FHIR-Based Clinical Decision Support

Analysis and Recommendations for the use of FHIR in the CDS Quality Domain

# Overview

This document describes a potential approach to the use of FHIR as a basis for Clinical Decision Support. The analysis focuses on two primary use cases, as identified by the Health eDecisions S&I Framework Initiative:

* Use Case 1 – Standards-based Sharing of Knowledge Artifacts
* Use Case 2 – Standards-based Guidance Request/Response

The following current/developing standards are considered as part of this process:

* Clinical Decision Support Knowledge Artifact Specification, DSTU 3
* Clinical Quality Language Specification, Release 1
* Clinical Quality Common Metadata Conceptual Model, Release 1
* Decision Support Service, Release 2
* Decision Support Service Implementation Guide, Release 1
* Health Quality Measures Format, Release 2.1
* QDM-Based HQMF Implementation Guide
* CQL-Based HQMF Implementation Guide
* FHIR eCQM Profiles

The analysis and design approach presented here is part of the FHIR-based Clinical Decision Support project, sponsored by the Clinical Decision Support Workgroup, and co-sponsored by the Clinical Quality Information Workgroup and the FHIR Infrastructure Workgroup.

The intent is to sketch a roadmap and potential approach to achieve two overall goals:

1. Short-term pilot implementation strategies for Use Case 1 and Use Case 2 to move the current standards forward.
2. Long-term standards development strategies for Use Case 1 and Use Case 2 to support emerging consensus within the community around the use of FHIR in both the Decision Support and Quality Measurement domains.

# Background

Over the past year, the S&I Framework Clinical Quality Framework Initiative has focused on harmonizing the historically disjoint specifications used by the Clinical Quality Measurement and Clinical Decision Support communities. Specifically, the initiative has focused on the specifications used to represent knowledge artifacts within the two communities. The strategy employed has been to break the conceptual content of knowledge artifacts into three core components:

1. Metadata – Descriptive information about the artifact and its content
2. Clinical Information – The representation used to carry clinical information about the patient or population of concern within a given artifact
3. Logic – The representation used to convey the logic involved in the artifact

The first component has resulted in the Clinical Quality Common Metadata Conceptual Model, an informative document harmonizing metadata requirements between Quality Measurement and Decision Support artifacts.

The second component has resulted in the QUICK Conceptual and Logical Models, a harmonization of the Virtual Medical Record used in Decision Support, and the Quality Data Model used in Quality Measurement, realized in FHIR as the QI-Core profiles.

And finally, the third component has resulted in the Clinical Quality Language Specification, a harmonization of the expressive capabilities of the Clinical Decision Support Knowledge Artifact Specification, and the Health Quality Measures Format.

As part of the Phase II Pilot efforts, these developing specifications are being used to support both Use Case 1 and Use Case 2. The next step in this process involves the use of the Decision Support Service standard and its accompanying implementation guide to support evaluation of a guidance request using the QI-Core profiles as the payload. To achieve this goal, a new profile for the DSS IG is being developed to allow FHIR payloads within a DSS service, as well as a new FHIR Implementation Guide to describe a Use Case 2 interchange as an operation of a FHIR server.

In addition, the long-term impact of FHIR as a potential medium for the expression of knowledge artifacts is being considered.

# Components of a Guidance Request/Response

As described in the currently published Decision Support Service Implementation Guide, Release 1, a Clinical Decision Support Guidance request and response uses the following components:

|  |  |
| --- | --- |
| Component | Description |
| Virtual Medical Record (vMR) | Contains patient information required for the guidance request to be evaluated. |
| CDSContext | Contains request context such as the initiator and intended recipient, as well as workflow context. |
| CDSInput | A generic container for the context and patient information, as well as general parameters to the evaluation. |
| CDSOutput | A generic container for the output of the evaluation. |
| CDSActionResponse | Evaluation output specifically containing Actions as defined by the Clinical Decision Support Knowledge Artifact Specification. |
| CDSExecutionMessage | A description of any messages that occurred during the evaluation. |

For the FHIR-based request/response, FHIR equivalents for each of these components must be provided. In addition, an analysis of the most appropriate way to express a clinical decision support request/response within FHIR is warranted.

# Use Case 2 on FHIR

As described in the FHIR description of operations (<http://hl7.org/fhir/2015May/operations.html>), the *OperationDefinition* resource can be used to describe operations provided by a FHIR server. In the general case, the operation is performed by POSTing a document containing a *Parameters* resource with the relevant input parameters. If successful, the response is returned as a document containing a *Parameters* resource with the relevant output parameters (or a specific resource if there is only one output parameter named *result*). In addition, this mechanism supports asynchronous operation calls using the FHIR messaging protocol.

A native-FHIR expression of a Clinical Decision Support guidance request would therefore involve describing the components of the request and response as input and output parameters in an operation definition.

In addition, to ensure that the approach taken here can encompass not only decision support but measure evaluation, the KnowledgeRequest and KnowledgeResponse resources will include only the information that is common to all quality-related requests. CDS-specific information will be introduced in GuidanceRequest and GuidanceResponse derivatives.

The following table broadly describes the FHIR-equivalent representation of each of the components involved:

|  |  |
| --- | --- |
| Component | FHIR Equivalent |
| Virtual Medical Record (vMR) | QI-Core Profiles |
| CDSContext | A *KnowledgeRequest* (profile of Basic) |
| CDSInput | As specified by FHIR, the *Parameters* resource will be the container for the information required by the operation. |
| CDSOutput | As specified by FHIR, the *Parameters* resource will be the container for the information returned by the operation. |
| CDSActionResponse | A new *KnowledgeResponse* resource modeling the result of the Guidance evaluation. |
| CDSExecutionMessage | The *OperationOutcome* resource will be used to describe any messages resulting from the evaluation request. |

In addition to the request and response structures, the Decision Support Service specification defines the general notion of a knowledge *module* that allows services to define the types of decision support that they expose. These modules may correspond directly to a single artifact, or they may correspond to a group of artifacts that deal with related support services, or they may correspond to internal logic that is not necessarily represented by any concrete artifact. In order to support all these possibilities, and simplify the communication involved, the knowledge request and response will be always be based on a single specific module id. Note that this does not preclude packaging multiple requests in a single network call; that aspect will be considered in more detail in the FHIR DSS IG Profile and FHIR Operation Definition sections.

The description of knowledge modules in FHIR will be discussed in the section on knowledge artifact representation below. For the purposes of the request/response, only the module identifier is relevant, modeled using the FHIR Identifier type.

## KnowledgeRequest

The *KnowledgeRequest* resource provides the information required to perform the requested evaluation, including the context information, and any input parameters (not FHIR operation parameters, but artifact-specified parameters; these will be described in more detail in later sections).

The following table details the mapping from the CDS input relevant structures to their FHIR equivalents:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Element/Attribute | Type | C | Description | FHIR-Equivalent | Notes |
| templateId | vmr:CodedIdentifier | 0..\* | Template Constraint | Profile | This element is part of the V3 equivalent of FHIR Profiles |
| cdsInitiatingOrganization | vmr:Organization | 0..1 | Organization initiating the CDS Request | Organization |  |
| cdsInitiatingPerson | vmr:Person | 0..1 | Person initiating the CDS Request | Person|Patient|Practitioner|RelatedPerson |  |
| cdsSystemUserType | dt:CD | 0..1 | The type of individual using the CDS system | CodeableConcept | Valueset? |
| cdsSystemUserPreferredLanguage | dt:CD | 0..1 | Preferred language of the person using the system | CodeableConcept | IETF Language Tag (http://tools.ietf.org/html/bcp47) |
| cdsSystemUserTaskContext | dt:CD | 0..1 | The task that a CDS system user is performing. | CodeableConcept | Valueset? |
| cdsReceivingOrganization | vmr:Organization | 0..1 | Organization that the response will be directed towards | Organization |  |
| cdsReceivingPerson | vmr:Person | 0..1 | Person that the response will be directed towards | Person|Patient|Practitioner|RelatedPerson |  |
| cdsInformationRecipientType | dt:CD | 0..1 | Type of user consuming the CDS content | CodeableConcept | Valueset? |
| cdsInformationRecipientPerferredLanguage | dt:CD | 0..1 | Preferred language of the person consuing the CDS content | CodeableConcept | IETF Language Tag (http://tools.ietf.org/html/bcp47) |
| cdsEncounterType | dt:CD | 0..1 | The type of the patient encounter | CodeableConcept | Currently bound to ActEncounterCode (2.16.840.1.113883.1.11.13955). In FHIR, most reasonable valueset is: http://hl7.org/fhir/encounter-class |
| cdsSubTopic | dt:CD | 0..1 | Narrows down the knowledge request by specifying a subdomain of interest | CodeableConcept | Valueset? |
| extension | vmr:NameValuePair | 0..\* | Extended attributes | Extension | This element is part of the vMR equivalent of FHIR Extensions |

Based on the above representations, the core *KnowledgeRequest* profile would contain the following elements:

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Type | Cardinality | Description |
| requestIdentifier | Identifier | 0..1 | The identifier for the request. |
| moduleIdentifier | Identifier | 1..1 | The specific module(s) to be evaluated |
| moduleVersion | string | 0..1 | A version identifier for the module, if any |
| inputParameters | Parameters | 0..1 | Optional parameters, providing parameter values for the request |

And the *GuidanceRequest* derived profile would introduce the following additional elements:

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Type | Cardinality | Description |
| initiatingOrganization | Organization | 0..1 | The organization initiating the request |
| initiatingPerson | Person|Patient|Practitioner|RelatedPerson | 0..1 | The person initiating the request |
| systemUserType | CodeableConcept | 0..1 | The type of user initiating the request |
| systemUserLanguage | CodeableConcept | 0..1 | The language of the user initiating the request |
| systemUserTaskContext | CodeableConcept | 0..1 | The workflow context in which the request was initiated |
| receivingOrganization | Organization | 0..1 | The organization intended to receive the results of the evaluation. |
| receivingPerson | Person|Patient|Practitioner|RelatedPerson | 0..1 | The person intended to receive the results of the evaluation. |
| recipientType | CodeableConcept | 0..1 | The type of recipient |
| recipientLanguage | CodeableConcept | 0..1 | The language of the intended recipient |
| encounterType | CodeableConcept | 0..1 | The encounter type in which the request was initiated |
| subtopic | CodeableConcept | 0..1 | Additional information identifying the encounter type |

## KnowledgeResponse

The *KnowledgeResponse* resource will model the output of the evaluation request, and will contain the following attributes:

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Type | Cardinality | Description |
| responseIdentifier | Identifier | 1..1 | The response identifier. |
| requestIdentifier | Identifier | 0..1 | The request identifier, if known. |
| moduleIdentifier | Identifier | 1..1 | The module that was evaluated to produce this response |
| moduleVersion | string | 0..1 | The version identifier of the module that was evaluated to produce the response, if any. If a specific version of the module was requested, this is the same as the request version. If no version was requested, and the module has a version, this is the version of the module. |
| status | code | 1..1 | Whether the operation was successful (http://hl7.org/fhir/2015May/response-code.html) |
| evaluationMessage | OperationOutcome | 0..\* | Any messages resulting from the evaluation. |
| outputParameters | Parameters | 0..1 | The output of the evaluation, if specified. |

And the *GuidanceResponse* derived profile introduces the following additional elements:

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Type | Cardinality | Description |
| action | Action | 0..1 | The actions to be performed |
| action.actionId | Identifier | 0..1 | A unique identifier for the action |
| action.number | String | 0..1 | User-visible number for the action |
| action.evidence | Evidence | 0..\* | Evidence associated with the action |
| action.documentation | DocumentReference | 0..\* | Documentation for the action |
| action.participant | Person|Patient|Practitioner|RelatedPerson | 0..\* | Participants in the action |
| action.title | String | 0..1 |  |
| action.description | String | 0..1 |  |
| action.textEquivalent | String | 0..1 | Could be “narrative”... |
| action.concepts | CodeableConcept | 0..\* |  |
| action.type | code | 0..1 | Action type (create|update|remove...) |
| action.resource | Resource | 0..1 | The resource that is the target of the action (e.g. CommunicationRequest) |
| action.actions | Action | 0..\* |  |

Note that this is a draft, and does not include the specification of behaviors or conditions. In addition, this resource is deliberately modeling the actual response, not the definition of the response that is defined by the Knowledge Artifact Specification.

With these resources, the request/response for guidance from a Clinical Decision Support Service can be modeled appropriately.

# FHIR DSS IG Profile

With the *KnowledgeRequest* and *KnowledgeResponse* resources defined, the DSS IG can be modified to include a FHIR-based profile, which would introduce new Semantic Signifiers for these resources and encode the request/response as the payloads in the existing message infrastructure.

# FHIR Operation Definition

These same resource definitions can be used to express a native-FHIR *OperationDefinition* that would describe the CDS Guidance request/response as a *system* operation of a FHIR server (i.e. not related to any specific resource type or resource instance). The following table describes the parameters of the CDS guidance operation definition:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Use | Type | C | Documentation |
| request | in | KnowledgeRequest | 1..\* | The input guidance request information |
| inputResource | in | Resource | 0..\* | Input data for the request |
| response | out | KnowledgeResponse | 1..\* | The results of the request |
| outputResource | out | Resource | 0..\* | Output resources of the request |

Note that the operation definition allows multiple requests to be issued as part of a single operation. This allows multiple requests that may share overlapping input resources to be performed at the same time, avoiding the need to submit the same data multiple times.

Note also that the input patient resources are always optional, if the FHIR service that is performing the evaluation already has access to the patient information (such as in an embedded DSS, quality measurement, or population health management scenario), then the request would not include the relevant patient data.

# Use Case 1 on FHIR

Due to the way the DSS IG and CDS KAS specifications are structured, there are several aspects of defining a knowledge artifact that are also used as part of the request/response. Specifically, the metadata types associated with modeling participants such as practitioners and organizations, as well as supporting evidence, and the actions performed, are all modeled using the same common structures within both the CDS KAS and the DSS IG.

However, many of these structures are represented differently in FHIR, including the core data types on which these structures are built. The vMR and CDS KAS use the HL7 V3 data types, whereas FHIR uses the FHIR core data types. There exists a straightforward mapping between the two, and in the short-term, mixing these types will sometimes be required as different parts of the specifications move forward at different rates.

For the short-term strategy, the Use Case 2 approach described above relies on the complete expression of required information within FHIR, but this involves restating, rather than reusing, the descriptions borrowed from the CDS KAS such as ActionGroup.

Long-term, this approach is aligned with a FHIR-based CDS KAS, as it provides a representation for much of the Metadata and Action components of that specification. However, significant effort is still required to produce a fully FHIR-based CDS KAS, if that ends up being the direction overall. To help support that goal, this analysis includes mappings for many of the components involved.

The following table defines the FHIR-equivalents for the Metadata Conceptual data types:

|  |  |  |
| --- | --- | --- |
| Name | V3 Representation | FHIR Representation |
| Code | CD | CodeableConcept |
| Identifier | II | Identifier |
| Name | PN | HumanName |
| Number | Quantity | Quantity |
| Contact | ADDR or TELCOM | Address or ContactPoint |
| Set<Type> | Set<> | <Cardinality> |
| String | ST | String |
| Timestamp | TS | DateTime |
| TimeInterval | IVL\_TS | Period |
| Person | Person | Person |
| Organization | Organization | Organization |
| System | Device | Device |
| Approval | N/A | ?? |
| Link | Act.id, Act.text.reference, ActRelationship.typeCode | link element as modeled in the Bundle resource |
| Prior State | Act.statusCode, N/A | Use ConformanceResourceStatus to model status, will need Time and Participant elements |

The following table defines the FHIR representation for the Metadata attributes:

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Data Type | V3 Representation | FHIR Representation |
| Instance Identifier | Identifier | Act.id | moduleIdentifier + version |
| Version Set Identifier | Identifier | ContextStructure.setId | moduleIdentifier |
| Version Label | String | ContextStructure.versionNumber | version |
| Title | String | Act.title | title |
| Subjects | Set<Code> or Set<String> | Role.code OR Role.text | parameter |
| Subject Parties | Set<Entity> | Participant (typeCode = SBJ) | Request inputResource |
| Subject Date Range | TimeInterval | N/A | Request inputParameters |
| Classification | Set<Code> | N/A | topic  keyword |
| Task\* | Set<Code> | Act.code | task |
| Facility Type\* | Set<Code> | ServiceDelivery LocationRoleType | facilityType |
| Clinical Specialties\* | Set<Code> | Role.code | specialty |
| Audience\* | Set<Code> | IntendedRecipient | recipientType |
| Purpose | String |  | purpose |
| Description | String |  | description |
| Usage | String |  | usage |
| Audit | Set<PriorState> |  | FHIR versioning |
| Type of Artifact | Code |  | Module, Measure, Rule, Documentation Template, Order Set, Library |
| Artifact Format | Code |  | KnowledgeModule |
| Artifact Structure | Code |  | KnowledgeModule |
| Language | Set<Code> |  | Resource.language |
| Date of Creation | Timestamp |  | Resource.meta.lastUpdated of oldest version of the resource |
| Date of Last Revision | Timestamp |  | Resource.meta.lastUpdated |
| Date of Last Review | Timestamp |  | lastReviewDate |
| Effective Date Range | TimeInterval |  | period |
| Publication Date | Timestamp |  | date |
| Status | Code |  | status |
| Prior Version | Link |  | relatedResource |
| Successor | Link |  | relatedResource |
| Security Tags | Set<Code> |  | FHIR metadata |
| Integrity Verification |  |  | FHIR signature |
| Author | Set<Person or Organization> |  | author |
| Authoring System\* | Set<System> |  | authoringSystem |
| Oversight Entities\* | Set<Organization> |  | oversightEntity |
| Steward\* | Organization |  | steward |
| Publisher | Organization |  | publisher |
| Rights | String |  | rightsDeclaration |
| Repository Location | Address or Identifier |  | repositoryLocation |
| Link | Set<Link> |  | relatedResource |
| Bibliographic References | Set<String> |  | relatedResource |
| Value Sets | Set<Identifier> |  | codeFilter.valueSet |

\*These aspects of the knowledge module may be introduced by further profiling, and are not modeled as part of the basic module.

A potential approach to the representation of a Knowledge Artifact within FHIR would be to define a *KnowledgeModule* resource with attributes as defined by the Clinical Decision Support Knowledge Artifact Specification. This effort should be closely aligned with the FHIR eCQM Profile, as well as coordinated with efforts to expose repository-level functionality as described in the next section.

# Beyond Use Case 2

The DSS IG only deals with the *evaluate* and *evaluateAtSpecifiedTime* interfaces of the DSS. However, the underlying DSS standard specifies a rich set of interfaces for performing repository functions including querying knowledge modules and their associated data requirements. A complete FHIR-based DSS profile would need to expose this functionality as well. Towards that end, this analysis also includes a discussion of the CDSInputSpecification and CDSOutputSpecification types defined to enable the use of the repository-layer functions of the DSS with the vMR and DSS IG.

In general, the CDSInputSpecification schema is designed to specify the data requirements for Knowledge Artifacts that use the vMR as their data model. In particular, it models:

* Constraints related to CDSContext
* Required information related to the Patient
* Inclusion scope for related persons
* Type- and profile-based constraints for clinical statements
* Code-based criteria for clinical statements
* Temporal criteria for clinical statements
* Temporal criteria for related entities

Because these specifications are designed based on the way vMR is structured, the equivalent conceptual representation in FHIR takes a different form. Specifically, Profiles in FHIR handle the constraints expressed with templateIds in the vMR, and the Code-based and temporal criteria for clinical statements and related entities can be expressed using extensions of OperationDefinition.

In addition, patient-independent information, currently modeled with CDSResource can be represented in FHIR with an appropriate parameter in the same way parameters are defined in OperationDefinition. This definition could easily be dynamically generated based on the set of parameters defined within the artifact or artifacts that will be evaluated.

The data requirements required for evaluation of a particular knowledge module can be represented with the following elements:

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Type | C | Description |
| data | inline-element | 0..\* |  |
| data.type | OperationParameterType | 1..1 | The type of the data requirement |
| data.profile | Reference(StructureDefinition) | 0..1 | The profile of the data requirement |
| data.codeFilter | inline-element | 0..\* | The code-filter of the data requirement |
| data.codeFilter.path | String | 1..1 | The code-valued attribute of the filter |
| data.codeFilter.valueSet | ValueSet | 0..1 | The valueset for the code filter |
| data.codeFilter.codeableConcept | CodeableConcept | 0..\* | The codeable concept for the code filter |
| data.dateFilter | inline-element | 0..\* | The date-filter of the data requirement |
| data.dateFilter.path | String | 1..1 | The date-valued attribute of the filter (can be any Date-valued attribute including, Schedule and Period) |
| data.dateFilter.period | Period | 0..1 | The period of the filter |
| data.dateFilter.dateTime | dateTime | 0..1 | The date time of the filter |

Note that this is draft of the proposed elements does not include support for inclusion scope of related persons, related entities, or related clinical statements. However, these aspects may be more appropriately represented within FHIR as profiles.

For the CDSOutputSpecification, the same resource can be used, specifying the type of the output parameter as the “result” parameter in the *Parameters* element of the operation definition.

As defined within the Decision Support Service specification, the basic unit for the description of supported services is called a *knowledge module*. To support a broad spectrum of potential use cases, these knowledge modules may correspond with a specific artifact or group of artifacts, or they may not correspond to any concrete artifact, but merely representing specific functions made available by the service.

To support modeling this same level of functionality, the *KnowledgeModule* profile of the *Basic* resource can be used:

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | C | Description |
| moduleIdentifier | Identifier | 0..\* | Logical identifiers for the knowledge module. |
| moduleVersion | string | 0..1 | The version of the module, if any |
| title | string | 0..1 | The title of the module |
| moduleType | code | 0..1 | The type of module being represented (requirements, module, measure, rule, etc.) |
| description | string | 0..1 | A description of the knowledge module |
| purpose | string | 0..1 | The purpose of the knowledge module |
| usage | string | 0..1 | Additional notes on usage |
| model | Element | 0..\* | A model reference used by the content. |
| model.name | string | 0..1 | The name of the model |
| model.uri | uri | 1..1 | The uri for the model |
| library | Element | 0..\* | A library reference used by the content. |
| library.name | string | 0..1 | The local name for the library |
| library.document | DocumentReference | 1..1 | A document reference to the library |
| topic | CodeableConcept | 0..\* | Clinical topics of the module |
| keyword | string | 0..\* | Keywords associated with module |
| facilityType | CodeableConcept | 0..\* | Relevant facility types |
| task | CodeableConcept | 0..\* | Relevant task types |
| specialty | CodeableConcept | 0..\* | Relevant clinical specialties |
| recipientType | CodeableConcept | 0..\* | Relevant recipient types |
| publicationDate | Date | 0..1 | Publication date |
| lastReviewDate | Date | 0..1 | Date of last review |
| effectivePeriod | Period | 0..1 | Effective date of the module |
| status | code | 0..1 | active, draft, retired |
| contributor | Element | 0..\* | A contributor to the module |
| contributor.type | code | 1..1 | author, editor, endorser, reviewer |
| contributor.party | Person|Organization | 0..1 | The party providing the contribution |
| steward | Organization | 0..1 | The organization responsible for stewardship of the module |
| publisher | Organization | 0..1 | The organization publishing the module |
| rightsDeclaration | string | 0..1 | The legal rights declaration for the module |
| relatedResource | Element | 0..\* | Related resources, such as additional documentation, supporting evidence, bibliographic references |
| relatedResource.type | code | 1..1 | The type of the resource (supporting evidence, documentation, citation, etc.) |
| relatedResource.document | DocumentReference  |Evidence | 1..1 | The document being referenced. |

In addition to the above elements, the *KnowledgeModule* profile would have the data requirements elements defined previously. With these elements, the *KnowledgeModule* profile can be used in the following scenarios:

* Data Requirements Representation – The profile can be used as the result of a data requirements request to describe the data of interest for a module or set of modules, or as part of a knowledge response to indicate that additional information is required to continue evaluation.
* Knowledge Module – The profile can be used as a persistent resource to describe the knowledge modules available for a particular decision support service.
* Knowledge Artifact – The profile can be used as the base profile for the description of a knowledge artifact such as a measure or decision support rule.

With this profile established, a *knowledgeRequirements* operation can be defined to allow clients to request the required data for a particular module using a FHIR server. This operation would have the following parameters:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Use | Type | C | Documentation |
| moduleIdentifier | in | Identifier | 0..\* | The identifiers of the modules for which data requirements should be retrieved. |
| result | out | KnowledgeModule | 1..1 | The aggregated data requirements for the requested modules. |

In addition, the *KnowledgeModule* resource can be added as an optional component of the *KnowledgeResponse* to indicate that additional information is required for the evaluation, allowing iterative request/response evaluations to be performed.

# Conclusions

In the short term, a FHIR-based representation of Guidance actions that is focused on delivery, rather than definition within artifacts, combined with the use of FHIR operation definitions can be used to define a first-round FHIR CDS Implementation Guide, as well as add a FHIR-based Profile to the DSS IG. These changes will provide complete specifications for FHIR-based implementation of Use Case 2.

In the long term, a FHIR-based expression of decision support artifacts, coordinated with representation of clinical quality measures, can be built as a FHIR CDS Artifact Implementation Guide, building on the Guidance representations established for Use Case 2, to enable complete FHIR-based implementation of Use Case 1.

In addition, further implementation of the DSS interfaces for CDS repository functionality can be provided, again by utilizing the Operation framework provided by FHIR.