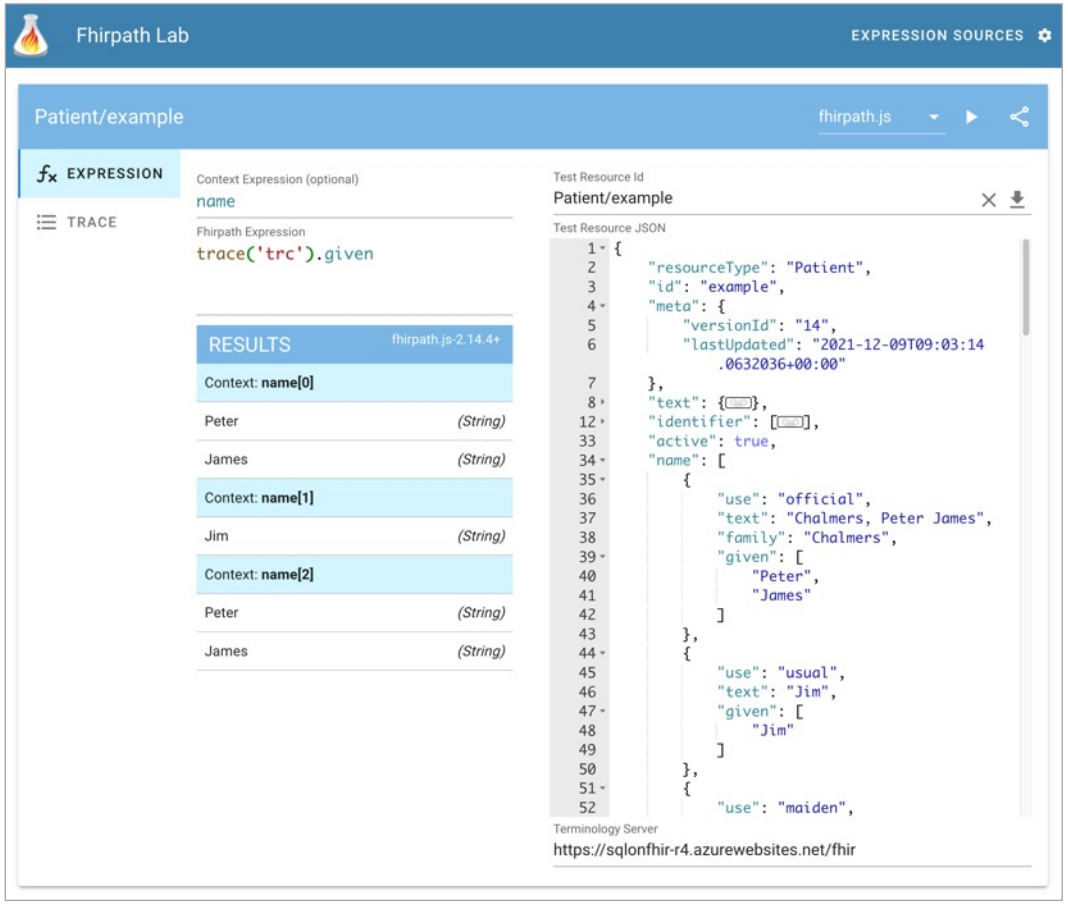
```
Invariant: pat-1
Severity: #error
Description: "SHALL at least contain a contact's details or a reference to an organization"
Expression: "name.exists() or telecom.exists() or address.exists() or organization.exists()"
XPath: "exists(f:name) or exists(f:telecom) or exists(f:address) or exists(f:organization)"

Profile: PatientWithContactInvariant
Id: example-patient-w-contact-invariant
Parent: Patient
* contact obeys pat-1
```



Testing & Debugging FHIRPath

- FHIRPath Lab (New!)
  - Test and explore FHIRPath from multiple sources
  - Choose from four FHIRPath implementations
  - https://fhirpath-lab.azurewebsites.net/
- FHIRPath.js Test App
  - Test FHIRPath against arbitrary JSON/YAML
  - Uses JavaScript FHIRPath implementation
  - https://hl7.github.io/fhirpath.js/
- IG Publisher / Validator
  - Flags instances that fail FHIRPath-based invariants
  - Testing and debugging is possible via trial and error
  - Uses Java (HAPI) FHIRPath implementation



INTENSIONAL VALUE SETS

You are dolphinitely doing great!

Value Sets (Review)

- Value Sets define a set of codes for a purpose
  - Codes can be drawn from one or more Code Systems
- Value Sets are *intentional* or *extensional*
  - **Intensional**: defined by algorithms; dynamically updated.
  - **Extensional**: defined code-by-code; manually updated.
- Value Set composition can *include* or *exclude* codes
- Value Set *expansion* uses the Value Set *composition* to produce a fully enumerated set of codes

HINT: Authors should prefer intensional composition for large Value Sets since extensional Value Sets can be hard to maintain.

10.117.1 ValueSet: Detailed ethnicity

Summary

Defining URL:	http://hl7.org/fhir/us/core/ValueSet/detailed-ethnicity
Version:	4.0.0
Name:	DetailedEthnicity
Title:	Detailed ethnicity
Status:	Active as of 2019-05-21
Definition:	The 41 CDC ethnicity codes that are grouped under one of the 2 OMB ethnicity category codes.
Publisher:	HL7 International - US Realm Steering Committee
Copyright:	Used by permission of HL7 International, all rights reserved Creative Commons License
Source Resource:	XML / JSON / Turtle

References

- US Core Ethnicity Extension

10.117.1.1 Logical Definition (CLD)

This value set includes codes based on the following rules:

- Include codes from `urn:oid:2.16.840.1.113883.6.238` where concept is-a 2133-7

This value set excludes codes based on the following rules:

- Exclude these codes as defined in `urn:oid:2.16.840.1.113883.6.238`

Code	Display	Definition
2135-2	Hispanic or Latino	Hispanic or Latino
2186-5	Not Hispanic or Latino	Note that this term remains in the table for completeness, even though within HL7, the notion of "not otherwise coded" term is deprecated.

10.117.1.2 Expansion

This value set contains 42 concepts

Expansion based on Race & Ethnicity - CDC v4.0.0 (CodeSystem)

All codes from system `urn:oid:2.16.840.1.113883.6.238`

Code	Display	Definition
2133-7	Ethnicity	Ethnicity Note that this is an abstract 'grouping' concept and not for use as a real concept
2137-8	Spaniard	Spaniard
2148-5	Mexican	Mexican
2155-0	Central American	Central American

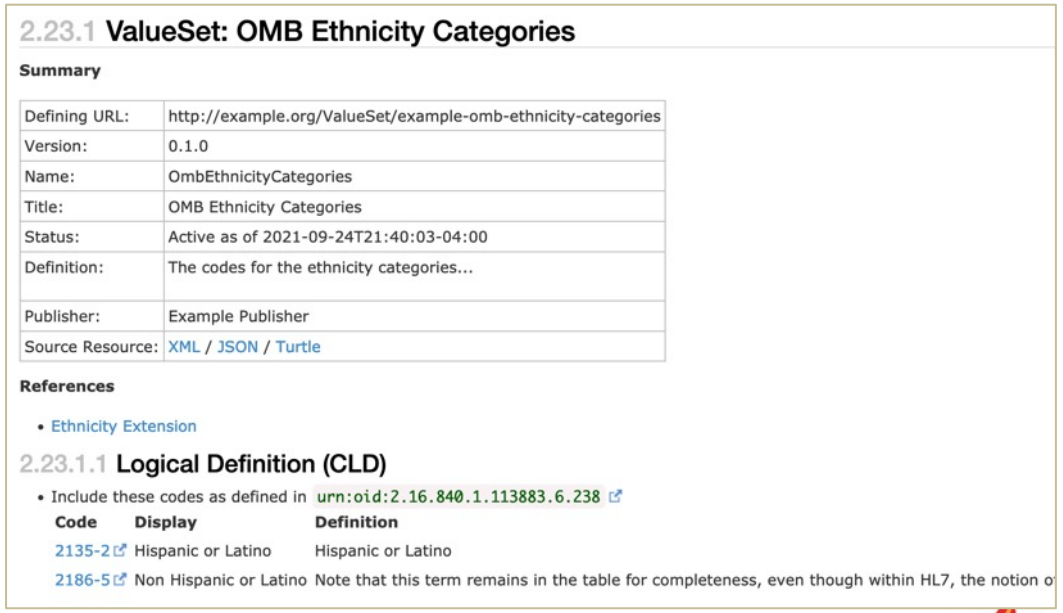
US Core Detailed Ethnicity (Partial Screenshot)

Defining Value Sets in FSH

FSH Keyword	Usage	Element in ValueSet	Data Type	Required
ValueSet	Name of the value set	name	name	Yes
Id	Identifier of the value set	id	id	No
Title	Title of the value set	title	string	No
Description	Human-readable description	description	string	No

Example Extensional Value Set

```
ValueSet: OmbEthnicityCategories
Id: example-omb-ethnicity-categories
Title: "OMB Ethnicity Categories"
Description: "The codes for the ethnicity categories..."
* $CDC_RACE_ETHN#2135-2 "Hispanic or Latino"
* $CDC_RACE_ETHN#2186-5 "Non Hispanic or Latino"
```



2.23.1 ValueSet: OMB Ethnicity Categories

Summary

Defining URL:	http://example.org/ValueSet/example-omb-ethnicity-categories
Version:	0.1.0
Name:	OmbEthnicityCategories
Title:	OMB Ethnicity Categories
Status:	Active as of 2021-09-24T21:40:03-04:00
Definition:	The codes for the ethnicity categories...
Publisher:	Example Publisher
Source Resource:	XML / JSON / Turtle

References

- Ethnicity Extension

2.23.1.1 Logical Definition (CLD)

- Include these codes as defined in urn:oid:2.16.840.1.113883.6.238

Code	Display	Definition
2135-2	Hispanic or Latino	Hispanic or Latino
2186-5	Non Hispanic or Latino	Note that this term remains in the table for completeness, even though within HL7, the notion o

Value Set Rules

Include or exclude individual codes

```
* $SCT#1149162008 "International Staging System for multiple myeloma (staging scale)"
* include $SCT#1149162008 "International Staging System for multiple myeloma (staging scale)"
* exclude $SCT#42114005 "Walter Reed stage 1 (tumor staging)"
```

Include or exclude entire code systems

```
* include codes from system http://www.cms.gov/Medicare/Coding/ICD10
* exclude codes from system http://www.ama-assn.org/go/cpt
```

Include or exclude entire value sets

```
* include codes from valueset BodyLocationAndLateralityQualifierVS
* exclude codes from valueset LateralityQualifierVS
```

NOTE: As shown above, you can refer to code systems and value sets using URL, alias, name, or id.

Value Set Rules: Unions & Intersections

Use multiple include rules to specify a *union*

```
// Include all codes from TeleradiotherapyModalityVS and BrachytherapyModalityVS
* include codes from valueset TeleradiotherapyModalityVS
* include codes from valueset BrachytherapyModalityVS
```

Use one include rule with “and” to specify an *intersection*

```
// Include only codes that UnitsOfTime and AgeUnits have in common
* include codes from valueset $UnitsOfTime and $AgeUnits
```

```
// Include only SNOMED codes from ImmunizationStatusReason
* include codes from system $SCT and valueset $ImmunizationStatusReason
```

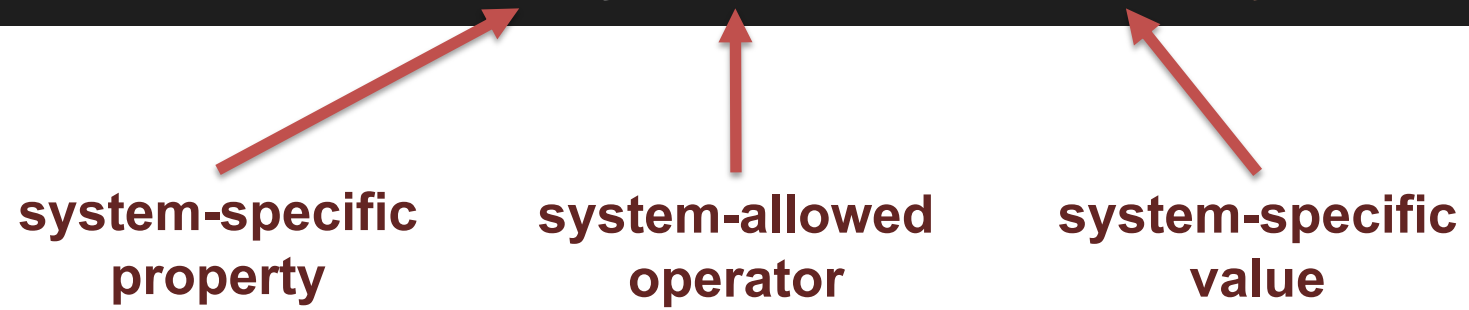
Value Set Rules: Filters

Filters specify codes using *system-specific* expressions

```
* include codes from system {CodeSystem} where {filter1} and {filter2}...
  // where each filter has syntax {property} {operator} {value}
```

Example of a filter rule using SNOMED-CT

```
* include codes from system $SCT where concept is-a #123037004 "Body Structure"
```



FHIR-defined Filter Operators

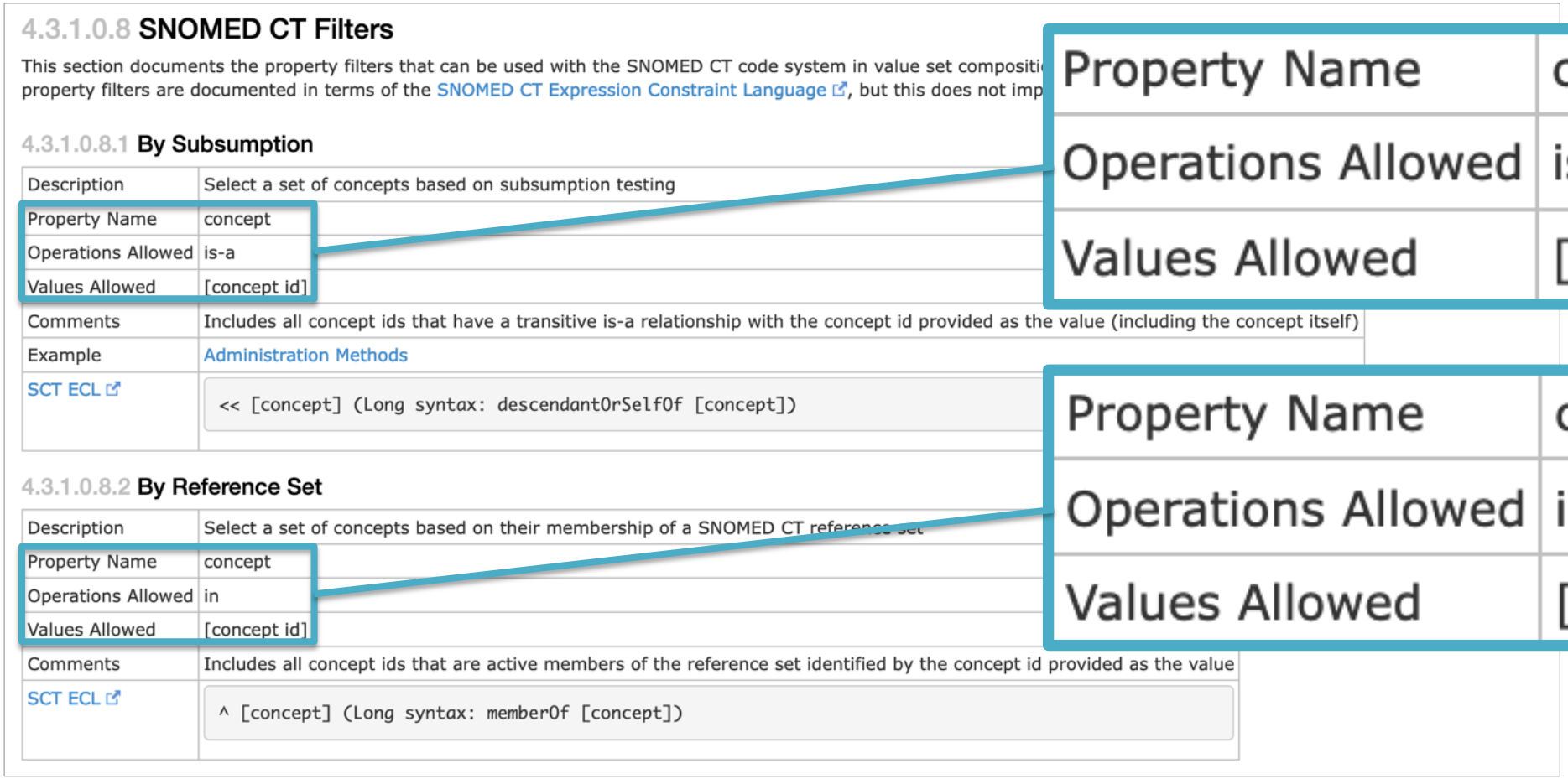
From filter-operator value set documentation (http://hl7.org/fhir/valueset-filter-operator.html)

Code	Display	Definition
=	Equals	The specified property of the code equals the provided value.
is-a	Is A (by subsumption)	Includes all concept ids that have a transitive is-a relationship with the concept Id provided as the value, including the provided concept itself (include descendant codes and self).
descendent-of	Descendent Of (by subsumption)	Includes all concept ids that have a transitive is-a relationship with the concept Id provided as the value, excluding the provided concept itself i.e. include descendant codes only).
is-not-a	Not (Is A) (by subsumption)	The specified property of the code does not have an is-a relationship with the provided value.
regex	Regular Expression	The specified property of the code matches the regex specified in the provided value.
in	In Set	The specified property of the code is in the set of codes or concepts specified in the provided value (comma separated list).
not-in	Not in Set	The specified property of the code is not in the set of codes or concepts specified in the provided value (comma separated list).
generalizes	Generalizes (by Subsumption)	Includes all concept ids that have a transitive is-a relationship from the concept Id provided as the value, including the provided concept itself (i.e. include ancestor codes and self).
exists	Exists	The specified property of the code has at least one value (if the specified value is true; if the specified value is false, then matches when the specified property of the code has no values).

NOTE: Most code systems only support a subset of filter operators.

Hint: Check “Using {CodeSystem}” for valid filters

From “Using SNOMED CT with FHIR” (http://hl7.org/fhir/snomedct.html)



4.3.1.0.8 SNOMED CT Filters

This section documents the property filters that can be used with the SNOMED CT code system in value set compositi
property filters are documented in terms of the SNOMED CT Expression Constraint Language, but this does not imp

4.3.1.0.8.1 By Subsumption

Description	Select a set of concepts based on subsumption testing
Property Name	concept
Operations Allowed	is-a
Values Allowed	[concept id]
Comments	Includes all concept ids that have a transitive is-a relationship with the concept id provided as the value (including the concept itself)
Example	Administration Methods
SCT ECL	<< [concept] (Long syntax: descendantOrSelfOf [concept])

4.3.1.0.8.2 By Reference Set

Description	Select a set of concepts based on their membership of a SNOMED CT reference set
Property Name	concept
Operations Allowed	in
Values Allowed	[concept id]
Comments	Includes all concept ids that are active members of the reference set identified by the concept id provided as the value
SCT ECL	^ [concept] (Long syntax: memberOf [concept])

Property Name	concept
Operations Allowed	is-a
Values Allowed	[concept id]

Property Name	concept
Operations Allowed	in
Values Allowed	[concept id]

Review of Value Set Rules

```
* $SCT#1149162008 "International Staging System for multiple myeloma (staging scale)"
* include $SCT#1149162008 "International Staging System for multiple myeloma (staging scale)"
* exclude $SCT#42114005 "Walter Reed stage 1 (tumor staging)"
```

```
* include codes from system http://www.cms.gov/Medicare/Coding/ICD10
* exclude codes from system http://www.ama-assn.org/go/cpt
```

```
* include codes from valueset BodyLocationAndLateralityQualifierVS
* exclude codes from valueset LateralityQualifierVS
```

```
* include codes from valueset $UnitsOfTime and $AgeUnits
```

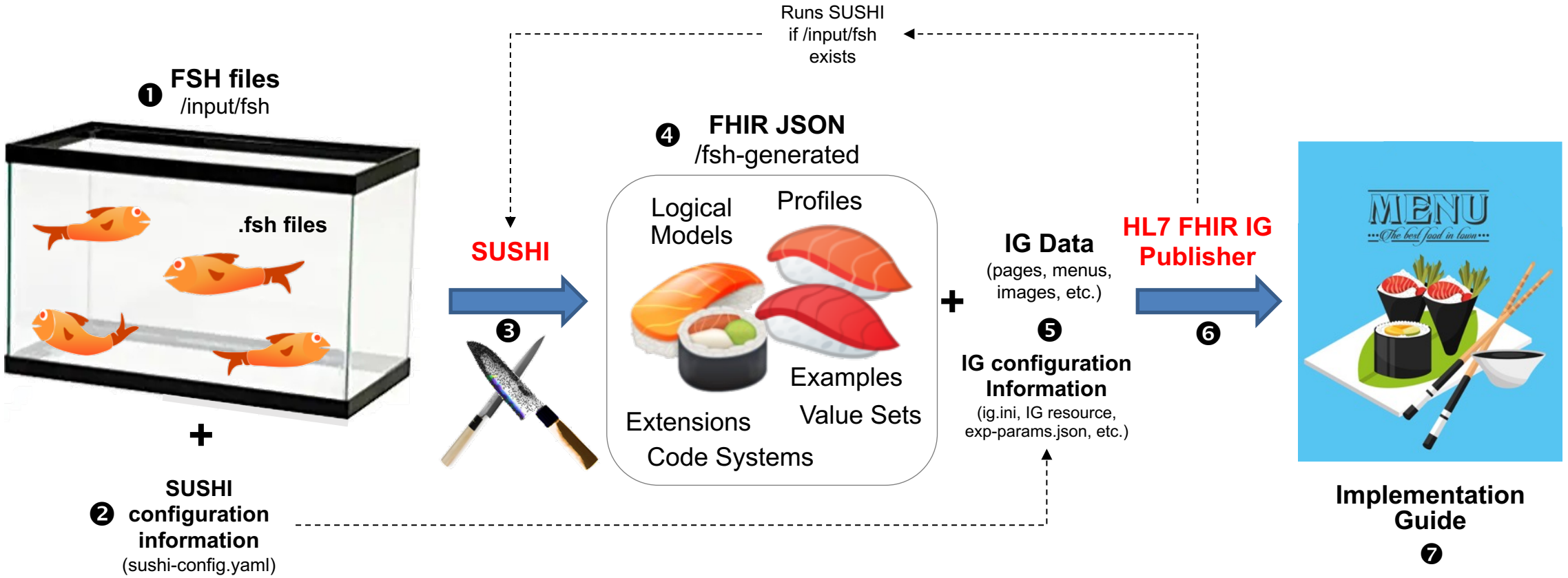
```
* include codes from system $SCT and valueset $ImmunizationStatusReason
```

```
* include codes from system $SCT where concept is-a #123037004 "Body Structure"
```


IG CONFIGURATION

Ac-clam-ations!

Overview of FSH Publishing Workflow



Sushi clipart from Google and WhatsApp rendering of Unicode 6.0 sushi emoji [Japanese Cuisine Sushi Menu Restaurant](), Non-commercial use via pngwing.com

Minimal SUSHI IG Project Directory Structure

For Github integration (directories to ignore)

Scripts to run IG publisher

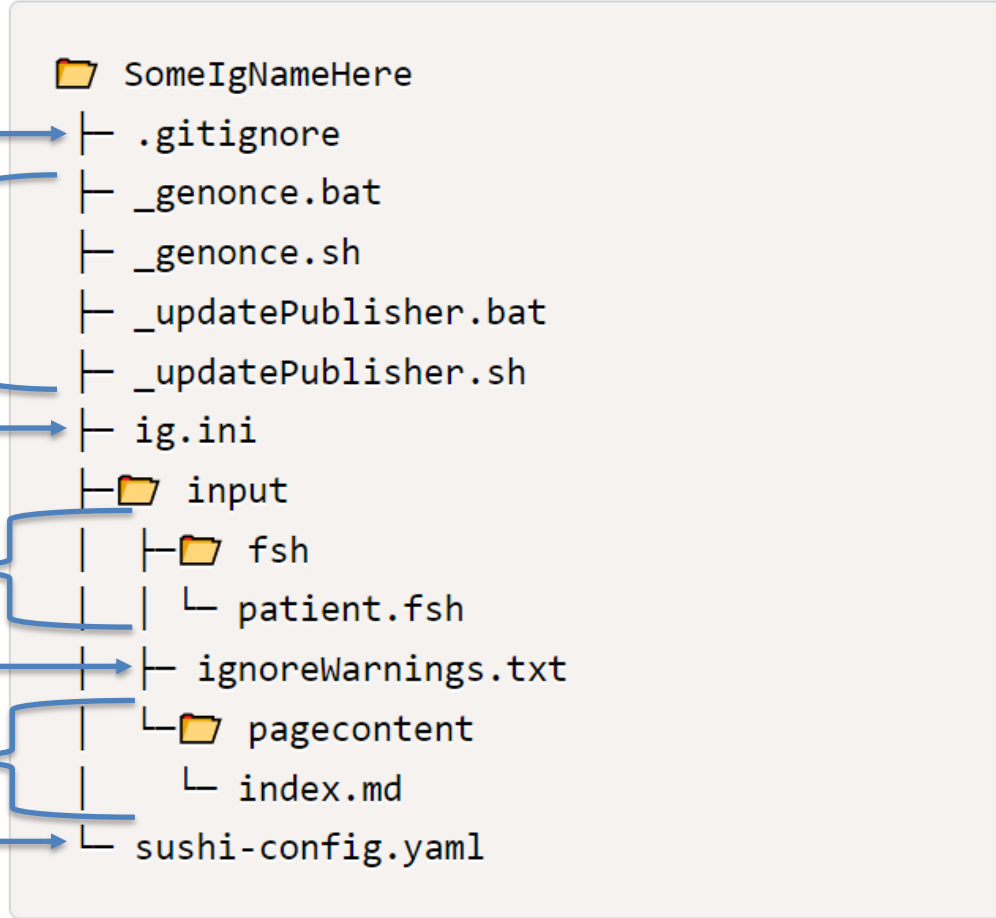
Required by IG Publisher; Names template & IG resource

FSH content

Another IG Publisher file, suppresses QA warnings

Narrative Content in markdown or XHTML format

SUSHI configuration parameters



`publisher.jar` goes in input-cache directory (not shown)

Configuration: sushi-config.yaml

- Configuration defined by sushi-config.yaml in root of project
- sushi-config.yaml is in YAML format
  - White space (new lines and indentation) is significant
  - Information is presented in *key:value* pairs
  - Strings don't have to be quoted unless they contain reserved characters
  - Items in arrays (a.k.a. sequences) have a preceding "-"
- Properties and values *loosely* follow ImplementationGuide resource
  - All properties in ImplementationGuide are accessible in sushi-config.yam
  - Some property names and formats are optimized for user-friendly access
  - Additional (non-IG) properties are available to specify SUSHI behavior

Minimal sushi-config.yaml for IG

```yaml
id: fhir.us.example
canonical: http://hl7.org/fhir/us/example
name: ExampleIG
status: draft
version: 0.1.0
fhirVersion: 4.0.1
copyrightYear: 2022+
releaseLabel: ci-build
```

Status
draft
active
retired
unknown

ReleaseLabel
ci-build
draft
qa-preview
ballot
trial-use
release
update
normative+trial-use

Recommended sushi-config.yaml for IG

```yaml
id: fhir.us.example
canonical: http://hl7.org/fhir/us/example
name: ExampleIG
title: "HL7 FHIR Implementation Guide: Example IG Release 1 - US Realm | STU1"
description: An example IG that exercises many of the fields in a SUSHI configuration
status: draft
license: CC0-1.0
version: 0.1.0
fhirVersion: 4.0.1
copyrightYear: 2022+
releaseLabel: ci-build
publisher:
  name: HL7 International - US Realm Steering Committee
  url: http://www.hl7.org/Special/committees/usrealm/index.cfm
  email: usrsc@lists.HL7.org
dependencies:
  hl7.fhir.us.core: 5.0.1
```

Configuration: IG Parameters

Control IG Publisher behavior using IG parameters

- E.g., apply, logging, special-url, suppressed-ids, validation, …
- Use *key:value* pairs in sushi-config.yaml, where parameter code is the key
- As of Sep 2022, allowed parameters are now specified in two code systems:
  - http://build.fhir.org/valueset-guide-parameter-code.html
  - http://build.fhir.org/ig/FHIR/fhir-tools-ig/branches/master/CodeSystem-ig-parameters.html

```
parameters:
  excludettl: true
  validation: [allow-any-extensions, no-broken-links]
  show-inherited-invariants: false
```

Configuration: SUSHI-specific Properties

```yaml
# The FSHOnly flag indicates if only FSH resources should be exported.
# If set to true, no IG related content will be generated.
# The default value for this property is false.
FSHOnly: false

# When set to true, the "short" and "definition" field on the root element of an Extension will
# be set to the "Title" and "Description" of that Extension. Default is true.
applyExtensionMetadataToRoot: false

# The instanceOptions property is used to configure certain aspects of how SUSHI processed instances.
# See the individual option definitions below for more detail.
instanceOptions:
  # Determines for which types of Instances SUSHI will automatically set meta.profile
  # if InstanceOf references a profile. Options are:
  # - always: Set meta.profile for all Instances of profiles (default)
  # - never: Do not set meta.profile on any Instances
  # - inline-only: Set meta.profile for only Instances of profiles with Usage set to #inline
  # - standalone-only: Set meta.profile for only Instances of profiles where Usage is any value other than #inline
  setMetaProfile: always
  # Determines for which types of Instances SUSHI will automatically set id
  # if InstanceOf references a profile. Options are:
  # - always: Set id for all Instances (default)
  # - standalone-only: Set id for only Instances where Usage is any value other than #inline
  setId: always
```

Adding Pages to an IG

- Pages are defined using Markdown or XHTML
- Markdown pages are rendered using Jekyll
- Authors can use automatic or manual page organization
- Relevant folders in an IG project
  - input/pagecontent: markdown (.md) and XHTML (.xml) files
  - input/intro-notes: content to embed in formal resource views
  - input/images: binary files such as images and downloads
  - input/includes: special includes files for Jekyll power users

Markdown Cheat Sheet (Part 1)

```
# Level 1 Header
## Level 2 Header
### Level 3 Header

Use two asterisks to specify **bold text**.

Use underscores to specify _italic text_.

Use backticks for `inline code`.

Link to [HL7 FHIR](https://www.hl7.org/fhir/).

Ordered list:
1. item a
2. item b

Unordered list:
- item a
- item b
```

Level 1 Header

1 Level 2 Header

1.1 Level 3 Header

Use two asterisks to specify **bold text**.

Use underscores to specify *italic text*.

Use backticks for `inline code`.

Link to HL7 FHIR.

Ordered list:

1. item a
2. item b

Unordered list:

- item a
- item b

Markdown Cheat Sheet (Part 2)

````
```
Use three backticks before and after
a multi-line block of code.
```

> Use leading greater-than symbol for
> a quoted block of text.

| Question                | Answer                 |
| ----------------------- | ---------------------- |
| Is this a table?        | Yes                    |
| Do I have to align it?  | No, but it looks nice. |
{: .grid }

![HL7 Logo](hl7-logo.png)
````

```
Use three backticks before and after
a multi-line block of code.
```

> Use leading greater-than symbol for a quoted block of text.

Question	Answer
Is this a table?	Yes
Do I have to align it?	No, but it looks nice.

Automatic Page Organization

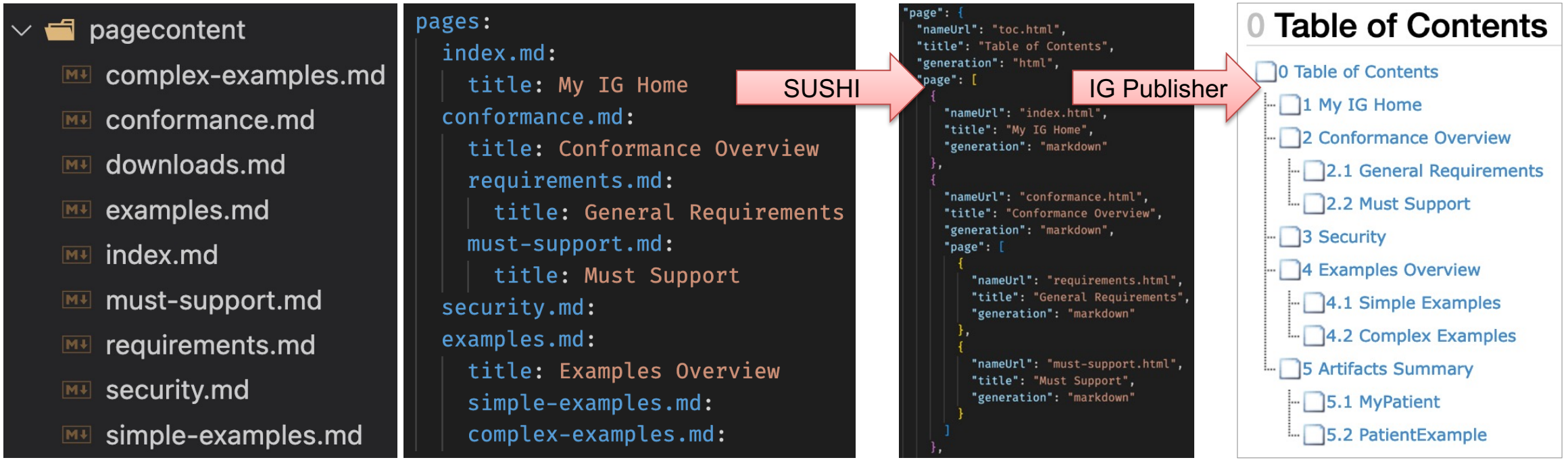
SUSHI can automatically organize your pages based on file name

- Order is determined by numeric prefixes, otherwise alphabetical
- Word separation in titles is determined by camel-case

Manual Page Organization

Authors can specify page titles & organization in sushi-config.yaml

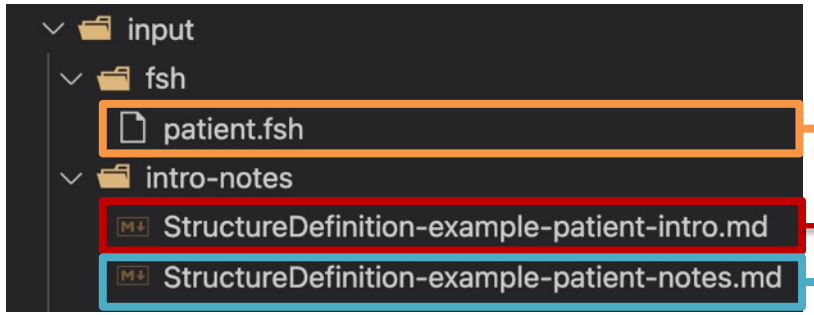
- File name is key, with optional *title* and *generation* sub-properties
- Nested file name keys indicate page hierarchy

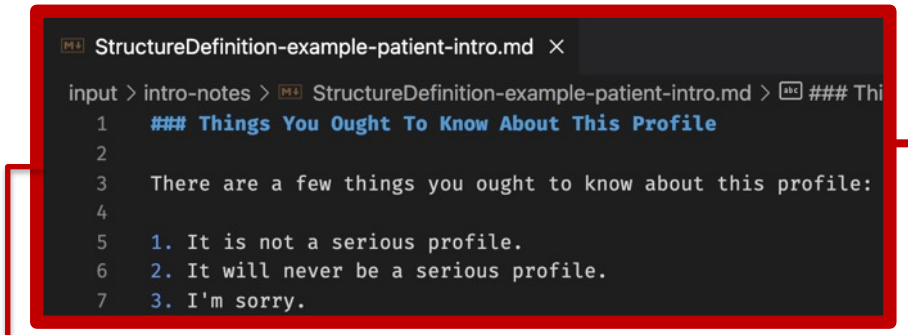


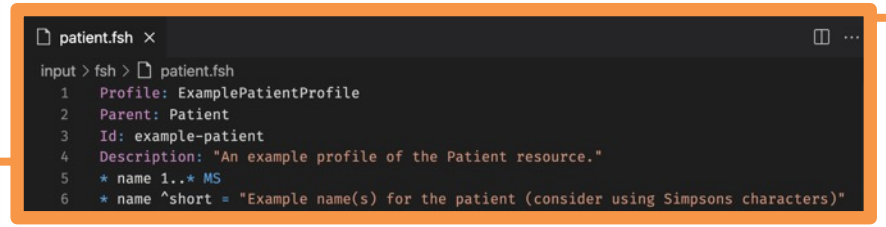
Intro and Notes Documentation

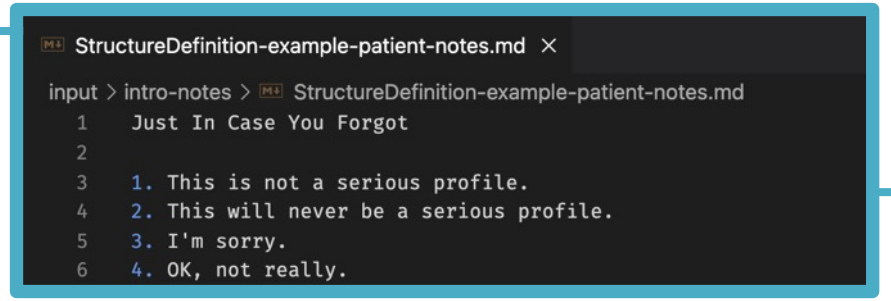
Content before/after formal views

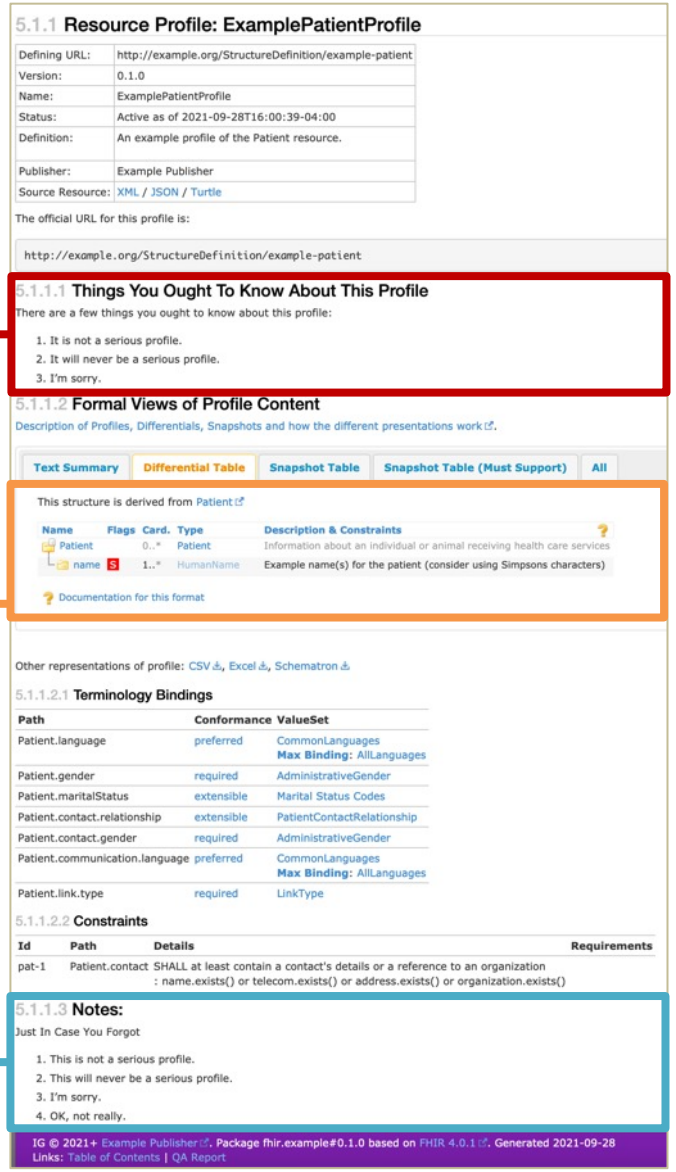
- Put content in *input/intro-notes*
- Before formal: {type}-{id}-intro.{md|xml}
- After formal: {type}-{id}-notes.{md|xml}











Configuring the Menu

Configure the top-level menu in sushi-config.yaml

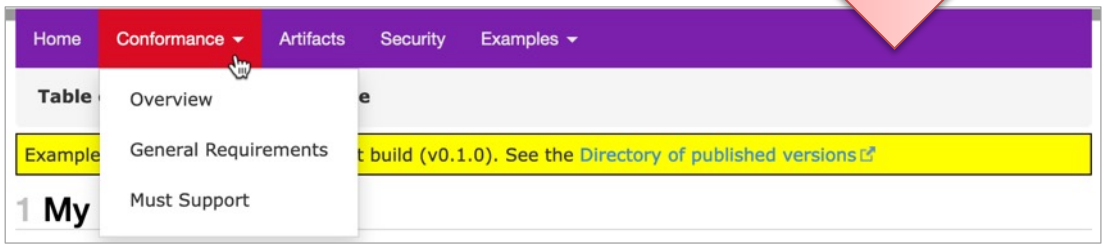
- Key is menu item and value is HTML file name or nested menu items
- Menus can only go one level deep

```yaml
menu:
  Home: index.html
  Conformance:
    Overview: conformance.html
    General Requirements: requirements.html
    Must Support: must-support.html
  Artifacts: artifacts.html
  Security: security.html
  Examples:
    Overview: examples.html
    Simple Examples: simple-examples.html
    Complex Examples: complex-examples.html
```

SUSHI

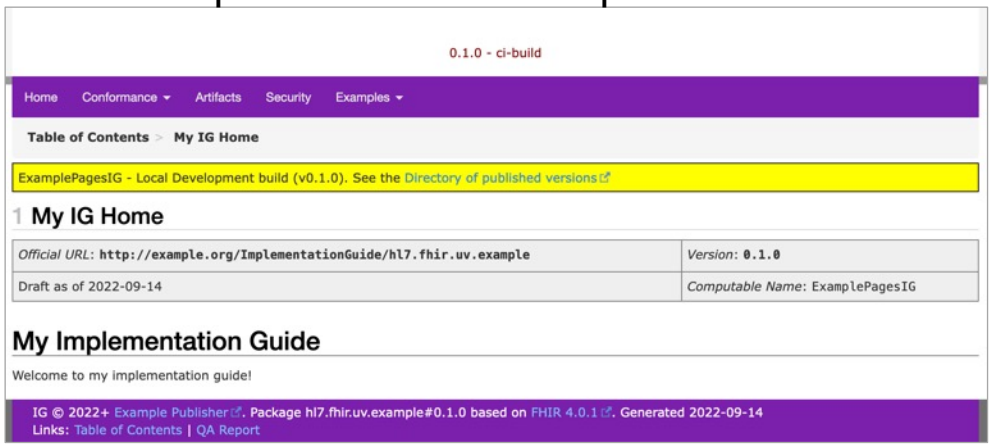
```html
<ul xmlns="http://www.w3.org/1999/xhtml" class="nav navbar-nav">
  <li><a href="index.html">Home</a></li>
  <li class="dropdown">
    <a data-toggle="dropdown" href="#" class="dropdown-to
      <b class="caret"></b>
    </a>
    <ul class="dropdown-menu">
      <li><a href="conformance.html">Overview</a></li>
```

IG Publisher

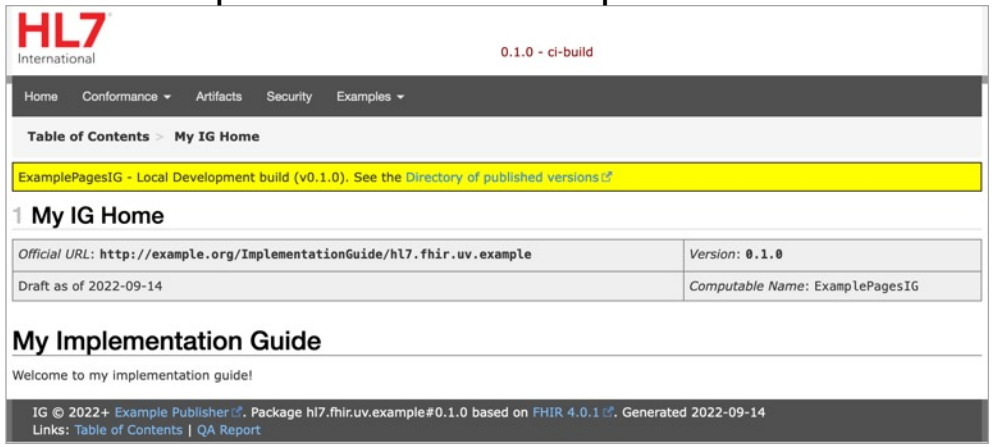


Specify the IG's Template in ig.ini

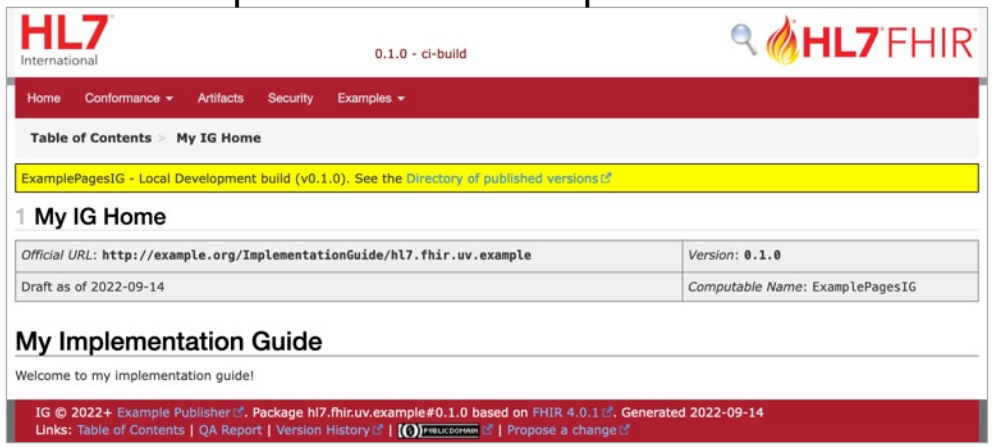
template = fhir.base.template#current



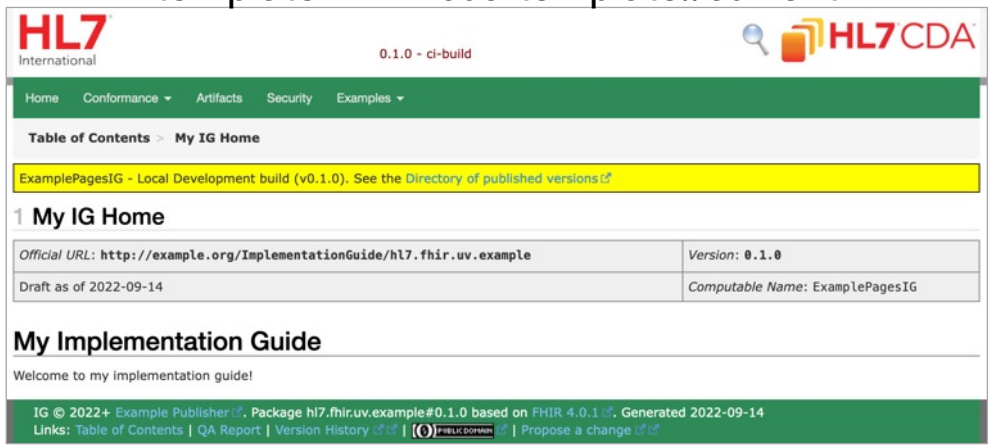
template = hl7.base.template#current



template = hl7.fhir.template#current



template = hl7.cda.template#current



Exercise: IG Configuration

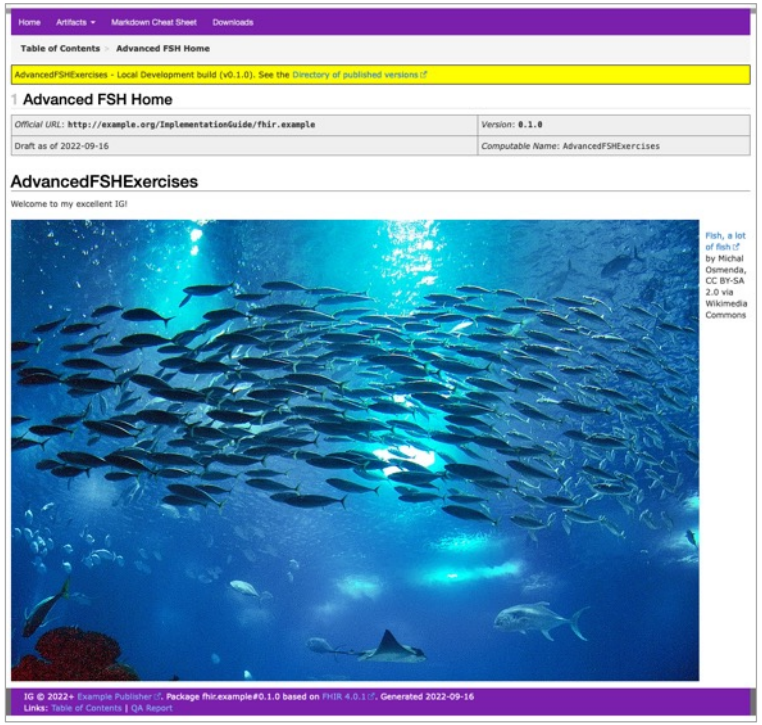
GOAL: Fill out your IG with additional documentation

1. Add at least two additional pages to your IG
2. Add an image to your IG and display it on a page
3. Update your IG's menu to point to the new pages
4. Add an introduction and notes to a profile's page

FSH Project Structure: https://bit.ly/**fsh-ps**

FSH Configuration: https://bit.ly/**fsh-config**

Using IG Templates: https://bit.ly/**fhir-templates**



New treadmill – JLL S400 by CharmaineZoe, CC BY 2.0 via Flickr Cartoon Fish, public domain via FreeSVG.org

GOFSH

Well hooked and landed!

GoFSH

Convert FHIR XML/JSON to FSH

- Command line interface
- Supports FSH 2.0
- Multiple output styles
- Common uses:
  - Kickstart an IG conversion to FSH
  - Learn about FSH through examples

Install: npm install -g gofsh

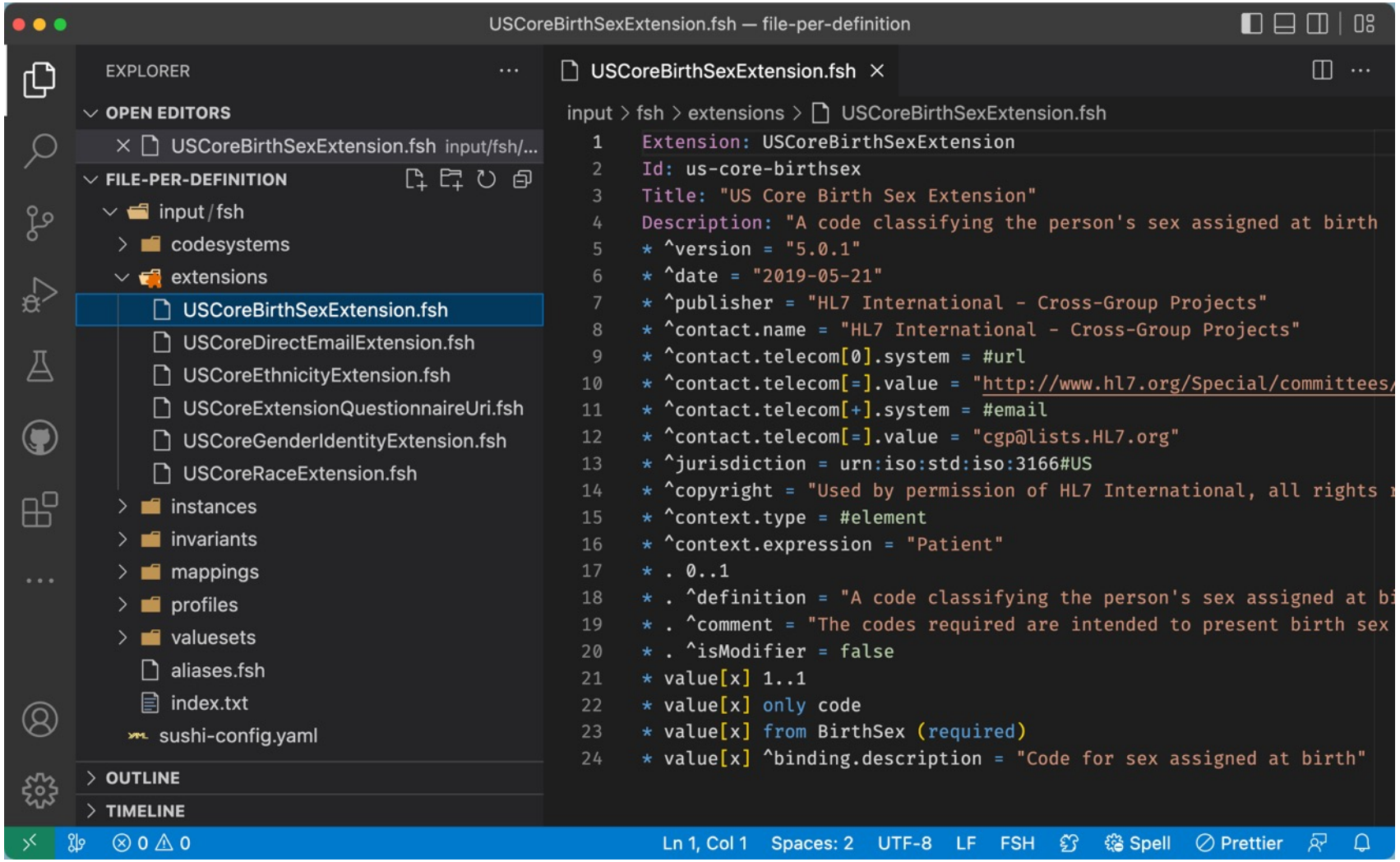
Hand holding fishing rod by Santeri Viinamäki, CC BY-SA 4.0 via Wikimedia Commons

GoFSH Usage

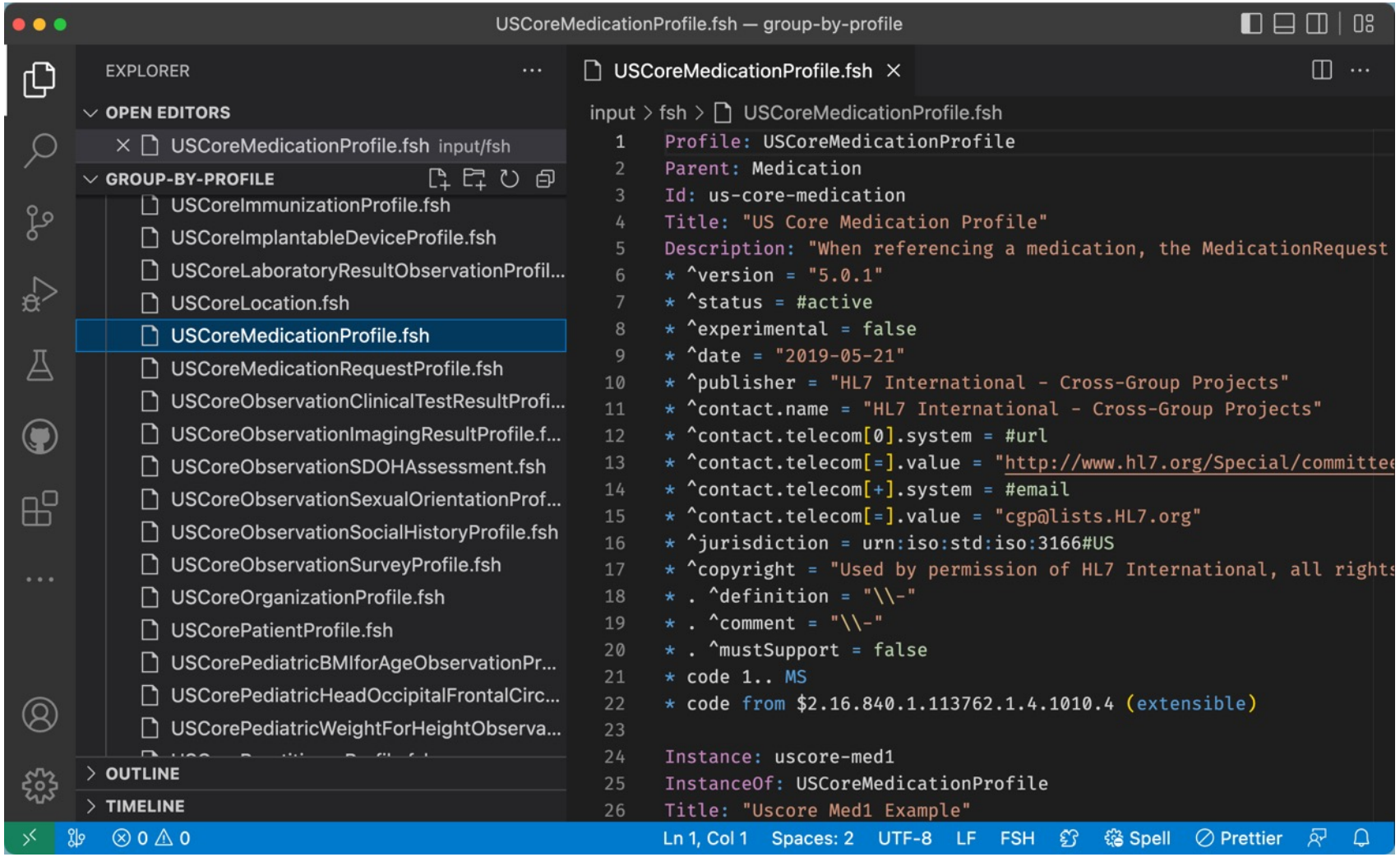
```
❯ gofsh --help
Usage: goFSH [path-to-fhir-resources] [options]

Options:
  -o, --out <out>                      the path to the output folder
  -l, --log-level <level>              specify the level of log messages: error, warn, info (default), debug
  -d, --dependency <dependency...>     specify dependencies to be loaded using format dependencyId@version (FHIR R4
                                       included by default)
  -s, --style <style>                  specify how the output is organized into files: file-per-definition (default),
                                       group-by-fsh-type, group-by-profile, single-file
  -f, --fshing-trip                    run SUSHI on the output of GoFSH and generate a comparison of the round trip
                                       results
  -i, --installed-sushi                use the locally installed version of SUSHI when generating comparisons with the
                                       "-f" option
  -t, --file-type <type>               specify which file types GoFSH should accept as input: json-only (default),
                                       xml-only, json-and-xml
  --indent                             output FSH with indented rules using context paths
  --meta-profile <mode>                specify how meta.profile on Instances should be applied to the InstanceOf
                                       keyword: only-one (default), first, none
  -a, --alias-file <alias-filePath>    specify an existing FSH file containing aliases to be loaded.
  --no-alias                           output FSH without generating Aliases
  -u, --useFHIRVersion <fhirVersion>   specify which FHIR version to use when it cannot be inferred
  -v, --version                        print goFSH version
  -h, --help                           display help for command
```

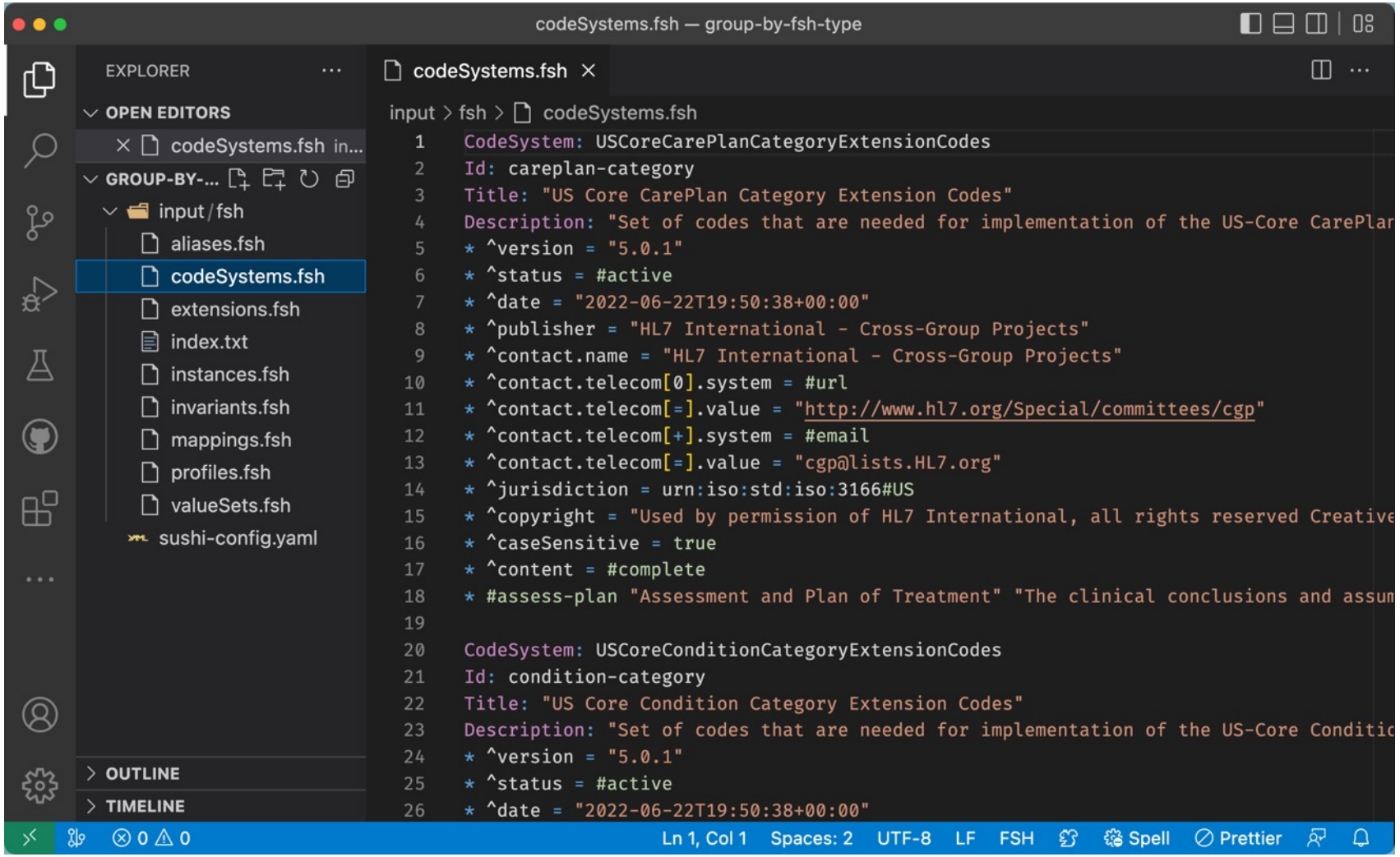
GoFSH Options: --style file-per-definition



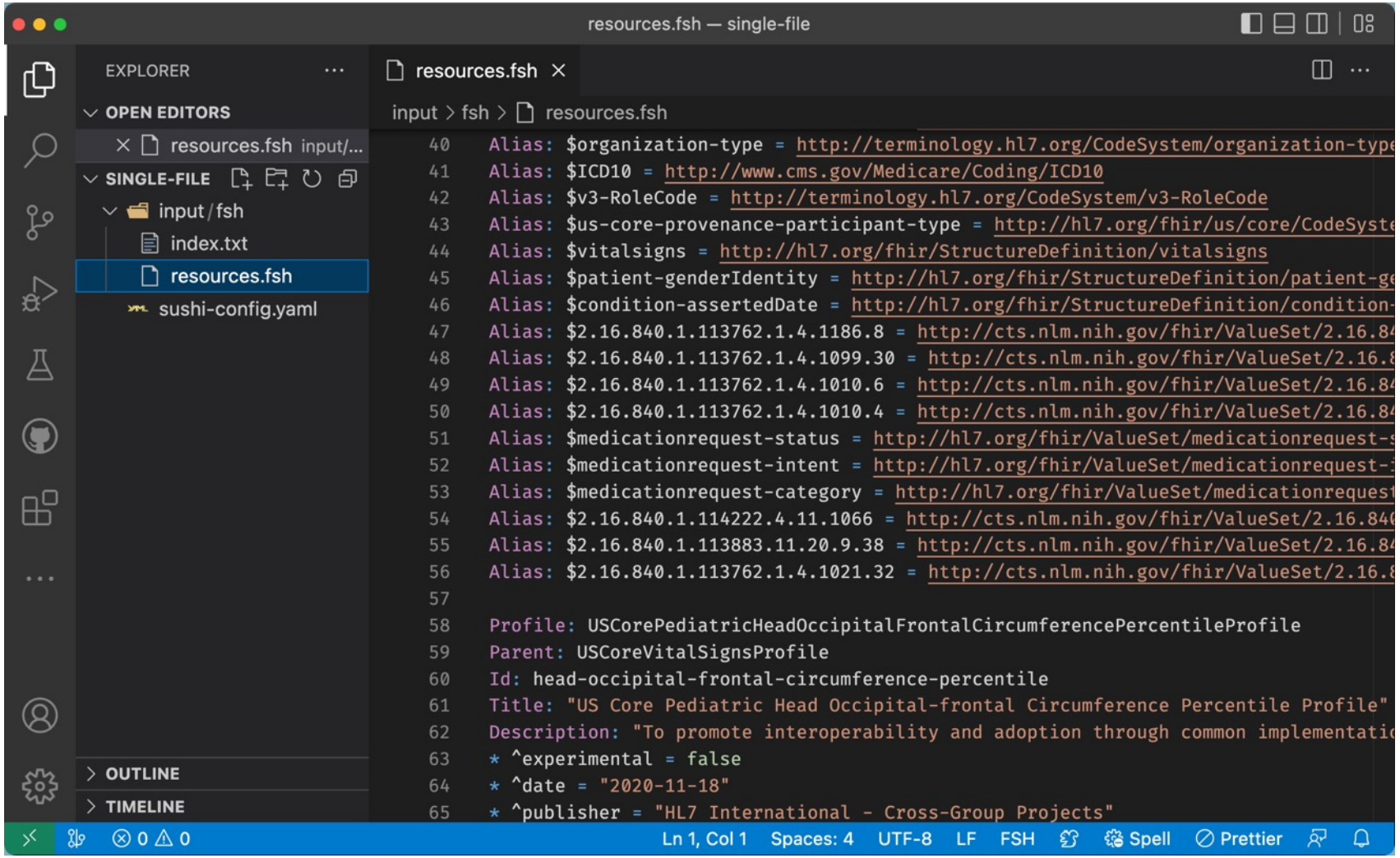
GoFSH Options: --style group-by-profile



GoFSH Options: --style group-by-fsh-type



GoFSH Options: --style single-file



GoFSH Options: --fshing-trip

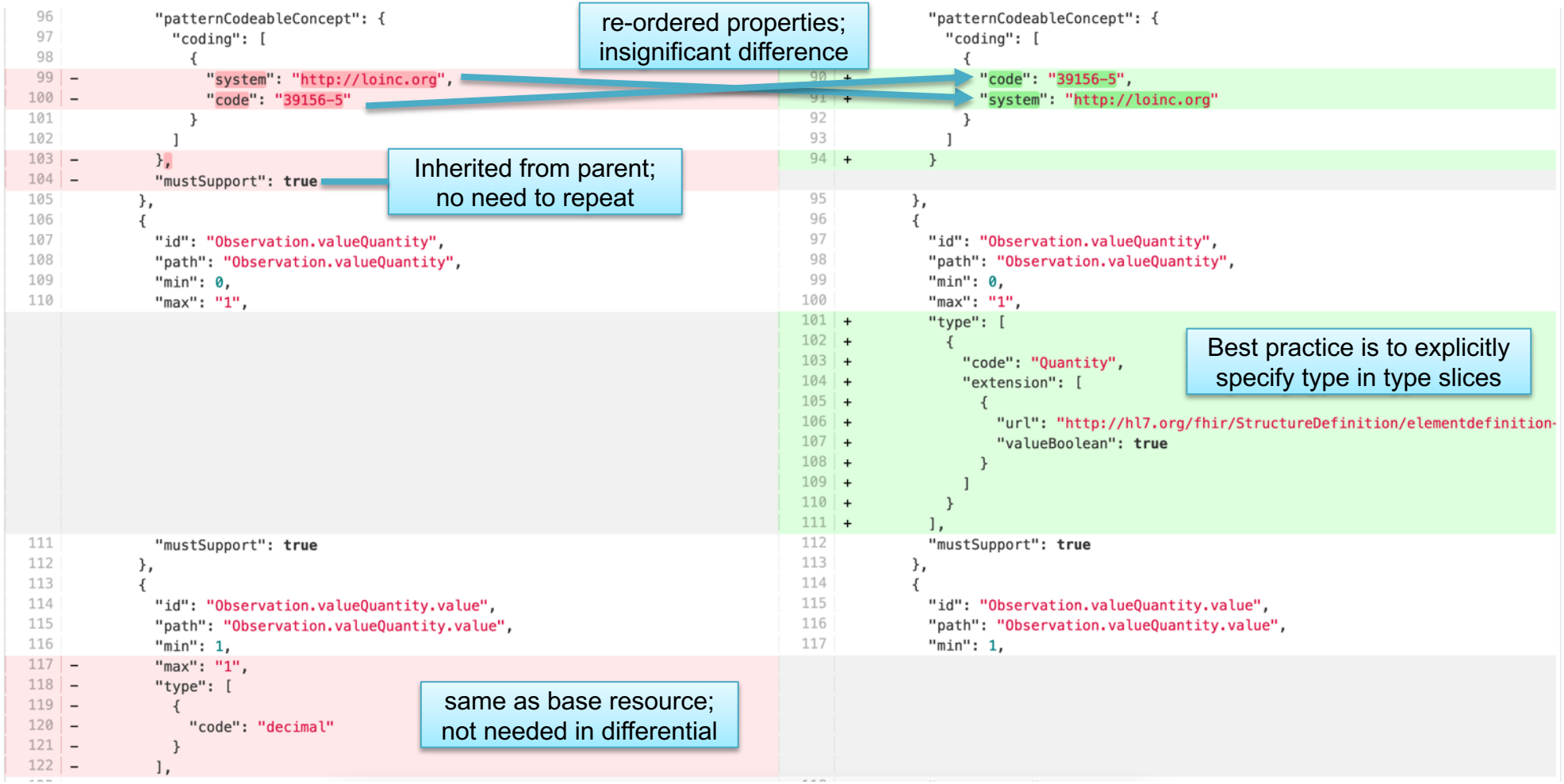
FSHing Trip provides a *round-trip* analysis of generated FSH

FSHing Trip Comparison

Files changed (61) hide

{package/example → fshing-trip/fsh-generated/resources}/Bundle-66c8856b-ba11-4876-8aa8-467aad8c11a2.json	+8	-20
{package/example → fshing-trip/fsh-generated/resources}/Bundle-c887e62f-6166-419f-8268-b5ecd6c7b901.json	+6	-14
{package/example → fshing-trip/fsh-generated/resources}/Bundle-uscore-mo3.json	+1	-9
{package/example → fshing-trip/fsh-generated/resources}/CarePlan-colonoscopy.json	+8	-8
{package → fshing-trip/fsh-generated/resources}/CodeSystem-careplan-category.json	+16	-16

GoFSH: FSHing Trip Comparison



GoFSH: FSHing Trip Comparison

```
        {
-         "id": "Observation.category:us-core/social-history",
-         "path": "Observation.category",
-         "sliceName": "us-core/social-history",
-         "requirements": "Used for filtering that this is a social history observa
-         "min": 1,
-         "max": "1",
-         "patternCodeableConcept": {
-           "coding": [
-             {
-               "system": "http://terminology.hl7.org/CodeSystem/observation-catego
-               "code": "social-history"
-             }
-           ]
-         },
-         "mustSupport": true
-       },
-       {
          "id": "Observation.category:sdoh",
          "path": "Observation.category",
```

```
        {
          "id": "Observation.category:sdoh",
          "path": "Observation.category",
```

Missing a whole slice?
That could be a problem…

Better Investigate!

GoFSH *did* emit an error that hinted there might be an issue here:

```
error Element sliceName "us-core/social-history" is not correctly used to populate id "Observation.category:us-core/social-history" according
 to the algorithm specified here: https://www.hl7.org/fhir/elementdefinition.html#id. The value implied by the id will be used.
```

And so did SUSHI:

```
error No element found at path category[us-core] for ContainsRule in USCoreObservationSocialHistoryProfile, skipping rule
  File: /Users/cmoesel/dev/HL7/uscore-501/fshing-trip/input/fsh/profiles/USCoreObservationSocialHistoryProfile.fsh
  Line: 24
```

HL7 International

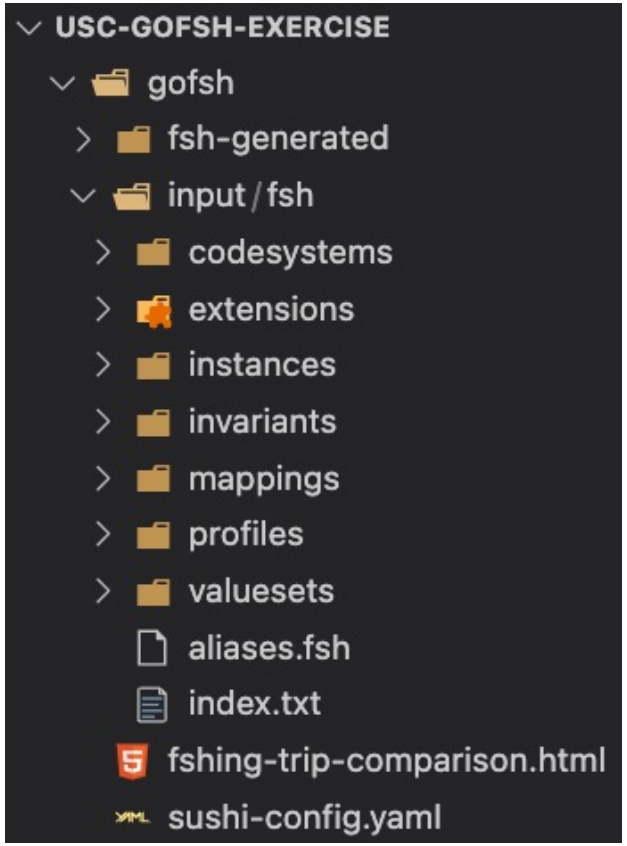
GoFSHing Tips

- GoFSH works best when provided clean input
  - Ideally, no (or few) errors in the IG's QA report
  - Preferably, from a downloaded package or IG /output folder
  - If possible, use packages that contain profiles' snapshots
  - If possible, avoid duplicate files and non-FHIR XML/JSON files
- GoFSH or SUSHI may find problems in the original source
- GoFSH is not perfect
  - Always review the generated FSH and final outputs
  - Consider optimizing FSH (e.g., reduce redundancy w/ RuleSets)

Exercise: GoFSH

GOAL: Convert US Core FHIR definitions to FHIR Shorthand

1. Download and unzip the US Core 5.0.1 package
2. Run GoFSH against the unzipped package
3. Run SUSHI against the resulting files in “gofsh”
4. Find and fix the errors in the FSH source code
   - Cannot override required binding with extensible binding
   - Incorrect slice paths in the social history profile



US Core 5.0.1 Package: https://bit.ly/**usc501-pkg**

Running GoFSH: https://bit.ly/**gofsh-run**

New treadmill – JLL S400 by CharmaineZoe, CC BY 2.0 via Flickr Cartoon Fish, public domain via FreeSVG.org

REVIEW

Tank you very much!

What You (Hopefully) Learned

- Back to the Basics
- Tools of the Trade: VS Code
- Tricks for Tackling Tediosity
- Slicing (without Losing a Finger)
- ~~Finvariants~~ Invariants
- Intensional Value Sets
- IG Configuration
- GoFSH
- Review

So long and thanks for all the FSH!

Bottlenose Dolphin, CC0 1.0 via Wikimedia Commons