Using FAIMS Mobile for Field Data Recording

Brian Ballsun-Stanton (Macquarie University), Jens Klump (CSIRO), Shawn Ross (Macquarie University)

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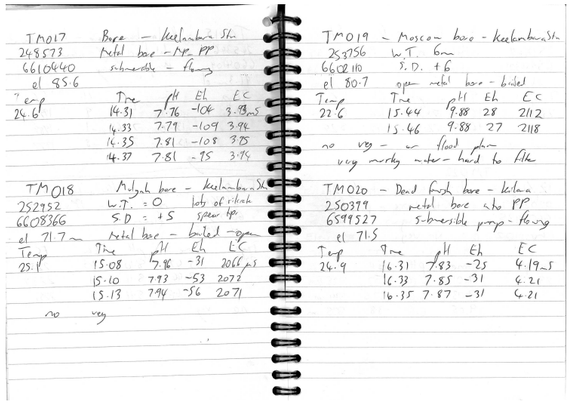
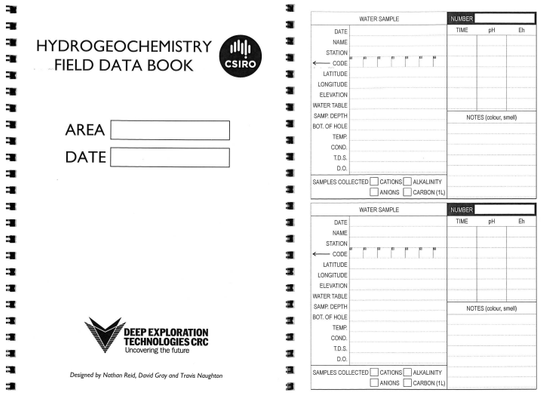
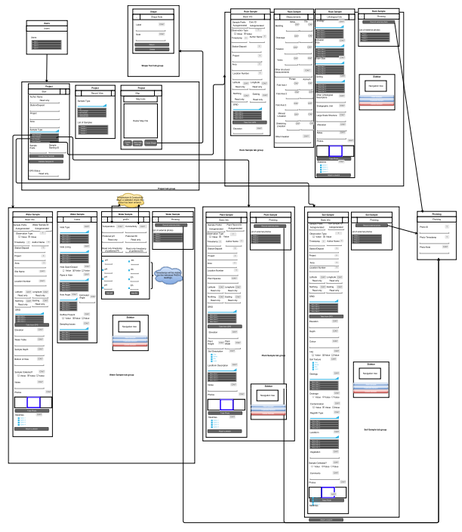






Data Schema (XML)

Logic (Beanshell)

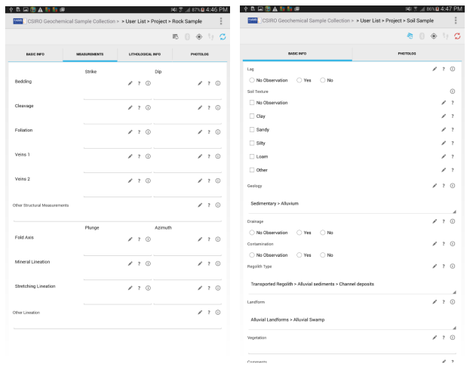
UI Schema (XML)

Geosampling data was initially collected via notebook.

CSIRO Researchers then moved to pre-printed field notebooks for more accurate data entry.

Imported into FAIMS Mobile, the CSIRO workflow was deployed for multi-device field recording.

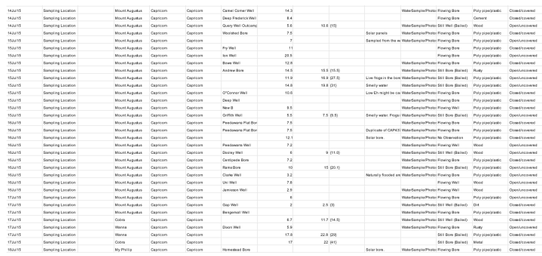
Three customisable primary files implement a model, view, and controller field data recording system.



After extensive testing, this recording system (`module') was deployed. These two screenshots from the app show multi-column formats, radiobuttons, checkboxes, and hierarchical dropdowns.

Data was collected on multiple tablets in remote field locations, offline.

FAIMS Mobile allows asynchronous work on tablets with eventual synchronisation, when the tablets connect to a local or online network. A local server, shown here, was mounted in a truck for fieldwork.



After return to base, data was exported to shapefiles, a sqlite database, and CSVs. Upon export, all images were automatically renamed and tagged with metadata using information from the associated record.

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ArchEntity Table

Identifier	Location	Author
Potsherd 0017	-33.9 151.23	Jim F.
Potsherd 0018	-33.9 151.23	Sarah H.
Lithic 01	-33.9 151.24	Sarah H.

Attribute Table

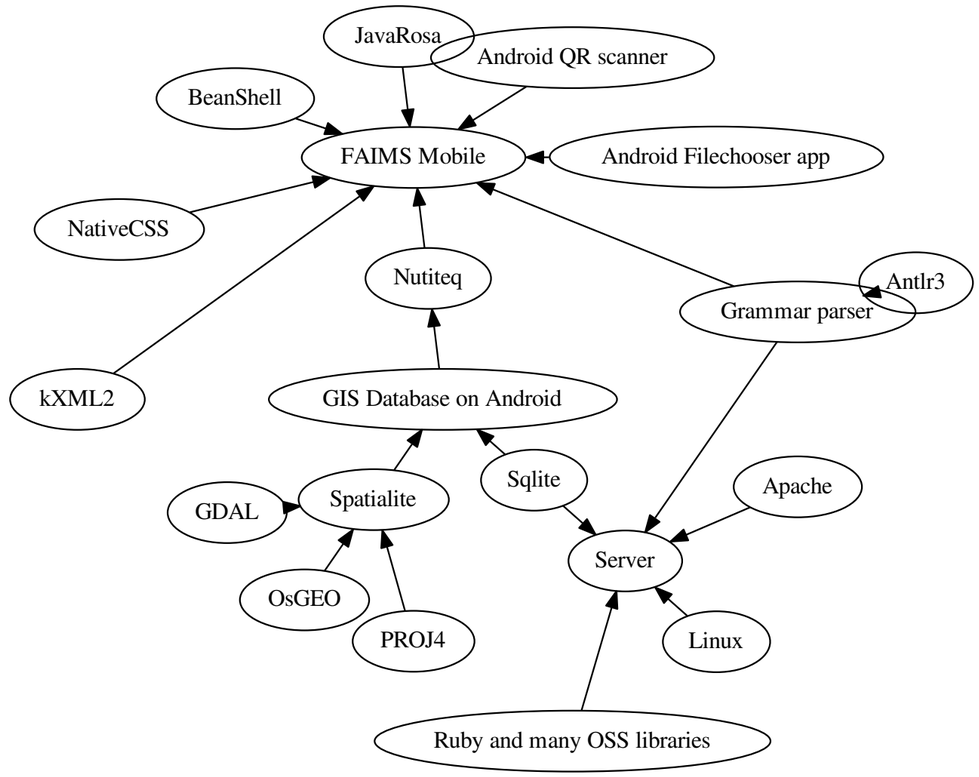
Attribute Name	Metadata
Unit	Part of DOI
Length	Multivalued
Shape	

Original Table

	Unit	Length	Shape
Potsherd 0017	155	8mm, 10mm @ Rim	Bowl
Potsherd 0018	156		
Lithic 01	157		

AEntValue Table

Identifier	Attribute	Value
Potsherd 0017	Length	8mm
Potsherd 0017	Length - Rim	10mm
Potsherd 0017	Unit	155
Potsherd 0017	Shape	Bowl



Records are defined in 3 logical tables[1] 'Rows' are defined in the ArchEntity table, which also holds cruical GIS data. 'Columns' are defined by the attribute and Ideal Entity tables. The Attribute table defines what attributes are possible, their names, and their list/export formats. The Ideal Entity table defines which attributes belong to which entity. By defining these tables in DML (Data *Manipulation* Language) rather than DDL (Data *Definition* Language), the structure of the database remains consistent. This consistent structure allows for significant query reuse and allows us to dynamically script the fields of a workflow *after* all the fundamental data interactions of FAIMS Mobile have been rewritten.

Image by Geoff Matheson.

The three *sine qua non* open-source libraries of this project are:

- JavaRosa which allows us to parse XML into native android elements;
- BeanShell which allows us to include a java-like scripting language;
- Sqlite which is a supremely stable single-user database;

By relying on stable, free, and public code we did not have to reinvent the wheel. We could, instead, focus on implementing our data schema and the novel features required by our environment.

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Quick Navigation:

Abstract:

FAIMS Mobile was originally developed for field data recording in archaeology. It has since been adapted for use in other disciplines.

The app is based on open-source software with open data formats to allow easy federation with other data formats. This presentation describes the internal architecture of FAIMS Mobile and how it can be used.

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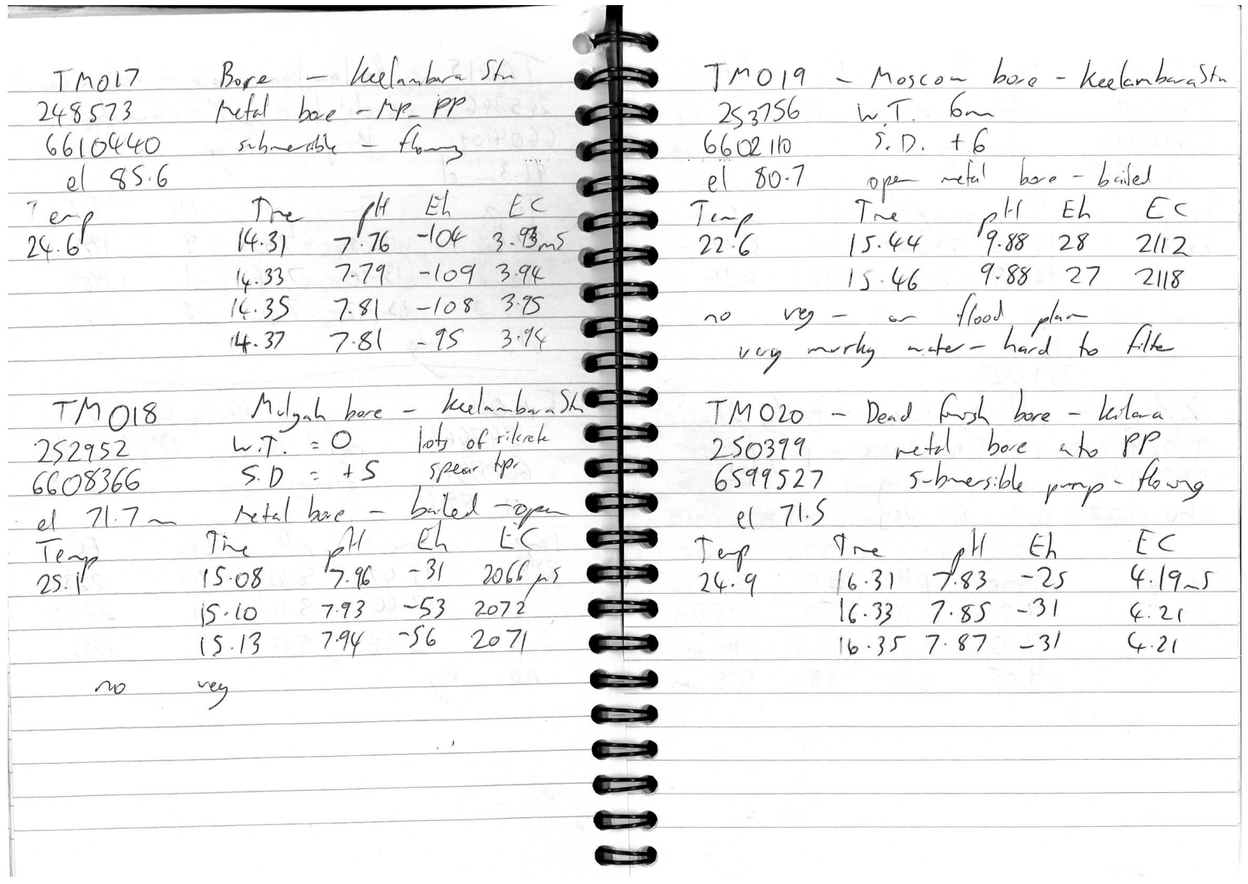
CSIRO Workflow

FAIMS Mobile is an open-source software platform (comprising an android client and ruby server on ubuntu) funded by the Australian Research Council, the National eResearch Tools and Resources scheme (Australia), and six Australian universities. It is designed to provide a means of collecting rich, geospatial, and multi-media field data on multiple tablets with no network connectivity in the middle of nowhere. While originally intended to support archaeologists, FAIMS Mobile provided a sufficiently general field recording framework to allow for geochemical and biological sampling by multiple teams of CSIRO researchers.



Critical to the narrative is that the data design implemented by FAIMS Mobile existed first as data collected freehand in a field notebook. Field researchers have their own workflows to reflect methodologies and *imposition* of workflow changes, however slight,

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can render data incommensurate.

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HYDROGEOCHEMISTRY
FIELD DATA BOOK

CSIRO

AREA

DATE

DEEP EXPLORATION TECHNOLOGIES CRC
Uncovering the future

Designed by Nathan Reid, David Gray and Travis Naughton

WATER SAMPLE		NUMBER		
DATE		TIME	pH	Eh
NAME				
STATION				
← CODE	1 2 3 4 5 6 7			
LATITUDE				
LONGITUDE				
ELEVATION				
WATER TABLE				
SAMP. DEPTH		NOTES (colour, smell)		
BOT. OF HOLE				
TEMP.				
COND.				
T.D.S.				
D.O.				
SAMPLES COLLECTED ☐ CATIONS ☐ ALKALINITY ☐ ANIONS ☐ CARBON (1L)				

WATER SAMPLE		NUMBER		
DATE		TIME	pH	Eh
NAME				
STATION				
← CODE	1 2 3 4 5 6 7			
LATITUDE				
LONGITUDE				
ELEVATION				
WATER TABLE				
SAMP. DEPTH		NOTES (colour, smell)		
BOT. OF HOLE				
TEMP.				
COND.				
T.D.S.				
D.O.				
SAMPLES COLLECTED ☐ CATIONS ☐ ALKALINITY ☐ ANIONS ☐ CARBON (1L)				

The next stage of field data collection entailed typesetting data collection forms based on the field notebook. These spiral bound data collection forms embodied the workflows of geosampling and critically moved the workflow from knowledge-in-the-head where the workflow was *present-at-hand* (i.e. after consideration of the tool, the researcher knew what data to enter next from their personal knowledge of the workflow) to *ready-to-hand.* The ready-to-hand workflow, embodied in these typeset forms, allowed the workflow to be embodied in the page: reducing errors, reducing cognitive load, and allowing the researcher to focus on the field research, instead of the methods of research.

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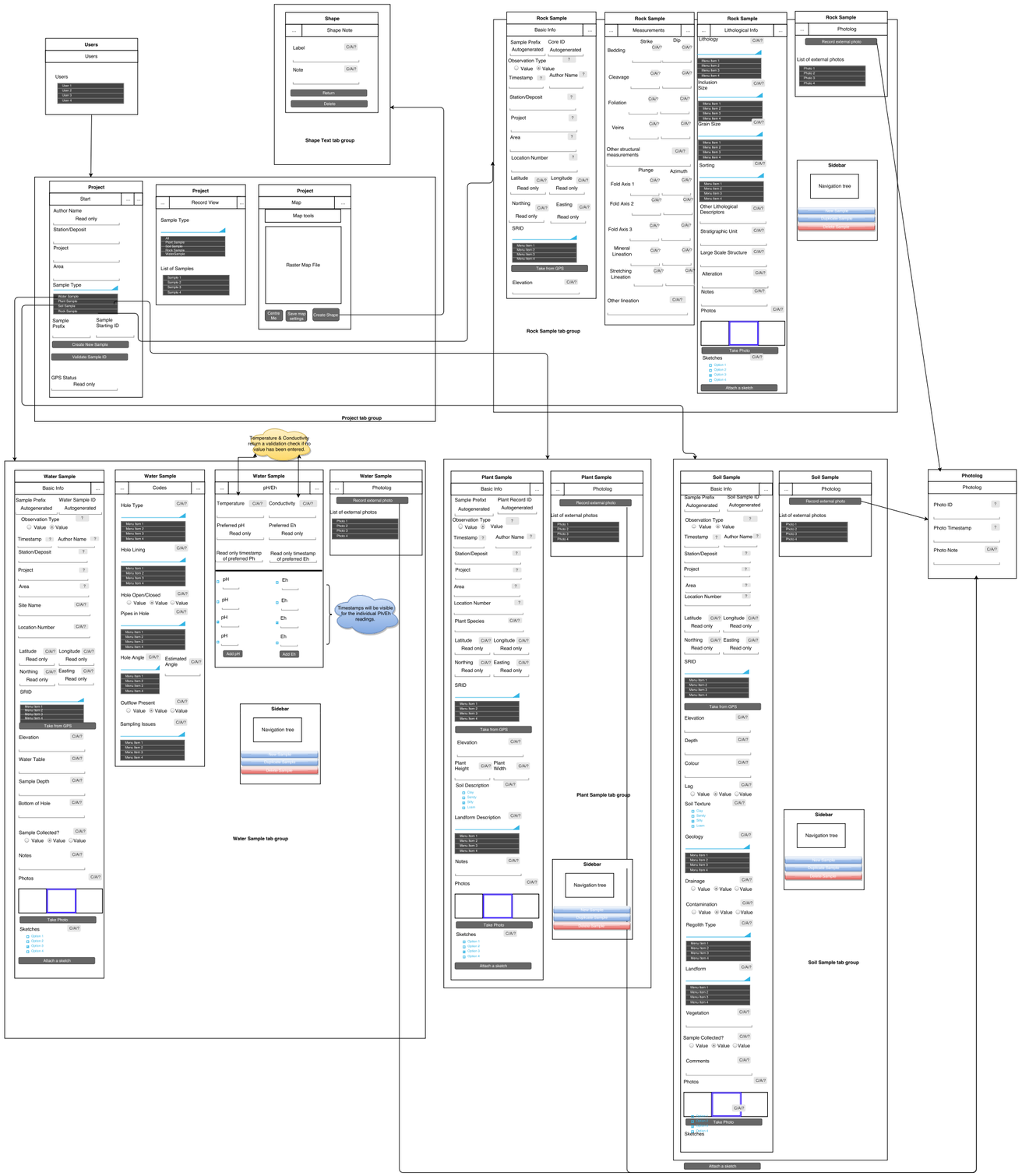

Imported into FAIMS Mobile, the CSIRO workflow was deployed for the multi-device field recording. This workflow implements a waterfall methodology. Due to the requirements of offline field research and the asynchronous sync, *changes* to a module in the field are quite difficult and so we've embraced a waterfall model to get the design 'right' in the first place.

This wireframe diagram diagrams every attribute to appear in the module as well as the workflows of movement from screen to screen. It is both intended as a representational explainer as well as a design document. It allows everyone to understand the module to be in a way that reduces misunderstandings. This wireframe demonstrates how four different field collection methods: Water samples, rock samples, soil samples, and plant samples were all incorporated into the same data collection module.

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Data Schema (XML)

```xml
<?xml version="1.0" encoding="UTF-8"?>
<dataSchema>
  <RelationshipElement name="Water Sample pH" type="bidirectional">
    <description>Implements a 1:N relationship between Water Samples and pH</description>
  </RelationshipElement>
  <RelationshipElement name="Water Sample Eh" type="bidirectional">
    <description>Implements a 1:N relationship between Water Samples and Eh</description>
  </RelationshipElement>
  <RelationshipElement name="Sample Photolog" type="bidirectional">
    <description>Implements a 1:N relationship between Samples and Photologs</description>
  </RelationshipElement>

  <ArchaeologicalElement name="Water Sample">
    <description></description>
    <property name="Water Sample Prefix" type="freetext" isIdentifier="true">
      <description></description>
      <formatString><![CDATA[$2]]></formatString>
    </property>
    <property name="Water Sample ID" type="measure" isIdentifier="true">
      <description></description>
      <formatString><![CDATA[$2 - Water - ]]></formatString>
    </property>
    <property name="Water Sample Date" type="measure" isIdentifier="true">
      <description></description>
      <formatString><![CDATA[$2]]></formatString>
    </property>
    <property name="Observation Type" type="vocab">
      <description></description>
      <formatString><![CDATA[{{if $1 then "$1 "}}{{if $2 then "$2 "}}{{if $3 then "{$3} "}}{{if lessThan($4, 1.0) then "[$4] "}}]]></formatString>
      <lookup>
        <term> {Sampling_Location}
          <description></description>
        </term>
        <term> {Observation_Only}
          <description></description>
        </term>
      </lookup>
    </property>
    <property name="Location Number" type="measure">
      <description></description>
    <formatString><![CDATA[{{if $1 then "$1 "}}{{if $2 then "$2 "}}{{if $3 then "{$3} "}}{{if lessThan($4, 1.0) then "[$4] "}}]]></formatString>
    </property>
    <property name="Station" type="freetext">
      <description></description>
    <formatString><![CDATA[{{if $1 then "$1 "}}{{if $2 then "$2 "}}{{if $3 then "{$3} "}}{{if lessThan($4, 1.0) then "[$4] "}}]]></formatString>
    </property>
    <property name="Project" type="freetext">
```

Logic (Beanshell)

```
onEvent("Project/Start/New_Sample", "delayClick", "newSample();");
onEvent("Project/Start/Check_For_Duplicates", "click", "checkForDuplicates();");
onEvent("Project/Start/Duplicate_ID_List", "click", "loadSample();");

onEvent("Project/Search",              "show",        "loadSearch();");
onEvent("Project/Search/searchButton", "click",       "loadSearch();");
onEvent("Project/Search/Sample_Types", "click",       "loadSearch();");
onEvent("Project/Search/users",        "click",       "loadSearch();");
onEvent("Project/Search/Sample_List",  "click",       "loadSample();");

onEvent("Project/Map", "show", "renderDynamicMapViews();");
onEvent("Project/Map/Centre_Map", "click", "centreMap();");
onEvent("Project/Map/Save_Map_Settings", "click", "saveMapSettings();");
onEvent("Project/Map/Create_Shape", "click", "createShape();");

/* Generates of sample types for dropdown selection. */
sample_types = new ArrayList();
sample_types.add(new NameValuePair("{Water_Sample}", "Water Sample"));
sample_types.add(new NameValuePair("{Plant_Sample}", "Plant Sample"));
sample_types.add(new NameValuePair("{Soil_Sample}", "Soil Sample"));
sample_types.add(new NameValuePair("{Rock_Sample}", "Rock Sample"));
populateDropDown("Project/Start/Sample_Types", sample_types);
sample_types.add(0, new NameValuePair("{All}", "Sample"));
populateDropDown("Project/Search/Sample_Types", sample_types);


setStationDeposit(String value) {
    setFieldValue("Project/Start/Station_Deposit", value);
    fetchOne("REPLACE INTO localSettings(key, value) VALUES('Station_Deposit', '" + value + "');", null);
}

loadStationDeposit() {
    fetchOne("SELECT value FROM localSettings WHERE key = 'Station_Deposit';", new FetchCallback() {
        onFetch(result) {
            print("[loadStationDeposit()] fetched Station_Deposit from localSettings: " + result);
            if (!isNull(result)) {
                value = result.get(0);
                setFieldValue("Project/Start/Station_Deposit", value);
                print("[loadStationDeposit()] set Station_Deposit to: " + value);
            }
        }
    });
}

setProject(String value) {
    setFieldValue("Project/Start/Project", value);
```

UI Schema (XML)

```xml
    <label>{Water_Sample}</label>
    <group ref="Basic_Info">
      <label>{Basic_Info}</label>
      <group ref="container0" faims_style="orientation">
        <label></label>
        <group ref="child1" faims_style="even">
          <label></label>
          <input ref="Water_Sample_Prefix" faims_attribute_name="Water Sample Prefix" faims_attribute_type="measure" faims_certainty="false"
          faims_annotation="false" faims_read_only="true">
            <label>{Water_Sample_Prefix}</label>
          </input>
        </group>
        <group ref="child2" faims_style="even">
          <label></label>
          <input ref="Water_Sample_ID" faims_attribute_name="Water Sample ID" faims_attribute_type="measure" faims_certainty="false" faims_annotation
          ="false" faims_read_only="true">
            <label>{Water_Sample_ID}</label>
          </input>
        </group>
      </group>
      <group ref="container1" faims_style="orientation">
        <label></label>
        <group ref="child1" faims_style="even">
          <label></label>
          <input ref="Timestamp" faims_certainty="false" faims_annotation="false" faims_read_only="true">
            <label>{Timestamp}</label>
          </input>
        </group>
        <group ref="child2" faims_style="even">
          <label></label>
          <input ref="Author_Name" faims_certainty="false" faims_annotation="false" faims_read_only="true">
            <label>{Author_Name}</label>
          </input>
        </group>
      </group>
      <input ref="Station_Deposit" faims_attribute_name="Station" faims_attribute_type="measure" faims_certainty="false" faims_annotation="false"
      faims_read_only="true">
        <label>{Station_Deposit}</label>
      </input>
      <input ref="Project" faims_attribute_name="Project" faims_attribute_type="measure" faims_certainty="false" faims_annotation="false"
      faims_read_only="true">
        <label>{Project}</label>
      </input>
      <input ref="Area" faims_attribute_name="Area" faims_attribute_type="measure" faims_certainty="false" faims_annotation="false" faims_read_only="
      true">
        <label>{Area}</label>
```

These are the primary files which implement a scriptable model (data schema), view (ui schema), and controller (ui logic) field data recording implementation. By scripting a field recording workflow, FAIMS Mobile itself can function on supporting field recording in network-degraded environments, and individual 'modules' (functioning sets of these scripts) can focus on implementing highly specific and customised workflows.

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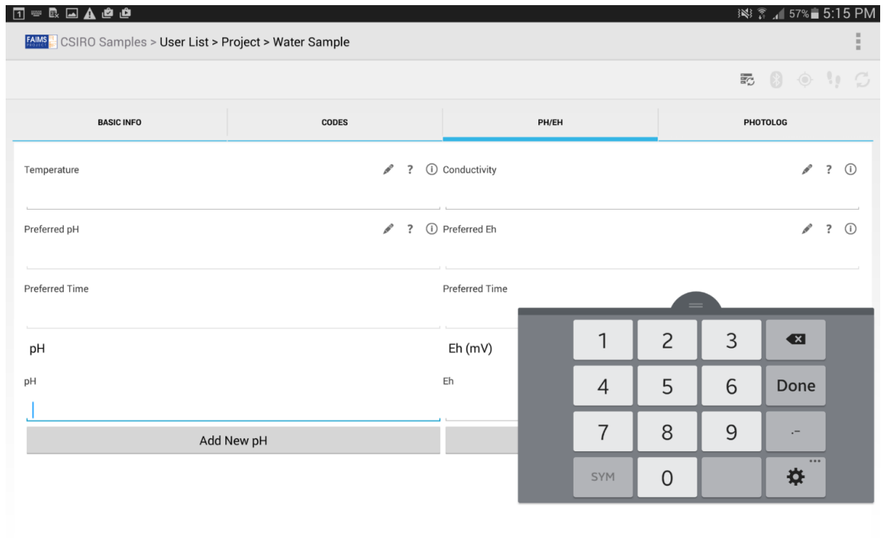
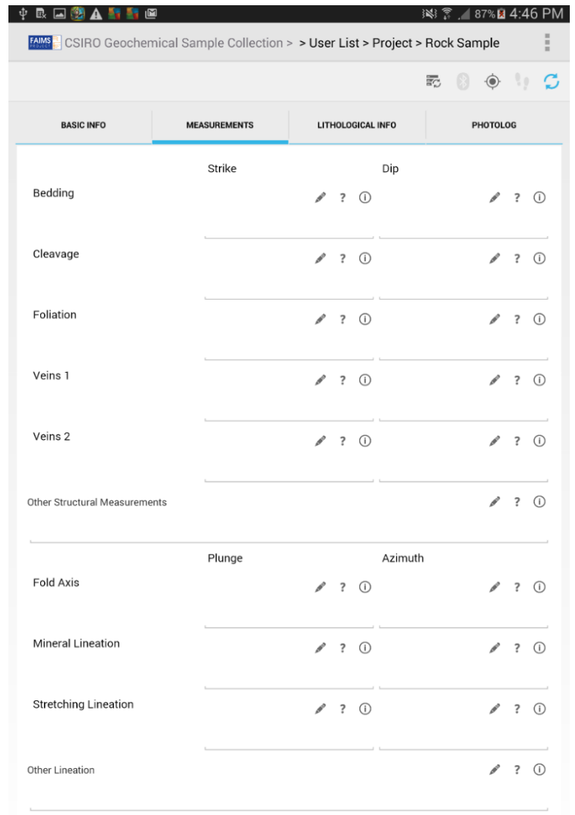
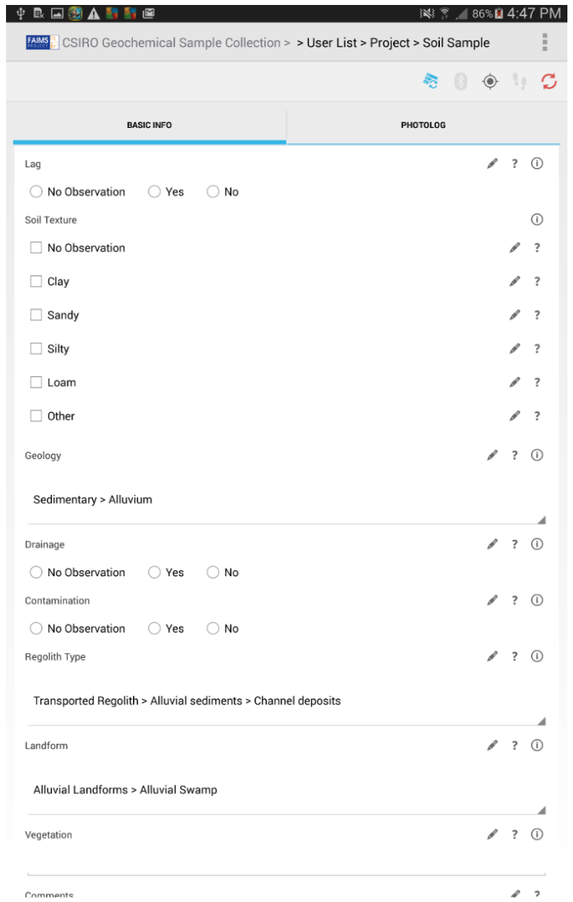


Multiple Ph/Eh measurements can be taken. We have support for a dynamic UI, so the number of measurements is finite, but unbounded. The 'best' measurement can then be written back into the parent entity.



Multi-column layouts are possible for 'tabular' data. The choice of the number of columns is mainly a choice of device size: smaller androids do not deal with many columns well.



We support checkboxes, drop-downs, and radio buttons. Dropdowns can have a hierarchical navigation, for rapid selection among hundreds of choices.

These are three screens from the FAIMS Mobile module showing some of the configurations of attributes suitable for this workflow. Of note, each attribute has annotation (the little pencil) and certainty (the little ?), allowing users, with a long-press, to 'write in the margins' of that attribute. The circled-i icon represents a description or information box, allowing descriptive or assistive text to appear for the attribute and any elements of the constrained vocabularies it has, thereby providing the benefit of a contextual field manual. Records autosave, meaning users can interact with the module in much the same way they do with paper and pencil.

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Alistair White checking on the server mounted in his truck.

Data was collected on multiple tablets in the field. These tablets were offline to save battery. Different sampling teams (Water, rock, soil, and plant) all went out to rural Australia and were able to use this module to record data, take pictures, and take GIS points all in the same framework. The data, collected at the same time while tablets were offline, was able to sync after the tablets came back into server range. This synced data then resulted in a singular export, with all data present.

FAIMS PROJECT

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AUSTRALIA

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SoilSample.shx	172 bytes	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
SoilSample.shp	288 bytes	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
SoilSample.dbf	10.3 kB	Xbase docu…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
shape.sqlite3	4.5 MB	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
RockSample.shx	212 bytes	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
RockSample.shp	316 bytes	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
RockSample.dbf	17.3 kB	Xbase docu…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Relationship-WaterSamplePH.csv	4.4 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Relationship-WaterSampleEh.csv	3.7 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Relationship-SamplePhotolog.csv	0 bytes	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
PlantSample.shx	172 bytes	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
PlantSample.shp	320 bytes	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
PlantSample.dbf	11.6 kB	Xbase docu…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
MQ50_Water_17Oct15_1.jpg.json	2.5 kB	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps/WaterSample/Photos
MQ50_Water_17Oct15_1.jpg	1.7 MB	JPEG Image	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps/WaterSample/Photos
mq10_Water_21Oct15_1a.jpg.json	2.5 kB	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps/WaterSample/Photos
mq10_Water_21Oct15_1a.jpg	1.3 MB	JPEG Image	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps/WaterSample/Photos
G2G13_Location_empty_Rock_21Oct15_1a.j…	2.8 kB	unknown	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps/RockSample/Photos
G2G13_Location_empty_Rock_21Oct15_1a.jpg	518.8 kB	JPEG Image	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps/RockSample/Photos
Entity-WaterSample.csv	17.8 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Entity-SoilSample.csv	4.3 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Entity-RockSample.csv	7.9 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Entity-PlantSample.csv	4.6 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Entity-Photolog.csv	1.1 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Entity-pH.csv	5.2 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps
Entity-Note.csv	1.6 kB	CSV docum…	05 April 201…	/CSIROGeochemicalSampleCollectionSydneyMaps

14Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Camel Corner Well	14.3				WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
14Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Deep Frederick Well	8.4					Flowing Bore	Cement	Closed/covered
14Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Query Well Outcamp	5.6	10.6	(15)		WaterSample/Photol	Still Well (Bailed)	Wood	Open/uncovered
14Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Woolshed Bore	7.5			Solar panels	WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn		7			Sampled from the w	WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Open/uncovered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Fry Well	11					Flowing Bore	Poly pipe/plastic	Closed/covered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Ion Well	20.5					Flowing Bore	Poly pipe/plastic	Open/uncovered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Bowe Well	12.8				WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Andrew Bore	14.5	15.5	(15.5)		WaterSample/Photol	Still Bore (Bailed)	Rusty	Open/uncovered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn		11.9	16.9	(27.5)	Live frogs in the bore	WaterSample/Photol	Still Bore (Bailed)	Poly pipe/plastic	Open/uncovered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn		14.8	19.8	(31)	Smelly water	WaterSample/Photol	Still Bore (Bailed)	Poly pipe/plastic	Open/uncovered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	O"Connor Well	10.6			Low Eh might be ca	WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Deep Well					WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	New B	9.5				WaterSample/Photol	Flowing Well	Poly pipe/plastic	Closed/covered
15Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Griffith Well	5.5	7.5	(9.5)	Smelly water. Frogs	WaterSample/Photol	Still Bore (Bailed)	Poly pipe/plastic	Open/uncovered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Peedawarra Flat Bor	7.5				WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Peedawarra Flat Bor	7.5			Duplicate of CAP43	WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn		12.1			Solar bore.	WaterSample/Photol	No Observation	Poly pipe/plastic	Closed/covered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Peedawarra Well	7.2				WaterSample/Photol	Flowing Well	Wood	Open/uncovered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Dooley Well	6	9	(11.0)		WaterSample/Photol	Still Well (Bailed)	Wood	Open/uncovered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Centipede Bore	7.2				WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Rams Bore	10	15	(20.1)		WaterSample/Photol	Still Bore (Bailed)	Poly pipe/plastic	Open/uncovered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Clarke Well	3.2			Naturally flooded are	WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Open/uncovered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Uni Well	7.8					Flowing Well	Wood	Open/uncovered
16Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Jamieson Well	2.9				WaterSample/Photol	Flowing Well	Wood	Open/uncovered
17Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn		6				WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Open/uncovered
17Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Gap Well	2	2.5	(3)		WaterSample/Photol	Still Well (Bailed)	Dirt	Closed/covered
17Jul15	Sampling Location		Mount Augustus	Capricorn	Capricorn	Bengemall Well					WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered
17Jul15	Sampling Location		Cobra	Capricorn	Capricorn		6.7	11.7	(14.5)		WaterSample/Photol	Still Well (Bailed)	Wood	Closed/covered
17Jul15	Sampling Location		Wanna	Capricorn	Capricorn	Dixon Well	5.9				WaterSample/Photol	Flowing Bore	Rusty	Open/uncovered
17Jul15	Sampling Location		Wanna	Capricorn	Capricorn		17.8	22.8	(29)			Still Bore (Bailed)	Poly pipe/plastic	Closed/covered
17Jul15	Sampling Location		Cobra	Capricorn	Capricorn		17	22	(41)			Still Bore (Bailed)	Metal	Closed/covered
18Jul15	Sampling Location		My Phillip	Capricorn	Capricorn	Homestead Bore				Solar bore.	WaterSample/Photol	Flowing Bore	Poly pipe/plastic	Closed/covered

After return to base, data exported (via customisable exporter) into shapefiles, a sqlite database, and CSVs. All pictures are renamed to the record they belong to and tagged with their record's metadata. This exporter (https://github.com/FAIMS/shapefileExport) is also completely customisable, up to and including running arbitrary linux programs. This one uses imagemagick and mogrify to properly export photos as well as spatialite-tool to export shapefiles.

The exporter is a shell script calling python scripts all hosted in their own github repository. This allows for arbitrary customisation on export to whatever format is appropriate. We use spatialite to export shapefiles and exiftool to write identifiers, authors, creation times, and the entire record they come from *to* each picture. By writing the exifdata to each picture, we ensure that the pictures, even if separated, retain their connection to the original record.

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www.faims.edu.au

FAIMS Internal Architecture

ArchEntity Table

Identifier	Location	Author
Potsherd 0017	-33.9 151.23	Jim F.
Potsherd 0018	-33.9 151.23	Sarah H.
Lithic 01	-33.9 151.24	Sarah H.

Attribute Table

Attribute Name	Metadata
Unit	Part of DOI
Length	Multivalued
Shape	

Original Table

	Unit	Length	Shape
Potsherd 0017	155	8mm, 10mm @ Rim	Bowl
Potsherd 0018	156		
Lithic 01	157		

AEntValue Table

Identifier	Attribute	Value
Potsherd 0017	Length	8mm
Potsherd 0017	Length - Rim	10mm
Potsherd 0017	Unit	155
Potsherd 0017	Shape	Bowl

Image by Geoff Matheson.

Each attribute has four sub-attributes reflecting the needs of field data recording and can be multivalued if multiple rows share a timestamp. An attribute can comprise a set of:

- a constrained vocabulary (dropdowns, checkboxes, and radio buttons);
- a unconstrained measurement;
- an annotation (to represent a way of scribbling in the margins); and
- a certainty (to otherwise rate uncertainty of the data reliability).

By combining these in a single 'measurement.' Highly nuanced but machine readable data can be recorded in such a way as to fit the needs of the recording workflow.

The fundamental innovation of FAIMS Mobile is the domain-key normal form append only datastore. Each record is identified by two naturally-unique identifiers: the user and the time of creation. Beyond that, every action is timestamped to allow for full histories and audit trails. Because every record and every action is timestamped and unique to a user, we can combine different versions of the database (i.e. those created on multiple devices over a week's trek through the Australian Outback) without any risk of clobbering edits or data. The most recent activity is 'true'.

Records are defined in 3 logical tables. 'Rows' are defined in the ArchEntity table, which also holds cruical GIS data. 'Columns' are defined by the attribute and Ideal Entity tables. The Attribute table defines what attributes are possible, their names, and their list/export formats. The Ideal Entity table defines which attributes belong to which entity. By defining these tables in DML (data manipulation language) rather than DDL (Data Definition Language), the structure of the database remains consistent. This structure allows for query reuse and allows us to script the fields of a workflow after all the fundamental data interactions of FAIMS Mobile have been written.

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Append-Only Datastore

Water Sample Prefix	Water Sample ID	Water Sample Date	Observation Type	Location Number	Station	Project	Area	Site Name	Water Table	Sample Depth	Bottom of Hole	Notes	Photos	Hole Type	Hole Lining	Hole Open or Closed
879gg Last Edit by: Faims Admin at 2015-04-13 03:20:51	0 - Water - Last Edit by: Faims Admin at 2015-04-13 03:20:51	13Apr15 Last Edit by: Faims Admin at 2015-04-13 03:20:51	{Sampling_Location} Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	adsfasdfasdf Last Edit by: Faims Admin at 2015-04-13 03:20:51	Projection Last Edit by: Faims Admin at 2015-04-13 03:20:51	The Pentagon Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	files/app/034beed5-31e4-467d-b51c-7766e2a884f8_image-1428898938730.original.jpg | files/app/391c2086-81ea-4b04-939a-a53b2983d440_image-1428898918066.original.jpg Last Edit by: Faims Admin at 2015-04-13 04:22:27	{No_Observation} Last Edit by: Faims Admin at 2015-04-13 03:20:51	{No_Observation} Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51
879gg Last Edit by: Faims Admin at 2015-04-13 03:20:51	0 - Water - Last Edit by: Faims Admin at 2015-04-13 03:20:51	13Apr15 Last Edit by: Faims Admin at 2015-04-13 03:20:51	{Sampling_Location} Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	adsfasdfasdf Last Edit by: Faims Admin at 2015-04-13 03:20:51	Projection Last Edit by: Faims Admin at 2015-04-13 03:20:51	The Pentagon Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51	files/app/391c2086-81ea-4b04-939a-a53b2983d440_image-1428898918066.original.jpg Last Edit by: Faims Admin at 2015-04-13 04:22:11	{No_Observation} Last Edit by: Faims Admin at 2015-04-13 03:20:51	{No_Observation} Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51
879gg Last Edit by: Faims Admin at 2015-04-13 03:20:51	0 - Water - Last Edit by: Faims Admin at 2015-04-13 03:20:51	13Apr15 Last Edit by: Faims Admin at 2015-04-13 03:20:51	{Sampling_Location} Last Edit by: Faims Admin at 2015-04-13 03:20:51	NULL Last Edit by: Faims Admin at	adsfasdfasdf Last Edit by: Faims Admin at 2015-04-	Projection Last Edit by: Faims Admin at	The Pentagon Last Edit by: Faims Admin at	NULL Last Edit by: Faims Admin	NULL Last Edit by: Faims Admin	NULL Last Edit by: Faims Admin	NULL Last Edit by: Faims Admin	NULL Last Edit by: Faims Admin	NULL Last Edit by: Faims Admin at 2015-04-13 03:20:51 Deleted	{No_Observation} Last Edit by: Faims Admin at 2015-04-13	{No_Observation} Last Edit by: Faims Admin at 2015-04-13	NULL Last Edit by: Faims Admin

Developed by Intersect Australia Ltd.

This domain-key structure is also necessary to support the append only design. As each 'event' (insertion, updates, and 'deletion') occupies its own row, we use GROUP BY and HAVING max(timestamp) to emit the latest versions of each attribute. Event uniqueness is guaranteed by UUID (user creation + time of creation due to the length limits of integers as primary keys in Sqlite), acting userid, and time of event. Therefore, by virtue of the need of having 'eventually consistent' data stores, we also have a complete action log for every record: it shows when each attribute was edited and by whom. This allows granular control and review of records, as individual attributes can be 'rolled back' to a more authoritative/correct state by users on the server.

The append-only design also protects against data-loss, as 'deletions' are merely a flag on the record which hides it from normal view. Thus, this database is designed to preserve user actions at all costs, allowing differences in datastores to be sent to the server and thereby distributed to all devices. This also has the virtue, so long as devices sync relatively often, of creating a complete backup of the datastore on every device, further armouring the database against mischance.

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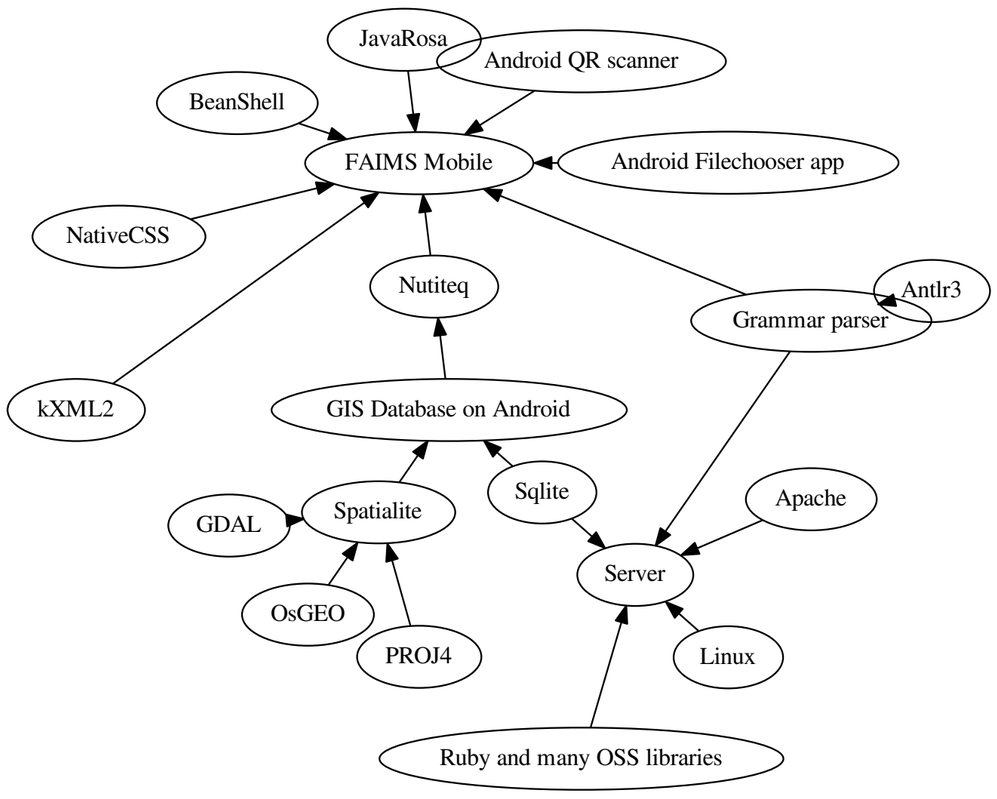
Open-source Heritage graph



FAIMS Mobile stands on the shoulders of giants. The only way an app this complex would be possible would be via the contributions of many open-source projects – which is why our own work is released under the GPLv3. Crucial technologies include:

- JavaRosa which allows us to parse XML into native android elements;
- NativeCSS which allows us to include some runtime stylings for elements;
- BeanShell which allows us to dynamically include a java-like scripting language;
- Spatialite which allows GIS operations inside the database;
- Sqlite which is a supremely stable single-user database;
- Ruby, Apache, Linux which allows us to write a sophisticated server running on a completely open source stack.

Choices of the fundamental libraries were made in 2012, when the project was commissioned as part of NeCTAR (National eResearch Collaboration Tools and Resources project) eResearch tools initiative and the libraries remain solid (if slower than some newer iterations) for the next few years to come.

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- To try this module, download FAIMS to your Android 4.4+ device, and download the CSIRO Geochemical Sample Collection module from the demo server.
- For additional user guidelines, please see our `cheatsheets' at: https://www.fedarch.org/resources/handouts.pdf
- You can make your own data-collection modules for free via the user to developer documentation at https://www.fedarch.org/support/2.
- Code for this module is available at: https://github.com/FAIMS/CSIRO-Geochemistry-Sampling
- Source code for this presentation (compiled in ConTEXt) is available at: https://github.com/FAIMS/EGU2016-Presentation
- If you have any questions, contact enquiries@fedarch.org.

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