Development of a multidimensional and customizable decision support tool for dairy culling management

H. Simon, E. Reding, C. Grelet, M.N Tran, WalleSmart consortium, & F. Dehareng

Introduction: The Importance of Good Economic Health of Dairy Farms

Why is it crucial?

- Dairy farms play an **essential role in the agricultural economy**, providing stable income and contributing to food security
- Belgian dairy industry has a **turnover of €7.1 billion**, representing 10% of the turnover of the Belgian food industry
- Good economic health allows for **maintaining profitability**, investing in **innovative technologies**, and improving the **quality of production**

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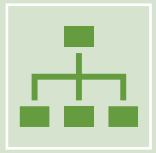
Factors influencing the profitability of dairy farms



Efficient resource management: Optimum use of food, water and energy.

Genetic selection and herd management: Choosing the most productive and suitable cows.

Controlling production costs: Minimising costs while maximising the quality and quantity of milk produced

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Maximise profits by culling optimally

Challenges :

- Culling too early: Financial losses and loss of young cows potential
- Culling too late: High opportunity costs, keeping under-performing cows

Reform developments and evolutions

Beaudeau et al. (1996) :
Reform based on low production or health problems

Weigel et al. (2003) :
Taking into account dairy performance, longevity and economic analysis

Fetrow et al. (2006) :
Renewal planning based on production, health and costs

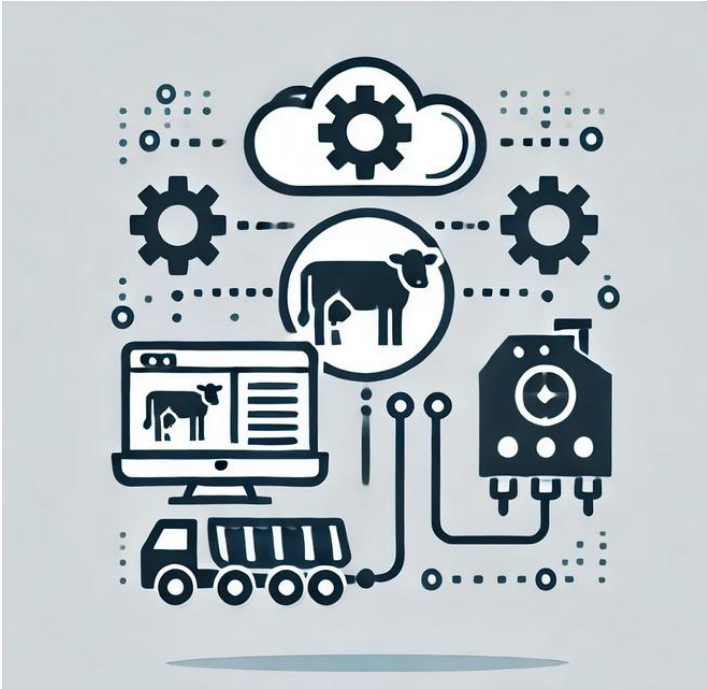
Hadley et al. (2006) :
The importance of animal health, productivity and awareness raising among farmers

Advantages of computerised reforms

Scientific models offer **greater accuracy** than human intuition

Simplified tools require **no additional data entry**

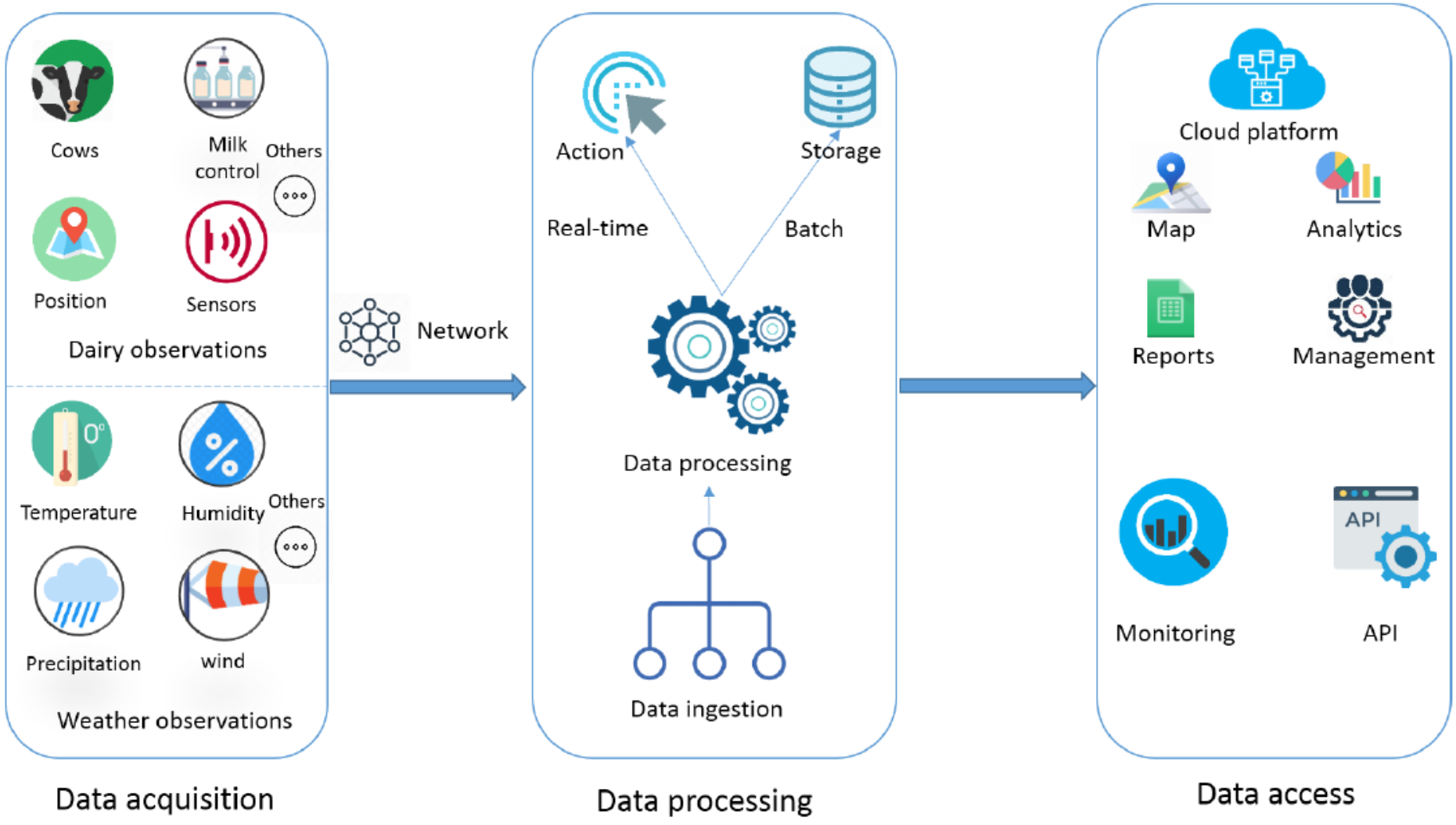
Enables **better planning** and **reduced costs**



Objectives and Solutions

- **Challenge:** Selecting the cows best suited to the production system
- **Problem :** Time-consuming data entry and analysis
- **Solution :** Data centralisation service to simplify access and optimise decision-making

Wallesmart project



WIN/LOS€

The Win/Lose index is made up of 3 parts:

1. **Expected profit** from current lactation (CL)
2. **Customisation** by the breeder
3. **Alert system** for the transition from SCC group to another SCC group at next lactation

Home page

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Home About the Application Software Contact

Welcome to our Win Lose reform aid tool!

Our application is designed to provide you with a reform aid tool, allowing you to rank cows within your herd. Based on detailed information related to production, health, and much more, we help you make informed decisions to optimize your herd management. Discover how our tool can transform your herd management by providing precise analyses and personalized recommendations for each animal.

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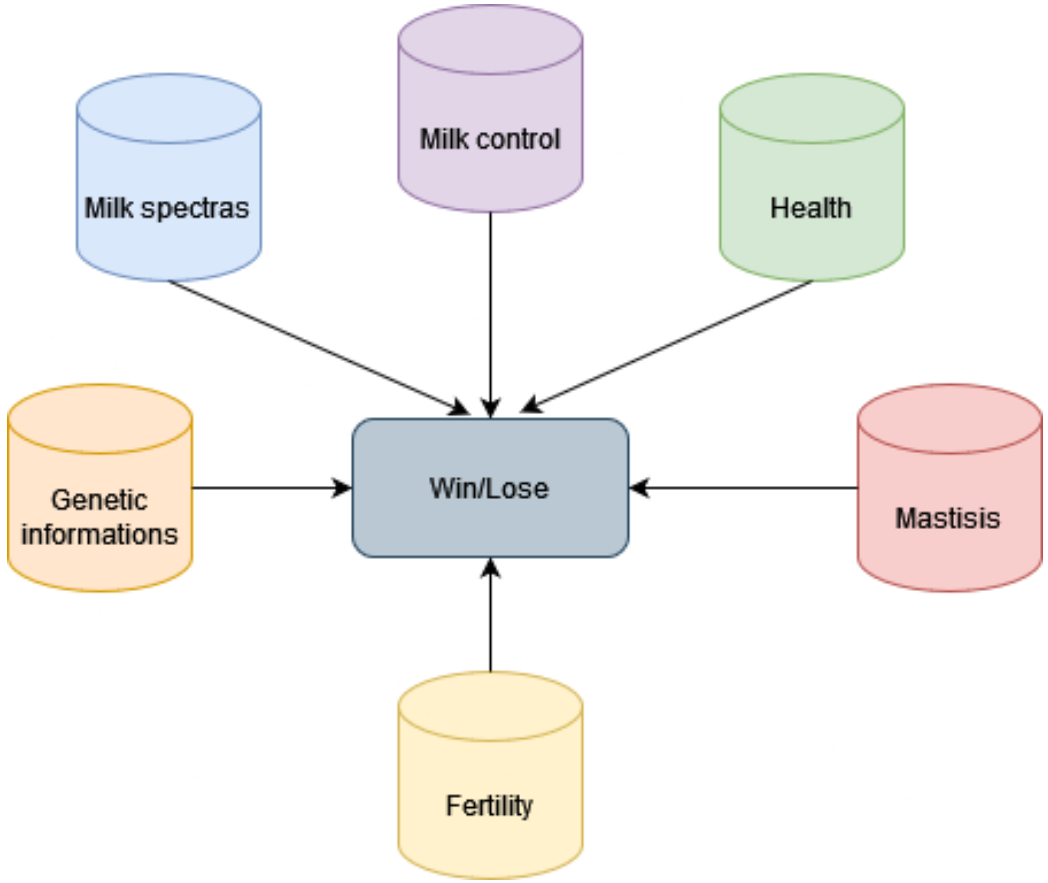
Expected profit from current lactation (CL)



$$CL = \sum_{\{t=1\}}^{\{4\}} (PNM_t \cdot VPE_t) + Fert$$

CL : Expected profile for the **current lactation**
PNM_t : Current **net margin**
VPE_t : **Estimated performance** over the whole lactation

	€/unity
Milk yield (kg)	-0.05 *
Fat content (kg)	3.57 *
Protein (Kg)	2.76 *
SCC (natural log of SCC)	°-43.49

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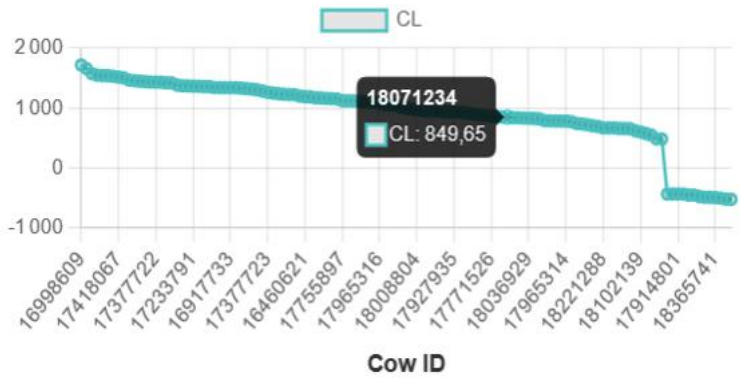
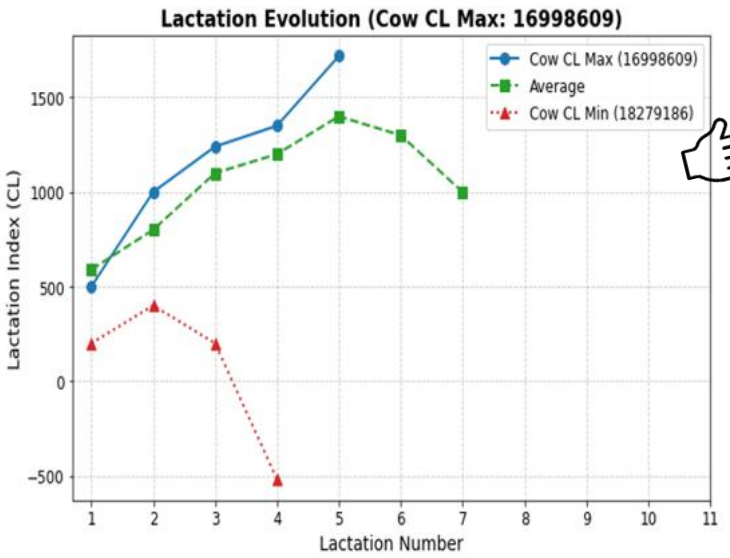
Your Farm Dashboard

Home Dashboard Customize Analysis View Alerts

Farm ID Search

Win/Lose





Top 10 CL Max

Top 10 CL Min

ID_ANIMAL	Current Lactation Index	ID_ANIMAL	Current Lactation Index
16998609	1719	17933299	-430
16876903	1659	17705257	-448
17270754	1575	17677015	-448
17496169	1549	17978287	-470
17292651	1542	17962569	-485
17586781	1541	18371795	-485
17123782	1530	18365741	-490
17418067	1517	18352682	-500
17024477	1504	17962571	-515
16858551	1467	18279186	-518

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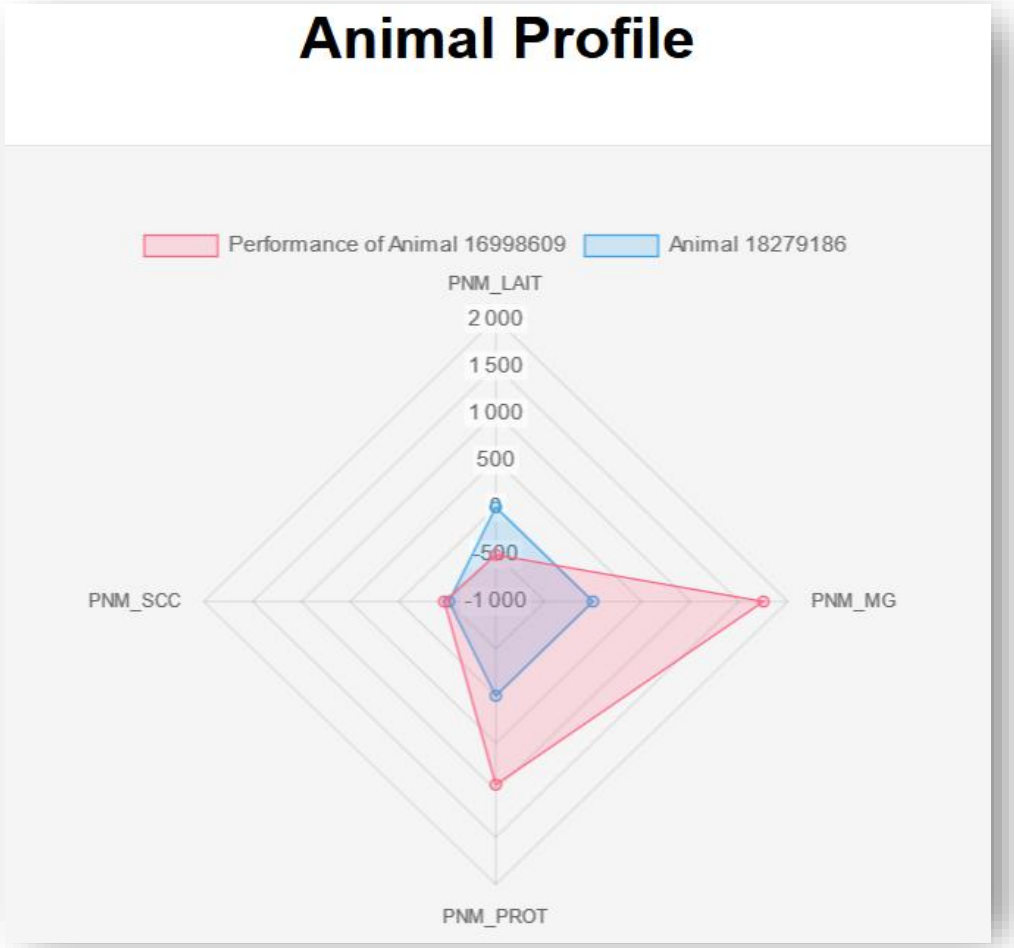
Expected profit from current lactation (CL)



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Customisation by the breeder

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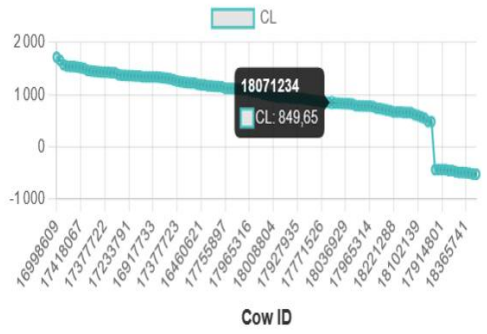
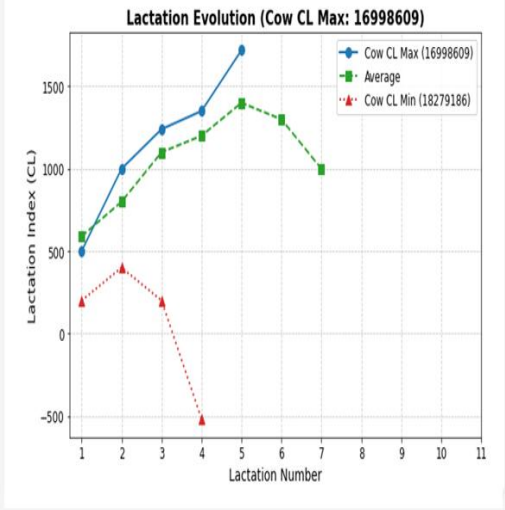
Farm ID Search

Win/Lose





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Analysis Customization for Cows

- ☐ Cheese Making Properties
- ☐ Minerals
- ☐ Energy Balance
- ☐ Infections
- ☑ Methane Production

Analyze

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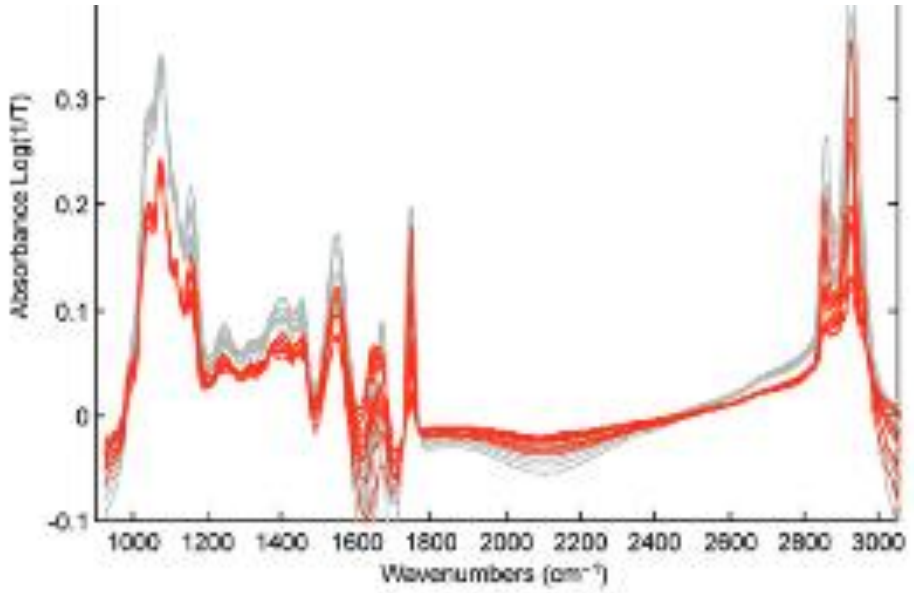
Customisation by the breeder



Prediction models

Top 10 CL Max

ID_ANIMAL	Current Lactation Index	CH4 g/day
16998609	1719	609.75
16876903	1659	595.88
17270754	1575	681.55
17496169	1549	603.77
17292651	1542	597.21
17586781	1541	595.63
17123782	1530	810.89
17418067	1517	677.94
17024477	1504	633.28
16858551	1467	621.33

Top 10 CL Min

ID_ANIMAL	Current Lactation Index	CH4 g/day
17933299	-430	368.37
17705257	-448	401.56
17677015	-448	321.93
17978287	-470	351.59
17962569	-485	343.54
18371795	-485	386.1
18365741	-490	386.87
18352682	-500	394.82
17962571	-515	387.45
18279186	-518	399.14

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Alert system for the transition from Somatic Cell Count group to the next lactation

Goal: Alert when a cow has a high chance to **change of somatic cell count category** (Low , Middle, High) or stay in high group

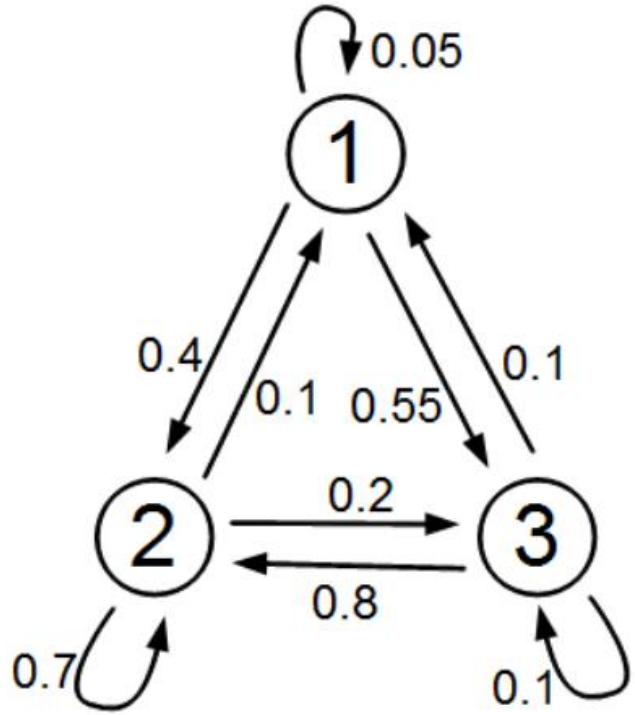
Strategy: Transition Matrix and same approach than M.M Kelleher (2014)

What is a Transition Matrix?

It represents the probabilities of **moving from one state to another** in a given system

Structure:

A **model** that shows the **possible transitions between three states** (1, 2, 3) with associated probabilities for each transition.



The arrows indicate the possible changes from one state to another, as well as the **probabilities of staying in the same state or moving to a different state**. This model is used to represent **random processes** in various contexts.

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Alert system for the transition from SCC to the next lactation

Structure of data:

Observations : 114 000 obs

Phenotype for SCC : 1 to 9 081 *10^3 unit/ml

Construction:

3 groups of somatic cell count :

- Low : < 150 * 10^3 cell/ml
- Middle : 150 * 10^3 to 400 *10^3 cell/ml
- High: > 400 * 10^3 cell/ml

Parity	SCC NOW	SCC Next	1	2	3	4	5	6	7	8	9	10
1	Low	Low	0.758	0.776	0.686	0.695	0.64	0.619	0.611	0.5	0.486	0.448
1	Low	Middle	0.139	0.154	0.18	0.188	0.228	0.238	0.227	0.299	0.35	0.355
1	Low	High	0.103	0.071	0.135	0.117	0.132	0.143	0.162	0.201	0.164	0.198
1	Middle	Low	0.556	0.461	0.434	0.458	0.512	0.412	0.423	0.385	0.375	0.455
1	Middle	Middle	0.296	0.315	0.408	0.265	0.3	0.279	0.295	0.292	0.375	0.309
1	Middle	High	0.148	0.225	0.158	0.277	0.188	0.309	0.282	0.323	0.25	0.236
1	High	Low	0.375	0.46	0.5	0.364	0.343	0.41	0.5	0.294	0.389	0.333
1	High	Middle	0.275	0.26	0.182	0.303	0.286	0.179	0.238	0.235	0.278	0.167
1	High	High	0.35	0.28	0.318	0.333	0.371	0.41	0.262	0.471	0.333	0.5

$$P_{ij} = \frac{Number\ of\ transition\ from\ state\ i\ to\ state\ j}{Total\ number\ of\ transitions\ from\ state\ i}$$

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Alert system for the transition from SCC to the next lactation

Informations of parity & Somatic cell count

Transition matrix of somatic cells

High probabilities to stay in high group	High probabilites to go in high group
ID_13522582	ID_13611350
ID_13633199	ID_13801550
ID_13641888	ID_13802053
ID_13641918	ID_13883347
ID_13761733	ID_13889665

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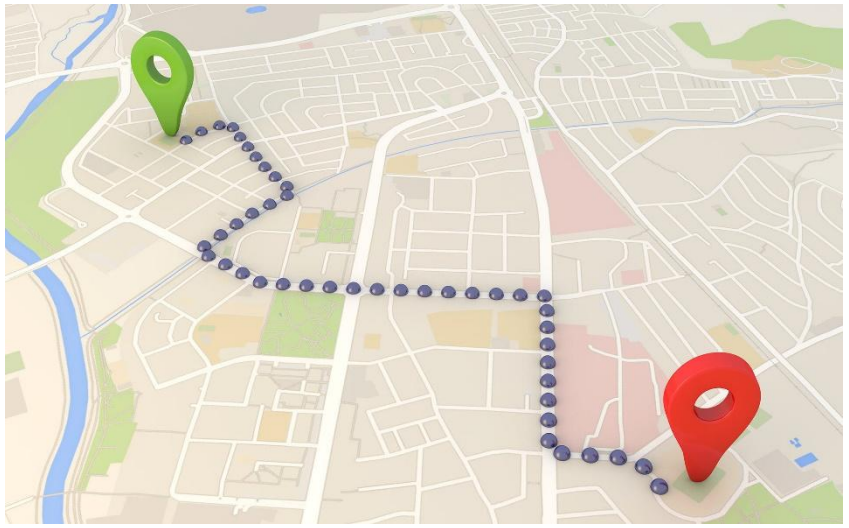
Conclusion

The **COW index** can be generated from the central dairy register database

Our goal is not to add more data but to **provide a tool** that serves as a synthesis and indicator.

As a GPS guiding you to the conference, our tool aims at **helping farmers and stakeholders** to make **informed decisions** effectively.



Next steps

- Consider the **cost of replacement** in our index
- Add an **economic value** for future lactations
- **Include more data** for the construction the transition matrix
- **Conduct a survey** targeted at farmers **to identify potential barriers in adopting** our decision **support tool for reform**
- **Provide case studies and testimonials** from early adopters to build trust and credibility

Thank you for your attention

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Support Evaluation of lactation

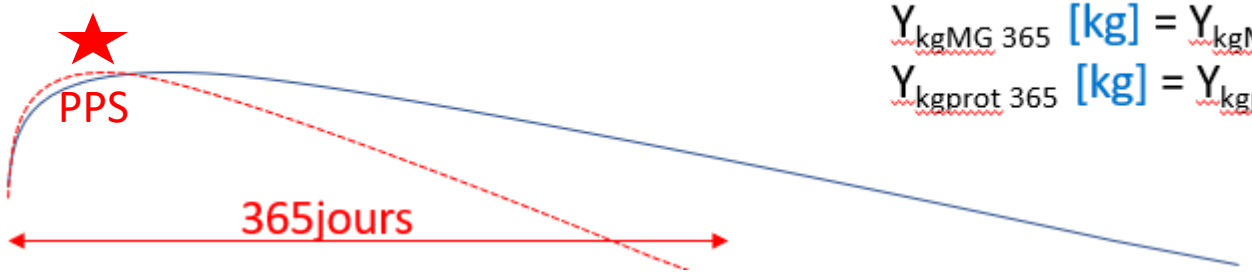
We deduce from the known events (inseminations, pregnancy tests, heat cycles, etc.) for the animal the probable CI (calving interval) and the probable drying-off date.

Calculate the cumulative MILK, FAT, PROTEIN (from the calving date to the probable drying-off date) over the entire lactation as if the cows:

- had always been in the same herd
- had all calved on January 1st of the current year
- were all in their second lactation
- had all calved at the same age

Thus, the observed differences are solely due to the animals (genetic and non-genetic) without taking into account the effect of the elements mentioned above.
These cumulative productions (MILK, FAT, PROTEIN) are then adjusted to a 365-day basis.

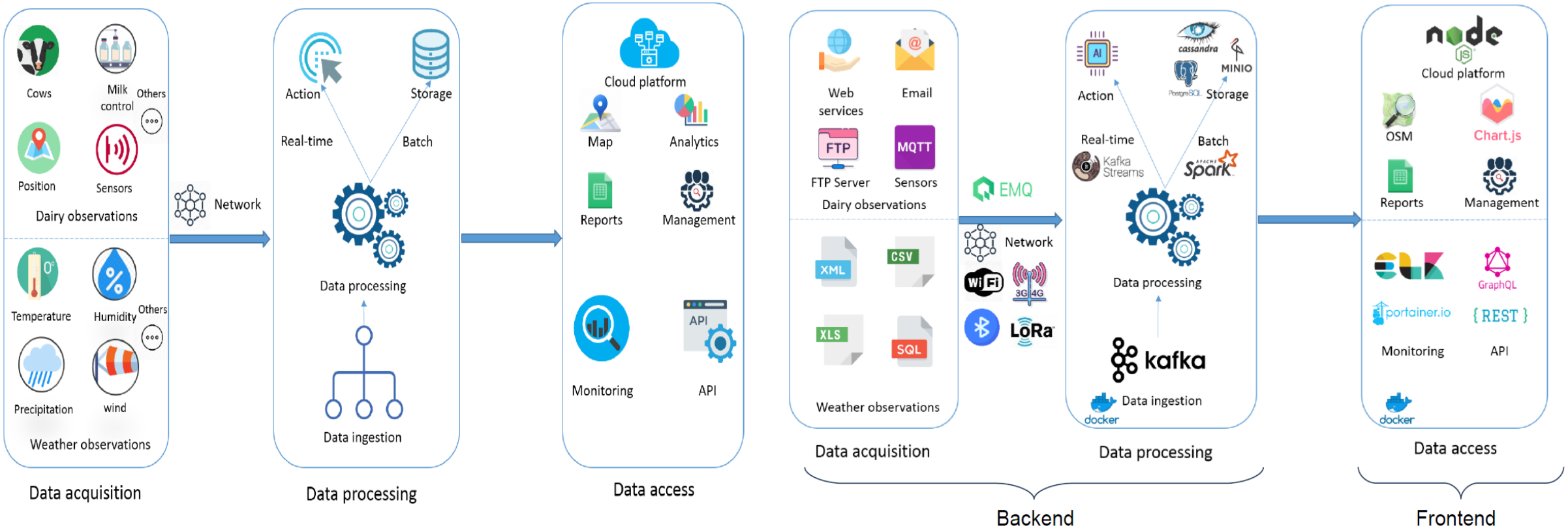
$$Y_{kglait\ 365}\ [kg] = Y_{kglait} / IVV * 365$$
$$Y_{kgMG\ 365}\ [kg] = Y_{kgMG} / IVV * 365$$
$$Y_{kgprot\ 365}\ [kg] = Y_{kgprot} / IVV * 365$$



Support: Customization parameters

Cheese making properties	Minerals	Energy balance	Infections / mastisis	Methane production
Acidity	Na (mg/kg)	milk_bhb_svm	Milk_nagase	Ch4 (g/day)
Cheese Yield curd	Ca (mg/kg)	milk_acetone_svm	Lactoferine	
Cheese Yield solid	P (mg/kg)	milk_citrate_svm		
FreshLabCheeseYield	Mg (mg/kg)			
DryLabCheeseYield	K (mg/kg)			
TotalCaseins				

Support : Information about WalleSmart



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Characteristics of the Application

- **Developed using Microsoft Visual Studio 2022**

- **Backend built with Flask (Python)**

- **Frontend uses HTML, CSS, and Jinja2 templating**

- **Data Interchange:**

Uses **JSON** for exchanging data between the frontend and backend.
JSON responses are used in RESTful API endpoints to provide data dynamically to the client.
Handles **JSON requests** to parse and process incoming data from client-side applications or scripts.

- **Features:**
- **Calculation of various indices** (e.g., lactation index) for livestock management.
- **Dynamic data filtering** based on user input, allowing users to view customized reports and analyses.

Why Use a Stochastic Model for Predicting Future States of Somatic Cell Groups?

Handles Uncertainty and Variability:

- Somatic cell counts (SCC) can vary widely due to **multiple factors such as cow health, environmental conditions, and management practices.**

Incorporates Probabilistic Transitions:

- Stochastic models, like Markov models, **use transition probabilities to predict the likelihood of moving from one state to another** (e.g., low SCC to high SCC).

Adaptive to Changing Conditions:

- As new data becomes available, **the model can be updated** to reflect changing conditions on the farm.
- This adaptability ensures that predictions remain relevant and accurate over time.

Provides Insights into Risk and Trends:

- By **simulating multiple future scenarios, a stochastic model helps in identifying potential risks** (e.g., the risk of a high SCC outbreak).
- It allows farmers to take preemptive actions based on predicted trends and probabilities.

Supports Decision-Making:

- Helps farmers and veterinarians make informed decisions about herd management, such as interventions to prevent increases in SCC.
- **Offers a quantitative basis for choosing management strategies** that minimize risk and optimize milk quality.

Conclusion:

- A stochastic model is ideal for **predicting future states of somatic cell groups because it captures the inherent uncertainty, adapts to new data, and provides actionable insights for better herd management.**

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