Farm Management Information System

Chapter 02

Background

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Background:

This chapter presents the summary of the literatures we studied so far for our projects. Literatures consist of different reading materials such as books, thesis, and related web articles. It also includes analysis of some related research, a thoroughly benchmark study, and the gap analysis regarding current farm management information systems.

2.1 Preliminaries:

This chapter is mostly based on research and studies we conducted on different aspects of Farm Management Information System.

A Farm Management Information System (FMIS) is a computerized system that facilitates managing, organizing and operating a farm.

In the literature review part, a reference architecture for Farm Management Information Systems has been discussed. A reference architecture (RA) is a generic architecture in software architecture design, which can be used as a guide for designing software architecture for a specific domain.

In the later part of the chapter, we explored some existing FMISs and mentioned their features and functionalities.

We mentioned related researches and key information we gained from these research papers and articles in the related research part.

Lastly, the GAP analysis of our project is mentioned in the GAP analysis part.

2.2 Literature Review:

Why we choose this Journal:

The article we studied is titled “Reference Architecture Design for Farm Management Information System”. It is part of the journal named “Precision Agriculture” with an impact factor of 4.454. As the title suggests, this article is about reference architecture for Farm Management Information System applications. Here, authors analyzed key aspects of farm management and studied current reference architectures and based on their findings endeavor to provide improved reference architecture.

As we intend to build a farm management information system it is crucial that we build software architecture first. There is a domain specific general architecture understanding and using which application architecture can be built easily. It is called reference architecture. Reference architecture on Farm Management Information System can give us key concepts about how a proper farm management application should be. Reference architecture can help us build our application architecture efficiently. We can have a technical and logical guideline which will help us to decide how our farm management application should behave.

Abstract:

Farm management information system is responsible for data management, analytics and subsequent decision support. In the development of Farm management information system, software architecture is a key element that defines the gross level structure of the system. For understanding the system, analyzing the design decision and guiding the further development the software architecture plays a vital role.

Here, a reference architecture dedicated to the Farm management information system domain is described. The systematic approach for deriving application architecture from the proposed reference architecture is also provided here.

Introduction:

A continuous development in the information technology is taking place. It has a substantial amount of impact on various industrial domains including farming sector. For example, field monitoring, plant/breed selection, pest management, irrigation etc can be done more precisely with the help of IOT. A farm management information system becomes a great and time-befitting tool to manage the large amount of information involved in various farming processes and to keep track of and support the farm activities.

Software architecture is a very crucial point to the design of an application. It is defined as, how we define relationships among different components of an application. Properties of each component are also well defined in the architecture.

When a specific type of software architecture is generic for a particular domain and can be used as a reference to design specific software architecture, it can be termed as reference architecture.

Reference architecture is used to derive specific application architecture. It helps design application architecture quicker and with greater quality.

FIMS (Farm Management Information System):

There are some definitions of FMIS. They can be summarized as a planned system for the collecting, processing, storing and dissemination of data in the form of information needed to carry out the operational functions of the farm.

The Primary goal of FMIS is to reduce the production cost, maintain high quality and comply with the agricultural standards.

Stakeholder is a key concept in the realm of software architecture design. It can be defined as an individual, group or organization, who may affect, be affected by or perceive itself to be affected by the decision, activity or outcome of a system.

A study conducted on a unique set of relevant stakeholders and their concerns regarding the development of FMISs is shown in the table given below.

Table 1 The identified stakeholder and their concerns. Adapted from Tummers et al. (2019)

Role	Concerns
Farmer	Responsible person on the farm and end-user of the system
Government	Has an interest in FMISs for registration purposes, and to obtain farm information
Agricultural expert	Has expert knowledge about the agricultural sector and can be used for requirements for FMISs
Farm employee	Works on the farm and has to work with the FMIS
Research Institute	Multiple kinds of researchers and institutes can be used as knowledge input for FMISs
FMIS developer	Develops the FMIS and its underlying software
Input supplier	Delivers inputs to the farm; these inputs can be registered in an FMIS
Agricultural advisor	Helps the farmer with making decisions based on their knowledge, an FMIS can assist them
Agriculture service provider	Assists the farmer with the provision of services. Can use FMIS for registration purposes
Contractor	Hired by the farmer to perform field tasks. FMISs can improve communication with the farmer
Equipment producer	Makes new machinery for the farmer, an FMIS can provide machinery management
Customer	Companies and other entities greater than the individual consumer. FMISs can provide details about the purchased products
Administrator	Can set up system, and manages the FMIS. Is not necessarily the FMIS developer
Farmers association	Organised group of farmers with common interests. Wants FMIS for the implementation of modern technology
Neighbour	Can be influenced by decisions of FMIS (odour nuisance, noise disturbance, etc.)
Non-governmental	Group of persons with their own (ecological) interest that can be intertwined with the FMIS
Product processor	FMIS can provide information on products coming from the farm
Veterinarian	Can use the FMIS for retrieving animal information and can register veterinarian actions
Accountant	Can use the financial modules of FMISs to verify and assist the farmer with bookkeeping
Equipment dealer	Can provide machinery support and services via the FMIS
Media	Provides communication with the outside world and has an influence on the farm image
Weather service provider	Provides weather information as input for the FMIS

Feature:

A feature is defined as a prominent or distinctive user visible aspect, quality or characteristic of a software system or system.

A feature model is a tree shaped model. It shows common, alternative and optional features of a system.

The feature model provided below contains the features for the FMIS and it is divided into four groups namely as

a. General management information system: Features that are not agriculture specific. It is rather management specific.

b. Data management: Features related to management of data and data-based decision making.

c. Crop management: Features related to crop farming.

d. Animal management: Features related to animal management.


Legend:
Mandatory
Optional
Abstract
Concrete
Collapsed
FMIS
General MIS
Financial management & Accounting
Report generation
Operation plan generation
Resource management 6
Human resource management
Energy management
Sensor management 2
Sales management 3
Scheduling and strategic planning 2
Legal management
Real estate management
Traceability
Data management
Data transfer
Knowledge and experience management
Data storage
Data processing and sharing
Data aquisition
Decision support
Crop farming
Crop management 5
Field monitoring 2
Field mapping
GIS management
Irrigation management
Seed management
Yield management 2
Animal farming
Herd management 3
Reproductivity management
Feed management
Yield an growth management 2

Architecture Design:

Each software has an architecture that defines its structure. It is an abstract representation of the system.

It is important for supporting communication among stakeholders, for guiding design decisions and for the analysis of the overall system.

The architecture model used here is known as Architecture view model. It consists of multiple views and viewpoints.

Each view addresses the whole system from the perspective of one or more of the stakeholder concerns. Each viewpoint focuses on a particular aspect of the architecture. The architecture view describes the architecture of a system.

Current Reference Architecture:

There are few reference architectures for Farm management information system.

A class diagram of a reference architecture describing relationships between different components in the FMIS is given. The components are application components, ICT components, Information system and Agri-food Company.

Furthermore, relationship between different actors was shown. These actors farm manager, farm owner, customer, government, infrastructure provider etc.

Context diagram to show how different entities are connected to the system and a visual representation of all the possible modules are also provided.

It is seen that the farm, clients and sensors in the fields might use different applications and UIs. Sometimes they can be from different vendors as well. There can also be a cloud node.

Reference Architecture:

Selection of views:

Two sets of viewpoints have been used for the reference architecture. These viewpoints are Context viewpoints and Decomposition viewpoints. These viewpoints can be applied for both application and stakeholder concerns. Few crucial points are taken into the consideration while designing the reference architecture. Points such as features supporting long term vision along with flexibility to customize the architecture for different sectors of farming.

Context view:

The context view of a system is represented using a so-called context diagram. This diagram represents the overall purpose of the system and its interfaces with an external environment. It shows the system boundaries, its environment and the entities it interacts with


Farm manager
Operation management
Decision making
Reports
Best practise advise
Farm owner
High level management
Reports
Government
Obtain reports
Agricultural expert
Set up requirements
Deliver knowledge and advice
Farm employee
Operation management
Register actions
Best practice advise
Research institute
Deliver knowledge
FMIS developer
Develop FMIS
Input supplier
Register inputs
Stock information
Agricultural advisor
Assist with decision making
Agriculture service provider
Register activities
Contractor
Field management
Register activities
Equipment producer
Machinery information
Plug-in developer
Deliver plug-ins
Receive money
FMIS
Provide product details
Product properties
Customer
Set up and manage FMIS
Administrator
Implement technologies
Farmers association
Obtain reports
Non-governmental
Request data
Send data
Automated user (sensor, robot)
Product information
Product properties
Product processor
Animal information
Register actions
Veterinarian
Obtain stock information
Obtain reports
Check bookkeeping
Accountant
Machinery information
Give machinery support
Equipment dealer
Company information
News information
Media
Weather information
Weather service provider
Farm data
Farm data
Other FMIS
Key
External entity
X interacts with Y
System
Optional External Entity
Optional Interaction

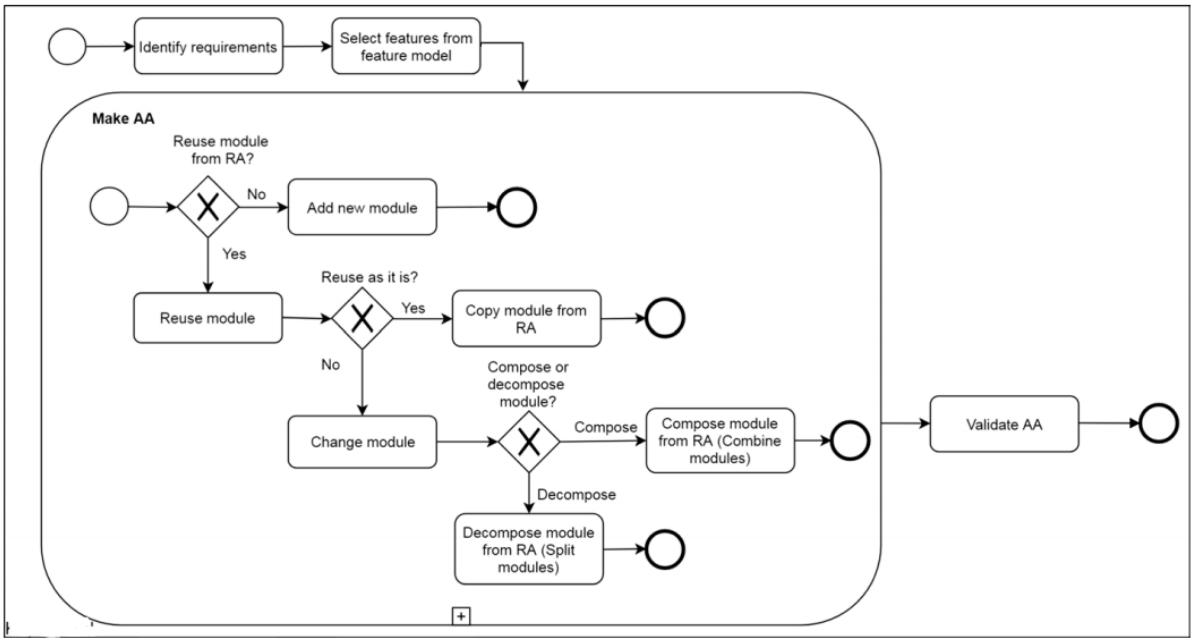
Decomposition view:

The decomposition view defines the decomposition of the system over different modules. The only relation that is used is the decomposition relation which is usually shown by embedding a module in the overall system module. The view thus shows the decomposition of larger modules into smaller modules. The modules from the decomposition view should cover all features.


Financial management
Resource management
Scheduling & Strategic planning
Energy management
Reporting
Sales management
Legal management
Sensor management
Operational plan generation
Human resource management
Real estate management
Traceability
Data transfer
Data storage
Data acquisition
Herd management
Knowledge management
Data processing
Decision support
Feed management
Crop management
Field mapping
Irrigation management
Yield and growth management
Field monitoring
GIS management
Seed management
Reproductivity management
Weather service

Deriving application architecture from reference architecture:

A specific view from the RA is reused to derive the corresponding view of the AA. First the requirements of the application are identified. Based on these requirements, features from the family feature model are selected. Based on the selected features, the required FMIS modules for the AA are selected from the FMIS RA. If the required module can be found in the RA, then this will be reused; if not, a new module will be added to the AA.



2.2.1 Similar Applications:

Farming is not only a combination of activities to produce food for domestic consumption. It's also a business venture. Farming has also challenges like resource limitations, management complexities etc. With the help of farm management software, farm owners can monitor various farm activities easily. It helps them acquire different information as well as makes decision making easier and real time oriented. Our Analysis of few farm management software is given below.

1. **Agrivi** (www.agrivi.com): This software is used for planning, monitoring and analyzing farm activities like planting, spraying, fertilization, irrigation, harvesting etc.
   Some features of Agrivi:
   a. Management of activities such as finance, inventory, workforce, resource etc.
   b. Analytics to monitor farm performance.
   c. Weather monitoring and pest detection.

2. **Granular** (granular.ag): This is software allows farm owners and managers to monitor all aspects of operation, enabling them to make informed real time decisions. Owners and managers can assign tasks to their workers using this software. This software also has native apps for Android and iOS devices. This software has three different packages namely as Insight, Business and Agronomy.
   Some features of Granular:
   a. Pinpoint and fix production issues.
   b. 3-m satellite imagery
   c. Analyze profits
   d. Control inputs and inventory
   e. Crop and field planning
   f. Mobile access

3. **FarmERP** (www.farmerp.com): This is a complete ERP solution for farming and agriculture-based businesses. This software is the most widely used software for farm management. It is highly scalable. It has a good data management and analysis feature along with solutions covering critical business functions.
   Some features of FarmERP:
   a. Input management
   b. HR management
   c. Production management
   d. Financial and marketing management
   e. Resource optimization
   f. Managing multiple farms at multiple locations

2.2.2 Related research:

In the book titled ***"Information Systems for Management: A Book of Readings",*** it is stated that an MIS is an organizational method of providing past, present and projected information related to internal operations and external intelligence." It is also mentioned the book that Supporting decision making is one of its main objectives which it aims to accomplish by providing timely information about the planning, control and operational functions of an organization.

In the article titled ***"Conceptual model of a future farm management information system"*** from journal ***"Computers and Electronics in Agriculture"***, A Farm management information system is defined as a planned system for the collecting, processing, storing and dissemination of data in the form of information needed to carry out the operations functions of the farm.

Another article titled "***Farm management information systems: Current situation and future perspectives"*** from the same journal mentioned that an FMIS can support decision making by finding the best practices for farm management. The

main purpose of existing FMISs is to reduce the production cost, maintain high product quality and safely, and to comply with agricultural standards.

Article ***"Farming for the Future towards better information-based decision-making and communication"*** defined feed management referring to managing the quantity of nutrients fed to livestock and poultry, financial management and labor management as some widely supported features of FMIS.

Different FMISs are developed for different sectors of agriculture. There are FMISs designed for arable farming, livestock farming etc. FMISs also vary in context of licensing and delivery models. Some of them can be used in mobile phones, some of them can be used in desktop computers and some of them can be used in both platforms.

In the article "***Farm management information systems: Current situation and future perspectives"*** a study was conducted to set standard features for FMIS, where 141 different commercial FMISs coming from 75 vendors were explored. A set of 11 different major features were extracted. These features are field operation management, best practices to support decision making, finance, inventory, traceability, reporting, site-specific features, sales, machinery management, human resource management, and quality assurance.

In their research article titled ***"Data standards used for data-exchange of FMIS"***, Robbemond and Kruize conducted a similar study and enlisted a set of 11 features for FMISs. These features are procurement, inventory management, product management, marketing and sales, human resource management, technology management, energy management, real-state management, quality assurance, finance and accounting.

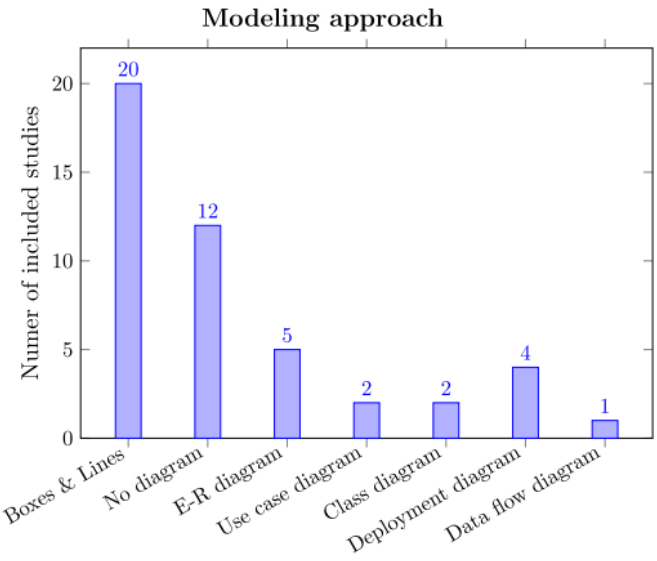
Capterra (www.capterra.com) a leading web platform for software review and selection, explored 156 farm management software. In their review they mentioned 13 key functionalities for FMISs. These functionalities are bar coding, contract management, crop management, customer management, financial management, green house management, inventory management, labor

management, livestock management, order processing, pricing management, supplier management and traceability.

The article ***"Obstacles and features of Farm Management Information Systems: A systematic literature review"*** from journal ***"Computer and Electronics in Agriculture"***, describes that precision agriculture and Management Information System (MIS) is mostly used for the arable farming. Livestock is the second domain that makes the most use of these technologies after arable farming.

In this article modeling approaches that are applied to FMISs are also described. Software modelling can be done following Unified Modeling Language (UML). There are other modeling methods such as E-R diagram, data flow diagram. E-R diagram represents data model and shows data layer of a system. Data flow diagram represents logic models and shows how data is transformed in a system.

Other UML diagrams such as use case diagram, class diagram, deployment diagrams are also mentioned this article. Use case diagrams shows use cases and the concerned actors. Class diagram represents different objects of the system and relationships among them. Deployment diagram shows physical relationship among software and hardware components in the delivered system.



The used modeling approach for the 38 primary studies. A study can describe zero (No Diagram), one, or multiple modeling approaches.

This article explains different delivery models for FMISs. Delivery models are mainly divided into 2 categories. These are application and Platform.

The article considered a platform as a software that can be customized and extended in context of functionalities. An application is a computer program that can perform tasks directly and can be deployed locally and used directly.

FMISs are further divided into 3 types. These are Web-based FMIS, Mobile-based FMIS, and Standalone/Desktop FMIS.

There are two types of licenses namely as Academic and Commercial. Academic license allows the software to be used for academic or research purposes. Commercial license allows the user to use the software for the commercial purposes.

According to the ***Project Management Institute (PMI),*** *stakeholder for a project is defined as an individual, group, or organization, who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project.*

22 different stakeholders are identified in the article ***"Obstacles and features of Farm Management Information Systems: A systematic literature review"*** from journal ***"Computer and Electronics in Agriculture"***. These stakeholders are presented in the following table.

The identified stakeholders and their relationship to FMISs.

Stakeholder name	Description	#
Farmer	Responsible person on the farm and end-user of the system.	38
Governmental	Umbrella term for multiple stakeholders that relate to the government. Has an interest in FMIS for registration purposes, and to obtain farm information	10
Agricultural expert	Has expert knowledge about the agricultural sector and can be used for requirements for FMISs.	7
Farm employee	Works on the farm and has to work with the FMIS.	6
Research Institute	Multiple kinds of researchers and institutes can be used as knowledge input for FMISs.	6
FMIS developer	Develops the FMIS and its underlying software.	5
Input supplier	Delivers inputs to the farm, these inputs can be registered in an FMIS	5
Agricultural advisor	Helps the farmer with making decisions based on their knowledge, an FMIS can assist them.	4
Agriculture service provider	Assists the farmer with the providence of services. Can use FMIS for registration purposes.	4
Contractor	Hired by the farmer to perform field tasks. FMISs can improve the communication with the farmer.	4
Equipment producer	Makes new machinery for the farmer, an FMIS can provide machinery management.	4
Customer	Companies and other entities greater than an individual consumer. FMIS can provide details about the purchased products.	3
Administrator	Can setup system, and manages the FMIS. Is not necessary the FMIS developer.	2
Farmers association	Organized group of farmers with common interests. Want FMIS for implementation of modern technology.	2
Neighbour	Is influenced by decisions of FMIS (Odor nuisance, noise disturbance, etcetera).	2
Non-governmental	Group of persons with their own (ecological) interest that can be intertwined with the FMIS.	2
Product processor	FMIS can provide information on products coming from the farm.	2
Veterinarian	Can use the FMIS for retrieving animal information and can register veterinarian actions.	2
Accountant	Can use the financial modules of FMISs to verify and assist the farmer with bookkeeping.	1
Equipment dealer	Can provide machinery support and services via the FMIS.	1
Media	Provides communication with the outside world and has an influence on the farm image.	1
Weather service provider	Provides weather information as input for the FMIS.	1

2.3 GAP Analysis:

Understandability: Farm owners or farmers are often not well educated. They might lack complex skills to operate a FMIS. Moreover, complex UI can make it very difficult for them to use a FMIS. This might discourage farm owners to use FMISs.

The UX and UI design of a FMIS must be easy-to-understand. Our FMIS should support Bangla language so that farm owners and farmers with less educational qualification can easily operate the system.

2.4 Summary:

To have a better view on the system, we studied different articles, research papers. Essence of our literature review is mentioned in this article. This study provides us with a step-by-step guide on how to design and implement our project. We explored different similar applications. It helped us to identify existing features and functionalities of Farm Management Information Systems. We conducted a GAP analysis, that enabled us to see current obstacles and challenges of developing FMISs. We also discussed some possible solutions to overcoming these obstacles.