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## Towards decision support system for the agri-food sector using heterogeneous scientific data annotated with an ontology and Bayesian networks: a proof of concept applied to milk microfiltration

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Towards decision support system for the agri-food sector using heterogeneous scientific data annotated with an ontology and Bayesian networks: a proof of concept applied to milk microfiltration

Cédric Baudrit, **Patrice Buche**, Nadine Leconte, Christophe Fernandez, Maëllis Belna, Geneviève Gésan-Guiziou  
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CATI DIISCICO

## ➤ Motivation and issues

**Decision tasks** based on the **scientific literature in the agri-food sector** (here milk microfiltration) because:

- Key role in the sector (here dairy sector)
- Need to improve prediction of unit operation performances and optimize plant design (here microfiltration)
- Existing models only available on restricted operating conditions

Issues

- Scientific data **heterogeneously** structured, available in textual format
- Data **uncertainty** due to processes involving biological material
- Data **reliability** due to the way experiments have been conducted



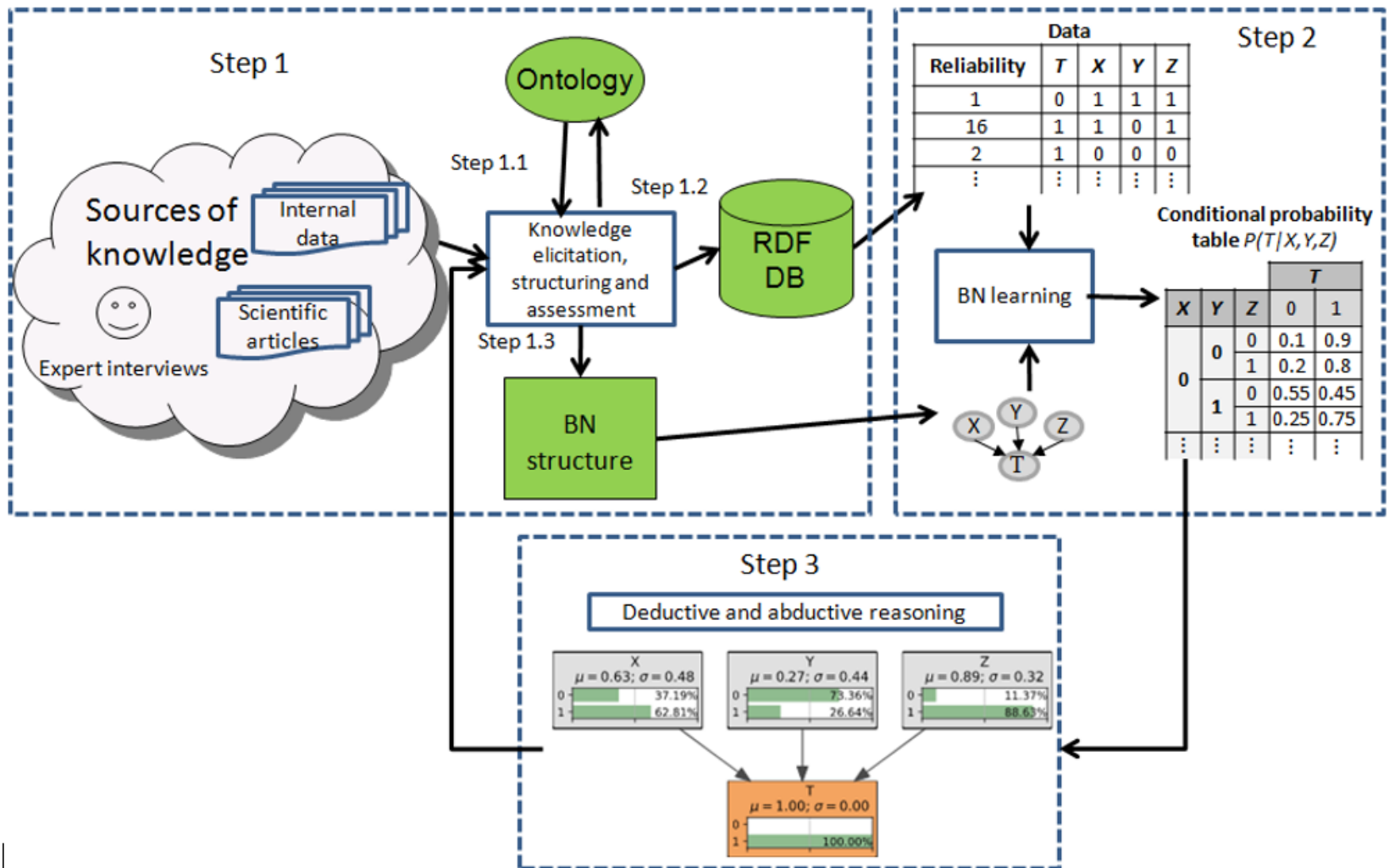
## > Proposal

A **Decision Support System (DSS)** based on ontology and Bayesian networks which deals with the preceding issues in order to:

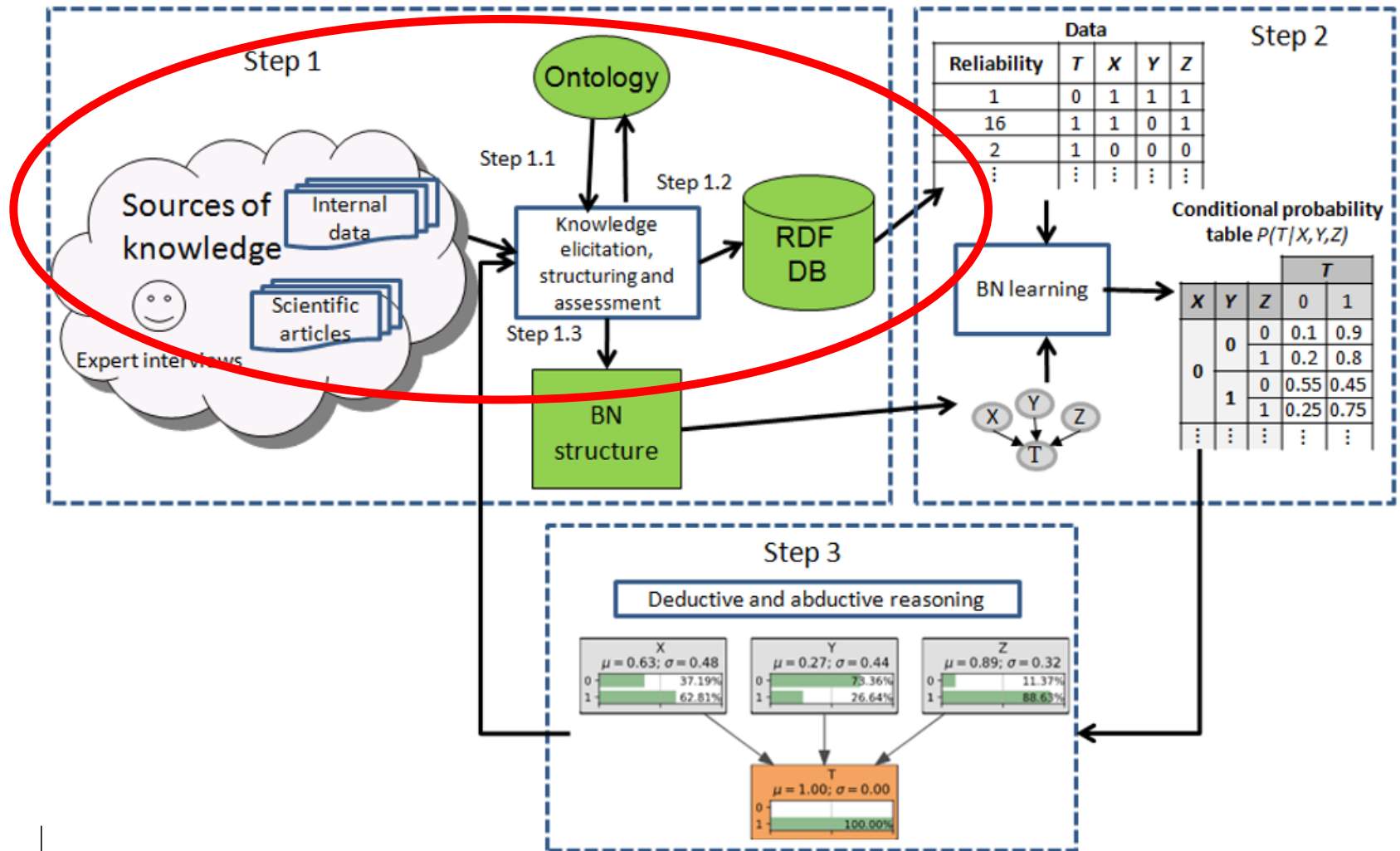
- **structure and integrate** heterogeneous experimental data sources by using **ontologies**
- **provide open access** to annotated data
- **assess** data source reliability
- **learn Bayesian networks using uncertain data** taking into account data reliability



# ➤ Decision Support System workflow



# ➤ Decision Support System workflow



## ➤ Key ideas to integrate data

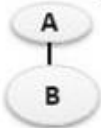
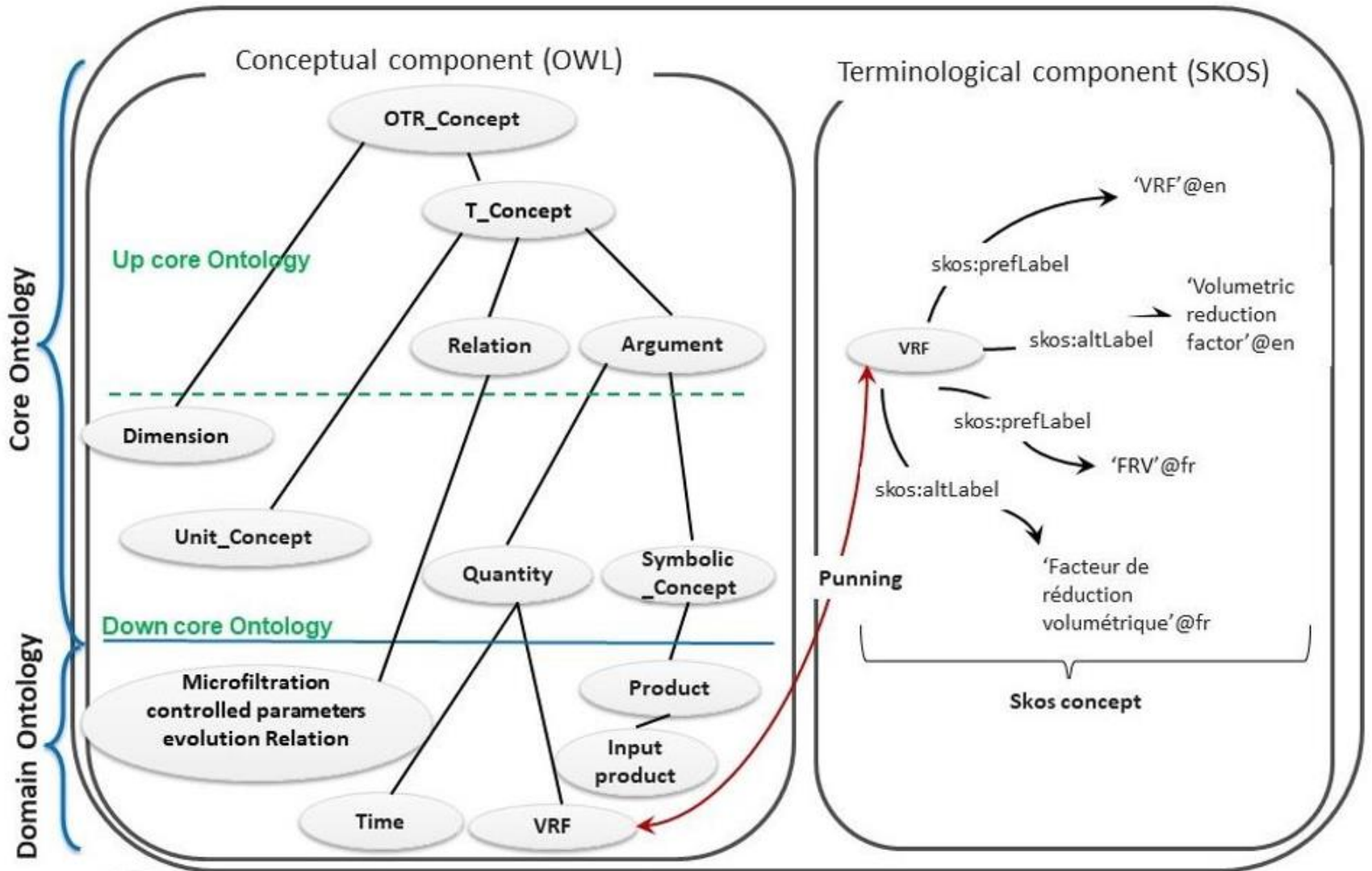
**Representing knowledge using international standards to represent ontologies and data (semantic web languages as OWL/RDF)**

Using an ontological model to provide a reading grid for article annotation

Developing end-user oriented Web applications for ontology and data management based on semantic web languages



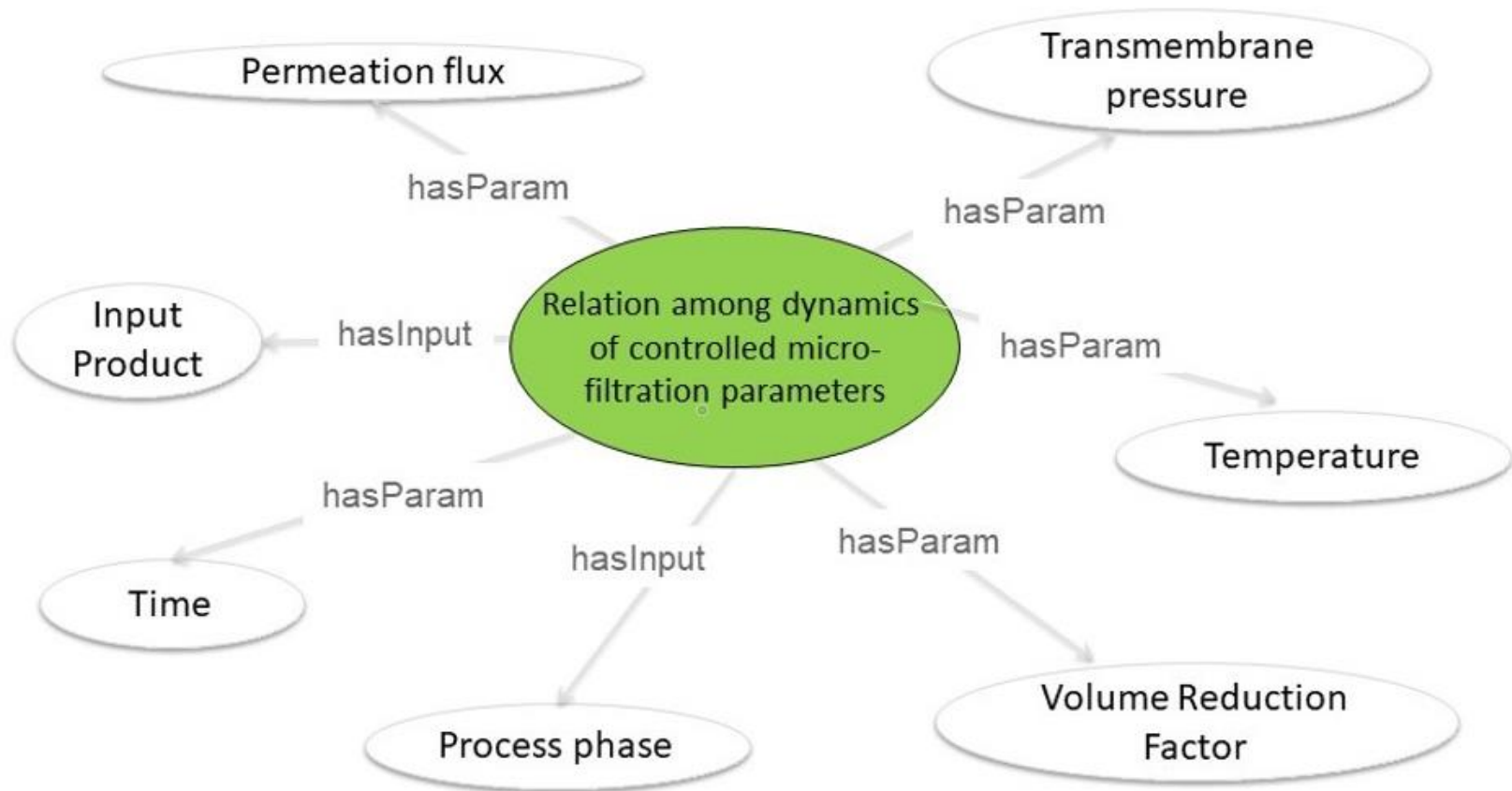
# ➤ naRyQ Termino-Ontological Resource (TOR)



Specialisation relation: B is more specific than A



# ➤ OWL Relation concept to model unit operation involved in a bioprocess



<https://doi.org/10.15454/5MQMKG>  
Milk Microfiltration v1.5

## ➤ Key ideas to integrate data

Representing knowledge using international standards to represent ontologies and data (semantic web languages as OWL/RDF)

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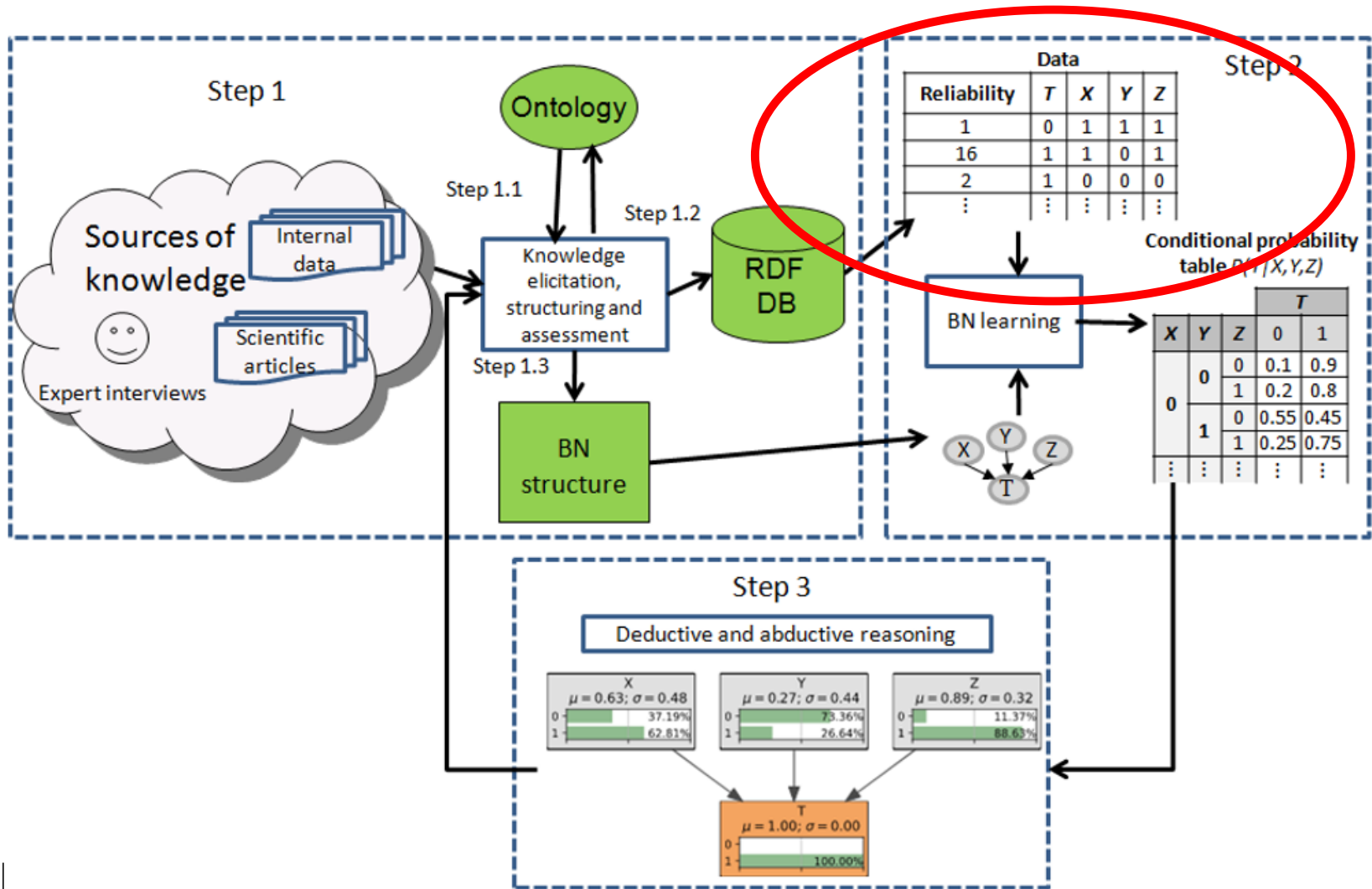
Developing end-user oriented Web applications for ontology and data management based on semantic web languages



## ➤ Relation concept instantiation in @Web import template CSV file

	P	S	V	X	Y	AC	AD	AE	AM	AO	AP	AT	AW	AY	BE	BI
1	Experience	Process step	Time	Time_UNIT	Process phase	VRF_AVG	VRF_STD	VRF_UNIT	Temperature	Temp	TMP_MIN	TMP_UNIT	Jp_AVG	Jp_UNIT	Crossflow ve	Crossf
370	1	5	90 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	71,8369131	kPa	58,9	l.h-1.m-2		6,9 m.s-1
371	1	5	95 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	73,6860843	kPa	58,9	l.h-1.m-2		6,9 m.s-1
372	1	5	100 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	74,7661331	kPa	58,9	l.h-1.m-2		6,9 m.s-1
373	1	5	105 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	75,5516231	kPa	58,9	l.h-1.m-2		6,9 m.s-1
374	1	5	110 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	76,0425544	kPa	58,9	l.h-1.m-2		6,9 m.s-1
375	1	5	115 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	76,9262307	kPa	58,9	l.h-1.m-2		6,9 m.s-1
376	1	5	120 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	78,6935832	kPa	58,9	l.h-1.m-2		6,9 m.s-1
377	1	5	125 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	79,4790732	kPa	58,9	l.h-1.m-2		6,9 m.s-1
378	1	5	130 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	78,6935832	kPa	58,9	l.h-1.m-2		6,9 m.s-1
379	1	5	135 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	80,559122	kPa	58,9	l.h-1.m-2		6,9 m.s-1
380	1	5	140 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	81,4427983	kPa	58,9	l.h-1.m-2		6,9 m.s-1
381	1	5	145 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	83,1119646	kPa	58,9	l.h-1.m-2		6,9 m.s-1
382	1	5	150 min		Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	82,8174058	kPa	58,9	l.h-1.m-2		6,9 m.s-1

# ➤ Decision Support System workflow



## ➤ Key ideas to assess data source reliability

**Defining meta data to evaluate (milk microfiltration) data source reliability**

Using a model to merge metadata quotations

Developing end-user oriented Web applications



# ➤ Meta data quotations (milk microfiltration)

@Web

Ontology

Documents

Query

Login :

Password :

Sign in / Sign up

▶ BIOREFINERY - V 95

▶ DURUM\_WHEAT - V 44

▶ FOOD\_COMPO - V 2

▶ FOOD\_TEXTURE - V 56

▼ MICROFILTRATION - V 70

Download

Generate template import

View

Explore

View judgements on criteria

▶ TRANSMAT - V 107

▶ VALORCARN - V 19

▶ Unit Ontology

	unknown	not at all reliable	not at all or hardly	hardly reliable	hardly or average	average reliable	average or reliable	reliable	reliable or very	very reliable
<b>MF-Number of repetitions - Compositional analysis</b>										
> 3 or more										++
> 2								+		
> 1				-						
<b>MF-Source Type</b>										
> Book								+		
> Proceeding				-						
> Journal article superior IF quarter (in at least one area)										++
> Journal article second IF quarter (in at least one area)								+		
> Journal article third IF quarter (in at least one area)				-						
> Journal article inferior IF quarter (in at least one area)		--								
> Encyclopedia article								-+		
> Patent				-						
> Report				-						
> Thesis								-+		
> Science popularization article				-						

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See Buche et al. 2021 ( <https://doi.org/10.1016/j.dib.2021.107063> ) for a complete description of the 8 meta data

## ➤ Key ideas to assess data source reliability

Defining meta data to evaluate (milk microfiltration) data source reliability

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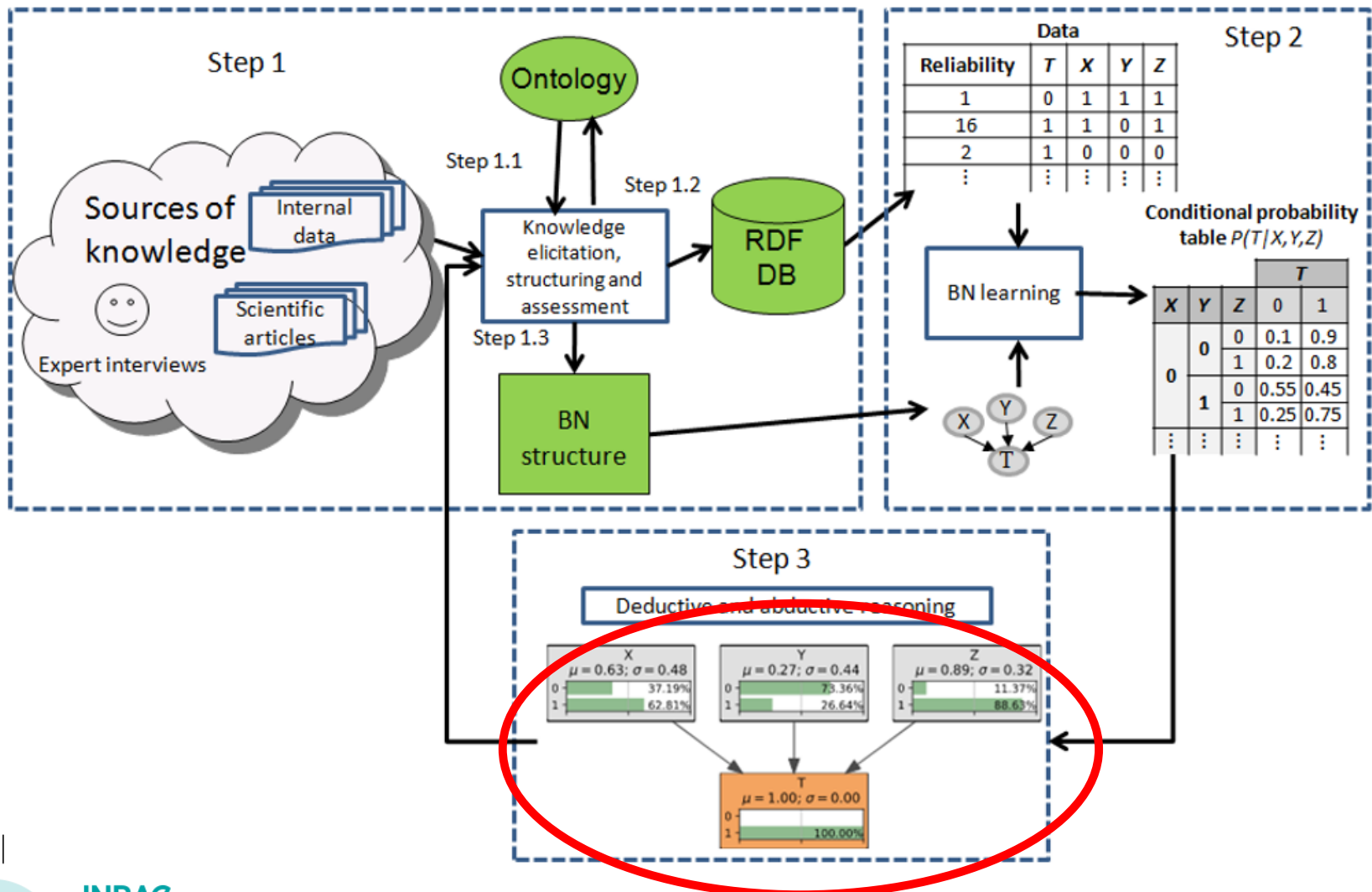
## ➤ Model with belief functions

- Inputs: metadata associated with the data source and expert quotations associated with metadata values
- Model with belief functions: merging quotations associated with metadata for a given data source (able to model ignorance, identify and manage conflicts)
- Output: estimated reliability  $\left[ \underline{E}_{d_i}, \overline{E}_{d_i} \right]$
- Usefulness: ranking of sources based on interval comparisons

$d_i$	(#cit vs age)	repetitions	source type	$\left[ \underline{E}_{d_i}, \overline{E}_{d_i} \right]$
$d_1$	-	No	Journal paper	[1.40,4.66]
$d_2$	(79,3)	Yes	Journal paper	[4.67,4.97]
$d_3$	-	No	Technical sheet	[1.05,1.40]

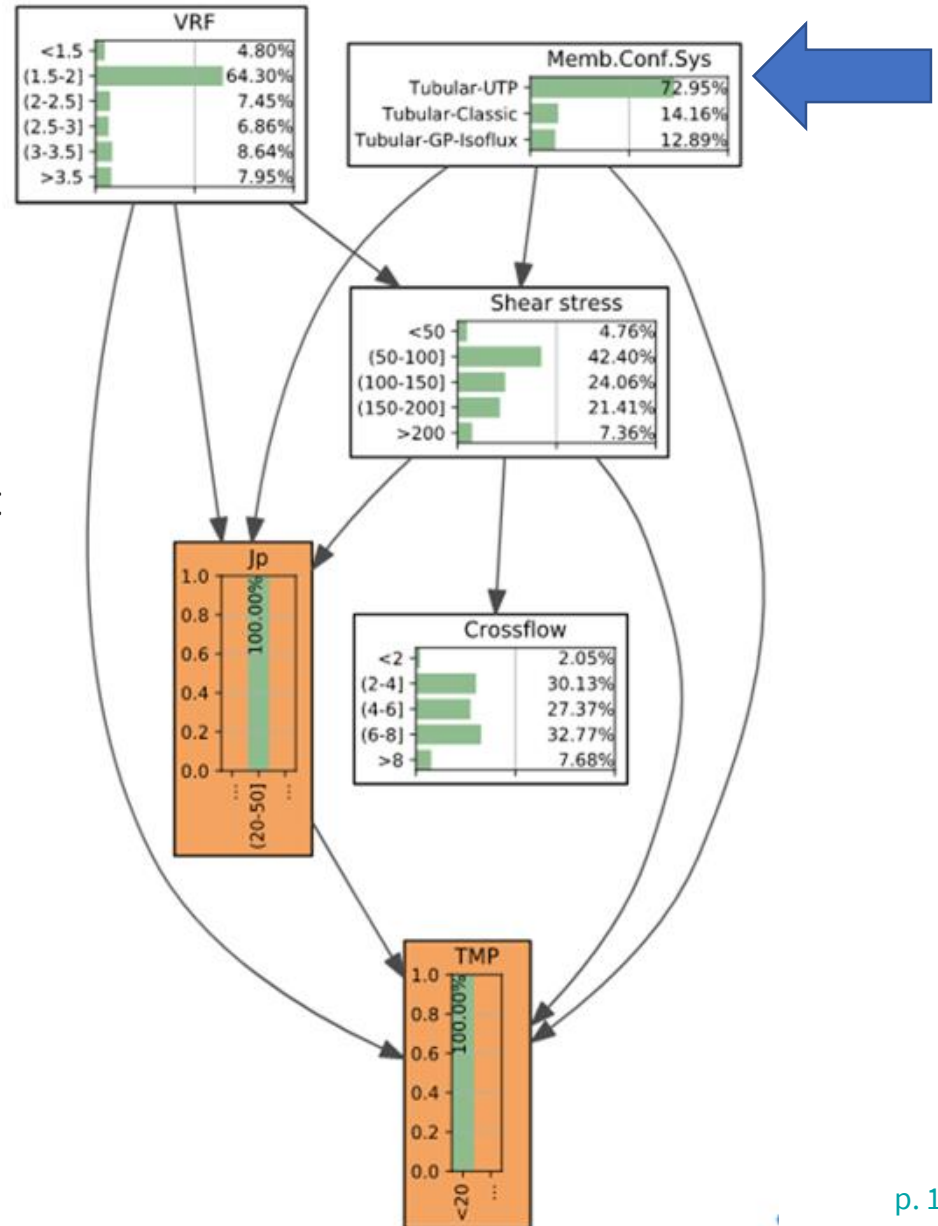


# ➤ Decision Support System workflow



# ➤ Decision support using Bayesian network learned with data

Including data reliability in model's predictive accuracy based on leave-one-out cross-validation for prediction of  $J_p$  given shear stress, VRF constraints and the type of membrane used increases the overall accuracy from 42% to 70%



## ➤ Conclusion-perspectives

### Conclusion

- Proposition of a generic ontological model (and associated tool) to guide manual annotation of scientific papers
- Reuse of annotated scientific data available in a SPARQL endpoint to learn a BN model for DSS
- Reliability assessment of data sources enhances model's predictive accuracy
- Preliminary version of a DSS dedicated to Milk Microfiltration taking into account large operating conditions

### Perspectives

- Speeding up annotation using NLP guided by ontology (cf Martin's speech)
- impacts assessment of process parameters on milk quality parameters



## > Questions ?

### References

Buche, P., Dervaux, S., Leconte, N., Belna, M., Granger-Delacroix, M., Garnier-Lambrouin, F., Gesan-Guiziou, G. (2021). Milk microfiltration process dataset annotated from a collection of scientific papers. Data in Brief, 36 doi:10.1016/j.dib.2021.107063

Baudrit Cédric, Buche, P., Leconte, N., Belna, M., Fernandez C., Gesan-Guiziou, G. (2021). Decision support tool for the agri-food sector using data annotated by ontology and Bayesian network: a proof of concept applied to milk microfiltration (submitted to IJAEIS)

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## ➤ Key ideas to integrate data

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# ➤ Relation concept instantiation in @Web web app

**@Web**    [Ontology](#)   **[Documents](#)**   [Query](#)    Login :    Password :    [Sign in](#) / [Sign up](#)

Microfiltration process description

n°	Treatment	Input product	Experience number Unit : 1	Process step number Unit : 1	Treatment duration Unit : s	Temperature Unit : oC	Rotation speed	Membrane Reference	Manufacturer	Membrane material	Membrane Configuration
1	Skimming	Milk	Experience number 1.000e+00	Process step number 1.000e+00		Temperature 4.000e+00	Rotation speed				
2	Heat Treatment Pasteurization	Intermediate product	Experience number 1.000e+00	Process step number 2.000e+00	Treatment duration 1.600e+01	Temperature 7.200e+01					
3	Storage	Intermediate product	Experience number 1.000e+00	Process step number 3.000e+00							
4	Temperature Holding	Intermediate product	Experience number 1.000e+00	Process step number 4.000e+00		Temperature 5.000e+01					
5	Microfiltration Separation Micelles-Seric protein	Product input separation step	Experience number 1.000e+00	Process step number 5.000e+00	Treatment duration 1.200e+02			FR FG7838-OS0x-S	Parker-Hannifin	PVDF	Spiral

←    →

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## ➤ Key ideas to assess data source reliability

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# ➤ Data source reliability assessment

## Document's general information

### Document's name :

Optimization of protein fractionation by skim milk microfiltration: Choice of ceramic membrane pore size and filtration temperature

Associate topic : MFMilk HT-MF

Associate ontology : MICROFILTRATION

Accepted Tables : 5

Rejected Tables : 0

Untreated Tables : 0

### Authors :

Jorgensen, C. E., Abrahamsen, R. K., Rukke, E.-O., Johansen, A.-G., Schüller, R. B., Skeie, S. B.

Journal : Journal of Dairy Science

Year : 2016

Volume : 99

Issue : 2016P 6164-6179.

Identifier : <http://doi.org/10.3168/jds.2016-11090>

## Document criteria values

### Criterion MF-Number of replicates - Compositional analysis

MF-Number of replicates - Compositional analysis : 3 or more

### Criterion MF-Source Type

MF-Source Type : Journal article first IF quartile (in at least one area)

### Criterion MF-Assay type

MF-Assay type : As a function of time (<2h)

### Criterion MF-Number of replicates - Microfiltration essays

MF-Number of replicates - Microfiltration essays : 2 or more

### Criterion MF-Operating mode

MF-Operating mode : Batch (UTP/GP)

### Criterion MF-Number of automatic parameter controls during MF

MF-Number of automatic parameter controls during MF : 4 or more

### Criterion MF-Initial product state

MF-Initial product state : Liquid milk

### Criterion MF-Protein analysis method

MF-Protein analysis method : Kjeldahl

Reliability  
model



## Reliability assessment document information

### Reliability results

Low expectation : 4.7 ; High expectation : 4.99

Known criteria values rate : 100.0 %

Last assessment date (yyyy-mm-dd) : 2020-03-09