FHIR 101 Refresher

April 28, 2021

Agenda & Structure

1. Introduction and house rules

2. Standardization topics

3. FHIR Basics – Recap + shallow dive
    1. Why FHIR, what is FHIR, resource types, data types, exchange methods, terminologies, search; Q&A
    2. Putting it all together – references, contained, bundles, documents
    3. How we make and extend FHIR ; Q&A
    4. FHIR community, tools, documentation

4. Q&A, Discussion, next activities

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Goals

- This presentation is a collection of freely available materials.
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- Our goal is to help / refresh navigation and discovery skills. The content used is not exhaustive, and aims to be broader in scope than deeper.
- We have little time, but we'll try to entertain questions – and we'll value your input for next sessions

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Before we start…

- **The most important outcome of this is that we collaborate, experiment and participate**
  - https://chat.fhir.org
  - http://community.fhir.org

- Coming events: DevDays 2021
  - https://www.devdays.com/june-2021/registration/

- ***Participants from Low and Lower Middle Income Countries***
  For those living in low and lower-middle-income countries, an opportunity to register at a discounted fee is available. The fee for those from Africa is $50 USD. The fee for other low and lower-middle-income countries is $100 USD (early bird before May 14, 2021) and $150 USD (regular after May 14, 2021).

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Notes on Standardization

digital square

Motivations for Standardization

- Be conformant to standard X
- Support internationalization
- Be compatible with solution Y
- Standardize the data
- Reduce complexity while supporting variety

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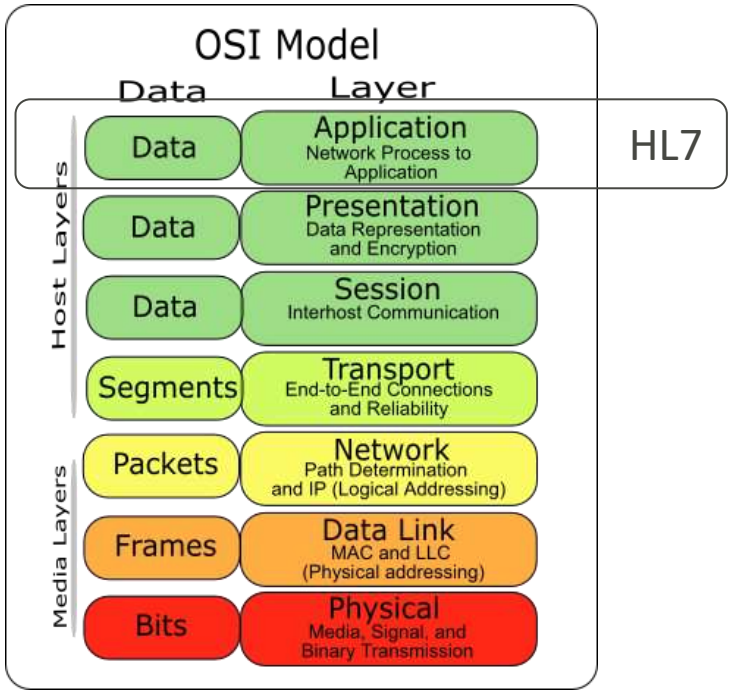
Situation: Levels / types of standards



	Why	How	What	Who	Where	When
Contextual	Goal List	Process List	Material List	Organisational Unit & Role List	Geographical Locations List	Event List
Conceptual	Goal Relationship	Process Model	Entity Relationship Model	Organisational Unit & Role Relationship Model	Locations Model	Event Model
Logical	Rules Diagram	Process Diagram	Data Model Diagram	Role Relationship Diagram	Locations Diagram	Event Diagram
Physical	Rules Specification	Process Function Specification	Data Entity Specification	Role Specification	Location Specification	Event Specification
Detailed	Rules Details	Process Details	Data Details	Role Details	Location Details	Event Details

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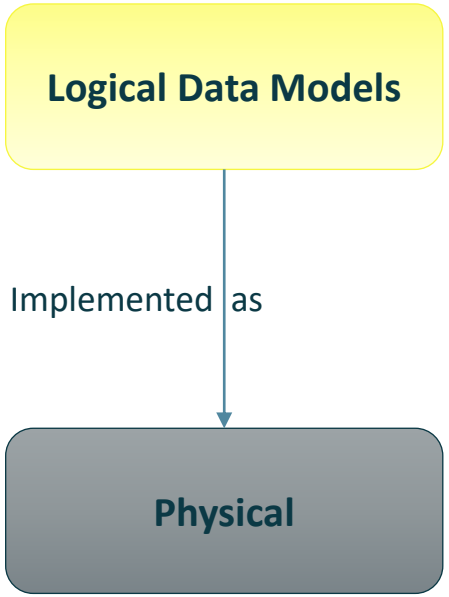
Information levels



How it is modelled

Descriptions of how the data is modelled, with entities, attribute, and notions of cardinality, relations, data types, etc.

How it is implemented

A data element in a file, e.g. Patient.name[0].given

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What is FHIR?

- Fast Healthcare Interoperability Resources

- A technical specification for data exchange
- Computable specification
- Relying on industry-standard technologies and formats (JSON, XML, REST…)
- Defines standard data objects (resources) which can be composed to form any type of communication – from reporting a blood pressure measurement, to querying for available inventory items…
- Addressing some of the challenges in standardisation
- Supported by a large community

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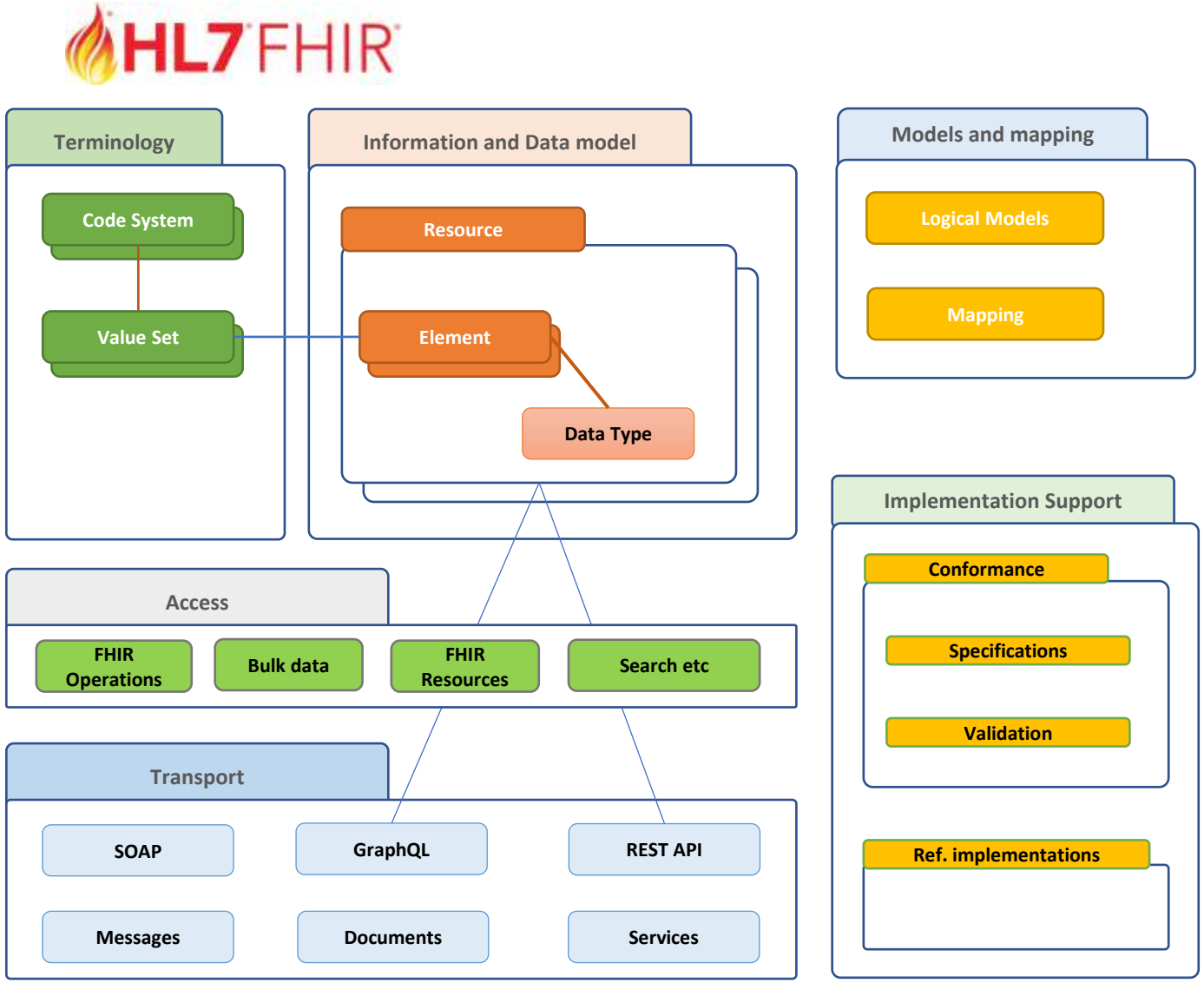
The HL7® FHIR® standard



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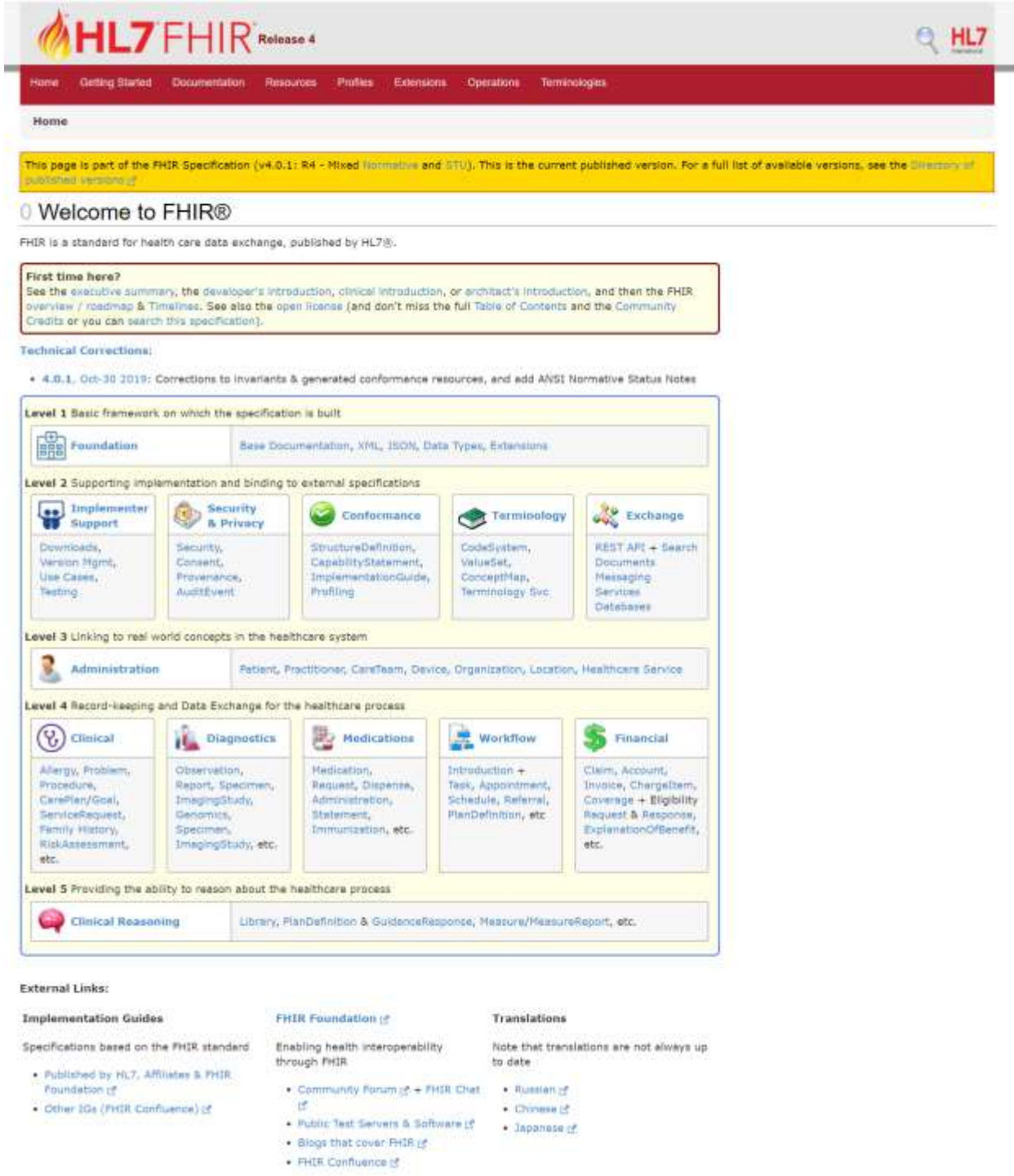
FHIR publication (always) online

http://hl7.org/fhir.org

http://build.fhir.org



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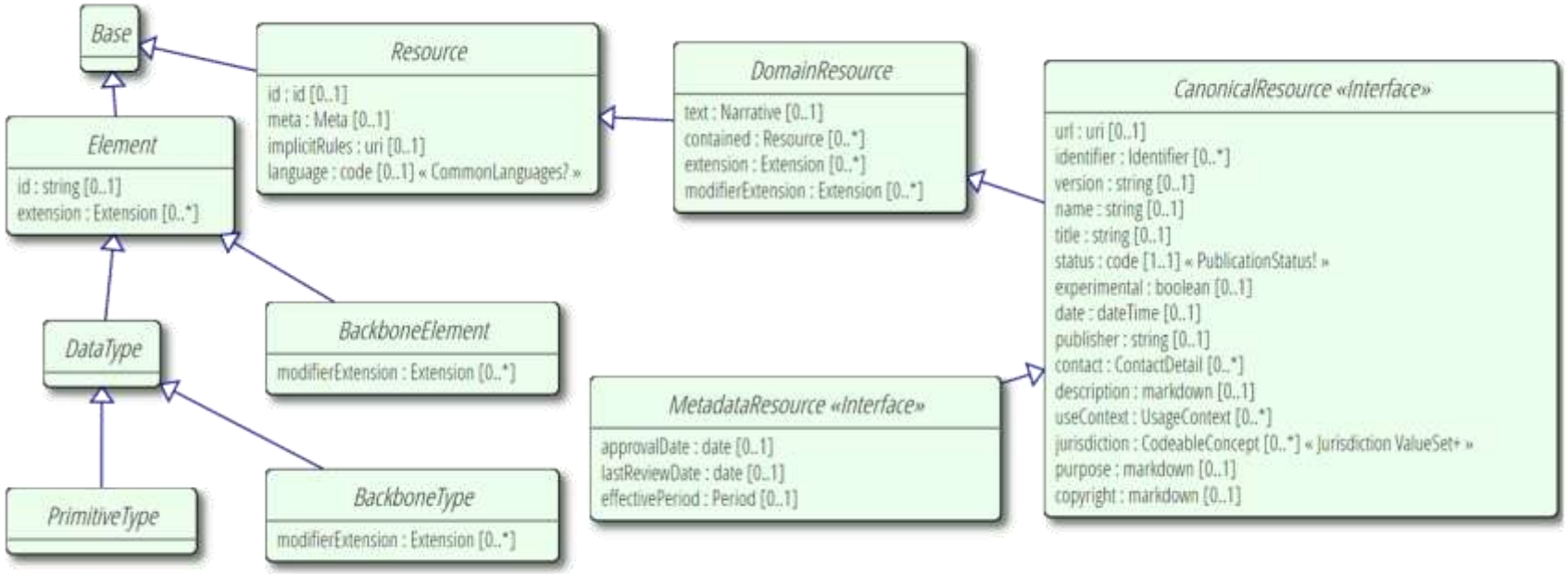
FHIR resource types



http://build.fhir.org/types.html

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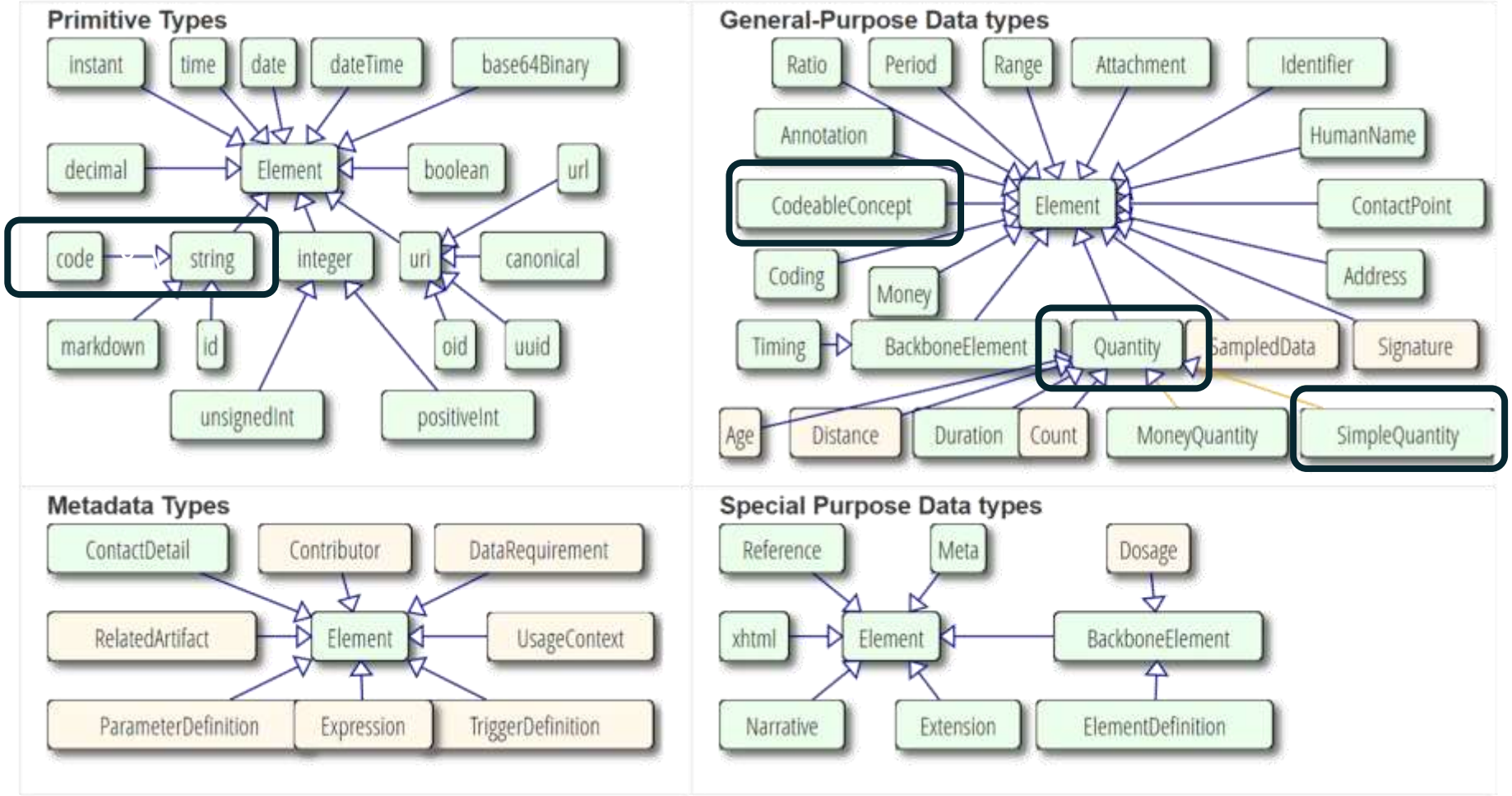
Data types



http://build.fhir.org/datatypes.html

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Primitive Types

FHIR Name	Value Domain	XML Representation	JSON representation
boolean	true | false Regex: `true|false`	xs:boolean, except that **0 and 1 are not valid values**	JSON boolean (true or false)
integer	A signed integer in the range −2,147,483,648..2,147,483,647 (32-bit; for larger values, use decimal) Regex: `[0]|[-+]?[1-9][0-9]*`	xs:int, except that **leading 0 digits are not allowed**	JSON number (with no decimal point)
string	A sequence of Unicode characters Note that strings SHALL NOT exceed 1MB (1024*1024 characters) in size. Strings SHOULD not contain Unicode character points below 32, except for u0009 (horizontal tab), u0010 (carriage return) and u0013 (line feed). Leading and Trailing whitespace is allowed, but SHOULD be removed when using the XML format. Note: This means that a string that consists only of whitespace could be trimmed to nothing, which would be treated as an invalid element value. Therefore strings SHOULD always contain non-whitespace content This data type can be bound to a ValueSet Regex: `[ \r\n\t\S]+` (see notes below)	xs:string	JSON String
decimal	Rational numbers that have a decimal representation. See below about the precision of the number Regex: `-?(0|[1-9][0-9]*)(\.[0-9]+)?([eE][+-]?[0-9]+)?`	union of xs:decimal and xs:double (see below for limitations)	A JSON number (see below for limitations)
uri	A Uniform Resource Identifier Reference (RFC 3986). Note: URIs are case sensitive. For UUID (urn:uuid:53fefa32-fcbb-4ff8-8a92-55ee120877b7) use all lowercase Regex: `\S*` (This regex is very permissive, but URIs must be valid. Implementers are welcome to use more specific regex statements for a URI in specific contexts) URIs can be absolute or relative, and may have an optional fragment identifier This data type can be bound to a ValueSet	xs:anyURI	A JSON string - a URI
url	A Uniform Resource Locator (RFC 1738). Note URLs are accessed directly using the specified protocol. Common URL protocols are `http(s):`, `ftp:`, `mailto:` and `mllp:`, though many others are defined	xs:anyURI	A JSON string - a URL
canonical	A URI that refers to a resource by its canonical URL (resources with a `url` property). The `canonical` type differs from a `uri` in that it has special meaning in this specification, and in that it may have a version appended, separated by a vertical bar (|). Note that the type `canonical` is not used for the actual canonical URLs that are the target of these references, but for the URIs that refer to them, and may have the version suffix in them. Like other URIs, elements of type `canonical` may also have #fragment references	xs:anyURI	A JSON string - a canonical URL
base64Binary	A stream of bytes, base64 encoded (RFC 4648) Regex: `(\s*([0-9a-zA-Z\+\=]){4}\s*)+` There is no specified upper limit to the size of a binary, but systems will have to impose some implementation based limit to the size they support. This should be clearly documented, though there is no computable for this at this time	xs:base64Binary	A JSON string - base64 content
instant	An instant in time in the format YYYY-MM-DDThh:mm:ss.sss+zz:zz (e.g. 2015-02-07T13:28:17.239+02:00 or 2017-01-01T00:00:00Z). The time SHALL specified at least to the second and SHALL include a time zone. Note: This is intended for when precisely observed times are required (typically system logs etc.), and not human-reported times - for those, use date or dateTime (which can be as precise as `instant`, but is not required to be). `instant` is a more constrained dateTime Note: This type is for system times, not human times (see date and dateTime below). Regex: `([0-9]([0-9]([0-9][1-9]|[1-9]0)|[1-9]00)|[1-9]000)-(0[1-9]|1[0-2])-(0[1-9]|[1-2][0-9]|3[0-1])T([01][0-9]|2[0-3]):[0-5][0-9]:([0-5][0-9]|60)(\.[0-9]+)?(Z|(\+|-)((0[0-9]|1[0-3]):[0-5][0-9]|14:00))`	xs:dateTime	A JSON string - an xs:dateTime
date	A date, or partial date (e.g. just year or year + month) as used in human communication. The format is YYYY, YYYY-MM, or YYYY-MM-DD, e.g. 2018, 1973-06, or 1905-08-23. **There SHALL be no time zone.** Dates SHALL be valid dates Regex: `([0-9]([0-9]([0-9][1-9]|[1-9]0)|[1-9]00)|[1-9]000)(-(0[1-9]|1[0-2])(-(0[1-9]|[1-2][0-9]|3[0-1]))?)?`	union of xs:date, xs:gYearMonth, xs:gYear	A JSON string - a union of xs:date, xs:gYearMonth, xs:gYear
dateTime	A date, date-time or partial date (e.g. just year or year + month) as used in human communication. The format is YYYY, YYYY-MM, YYYY-MM-DD or YYYY-MM-DDThh:mm:ss+zz:zz, e.g. 2018, 1973-06, 1905-08-23, 2015-02-07T13:28:17-05:00 or 2017-01-01T00:00:00.000Z. If hours and minutes are specified, a time zone SHALL be populated. Seconds must be provided due to schema type constraints but may be zero-filled and may be ignored at receiver discretion. Dates SHALL be valid dates. **The time "24:00" is not allowed**. Leap Seconds are allowed - see below Regex: `([0-9]([0-9]([0-9][1-9]|[1-9]0)|[1-9]00)|[1-9]000)(-(0[1-9]|1[0-2])(-(0[1-9]|[1-2][0-9]|3[0-1])(T([01][0-9]|2[0-3]):[0-5][0-9]:([0-5][0-9]|60)(\.[0-9]+)?(Z|(\+|-)((0[0-9]|1[0-3]):[0-5][0-9]|14:00)))?)?)?`	union of xs:dateTime, xs:date, xs:gYearMonth, xs:gYear	A JSON string - a union of xs:dateTime, xs:date, xs:gYearMonth, xs:gYear
time	A time during the day, in the format hh:mm:ss. There is no date specified. Seconds must be provided due to schema type constraints but may be zero-filled and may be ignored at receiver discretion. **The time "24:00" SHALL NOT be used. A time zone SHALL NOT be present.** Times can be converted to a Duration since midnight. Regex: `([01][0-9]|2[0-3]):[0-5][0-9]:([0-5][0-9]|60)(\.[0-9]+)?`	xs:time	A JSON string - an xs:time
code	Indicates that the value is taken from a set of controlled strings defined elsewhere (see Using codes for further discussion). Technically, a code is restricted to a string which has at least one character and no leading or trailing whitespace, and where there is no whitespace other than single spaces in the contents Regex: `[^\s]+(\s[^\s]+)*` This data type can be bound to a ValueSet	xs:token	JSON string
oid	An OID represented as a URI (RFC 3001); e.g. urn:oid:1.2.3.4.5 Regex: `urn:oid:[0-2](\.(0|[1-9][0-9]*))+`	xs:anyURI	JSON string - uri
id	Any combination of upper- or lower-case ASCII letters ('A'..'Z', and 'a'..'z', numerals ('0'..'9'), '-' and '.', with a length limit of 64 characters. (This might be an integer, an un-prefixed OID, UUID or any other identifier pattern that meets these constraints.) Regex: `[A-Za-z0-9\-\.]{1,64}`	xs:string	JSON string
markdown	A FHIR `string` (see above) that may contain markdown syntax for optional processing by a markdown presentation engine, in the GFM extension of CommonMark format (see below) Regex: `\s*(\S|\s)*` (can't put size limit in the regex - too large)	xs:string	JSON string
unsignedInt	Any non-negative integer in the range 0..2,147,483,647 Regex: `[0]|([1-9][0-9]*)`	xs:nonNegativeInteger	JSON number
positiveInt	Any positive integer in the range 1..2,147,483,647 Regex: `[1-9][0-9]*`	xs:positiveInteger	JSON number
uuid	A UUID (aka GUID) represented as a URI (RFC 4122); e.g. urn:uuid:c757873d-ec9a-4326-a141-556f43239520	xs:anyURI	JSON string - uri

- Can be further constrained

Data types in instances

```
{
  "resourceType" : "Patient",
  "id" : "43961584-bf55-4ddf-9462-a37465fe4440",
  "identifier" : [
    {
      "type" : {
        "coding" : [
          {
            "system" : "http://terminology.hl7.org/CodeSystem/v2-0203/",
            "code" : "MR",
            "display" : "Medical record number"
          }
        ]
      },
      "system" : "http://myhospital.org/identifiers/patients",
      "value" : "P0000001"
    }
  ],
  "name" : [
    {
      "family" : "Doe",
      "given" : [
        "John"
      ]
    }
  ],
  "gender" : "male",
  "birthDate" : "1971-04-28T00:20:00Z"
}
```

Name	Flags	Card.	Type	Description & Constraints
Identifier	Σ N		Element	An identifier intended for computation Elements defined in Ancestors: id, extension
use	?! Σ	0..1	code	usual | official | temp | secondary | old (If known) IdentifierUse (Required)
type	Σ	0..1	CodeableConcept	Description of identifier IdentifierType (Extensible)
system	Σ	0..1	uri	The namespace for the identifier value
value	Σ	0..1	string	The value that is unique
period	Σ	0..1	Period	Time period when id is/was valid for use
assigner	Σ	0..1	Reference(Organization)	Organization that issued id (may be just text)

Documentation for this format

Name	Flags	Card.	Type	Description & Constraints
CodeableConcept	Σ N		Element	Concept - reference to a terminology or just text Elements defined in Ancestors: id, extension
coding	Σ	0..*	Coding	Code defined by a terminology system
text	Σ	0..1	string	Plain text representation of the concept

Name	Flags	Card.	Type	Description & Constraints
Coding	Σ N		Element	A reference to a code defined by a terminology system Elements defined in Ancestors: id, extension
system	Σ	0..1	uri	Identity of the terminology system
version	Σ	0..1	string	Version of the system - if relevant
code	Σ	0..1	code	Symbol in syntax defined by the system
display	Σ	0..1	string	Representation defined by the system
userSelected	Σ	0..1	boolean	If this coding was chosen directly by the user

Name	Flags	Card.	Type	Description & Constraints
HumanName	Σ N		Element	Name of a human - parts and usage Elements defined in Ancestors: id, extension
use	?! Σ	0..1	code	usual | official | temp | nickname | anonymous | old | maiden NameUse (Required)
text	Σ	0..1	string	Text representation of the full name
family	Σ	0..1	string	Family name (often called 'Surname')
given	Σ	0..*	string	Given names (not always 'first'). Includes middle names This repeating element order: Given Names appear in the correct order for presenting the name
prefix	Σ	0..*	string	Parts that come before the name This repeating element order: Prefixes appear in the correct order for presenting the name
suffix	Σ	0..*	string	Parts that come after the name This repeating element order: Suffixes appear in the correct order for presenting the name
period	Σ	0..1	Period	Time period when name was/is in use

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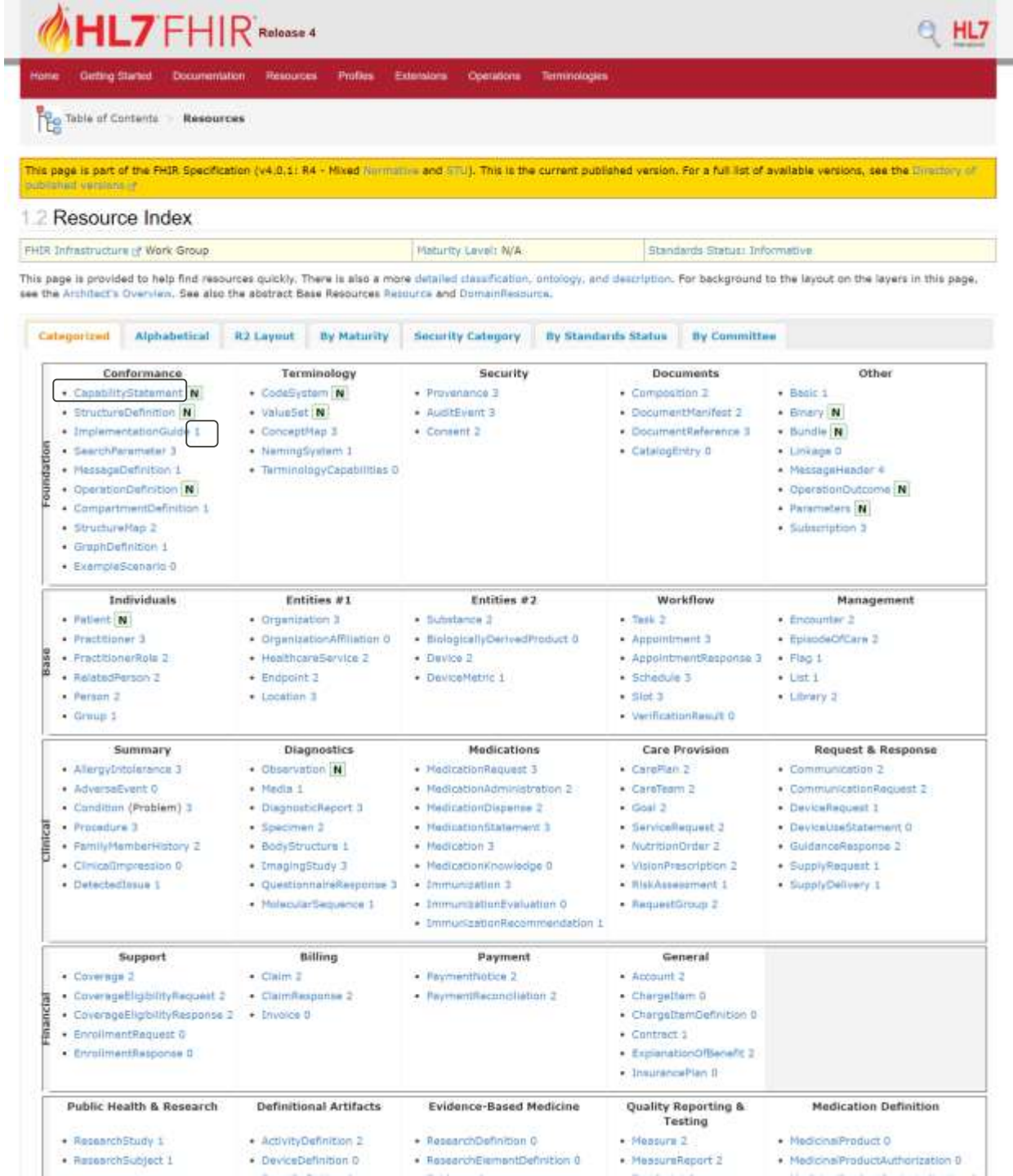
FHIR resource types

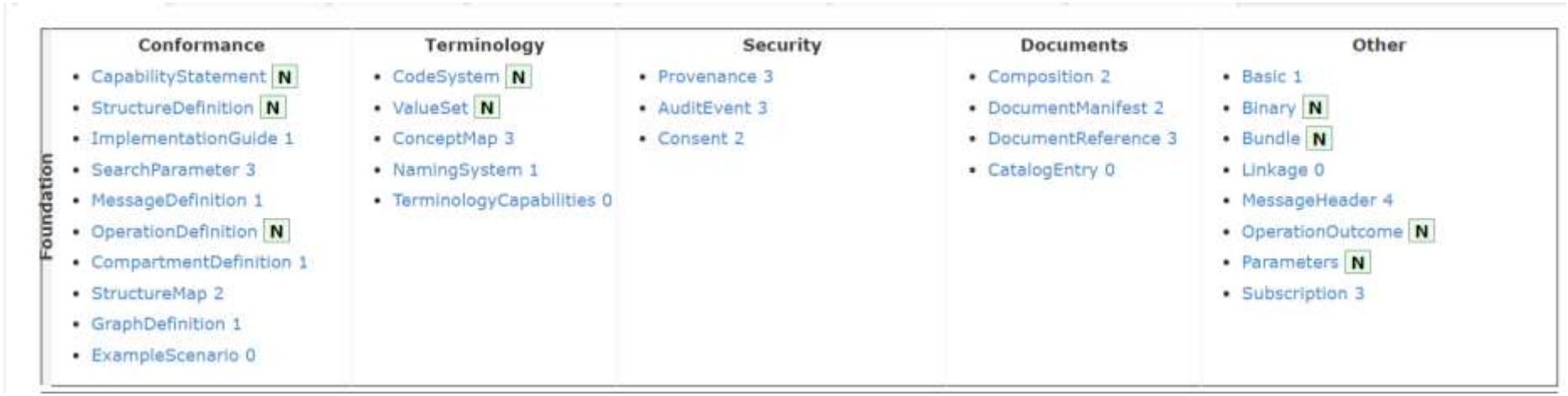
- Are defined computably
- Can be extended (like most other types)

http://hl7.org/fhir/resourcelist.html



FHIR “special” resource types

- Foundational resources: used to define fundamental aspects of FHIR (resources, maps, operations, capabilities)



http://hl7.org/fhir/resourcelist.html

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FHIR development process

- HL7 Working Groups continuously analyse needs and enhance the standard content – resources, guidance, etc.
- HL7 and FHIR community continuously improves the ecosystem and supports the adoption
- International and national working groups can do the same

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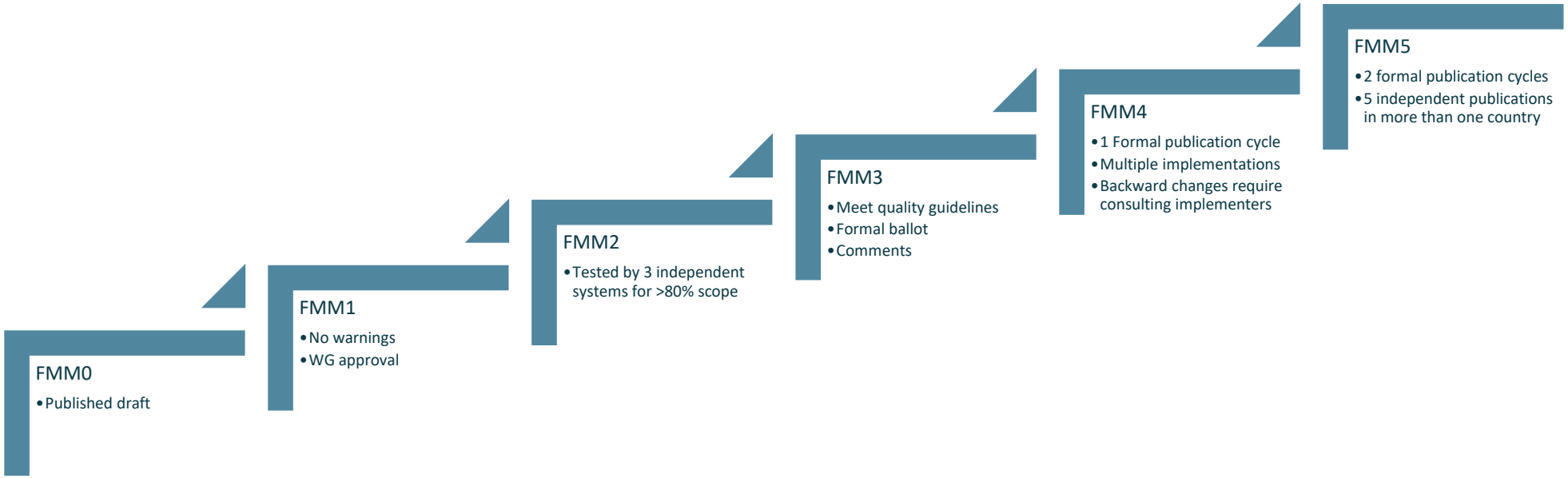
FHIR Maturity Levels

- **FHIR Resources (i.e. all conformance artifacts) have a FHIR Maturity Model (FMM) level**



- **Implementer feedback is welcome – and part of the process**

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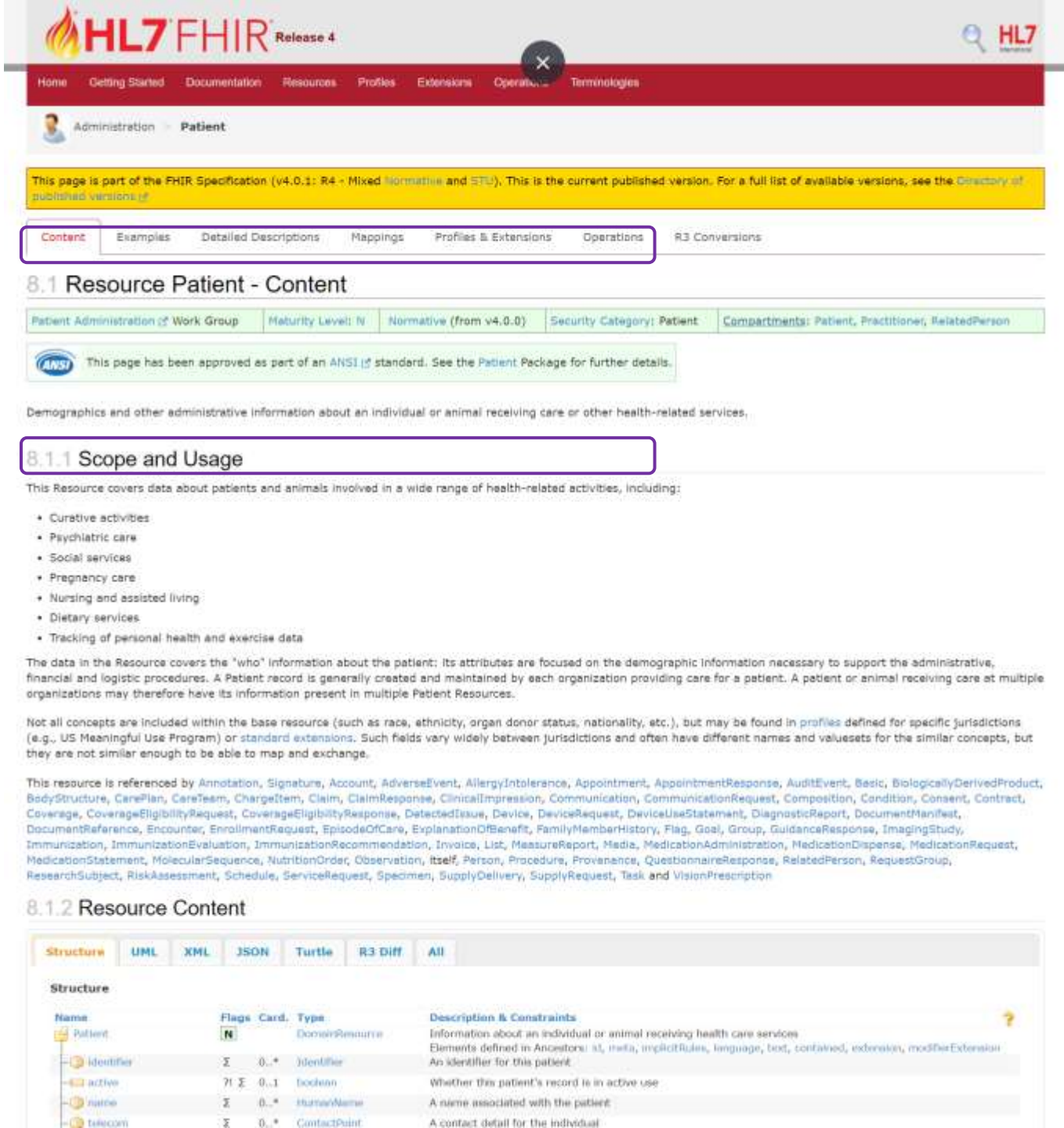
Patient resource

- Scope and usage

http://hl7.org/fhir/patient.html



Resource content

8.1.2 Resource Content

Structure | UML | XML | JSON | Turtle | R3 Diff | All

Structure

Name	Flags	Card.	Type	Description & Constraints
Patient	N		DomainResource	Information about an individual or animal receiving health care services Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extension, modifierExtension
identifier	Σ	0..*	Identifier	An identifier for this patient
active	?! Σ	0..1	boolean	Whether this patient's record is in active use
name	Σ	0..*	HumanName	A name associated with the patient
telecom	Σ	0..*	ContactPoint	A contact detail for the individual
gender	Σ	0..1	code	male | female | other | unknown AdministrativeGender (Required)
birthDate	Σ	0..1	date	The date of birth for the individual
deceased[x]	?! Σ	0..1		Indicates if the individual is deceased or not
deceasedBoolean			boolean	
deceasedDateTime			dateTime	
address	Σ	0..*	Address	An address for the individual
maritalStatus		0..1	CodeableConcept	Marital (civil) status of a patient MaritalStatus (Extensible)
multipleBirth[x]		0..1		Whether patient is part of a multiple birth
multipleBirthBoolean			boolean	
multipleBirthInteger			integer	
photo		0..*	Attachment	Image of the patient
contact	I	0..*	BackboneElement	A contact party (e.g. guardian, partner, friend) for the patient *+ Rule: SHALL at least contain a contact's details or a reference to an organization*
relationship		0..*	CodeableConcept	The kind of relationship Patient Contact Relationship (Extensible)
name		0..1	HumanName	A name associated with the contact person
telecom		0..*	ContactPoint	A contact detail for the person
address		0..1	Address	Address for the contact person
gender		0..1	code	male | female | other | unknown AdministrativeGender (Required)
organization	I	0..1	Reference(Organization)	Organization that is associated with the contact
period		0..1	Period	The period during which this contact person or organization is valid to be contacted relating to this patient
communication		0..*	BackboneElement	A language which may be used to communicate with the patient about his or her health
language		1..1	CodeableConcept	The language which can be used to communicate with the patient about his or her health Common Languages (Preferred but limited to AllLanguages)
preferred		0..1	boolean	Language preference indicator
generalPractitioner		0..*	Reference(Organization | Practitioner | PractitionerRole)	Patient's nominated primary care provider
managingOrganization	Σ	0..1	Reference(Organization)	Organization that is the custodian of the patient record
link	?! Σ	0..*	BackboneElement	Link to another patient resource that concerns the same actual person
other	Σ	1..1	Reference(Patient | RelatedPerson)	The other patient or related person resource that the link refers to
type	Σ	1..1	code	replaced-by | replaces | refer | seealso LinkType (Required)

Documentation for this format

See the Profiles & Extensions and the alternate definitions: Master Definition XML + JSON, XML Schema/Schematron + JSON Schema, ShEx (for Turtle) + see the extensions & the dependency analysis

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Terminology bindings & Constraints

- Some data types can have terminology bindings (with varying strength)
- Any elements can have (computable) constraints
  - Constraints are also inherited

See the Profiles & Extensions and the alternate definitions: Master Definition XML + JSON, XML Schema/Schematron + JSON Schema, ShEx (for Turtle) + see the extensions & the dependency analysis

8.1.2.1 Terminology Bindings

Path	Definition	Type	Reference
Patient.gender Patient.contact.gender	The gender of a person used for administrative purposes.	Required	AdministrativeGender
Patient.maritalStatus	The domestic partnership status of a person.	Extensible	Marital Status Codes
Patient.contact.relationship	The nature of the relationship between a patient and a contact person for that patient.	Extensible	PatientContactRelationship
Patient.communication.language	A human language.	Preferred, but limited to AllLanguages	CommonLanguages
Patient.link.type	The type of link between this patient resource and another patient resource.	Required	LinkType

8.1.2.2 Constraints

id	Level	Location	Description	Expression
pat-1	Rule	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()`

Notes:

- multipleBirth can be either expressed as a Boolean (just indicating whether the patient is part of a multiple birth) or as an integer, indicating the actual birth order.
- Patient records may only be in one of two statuses: in use (active=true) and not in use (active=false). A normal record is active, i.e. it is in use. Active is set to 'false' when a record is created as a duplicate or in error. A record does not need to be linked to be inactivated.
- The *link* element is used to assert that two or more Patient resources are both about the same actual patient. See below for further discussion
- There should be only one preferred language (Language.preference = true) per mode of expression.
- The Contact for a Patient has an element *organization*, this is for use with guardians or business related contacts where just the organization is relevant.

8.1.3 Patient ids and Patient resource ids

A Patient record's Resource Id can never change. For this reason, the identifiers with which humans are concerned (often called MRN - Medical Record Number, or UR - Unit Record) should not be used for the resource's id, since MRN's may change, i.e. as a result of having duplicate records of the same patient. Instead they should be represented in the *Patient.identifier* list where they can be managed. This is also useful for the case of institutions that have acquired multiple numbers because of mergers of patient record systems over time.

Where there is a need to implement an automated MRN Identifier created for a patient record, this could be achieved by providing an identifier in the patient with an appropriate assigner, MRN Type and/or system but with no value assigned. Internal business rules can then detect this and replace/populate this identifier with 1 or more identifiers (as required).

8.1.4 Linking Patients

The *link* element is used to assert that patient resources refer to the same patient. This element is used to support the following scenarios where multiple patient records exist:

8.1.4.1 Duplicate Patient records

Managing Patient registration is a well-known difficult problem. Around 2% of registrations are in error, mostly duplicate records. Sometimes the duplicate record is caught fairly quickly and retired before much data is accumulated. In other cases, substantial amounts of data may accumulate. By using a link of type 'replaced-by', the record containing such a link is marked as a duplicate and the link points forward to a record that should be used instead. Note that the record pointed to may in its turn have been identified as created in error and forward to yet another Patient resource. Records that replace another record may use a link type of 'replaces' pointing to the old record.

8.1.4.2 Patient record in a Patient index

A Patient record may be present in a system that acts as a Patient Index: it maintains a (summary of) patient data and a list of one or more servers that are known to hold a more comprehensive and/or authoritative record of the same patient. The link type 'refer' is used to denote such a link. Note that linked records may contain contradictory information. The record referred to does not point back to the referring record.

8.1.4.3 Distributed Patient record

In a distributed architecture, multiple systems keep separate patient records concerning the same patient. These records are not considered duplicates, but contain a distributed, potentially overlapping view of the patient's data. Each such record may have its own focus or maintaining organization and there need not be a sense of one record being more complete or more authoritative than another. In such cases, links of type 'see also' can be used to point to other patient records. It is not a requirement that such links are bilateral.

8.1.5 Patient vs. Person vs. Patient.Link vs. Linkage

The Person resource on the surface appears to be very similar to the Patient resource, and the usage for it is very similar to using the Patient.Link capability.
The intention of the Person resource is to be able to link instances of resources together that are believed to be the same individual. This includes across resource types, such as RelatedPerson, Practitioner, Patient and even other Person resources.
The Patient Link however is only intended to be used for Patient resources.

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Search parameters

8.1.12 Search Parameters

Search parameters for this resource. The common parameters also apply. See Searching for more information about searching in REST, messaging, and services.

Name	Type	Description	Expression	In Common
active TU	token	Whether the patient record is active	Patient.active	
address TU	string	A server defined search that may match any of the string fields in the Address, including line, city, district, state, country, postalCode, and/or text	Patient.address	3 Resources
address-city TU	string	A city specified in an address	Patient.address.city	3 Resources
address-country TU	string	A country specified in an address	Patient.address.country	3 Resources
address-postalcode TU	string	A postalCode specified in an address	Patient.address.postalCode	3 Resources
address-state TU	string	A state specified in an address	Patient.address.state	3 Resources
address-use TU	token	A use code specified in an address	Patient.address.use	3 Resources
birthdate TU	date	The patient's date of birth	Patient.birthDate	2 Resources
death-date TU	date	The date of death has been provided and satisfies this search value	(Patient.deceased as dateTime)	
deceased TU	token	This patient has been marked as deceased, or as a death date entered	Patient.deceased.exists() and Patient.deceased != false	
email TU	token	A value in an email contact	Patient.telecom.where(system='email')	4 Resources
family TU	string	A portion of the family name of the patient	Patient.name.family	1 Resources
gender TU	token	Gender of the patient	Patient.gender	3 Resources
general-practitioner TU	reference	Patient's nominated general practitioner, not the organization that manages the record	Patient.generalPractitioner (Practitioner, Organization, PractitionerRole)	
given TU	string	A portion of the given name of the patient	Patient.name.given	1 Resources
identifier TU	token	A patient identifier	Patient.identifier	
language TU	token	Language code (irrespective of use value)	Patient.communication.language	
link TU	reference	All patients linked to the given patient	Patient.link.other (Patient, RelatedPerson)	
name TU	string	A server defined search that may match any of the string fields in the HumanName, including family, give, prefix, suffix, suffix, and/or text	Patient.name	
organization TU	reference	The organization that is the custodian of the patient record	Patient.managingOrganization (Organization)	
phone TU	token	A value in a phone contact	Patient.telecom.where(system='phone')	4 Resources
phonetic TU	string	A portion of either family or given name using some kind of phonetic matching algorithm	Patient.name	3 Resources
telecom TU	token	The value in any kind of telecom details of the patient	Patient.telecom	4 Resources

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Resource instance


```
{
  "resourceType" : "Patient",
  "id" : "43961584",
  "meta" : {
    "versionId" : "1",
    "lastUpdated" : "2020-09-11T13:48:11.266Z"
  },
  "text" : {
    "status" : "generated",
    "div" : "<div xmlns=\"http://www.w3.org/1999/xhtml\"><p><b>Generated Narrative with Details</b></p><p><b>id</b>:
1</p><p><b>identifier</b>: Medical record number = P0000001</p><p><b>name</b>: John Doe </p><p><b>gender</b>: other</p><p><b>birthDate</b>:
28/04/1971 0:20:00 AM</p></div>"
  },
  "identifier" : [
    {
      "type" : {
        "coding" : [
          {
            "system" : "http://terminology.hl7.org/CodeSystem/v2-0203/",
            "code" : "MR",
            "display" : "Medical record number"
          }
        ]
      },
      "system" : "http://myhospital.org/identifiers/patients",
      "value" : "P0000001"
    }
  ],
  "name" : [
    {
      "family" : "Doe",
      "given" : [
        "John"
      ]
    }
  ],
  "gender" : "male",
  "birthDate" : "1971-04-28T00:20:00Z"
}
```

FHIR Search

- FHIR servers can support search using GET or POST
- Search possibilities can be configured for individual systems
- Search can include additional resources, or limit the data…

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FHIR Search

- Search works as a filter:
  - GET /Patient – all patients
  - GET /Patient?_id=180252 – only the patient with that ID
  - GET /Patient?identifier=http://hl7.org/fhir/sid/us-mbi|0000-000-0000
  - GET/Patient?birthdate=lt2010-10-01

- **A resource can be searched by its search parameters**
- **A server can be searched across resources**

https://www.hl7.org/fhir/search.html

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Search parameters

In the simplest case, a search is executed by performing a `GET` operation in the RESTful framework:

```
GET [base]/[type]?name=value&...{&_format=[mime-type]}
```

For this RESTful search (see definition in RESTful API), the parameters are a series of name=[value] pairs encoded in the URL or as an application/x-www-form-urlencoded submission for a POST:

```
POST [base]/[type]/_search{?[parameters]{&_format=[mime-type]}}
```

Search Parameter Types	Parameters for all resources	Search result parameters

Number
Date/DateTime
String
Token
Reference
Composite
Quantity
URI
Special
	`_id`
	`_lastUpdated`
	`_tag`
	`_profile`
	`_security`
	`_text`
	`_content`
	`_list`
	`_has`
	`_type`
		`_sort`
		`_count`
		`_include`
		`_revinclude`
		`_summary`
		`_total`
		`_elements`
		`_contained`
		`_containedType`

In addition, there is a special search parameters `_query` and `_filter` that allow for an alternative method of searching, and the parameters `_format` and `_pretty` defined for all interactions.

Structure

Name	Flags	Card.	Type	Description & Constraints
Practitioner	TU		DomainResource	A person with a formal responsibility in the provisioning of healthcare or related services Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extension, modifierExtension
identifier	Σ	0..*	Identifier	An identifier for the person as this agent
active	Σ	0..1	boolean	Whether this practitioner's record is in active use
name	Σ	0..*	HumanName	The name(s) associated with the practitioner
telecom	Σ	0..*	ContactPoint	A contact detail for the practitioner (that apply to all roles)
address	Σ	0..*	Address	Address(es) of the practitioner that are not role specific (typically home address)
gender	Σ	0..1	code	male | female | other | unknown AdministrativeGender (Required)
birthDate	Σ	0..1	date	The date on which the practitioner was born
photo		0..*	Attachment	Image of the person
qualification		0..*	BackboneElement	Certification, licenses, or training pertaining to the provision of care
identifier		0..*	Identifier	An identifier for this qualification for the practitioner
code		1..1	CodeableConcept	Coded representation of the qualification v2 table 0360, Version 2.7 (Example)
period		0..1	Period	Period during which the qualification is valid
issuer		0..1	Reference(Organization)	Organization that regulates and issues the qualification
communication		0..*	CodeableConcept	A language the practitioner can use in patient communication Common Languages (Preferred but limited to AllLanguages)

Documentation for this format

See the Profiles & Extensions and the alternate definitions: Master Definition XML + JSON, XML Schema/Schematron + JSON Schema, ShEx (for Turtle) + see the extensions & the dependency analysis

8.4.4.1 Terminology Bindings

Path	Definition	Type	Reference
Practitioner.gender	The gender of a person used for administrative purposes.	Required	AdministrativeGender
Practitioner.qualification.code	Specific qualification the practitioner has to provide a service.	Example	v2.0360.2.7
Practitioner.communication	A human language.	Preferred, but limited to AllLanguages	CommonLanguages

8.4.5 Notes:

- The practitioner's Qualifications are acquired by the practitioner independent of any organization or role, and do not imply that they are allowed/authorized to perform roles relevant to the qualification at any specific Organization/Location.

8.4.6 Search Parameters

Search parameters for this resource. The common parameters also apply. See Searching for more information about searching in REST, messaging, and services.

Name	Type	Description	Expression	In Common
active	token	Whether the practitioner record is active	Practitioner.active	
address	string	A server defined search that may match any of the string fields in the Address, including line, city, district, state, country, postalCode, and/or text	Practitioner.address	3 Resources
address-city	string	A city specified in an address	Practitioner.address.city	3 Resources
address-country	string	A country specified in an address	Practitioner.address.country	3 Resources
address-postalcode	string	A postalCode specified in an address	Practitioner.address.postalCode	3 Resources

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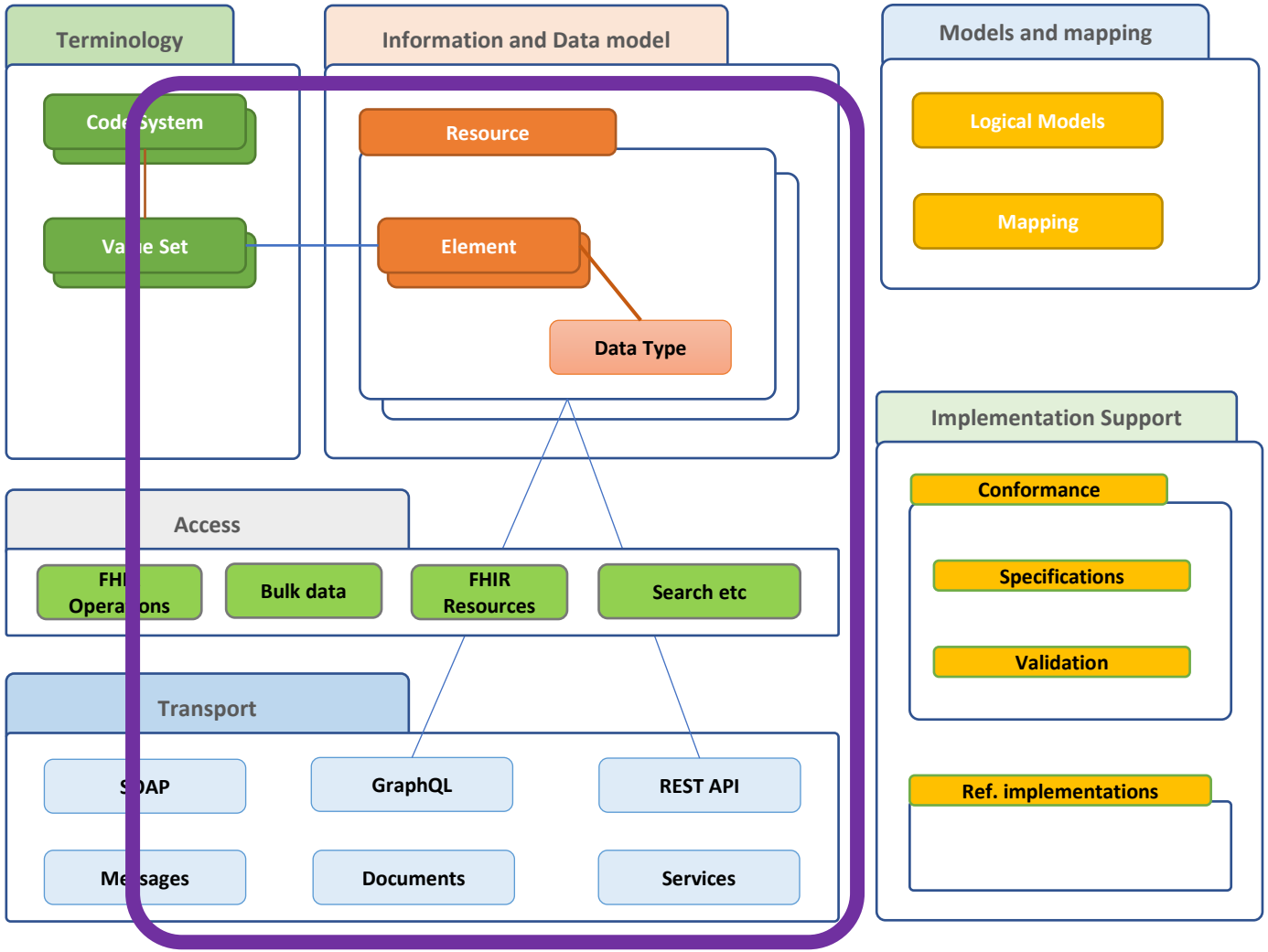
FHIR & terminologies



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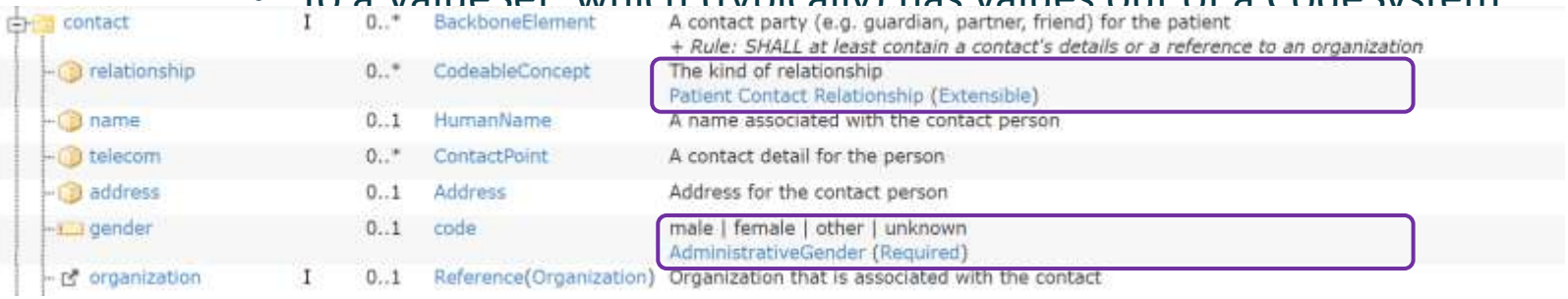
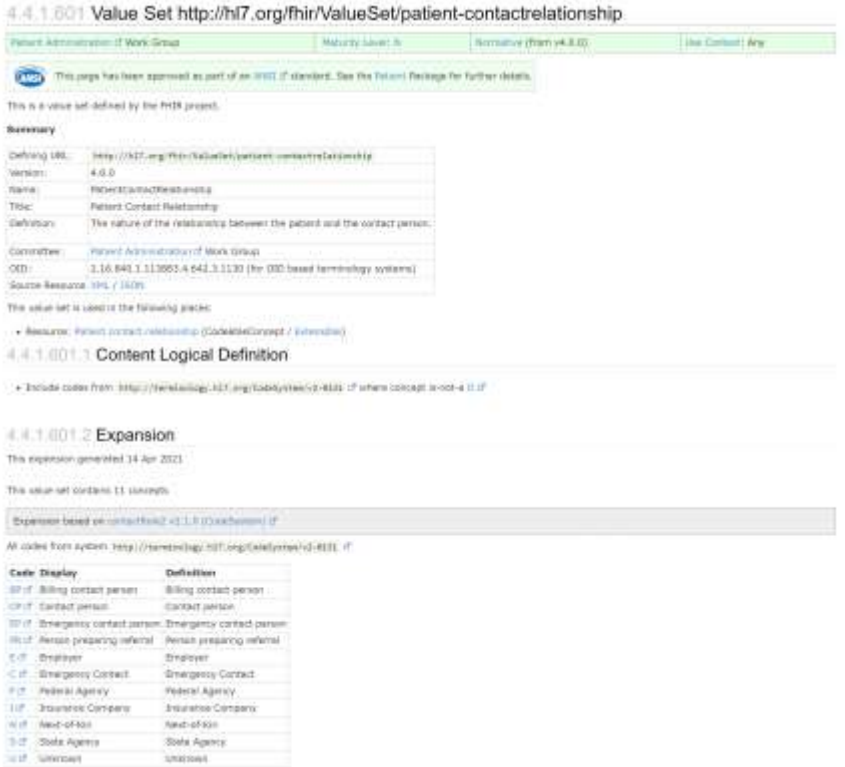
FHIR use of terminology

- Some data elements have a terminology binding (of a specified strength)
  - To a ValueSet, which (typically) has values out of a CodeSystem





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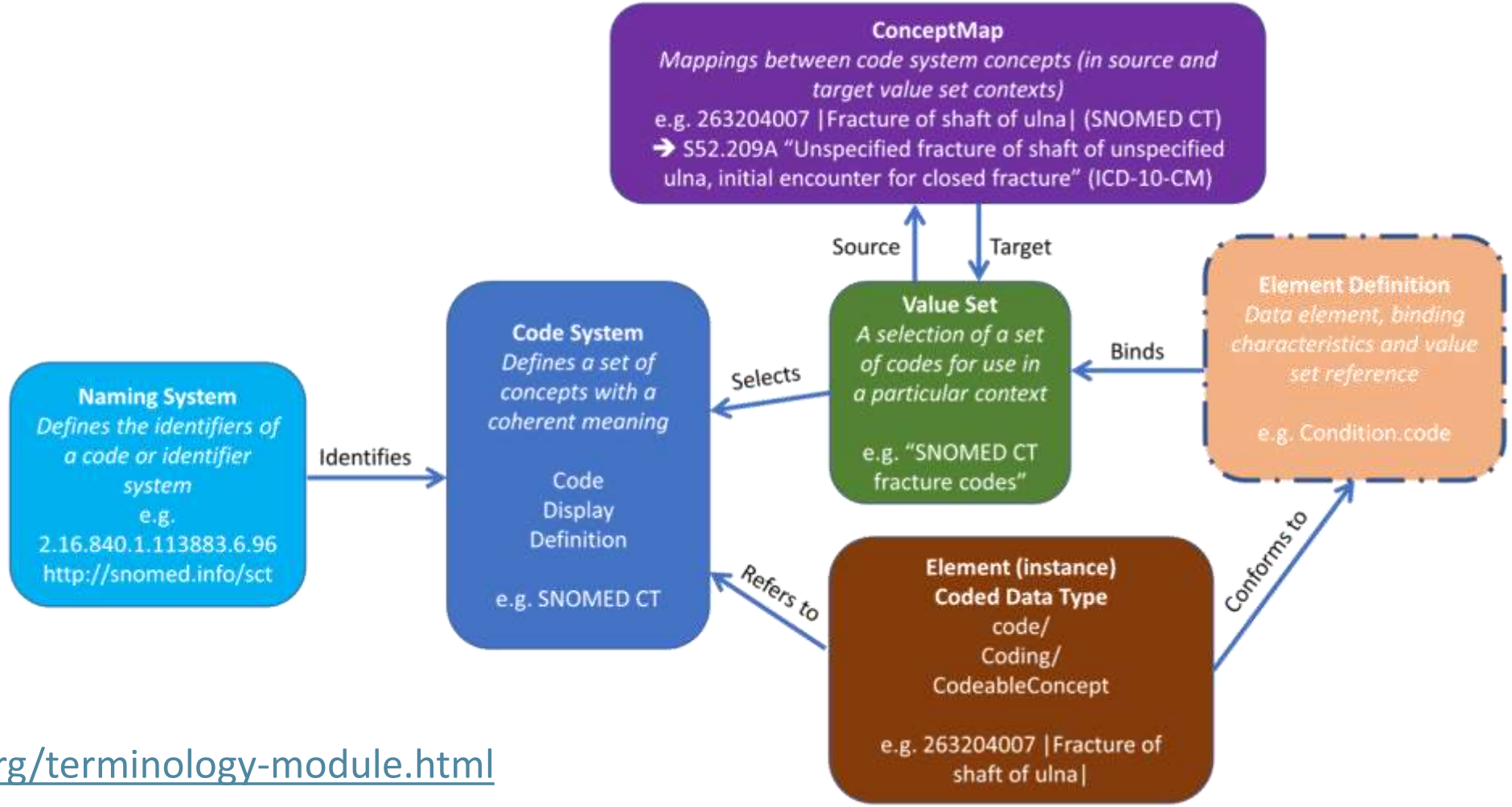

http://build.fhir.org/terminology-module.html

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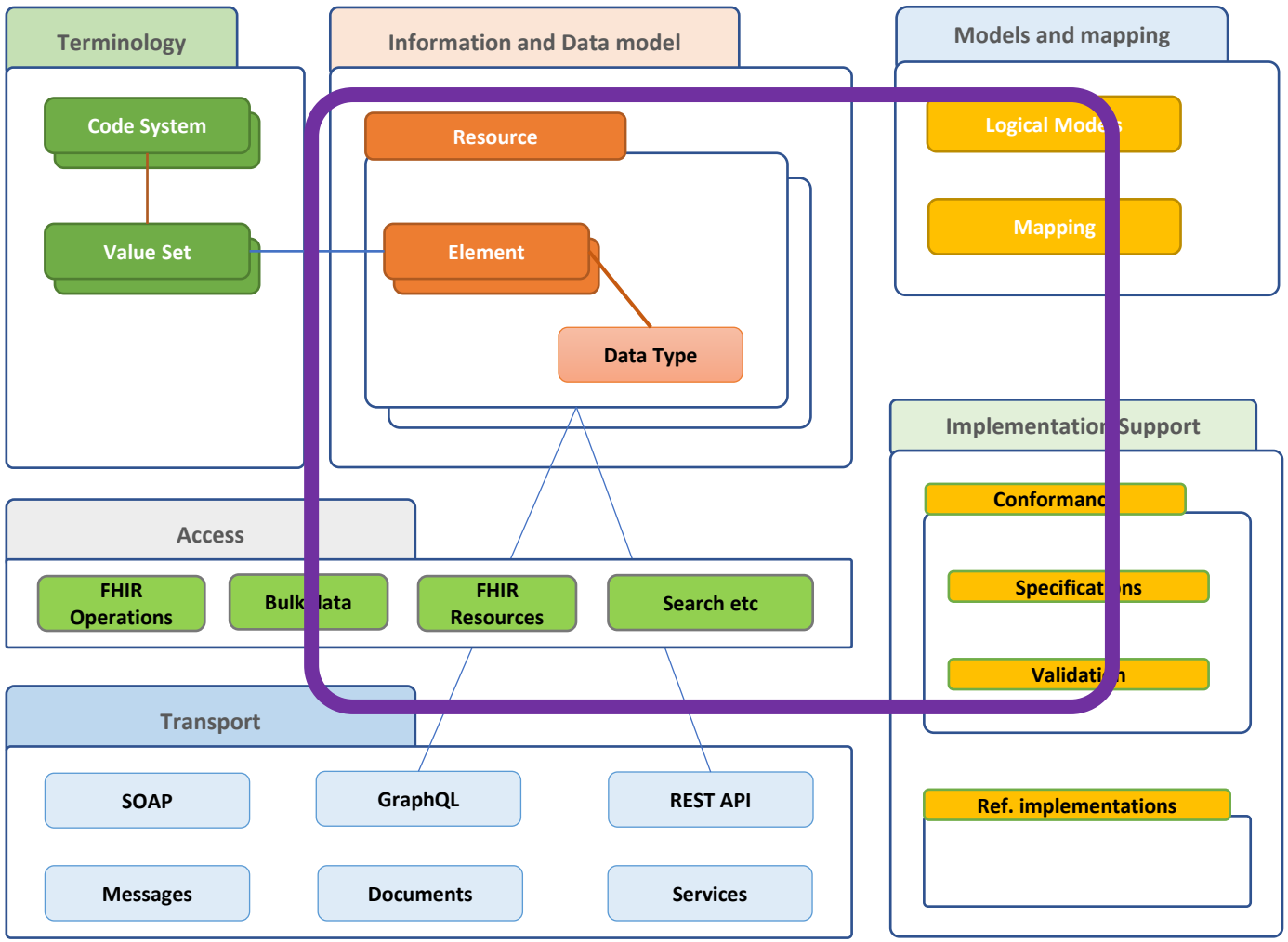
Q&A

Putting FHIR together



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Resource References

A Resource is normally the atomic exchange unit. Resources relate to each other.

subject	Σ	1..1	Reference(Patient | Group)
encounter		0..1	Reference(Encounter)
supportingInformation		0..*	Reference(Any)
authoredOn	Σ	0..1	dateTime
requester	Σ	0..1	Reference(Practitioner | PractitionerRole | Organization | Patient | RelatedPerson | Device)
performer		0..1	Reference(Practitioner | PractitionerRole | Organization | Patient | Device | RelatedPerson | CareTeam | HealthcareService)

Name	Flags	Card.	Type	Description & Constraints
Reference	Σ N		Element	A reference from one resource to another + *Rule: SHALL have a contained resource if a local reference is provided* Elements defined in Ancestors: id, extension
reference	Σ I	0..1	string	Literal reference, Relative, internal or absolute URL
type	Σ	0..1	uri	Type the reference refers to (e.g. "Patient") ResourceType (Extensible)
identifier	Σ	0..1	Identifier	Logical reference, when literal reference is not known
display	Σ	0..1	string	Text alternative for the resource

2.3.0.2 Literal References

The `reference` is the key element - resources are identified and addressed by their URL. It contains a URL that is either

- an absolute URL
- a relative URL, which is relative to the Service Base URL, or, if processing a resource from a bundle, which is relative to the base URL implied by the `Bundle.entry.fullUrl` (see Resolving References in Bundles)
- an internal fragment reference (see "Contained Resources" below)

A relative reference to the Patient "034AB16" in an element named `subject` on a FHIR RESTful server:

```
<subject>
  <reference value="Patient/034AB16" />
</subject>
```

An absolute reference to a Structure Definition in an element named `profile`:

```
{
  "profile" : {
    "reference" : "http://fhir.hl7.org/svc/StructureDefinition/c8973a22-2b5b-4e76-9c66-00639c99e61b"
  }
}
```

2.3.0.3 Logical References

In many contexts where FHIR is used, applications building a resource may know an identifier for the target of the reference, but there is no way for the application to convert this to a literal reference that directly references an actual resource. This situation may arise for several reasons:

- There is no server exposing any such resource. This is often the case with national identifiers (e.g. US SSN or NPI), and such identifiers are widely used
- The server that exposes the resource is not available to the source application, so it has no way to resolve an identifier to a reference
- The application is not in a RESTful environment - it is creating a message or a document

For further discussion of the use of identifiers on resources, see Consistent Resource Identification. In these cases, the source application may provide the identifier as a logical reference to the entity that the target resource would describe.

A logical reference to the Patient with an SSN of 000111111:

```
<patient>
  <identifier>
    <system value="http://hl7.org/fhir/sid/us-ssn" />
    <value value="000111111" />
  </identifier>
</patient>
```

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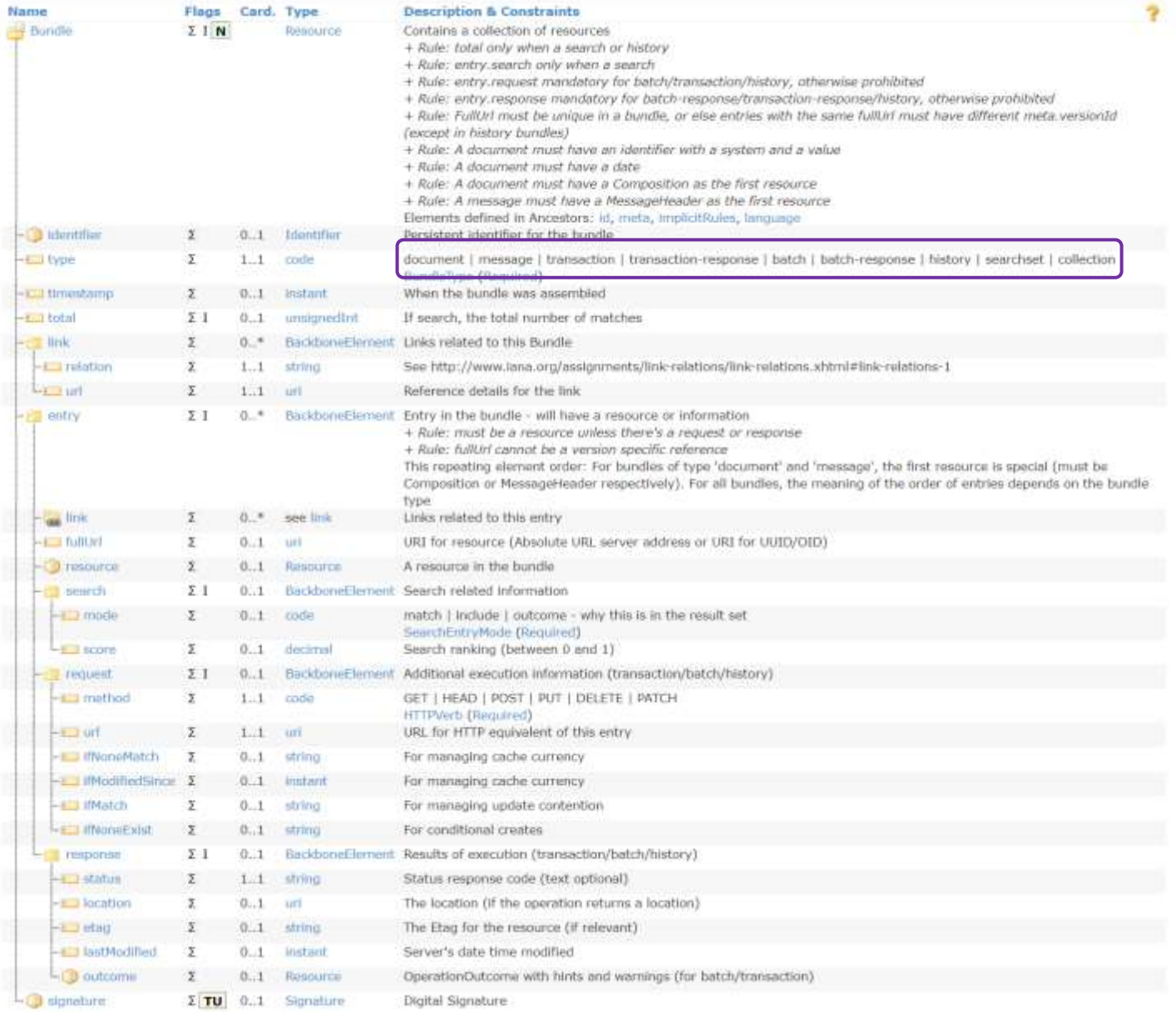
Bundle

- Used to contain and group resources
- Different bundle types
- Others resources for grouping only:
  - List
  - Composition
  - (Group)



Name	Flags	Card.	Type	Description & Constraints
Bundle	Σ I N		Resource	Contains a collection of resources + Rule: total only when a search or history + Rule: entry.search only when a search + Rule: entry.request mandatory for batch/transaction/history, otherwise prohibited + Rule: entry.response mandatory for batch-response/transaction-response/history, otherwise prohibited + Rule: FullUrl must be unique in a bundle, or else entries with the same fullUrl must have different meta.versionId (except in history bundles) + Rule: A document must have an identifier with a system and a value + Rule: A document must have a date + Rule: A document must have a Composition as the first resource + Rule: A message must have a MessageHeader as the first resource Elements defined in Ancestors: id, meta, implicitRules, language
identifier	Σ	0..1	Identifier	Persistent identifier for the bundle
type	Σ	1..1	code	document | message | transaction | transaction-response | batch | batch-response | history | searchset | collection BundleType (Required)
timestamp	Σ	0..1	instant	When the bundle was assembled
total	Σ I	0..1	unsignedInt	If search, the total number of matches
link	Σ	0..*	BackboneElement	Links related to this Bundle
relation	Σ	1..1	string	See http://www.iana.org/assignments/link-relations/link-relations.xhtml#link-relations-1
url	Σ	1..1	url	Reference details for the link
entry	Σ I	0..*	BackboneElement	Entry in the bundle - will have a resource or information + Rule: must be a resource unless there's a request or response + Rule: fullUrl cannot be a version specific reference This repeating element order: For bundles of type 'document' and 'message', the first resource is special (must be Composition or MessageHeader respectively). For all bundles, the meaning of the order of entries depends on the bundle type
link	Σ	0..*	see link	Links related to this entry
fullUrl	Σ	0..1	url	URI for resource (Absolute URL server address or URI for UUID/OID)
resource	Σ	0..1	Resource	A resource in the bundle
search	Σ I	0..1	BackboneElement	Search related information
mode	Σ	0..1	code	match | include | outcome - why this is in the result set SearchEntryMode (Required)
score	Σ	0..1	decimal	Search ranking (between 0 and 1)
request	Σ I	0..1	BackboneElement	Additional execution information (transaction/batch/history)
method	Σ	1..1	code	GET | HEAD | POST | PUT | DELETE | PATCH HTTPVerb (Required)
url	Σ	1..1	url	URL for HTTP equivalent of this entry
ifNoneMatch	Σ	0..1	string	For managing cache currency
ifModifiedSince	Σ	0..1	instant	For managing cache currency
ifMatch	Σ	0..1	string	For managing update contention
ifNoneExist	Σ	0..1	string	For conditional creates
response	Σ I	0..1	BackboneElement	Results of execution (transaction/batch/history)
status	Σ	1..1	string	Status response code (text optional)
location	Σ	0..1	url	The location (if the operation returns a location)
etag	Σ	0..1	string	The Etag for the resource (if relevant)
lastModified	Σ	0..1	instant	Server's date time modified
outcome	Σ	0..1	Resource	OperationOutcome with hints and warnings (for batch/transaction)
signature	Σ TU	0..1	Signature	Digital Signature

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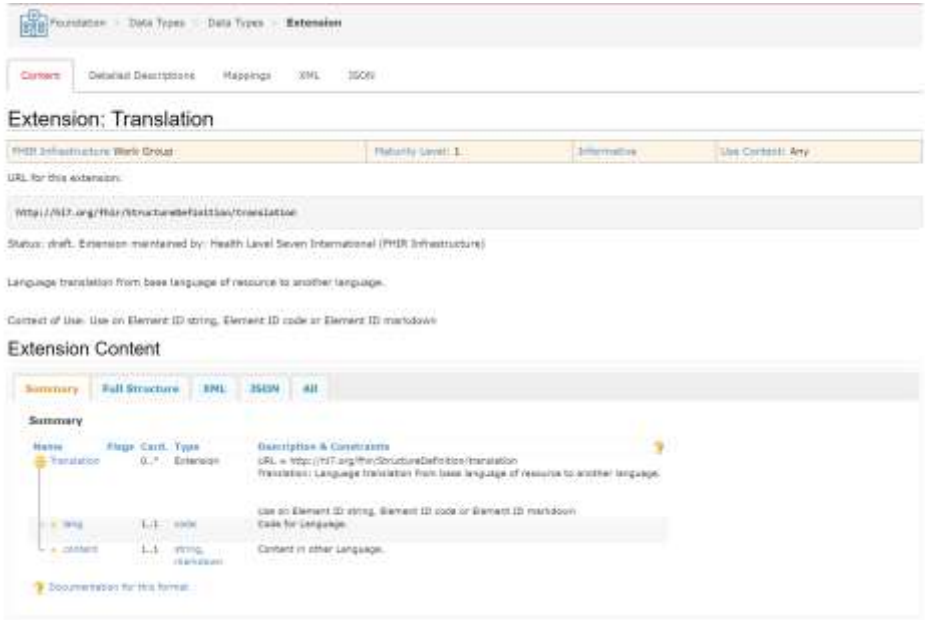
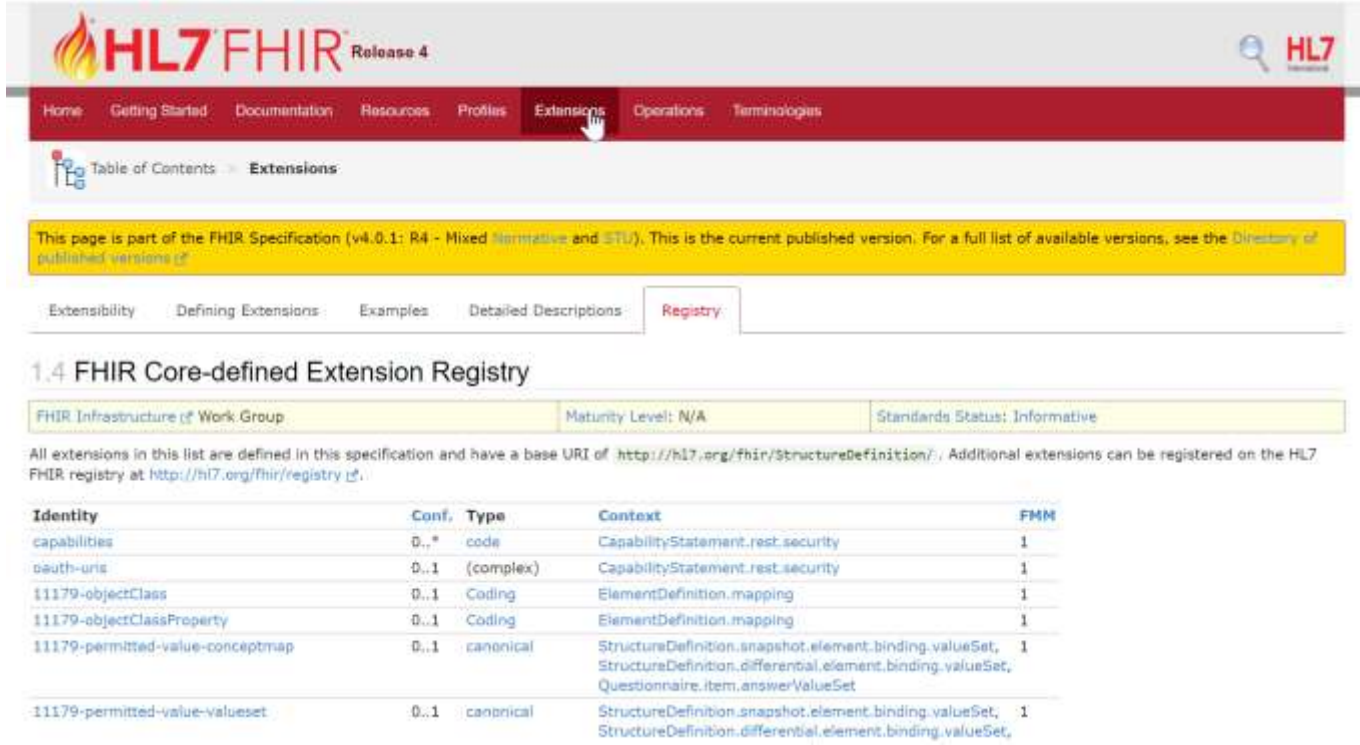
FHIR extensions

- The way to add elements to a structure while keeping conformant
- Extensions are also defined using FHIR
- FHIR does provide some standard extensions: where the data element is not very common, but where there's utility in having a common way to express it





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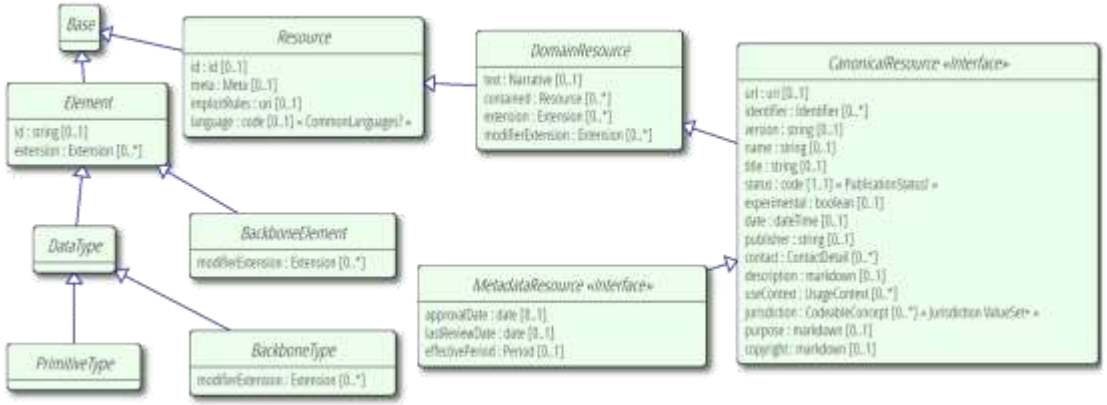
Contained resources, extensions

- Resources can contain other resources



Most anything in FHIR can be extended

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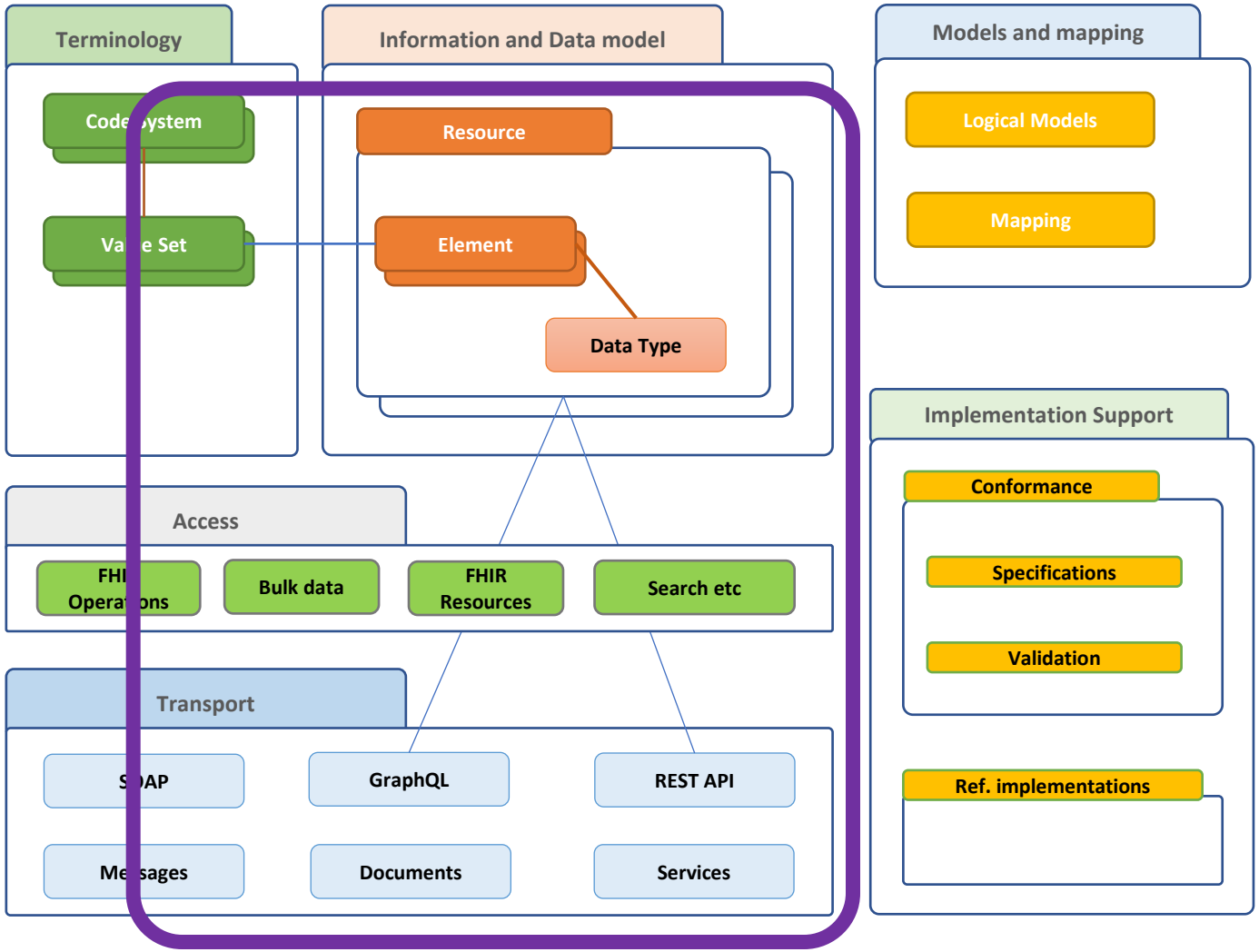
```
{
  "resourceType" : "Patient",
  "id" : "43961584-bf55-4ddf-9462-a37465fe4440",
  "contained" : [
       {
         "resourceType": "Organization",
         "id": "123",
         "identifier": [
           {
             "system": "urn:ietf:rfc:3986",
             "value": "urn:oid:2.16.840.1.113883.19.5"
           }
         ],
         "name": "Good Health Clinic"
       }
  ],
  "extension" : [
    {
      "url" : "http://hl7.org/fhir/StructureDefinition/patient-birthPlace",
      "valueAddress" : {
        "city" : "Muenchen",
        "country" : "Germany"
      }
    }
  ],
  "identifier" : [
    {
      "type" : {
        "coding" : [
          {
            "system" : "http://terminology.hl7.org/CodeSystem/v2-0203/",
            "code" : "MR",
            "display" : "Medical record number"
          }
        ]
      },
      "system" : "http://myhospital.org/identifiers/patients",
      "value" : "P0000001"
    }
  ],
  "name" : [
    {
      "family" : "Doe",
      "given" : [ "John" ]
    }
  ],
  "gender" : "male",
  "birthDate" : "1971-04-28T00:20:00Z"
}
```

FHIR data exchange



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Exchange paradigms

- FHIR supports 4 paradigms
  - RESTful API hl7.org/fhir/http.html
  - Documents (like CDA) hl7.org/fhir/documents.html
  - Services (SOA techniques) hl7.org/fhir/services.html
  - Messages hl7.org/fhir/messaging.html

http://www.healthintersections.com.au

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REST

- Most common approach

- GET (the “read” verb)
  - GET a single resource: GET Patient/43961584
  - GET a set of resources GET Patient (?...)
  - Response is a resource (a Patient, or a Bundle, or an OperationOutcome)
- POST (create)
- PUT (update)
- DELETE (delete)

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Example

```
(GET) http://test.fhir.org/r4/Patient/43961584/_history/4?_format=json
```

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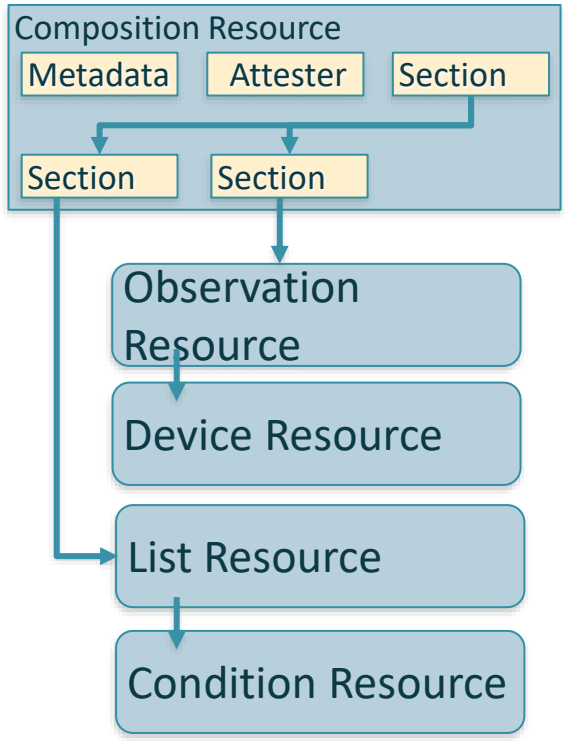
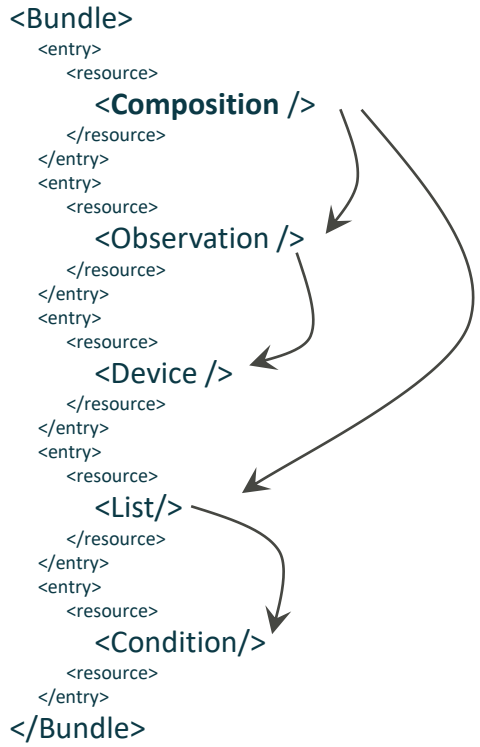
Documents

- A Bundle with
  - Type = document
  - 1st Entry is a Composition
  - N entries referenced by Composition
  - Signature and Provenance

- Used for
  - Persistence
  - Stewardship
  - Authentication
  - Context
  - Integrity
  - Human Readability





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Reg. U.S. TM Office.

http://build.fhir.org/documents

FHIR Subscriptions

- Potentially interesting for “listening” to events

  - SubscriptionTopic resources
    - Define the **data** and **change** used to trigger notifications
    - Define the filters allowed to clients
  - Subscription resources
    - Describe a client's request to be notified about events defined in a `SubscriptionTopic`
    - Set filters on events (as defined in the referenced `SubscriptionTopic`)
    - Describe the channel and endpoint used to send notifications
    - Describe the payload included in notifications (MIME type, content level, etc.)
  - subscription-notification Bundles
    - Describe a notification (using a SubscriptionStatus)
    - Contain zero or more notification payloads

http://build.fhir.org/subscriptions

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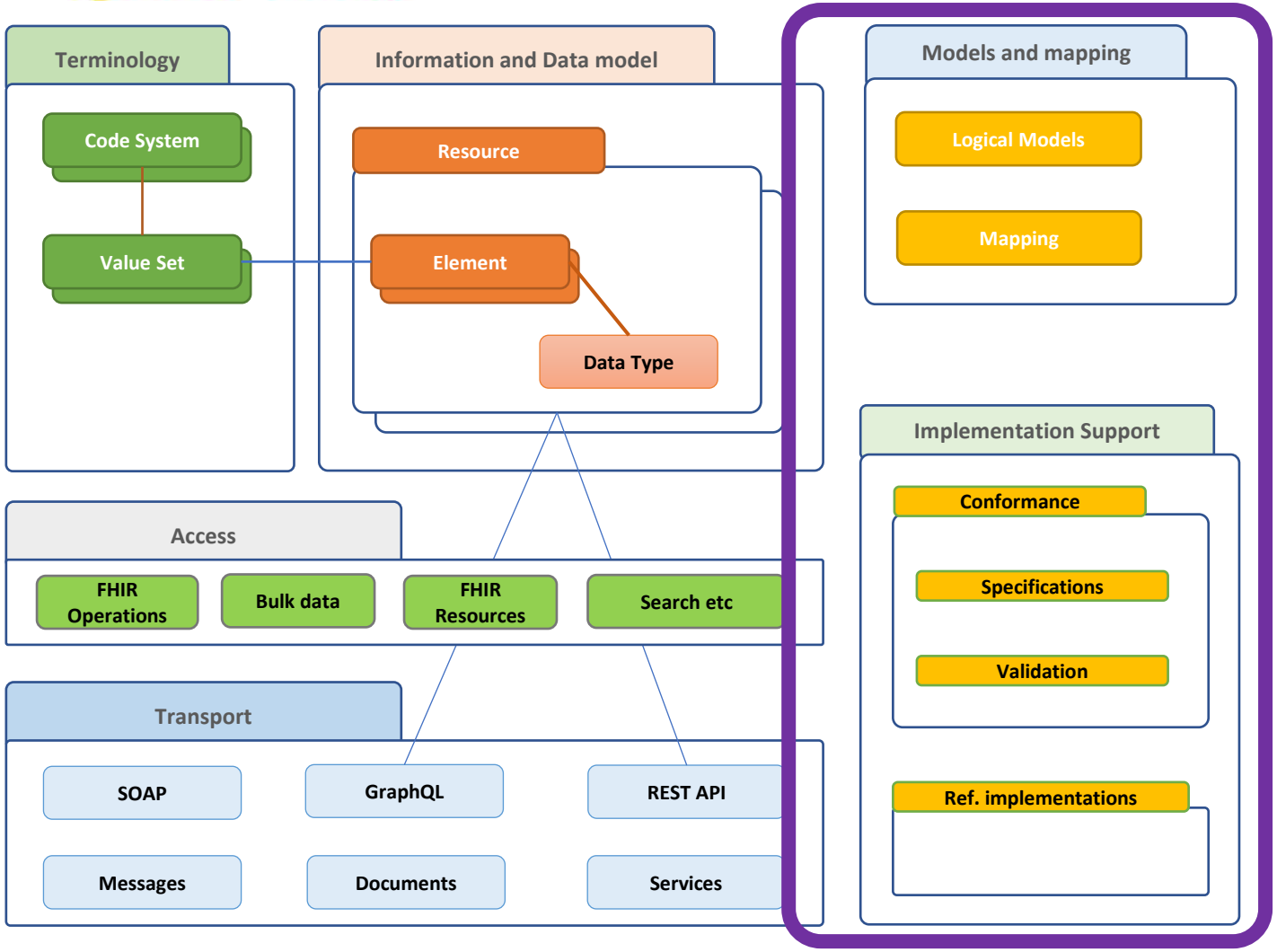
Q&A

FHIR Implementation



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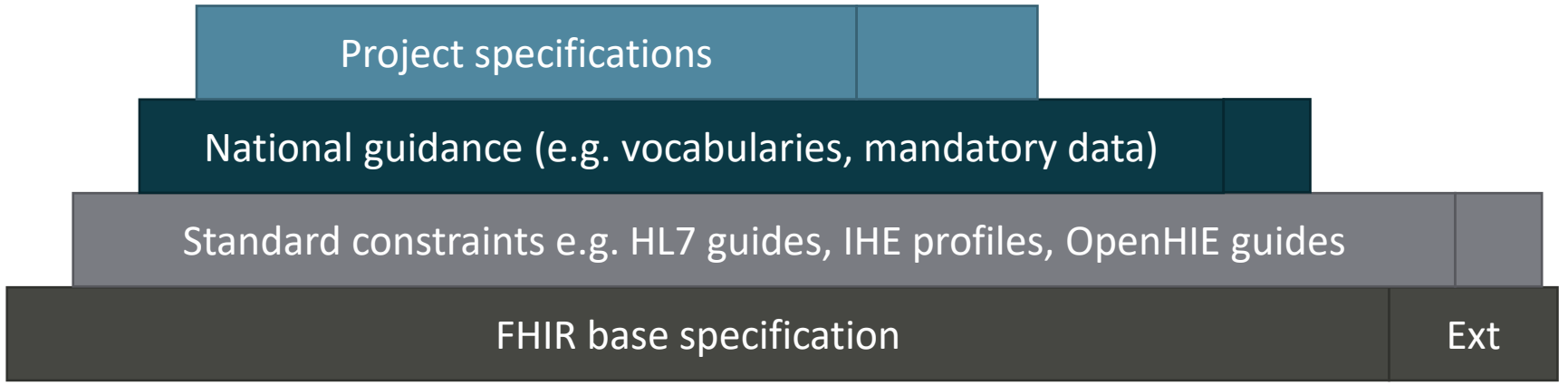
Using FHIR in an implementation

- Will be subject of a dedicated intro session
- There can be different levels – look for already existing guidance (or help build it)
- A FHIR specification can add constraints and extensions to the specification it depends on



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Constraining FHIR

- Cardinalities can be further reduced
- Vocabulary bindings can be further reduced
- Slices can be created

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FHIR Tools

- FHIR servers
  - Readily available:
    - http://test.fhir.org/r4
    - http://hapi.fhir.org/

- Reference implementations (servers and clients on several technology platforms)

  https://confluence.hl7.org/display/FHIR/Open+Source+Implementations

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Get in touch, be active

- Check with others (at chat.fhir.org or community.fhir.org)
- Create (or ask someone to create) a change request
- Join a FHIR event like DevDays (devdays.com), discuss
- Join a FHIR connectathon, test and provide feedback

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Feedback, Q&A, Discussion

Next sessions

Upcoming sessions

- **FHIR profiling & documentation: May 26th**
  - In this webinar we'll explore the basics for creating and documenting a FHIR® specification for a project, a country, or an individual application. We'll see how the FHIR® specification can be extended and constrained to support specific needs. After identifying what is contained in a FHIR® specification, we'll see how such specifications are documented, and how this is done in a good way to accelerate delivery through validation, testing, and automation. We'll remember some of the basic FHIR® features around localization and multi-language which become more important when implementing FHIR® profiles.

- **FHIR and Terminology: Jun 30th**
  - This session will introduce the FHIR® support for terminologies: Standard (global) terminologies like SNOMED CT, LOINC, or local terminologies (for example national codes) vs project-specific terminologies. We'll look at the FHIR® resources for terminologies, how they are used in the other FHIR® resources, and how to define new terminology resources, as well as how to localize the value sets. We'll also take a quick look at the basic FHIR® terminology operations and provide some pointers to additional resources and terminology servers.

- **FHIR Implementation Guide / Advanced Usage: Jul 28th**
  - The culmination of this foundational series will be a practical workshop-like session, with an example for anyone that wishes to create their first FHIR® specification publication. We will use the open-source tools (we will provide installation instructions beforehand) and we'll guide you through the creation of a publication of an Implementation Guide in the most fundamental aspects: Setting up a (shared) repository, adding FHIR® conformance resources (e.g. profiles, extensions, value sets), importing dependencies from other specifications, adding narrative text and diagrams, and using a shorthand language to accelerate the work. At the end, you will be able to find the published content on your machine, ready for sharing - or you can use the community continuous delivery tools to share the result online directly from your repository.

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