



FHIR Starter: Architecture

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Good morning. I've wanted to visit Russia since my grade 9 teacher tried to organize a trip. (Grade 9 was a LONG time ago...) That trip never happened, so my thanks to Pavel and Nicolai for finally giving me a chance to see a small piece of your beautiful country in person.

Who am I?



- Name: Lloyd McKenzie
- Company: Gevity
- Background:
 - One of FHIR's 3 initial editors
 - Co-chair FMG, FHIR-I and MnM
 - HL7 Fellow
 - Heavily involved in HL7 and healthcare exchange for last 19 years
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My name is Lloyd McKenzie. I'm an employee in a company called Gevity that does healthcare interoperability consulting in Canada, the US, Europe and Asia and now, at least a little bit I guess, in Russia ☺

I've been working with HL7 for 19 years now and have lots of experience with HL7 v2, v3, CDA and now FHIR. I spend about 1/3 of my work time and most of my spare time doing volunteer work with FHIR, including supporting the community. And most of my day job is working with FHIR too, so – like Grahame – I'm pretty much “all FHIR, all the time...”

This presentation



- Can be downloaded here:
 - <https://github.com/FHIR/documents/blob/master/presentations/2018-06%20Russia/FHIR%20Architecture.pptx>
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Learning Objectives



■ You should be able to:

- List FHIR's interoperability paradigms and describe some of the pros and cons of each
- Identify some of the architectural considerations associated with FHIR
- Understand a little bit about FHIR profiling

This morning I'd like to talk to you about some of the architectural decisions involved when you implement FHIR. I will talk about some of the questions you should be asking. Because we won't have a lot of time I can't spend too much time on how to figure out the answers. However, the nice thing about FHIR is that there's lots of free stuff available.

Paradigms

- FHIR supports 3 main interoperability paradigms



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Let's start with paradigms.

Once you've figured out what resources the data you care about maps to, your first architectural decision will be what “communication paradigm” you want to support. FHIR supports 3 primary communication paradigms, plus some other options. The main paradigms are REST, Documents and Messaging.

REST



- Simple, out-of-the-box interoperability
- Leverage HTTP: GET, POST, etc.
- Pre-defined operations
 - Create, Read, Update, Delete
 - Also: Read Version, Search (resource/type/server), History (resource/type/server), Capabilities, Patch, Batch & Transaction



REST is the most popular. It requires the least negotiation. It handles simple cases easily. It's fast and light-weight. It builds on standard web technology. With FHIR, it can handle batch and transactional behavior too.

FHIR REST



Pros

- Easy to use
- Builds on the HTTP Stack
- Fast and light-weight
- Minimal negotiation required

Cons

- No context about what's happening
- Requires client-server architecture
- Requires identity at the resource level

However, REST has drawbacks. Among them: It doesn't give you context about what's happening. For example, "All of this information is because I'm admitting a patient". It requires that each record have persistent identity and that there be a clear client and server in the exchange.

Documents



- Similar to CDA
- Collection of resources bound together
 - Root is a “Composition” resource
 - Just like CDA header
- Sent as a Bundle resource
- One context
- Can be signed, authenticated, etc.



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Documents in FHIR work like HL7 CDA, though they don't have to be patient-specific. You collect a set of resources together that share a common context. For example, a pathology report, a discharge summary, a referral letter, etc.



FHIR Documents

Pros

- Familiar paradigm to clinicians
- Expectation is all data retained
- Tight control over display

Cons

- More overhead to share data
- No ability to initiate workflow
- More negotiation required

Documents are intended to be persisted “as is”. They also have tight rules on how the information in them should be displayed to users. Documents don’t drive workflow though. When someone reads a document, they don’t immediately start counting pills or picking up a scalpel. Documents also require more negotiation as you need to agree on codes for the type of document and what resources should be inside it.

Messages



- Similar to v2 and v3 messaging
- Also a collection of resources as a Bundle resource
- Allows request/response behavior with bundles for both request and response
- Event-driven
 - E.g. Send lab order, get back result
- Can be asynchronous and/or indirect



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Messaging is the most traditional of paradigms. HL7 has been doing messaging for over 30 years. In response to some real-world event – a status change, someone pushing a button, etc. – a Bundle of resources is transmitted from a sending system to a receiving system. The receiver of the bundle might then send a message back in response.

FHIR Messaging



Pros

- Most familiar paradigm for legacy implementers
- Supports complex workflows
- Can be asynchronous or routed

Cons

- More overhead
- Lots of negotiation required

Messages can be asynchronous and they can be routed. But they also require the greatest amount of negotiation. Not only do you need to standardize the event codes and content of the message, you also need to standardize what messages are allowed to be returned in response – and their events and content.

Other



- FHIR can be used for interoperability in other ways too
 - REST-like remote procedure calls
 - Payload in SOAP messages
 - Persistence model for shared database interface
 - ...
- Only requirement is that data complies with one of the FHIR syntaxes and the FHIR semantics



Other architectural approaches include using FHIR's "operations" which let you do remote procedure calls over REST, writing and querying resources from a shared persistence model, sending FHIR over traditional pipelines like SOAP or SMTP, etc.



Combining paradigms

- No requirement for a system to only support one paradigm
 - E.g. hospital may be primarily messaging, but use documents for discharge summaries and reports and expose registries and appointments via REST with a few custom services for decision support or specialized workflow
- Data (generally) shared easily across paradigm boundaries

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One of the important things with FHIR is that you can choose the paradigm that fits your use-case. You can receive data over one paradigm and send it over a different paradigm. So information might come in as a message, then get passed to decision support using REST and later packaged into a document as a discharge summary. The structure of the data – the schema and the content - remains the same regardless of how you share it.



And the architecture decisions that go with them

FHIR FEATURES

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I'm next going to give you an overview of some of the features in FHIR that might drive some of your implementation considerations – and give you a list of some things to think about. This is just to give you a sampling of what things you might want to drill a little deeper into.

Narrative



```
<text>
  <status value="generated"/>
  <div xmlns="http://www.w3.org/1999/xhtml">

    <h3>CBC Report for Wile. E. COYOTE (MRN: 23453) issued 3-Mar 2011 11:45</h3>

    <pre>
      Test          Units   Value   Reference Range
      Haemoglobin  g/L     176     135 - 180
      Red Cell Count x10*12/L 5.9     4.2 - 6.0
      Haematocrit        0.55+   0.38 - 0.52
      Mean Cell Volume   fL     99+    80 - 98
      Mean Cell Haemoglobin pg    36+    27 - 35
      Platelet Count     x10*9/L 444    150 - 450
      White Cell Count   x10*9/L 4.6    4.0 - 11.0
    </pre>
    <p>Acme Laboratory, Inc signed: Dr Pete Pathologist</p>
  </div>
</text>
```



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FHIR Narrative is an HTML rendering of the important clinical or business information in the resource for human viewing.

The inclusion of Narrative in almost all FHIR resources is a lesson we took from CDA. While our objective with FHIR is computable interoperability – sharing healthcare data in a way that lets computers understand it, it turns out that having human readability as a fallback is really useful. The reason is that not all systems that receive a FHIR instance are likely to support exactly the same data elements and extensions. Systems might get updated at different times. Data might propagate from one system to another to another or be stored and not looked at for a decade. At some point, a system is going to look at the data and not understand all of it. Being able to display all of the “important” information to a human user is therefore important.

Narrative isn't mandatory, but if you're storing data that might be shared at some point in the future, populating narrative is a really good idea.

Narrative Considerations



- Should narrative be generated or human-entered?
- What should be included and how should it be formatted?
- When should you display narrative?

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There are several things to consider in your design with respect to narrative:

Will you generate the narrative from discrete data or allow a human to enter it. For something like a pathology report or perhaps a simple care plan, all you might have is narrated text

If you generate the narrative, what should be in it? What should appear first? How should it be formatted? What information do users want to see and what would be ‘noise’ to them?

If you receive narrative, when should the user see it? We have a flag that indicates whether the narrative was generated that can help with this.

Extensions



```
<Patient>
  <extension url="http://acme.org/fhir/StructureDefinition/trial-status" >
    <extension url="code" >
      | <valueCode value="unsure" />
    </extension>
    <extension url="date" >
      | <valueDate value="2009-03-14" />
    </extension>
    <extension url="registrar" >
      | <valueReference>
        | <reference value="Practitioner/example" />
      </valueReference>
    </extension>
  </extension>
  <!-- other data for patient -->
</Patient>
```

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The next thing I want to talk to you about is extensions.

Extensions are an essential part of FHIR. In FHIR, we only include elements in the core specification if we believe most implementers throughout the world will support that element. However, every country, medical discipline and organization will have “extra” data. In the Netherlands, they have an address part for “boat across the street from”. In Saudi Arabia, they record birth date in both the Gregorian and the Hijri calendars. In Canada, when we capture your health card number, we also capture the version number on the card. All these elements are managed as extensions – so most implementers don’t have to worry about them.

Extensions keep the FHIR core specification ‘simple’. Without extensions, the Patient resource would have 300 or more data elements instead of 25.

In FHIR, extensions are built into the schema and are identified by a resolvable URL.

Extension Considerations



- What do you do if you receive an unrecognized extension?
- Should you store unrecognized extensions?
- Should you display unrecognized extensions?
- What should you expose as an extension?
- Where should you register your extensions?

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There are several things to consider when it comes to extensions:

What do you do if you receive an extension you don't recognize? (Hint – it's bad practice to reject instances just because you don't recognize an extension – extensions can be safely ignored.)

Should you store unrecognized extensions? If so, how could you do that?

What about displaying unrecognized extensions?

How do you decide whether to expose your own data as an extension?

If you create an extension, implementers need to be able to find it – where should you register it?

Modifier Extensions



■ Also a core part of FHIR

- Needed because some extensions can't be safely ignored
- Can't compute on an element containing an unrecognized modifier extension. However, can:
 - Reject instance
 - Remove element containing unrecognized modifier extension
 - Just display narrative
 - Retrieve definition & seek human review
- When should you introduce them?

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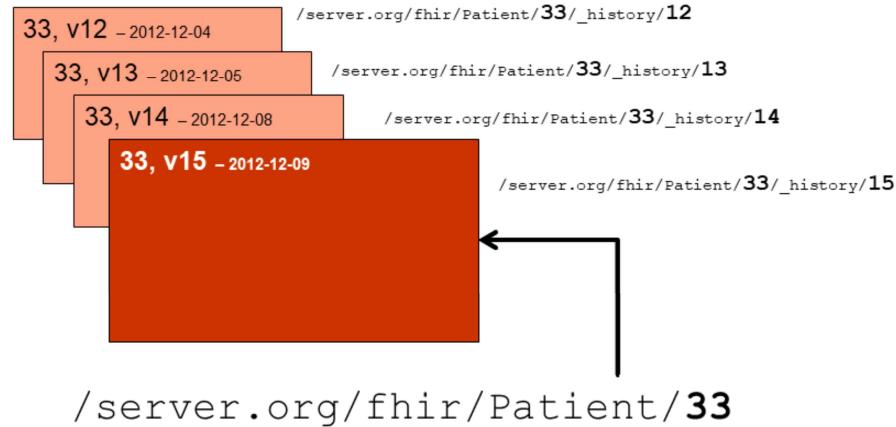
Modifier extensions are a pain in the butt. A modifier extension is a special type of extension that can change the meaning of other information in the instance. For example, a flag allowing you to say that “patient **did not** have an appendectomy”. Modifier extensions have a different name because they’re not safe to ignore.

The first question to consider around modifier extensions is what to do if you see one you don’t recognize. Do you reject the instance? Strip out the containing element (for example, stripping off a Patient contact with a flag that says “do not contact”)? Display only the narrative? Have a human look at it and decide what to do?

The other thing to decide is when is it necessary to introduce them – keeping in mind that modifier extensions can interfere with interoperability.



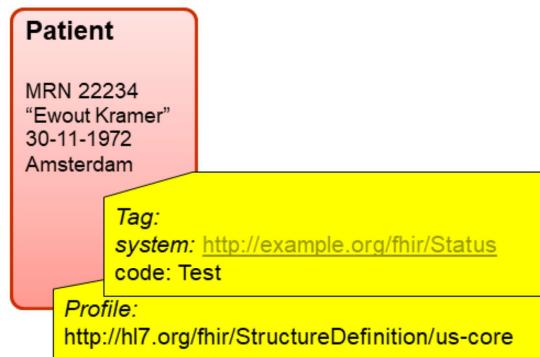
Versions



Whenever you create or update a resource in FHIR, you're implicitly creating a new “version” of that resource. However, systems are permitted to have a varying degree of version awareness – from full ability to return any historical version through to not having any clue if the record has changed, let alone who changed it or when.



Tags



Tags give a mechanism of capturing additional information about a resource that live outside the content typically signed.



Tags

- Allow data to be attached to a resource “outside” the resource

- Doesn’t break signature when added/changed
- 3 types:
 - Security
 - Profile
 - General (workflow, etc.)
- Require business agreement
 - Can’t search by tag if authors don’t include them
 - And populate the same way . . .

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Possibilities include security tags such as “this resource is extra sensitive” or “the information in this resource shouldn’t be shared with the patient”. They can also be used to capture what profile or profiles an instance complies with or to manage workflow, such as “Dr. Smith needs to see this report”. One of your architectural considerations will be what tags your system will leverage and how you’ll ensure that your communication partners either populate or understand those tags.

Reference libraries



- Currently 5:
 - C#, Java, Pascal (Delphi), Javascript, Swift
 - More to come?
- Handle parsing, serialization, validation, etc.
- Also open source servers, basic clients

HL7 provides reference libraries for many software languages that handle parsing, serialization and performing basic REST operations. Some of them also support validation and other functions. You'll need to decide whether to leverage those open source libraries or build your own equivalents – and if leveraging, how you'll manage as the libraries get updated from time to time to reflect enhancements, fixes and newer versions of FHIR.

Resource identity and location



- What relationships will you need?
- Where will referenced resources live?
- How will you reference those resources?
- Where's the resource – bundled, contained, remote?

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FHIR resources exist in a cloud or network of interlinked instances. For example, an Observation might point to a Patient, a Practitioner and an Encounter. The Encounter might then point to the same Patient and a different Practitioner as well as a Condition which also points to the Patient... Those resources might be all packaged together in a message or document Bundle or they might be accessed separately, either on the same RESTful server or on separate ones.

FHIR provides a few options for referencing and containing resources. In REST, resources are referenced by URL – but those references can be generic or version-specific. In messages and documents, they can also be identified by GUIDs – which means there's no mechanism to resolve them outside of the message or document.

In addition to remote and bundled resources, FHIR also allows “containing” resources. This is used when a resource has no independent identity and doesn't have enough information to stand on its own. For example, if all you know about a prescription is that it was prescribed by “Dr. Petrov”, that's not enough information to create an independent Practitioner resource.

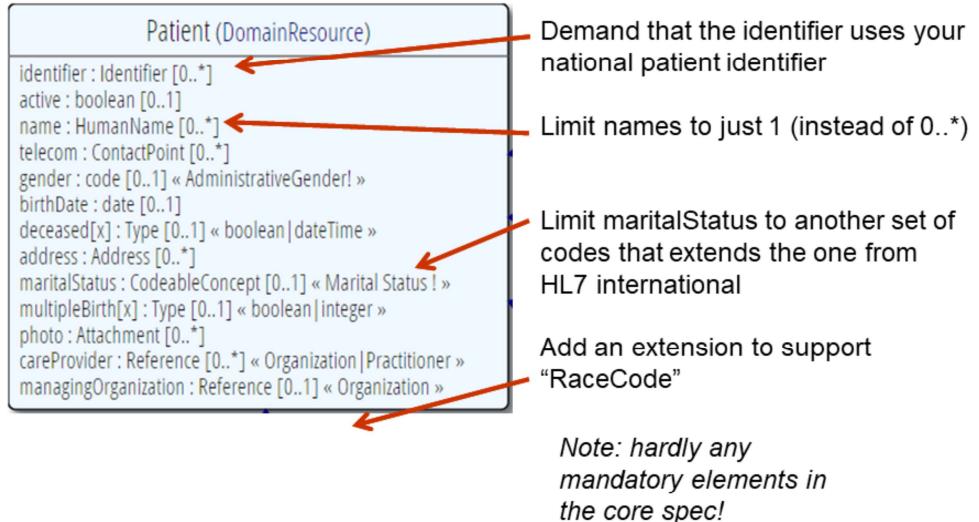


PROFILED FHIR

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When you look at FHIR resources, you'll see that very few elements are mandatory. If you look at the Patient resource, **none** of the root data elements are mandatory. That's because there are valid use-cases in at least some systems where any one of those data elements are allowed to be missing. In fact, it's completely legitimate for a system to not be **able** to store patient names. Maybe it's an application for anonymized reporting. Or maybe it deals with cows or chickens.

Profiling a resource



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Profiles are FHIR's mechanism for describing tighter rules for resources in the context of a particular implementation space. You can make elements mandatory. You can require that systems use particular code systems. You can tighten down what data types are allowed, for example saying that you can't just have a deceased flag but must always specify a full "deceased date". You can indicate what extensions are expected to be supported or define new extensions. You can also provide additional guidance and instructions about how implementers should map or interpret data.

Packages of these profiles can then be packaged together with related value sets and code systems, examples, capability statements and other conformance artifacts to form a FHIR Implementation Guide – a set of guidance for how to use FHIR to solve a particular set of problems in a specific environment.

Profile-less FHIR



- You don't need profiles to interoperate with FHIR
 - Resources are "discrete" enough that mechanism to populate most elements is clear
- Approach
 - Populate/consume all elements you know, use HL7 or country-standard extensions for extras
 - Map to/from "recommended" terminologies as much as possible, populate CodeableConcept.text
 - Expose capabilities in CapabilityStatement resource

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Unlike CDA, you can get a reasonable degree of interoperability with FHIR without using Profiles at all. FHIR is much more concrete than CDA. Thus, different developers are much more likely to interpret the specification the same way for most elements. As a result, FHIR has pretty good "drive by interoperability" where you just hook up two systems and see what information can flow without specially configuring them. However, if you want to be sure that all information will flow, you'll need profiles.



Profile Uses

■ Profiles are still quite useful

- Define document and message boundaries
- Define extensions
- Set interoperability expectations in a particular context
 - National standards, types of care, business patterns
- Clinical practice guidelines / detailed clinical models
- Document system capabilities

Profiles can be used for many things. You need them to define what content will be inside the Bundle for documents and messages. We use them to define new extensions. We use them when creating implementation guides, whether at the national, international or local level. You can use them to define clinical practice guidelines and best practices – for example “What should a blood pressure look like?” or “What should a pediatric oncology referral look like?”. Profiles are also used to describe what your system actually does.

Profiled Observation (Blood Pressure)



Name	Flags	Card.	Type	Description & Constraints
Observation		0..*		FHIR Blood Pressure Profile
code		1..1	CodeableConcept	Blood Pressure
coding			Coding	<i>Slice:</i> Unordered, Open by value:code
coding		0..*	Coding	
system		0..1	uri	
code		0..1	code	Fixed Value: http://loinc.org
valueQuantity		0..0		Fixed Value: 85354-9
component		0..*	BackboneElement	<i>Slice:</i> Unordered, Open by value:code.coding.code
component		0..*	BackboneElement	
code		1..1	CodeableConcept	
coding			Coding	<i>Slice:</i> Unordered, Open by value:code
coding		0..*	Coding	Systolic Blood Pressure
system		0..1	uri	Fixed Value: http://loinc.org
code		0..1	code	Fixed Value: 8480-6
valueQuantity		0..1	Quantity	
code		1..1	code	Fixed Value: mm[Hg]
component		0..*	BackboneElement	



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This is an example of a blood pressure profile. It sets constraints on what the Observation code is to provide a standard way of saying “this is a blood pressure”. Because blood pressure has two parts – systolic and diastolic, it prohibits specifying a value for the Observation overall, and instead defines two slices on Observation.component. Each slice sets the rules for a separate repetition. One repetition must have the code for “systolic blood pressure”. The other for “diastolic blood pressure”. Both require the units to be “millimeters of mercury”.

Profiles to guide behavior



- Profiles can be used to dynamically configure system behavior

- Load a profile to guide data entry
 - E.g. Oncology referral
- Load a profile to guide data display

One of the interesting things about profiles is that because they are computable and behave like any other resource, you can have a system that changes behavior after loading a profile – using the profile to guide what data gets entered or what data it already has that should be displayed to the user.



WHAT NOW?

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10:00

Dealing with STU



- FHIR is a “standard for trial use”
 - Anything can change – no compatibility promised
 - Changes driven by implementation feedback
 - Most changes expected in resources
 - Already significant implementation experience through reference implementations, connectathons
 - Some needed resources aren’t yet defined
 - Outbreak, Public Health Case, etc.
 - Some content will (hopefully) become normative in FHIR R4 (2018), but most won’t
 - What goes normative when will depend on degree of implementation



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FHIR is still a Standard for Trial Use. Some portions of it should be locked down at the end of this year, but most resources won’t be locked down until the next release at the earliest (in about 2 years) or even longer. The Trial Use phase allows us to gather feedback from implementers and make fixes if things aren’t right. As well, new content will continue to be added to the specification over time and that content will also need time for implementers to beat on it before we lock it down. As a result, if you’re implementing FHIR now, you need to allow for the possibility that some pieces of it might change in the future. It also means that *you* have an opportunity to change FHIR if you don’t think it’s doing something correctly.

Estimating



■ How much will implementing a FHIR solution cost?

➤ Considerations

- Reference implementations help
- Learning curve is lower
 - Still a curve if unfamiliar with XML / JSON / REST
- Faster to “drive by” interoperability
- Can’t speed consensus
- Tools to help with mapping to internal codes and structures, still takes time
- Anecdotal is “faster” to “significantly faster” to implement



When we set out to build FHIR, we wanted something that was faster and easier than what we’ve done before. Based on feedback from implementers, we’ve largely succeeded. FHIR has a lower learning curve, provides reference implementations so implementers can focus on their business rather than encoding rules. Anecdotally, the community indicates that solutions using FHIR get to production “faster” or “significantly faster” than those using previous standards.

However, it’s important to be realistic. FHIR doesn’t make mapping terminologies easier. FHIR doesn’t make doctors agree faster. FHIR won’t suddenly make the business processes of other systems align with your own. In other words, FHIR isn’t magic 😊

be too busy to teach this course . . .

Resources wiki.hl7.org/?title=FHIR



FHIR Implementation

- The current specification: <http://www.HL7.org/fhir/> (or the development version [\)](#)
 - [FHIR Specification Feedback \(DSTU 2\)](#)
 - [FHIR Profiles from other Organizations](#)
- Contact Information
 - [FHIR Support Page](#)
 - Implementation help: [\[ask questions about FHIR\]](#)
 - Formal Contact point for the project: fmgcontact@hl7.org
 - [FHIR Chat \(Zulip\)](#) [chat.fhir.org](#) [community expectations](#)
 - [FHIR gForge Tracker](#) [for change requests/corrections](#)
 - FHIR Project Team Leads (FHIR Core Team): [\[Grahame Grieve\]](#), [\[Ewout Kramer\]](#), [\[Lloyd Mckenzie\]](#)
 - [List server](#) - project email list
- Help / Getting Started
 - [FHIR Starter](#) - tutorial for FHIR newbies
 - [FHIR Teaching](#) - sources of FHIR teaching, training, and tutorials
 - [FHIR Cheat Sheet](#) [\(DSTU 1\)](#)
 - [FHIR Cheat Sheet](#) [\(DSTU 2\)](#)
 - [FHIR Cheat Sheet](#) [\(DSTU 3\)](#)
- Testing
 - [Publicly Available FHIR Servers for testing](#)
 - [Open Source FHIR implementations](#)
 - [Organizations interested in FHIR](#)
 - [Profile Tooling](#)
 - [ClinFHIR](#) [- web-based generic FHIR client](#)
 - [FHIR Testing Platforms](#)
- [FHIR Implementations](#)
- [FHIR R2/R3 Transformation page](#)
- Connectathons
 - Connectathon Process
 - [FHIR Connectathon Track Process](#)
 - [Proposed connectathon tracks for Madrid, Spain - May 2017](#)
 - [Previous connectathon tracks in San Antonio, TX - January 2017](#)
 - Upcoming Connectathons
 - [Connectathon 15](#) [\(May 6-7, 2017, Madrid, Spain\)](#)
- Previous Connectathons and other events
 - [Historical Connectathons](#) (list)

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As Grahame said earlier, a key part of FHIR is the community. That community has put together a lot of resources to help new implementers. The best place to look for them is on the FHIR wiki. There you can find open source tools, tutorials, cheat sheets, public test servers, upcoming events, blogs and more.

To be really successful with FHIR, it's important that you connect with the community. The best way to do that is through [chat.fhir.org](#). If you have a question about something in the spec, ask. Someone probably has an answer and you're much more likely to interoperate if you do what the rest of the community is doing. And once you're up to speed a bit, don't be afraid to answer questions either...

If you see something in the spec that doesn't seem right or could be better, please use the "propose a change" link at the bottom of each page in the spec. In the last 6 years, we've received over 10,000 change requests. We consider and respond to every single one.

Next Steps for **you**



- Read the spec: <http://hl7.org/fhir>
- Join <http://chat.fhir.org>
- Submit feedback (Propose a Change link)
- Form your own local community
- Come to FHIR Developer Days
- Come to an HL7 WGM



If you're able to travel (which I know isn't easy), coming to a Developer Days or HL7 WGM is a great way to learn the details of the spec, meet others who are also using FHIR and influence the evolution of the standard. If you can't do that, then form your own local community and learn from each other.

Questions?



<http://hl7.org/fhir>

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I hope you've found that architectural overview helpful. As you dig deeper, if you run into questions, please reach out to the community. We're there to help.