Support to decision-making

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- Planning and optimization
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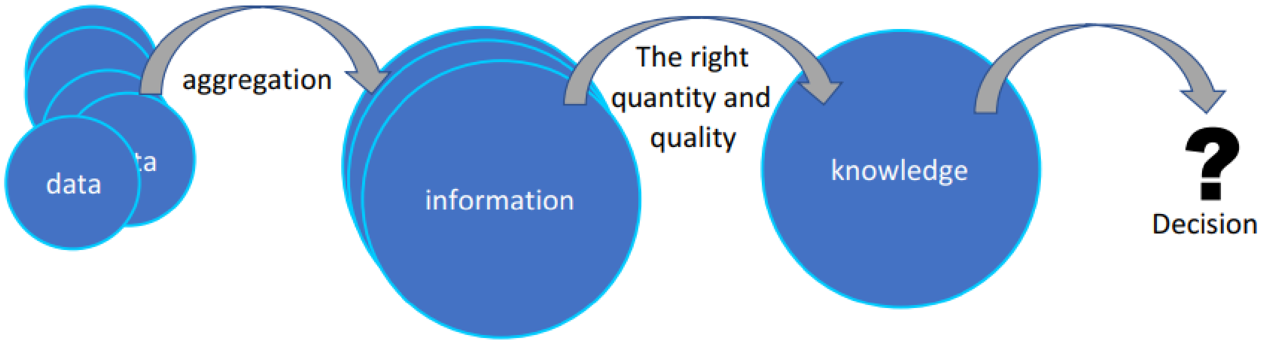
Introduction to decision support Functions

- Decision support is about providing the user of a DSS (decision support system) means to make a decision
- Classical Metaphor: “knowledge vs information”
- Interactivity required by the user of a DSS can be analysed:
  1. choosing which alternatives to evaluate and compare
  2. selecting data (providing a data context)
  3. choosing one or several evaluation and comparison methods (using models applied to the data)
  4. perform evaluations and comparisons

Introduction to decision support Functions



Introduction to decision support Functions

- **Desirable functions in a DSS for smart farming:**

    1. Defining the decision space
    2. Selecting the data
    3. Selecting the models, evaluation functions and comparison methods
    4. Evaluating and comparing alternatives

From spatial data to site-specific decisions and action

- **Emerging technologies in agriculture splits into two categories**
  - embedded knowledge
  - information-intensive
- **Difference:**
  - guided/autosteer tractors -> embedded knowledge
    - most widely adopted technology today
    - there has also been a realization that autosteer system dramatically reduces stress and fatigue on the operator
  - variable-rate nitrogen (VRN) based on optical sensing ->information-intensive
    - highly desirable, as the ability to optimize or improve nitrogen use efficiency is known to have a large effect on profitability

From spatial data to site-specific decisions and action

- **Specifying the decision to be supported**
  - As indicated previously, it is the decision, and not the technology, that should frame the DSS.
- **The right information at the right resolution for the right decision**
  - Different decisions will require different information
  - example, within a wine grape cropping system, frost protection action requires weather data but no plant-based information, while irrigation management of elevated vine stress requires particular information on vine water status (and its temporal evolution)

From spatial data to site-specific decisions and action

- **The resolution of available data**
  - Spatial
  - Temporal

- **Examples of available data in Agriculture systems are generated through:**
  - optical (visible near infrared) sensors
  - soil moisture sensors
  - Biomass imagery

From spatial data to site-specific decisions and action

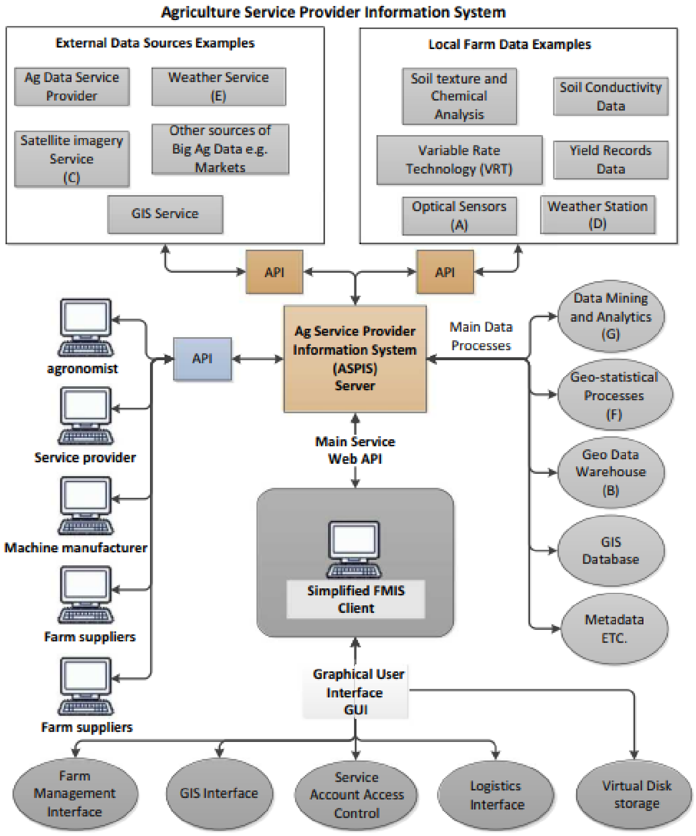
- **A Desired System:**
  - generates high-resolution data in both space and time
  - has data/information that directly measures the attribute(s) of interest to the decision process.

- Such systems are rare to find!

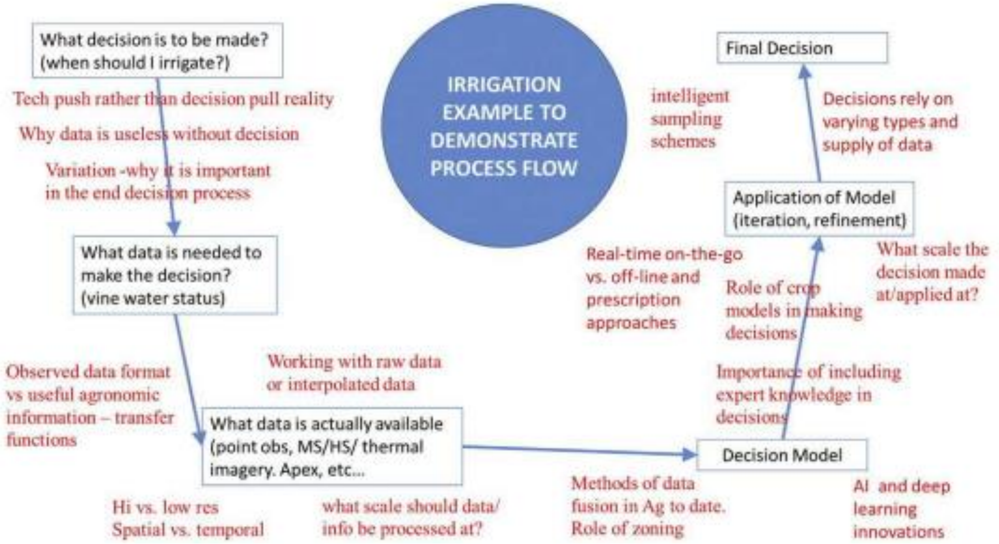
From spatial data to site-specific decisions and action

A theoretical scheme illustrating the evolution of next-generation farm management information systems into cloud-based (service provider-based) information systems. Producers will access the information system via a web interface, rather than via a desktop system

- API
- GUI



Planning and Optimization



Planning and optimization Process

Exact optimization methods

- Data Structure
- Algorithm Complexity
- Linear Programming
- Constraint Programming
- Branching Methods
  - Branch and bound
  - Branch and cut
  - Branch and price
- Dynamic Programming

Planning and Optimization

When the size of the problem at hand makes exact optimization unpractical (e.g., computation time or space incompatible with requirements), then approximate methods, such as metaheuristics, come handy.

Planning and Optimization

Because of weather uncertainty, market and price uncertainty and all kind events that may happen throughout the agri-food supply and production chain, handling uncertainty when optimizing is often desirable

Two branches of mathematical programming have produced many research results on how to handle uncertainty: **stochastic programming** and **robust programming.**

Stochastic Programming

A two stage stochastic program is refereed for such systems.

First Stage: Resources (land, manpower, water, etc.) and crops (which to plant where) are planned at this stage
Second Stage: Information about prices and yields are provided
A distribution of scenarios can be calculated for this uncertain information taking into account the correlations of uncertain variables (such as in this case prices and yields)
Last but not least: Optimization is run for each of the scenarios

Robust Programming

The robust programming approach has been developed to cope with situations in which the probabilistic knowledge is poor or inexistent.

The uncertain parameters may be represented by intervals (grey numbers) or fuzzy parameters.

Information systems for smart farms

An information system is a set of resources (human, procedures, tools) that aims to bring together, extract, analyse, evaluate and distribute in a timely manner, relevant, valid and sufficient information from heterogeneous sources (within and outside the referred domain) to support decision-making processes

Information systems for smart farms

Basic Concepts needed:

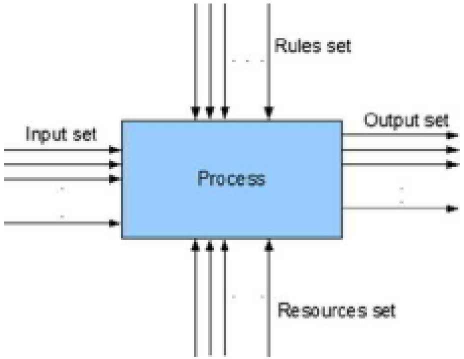
Aggregation - It is necessary to aggregate data, in some way, to construct information.
Validity - this is an attribute that delineates the quality of the data and therefore the information that derives from it
Sufficiency - "a must" to start any decision-making process
Availability - The data, and therefore the information, must be available when needed.

Information systems for smart farms

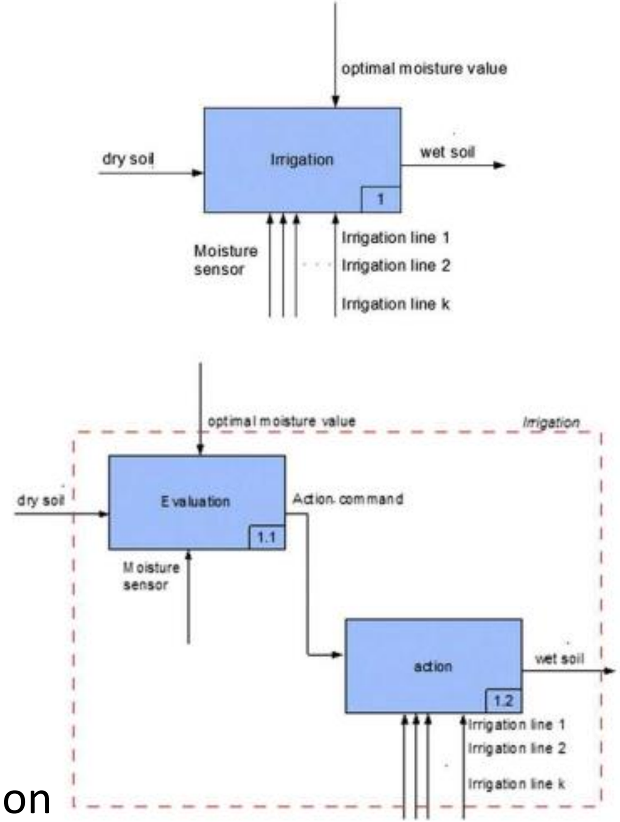
The Theory to design information systems:

1. Current processes analysis of the reference domain, construction of the AS-IS (current) process model
2. Requirements analysis
3. BPR and process redesign: construction of the TO-BE (future) process model
4. Preliminary design of the information system
5. Implementation of TO-BE processes
6. Definitive design and implementation of the information system 7. Delivery and roll-out of the system

Information systems for smart farms



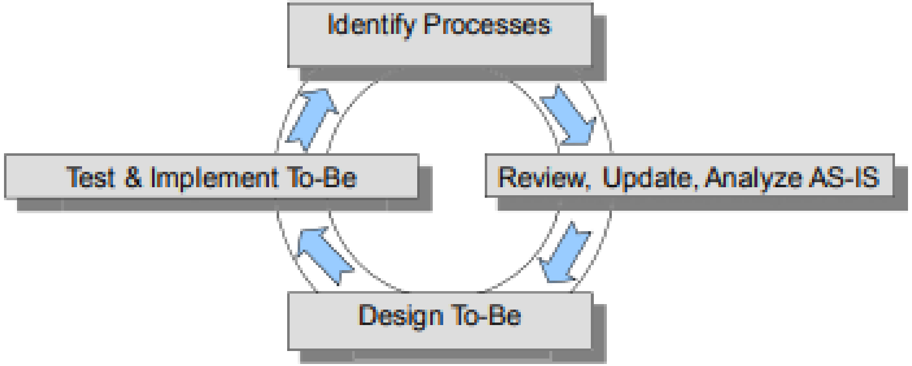
IDEF0 e standard process notation



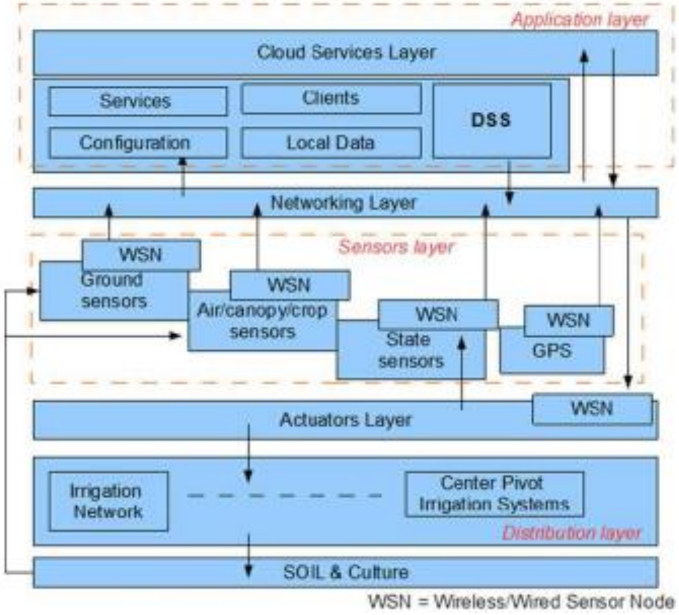
Smart irrigation process e IDEF0 notation

Information systems for smart farms

The AS-IS and TO-BE process models

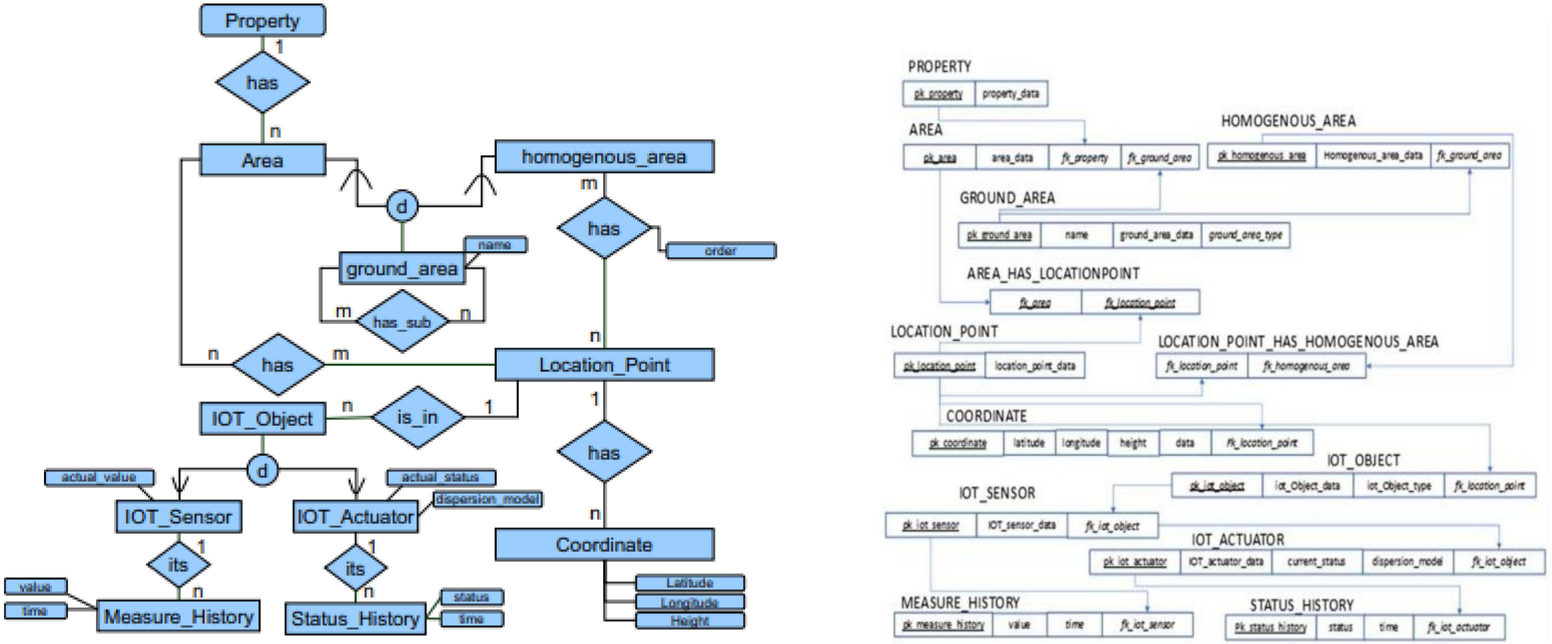


Information systems for smart farms



Information system architecture for smart farming

Information systems for smart farms



Enhanced entity-relationship model and table representation example for managing data in a smart agriculture information system

Session Q&A