



Mobile PROs with FHIR

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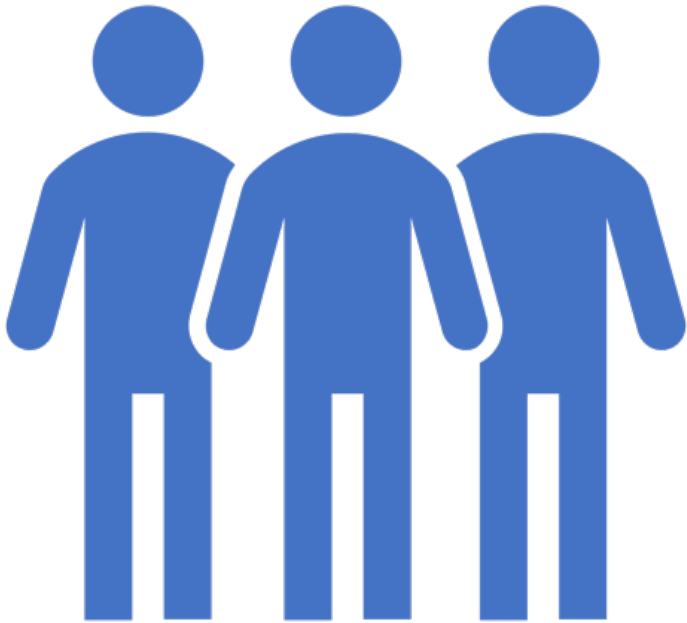
- This is a work in progress
- This is my first time developing a FHIR application
- Some of the technologies we are using/considering are new to myself and CIRG

I'd love to hear your thoughts, ideas, and feedback!

Patient Reported Outcomes (PROs)

PROs are

- An opportunity to administer **screening tools**
 - E.g. depression and anxiety questionnaires
- A **window into the patient experience** for the purpose of tracking treatment progress and effectiveness
 - E.g. pain tracking
- An opportunity for the patient to take an **active part in their care**





Mobile Health Apps

Consumer health applications can help users manage their health issues:

- **Smartphones are becoming ubiquitous companions** and are thus well suited to
 - Deliver reminders
 - Facilitate regular check-ins
 - Engage users through gamification
- mHealth apps also present unique opportunities through **integration with sensors and other hardware**

Objective

Develop a mobile app for collecting PROs that is

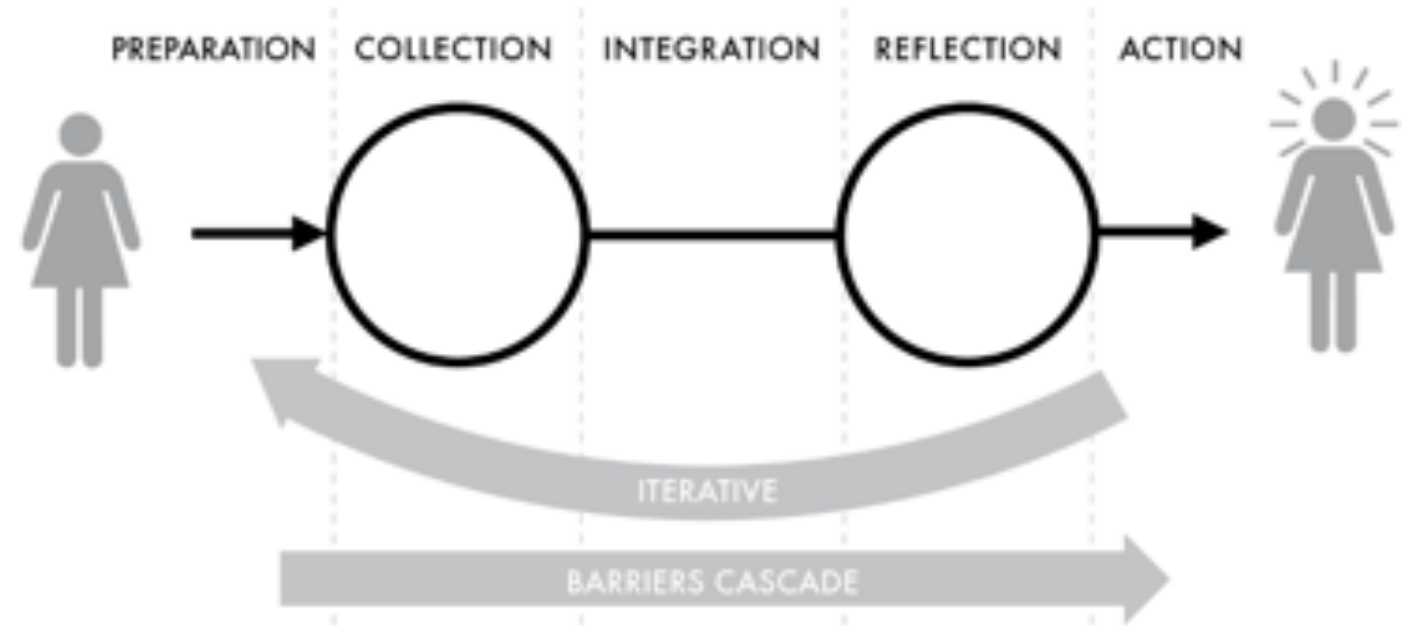
adaptable

cross-platform

offline-first

PRO App Requirements

- Facilitate planning
- Collect data:
 - Subjective – questionnaires
 - Objective – sensors
- Visualize trends



Stage-based model of personal informatics (Li et al., 2010)

Health issues

	Questionnaire	Treatment activity	Sensor opportunity
Urinary incontinence	Incontinence questionnaire	Pelvic floor muscle training sessions	
Physical therapy	Mobility questionnaire	-Exercises -Walking	Activity tracker
Mental health	Depression, anxiety, stress questionnaires	-Mindfulness -Thought exercises	-Sleep quality trackers -Mindfulness app usage

FHIR can make our app re-usable for different health problems



CAREPLAN



QUESTIONNAIRE



PROCEDURE

CarePlan

```
{
  "resourceType": "CarePlan",
  // from Resource: id, meta, implicitRules, and language
  // from DomainResource: text, contained, extension, and modifierExtension
  "identifier": [{ Identifier }], // External Ids for this plan
  "instantiatesCanonical": [{ canonical(PlanDefinition|Questionnaire|Measure|
    ActivityDefinition|OperationDefinition) }], // Instantiates FHIR protocol or definition
  "instantiatesUri": ["<uri>"], // Instantiates external protocol or definition
  "basedOn": [{ Reference(CarePlan) }], // Fulfills CarePlan
  "replaces": [{ Reference(CarePlan) }], // CarePlan replaced by this CarePlan
  "partOf": [{ Reference(CarePlan) }], // Part of referenced CarePlan
  "status": "<code>", // R! draft | active | suspended | completed | entered-in-error | cancel
    led | unknown
  "intent": "<code>", // R! proposal | plan | order | option
  "category": [{ CodeableConcept }], // Type of plan
  "title": "<string>", // Human-friendly name for the care plan
  "description": "<string>", // Summary of nature of plan
  "subject": { Reference(Patient|Group) }, // R! Who the care plan is for
  "encounter": { Reference(Encounter) }, // Encounter created as part of
  "period": { Period }, // Time period plan covers
  "created": "<dateTime>", // Date record was first recorded
  "author": { Reference(Patient|Practitioner|PractitionerRole|Device|
    RelatedPerson|Organization|CareTeam) }, // Who is the designated responsible party
  "contributor": [{ Reference(Patient|Practitioner|PractitionerRole|Device|
    RelatedPerson|Organization|CareTeam) }], // Who provided the content of the care plan
  "careTeam": [{ Reference(CareTeam) }], // Who's involved in plan?
  "addresses": [{ Reference(Condition) }], // Health issues this plan addresses
  "supportingInfo": [{ Reference(Any) }], // Information considered as part of plan
  "goal": [{ Reference(Goal) }], // Desired outcome of plan
  "activity": [{ // Action to occur as part of plan
    "outcomeCodeableConcept": [{ CodeableConcept }], // Results of the activity
    "outcomeReference": [{ Reference(Any) }], // Appointment, Encounter, Procedure, etc.
    "progress": [{ Annotation }], // Comments about the activity status/progress
    "reference": { Reference(Appointment|CommunicationRequest|DeviceRequest|
      MedicationRequest|NutritionOrder|Task|ServiceRequest|VisionPrescription|
      RequestGroup) }, // C? Activity details defined in specific resource
    "detail": { // C? In-line definition of activity
      "kind": "<code>", // Kind of resource
      "instantiatesCanonical": [{ canonical(PlanDefinition|ActivityDefinition|
        Questionnaire|Measure|OperationDefinition) }], // Instantiates FHIR protocol or definition
      "instantiatesUri": ["<uri>"], // Instantiates external protocol or definition
      "code": { CodeableConcept }, // Detail type of activity
      "reasonCode": [{ CodeableConcept }], // Why activity should be done or why activity was p
        rohibited
      "reasonReference": [{ Reference(Condition|Observation|DiagnosticReport|
        DocumentReference) }], // Why activity is needed
      "goal": [{ Reference(Goal) }], // Goals this activity relates to
      "status": "<code>", // R! not-started | scheduled | in-progress | on-hold | completed |
        cancelled | stopped | unknown | entered-in-error
      "statusReason": { CodeableConcept }, // Reason for current status
      "doNotPerform": <boolean>, // If true, activity is prohibiting action
      // scheduled[x]: When activity is to occur. One of these 3:
      "scheduledTiming": { Timing },
      "scheduledPeriod": { Period },
      "scheduledString": "<string>",
      "location": { Reference(Location) }, // Where it should happen
      "performer": [{ Reference(Practitioner|PractitionerRole|Organization|
        RelatedPerson|Patient|CareTeam|HealthcareService|Device) }], // Who will be responsible?
      // product[x]: What is to be administered/supplied. One of these 2:
      "productCodeableConcept": { CodeableConcept },
      "productReference": { Reference(Medication|Substance) },
      "dailyAmount": { Quantity(SimpleQuantity) }, // How to consume/day?
      "quantity": { Quantity(SimpleQuantity) }, // How much to administer/supply/consume
      "description": "<string>" // Extra info describing activity to perform
    }
  ]},
  "note": [{ Annotation }] // Comments about the plan
}
```

CarePlan

```
{
  "resourceType" : "CarePlan",
  // from Resource: id, meta, implicitRules, and language
  // from DomainResource: text, contained, extension, and modifierExtension
  "identifier" : [{ Identifier }], // External Ids for this plan
  "instantiatesCanonical" : [{ canonical(PlanDefinition|Questionnaire|Measure|
    ActivityDefinition|OperationDefinition) }], // Instantiates FHIR protocol or definition
  "instantiatesUri" : ["<uri>"], // Instantiates external protocol or definition
  "basedOn" : [{ Reference(CarePlan) }], // Fulfills CarePlan
  "replaces" : [{ Reference(CarePlan) }], // CarePlan replaced by this CarePlan
  "partOf" : [{ Reference(CarePlan) }], // Part of referenced CarePlan
  "status" : "<code>", // R! draft | active | suspended | completed | entered-in-error |
  // stopped | unknown
  "intent" : "<code>", // R! proposal | plan | order | option
  "category" : [{ CodesableConcept }], // Type of plan
  "title" : "<string>", // Human-friendly name for the care plan
  "description" : "<string>", // Summary of nature of plan
  "subject" : { Reference(Patient|Group) }, // R! Who the care plan is for
  "encounter" : { Reference(Encounter) }, // Encounter created as part of
  "period" : { Period }, // Time period plan covers
  "created" : "<dateTime>", // Date record was first recorded
  "author" : { Reference(Patient|Practitioner|PractitionerRole|Device|
    RelatedPerson|Organization|CareTeam) }, // Who is the designated responsible party
  "contributor" : [{ Reference(Patient|Practitioner|PractitionerRole|Device|
    RelatedPerson|Organization|CareTeam) }], // Who provided the content of the care plan
  "careTeam" : [{ Reference(CareTeam) }], // Who's involved in plan?
  "addresses" : [{ Reference(Condition) }], // Health issues this plan addresses
  "supportingInfo" : [{ Reference(Any) }], // Information considered as part of plan
  "goal" : [{ Reference(Goal) }], // Desired outcome of plan
  "activity" : [{ ActivityDefinition }], // Activities to be performed
```

CarePlan

```
"addresses" : [{ Reference(Condition) }], // Health issues this plan addresses
"supportingInfo" : [{ Reference(Any) }], // Information considered as part of plan
"goal" : [{ Reference(Goal) }], // Desired outcome of plan

"activity" : [{ // Action to occur as part of plan
  "outcomeCodeableConcept" : [{ CodeableConcept }], // Results of the activity
  "outcomeReference" : [{ Reference(Any) }], // Appointment, Encounter, Procedure, etc.
  "progress" : [{ Annotation }], // Comments about the activity status/progress
  "reference" : { Reference(Appointment|CommunicationRequest|DeviceRequest|
MedicationRequest|NutritionOrder|Task|ServiceRequest|VisionPrescription|
RequestGroup) }, // C? Activity details defined in specific resource
  "detail" : { // C? In-line definition of activity
    "kind" : "<code>", // Kind of resource
    "instantiatesCanonical" : [{ canonical(PlanDefinition|ActivityDefinition|
Questionnaire|Measure|OperationDefinition) }], // Instantiates FHIR protocol or definition
    "instantiatesUri" : ["<uri>"], // Instantiates external protocol or definition
    "code" : { CodeableConcept }, // Detail type of activity
    "reasonCode" : [{ CodeableConcept }], // Why activity should be done or why activity was p
rohibited
    "reasonReference" : [{ Reference(Condition|Observation|DiagnosticReport|
DocumentReference) }], // Why activity is needed
    "goal" : [{ Reference(Goal) }], // Goals this activity relates to
    "status" : "<code>", // R! not-started | scheduled | in-progress | on-hold | completed |
cancelled | stopped | unknown | entered-in-error
    "statusReason" : { CodeableConcept }, // Reason for current status
    "doNotPerform" : <boolean>, // If true, activity is prohibiting action
    // scheduled[x]: When activity is to occur. One of these 3:
    "scheduledTiming" : { Timing },
    "scheduledPeriod" : { Period },
    "scheduledString" : "<string>",
    "location" : { Reference(Location) }, // Where it should happen
    "performer" : [{ Reference(Practitioner|PractitionerRole|Organization|
RelatedPerson|Patient|CareTeam|HealthcareService|Device) }], // Who will be responsible?
    // product[x]: What is to be administered/supplied. One of these 2:
    "productCodeableConcept" : { CodeableConcept },
    "productReference" : { Reference(Medication|Substance) },
    "dailyAmount" : { Quantity(SimpleQuantity) }, // How to consume/day?
    "quantity" : { Quantity(SimpleQuantity) }, // How much to administer/supply/consume
    "description" : "<string>" // Extra info describing activity to perform
  }
}],

"note" : [{ Annotation }], // Comments about the plan
}
```


CarePlan

Questionnaire

```
"addresses" : [{ Reference(Condition) }], // Health issues this plan addresses
"supportingInfo" : [{ Reference(Any) }], // Information considered as part of plan
"goal" : [{ Reference(Goal) }], // Desired outcome of plan

"activity" : [{ // Action to occur as part of plan
  "outcomeCodeableConcept" : [{ CodeableConcept }], // Results of the activity
  "outcomeReference" : [{ Reference(Any) }], // Appointment, Encounter, Procedure, etc.
  "progress" : [{ Annotation }], // Comments about the activity status/progress
  "reference" : { Reference(Appointment|CommunicationRequest|DeviceRequest|
MedicationRequest|NutritionOrder|Task|ServiceRequest|VisionPrescription|
RequestGroup) }, // C? Activity details defined in specific resource
  "detail" : { // C? In-line definition of activity
    "kind" : "code", // Kind of resource
    "instantiatesCanonical" : [{ canonical(PlanDefinition|ActivityDefinition|
Questionnaire|Measure|OperationDefinition) }], // Instantiates FHIR protocol or definition
    "instantiatesUri" : ["<uri>"], // Instantiates external protocol or definition
    "code" : { CodeableConcept }, // Detail type of activity
    "reasonCode" : [{ CodeableConcept }], // Why activity should be done or why activity was p
rohibited
    "reasonReference" : [{ Reference(Condition|Observation|DiagnosticReport|
DocumentReference) }], // Why activity is needed
    "goal" : [{ Reference(Goal) }], // Goals this activity relates to
    "status" : "<code>", // R! not-started | scheduled | in-progress | on-hold | completed |
cancelled | stopped | unknown | entered-in-error
    "statusReason" : { CodeableConcept }, // Reason for current status
    "doNotPerform" : <boolean>, // If true, activity is prohibiting action
    // scheduled[x]: When activity is to occur. One of these 3:
    "scheduledTiming" : { Timing },
    "scheduledPeriod" : { Period },
    "scheduledString" : "<string>",
    "location" : { Reference(Location) }, // Where it should happen
    "performer" : [{ Reference(Practitioner|PractitionerRole|Organization|
RelatedPerson|Patient|CareTeam|HealthcareService|Device) }], // Who will be responsible?
    // product[x]: What is to be administered/supplied. One of these 2:
    "productCodeableConcept" : { CodeableConcept },
    "productReference" : { Reference(Medication|Substance) },
    "dailyAmount" : { Quantity(SimpleQuantity) }, // How to consume/day?
    "quantity" : { Quantity(SimpleQuantity) }, // How much to administer/supply/consume
    "description" : "<string>" // Extra info describing activity to perform
  }
}],

"note" : [{ Annotation }] // Comments about the plan
}
```

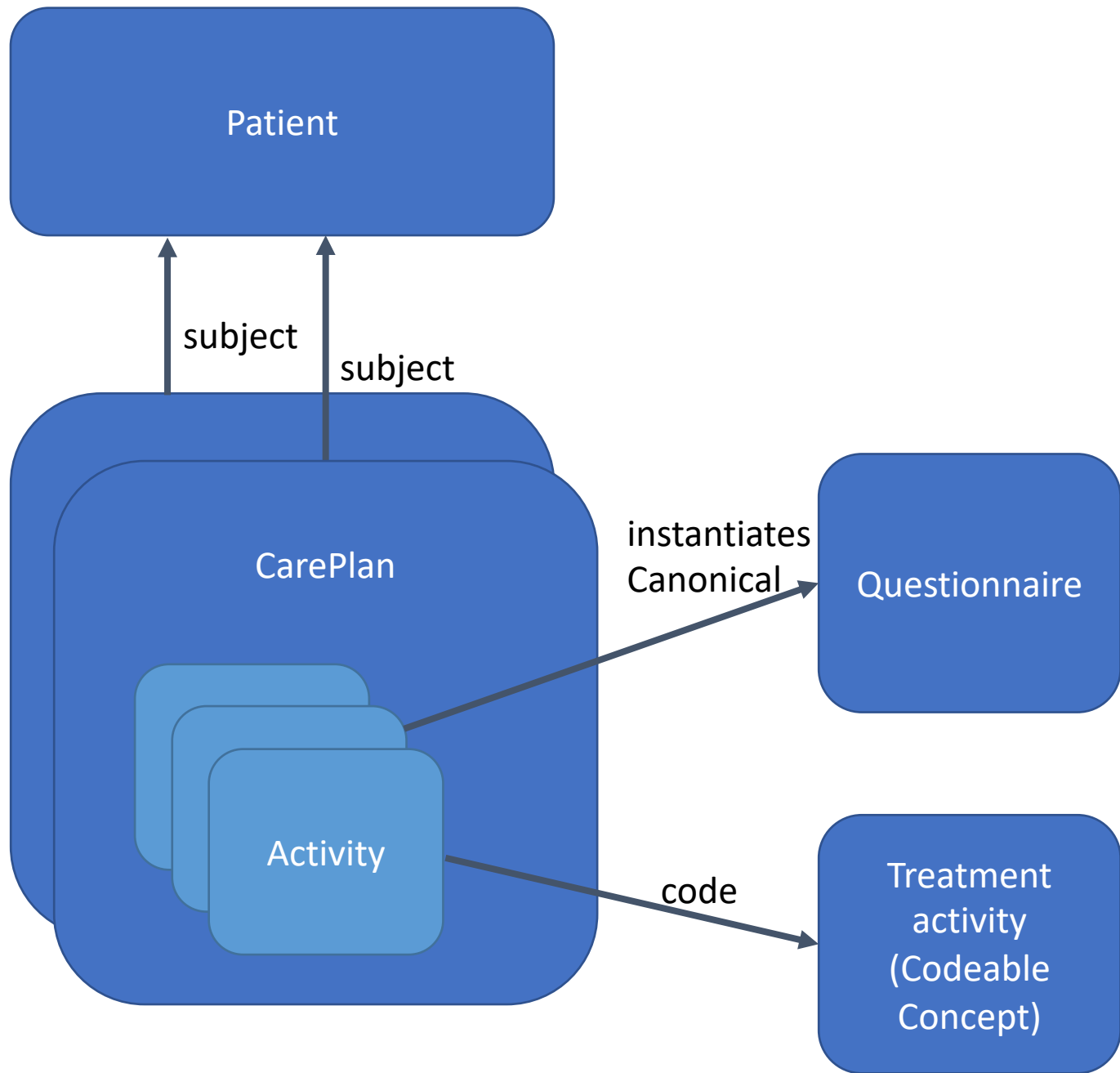
CarePlan

Treatment activity

```
"addresses" : [{ Reference(Condition) }], // Health issues this plan addresses
"supportingInfo" : [{ Reference(Any) }], // Information considered as part of plan
"goal" : [{ Reference(Goal) }], // Desired outcome of plan

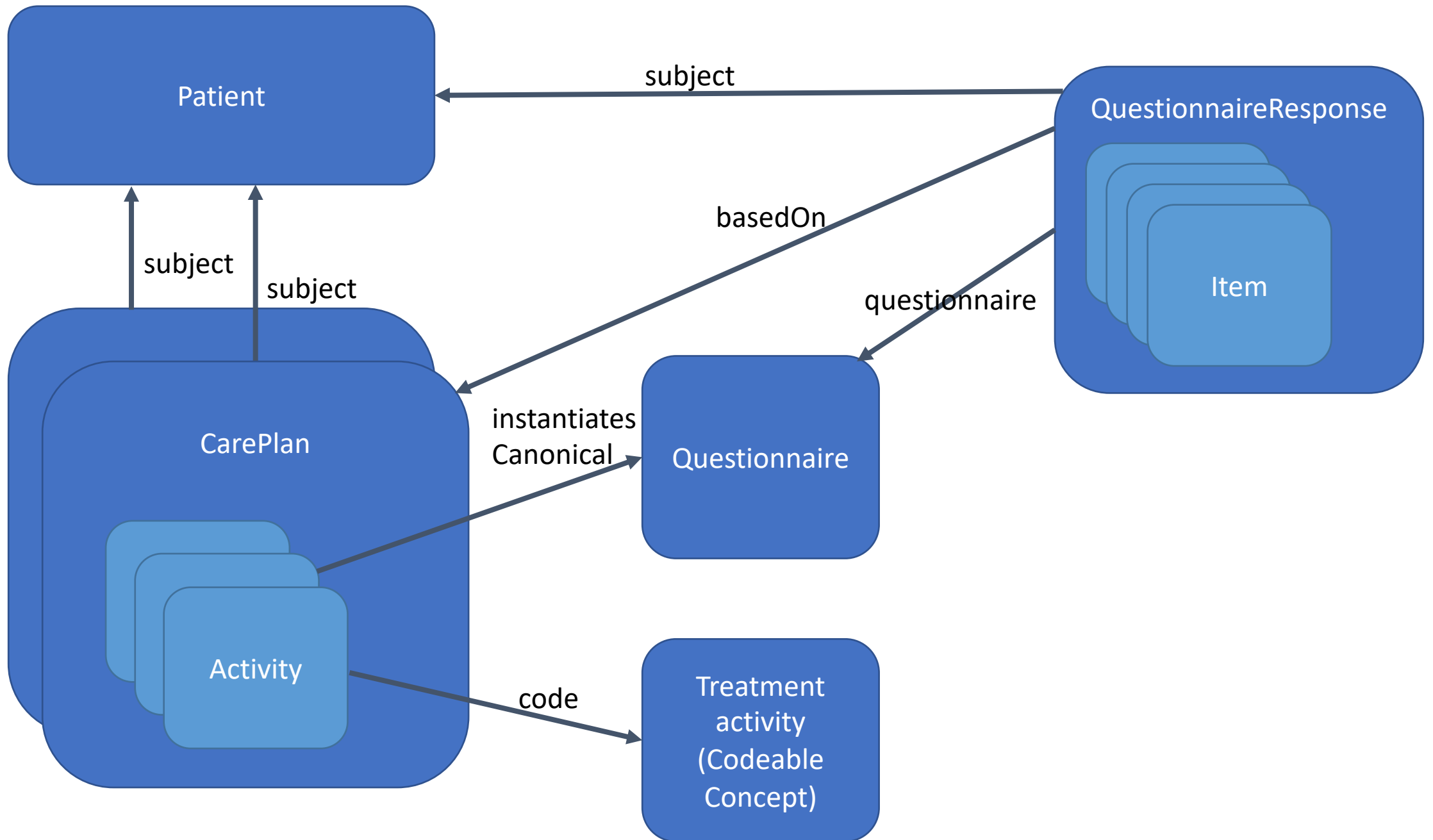
"activity" : [{ // Action to occur as part of plan
  "outcomeCodeableConcept" : [{ CodeableConcept }], // Results of the activity
  "outcomeReference" : [{ Reference(Any) }], // Appointment, Encounter, Procedure, etc.
  "progress" : [{ Annotation }], // Comments about the activity status/progress
  "reference" : { Reference(Appointment|CommunicationRequest|DeviceRequest|
    MedicationRequest|NutritionOrder|Task|ServiceRequest|VisionPrescription|
    RequestGroup) }, // C7 Activity details defined in specific resource
  "detail" : { // C7 In-line definition of activity
    "kind" : "<code>", // Kind of resource
    "instantiatesCanonical" : [{ canonical(PlanDefinition|ActivityDefinition|
      Questionnaire|Measure|OperationDefinition) }], // Instantiates FHIR protocol or definition
    "instantiatesUri" : [{ uri }], // Instantiates protocol or definition
    "code" : { CodeableConcept }, // Detail type of activity
    "reasonCode" : [{ CodeableConcept }], // Why activity should be done or why activity was prohibited
    "reasonReference" : [{ Reference(Condition|Observation|DiagnosticReport|
      DocumentReference) }], // Why activity is needed
    "goal" : [{ Reference(Goal) }], // Goals this activity relates to
    "status" : "<code>", // R1 not-started | scheduled | in-progress | on-hold | completed |
      cancelled | stopped | unknown | entered-in-error
    "statusReason" : { CodeableConcept }, // Reason for current status
    "doNotPerform" : <boolean>, // If true, activity is prohibiting action
    // scheduled[x]: When activity is to occur. One of these 3:
    "scheduledTiming" : { Timing },
    "scheduledPeriod" : { Period },
    "scheduledString" : <string>,
    "location" : { Reference(Location) }, // Where it should happen
    "performer" : [{ Reference(Practitioner|PractitionerRole|Organization|
      RelatedPerson|Patient|CareTeam|HealthcareService|Device) }], // Who will be responsible?
    // product[x]: What is to be administered/supplied. One of these 2:
    "productCodeableConcept" : { CodeableConcept },
    "productReference" : { Reference(Medication|Substance) },
    "dailyAmount" : { Quantity(SimpleQuantity) }, // How to consume/day?
    "quantity" : { Quantity(SimpleQuantity) }, // How much to administer/supply/consume
    "description" : <string> // Extra info describing activity to perform
  }
}],

"note" : [{ Annotation }] // Comments about the plan
}
```



Questionnaire Response

```
{
  "resourceType" : "QuestionnaireResponse",
  // from Resource: id, meta, implicitRules, and language
  // from DomainResource: text, contained, extension, and modifierExtension
  "identifier" : [ { Identifier } ], // Unique id for this set of answers
  "basedOn" : [ { Reference(CarePlan|ServiceRequest) } ], // Request fulfilled by this QuestionnaireResponse
  "questionnaire" : [ canonical(Questionnaire) ], // Form being answered
  "subject" : [ Reference(Any) ], // The subject of the questions
  "authored" : "<dateTime>", // Date the answers were gathered
  "actor" : [ Reference(Practitioner|PractitionerRole|Patient|RelatedPerson|Organization) ], // Person who received and recorded the answers
  "source" : [ Reference(Patient|Practitioner|PractitionerRole|RelatedPerson) ], // The person who answered the questions
  "item" : [ { // Groups and questions
    "linkId" : "<string>", // RI Pointer to specific item from Questionnaire
    "definition" : "<uri>", // ElementDefinition - details for the item
    "text" : "<string>", // Name for group or question text
    "answer" : [ { // The response(s) to the question
      // value[x]: Single-valued answer to the question. One of these 12:
      "valueBoolean" : <boolean>,
      "valueDecimal" : <decimal>,
      "valueInteger" : <integer>,
      "valueDate" : "<date>",
      "valueDateTime" : "<dateTime>",
      "valueTime" : "<time>",
      "valueString" : "<string>",
      "valueUri" : "<uri>",
      "valueAttachment" : { Attachment },
      "valueCoding" : { Coding },
      "valueQuantity" : { Quantity },
      "valueReference" : { Reference(Any) },
      "item" : [ { Content as for QuestionnaireResponse.item } ] // Nested groups and questions
    } ],
    "item" : [ { Content as for QuestionnaireResponse.item } ] // Nested questionnaire response item
  } ],
}
```

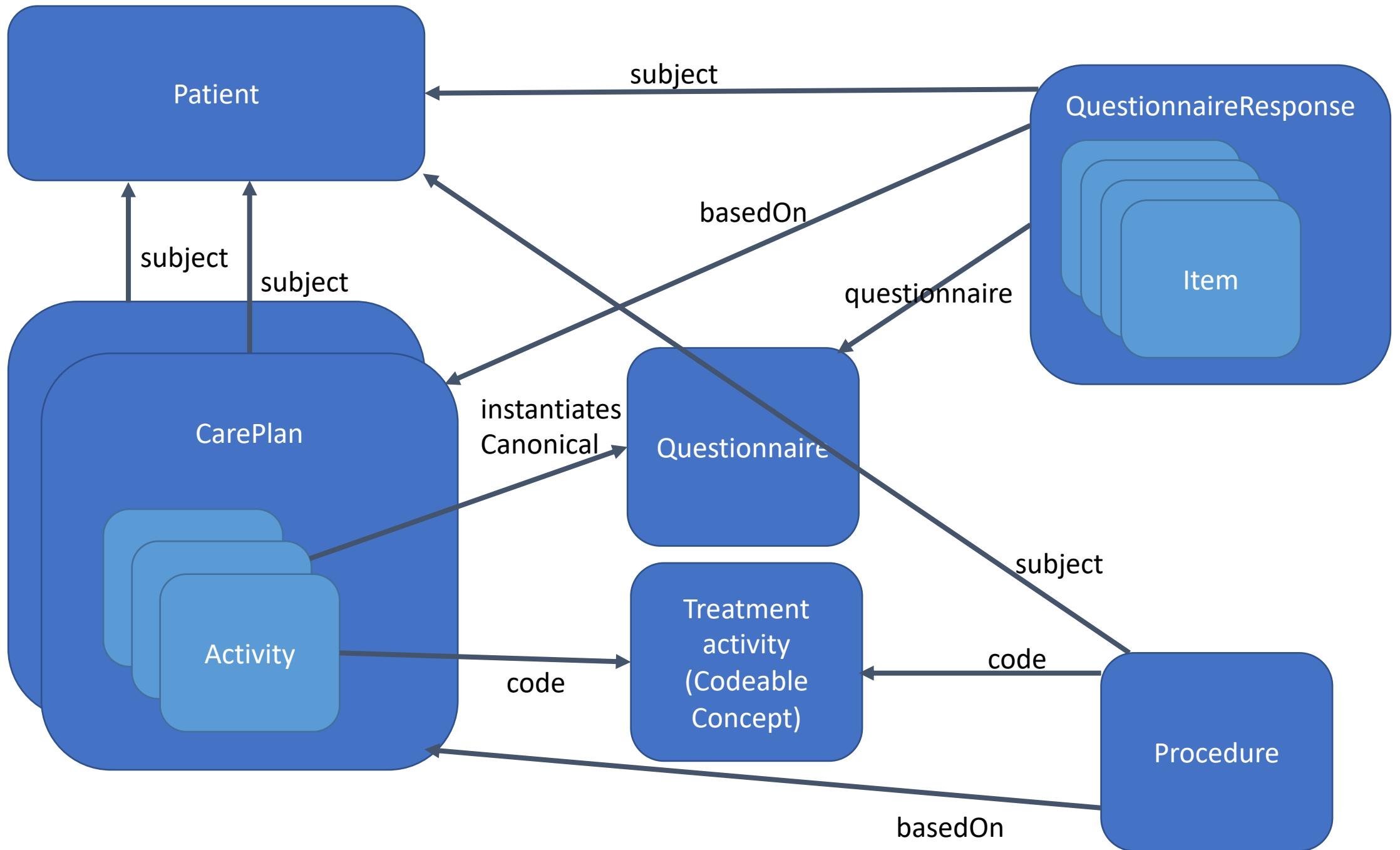


Procedure

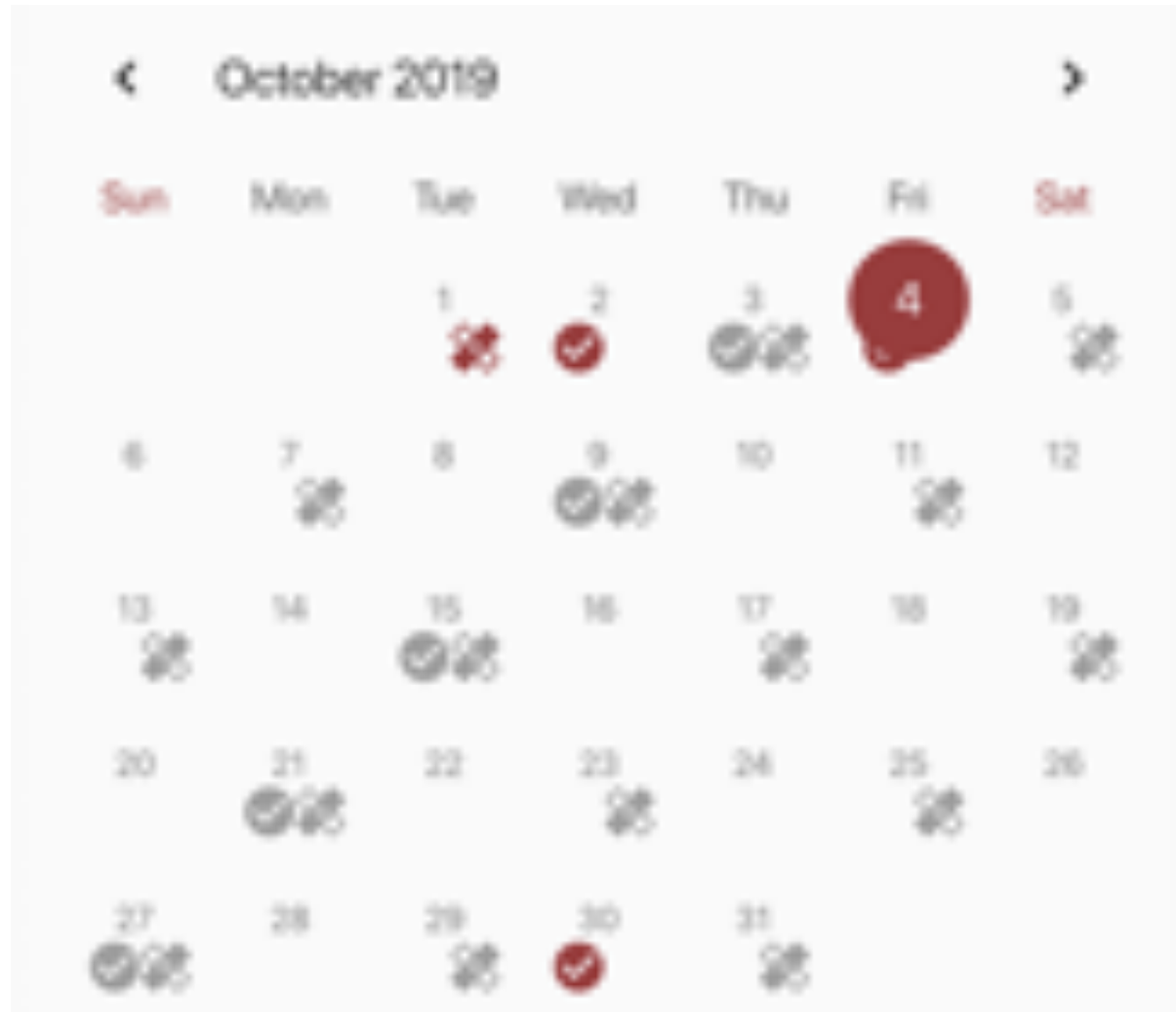
```
{
  "resourceType": "Procedure",
  // from Resource: id, meta, implicitRules, and language
  // from DomainResource: text, contained, extension, and modifierExtension
  "identifier": [{ Identifier }], // External Identifiers for this procedure
  "instantiatesCanonical": [{ canonical(PlanDefinition|ActivityDefinition|
    Measure|OperationDefinition|Questionnaire) }], // Instantiates FHIR protocol or definition
  "instantiatesUri": ["<uri>"], // Instantiates external protocol or definition
  "basedOn": [{ Reference(CarePlan|ServiceRequest) }], // A request for this procedure
  "partOf": [{ Reference(Procedure|Observation|MedicationAdministration) }], // Part of referenced event
  "status": "<code>", // R1 preparation | in-progress | not-done | suspended | aborted | completed | entered-in-error | unknown
  "statusReason": { CodeableConcept }, // Reason for current status
  "category": { CodeableConcept }, // Classification of the procedure
  "code": { CodeableConcept }, // Identification of the procedure
  "subject": { Reference(Patient|Group) }, // R1 Who the procedure was performed on
  "encounter": { Reference(Encounter) }, // Encounter created as part of
  // performed[x]: When the procedure was performed. One of these 5:
  "performedDateTime": "<dateTime>",
  "performedPeriod": { Period },
  "performedString": "<string>",
  "performedAge": { Age },
  "performedRange": { Range },
  "recorder": { Reference(Patient|RelatedPerson|Practitioner|PractitionerRole) }, // Who recorded the procedure
  "asserter": { Reference(Patient|RelatedPerson|Practitioner|PractitionerRole) }, // Person who asserts this procedure
  "performer": [{ // The people who performed the procedure
    "function": { CodeableConcept }, // Type of performance
    "actor": { Reference(Practitioner|PractitionerRole|Organization|Patient|RelatedPerson|Device) }, // R1 The reference to the practitioner
    "onBehalfOf": { Reference(Organization) } // Organization the device or practitioner was acting for
  }],
  "location": { Reference(Location) }, // Where the procedure happened
  "reasonCode": [{ CodeableConcept }], // Coded reason procedure performed
  "reasonReference": [{ Reference(Condition|Observation|Procedure|DiagnosticReport|DocumentReference) }], // The justification that the procedure was performed
  "bodySite": [{ CodeableConcept }], // Target body sites
  "outcome": { CodeableConcept }, // The result of procedure
  "report": [{ Reference(DiagnosticReport|DocumentReference|Composition) }], // Any report resulting from the procedure
  "complication": [{ CodeableConcept }], // Complication following the procedure
  "complicationDetail": [{ Reference(Condition) }], // A condition that is a result of the procedure
  "followUp": [{ CodeableConcept }], // Instructions for follow up
  "note": [{ Annotation }], // Additional information about the procedure
  "focalDevice": [{ // Manipulated, implanted, or removed device
    "action": { CodeableConcept }, // Kind of change to device
    "manipulated": { Reference(Device) } // R1 Device that was changed
  }],
  "usedReference": [{ Reference(Device|Medication|Substance) }], // Items used during procedure
  "usedCode": [{ CodeableConcept }], // Coded items used during the procedure
}
```

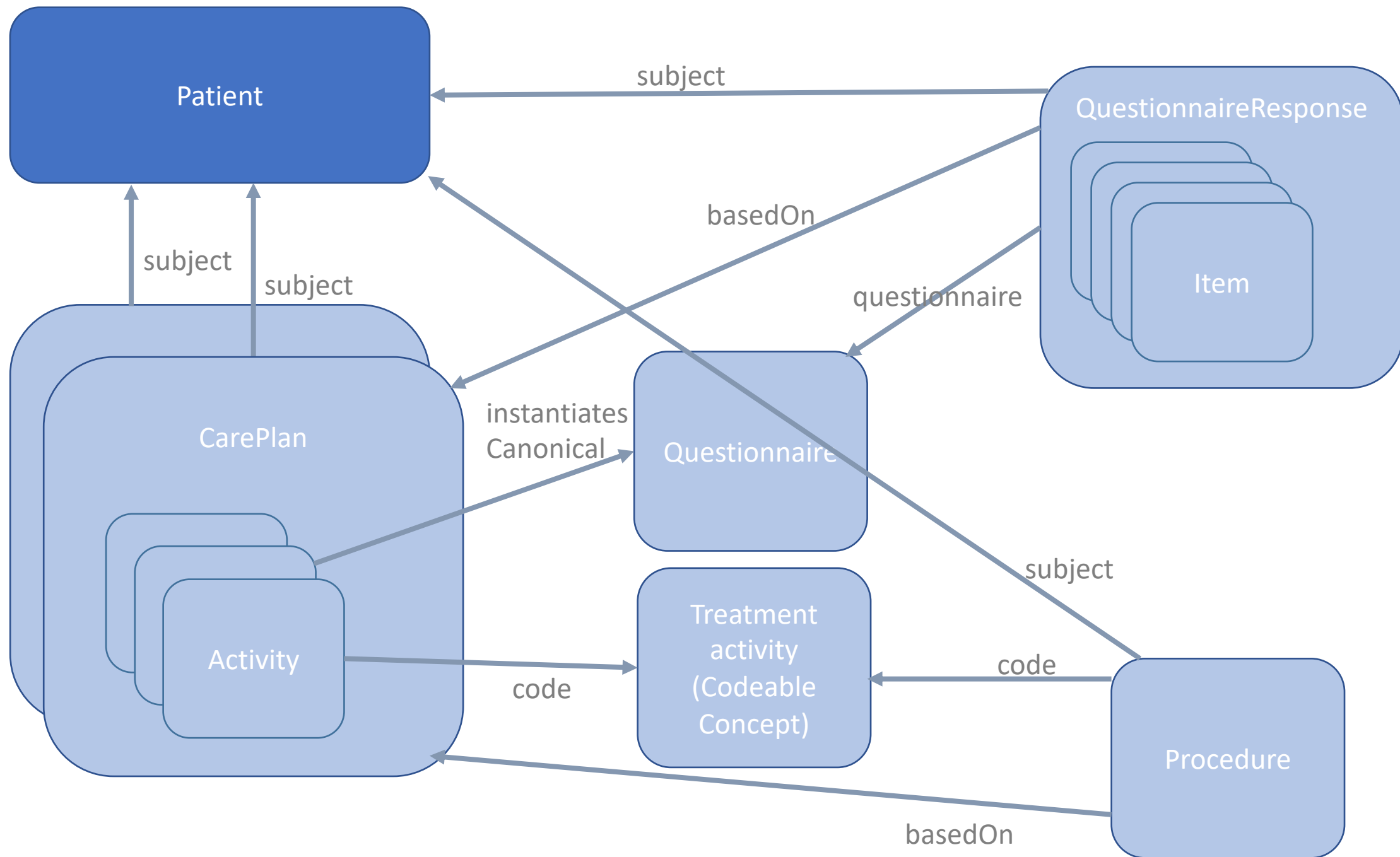
Procedure

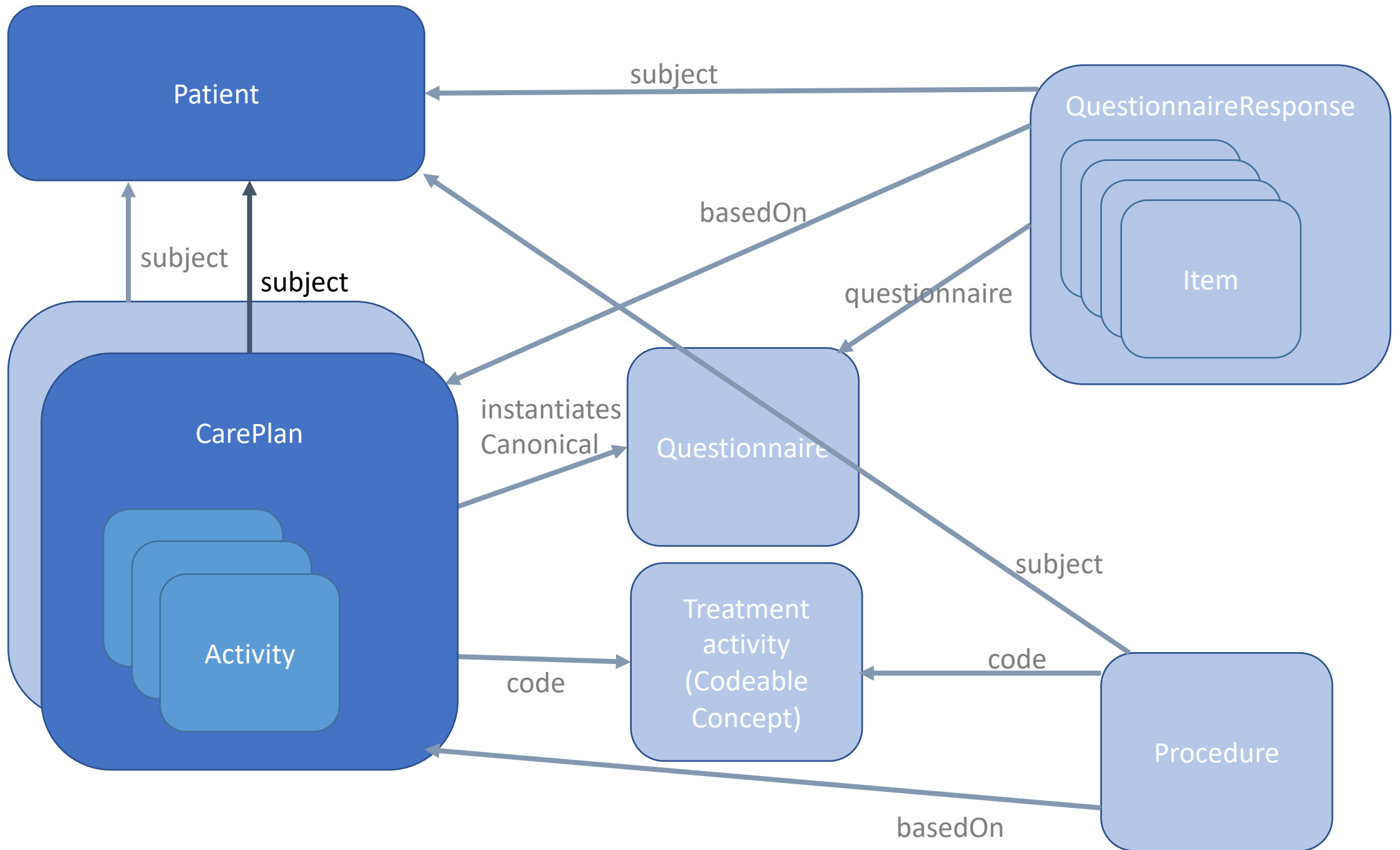
```
{
  "resourceType": "Procedure",
  // from Resource: id, meta, implicitRules, and language
  // from DomainResource: text, contained, extension, and modifierExtension
  "identifier": [{ Identifier }], // External Identifiers for this procedure
  "instantiatesCanonical": [{ canonical(PlanDefinition|ActivityDefinition|
    Measure|OperationDefinition|Questionnaire) }], // Instantiates FHIR protocol or definition
  "basedOn": [{ Reference(CarePlan|ServiceRequest) }], // A request for this procedure
  "partOf": [{ Reference(Procedure|Observation|MedicationAdministration) }], // Part of referenced event
  "status": "<code>", // R1 preparation | in-progress | not-done | suspended | aborted | completed | entered-in-error | unknown
  "statusReason": { CodeableConcept }, // Reason for current status
  "category": { CodeableConcept }, // Classification of the procedure
  "code": { CodeableConcept }, // Identification of the procedure
  "subject": { Reference(Patient|Group) }, // R1 Who the procedure was performed on
  "encounter": { Reference(Encounter) }, // Encounter created as part of procedure
  "performedDateTime": "<dateTime>",
  "performedPeriod": { Period },
  "performedString": "<string>",
  "performedAge": { Age },
  "performedRange": { Range },
  "recorder": { Reference(Patient|RelatedPerson|Practitioner|PractitionerRole) }, // Who recorded the procedure
  "asserter": { Reference(Patient|RelatedPerson|Practitioner|PractitionerRole) }, // Person who asserts this procedure
  "performer": [{ // The people who performed the procedure
    "function": { CodeableConcept }, // Type of performance
    "actor": { Reference(Practitioner|PractitionerRole|Organization|Patient|RelatedPerson|Device) }, // R1 The reference to the practitioner
    "onBehalfOf": { Reference(Organization) } // Organization the device or practitioner was acting for
  }],
  "location": { Reference(Location) }, // Where the procedure happened
  "reasonCode": [{ CodeableConcept }], // Coded reason procedure performed
  "reasonReference": [{ Reference(Condition|Observation|Procedure|DiagnosticReport|DocumentReference) }], // The justification that the procedure was performed
  "bodySite": [{ CodeableConcept }], // Target body sites
}
```

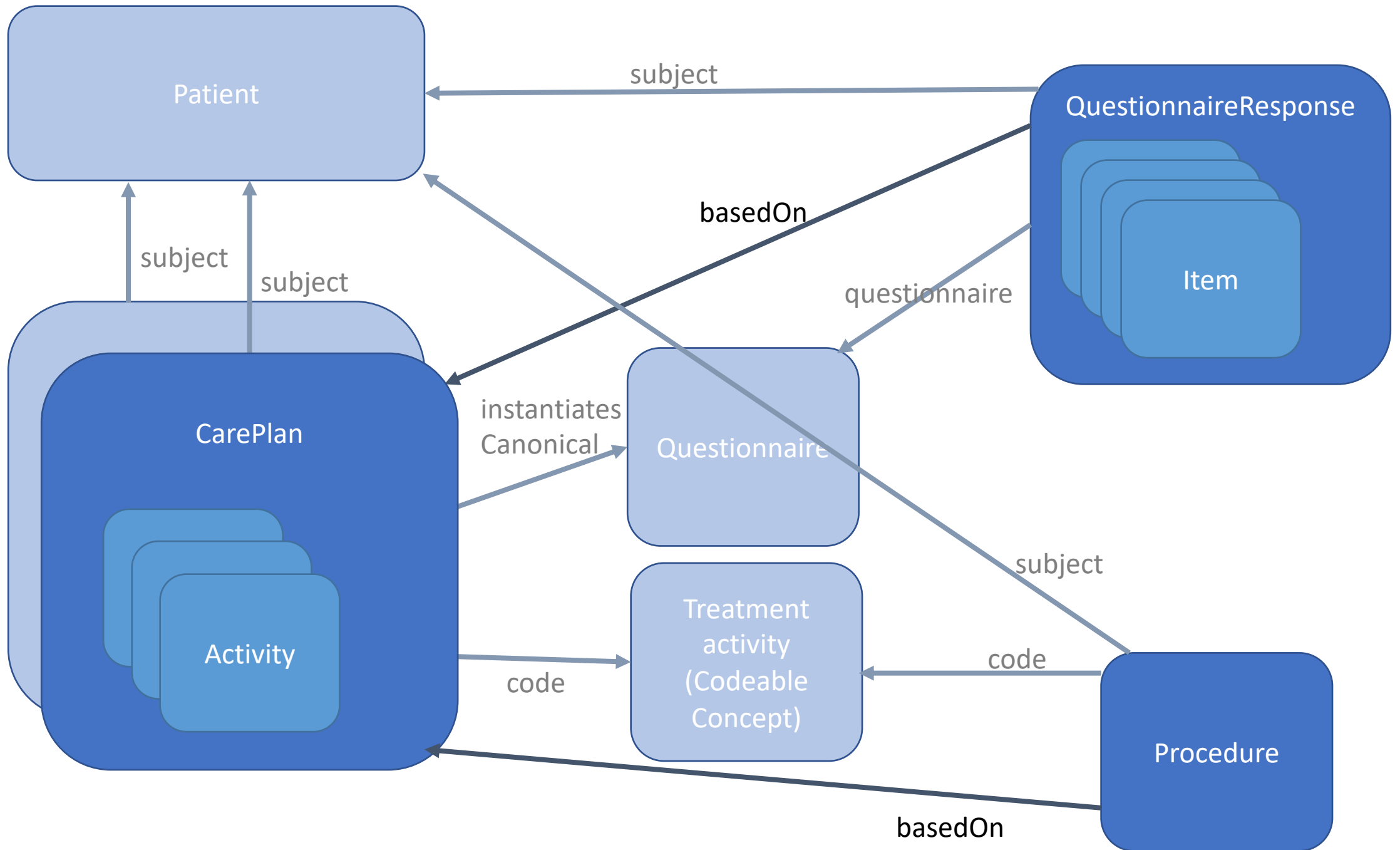


Calendar



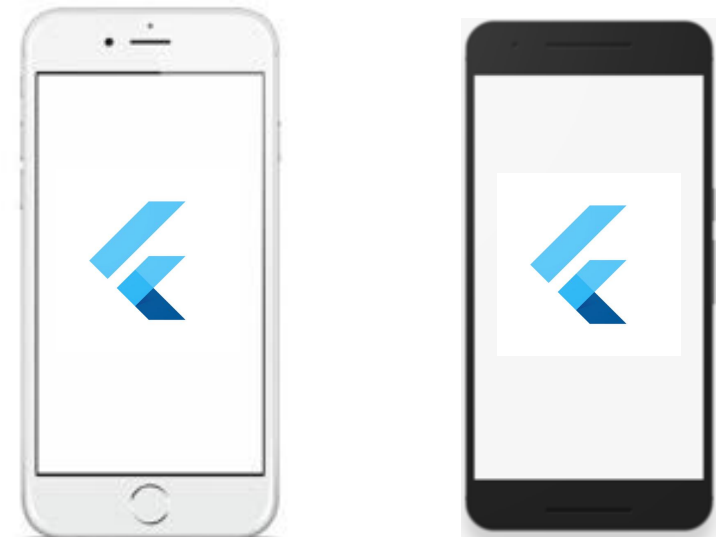
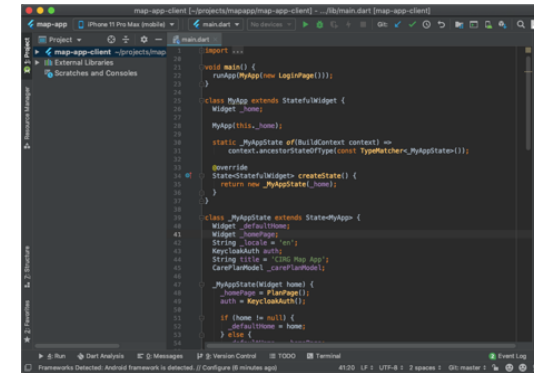







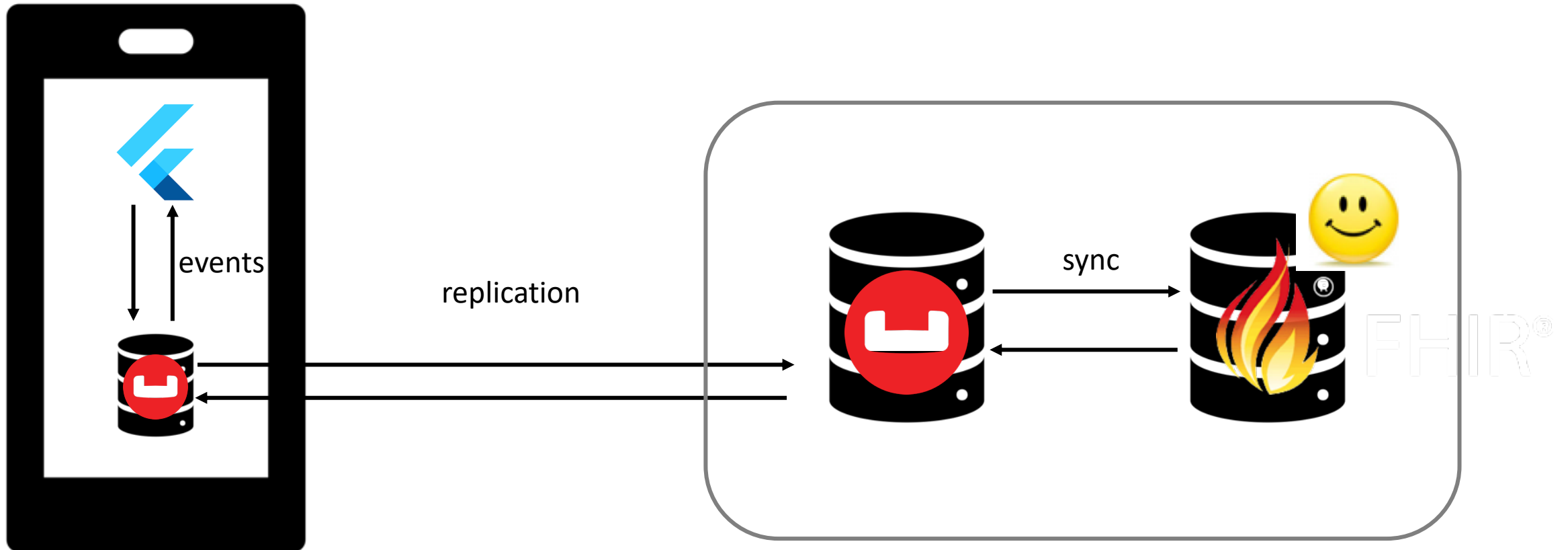


Cross-platform framework: Google's Flutter

- Deploy to iOS, Android, and Web
- Extensive catalog of community-contributed libraries
- User interface is rebuilt automatically when there is a change in the data model



Offline-first mobile app with  Flutter ,
 FHIR[®] and  Couchbase ?



Challenges

- FHIR resources
 - Procedure?
- Offline operation
 - CouchBase vs. CouchDB?
 - FHIR resource validation?
 - Offline login?

Thank you!